Soils of Urban Industrial Traffic
Mining and Military areas

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ABSTRACT BOOK

Acknowledgments

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Poster Abstract

Classes in Soil Taxonomy (2014) to Recognize Contaminated Soils – Gathering SUITMA Feedback for Urban and Anthropogenic Soils

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In the 2014 12th edition of Keys to Soil Taxonomy, the Soil Survey Staff did not add human-altered and human-transported (HAHT) material classes that had evidence of contamination severe enough to pose health and safety hazards for humans (public citizens and soil scientists). Metal contamination, hydrocarbon spills, chemical buildup, and radioactivity (native or anthropogenic) are factors that have been observed and are important to interpretation and use and management in onsite investigations. However, there was concern that we should not be sampling or digging in soils that were hazards to our health, so would not need to classify them at a family or series level. During a recent field trip to South Africa, however, gold mine tailings were observed and handled without apparent harm. There seems to be a need to identify where hazardous and semi-hazardous soils occur, and identify whether the contamination is natural or transported by humans and their activity. Even finer divisions may be needed for contaminated soils. For example, identifying whether the danger comes from direct contact versus indirect contact may be important to users, especially in brownfields that may be used for recreation or travelled across. The difference between the type of contaminating materials (heavy metals, hydrocarbons, radioactivity, or manufactured chemicals) may be important as well.

We have had two full field seasons since these Family classes were introduced worldwide for testing. Since Soil Taxonomy is a dynamic system, it will be helpful for the SUITMA group and also users of the World Reference Base for soil resources (2014) to review possible additions to US Soil Taxonomy and provide comments such as: 1) Are contaminations severe enough to cause harm to humans important enough to acknowledge in the soil classification? 2) Should the difference between direct versus indirect danger of exposure be separated? 3) Should the difference between contaminating material be separated in a soil classification system? 4) What are the pros and cons to their addition and acknowledgement? 5) Should the classes be different for HAHT soils versus more natural soils? i.e., do we need a Metalic subgroup for soils naturally high in heavy metals (Arsenic, Selenium) and an Anthrometalic subgroup for HAHT soils high in heavy metals?

Soil Survey Staff. 2014. Keys to Soil Taxonomy, 12th ed. USDA-Natural Resources Conservation Service, Washington, DC.

Why parent materials should be introduced into Technosols systematic?

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Soils and soil-like bodies on industrial wastes (Technosoils in WRB) recently became objects of soil classification and are included in some classification systems such as WRB (2007) and Russian (2004) systems. These soils and soil-like bodies usually are young formations with poorly formed and/or thin genetic horizons. Nevertheless, the criteria used for the full-profile soils are applied to such formations, and this is uncertain because of weak manifestations of pedogenesis and non-conventional features of substrates affecting soil properties and soil development, in particular, the thickness of horizons, hence, quantitative assessments.

Properties of soils on the surface of industrial waste heaps vary depending on the type of wastes, age and geographic location, as shown in the recent reviews made by two groups of Russian pedologists (Sokolov et al., 2014, Zamotaev et al., 2017). In numerous papers, we can see suggestions for classifying soils on various artificial objects; the authors often suggest to extend already existing classifications over SUITMAs, introduce new taxonomic levels, qualifiers, etc. (Uzarowicz, Skiba 2011; Charzyñski et al., 2013; Prokofieva et al., 2015). Natural landscapes around the waste heaps and the presence of remediated areas on their surface attribute additional specific features to these objects in terms of their diversity and pedogenetic trends. So, the diversity and variability of technogenic soils even within one industrial area is high (Androkhanov et al., 2004).

The studies performed at two groups of industrial objects in southern Siberia, served as a basis to discuss the following issues in the field of classification problems. When does the manifestation of pedogenesis permit to refer the object to soils, and how can we separate soils, pre-soils and non-soils? Isn't the effect of parent material underestimated in the classifications of industrial SUITMAs? How do different types of substrate affect the rate of evolving the non-soils into soils?

The study objects were contrasting in their properties, primarily, in their substrates, also in the natural landscapes around them; similar was their age – 25-30 years, and the research methods. Two types of industrial landfills are located in highly productive taiga biomes – fir forests with well-developed herbaceous layer. Technologically similar objects were also chosen in the forest-steppe to compare the effect of zonal conditions on initial pedogenesis.

Coal mining dumps are composed of a mixture of non-toxic fragments of overburden and host rocks and coal particles. Significant space between diverse rock fragments determines the heterogeneity of substrate and easy water percolation. Sulphur content is low (<0.06%). *Iron ore tailings* bodies are stratified – alternation of sand and silt layers owing to intermittent filling by wastes derived of host rock crushing, comminution and ore separation. Stratification causes water stagnation and surface compaction. Tailings contain significant amounts of sulphates and chlorides (Table 1).

Dumps and tailings in both natural zones are partially overgrown by grasses and bushes due to self-restoration and remediation. The plant-covered areas are larger on dumps; they occupy 70-80% there, while on tailings – less than 40-60%. Mostly, the combination of soil-forming factors is favourable for the development of soils, except for some sites: compacted, saline, poor in fine earth, burnt; therefore, the soil cover is discontinuous. At such sites, the soil is absent which means that the substrates are not changed by pedogenesis and cannot be qualified for soils. Soils on the dumps and tailings have simple profiles comprising a thin (2-5 cm) humus- or organo-accumulative horizon, abruptly or gradually merging into the substrate. Morphologically, the pedogenetic processes are manifested in the formation of humus horizons, differentiated pattern of fine particles in the profile, re-arrangement of solids, as well as in changing labile properties: profile differentiation of pH, content of soluble salts, sometimes, C_{org}.

Table 1. Main properties of coal dumps and ore tailings substrates

Characteristics	**Coal dumps**	**Iron ore tailings**
Rocks	Mixture of sandstone, siltstone, mudstone, coal fragments	Comminuted fragments of ore-bearing rocks, primary minerals: quartz, feldspars, amphibole, garnet
Fine fractions content in the upper 10 cm,%	10-20	100
Fabric	Highly heterogeneous	Stratified
pH_{water}	7.1-8.3	7.5-8.0
Salt content,%	0.01-0.03	0.11-3.02
Predominant micro-elements	Pb, As, Sr	V, Cr, Ni, Zn

Currently, in the Russian classification system (2004/2008), apart from soils, technogenic surface formations (TSF) are categorized. To discriminate them from soils, special verbal constructions were invented (Tonkonogov, 2001). TSFs comprise purposefully made soil-like bodies and products of industrial activities, either natural (relocated), or human-made (artificial). TSFs are subdivided in accordance with their composition at two levels: groups and subgroups. The coal dumps studied are composed of natural material modified in the course of extraction and dumping processes. Therefore, the surface formations on them may be referred to the group of *naturfabricats*, subgroup – *lithostrats* according to the proposed terminology. Such verbal constructions emphasize taking apart the TSFs with natural but human-translocated material deposited in a non-natural way, and soils with their genetic horizons. Substrates of tailings are wastes of processing industry, which makes it possible to refer them to the group of *artifabricats*, subgroup *artiindustrats*, i.e. artificial (arti) strata formed in the course of industrial (indu) activity. The next step in categorization the TSF bodies presumes considering in more detail the substrate fabric, which, in our case will be stony-mosaic and stratified, respectively. Basic chemical properties, in particular, those responsible for toxic effects, may be applied as criteria for the lower levels either. This approach may be useful for assessing "chances to become soil" for TSFs; it is also in line with the idea of Juilleret with co-authors (2015) to complement the WRB system with *subsolum* grouping.

The main difference between the young technogenic soils and the TSFs is the presence of a humus horizon. Soils on the investigated objects are characterized by weakly developed profiles and refer to the trunk of primary pedogenesis, where the character of parent rock is among criteria to identify soil types. Thus, there are several types there: *psammozems, pelozems, petrozems*. According to recent proposals of Prokofieva with co-authors (2015), soils on technogenic materials should be allocated as individual types in this trunk. These are: *technogenic petrozems* on hard rock or skeletal material (coal dumps substrates); *technogenic pelozems* and *technogenic psammozems* – on loamy and sandy materials, respectively (substrates of iron ore tailings). At lower taxonomic levels, criteria for natural soils may be used.

It's important to note that such SUITMAs are perceived as genetic continuation of TSFs (naturfabricats and artiindustrats), which determine their properties. Although the boundary between these two formations is unclear, an agreement about a certain conventional separating marker will help to reveal either the bonds between them, or the differences in their character, functioning, ongoing processes, etc. On the study objects, perfect markers are vegetation or humus horizon. If they are absent, the processes dominating in the waste body are limited by transformation of the initial technogenic substrates, and if they exist, these processes are slowed down and those of humus accumulation and formation of structure come to the fore.

The introduction of the technogenic parent materials systematic will facilitate the researcher's task in understanding with what kind of formation he or she works. When reading papers about Technosols you'll understand that this is exactly the soil, not just dumped rock fragments. In addition, by specifying the age of human-made object (e.g. 40 years) the presence of TSFs on its surface means that there are some restrictions of soil development. This approach will serve as an interpreter from the classification language to the language of real material objects.

Also, the experience of discriminating classifications for TSFs and soils on the contrasting technological objects shows that the properties of the substrates determine properties and development rates of soils. When comparing dumps and tailings with the same age, it can be seen that on the former, the rate of pedogenesis is much higher than on the latter. This may be attributed to toxicants in tailings substrates hindering their turning into the soils unlike the non-toxic substrates of coal dumps more favourable for plants.

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Functional-environmental and properties-oriented classifications of urban soils (In memoriam Marina Stroganova)

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A first comprehensive classification of urban soils in Russia was proposed by Marina Stroganova in the 1990-ies, and it was derived of the data collected in the course of working in the projects on the ecological status of Moscow city (Stroganova et al., 1998; Ecological.., 2000).

This classification had 4 particular features. (i) Being a soil classification, it had its objects, which were not always qualified for soils in those times. Therefore, there is an impression of arguing that urban soils are real soils). (ii) Consequently, it seems not impossible that preference was given to nomenclature similar to common soil names with the suffix "zem" on one hand, and to formative elements indicating the functions performed by soils, on the other hand, for example, recreazem, industrizem. This functional nomenclature was understandable for users and habitual to soil scientists. (iii) The difference was emphasized between the terms «urban soils» and «soils of the city», the latter referring to all soils that occur in the city; these are mostly intergrades between urban «zems» and natural soils, hence, they received a general name of urbo-soils. The same approach was accepted in the classification of soils of Russia: agro-soils and agrozems (Russian.., 2001). (iv) The classification of Stroganova has elements of a hierarchical system, although not strictly implemented at the upper taxonomic levels unlike the lower ones, where rules and criteria inherent to the traditional Russian soil systematic were essential. This feature has its rationale – availability to users, habit and link to the basic system.

Each of these four features–statements may be topics for further discussion and critical analysis and are related to the current challenges in soil classification. Thus, the first one: «soil – non-soil» is associated with the expansion of the perception of soil, such as «extreme» soils (Goryachkin et al., 2012), subaqueous soils (Demas et al., 1999), and Technogenic Surface Formations (TSF in Gerasimova et al., 2003; Russian…, 2001). The functionality of nomenclature may be regarded as a bridge to one of "hot spots" – role of soil forming agents in soil classification, as well as to specifying intergrades, whose position in the system is of special importance for the urban areas because of high diversity of human impacts on the original and already modified soils there, and continuously changing soil properties. Finally, hierarchy is an essential feature of most soil classifications, it provides their completeness (discriminating classifications from groupings of soils), illustrates conceptual priorities, and is useful for applied purposes. The hierarchy of Stroganova's system connects it with the basic Russian classifications.

Let us discuss the second aspect, namely, *functional nomenclature* and *intergrades*. Both elements became popular, are well known, frequently used and create the image of this system.

Solid-phase surface bodies in towns comprise soils, soil-like bodies, sediments; deeply transformed soils are represented by urbanozems subdivided into units (soil types?) in accordance with their *functions and/or location*: urbanozem *sensu stricto*, kulturozems, industrizems, intruzems, nekrozems; among soil-like bodies, replantozems and konstruktozems are specified; Stroganova, 1998). In some cases horizonation is taken into account. Clarity and universal character of these terms attract users; soil properties as criteria for further subdivision are removed to lower levels. Such factor-functional approach does not seem to be in good agreement with the principles of classifying urban soils in national and international systems declaring the priority of soil properties aggregated as diagnostic horizons. Nevertheless, groups of soils in the German classification (Arbeitskreis Stadtboden, 1994) are close to those in Stroganova's system, either in their essence, or terminology, f.i., intruzems and nekrozems. Obvious attention to soil properties may be found in the French "Référenciel pédologique", where among three Anthroposol References (transformés, artificiel, reconstitués) there are particular urban soils identified by properties of their profiles: truncated, mixed, compacted, polluted, with construction wastes, or sealed.

In the Technosol Reference Group introduced into WRB in 2006, there is only one – Urbic principal qualifier addressed directly to urban soils, whereas for a broader range of soils other special urban qualifies may be suitable, namely, Ekranic, Garbic, Isolatic, Reductic. Supplementary qualifiers indicate some particular features of urban soils: Grossartefactic, Archaic, Immissic, Transportic, as well as some manifestations of natural processes, like Fluvic, Gleyic, Mollic. When assessing all the supplementary qualifiers for Technosols (55!), it is hard to reveal priorities – soil forming conditions or soil properties? In our opinion, both approaches are involved. An imprint of ambiguity may be found even in the definition of Urbic qualifier representing a layer with ≥ 20% artefacts, part of which is related to human settlements.

Thus, addressing external conditions or events, primarily soil forming agents, when classifying urban soils is almost inevitable. It is required by the artificial origin of objects, their small age, even their transient status, and by quickly changing properties as probable responses to diverse impacts that are hard to be recorded without knowing their mechanisms. Complete refusal of external conditions for urban soils may produce erroneous taxonomic solutions.

Intergrades – urbo-soils (urbo-podzolic, urbo-chernozems, urbo-alluvial) were introduced into the classification system by Marina Stroganova and were actively supported by users. These soils have an urbic horizon ≤ 50 cm thick underlain by the remnants of former subsoils. It is a common case in the suburbs of megapolises and in small settlements. In terms of taxonomy, urbo-soils are subtypes and are further subdivided into genera, species, subspecies, varieties and phases in accordance with the criteria of the basic system for the natural (recent and former) properties. For example, a soil in a Moscow suburb may be named urbo-podzolic surface-gleyed, few-artifact, PAH-polluted loamy sandy on glaciofluvial sands.

Recently, a group of soil scientists made efforts to embed urban soils into the new classification system of soils of Russia – CSR (Prokofieva et al., 2014) following its concepts and diagnostic criteria. Unexpectedly, it proved to be rather easy, technogenic (TCH), and recultivation-mixed (RAT) horizons were introduced along with qualifiers – weakly expressed features of the above mentioned and some other horizons in CSR.

Since the profiles of urban soils are growing upward owing to all kinds of additions, they should be qualified for stratozems in CSR, hence, type of urbostratozems (UR-C, UR-D) is added to the stratozem order; other types are urbostratozems on buried soil (UR-[ABC]) and technogenic urbostratozems (UR-TCH). Urbo-soils found their due place in almost all orders of the postlithogenic trunk, for example, urbo-chernozem migrational-mycellary (UR- BCAlc–BCAnc–Cca). Technogenic parent material (TCH) served as diagnostic tool for soils with any humus- or organo-accumulative horizon (for example, AU – TCH, O – TCH) to form new types. Variants of TCH material were also introduced into the world of Technogenic Surface Formations, non-soils and artificial semi-soils – quasizems (corresponding to replantozems and konstruktozems).

Among the objectives for the development of urban soil classification is mapping, and the system proposed by Stroganova was created in the process of compiling a map. This was the first soil map of a whole city – map of Moscow for the Ecological Atlas of Moscow (2000). As in the soil map of West Berlin (Grenzius, 1987), the city area was subdivided in accordance with geomorphological regions, in which natural, urban soils and intergrades were presented. Very soon one more map of a megapolis appeared in Russia – Rostov-on-Don (Bezuglova et al., 2000); later, a detailed map of St.Petersburg was published (Aparin, Sukhacheva, 2014). The array of soil maps couldn't be compiled without urban soil classification, and this is one more proof of its importance in the applied and conceptual spheres, and Marina Stroganova was pioneer and great enthusiast of urban soil science in our country.

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Result of soil evolution on 60-year-old technogenic deposits of the Lomonosov Moscow State University campus

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Modern urban environments are characterized by the active relocation of ground masses with the formation of new layers of technogenic deposits. The surfaces undergo continuous changes caused by intensive land use and the development of newly built-up areas. As a result, city soils, as a rule, are quite young.

The complex of buildings of the main campus of the Lomonosov Moscow State University (LMSU) on the Leninskie Hills at the south-west of the city was constructed in the middle of the 20th century. Following the completion of the buildings, a botanical garden was established together with general land ameliorations within the LMSU campus. Prior to the campus construction, the whole area of Vorob'evy Hills was occupied by rural settlements, fields and woodland patches.

The soils studied were formed on similar technogenic deposits – 'building grounds', from 0.3 to 3 m thick, composed of mixed silty-loamy materials with fragments of horizons of native soils (Albic Retisols) and inclusions of building waste. Calcareous inclusions were very rare or absent within the surface layer, where the modern pedogenesis takes place. The pedogenesis on these deposits began over 60 years ago, at the time of general land ameliorations following the construction of the LMSU campus. Currently, the campus includes a harmonious combination of buildings, roads of various sizes, lawns, planted trees and the botanical garden comprising dendrarium, orchard, plots of cultivated plants, etc.

Studied soil pits were located in the botanical garden, on road-side lawns and under planted trees. The land management within the botanical garden involved the complete removal of fallen leaves in autumn from all parts of the garden, except the dendrarium. However, since 2011, only a partial removal of leaves has been practiced. The lawns have been regularly improved by additions of fertile composts.

The botanical garden soils had a magnetic susceptibility of 0.5-0.1 SI, which is a double or triple of that in background soils. The road-side lawn soils had a magnetic susceptibility of 1-3 SI, which is comparable to mean values over the city. The rate of accumulation of airborne solid deposits varied from 100 to 400 kg/km^2 per day in the soils studied, which corresponds to low and medium accumulation rates within Moscow that are themselves 10-40 times higher than those outside the city (Prokofieva et al., 2017).

Most soils of the study site can be classified as Technosols and Anthrosols, according to the WRB. They can be subdivided into two groups depending on general pedogenetic trends. The first group includes soils having typical postlithogenic pedogenesis and the A-AC-C profile, located within areas of low anthropogenic pressure. The second group connected with the synlithogenic trend of pedogenesis comprises a greater diversity of soils: some of them have an incrementally growing humus horizon due to compost additions, while others have a specific urban humus horizon (urbic) and have been termed by us as Urbostratozems (Prokof'eva et al., 2014). Urbostratozems are formed within areas, where a significant rate of airborne dust deposition is combined with occasional deposition of solid waste and possible additions of fertile composts. The urbic horizons that developed over a period of 60 years were relatively thick, with a distinct tendency for horizontal splitting of structural units, high contents of artefacts of all sizes and well-developed processes of chemical properties transformation. There were also some buried soils, both natural and agriculturally transformed, preserved under shallow technogenic deposits within the botanical garden.

All studied soils were characterized by eutrophication of their surface horizons due to depositions of airborne alkali salts and ice-melting agents leaking from roads. Soils with neutral to alkaline reaction developed on initially non-calcareous and weakly-calcareous parent rocks. Their surface horizons contained up to 3% of carbonates. The high content of phosphorus compounds in non-fertilized soils outside the botanical garden could have originated from the excreta of domestic animals and city birds. Soil pollution by microelements was at low to medium levels.

Judging by the particle-size distribution, the natural and technogenic parent rocks were silty loams. The urbic horizons of soils subjected to higher anthropogenic pressure near roads were sandy loams. According to bulk density measurements, soil compaction was insignificant.

A general trend of the current formation of highly humified horizons was revealed. The absence of the removal of fallen leaves within the dendrarium of the botanical garden resulted in the formation of horizons with humus content up to 9-11%. There was a lesser degree of organic matter accumulation under conditions of soil improvement through compost additions. The organic matter in the soils studied has different characteristics from that in native soils of the southern taiga belt, i.e., it has features typical for more southern pedogenesis. However, a general 'forest-type' character of humus is preserved (Rozanova et al., 2015).

Macromorphologically, the results of 60-year-long pedogenesis were expressed in the formation of humus horizons. Micromorphologically, soil-forming processes were identified as follows: structuring of technogenic grounds due to their processing by soil fauna; vertical migration of humus and clay in the absence of carbonates; mineral weathering and decomposition of inclusions within soil; and the formation of calcareous and ferruginous pedofeatures. The processes of iron redistribution and disperse humus accumulation have led to the formation of films on the surfaces of calcareous nodules, which apparently improved the stability of such nodules under conditions of a percolative water regime.

Thus, general trends of soil development within the LMSU campus, where pedogenesis has not been interrupted by new additions of technogenic grounds for a period of 60 years, are determined by a combination of non-catastrophic anthropogenic impacts. Namely, there are depositions of inorganic materials onto the soil surface (airborne dust deposition, waste accumulation and compost addition) and accumulations of organic matter varying in volume and composition (removal or non-removal of fallen leaves, addition of organic-rich composts and pollution by carbohydrates). The subdivision of pedogenesis into two main directions, postlithogenic and synlithogenic, depends on the rate of mineral matter accumulation on soil surface and applies to the road-side locations and the areas, where soils have been improved by regular compost additions.

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Diagnostic key feature for Technosol: human transported and altered material and artefacts

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Following an internationally acceptable consensus in differentiation of terms: urban soils as general term for soils located in SUITMA areas and anthropogenic soils (terminology for soil classification) we have focused on Technosols (WRB 2014, Charzynski *et al.* 2013, Gerasimova *et al.* 2003).) i.e. SUITMA soils). The approach of the technogenic soil classification involved in the WRB system can be interpreted by soil scientists differently, and diagnostic features can be vague. According to the new version of the Slovak anthropogenic soils classification (2014) the key features recognizes Technosols as separate classification soil group having human-transported and altered material (HTAM), and artefact content. Technozem (in Slovak language) is characterized as "*ex-situ*" deposited material, largely affected by physical-mechanical excavation, transportation and spread, prevailingly mixing, and containing artefacts. Field survey has to involve into description – features of anthro-pedoturbation and pedovariability on which a like "new pedogenesis" takes place very often (Sobocká 2010).

The Slovak Soil Classification System characterizes Technozems like soils developing or consisting of human-transported and altered material (HTAM) and recognizes two horizons – technogenic top horizon and technogenic subsoil horizon. Three varieties of HTAM layers are classified:

HTAM of natural origin – with share of < 10 % artefacts

HTAM of natural-technogenic origin with share of 10 – 40 % artefacts

HTAM of technogenic origin with share > 40 % artefacts.

Top horizon can be developed as a result of initial pedogenetic processes or as a result of recultivation measures. Also gleyic or stagnogleyic processes are taken into consideration. The cumulative horizons of HTAM for Technozem diagnostics must to have the thickness > 60 cm.

Artefacts (x) are solid or liquid (gaseous rarely) in soil, which are manufactured or modified by man as a result of industrial, construction, mining and other activities. Examples are buildings materials, glass, ceramics, rubber, plastics, metals, fly ash, petroleum products, sludge, textiles, etc. (WRB 2014).

Anthropogenic topsoil horizon Ad – surface horizon formed by human from transported heterogeneous earth or gravel materials (HTAM) having:

thickness > 1 cm;

organic carbon content C > 0,3 % weight.;

artefacts presence (fragments of bricks, glass, plastics, iron, slug, cinder, coal etc.).

Horizon varieties:

Anthropogenic initial Adi – primitive stage of top horizon with a thickness of 1 – 10 cm;

Anthropogenic recultivated Adr – top horizon enriched with humus and formed by recultivation processes with a thickness of more than 10 cm.

Sub-varieties of horizons are defined by HTAM characteristics like initial horizon developed from parent material of natural origin (Adiy); of natural and technogenic origin (Adiw); or technogenic origin (Adix); or recultivated horizon of natural origin (Adry), of natural and technogenic origin (Adrw), of technogenic origin (Adrx).

Anthropogenic subsoil horizon Hd – subsoil horizon formed by human-transported and altered material (HTAM), which is developed having

thickness > 1 cm;

artefacts presence (fragments of bricks, glass, plastics, iron, slug, cinder, coal etc.).

This horizon differs from top horizon or underlying layer by contrasting material.

Varieties of the horizon are the same as in the top horizon (Hdy, Hdw, Hdx).

There are introduced varieties typical Technozem characterize the specific soil properties regardless the depth of their occurrence in the soil profile.

dystric (d): sorption complex V < 30 % (extraction in 1M NH_4OAc);

non-saturated (a): V 30 - 50 % (extraction in 1M NH_4OAc);

saturated (n): sorption complex V > 50 % (extraction in 1M NH_4OAc);

calcareous (c): more than 0,3 % equiv. $CaCO_3$.

sulphate (t): extremely acid (pH v H_2O < 4)

silicate (q): absence of $CaCO_3$ in fine earth < 0,3 %;

leached (v): without carbonates in fine earth of A horizon to 20 cm from surface and their gradual increase toward to depth;

sulphide (d): contains pyrite as potential source of decomposition and sulphate weathering;

toxic contaminated (x): toxically antropogenic or geogenic contaminated at least part of the solum (toxic according to threshold limits);

imission contaminated (w): imission antropogenic or geogenic contaminated at least part of the solum (toxic according to threshold limits);

reductic (u): increased content of reductive active gases (methane, hydrogen sulfide, carbon dioxide) and oxygen deficiency by direct and/or indirect effects of human, and manifested by redox signs.

Forms according to anthropic features:

anthrozemic (aa): horizon thickness of the HTAM of natural or natural-technogenic materials to 100 cm from surface is less than 60 cm;

technozemic (ax): horizon thickness of the HTAM of technogenic materials to 100 cm from surface is less than 60 cm

garden (az): intensive soil cultivation in gardens, allotments especially by adding of soil improvers/fertilizers components (compost, pesticides)

terracing (at): soil cultivation by terracing on slopes with uneven thickness of cultivation Ak horizon;

trenching (ar): soil cultivation by trenching, applied in vineyards, orchards and hop gardens

terra-cetta (ao): stepped relief on soil surface situated on slope as a result of cattle grazing and frost movements;

drained (av): occurrence of weakly distinctive oxidative features reflecting changes in hydrological regime in the country;

compacted (ah): by human-induced compacted soil with presence of abnormal soil structure (ploughing layer, platy structure etc.);

urbic (au): a heap of organic-mineral material on artificially levelled or abandoned areas predominantly in urban areas, along roads and transport

landfill (ap): a heap of organic-mineral material on municipal and industrial wastes predominantly chemically active material;

spoil heap (ad): soil development from transported normally technogenic and natural-technogenic substrates (such as mining and industrial heap, etc.);

ekranic (ae): with the presence of impermeable or semi-permeable technogenic material on the soil surface (e.g. concrete, asphalt, pavement thickness < 0.2 m), which covers more than 80% of the polypedon

manufactured cover (ak): presence of short-term organic, mineral or industrial cover the soil surface rough <10 cm (e g. chipboard, mulch fabric, foil, etc.)

Two soil groups of anthropogenic soils involved in the Slovak Morphogenetic Soil Classification System (2014) are:

Group of cultivated soils: under a strong agricultural of soil-forming processes (in-situ soils): (21) Kultizem, (22) Hortizem.

Group of technogenic soils: with soil-forming processes significantly affected by technogenic human activity (ex-situ soils) (23): Anthrozem, (24) Technozem

(23) Soils having diagnostic anthropogenic top horizon with Adiy or Adry, and Adiw or Adrw and/or diagnostic subsoil Hdy or Hdw horizons made from HTAM of natural or natural-technogenic origin in cumulative thickness more than 60 cm:

ANTROZEM (AN), subtypes:

(23.1)…initial (ANä)
(23.2)…pseudogleiyc (ANg)
(23.3) …gleyic (AN_G)
(23.4)…recultivated (ANô)

(24) Soils having diagnostic anthropogenic top horizon with Adix or Adrx horizon, and/or diagnostic anthropogenic subsoil Hdx or Hdx horizons made from HTAM of technogenic origin in cumulative thickness more than 60 cm:

TECHNOZEM (TZ)
(24.1) …initial (TZä)
(24.2) …pseudogleyic (TZg)
(24.3) …gleyic (TZ_G)
(24.4) …recultivated (TZô)

Generally precise manual for anthropogenic, mainly technogenic soils description and evaluation is missing. Also methodology for better characterization of artefacts (technogenic material) is not available in Slovakia.

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Urban soils: diagnostics, classification, mapping

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The soil cover of any city is heterogeneous and characterized by significant spatial and temporal heterogeneity. To a large extent, this is due to the degree and scale of anthropogenic impact at different stages of the city construction and expansion, as well as in different city areas – in the center, on the outskirts, in forest parks, industrial areas and "sleeping" districts.

It is obvious that, when solving problems of diagnostics, classification positioning and mapping of urban soils, we must take into account the specifics of the soil structure and properties, being formed under direct or indirect anthropogenic influence, as one of the factors of soil formation. The human impact on the soils in an urbanized area can be manifested with a wide range: from insignificant changes in their properties to a radical transformation of the soil profile and creation of new soil forms.

The previous studies of soils in Saint Petersburg, a modern megacity, showed that one of the peculiarities of the soil formation process in an urban environment is rejuvenation of the soil profile as a result of a regular or periodic introduction of humus material on the surface. In a city, people are forced to construct, in place of the destroyed soils, soil-like formations with a fertile root layer, introducing external organic-and-mineral or organogenic soil materials – the product of long-term natural soil formation process. Usually, this material is taken from various soils in adjacent territories and is applied either upon the preserved horizons of the previous soils or upon the natural rocks exposed at the surface as a result of soil profile destruction or moved in the course of construction, or upon an artificially created mineral formation. Thus, the most biologically active part of the soil is transferred from its natural area into the urbanized territory. Although the soil formation process, as a particular, nature-immanent material movement form, begins immediately after stabilization of the ground surface on all mineral and organic-and-mineral substrates, hundreds of years are required to form a system of genetic horizons in the surface formation.

In the new human-made soil profile, the majority of morphological traits are preserved that allow for identifying the type of the moved horizons. Purposeful introduction of material from the humus (peat, peat-and-mineral) horizon into the urbanized environment is a kind of technogenic introduction, similar to the introduction of plants. As a results, soils are formed, the properties and morphological traits of which, on the one hand, are inherited from the mother soil, and, on the other hand, are related to anthropogenic impact. The moved humus or organogenic horizon features a sharp lower border with the underlying mineral substrate – the bedrock which normally differs from the natural ones both in terms of its composition and structure.

A distinctive feature of bedrocks is, as a rule, their heterogeneous composition and structure. They contain often a significant number of inclusions – artifacts of various composition, size and volume, and are characterized by the availability of geochemical barriers, sharp gradients of permeability, thermal conductivity, and water-holding capacity.

The system of mineral and energy metabolism in the profile of such soils is not balanced, and the absence or poor manifestation of any genetic link between the layers indicates the initial stage of soil profile formation process.

When assessing the age of urban area soils, we must take into account that the age of the introduced humus horizons at that of the mineral bedrock can be very significant, up to several thousand years, whereas the age of the soil profile itself can be less than one year.

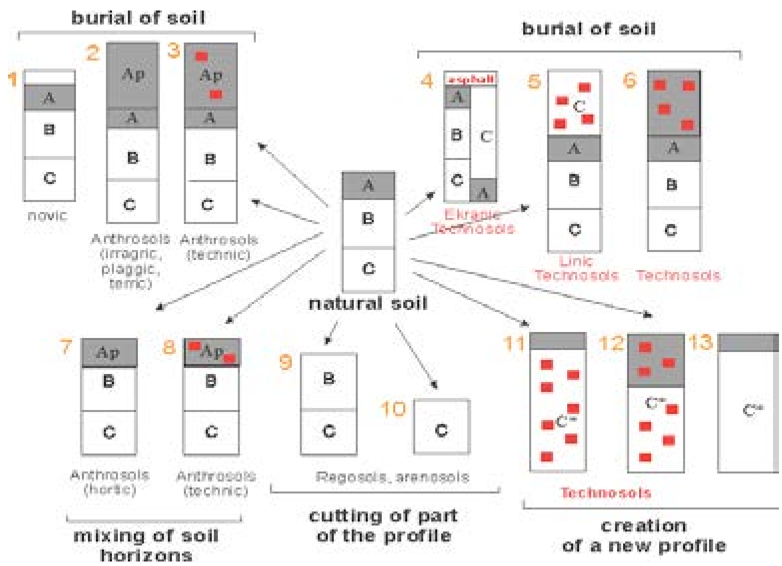
During the classification positioning of urbanized area soils within the WRB system, we should consider the following:

Firstly, the features reflecting the character of the soil profile anthropogenic transformation, that is manifested, first of all, in the burial, mixing or moving of humus horizon materials;

Secondly, the sequence of horizons (layers) and the existence or absence of a genetic link between the same (a sharp transition from one soil layer to another one in the absence of any signs of contingency between the adjacent layers – bringing the substance to the surface and substance accumulation).

For the diagnostics of horizons in anthropogenic soils and their classification positioning, the priority attributes are those inherited from natural soils.

The process of territory urbanization is accompanied with four type of changes in the soil profile: mixing the soil horizons, cutting a part of the profile, burial of soil and "construction" of a new profile (Fig.)



In the WRB, variants 1–4 and 7–9 (Fig.) are considered as soils of various reference groups with qualifiers Novic, Urbic, Ekranic, Antric and different Anthrosols. Variants 4-6 and 11-12 (Fig.) are different Technosols. Variant 10 (Fig.) is the rock. Thus, the WRB system does not reflect the classification positioning only for those soil that have an introduced humus horizon on a mineral bedrock (Variant 13).

In connection with the above, we suggest to introduce a new reference group to the WRB system, to include soils with an external (introduced) horizon.

Integrating natural, anthropogenically transformed and properly anthropogenic soils into a single classification scheme allows us to consider, from the same standpoints, the variety of soils and their changes in the soil cover of any city both in space and in time.

In urbanized territories, we need new approaches to the analysis of soil space distribution and mapping.

For this purpose, it is advisable to introduce the notion of soil urbanized space. Its distinctive features are the discontinuity of the soil cover and clear geometrical shapes of areas, as well as fine outlines that generally cannot be reflected on the scale of a map. Obligatory elements in the structure of the soil urbanized space are non-soil formations (buildings, streets), that disrupt the continuity of the soil cover.

When mapping urban soils, we must be based on the following facts:

In a large area of the city, there are no soil combinations formed by genetically interrelated components. The relationship between soil cover components has been destroyed during the construction of buildings, streets and avenues, or it was absent initially, as the majority of soils are man-constructed.

In a space limited by the pattern of streets and avenues, a geometrically specific type of surface is formed – urbopedocombinations. To create a soil map, we have to carry out their typification in terms of the ratio of soil area surfaces to those of non-soil formations; the area geometric shape, the character of their distribution and their composition.

The legend of the soil map of Saint-Petersburg created by the authors (Aparin, Sukhacheva, 2013), consists of three groups of mapping units. The units showing one predominant soil belong to the first group. It includes natural, anthropogenically transformed, introduced and composite soils.

The second group includes a combination of soils. This group consists of three subgroups:

combination of natural soils,

combination of natural and anthropogenically transformed or introduced soils;

urban pedological combinations – combinations of natural and anthropogenically transformed and introduced soils, and non-soil formations.

In order to show the peculiarities of the urban pedological combinations, the legend includes the geometry features of soils and non-soil formations.

The third group is represented by one unit – non-soil surface formations.

Thus, the legend to the soil map of Saint Petersburg with a scale of 1:50,000 comprises more than 60 units, including 12 natural soil units, 4 anthropogenically transformed units, 5 introduced soil units, 3 units with combinations of natural soils, 4 units with combinations of natural and anthropogenic transformed or introduced soils, more than 30 units with combinations of natural and anthropogenically transformed, introduced and non-soil surface formations.

Classification issues in restored aquatic habitats on reclaimed land: sediments, subaqueous soils, or submerged soils?

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Gyldensteen Strand presents a challenging case study for soil classification, and raises questions for substratum classification in general. This site has experienced a long history of intense anthropogenic alteration. Prior to 1871, it existed as a marine coastal lagoon on the northern coast of the Danish island of Fyn, alongside the town of Bogense. However, the second half of the 19th century was a period of massive land reclamation in Denmark, and this lagoon was one of many that was diked off from the sea and drained for use as agricultural land. The mindset at the time, following a loss of territory to Germany in the Second Schleswig War (Pedersen, 2010), was summed up by the common Danish saying "Hvad udad tabes, skal indad vindes. (What was lost without will be found within)" (Booth, 2014). Due to subsidence of the drained land, a dependence on inefficient windmill pumps to drain the land, and occasional breaches of the dike, this site was only used for grazing and hay-making until 1960. At this time, modern pumps were installed and the land was finally dewatered to a point that intensive agricultural management could begin for crop production. Even so, yields were relatively low in comparison to other agricultural land in Denmark. In 2011 the site was purchased by the Aage V. Jensen Naturfond, a nature conservation foundation. The site was divided, and in 2014 was restored in two ways; 142 hectares were separated by a dam and allowed to fill with meteoric water to form the freshwater lake Engsøen, and 214 hectares were restored as a coastal lagoon by breaching the dike to the sea and shutting off the water pumps.

The substratum of this area has therefore been subjected to a variety of pedogenic/diagenetic processes. The marine environment governed the properties of the substratum until 1871. Surface materials were marine sediments, which could have been classified as sediment using the Folk classification (Folk, 1954) or the Shepard classification as modified by Schlee (Schlee, 1973). Additionally, to reflect morphological properties within the upper meter they could have been classified as subaqueous soils using the United States *Soil Taxonomy* (Soil Survey Staff, 2014) or the *World Reference Base for Soil Resources* (Food and Agriculture Organization of the United Nations, 2015). From 1871 to 2014, and particularly after 1960, the substratum was subjected to subaerial pedogenic processes including Fe and Mn oxidation and concentration, sulfide oxidation, formation of soil structure, and accumulation of organic matter from plant roots. Additionally, agricultural management included tillage and fertilizer amendments. During this period, subaerial soils formed that are consistent with classical, agriculturally influenced, definitions of soil that involve the support of rooted plants (Hartemink, 2016; Jenny, 1941). After the landscape was flooded in 2014, subaerial pedogenesis ceased and sediment diagenesis/subaqueous pedogenesis began to act on these materials.

Samples were collected from thirty pedons distributed across four areas to determine the impact of this management history on these substrata. Samples were collected from the restored saltwater lagoon and the constructed freshwater lake to compare the impacts of these methods of restoration. An adjacent area that was drained during the same period of land reclamation and is still used for agriculture was sampled to provide a comparison to pre-flooding conditions. The shoreface just outside of the lagoon was sampled as well. This area was never drained, and allows a comparison to pre-reclamation conditions. Samples were described using standard US Soil Survey methods (e.g. Munsell color, texture, structure, description of concentrations) (Schoeneberger et al., 2012) and classified using US *Soil Taxonomy*. Subsamples were used for DNA extraction and molecular microbial community profiling to identify the influence of management history on microbial ecology. Laboratory analyses included particulate Fe fractionation, distillation of acid volatile sulfides (AVS) and Cr reducible sulfides (CRS), carbon content (organic and inorganic), and moist aerobic incubation for the identification of hypersulfidic materials.

This study adds to the ongoing discussion regarding the difficulties in classifying soils and sediments using different systems (Kristensen and Rabenhorst, 2015), addresses what "parent material" means in the context of this anthropogenic landscape, and supports the benefits of incorporating some marine sediments into soil classification systems.

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Spatial-temporal variability of SUITMAs' features and processes

Impact of building parameters on accumulation of heavy metals and metalloids in urban soils

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Introduction. It is known that the quality of the urban environment is determined by the allocation of pollution sources, in addition, a significant influence has relief, urban development features and also meteorological factors, which determine the diffusing and concentrating ability of the atmosphere (Baklanov et al, 2008, Regions ..., 2014). Urban districts, especially with high-rise buildings, represent a complex system of surfaces with different slope gradient located at different levels and blown by air fluxes. Buildings greatly alter wind patterns in the surface layer of the atmosphere, creating the locations where dust deposition takes place. These locations are usually restricted to closed yards while the effect of "canyon" occurs along the major highways. Such effects create a considerable heterogeneity of the pollution of urban environment.

However, consensus on the role of an artificial relief in the distribution of pollutants does not exist. Some researchers believe that urban buildings represent mechanical barrier screens that protect residential areas from pollution. According to other data, a sharp decrease in the wind velocity in areas with dense block patterns contributes to the deposition of harmful atmospheric impurities. In this paper, a first attempt have been made to evaluate the barrier function of urban development through the integrated analysis of the data on the heavy metal and metalloid (HMM) concentrations in the topsoils, their physical and chemical properties that define the fixing ability in relation to the HMMs, and the parameters of the artificial terrain (orientation and height of buildings, building density). The application of multivariate statistical analysis helps to determine the conditions of the pollutants precipitation from the atmosphere and to identify the location of geochemical anomalies in soil cover.

Objects and methods of the reseach. The object of the study is Ulan-Ude, a city with a population of over 400 thousand located in Ivolginsky-Uda intermountain basin, drained by the Selenga river and its right tributary, the Uda river. The climate is severely continental with the prevailing western winds. The topography patterns and composition of parent rocks as well as anthropogenical impact causes the variability of soil cover. Mechanically transformed soils, with modified structure of the soil profiles, include urbanozems, ekranozems, necrozems and culturozems. Chemically transformed soils incorporate industrizems and intruzems. According to the classification proposed in (Ilyin, Syso, 2001), the urban soils are characterized by low buffer capacity. They have relatively low level of physical clay (the particles less than 0.01 mm in diameter) (on average 5.8%), being formed on light textured parent rocks and man-made deposits. The pH reaction changes from alkaline (pH 8.5) to weakly acidic (6.1) in the sandy soils of the outskirt areas. The average humus content is rather low, equal to 2.5%.

Ulan-Ude is included in the priority list of the cities with air pollution index API ≥ 14 and has 35 potential pollution sources (plants on repair of locomotives and wagons, rolled metal products, aircraft and shipbuilding, etc.). However the main contribution to air pollution is made by coal-fired thermal power plant and vehicle emissions.

Soil-geochemical survey of the soil cover in the residential area of Ulan-Ude was held in summer, 2014. As a result 106 mixed (with 3 duplicates) soil samples from the surface (0-5 cm) horizons were taken. Samples were collected at grid points with grid size equal to 1000 m in the outskirt areas and 700 m in the central part of the city. The pollutant's fallout rates were evaluated using the data of snow survey conducted in winter 2014, as a result 27 samples were collected. 11 background soil samples and 4 samples of snow were taken in the reference sites, located 20-30 km to the south-west and east of the city. The solid and liquid phases of snow were separated by filtration.

The total contents of the HMMs in the snow solid fraction and in soils were determined by ICP/MS and ICP/AES analyses using "Elan-6100" and "the Optima-4300 DV" equipment. Conventional methods were applied to define the properties that affect soil ability to fix pollutants (pH, humus content, grain-size analysis, the contents of Fe, Mn, Al oxides). The priority pollutants of the soil and snow covers were identified on the basis of calculation of enrichment (*EF)* and fallout (*FF*) factors relative to reference (background) values. Fallouts of HMMs were derived from their concentrations in the solid fraction of the snow and the daily dust load *P*. The total geochemical load on soil or snow cover was evaluated using integral index of pollution Z_c and immission Z_d, respectively. These indices were calculated as $Z_c = \Sigma EF-(n-1)$; $Z_d = \Sigma FF-(n-1)$, where *n* – the number of chemical elements *EF* or *FF* > 1.0, *n* = 14 (Environmental ..., 1990).

The contours of buildings were obtained from the OpenStreetMap database. The heights of buildings (*H*) were determined by visual interpretation of GeoEye-1 satellite image (2015) using the database 2GIS. The area occupied by the buildings (*S*) was determined by a special tool for calculating the geometry in the software package ArcGis 10.0. The sum (ΣS) was used as a parameter to evaluate the density of the building patterns. The distance (*L*) from the sampling points to the buildings was measured using a distance tool which allowed also to identify the directions of the lines connecting the sampling points and the buildings.

Building parameters were determined in the zones with different radius where the central point was represented by a sampling point. To select the optimal radius we used the data derived from the snow survey. It corresponded to the distance at which the correlation between dust fallout *P* or the HMMs concentrations Z_d and the building parameters reached the maximum. The building parameters averaged („) for each point across major directions using one-way ANOVA analysis of variance.

To describe the geochemical heterogeneity of soil cover in relation to building parameters and a complex of soil factors, the method of regression trees (SPlus package) was used. This approach allows to predict the levels of pollutants in soils with different combinations of factors, and to assess their significance.

Results and its discussion

Determining the radius of impact zone. For all the radius of the impact zone the daily dust load P and the integral index of immission Z_d *increase with the growth of the building area (S) and a decline in the distances L (Table 1). The height of the buildings is not so important factor, as the city is dominated by low-rise (two- or one-storied) buildings. The greatest impact of the building patterns was identified in an area with a radius of 150 m in the south-west and north-east direction, which is consistent with the highest repeatability of the south-west winds in winter (Sutkin, 2010).*

Table 1. The coefficients of Spearman rank correlation between daily dust load *P*, integral index of immission Z_d and building parameters

Building para-meters	Correlation with *P*					Correlation with Z_d				
	Radius of the impact zone, m					Radius of the impact zone, m				
	50	100	150	200	250	50	100	150	200	250
*	–0.51 (1)		–0.55 (2)	–0.56 (2)	–0.51 (2)		–0.53 (3)	–0.50 (2)	–0.48 (2)	–0.44 (2)
			–0.55					–0.56		
*	0.52(1)		0.58(2)	0.45(2)	0.57(2)			0.56(2)	0.43(2)	0.51(2)
			0.51	0.43	0.44		0.46	0.55	0.40	
			0.40	0.44	0.43					
Σ*S**	0.61 (1)					0.56 (1)				

*across major directions: SW (1), NE (2), SE (3)

The building impact on the accumulation of HMMs in soils. The priority pollutants of soils in Ulan-Ude are Sb, Pb, Sn, Cd, Cu. In some areas of the city, in the vicinity of industrial enterprises and along major highways, geochemical anomalies of Mo, Ni, W, Zn, Cr, Bi were also identified (Kasimov et al., 2016). Multivariate regression analysis has shown the impact of the building parameters on the accumulation of almost all of HMMs (Table 2). With the dominance of low-rise buildings in the city the main factor which defines their function as barriers to the atmospheric transfer of HMMs is their surface area: its growth leads to an increase in topsoil concentrations of W, Bi, Zn (1.5-1.6 times), As, Sb, Mo, Sn (1.3-1.4). With the increasing building density (Σ*S*) the levels of Cd, Pb, Cu and Mo increase 1.4-2.2 times. The vicinity of the buildings to a sampling point in the north-western sector, contributes to the fallout from the atmosphere and accumulation in soils of Bi, Zn Cu (1.3-1.5 times). The exceptions are building density in north-western sector and vicinity of the buildings in south-western sector, whose growth decrease concentrations of Cr and Zn (1.4-1.6 times). This can be explained by the relative arrangement of the emission source of these elements and artificial relief features, which protect the soil in this case from the atmospheric Cr and Zn flux.

Table 2. The impact of building parameters and sorption properties of soils on accumulation of HMMs and integral pollution index Z_c of topsoils in Ulan-Ude

Factors	Cd	Pb	Sn	Sb	Zn	Cr	As	Cu	Mo	W	Bi	Z_c
			2+ NE	3+ SW	3+ NE		4+ SW		3+SE 4+SW	2+ NW	4+ SE	4+ SW
Σ*S*	3+	3+NE				2- NW		2+	1+ SW			
					1+SW 3-NW			3- NW			2-NW	3- NW
Fe_2O_3			2+			1+	1+		3+	1+		
Clay							2+			2+		
Humus	2+		1+		2+			2+	2+	3+	1+	1+
MnO						2+		1+				

Note: Ranks from 1 to 4 show a decrease in the factor significance, and the signs "+" or "-" positive or negative correlation, respectively. If the building parameters influence the accumulation of pollutants in a certain sector of the impact zone, it is specified by letters.

Integral soil pollution by HMMs (Z_c) is 1.6-2.0 times higher in the areas with high surface area of buildings and their proximity in prevailing NW, SW wind directions. The impact of sorption properties of the soils on the HMM content is more pronounced due to their low buffer capacity. The growth of Fe_2O_3 and humus contents lead to a significant increase in the accumulation of almost all of HMMs (Table 2).

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Geographic trends of some properties of the Russian urban soils

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Introduction

Increasing concentration of population in cities and urban agglomerations leads to a continuous expansion of urban territories, within which a specific natural-anthropogenic urban ecosystem is formed, interacting with all the geographical envelopes of the planet, including the pedosphere. The soil cover is an irreplaceable ecological basis for the biosphere functioning, humankind life and activity. Complex processes of elements and energy exchange between the atmosphere, the Earth's crust, the hydrosphere, and living organisms run through it.

According to the Federal State Statistics Service, in 2016 74% of Russia's population is located in cities (FSSS). The population census of 2010 showed, that there are 155,509 settlements in Russia, out of which 1098 are cities. Meanwhile, 85% of the cities have a population below 100 000 residents (All-Russia population census 2010).

Urbanized territories in Russia are located in all natural zones of the country, from tundra to semi-desert. Despite the fact, that transformation of soils and soil cover during urbanisation is well studied, it is still debatable, whether and to which extent a natural soil and vegetation zone, where settlement is situated, influences urban soils properties, or distinctions are determined exclusively by the type of land use and the history of a territory development.

The aim of the study was to analyse the content of soil organic carbon [SOC] and pH values of aqueous extracts in urban soils in different soil zones of Russia.

Methods

To approach the question there was an urban soils properties database created. The data was retrieved from the analysis of scientific publications and own materials. The database specifies the properties of the upper horizon of the urban soils of 60 Russian settlements, among which there are large cultural and industrial centres with a population of more than 1 million people (Moscow, St. Petersburg, Novosibirsk, Krasnoyarsk and others.), as well as medium-sized cities and rural settlements, including 2 abandoned ones.

According to the used sources, the number of sampling spots in settlements was from 4 to 20 on average for a city. In metropolises the number could reach a few hundreds, while in abandoned rural settlements there were not more than 2 spots.

The database included weighted average values for the territorial coverage.

Some studies provide only averaged data for city soils, not specifying the number of sampling spots, in this case they were included in the database as a single value. In the framework of this study the database contained information about 430 averaged spots of urban soils surface horizons of settlements in the Russian Federation.

The database indicates information about a natural soil and vegetation zone a city is located in, and continentality with value depth and duration of soils freezing. Grouping of cities by soil zones and continentality was conducted in accordance with a Map of soil-geographic regions with scale of 1:15 000 000 (Soil Atlas 2011).

The database included the properties of both, the urban soils and slightly disturbed soils of urban forests, parks, lawns and local open greenspaces. Therefore, the database specified a land use: an industrial area, a recreational area and a residential area. If possible residential area was further specified as a private sector, a multistorey buildings area or a central historical part with a high level of sealed surface.

In this research the values of pH of aqueous extracts and SOC (%) of topsoils were analyzed. According to the sources used, the power of topsoils ranged from 5 to 20 cm. Depths harmonization was not carried out due to the fact that a lot of the works studied indicated values for a single soil horizon.

Average city pH and SOC values have been analyzed. The average values of SOC and pH of each sample of urban soils were calculated within a city and within a soil zone. To calculate the average (median) pH values there were preliminary conversions of the logarithmic form into numerical made, followed by re-calculating the average value again in logarithmic. Since the Russian territory is stretched in the latitudinal direction and has a distinct continental trend in the properties of the natural soils, in particular, the SOC content in the soils of the same type increases from west to east. Continental influence on the properties of the urban soils has been analyzed.

Comparison of the two averages was carried out by Student's criteria for the SOC and the Mann-Whitney test for pH. For multiple comparisons of SOC values single-factor ANOVA was done. To test its applicability conditions, the homogeneity of variances was preliminarily evaluated. For multiple comparisons of pH values there was Kruskal-Wallis ANOVA & Median test applied. The statistical analysis was made with Statistica 10 package. All the hypotheses were tested with a significance level of 0.05.

Results

Analysis of the results of comparing the average content of SOC in the upper horizon of the urban soils has proved the presence of distinctions for average values for soil and vegetation zones. Three groups of values were distinguished. Average SOC content values for urban soils of the north taiga (1.53 %), the middle taiga (1.65 %), and dry steppes (1.6 %) with natural Stagnosols, Retisols, Podzols and Calcisols, respectively, are close to each other and significantly different from the urban soils of the southern taiga (3.25 %), broad-leaved forests, forest-steppe (3.57 %), and the northern steppe (4.15 %) with Eutric Retisols, Luvisols, Phaeozems and Luvic Chernozems, respectively. Urban soils in the typical and the southern steppes (2.71 % and 2.98 %, respectively) with Calcic Chernozems and Kashtanozems are in the middle.

Thus, it has been revealed that the low SOC values for natural zonal soils conform with low SOC values for urban soils. And vice versa, an increase in the SOC zonal soils conforms with SOC increase for urban soils.

No continental trend in SOC content of urban soils in boreal belt was detected. Most likely, it is the matter data lack, in particular data on the cities of the southern taiga zone of Siberia. The European part with moderately freezing and warm briefly freezing soils and the Siberian part with moderately and long freezing soils split by average SOC values in areas of steppe and steppe of semihumid and semiarid soil-bioclimatic region in the sub-boreal belt with Phaeozems and Luvic Chernozems. Meanwhile, as in the natural soils, the SOC content in urban soil increases from west to east: the average value for the European part was 2.06%, for Siberia - 4.02%.

Analysis of the average pH values of the urban soils demonstrated no zonal or continental trends even in the recreational areas. The differences in the medians for the gradations of these factors are not observed. However, dependence on the type of land use is identified. The average pH of the urban soils in the industrial zones and residential areas of the central historical parts of the cities is higher (8,17 and 7,87, respectively). Minimum values are typical for recreational areas, yet residential areas with modern multi-storey buildings and private sector residential areas are not significantly different from recreational areas if compared by the average pH values. On average they all have significantly lower values compared to the industrial areas and residential areas of the central part.

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Conclusions

Despite the fact that the anthropogenic factor significantly affects the properties of urban soils, approximating the values of soil acidity of the cities in the northern and southern latitudes, one can clearly trace some zonal trends in the SOC distribution. There was no significant impact of the type of land use on SOC observed. Thus, high values may be attributed to industrial areas - due to carbonaceous pollutants (soot, etc.), to recreational zones - due to added peat compost mixtures and to residential areas of the central area of old cities. SOC content and pH values for rural soils, including abandoned settlements, are comparable with the private sector.

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Changes in land use and soil cover (1934-2010) in Inowrocław city, central Poland as a result of the urban sprawl

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Introduction

Inowrocław city is located in the southern part of the Kuyavian-Pomeranian Voivodeship (52°47′45″N 18°15′40″E), central Poland. This medium-sized city has got over 800-year history, performing for many years a variety of functions, which include: industry (especially mining and chemical), spa, transport and agriculture. During the Second World War Inowrocław was not destroyed and only slightly depopulated (Biskup 1982). In recent years residential development increased. Current area of the city is 30.4 km^2 and population – 74 258 (www.bdl.stat.gov.pl/). Due to the fact that the city is located within the glacial till plain covered mostly by Mollic Gleysols (IUSS Working Group WRB 2015) – an important problem is decreasing area of fertile soils turning into the human transformed urban soils as a result of urban sprawl. The aim of this study is to analyse using GIS techniques the changes in the urban structure of the city (1934-2010), which leads to the soil transformations.

Methods

Due to the lack of historical cartographic materials for the whole area of the Inowrocław city, the analysis was performed only for two years: 1934 and 2010. To create a map of land cover changes, archival (Polish Military Geographical Institute topographic map in scale 1:25 000), current topographic maps and aerial photographs (www.geoportal.gov.pl/) were digitized. After that area of each land cover form unit were calculated and urban soils map were developed. The soil map units were described according to proposal by Stroganova et al. (1998, modified). The next step of research would be to compare results with demographic trends and urban development plans to predict the probable future changes.

Results and discussion

The land cover changes that occurred in the 1934-2010 period were presented in Table 1. Over the past decades, in relation to the city boundaries from 1934, the largest increase was observed in residential areas (from 8.8% to 20.7%), parks and gardens (from 1.9% to 16.1%) and industrial areas (from 10.8% to 13.9%). Furthermore, in connection with the development of the city, share of transport areas has considerably increased (from 2.7% to 5.6%). These changes led to decrease of share of arable lands (62.3% to 31.6%) and wetlands and meadows (7.2% to 5.0%) – the land was drained and used for the construction of new housing estates (the population in 2014 more than doubled in comparison to 1934) (Fig. 1, Tab. 1). However, due to the urban sprawl, area of undisturbed and weakly transformed soils decreased (Fig. 2). This was particularly evident referring to the city boundaries from 2010 (Table 1).

Table 1. Land cover changes in Inowrocław city in relation to the city administrative boundaries from 1934 and 2010

land use types	1934				2010			
	1934 boundaries		2010 boundaries		1934 boundaries		2010 boundaries	
	km^2	%	km^2	%	km^2	%	km^2	%
arable lands	11.4	62.3	19.9	65.4	3.3	17.8	9.6	31.6
urban areas	1.6	8.8	3.8	12.6	4.3	23.6	6.3	20.7
industrial areas	2.0	10.8	2.9	9.5	3.0	16.4	4.2	13.9
wetlands and meadows	1.3	7.2	1.3	4.1	0.9	5.1	1.5	5.0
roads and squares	0.5	2.7	0.5	1.7	1.1	6.2	1.7	5.6

parks and gardens	0.3	1.9	0.6	2.1	4.1	22.5	4.9	16.1
graveyards	0.2	1.2	0.2	0.7	0.2	1.0	0.2	0.6
spa	0.3	1.7	0.3	1.0	0.8	4.5	0.9	3.0
railroads	0.2	0.9	0.3	0.9	0.3	1.7	0.5	1.7
forest	0.1	0.7	0.2	0.7	0.1	0.1	0.0	0.1
water	0.2	0.8	0.2	0.7	0.1	0.6	0.3	0.9
wasteland	0.2	1.0	0.2	0.6	0.1	0.5	0.2	0.6
orchards	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
TOTAL	18.3	100	30.4	100	18.3	100	30.4	100

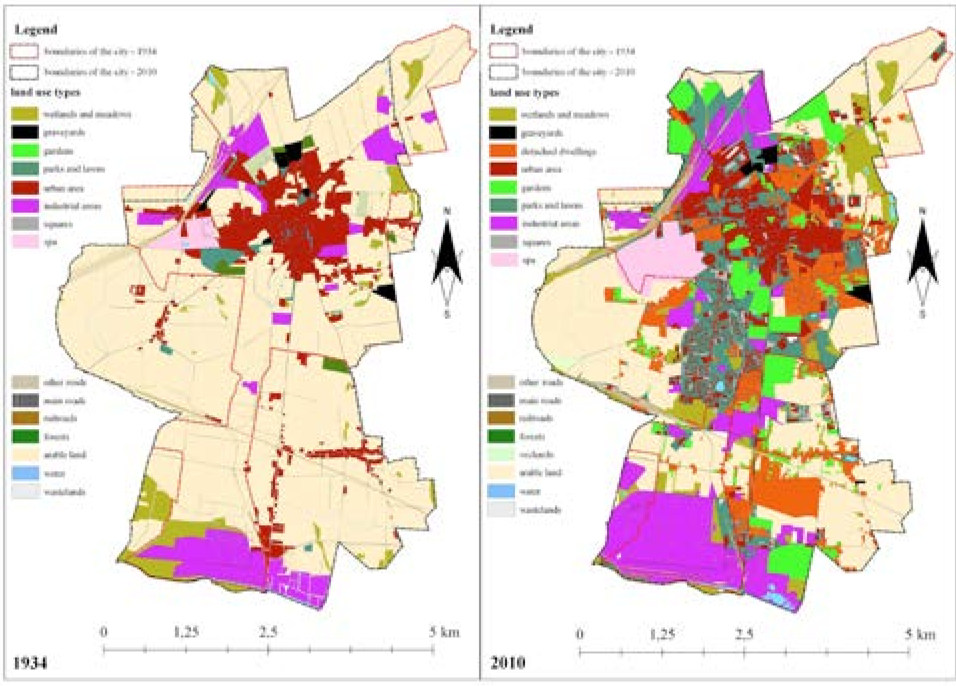

Fig. 1. Land cover changes in Inowrocław (1934-2010)

Among other studied by soil scientists Polish cities, not heavily affected by the Second World War damages – Toruń and Zielona Góra (Hulisz et al. 2016), Inowrocław is characterized by the largest share of technogenic soils. Slightly more than 58.7% of the city is now technogenically transformed (including culturozems, industrizems and urbanozems). In comparison in Toruń it is over 50%, and in Zielona Góra about 25%. According to the classification concerning the ecosystem services provided by urban soils (Morel et al. 2014), it can be stated that currently the largest area of Inowrocław city is occupied by vegetated pseudo-natural SUITMAs, vegetated engineered SUITMAs, and then by bare SUITMAs and dumping SUITMAs.

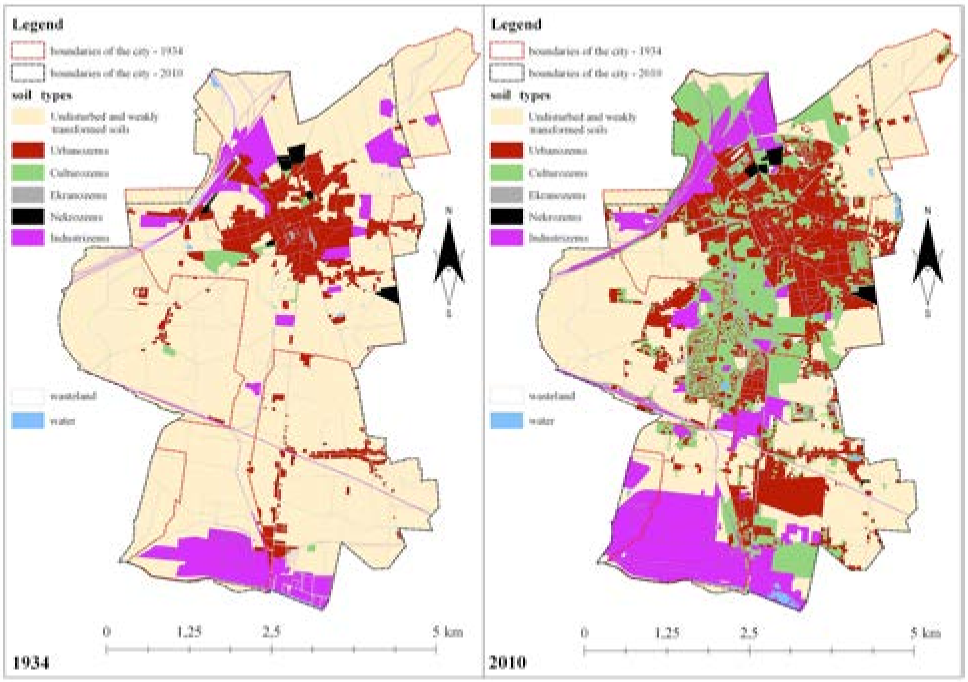

Fig. 2. Maps of dominant soils in Inowrocław city (1934 and 2010)

Conclusions

The development of the Inowrocław city in the years 1934-2010 led to significant changes in the structure of land use and soil cover. Moreover, according to spatial development plan (www.bip.inowroclaw.pl), whole area of arable land (Mollic Gleysols) is intended to be developed into residential and service areas, and thus percentage of SUITMAs will increase. It is necessary, but to prevent the loss of very fertile soils, local authorities should consider extending the city limits, including new acreages of soils with lower ecological and use value in the nearest future.

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Using soil spectra reflectability to characterize organic matter of urban soils of Moscow city areas

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The organic matter of urban soils includes residual humus from the original natural soils, as well as introduced and recently formed organic matter, the portion of which is higher in deeply transformed mature soils. The sources of organic matter in the urban soils, along with plant residues and animal and bird droppings, include organic fertilizers (manure in the preindustrial period and peat–compost mixtures); waste containing organic residues (wood, food waste, etc.); decomposition products of technogenic hydrocarbons; and aerogenic input (hydrocarbons, carbon particles, ash, fragments of rubber and asphalt coating, etc.), which significantly increased during the last decades due to the incomplete combustion products of fuels from power stations and transport. An increase in the content of organic carbon is most frequently noted in the urban soils of the forest zone compared to their natural analogues (Dolgikh 2010, Soils. City. Ecology. 1997, Pouyat et al. 2002), although reverse situations were also described, predominantly at the destruction of forest litter in the forest park and park areas and the over compaction of surface horizons (Sarah, Zhevelev 2007).

Some profiles were established in several Moscow parks: the Tushinskii park and its environments - TU3, a loamy/clay loamy soddy-podzolic soil under mixed forest (with the presence of forest litter); TU4, a loamy/clay loamy postagrogenic soddy-podzolic soil under secondary forest (birch with some mountain ash trees); P2, a deep loamy urbanozem in a recreation zone with ruderal plants (the former village of Aleshkino); TU6, a shallow loamy sandy/sandy loamy urbanozem under a lawn with some trees of a 40-year old residential quarter; and TUT, a loamy full profile gleyic technosoddy podzolic soil under a gravel road, where tree waste is partially trampled and mixed with material from the upper horizons. In the Pokrovskoe–Streshnevo park and its environments, the following profiles were described: V2, a loamy typical rzhavozem under a complex pine forest (with the presence of forest litter); V1, a sandy loamy/loamy sandy postagrogenic rzhavozem under a birch forest; PSTS, a sandy loamy postagrogenic urborzhavozem in the maple and lime park of a former country estate; V3, a shallow loamy sandy urbanozem of a lawn with ruderal plants in the yard of a residential quarter; PS1, a loamy sandy gleyic technorzhavozem under a gravel road, where tree waste is partially trampled into the upper horizons; PS12, a loamy sandy technozem (recreazem) under a lawn with some trees and ruderal grasses of a 30-year old residential quarter; PS15, a loamy sandy/coherent sandy technozem (replantozem) of a lawn near a 5-year old building in a residential quarter; and PS16, a shallow loamy sandy urbanozem in an abandoned fruit garden.

Some studies were performed to characterize the soils. The following parameters were determined: the Corg by the Hikitin modification of the Tyurin method with photometric detection using a Spekol-211 device, and the soil reflection spectra in the visible region (λ 400–750 nm) using an SF-2000 spectrophotometer.

Three groups of horizons were distinguished by the character of the reflectance spectra (the curve's shape and slope). It can be supposed that this classification reflects the differences in the formation conditions of these horizons. The first group includes the soil horizons highly enriched with organic matter (Fig. 1a). They are characterized by low reflection values ($\rho400 \sim 25\%$; $\rho750 \sim 35\%$; $tg\alpha \sim 0.0–0.02$), the flattened or concave character of the reflection curve, and the absence of inflections due to the presence of nonsilicate iron compounds in the middle spectral region. Under natural conditions, such curve shapes are typical for peat or peaty horizons. This group includes the RAT horizons, the U horizon, and the AY. These are relatively recent peat based remediation (RAT) horizons whose material is still not homogenized by the pedogenesis processes, the urbic horizons of soils fertilized by peat-compost mixtures (the V3 profile in the residential quarter), and horizons at different transformation stages. It can be seen that the curve of the restoring humus horizon of the postagrogenic rzhavozem containing less organic matter is slightly separated from the other curves (Prokof'eva, Rozanova, Poputnikov 2013).

Spectral reflectance curves for different horizons of urban soils. (a): (1) AY horizon, profile V1; (5) horizon U, profile V3; (8) horizon RAT, profile PS15; (10) horizon U1, profile PSTS; (11) profile U2, horizon PSTS; (16) horizon RAT, profile TU6. (b): (2) horizon AYpa, profile V1; (4) horizon AY, profile V2; (6) horizon TCH1, profile V3; (12) horizon AY, profile TU3; (14) horizon AY, profile TU4; (15) horizon AYpa, profile TU4; (17) horizon U, profile TU6; (18) horizon TCH, profile TU6; (19) horizon AU, profile P2; (20) horizon U1, profile P2; (21) horizon U3, profile P2; (22) horizon U4, profile P2; (23) horizon AYtch, profile TUT, (c): (3) horizon BFM, profile V1; (7) horizon AYur,pa, profile PS16; (9) horizon AYtch,e,g, profile PS1; (13) horizon BT, profile TU3.

However, the characteristic shape of the curve for this horizon is apparently due to the high content of coaly material, as for the U1 and U2 horizons of the profile established in the former Pokrovskoe–Streshnevo country estate. These horizons also contain significant amounts of calcareous inclusions and neoformations, which impart a nonuniform color to the horizon material. The second group includes the horizons of soils also characterized by the absence of inflections on relatively gentle reflection curves but having higher reflectance values at 400 and 750 nm (ρ400 ~ 30%; ρ750 ~ 40–55%; and tgα ~ 0.02–0.04) (Fig. 1b). They are clearer in color and have less humus than the horizons from the first group. Under natural conditions, such curves are typical for the upper (humus) horizons of automorphic soils. These are the TCH1 horizon; the AYpa horizons; and the AY horizons. It is noteworthy that the humus accumulative horizons of the natural and postagrogenic soils in both parks were in the same group with the low carbonate urbic horizons of the old settlements and new residential quarters and the technogenic horizons, which are mixed soil–sediment substrates. This fact can be indicative of the similar nature of the humification and humus accumulation processes in the natural and anthropogenically transformed soils controlled by the natural zonality. The third group (tgα ~ 0.06 and higher) includes the horizons having an inflection in the region of 450–680 nm due to the presence of nonsilicate iron compounds. Under natural conditions, these can be transitional (subhumus) horizons, in which organic films cannot completely mask the effect of nonsilicate iron. Along with the BFM and BT horizons of the rzhavozem and the soddy-podzolic soil, this group includes the buried low humus horizon and the upper of the technorzhavozem under the gravel road (PS1 profile), where the mineral basis is not masked by organic matter, as well as in the B horizons of the natural soils. It should be noted that measurement of soil reflectivity can give unexpected results for urban soils (Prokof'eva, Rozanova, Poputnikov 2013). The classifications of natural soil horizons based on their spectral reflectances were developed long ago and are well known. For urban soils, it is possible to use this method for revealing whether the organic matter was introduced as organic residues and/or peat mixtures and to determine the time elapsed since these events, as well as to conclude about the absence of such events.

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Analysis of the limiting ecological factors of soil CO_2 fluxes in three types of urban ecosystems in the forest-steppe zone of Central Russia

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Introduction Global climate changes are accompanied by fast growth of urban areas and population in the Central part of Russia. The urbanization process involves the new settlements formation with significant transformation in all surrounding landscapes. Urban areas are characterized by more intensive metabolism, which requires constant influx of additional energy (fuels and electricity), food, water, construction materials and produce the intense emissions. Urban ecosystems have considerable potential for carbon and energy accumulation, including C in the biomass of grasses, shrubs and trees due to their active growth and longer growing season, associated with the effect of "heat island" [4]. However, the outgoing flows as direct related to the intensification of soil and plant respiration, and indirect, due to the additional use of fertilizers, fuel consumption, etc. greatly exceed those in natural ecosystems [7].

Many assessments of urban CO_2 emissions underestimated the specific contribution of soil CO_2 fluxes in comparison with the emissions of transport, industrial and energy companies. However, its specific contribution can be essential [5, 8] and is constantly growing with urbanization and regulation of the specific emissions of transport and industry [1, 6]. The limiting ecological factors of soil CO_2 fluxes seasonal dynamics are usually the topsoil temperature and moisture, determining the functioning level of soil microbiota [2, 3] and soil organic carbon content as a principal source of soil CO_2 [9].

The Central Russia is characterized by the fastest growth of urban territories, which determines the increased activity of research with analysis of the limiting ecological factors in soil CO_2 fluxes seasonal dynamics there. Risks of man-made growth of soil GHG emission is especially high in case of Central Chernozemic region' cities – such as Kursk with dominance of Haplic, Luvic Chernozems, Chernic Phaeozems and based on them Urbosoils with increased pool of organic C [9, 11] and traditional zonation into residential, industrial and recreational functional areas.

Materials and methods Research has been conducted in Kursk representative urban ecosystems, located in three geographically separated functional zones: industrial, residential and recreational ones. Kursk location determines the moderate continental type of climate, the elevated and dissected terrain, the complex combinations of steppe vegetation with forest, Haplic and Luvic Chernozems with Chernic Phaeozems.

Urban monitoring sites were carried out in comparison with the background zonal soils (Luvic Chernozems and Chernic Phaeozems). Background loamy Chernic Phaeozems were studied in a natural reserve "Urochishche "Znamenskaya grove"" located in the northern part of the city (historic suburb). Background clay-loamy Luvic Chernozems has been investigated in the virgin plot of "Streletskaya steppe" at the Central Chernozem Reserve, in 10 km to the south from Kursk [10].

Located in the industrial, residential and recreational functional zones three urban representative plots have soil and landscape features comparable to their background. After soil pits and drills description, bulk density analysis and soil sampling there was permanently installed equipment for periodic measuring soil CO_2 fluxes by the chamber method with infrared gas analyzer Li-820, soil moisture by SM300 sensor, soil and air temperature inside and outside of the chambers. Each monitoring year (in 2013-2015) has been divided into 4 principal periods: spring, summer, autumn and winter – based on the meteorological criteria (0°C and 15°C in stable daily T). Monitoring measurements were performed every 10-14 days in 10 replications per each functional plot.

Results The comparative analysis of seasonal dynamics (Fig. 1) and average data on the daily air temperature and precipitation in 2013-2015 years shown common (normal) weather conditions in 2015, relatively dry one in 2014 and relatively humid one in 2013, that allow to take into attention the interseasonal features for interpretation environmental factors impact on the soil CO_2 fluxes (Fig. 2).

Fig. 1 Dynamics of average daily air temperature and precipitation in 2013-2015.

Although the seasonal soil CO_2 fluxes fluctuations were similar for the recreational area and natural background, the average CO_2 emission was significantly (from 9 to 41% during the season) higher in urban soils. Positive correlation between CO_2 emission, soil and air temperature was obtained for the observation period.

Fig. 2 Interseasonal dynamics of soil **CO_2** fluxes in Kursk different functional zones in comparison with their local background objects (forest ecosystem – For, recreational – Rec, residential – Res, industrial – Ind, steppe ecosystem – Stp).

The average data on soil CO_2 emissions in the investigated recreational and residential zones vary significantly between three monitoring years and within seasons. The lowest average efflux of 8 g CO_2 m^{-2} day^{-1} was in spring of 2014 and 2015. Measured in summer 2013 the highest emission was in 1.6 and 2.6 times more than one in 2014 and 2015 respectively. The difference between the autumn fluxes was even more evident: an average emission in 2013 was triple from 2014 and more 5.5 times higher than in 2015.

Similar seasonal fluctuations in soil CO_2 emissions have been shown for the industrial area and reference steppe plot in the Central Chernozemic Reserve, however the urban soil respiration was in 20 % lower in spring and 28-30% higher in summer compared to natural references. Urban soil emission in the relatively humid 2013 was in 17 % higher than background one, in the normal 2015 – in 13% lower compared to the natural reference. Similar average fluxes from both sites were found in relatively dry 2014. In the residential and recreational areas Urbosoil based on the Chernic Phaeozem have CO_2 emission strongly correlated with soil temperature in autumn and spring, whereas soil moisture effect dominates during the summer periods.

Conclusion Soil CO_2 fluxes in the Chernic Phaeozem-based Urbosoils in the representative for Central Chernozemic region of Russia recreational and residential zones of Kursk are usually considerably higher their local background Chernic Phaeozem in the forest ecosystem and mostly have the similar seasonal trends with them. In the recreational area soil CO_2 fluxes are in 9-41% higher than background one. Comparative analysis of soil CO_2 fluxes in the Luvic Chernozem-based Urbosoils in Kursk industrial area and their reference Luvic Chernozems in the Central Chernozemic Reserve steppe showed the similar seasonal trends with complicated dynamics of soil CO_2 fluxes in the Urbosoils: essential higher (+17 %) than background level in the relatively humid 2013 and lightly lower (up to – 13 %) in the normal 2015. Correlations of soil CO_2 fluxes with soil temperature and moisture are highest in the transitional conditions of fall (K_{TS}=0.39-0.68; K_{WS} =0.31- 0.74) and spring (K_{TS} =0.58-0.84; K_{WS} =0.61). The maximum domination of soil moisture factor was in summer of relatively dry 2014 in the industrial zone with soil maximum degradation – in comparison with its local background reference. It makes sense to speak about previous year fall precipitation condition and snow period duration on the soil CO_2 fluxes – especially during late-spring and summer periods.

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Polycyclic aromatic hydrocarbons in urban soils of Moscow (Eastern Administrative Okrug)

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Introduction

Industrialization and urbanization have promoted socioeconomic development. This, however, has led to variety of environmental problems in urban areas, including contamination by polycyclic aromatic hydrocarbons (PAHs) via various pathways. PAHs are considered to be ubiquitous environmental pollutants due to atmospheric and aquatic circulation. PAHs bio-accumulate through the food chain, thus they also may pose threat to human health over a long period. Some PAHs are known to be carcinogenic and mutagenic. These substances are longlasting, poorly degradable pollutants that accumulate in the environment and present a great affinity for organic materials in soil such as humus. Sixteen PAHs have been selected by the US EPA as Constant Decree priority pollutants for regulatory purposes.

Anthropogenic PAHs are mostly generated during the incomplete combustion of carbonaceous materials such as coals, and petroleum products - gasoline and diesel (Obiri et al., 2011). Airborne PAHs, either in gas or particle phases, are found to have a direct impact on human health. PAH containing atmospheric particles and dusts are considered to be the main source of pollutants spreading via urban and industrial areas, where the traffic emission contributes up to 90% (Liua et al., 2011). Atmospheric inputs lead to significant accumulation of PAHs in the urban soil, which thus turn into a secondary reemission source of PAHs (Agarwal, 2009; Lv et al., 2010).

The study of the PAHs concentrations and pattern in the soils and particulate matter of snow depositions can, therefore, provide useful and convenient information on environmental quality of urban areas. The aims of this work were to: 1) determine individual concentrations of PAHs pattern in airborne particles, in artificial constructed soils (konstruktozems) and undisturbed natural soil (soddy-podzolic soils) collected in Eastern Administrative Okrug of Moscow city; 2) identify seasonal variations of PAHs in upper soil layers; 3) evaluate possibilities of PAHs accumulation in urban soils via atmospheric inputs with particulate matter.

Materials and methods

Description of sampling sites Soil and snow samples were collected from various sites located at the territory of Eastern Administrative Okrug of Moscow city in municipal districts Metrogorodok and Golyanovo and in Losiny Ostrov National Park. The location of the sampling sites is displayed in Figure 1.

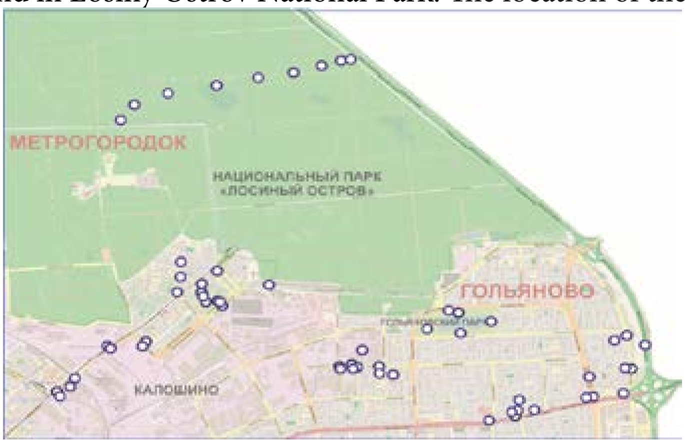

Figure 1. Location of the sampling sites.

Southern part of the investigated territory represents typical densely built-up urban areas with well-developed road network, industrial activities, large number of residential, commercial and public buildings, constantly visited walking recreational zones and, respectively, with multiply various sources of PAH contamination. All the sampling sites have well-cultured grass and deciduous tree cover with regular removing of fallen leaves. Soils of these sites are konstruktozems with periodical (once 3-5 years) changing of the upper lay, which represents a mixture of peat, loam and sand. Northern part of Eastern Okrug is occupied by natural ecosystems of Losiny Ostrov National Park – one of the largest forests located in the cities. The main anthropogenic source of PAH spreading via park zone is the Moscow Automobile Ring Road (MKAD) - one of the busiest high-speed vehicular traffic freeways in Moscow, which was built in 1961 and widened in 1999 from the initial four to ten lanes. On the territory of National Park sampling was conducted at the forested sites with deciduous (*Tilia cordata*) or coniferous (*Picea abies*) tree cover and with undisturbed soddy-podzolic soils.

Sampling Soil samples were collected in November 2011 and April 2012. Stainless steel core (5 cm diameter) was used to collect the soil samples from a depth of 0-10 cm. Fives soil samples were collected at each sampling site. The soil samples were dried, homogenized and sieved through a 1-mm sieve. Samples of atmospheric fallout were collected in sites with undisturbed snow cover before snow melting in March 2011-2013. 10 cm diameter tube was used to collect snow samples from 3-5 points at each sampling site. In the laboratory the snow samples were melted and filtered throw Millipore filter with pore diameter 0,45 mkm. Obtained filters with particulate matter were dried and weighted.

Sample analysis All samples were extracted with hexane and dichloromethane via pressurized liquid extraction using a Dionex ASE 200 extractor. Clean up analyses were performed on BCM solid phase extraction cartridges. The eluents were completely dried and subsequently dissolved in 1 ml of acetonitrile. The concentrations of PAHs were determined by high performance liquid chromatography using a Agilent 1100 HPLC System with binary pump, fluorescent detector and Eclipse XDB-C18 250 mm × 4,6mm × 5 mkm analytical column. Replicate analyses gave an error between 15%. All statistical analyses were performed with STATISTICA ver. 8.0.

Results and discussion

PAH pattern 11 PAHs were detected in all samples including phenanthrene, anthracene, fluoranthene, pyrene, benz(a)anthracene, chrysene, benz(b)fluoranthene, benz(k)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, benzo(ghi)perylene. Samples of atmospheric particulate depositions from different functional areas showed a similar PAH pattern (Fig. 2A). They consisted primarily of three to four ring PAHs, which accounted for about 85% of total PAHs content. The depositions from traffic areas exhibited a distinct abundance of anthracene.

Figure 2. PAH distribution patterns of atmospheric particulate depositions (A), of topsoils in autumn (B) and in spring (C) with the percentage of the individual substance to the total PAH concentration (C/Ctotal). 1 – recreational zone in National Park; 2 - recreational zone in densely built-up area.

In soil samples fluoranthene contributed a higher amount of total PAHs than other low molecular weight PAHs (Fig. 2B, 2C). When compared to atmospheric particles, topsoils contained more significant abundance of high molecular weight PAHs, especially benz(b)fluoranthene and benzo(ghi)perylene. 5-6-ring PAHs more easily accumulated in the topsoils, that suggests an existence of additional source of the high weight PAH molecules in upper soil layers besides of the anthropogenic airborne depositions. Figure 2B indicates the noticeable differences between PAH distributions for soils of National Park and densely built-up area in autumn, while in spring soils form green and urban areas showed more similar distribution patterns (Fig. 2C). Urban konstruktozems were found to have 2-3 times higher content of benzo(a)pyrene than forest soddy-podzolic soils.

PAH content Figure 3 summarizes data on the sums of 11 PAHs for different functional areas of investigated territory. PAH input with atmospheric particulate depositions was found to be 3-5 times higher at trafficked sampling sites, than at sites located in residential, recreational and green areas (Fig. 3A). Heavy traffic load on the MKAD caused higher concentrations of the total PAH depositions for the MKAD impact zone in National Park. Total PAH concentrations in the upper layers of urban konstruktozems ranged in wide limits with similar mean values of 1,52, 2,21, 1,97 mkg/g for recreational, residential and traffic zone respectively. The mean values of PAH content were comparable in autumn and spring for urban topsoils.

Upper layers of soddy-podzolic soils collected at recreational and traffic zones in National Park showed only slight differences in mean values of PAH content – 0,6 and 0,8 mkg/g, though PAH input with atmospheric particles was in the traffic zone 5 times higher (Fig 3B). The total PAH contents in all samples of natural topsoils from the park zone were 2 times lower, when compared with topsoils from the built-up area, despite equal level of atmosphere contamination on these territories.

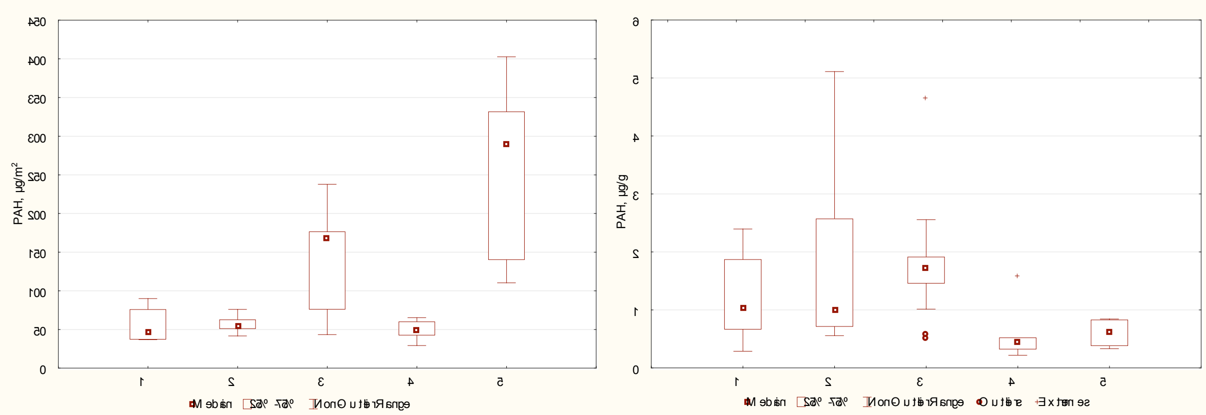

Figure 3. Comparisons of PAHs total concentrations in atmospheric particulate depositions (A) and topsoils (B) for different functional areas: 1 – recreational zone in densely built-up area; 2 – residential zone in densely built-up area; 3 – traffic zone in densely built-up area; 4 - recreational zone in National Park; 5 - traffic zone in National Park.

Based on the obtained data one can calculate, that modern pools of PAH in the all studied topsoils are two-three orders higher, than PAH annual depositions on the soil surface from the atmosphere. This fact, taking into account a short time of forming of the upper layers of konstruktozems (3-5 years), suggests mainly biogenic origin of PAH or presence of other contamination sources in the replaceable peat-contained mixture, which is used for construction of urban soils. The similar conclusion can be made for upper horizons of the soddy-podzolic soils in National Park - despite a longer time of formation they were under conditions of high traffic contamination from MKAD only within the last 15 years.

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Urban soils' functions and ecosystem services: from concepts to application

Technosols made of urban waste can sustain tree growth development

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Key words: structural soil, nutrients, pH, porosity, biomass production,

Vegetation in urban areas is generally living in a stress-inducing environment. In particular, urban soils are characterized by a high physico-chemical heterogeneity due to various and contrasted materials used. Its main differences from a natural soil are i) a lower nutrient content, ii) a higher pH and iii) a higher compaction due to mechanical stresses (road traffic) impacting root system and aboveground biomass development. Sustaining good conditions for tree growth by improving soil quality and favorable agronomic conditions is crucial to maintain productivity. Soil fertility can be evaluated from physical, chemical and biological properties but physical properties (fine soil granulometry, bulk density and aggregate stability) associated with soil nutrient availability are the essential drivers for tree growth.

Construction of urban soil to mimic natural fertile soils represent an engineering key issue. However, using topsoil from agricultural soils for urban greening is currently controversial due to the decrease in arable soils. An alternative for protecting these natural resources consists in reusing local waste materials in order to construct Technosols supporting essential functions (plant growth) similar to natural soils. Local wastes can also be a source of nutrients that need to be considered to help green city managers to select adequate wastes and mixing ratios.

The purpose of this study is to evaluate soil-plant interactions by considering soil physico-chemical properties and tree growth behavior in compact soil. Trees planted in streets are one of the most common model of green space categories in cities, generally present in the most urbanized areas, mainly found along roads and inside impervious places. In such a case, trees are growing in a limited soil volume where water and nutrient contents can be unsatisfactory. Thus, this study focuses on (1) investigating the dynamic of technosol agronomic properties, and (2) comparing tree growth performance in various waste mixtures. To do this, a 4-year experiment was conducted in lysimeters, with Norway maple trees (*Acer platanoïdes* L.)

Nine 0.480-m^3 lysimeters, along with three replicates of three distinct constructed soils, were built in Angers (France) in April 2013 and then allowed to evolve under to atmospheric conditions during 3 years. The growing material (GM), made of a mixture of bricks and green waste compost, (BR/CO 58/42 w/w) was set in a 0.025-m^3 cylinder at the center of the lysimeter and surrounded by some of structural material (SM). Three different structural materials were used (1) a mixture of acid earth material, demolition rubble (R) and green waste (G) (SM-RG, 22/75/3 w/w), or (2) a mixture of acid earth material, track ballast (B) and sewage sludge (S) (SM-BS, 20/76/4 w/w), and or (3) the actual SM used by Angers city for green spaces settlements (SM-reference, mixture of acid earth material, chalcedony and leaf mold, 27/70/3 w/w). A 2 year-old Norway mapple was planted in the GM of each lysimeter. Each year, one replicate was sacrified for soil and tree growth analyses. Soil physical properties measured were the soil water reservoir, macroporosity, bulk density and the saturated hydraulic conductivity and chemical analyses measured were organic matter content, pH, CEC, macro and oligo nutrients. Tree root and aboveground biomass was quantified, as long as tree branching and length.

In this experiment, waste characteristics and mixing proportions both affected Norway maple growth. This study showed that physical properties were not a limiting factor for tree growth, despite a relatively low soil water reservoir. Moreover, chemical properties of the materials, and mostly the low pH and low CEC, were underlined in SM-Reference conducting to a bad tree development, whereas the two other ones did not affected tree growth. After 3 years of growing, tree aerial biomass was 660, 1910 and 3930 g dw in SM-Reference, SM-BS and SM-RG, respectively. Tree root biomass was 420, 1190 and 2430 g dw, in SM-Reference, SM-BS and SM-RG, respectively. Then, the results confirmed that waste mixtures can sustain soil function for tree growth and present efficient physico-chemical properties for both the tree aboveground and root development.

Development of a tool for the diagnostic of urban soils quality and evaluation of the potential ecosystem services

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Abstract

Urban soils are a resource poorly taken into account for the conception and construction of sustainable cities (Morel et al., 2014). This can be explained by the fact that the intense human influences and the fast succession of land-uses lead to a great variety of soils on a limited surface area (compared to natural environments) and to a lack of spatial logic. Such heterogeneities, as well as a very large range of bio-physico-chemical features makes the diagnostic of urban soil quality very complex, even at the scale of a few hectares sites. Furthermore, adapted interpretation of soil properties in the urban context is required not only to take into account their original features, but also the specificity of urban land-uses (e.g. green infrastructures, urban square, buildings). Our work aims at developing an innovative tool that could not only permit a fast and simple diagnosis of the soils quality at the plot's scale, but could also calculate, with a scoring system, potential ecosystem services.

First, we have reviewed a selection of existing approaches to evaluate soil quality in the urban context. Then, we have developed the structure of a model that links relevant soil indicators to soil functions, then to soil covers and finally to ecosystem services as described by Dominati (2013) and Adhikari and Hartemink (2015). Finally, we have tested our method on two French urban brownfields.

From the review, it has been decided to consider a limited number of soil indicators (e.g. soil texture, soil structure, pH, organic matter content, % of artefacts). A ranking system has been developed for the evaluation of the urban soil functions that is based on the aggregation of indicators. A specific feature of the tool is to provide information on the soil covers that could or could not be fulfilled by the soils. A list of soil ecosystem services adapted to the urban context has been proposed. At last, for every possible soil cover, a semi-quantitative evaluation of all the ecosystem services is made. The confrontation of the initial parametrization with the data obtained in situ showed that some improvements are still needed, but that the tool is very promising.

Such an approach can be beneficial to improve how urban soils are taken into account in urban planning. The next step is the tangible development of a comprehensive tool that aimed at guiding urban planners in the decision processes required for a sustainable management of urban areas.

Keywords

Urban planning – urban brownfield - ecosystem service – soil indicators – soil quality –decision support system

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Ecological functions and ecosystem services of soils under the municipal solid waste landfill impact (Moscow region)

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The issues of the environmental sustainable management and protection have become very important. Urbanization processes are close connected with the increase of human needs in food, fresh water, minerals, that affected the ecosystems and led to their degradation; most of the changes are permanent, or is equal to that level. The list of anthropogenic factors and their negative impact on urban ecosystems is multifarious. The threat of a global ecological crisis in urban ecosystems defines the necessity to work out the strategy of optimal relation between humanity and nature, determine the main vital functions of the biological systems. The biosphere plays the regulator role and maintains the environmental parameters in a narrow value range suitable for humanity exist.

According to the National strategy (2001), the key function for human life is environmental functions, targeting to maintain the biosphere processes on the Earth and to form favorable human life conditions (including clean air, clean water, soil fertility, climate). The environmental function is defined as a regulating one in international documents (Common International Classification, 2011). In terms of economic principles and natural resource management environmental (regulating) functions turn into goods and ecosystem services. The ecosystem approach is an integrated management strategy of land, water and living resources that is especially crucial in the context of urbanization.

The soil is one of the main environment components that play a very important ecological role, providing numerous ecological relations between all living organisms on earth (including humans) and lithosphere, hydrosphere and atmosphere. The study about soil ecological functions (Dobrovolsky G.V., Nikitin E.D., 1990), established variety forms of soil participation in the ecosystem functioning and changing as well as in the biosphere. The analysis of the soil functions in ecosystems and the biosphere shows that the soil is the main component of the biosphere functioning, it has direct and feedback relations with other environment components. The soil diversity according to their properties, characteristics, functions determines their ecosystem functions. Following the authors (Ecosystem services, 2013) we understand ecosystem functions as ones that can be useful to humanity and provide ecosystem services. Soil ecosystem functions are determined by the set of their properties and soil formation processes, therefore, the soil becomes the connecting link between environment components, in particular hydrosphere. Thus, soil functions: substance transformation, protective function as a barrier to the pollutant migration into water, are significant environmental (regulating) functions.

The proposal of this work is to assess the quality of soils and associated aquatic environments at the area adjacent to the solid waste disposal, to analyze the ecological functions and ecosystem services, got by humanity from the environment.

The object of the study was soils developing along the creek, water and sediments from the creek under impact of municipal solid waste landfill in Moscow region. The landfill location is a swampy area, given a start to creek studied. The contamination source of environment is filtrate releasing from the landfill body. The filtrate is a saturated multicomponent aqueous solution. According to monitoring (2006-2012) main pollution substances are chrome, zinc, copper, lead, manganese, ammonium, chloride, nitrate, phosphate and sulfate ions (Kovaleva and et al., 2012, 2013).

Soil, water and sediment samples were collected at the control sites, made in the direction of relief gradient to the lowest landscape and also background areas for the environment assessment under municipal waste landfill impact. Samples of soils, sediments and waters were studied by marker indicators according to filtrate composition. The composition and properties of humus substances were studied as additional characteristics. Among the parameters of humus, reflecting the soil condition and fixing processes initiated by anthropogenic loads are the total organic carbon content and humus composition. Humic acid (HA), being a part of humus, are characterized by specificity composition, structure, properties (Dergacheva, 2008), reflecting biothermodynamic soil conditions that potentially allows to use them as an indicator to establish the stability soil limit (Kovaleva, Dergacheva, 2001) and limit capacity of anthropogenic load. HA were extracted from polluted soils and sediments and their background analogues; element composition and pollutants, found in filtrate, were determined in HA. Likewise, HA, extracted from sod podzolic gley soils columns of model experiment, were studied. Soil columns were poured with filtrate of different concentrations in amount equal to annual precipitation, modelling entering pollutants from landfill body.

The results of the study revealed the contamination of soils, water and sediments of the creek studied by pollutants, specific to the municipal waste landfill filtrate composition.

HA carbon content of polluted soils has changed in compare with the background one. The ratio of H/C in HA of background and polluted soils are 1,0-1,3, that indicates to low share of aromatic part in their composition. The oxidation degree of HA has decreased with increasing of pollutant concentration in soils, varying in the range of -0.7 to -1.1, reflecting the biochemical environment deterioration. Graphic and statistical analysis by Vang-Krevelen showed that the reaction providing the HA composition change can be a molecules decarboxylation. HA participate in interactions with heavy metals and the obtained data has shown that pH plays a very important role in their mobility. The largest share of HA associated with metals was characteristic to copper (up to 25%). It can be confirmed that that copper is bound mainly in the unavailable form.

The results have shown that the soil is the component purifying contaminated water, regulating the water quality and is the functioning component of the biosphere. Acting as a regulator of water quality, the soil performs important environmental (regulating) functions - protective and buffer biogeocenosis barrier, influenced to the ecosystem services. Thus, the function - the pollutant accumulation by the soil, being due to its properties, affects the ecosystem service of human supply by clean water.

Ecosystem services - the municipal waste landfill are provided by the ecosystem functions, such as provisioning and environmental (regulating). The municipal waste landfill as a factor of urbanization impacts the environment, leads to changes in environmental (regulating) functions that should be managed by man in order to maintain the environment biodiversity and physico-chemical state. The obtained data concerning the HA composition and properties is significant additional information to chemical parameters that allow to find the limit capacity of anthropogenic load.

The economic interpretation of the soil function and ecosystem services was done, basing on the parameter assessment of the soil, water, sediment quality degradation and their recovery.

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Variability of Infiltration Rates at Selected Bioswales in New York City

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Abstract

In New York City Green Infrastructure such as bioswales are designed to capture stormwater by diverting runoff from flowing into municipal sewer systems. Stormwater entering bioswales infiltrates into the subsurface, evaporates back into the atmosphere, or is retained in the soil. This reduces the burden on wastewater treatment plants during a storm and decreases the combined sewer overflow – which is the leading cause of water quality problems in New York Harbor. Infiltration rate is the most important measurement of a soil's capacity to capture stormwater for a green infrastructure system. Many factors can affect the rate of stormwater infiltration through engineered soils, such as sand content, compaction, plant root development, and fine sediment deposition at the surface. The objective of this study is to investigate the variability of infiltration rates and the factors controlling infiltration rates in these bioswales among twelve built sites in the Jamaica Bay Watershed. Infiltration tests will be conducted using three different types of infiltrometers, each serve different purposes. The double ring infiltrometer is used to measure infiltration rates under common flooding situations during a storm event; the amoozemeter is used to measure infiltration rates when the soil surface layer (0-5cm) is removed; and the Cornell Sprinkle Infiltrometer can be used to measure saturated infiltration rates but without ponding. The combination of these three different methods can help understand the degree to which surface soil and ponding depth control overall infiltration rates of a bioswale system. Data from these tests will be compared to double ring infiltrometer test rates measured during the first three years of operation (2011-2013). Preliminary results obtained in 2016 indicate a high variability for infiltration rates among different sites, within each site and for different types of infiltrometers. Results from this study can be used to inform design modifications and maintenance requirements that may be necessary in order to achieve and maintain optimal infiltration rates.

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Principles of monetary valuation of ecosystem services of soils and lands

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Consideration of ecosystem services in different types of environmental and economic assessment of soils and lands (determination of the damage caused by pollution, degradation and littering of land, economic assessment of land degradation based on a comparison of economic indicators of agricultural production under sustainable land management and the "traditional" land use ") is often accompanied by economic (monetary) evaluation of these services. Instrumentation of such monetary valuation can be divided into seven blocks (Perman, Ma, Makgilvri, 2006; Bobylev, Khodzhaev, 2004; Bobylev, Zakharov, 2009).

1) method of market prices;
2) the method of transport and travel costs;
3) the method of hedonic pricing;
4) the contingent valuation method;
5) the choice of modeling approach;
6) methods based on the production function;
7) methods based on the evaluation of replacement cost "shadow infrastructure."

Analysis of of all the methods mentioned above allows to formulate some general principles for the valuation of ecosystem services.

1) Translation of ecosystem services in money is carried by searching for market of adequate counterpart in conditions of local economy, and at the current time. All known methods of evaluating ecosystem services somehow satisfy given position. For the most of ecosystem services independent market does not exist, hence the need for simulation appeared, if there is a market, in such generalization it is possible to speak about full compliance with the analog. The only exception here may be a list of methods based on the survey, but we can point out that retrieves information about "willingness to pay" - the essence of all information is the same market analogy, which in this case exists only in the mind of the individual.

Thus, the entire set of methods can be classified according to 3 criteria: belonging to the current market, search for an analogue on the existing market, analysis of "non-existent analog" (pic. 1.).

This compilation gives us certain discretion in the evaluation of ecosystem services (within the general rules of logic and the theory of assessment), and suggests the possibility of the appearance of an extremely broad spectrum of the total cost of the same ecosystem service evaluation. In the transition from one block to another, the degree of "objectivity" assessment begins to "blur", which is associated with the choice of analogue and, in the case of methods based on the survey - sample of respondents.
Selection of each of the above methods, or establishing a new method based on the baseline criteria is carried out based on range of information available to the researcher.

2) As in the case of assessing the market value, valuation of ecosystem services is carried out only when the investigated system has a utility (the principle of utility in the evaluation) to human.

3) In each case it is necessary to determine their range of ecosystem services and evaluate them based on the realities of the regional economy.

Two fundamental points should be emphasized in the context of the third principle:
All services can be evaluated, but b) the purpose of the study and research object impose restrictions on the specific range of services for the evaluation.

In this case - for land degradation assessment, it must be limited to only those services, the characteristics of which changed during the degradation of each individual valued land.

In accordance with the principles formulated above the necessary and sufficient set of ecosystem services of soils and lands of Moscow State University UOPEC Chashnikovo was identified: direct provisioning (habitat, source material and energy for land organisms, transformation of surface water to groundwater), protection (barrier biogeocoenosis, absorption and retention of certain gases), maintenance of life, cultural services (educational services, education for students).

Economic interpretation of loss of these services, including those based on an assessment of indicators of deterioration of soil fertility and the development measures for the elimination this degradation.

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Urban soil sorption function

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In the face of accelerating anthropogenic impact, urban soil sorption function studies are of importance. So far, however, this function has been viewed only from the perspective of the sorption capacity to toxic heavy metals.

To estimate sorption function the properties of urban soils were compared between two different land uses in Saint Petersburg and with the properties of background natural soils influenced by relatively low anthropogenic impact. Also soil organic matter contribution to sorption function was assessed.

The urban soil samples were collected from the pit excavated in the park while other samples were obtained from the pit under the roadside lawn, which is located within the industrial district of Saint Petersburg. So, the road surface is an additional source of runoff and stormwater pollutants.

The samples of natural soils were collected from Lisinsky wildlife sanctuary of Leningrad region.

The first urban soil resembles natural zonal undisturbed soils with a well-developed profile formed on varved clays. However, urbanization is often accompanied by an overall introduction of building materials and peat-sandy mixes constructed for a reclamation goal, and the presence of artifacts is commonly assumed to be a characteristic feature of urban soil profiles. So, the first soil can be related to the category of surface-transformed urbo-soils or to soils with an introduced horizon.

The second soil profile is presented by another category of urban soils. Such soils preferentially form on anthropogenic materials and have distinctive features attributed to urbanization processes.

This near-neutral soil (pH 6.9-7.2) enriched in exchangeable cations (94-97 %) with little remaining exchange acidity. A relatively high pH value, a high organic matter content and the results of humus fraction distribution obtained may be associated with an imbalance between the processes of mineralization and organic matter accumulation and inputs of deicing reagents, anthropogenic calcareous contaminants, heavy metals and organic pollutants. In the surface horizons, urban soils contain fine coal-like particles showing little evidence of humification.

The soil features and properties mentioned above reflect a general image of urban soil ecosystems. Thus, some ideas of soil sorption capacity can be gained from the analysis of their morphological and substantial characteristics.

The performance of sorption function is best interpreted by the comparison the original samples with the modified samples, respectively. The modified samples were obtained by oxidizing with H_2O_2, after which the samples were analyzed in parallel ways. The same approach was applied when analyzing the modified samples. The amounts of organic matter retained after the chemical treatment are shown in Table 1.

In this research, soil sorption function is characterized by the following parameters: cation exchange capacity (CEC), surface area, water vapor adsorption.

Such artificial dehumification under laboratory conditions changes the properties responsible for sorption function. So, relying on the assumption about the equality of the soil textures, this approach envisages the revealing of organic matter contribution to soil sorption function.

In this research, it was deduced that the total surface area values of the both urban soils are low. Comparison of the modified and the initial samples revealed that oxidation after the treatment decreases the total surface area in the urban soils as it does in the natural soil (Table 1).

Explanation of this alteration may be attributed to the organic matter removal, for it is an important contributor to surface area value. However, the diminishing of the surface available for water adsorption in the urban soils is less than that in the considered natural forest soil, whereas the content of organic matter in the urban soils is higher than that in the natural soil. Probably, it could be linked to hydrophobic organic components inherent in humic acids. In contrast to the humus fraction distribution of the natural forest soil presented here, humic acids predominate in the humus fraction distribution of the urban soils, and the humic to fulvic acid ratio extraordinary for the zonal soils is indicated (C_{ha}/C_{fa} 1-1,6). Such a high proportion of humic acids is unlikely to reflect progressive acid polymerization. It could be a result of limited synthesis of "young" acids (a lack of new-generated acids) rather than intense humification.

Contaminant inputs discourage the activity of aerobic decomposer microbes prolonging leaves life-time and enhancing relative accumulation of humic acids. On the other hand, organic matter of the urban soils is partially presented by the inert carbon of technogenic origin which supports the low cation exchange capacity. Furthermore, in the urban soils, heavy metals content measured is several times as great as the toxic threshold value. Consequently, the exchangeable sites of the functional groups of the humic compounds appear to be occupied by heavy metals, so, the organic matter presented is less active with respect to basis cation exchange than found in the background soil. Such a conclusion is confirmed by the high concentrations of heavy metals liberated following the H_2O_2 treatment, further determined from the water and NH_4Ac extractions by an atomic absorption spectroscopy.

Presumably, the increase of the urban soils CEC values after the laboratory dehumification (Table 1) may be explained in the same way.

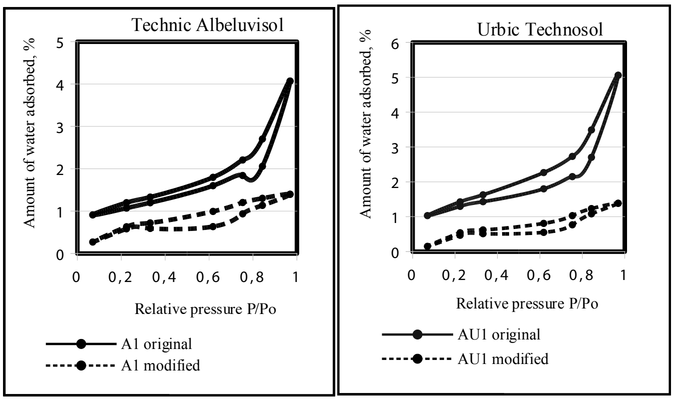
Table 1. Soil properties after modification

Soil type	Horizon	Original samples				Modified samples			
		OM %	CEC meq/ 100g soil	(Ca2+, Mg2+), meq/ 100g soil	Surface area m2/g	OM %	CEC meq/ 100g soil	(Ca2+, Mg2+),, meq/ 100g soil	Surface area m2/g
Technic Albeluvisol/ urbo-podzolic	A1	5,9	19,7	14,6	26,4	1,1	23	16	19
		2,8	17,7	12,5	29	0,6	20	15	21,5
	A2	0,7	12,6	7	34,1	0,2	14	10	24
	E	0,3	7,1	3,5	-	0	6	5	-
Urbic Technosol/ urbanozem	Au1	3,6	20,2	19,6	29	1,3	27,9	18	24,9
	Au2	3,4	19,1	18	35,1	1,1	24	16	22,7
Stagnic Albeluvisol	A	1,6	11	8,3	45,5	0,4	9	4	26,5
	E	0,9	6	3,3	-	0,1	5	4	-

Estimating soil water holding capacity from adsorption-desorption isotherms of water vapor (BET isotherms) determined the following. According to the IUPAC classification all the isotherms obtained for the original samples (Fig.1) are associated with the type IV which is related to capillary condensation in mesoporous solids. The hysteresis loop observed is considered to be characteristic of slit-shaped pored materials.

In comparison with the initial samples, the curves of the modified samples illustrated in Fig.1 show the translocation of the adsorption-desorption isotherms to the lower site of the equilibrium moisture content axis. The gentle slope of the treated samples curves is commonly inherent in narrow slit pores. These alterations of the pore forms give rise to a significant decrease of water holding capacity. Particularly, it can be clearly observed from the site of the curve associated with the beginning of capillary condensation.

Furthermore, from the plots already considered (Fig.1) it can be seen that the hysteresis loop of the dehumificated samples looks much more extended. Such type of hysteresis loop is commonly related to materials with disordered porous space. Thus, the loss of soil organic matter attendant on oxidation resulted in increasing the geometrical and energetic surface heterogeneity of solid soil components.



Thus, the aspects of the sorption function mentioned above may provide evidence for its degradation in the urban soils. It is difficult to attribute the degradation of this kind to any particular environmental factor. However, it should be taken to mean the significant influence of organic matter on the function performance

Figure1.BET adsorption-desorption isotherms

As far as the organic matter is concerned, according to the data presented here, it appears to be serviceable for water retaining, but there is a lack of cycling organic matter in urban soil surface horizons, whereas the organic matter available is not appropriate enough to support normal plant nutrition and to restrain flushing contaminants out of the soil profile. The mechanisms of degradation of sorption function in anthropogenic soils are destructive transformation of soil organic matter and the weakening of organic-mineral interactions.

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Bioremediation and reclamation of soils contaminated with oil-products, heavy metals and radionuclide

Studying soil development in ion-adsorbed REE mine tailings to assess the sustainability of the revegetation

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Introduction

Mining activities generate important ecosystem and soil degradation by earthwork and generation of by-products from the exploitation operations and the ore treatments. Remediation can use the processes of natural primary succession (Bradshaw, 2000) or pedological engineering to construct new soils fulfilling specific functions and providing specific ecosystem services (Séré et al., 2008; Morel et al., 2014; Ding et al., 2016). Such engineered soils could ensure the culture of economic plants (*e.g.* fiber and bioenergy crops) or accumulating plants of elements of interest (Tang et al., 2012) as in the Lorver project (Rees et al., 2014; Rodrigues et al., 2016).

New soils develop from the mine waste under the influence of environmental factors and remediation practices. Main processes observed in mine soils are OM accumulation, mineral (trans)formations and aggregation (Huot et al., 2015). Weathering rates of mine tailings depend on their reactivity, the climate and biological activity. Remediation practices (*e.g.* amendments, planting) were shown to accelerate some processes (*e.g.* formation of organo-mineral associations; Zanuzzi et al., 2009). High spatial variability in mine tailings may lead to variations in processes and their rate within short distance (Néel et al., 2003). Thus, the characterization of localized processes, such as the microstructure development and the rhizospheric processes at the microscopic scales is useful to investigate the formation of anthropic soils (Watteau et al., 2017).

The success of the remediation requires the soil re-functioning (*e.g.* structure development, water, OM and nutrient cycling), which will constrain the vegetation establishment (Li and Huang, 2015). More knowledge is needed about the processes, the rate and the drivers of the soil development and evolution, considering the objectives of the remediation and the timeframe to achieve them in order to assess the success and the sustainability of the remediation.

Objectives

The exploitation of ion-adsorption type rare earth element (REE) deposits in South China by heap leaching (*e.g.* excavation of deep REE-rich soil layer and leaching by ammonium sulfate) has generated important environmental damages, such as water contamination, erosion and landslides (Yang et al., 2013). The mining process generated compaction, increase in salinity and available N and decrease in OM and other nutrient concentrations. Microbial biomass and activity were strongly decreased in the tailings and plants have difficulty to grow on such materials (Liu et al., 2014; Zhou et al., 2015).

The objective of this research is to better understand the soil-forming processes under the influence of the reclamation (amendments, plantings) to determine a sustainable remediation solution in this area. A focus will be put on the fate of REEs during the soil development as they are of economic interest, emerging pollutants and have a potential for tracing the pedogenic processes (Laveuf and Cornu, 2009).

Material and methods

The demonstration base of the remediation project is situated in Ganzhou in the Jiangxi province in China on a mine tailing abandoned since ten years and landscaped three years ago. Since 2015, different parts of the site have been amended and planted.

Experimental plots were set up in July 2016 on the top of the tailing heap to monitor the soil and plant development depending on different remediation strategies:

- low-cost perennial cover to stabilize the tailings (grasses, *Miscanthus sinensis*);
- culture of fiber plants to stabilize the tailings and produce benefits (kenaf, ramie);
- culture of REE accumulating plants to extract REE from the tailings (*Phytolacca americana*, *Dicranopteris dichotoma*).

Thirteen treatments have been tested including controls (bare and amended tailings) with 5 plots (2x2 m) per treatment. Amendments were mixed in the first 10 cm of tailings before planting. The surface soil is monitored every 6 months for the following properties: total and $CaCl_2$-extractable major and REE concentrations, organic matter concentration, pH, cationic exchange capacity and exchangeable cations, bulk density and stability of aggregates. Profile development and microstructure using thin sections are described for controls and treatment with perennial cover. Plants are harvested once a year for biomass and major and trace element concentrations. Rhizospheric soils of some fiber and accumulating plants were also collected. Soil solution is collected in some plots using rhizons and analyzed for pH, organic carbon and total major and trace element concentrations.

In addition, the bulk and rhizospheric soils of plots planted with fiber plants in 2015 in the base were also investigated for elemental composition and chemical properties.

First results and conclusions

First results showed that the amendments and planting tended to slightly reduce the bulk density of the surface soil and increase the pH as well as the OM and nutrient concentrations in the soil solution and in the soil. More data will be acquired over time to better determine the effects of the different remediation treatments on the soil and plant development.

Preliminary investigations of the rhizosphere of ramie plants showed that rhizospheric soils were enriched in organic C and some nutrients and tended to display an higher extractability in some major elements (*e.g.* N, K, Fe, Si) and a reduced extractability in REEs in comparison to the bulk soil. Further analyses are required to better understand the contribution of the rhizospheric effects in the cycling of nutrients and REEs and in the development of the soil on the mine tailings.

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Determination of Total petroleum hydrocarbons, 3,4-Benzo(a) pyrene and various factions of Heavy Metals Concentrations in Urban Soils and City Dust on the South-Eastern Administrative District, Moscow

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Introduction. It is common knowledge that urban soils have specific adverse features such as unpredictable layering, poor structure, and high concentrations of trace elements (Kabata-Pendias, 2011). Urban soils are the end points of a large amount of Heavy Metals (HM), poly-aromatic hydrocarbons, petroleum hydrocarbons migration received from various sources including industrial emissions, the exhaust of internal combustion engines, and products of the combustion of coal and other sources. The combination of large amounts of people living in areas with large amounts of contaminated soil is one of the biggest dangers to human health in a big city. The dust generated from these (urban) soils can be toxic when inhaled or ingested by humans, particularly to children, posing a serious health hazard (Folinsbee, 1993). Moreover, the contamination of urban soils can lead to migration of the pollutants into groundwater, as the metals in the polluted urban soils tend to migrate to a greater extent than their unpolluted counterparts (Preciado HF et al., 2006).

Materials & methods. Urban soils and city dust were subjected to scrutiny in **the South-East Administrative District of Moscow**. **South-Eastern Administrative District** (SEAD) located on an extensive tract of land (12500 ha) in the central and the South-Eastern parts of Moscow city. The prevailing types of industry in the region– are energy, engineering, metalworking, chemical production (including petrochemical), textiles and the production of construction materials. There are 46 large industrial enterprises specializing in various fields, and several major highways and railways in the SEAD region (Avaliani SL et al., 2014).

Mixed soil samples were collected from $1m^2$ squares at 36 points located in the SEAD region from the upper 5 cm soil layer. Samples were collected from a variety of sources, such as vacant lots near industrial areas, lawns, side roads and railways, landscaped gardens and courtyards.

Samples of street dust were collected near the locations of soil sampling points. The soil samples were taken from the surfaces of roads and sidewalks, where dust is transported by the wind and surface runoff.

In the samples of dust and soil the following measurements were taken: Organic carbon (Vorobyova, L. A. 2006), pH_{H2O} (Vorobyova, L. A. 2006) and the composition of exchangeable cations (Vorobyova, L. A. 2006).

Water-soluble forms of HM were analyzed in the water extracts from the soil (the soil to water ratio is 1:10).

Bioavailable forms of HM were extracted from 5 g of 1 mm sieved soil by 50 ml of the ammonium acetate buffer (NH_4OAc) with a pH level of 4.8.

The total amount of HM was extracted from 0.5 g of 1 mm sieved soil and determined after microwave acid digestion with 16 ml (of the) aqua regia. The digested soil was transferred into a flask and filled to the 100 ml mark the deionized water.

All forms of HM were quantitatively detected by inductively-coupled plasma mass spectrometry (ICP-MS) at the Agilent 7500a.

TPH were extracted (from) 5 g of soil by 50 ml of carbon tetrachloride, extracts were separated from polar compounds by an aluminum oxide column and detected by spectrometry (λ=3.4 μm) with an infrared concentrator, according to the standardized technique (Federal environmental regulations № 16.1:2.2.22-98 (2005)).

3,4-Benzo(a)pyrene (b(a)p) was initially extracted from 2 g of soil with 50 ml of methylene chloride and separated by high performance liquid chromatography (HPLC) at Agilent 1200 with a fluorimetric detector.

Results and discussions

The soils at SEAD had neutral and alkalescent reactions (average pH=7,6), the organic carbon content is 3-4%. Carbonates were detected in examined soils. Calcium dominated among exchangeable cations, this could be linked with the presence of carbonates and an anthropogenic influence

Contamination by zinc, copper, lead and cadmium was observed in the examined soils in general. Very high amounts of zinc, copper and lead were found in several samples (Fig 1).

The content of HM in the aqueous extract from the soils was extremely small. The analysis of bioavailable forms of HM showed that in the examined soils the most significant concentration was observed for zinc (38 mg/kg). The average amount of bioavailable forms of zinc was about 1.5 times the Threshold limit value. The data indicates that most of the HM are fixed firmly in the soil and pose a weak threat to plants and the environment, with the exception of zinc.

Table 1. Total HM concentration in soil / dust samples, mg/kg

HM	**V**	**Cu**	**Zn**	**Cd**	**Pb**
Average value	26,6 / 39,8	39,9 / 86,6	162 / 222	0,85 / 0,57	53,4 / 49,6
Median value	25,2 / 40,5	33,3 / 69,6	139 / 203	0,56 / 0,46	37,3 / 48,8
Maximum	43,6 / 52,1	130 / 332	1149 / 615	3,14 / 1,66	519 / 103
Minimum	16,2 / 28,8	7,0 / 30,4	26,0 / 97,9	0,11 / 0,22	6,6 / 19,2
Threshold limit value for loamy soil*	**150**	**33**	**55**	**0,5**	**32**

*(State hygienic standard of Russian Federation 2.1.7.2041-06, 2006)

The amount of metals in the street dust (Copper, zinc and vanadium) is higher than in the soils (Table 1). Therefore, street dust, which is easily carried by the wind, can serve as a secondary source of soil contamination due to the presence of these elements.

The amount of metals **in the aqueous extract of the dust is also very low, as in the soils, but the concentration of bioavailable forms of** metals **in the dust exceeds that of those in the soil. The highest content observed for zinc and is about 70 mg/kg.**

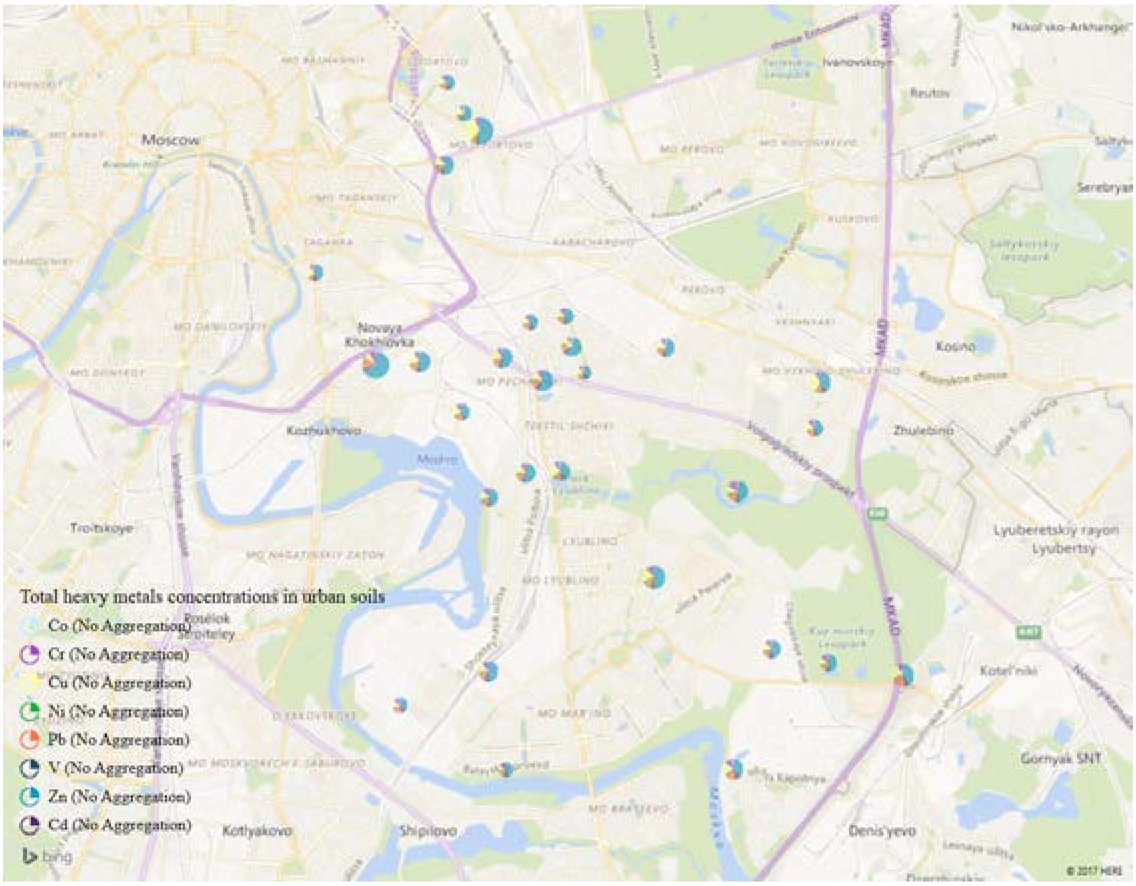
The amount of TPH in the soils on-average is 1335 mg/kg. In 75 % of the samples there was an excess of the Threshold limit value of TPH products. The average amount of TPH products is about 4.5 times higher than the Threshold limit value.

The average content of b(a)p in soils from the southeastern administrative region of Moscow is 0.08 mg/kg, which exceeds the permissible level 4 times over.

The amount of organic pollutants in the dust is higher than that in the soil. For TPH products – 18 times higher, (24322 mg/kg) for b(a)p -- 1.5 times higher, (0,135 mg/kg).

Conclusion

Due to the presence of significant sources of pollution and high concentrations of substances in the soil and the urban dust in the SEAD region that are dangerous to humans, it is advisable to systematically monitor the area to assess and predict future situations. It is also necessary to develop a system of measures aimed at reducing the level of pollution in the region.



Figures 1. HM concentration levels in SEAD soils. (Size) of diagram – the total amount of all investigated heavy metals, pie – the proportion of heavy metals in the total amount of all investigated heavy metals

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The bacterial community diversity in the rhizosphere and non-rhizosphere ultramafic soils of Ni-hyperaccumulator plants growing in Halmahera Island, Indonesia

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Keywords: microbial diversity; high-throughput 16S rRNA amplicon sequencing; nickel; ultramafic soils; hyperaccumulator plants; Halmahera Island

Introduction

Ultramafic soils form one of the major sources of nickel for the mining industry. Ultramafic bedrock is widespread and extensive in Indonesia, especially on Halmahera Island where with its surface of about 8000 km^2 it is probably one of the world's largest outcrops (Van der Ent *et al.,* 2013).

Soils derived from ultramafic bedrock have a number of extreme chemical properties that challenge plants to survive, which include a deficiency in the macronutrients phosphorus, potassium, calcium and nitrogen, and unusually high concentrations of magnesium and nickel which may act as toxins (O'Dell and Rajakaruna, 2011; Van der Ent *et al.,* 2013). Because of these inhospitable edaphic conditions, these soils are typically home to a very specialized flora including endemic species, called hyperaccumulator plants (Mengoni *et al.,* 2004). Nickel hyperaccumulators represent a rare group of plants, which have the ability to concentrate nickel in their living shoots at least 1% (Reeves and Brooks, 1983; Van der Ent *et al.,* 2012). Some native hyperaccumulator plant species could be used for the mine rehabilitation and for a phytoremediation approach in addition to replanting the area.

Despite the long history of interest in ultramafic flora and metal hyperaccumulator plants, the attention of microbiologists towards bacteria from ultramafic soils is more recent, with the relevant exception of Lipman (Lipman, 1926). Therefore, it is still essential to better understand the close correlations between rhizosphere microorganisms, host plants and surrounding soil, as well as the genetic diversity of rhizosphere bacterial communities in these ultramafic areas.

Unlike Sanger sequencing, recent advances in molecular biology and the development of the next generation sequencing (NGS) tools, enable now to deeply study the structure and diversity of microbial communities from diverse environments by high-throughput sequencing of many samples simultaneously (Rastogi and Sani, 2011).

The aim of the current work was to investigate the genetic diversity of bacterial communities present in the rhizosphere and non-rhizosphere ultramafic soils of Ni-hyperaccumulator plants growing in Halmahera Island, by using a high-throughput 16S rRNA gene amplicon sequencing with the Illumina platform. To our knowledge, this study is the first aiming at characterizing the microbiome present in the rhizophere and non-rhizosphere soils of the hyperaccumulator plants found in Halmahera Island and investigating the potential influence of edaphic factors (i.e. Ni availability, pH, cation exchange capacity).

Materials and methods

Rhizosphere and non-rhizosphere ultramafic soils of hyperaccumulator plants were sampled at 15 different sites to highlight the influence of plants and/or physicochemical parameters and localization on bacterial diversity. The rhizosphere soils were collected from 11 different nickel-hyperaccumulator plants.

Abiotic parameters, such as pH, cation exchange capacity (CEC), pseudo-total metals (aqua regia extractions) and available metals (DTPA extractions) were measured.

Total genomic DNA was extracted from 0.5 g soil samples using a Fast DNA® SPIN Kit for Soil (MP BioMedicals) according to the manufacturer's instructions. For the soil samples, barcoded amplicon sequencing was performed using the modified primers S-D-Bact-0909-a-S-18 and S-*-Univ-*-1392-a-A-15 (Klindworth *et al.*, 2013), targeting the V5-V8 region of the 16S rRNA gene. Sequencing was performed according to Illumina platform-compatible approach described elsewhere (Goux *et al.*, 2016). All sequence analyses were conducted using the MOTHUR, CLC Genomics Workbench and QIIME pipelines.

Results and discussion

A total of 3 744 752 bacterial 16S rRNA gene sequences were obtained from the 57 rhizosphere and non-rhizosphere soils analyzed. These sequences were clustered into 11 566 OTUs.

At the phylum level, 40 phyla were present and 16 with a relative abundance greater than 1%. The phyla with a relative abundance lower than 1% were grouped under "Others". Concerning rhizosphere soils, the major phyla were *Proteobacteria* (33.54 ± 1.67), *Acidobacteria* (20.87 ± 1.70), *Actinobacteria* (18.29 ± 2.38), *Chloroflexi* (8.57 ± 1.33) and *Nitrospirae* (4.31 ± 0.77), while for non-rhizosphere soils, they were *Proteobacteria* (31.83 ± 5.16), *Acidobacteria* (21.05 ± 2.84), *Actinobacteria* (14.49 ± 2.78), *Chloroflexi* (9.66 ±4.64), *Nitrospirae* (5.11 ± 1.75) and *Planctomycetes* (4.06 ± 1.04).

A Principal Component Analysis (PCA) was performed to characterize the effect of rhizosphere or non-rhizosphere soils and plant species on the most abundant phyla (Fig. 1). It seemed that whatever the type of soils (rhizosphere or non-rhizosphere soils) and the hyperaccumulator plant species, the localization of sampling was one of the major factor structuring the bacterial diversity. This observation could be linked to the physicochemical parameters and climatic conditions of each site.

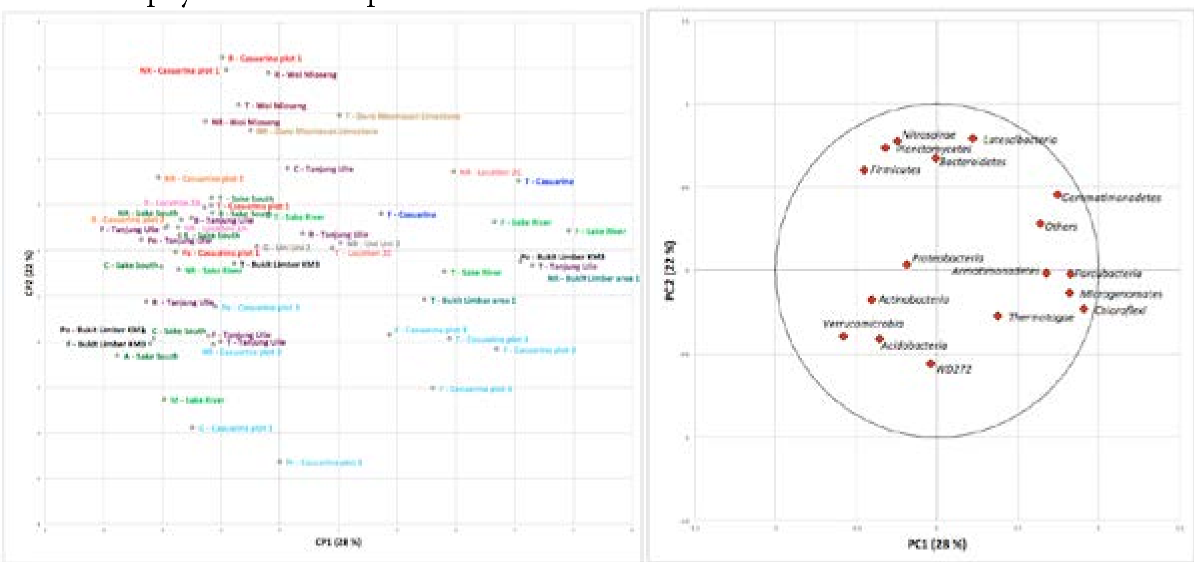

Fig. 1: (A) Ordination plot of rhizosphere and non-rhizosphere soil samples generated by PCA of the phyla. Rhizosphere soils of A: *Alstonia sp.*, B: *Barringtonia sp.*, C: *Cerbera cf. floribunda*, F: *Ficus sp.*, G: *Glochidion sp.*, M: *Macaranga sp.*, Pa: *Palaquium*, Po: *Pouteria sp.*, Pr: *Prunus sp.*, R: *Rinorea bengalensis*, T: *Trichospermum morotaiense* and Non rhizosphere soil: NR. **(B) Phyla involved in the discrimination of soil samples.**

If we only focus on the rhizosphere soils of the three-plant species mostly present in the different sites (*Rinorea bengalensis*, *Trichospermum morotaiense* and *Ficus sp.*) (Fig. 2), the *Rinorea* rhizosphere soils showed a stronger selectivity in bacterial communities by promoting some phyla such as *Planctomycetes*, *Bacteroidetes*, *Nitrospirae*, *Firmicutes*, *Actinobacteria* and *Verrucomicrobia*. Conversely, for *Trichospermum* and *Ficus* it was not possible to define a specific bacterial community.

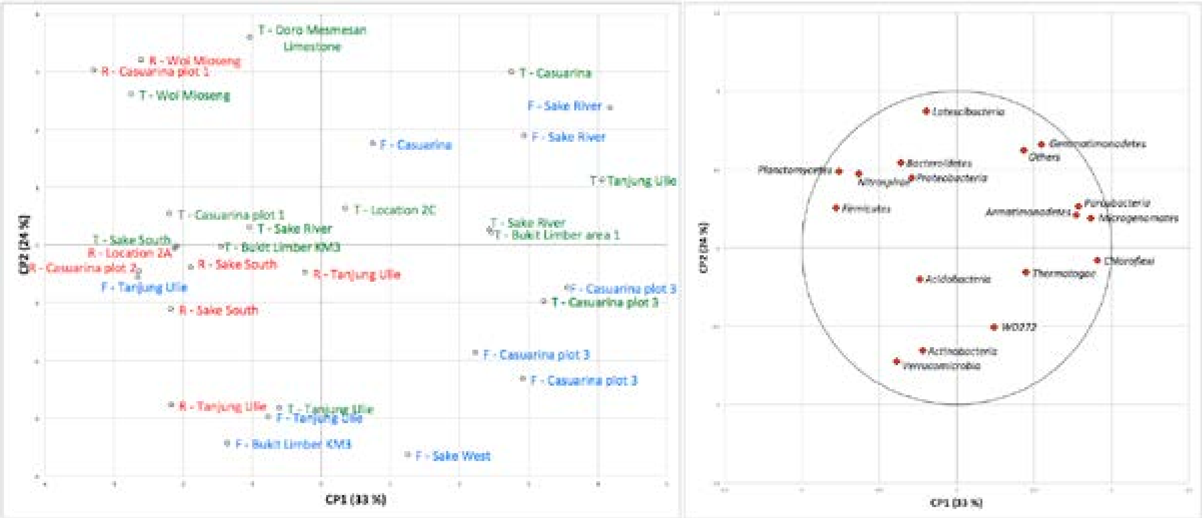

Fig. 2: (A) Ordination plot of the three major plants generated by PCA of the different phyla. F: *Ficus sp*., R: *Rinorea bengalensis* and T: *Trichospermum morotaiense.* **(B) Phyla involved in the discrimination of plant species.**

Conclusion

The first factor able to structure the bacterial diversity seemed to be the localization of soil samples, characterized by particular physicochemical parameters and climatic conditions. To a lesser extend, plant species characterized by specific root exudates, appeared to influence more or less the bacterial community diversity present in their rhizosphere.

It appears necessary to hierarchize the factors most influencing the structuration of the bacterial communities in ultramafic soils using statistical analysis based on the physicochemical, climatic and biotic parameters of these soils.

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Bioaccumulation and record changes in contaminated mining soils.

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Abstract

Mining activities have a number of impacts on the environment, including landscape disturbances and the long-term effects of waste deposits. The chemical properties of the residues, including the presence of heavy metals (derived either from the ore benefit processes or because they are constituents of the benefited rocks) are also environmental management challenges. Due to the above, it is necessary to develop management strategies to reduce the negative impact of the tailings. An assay of conifer species (*P. pseudostrobus, P. martinezii, P. leiophylla, P. devoniana* and *J. deppeana*) was carried out on a substrate obtained from a mine tailing to assess mercury bioaccumulation.

The results of plasma emission spectrometry analysis indicate that individuals of the species studied accumulate considerable amounts of mercury in their foliar tissues (23 ± 15 ppm), and also that accumulation varies among species. The species with the highest accumulation values was *P. leiophylla* (35 ± 24 ppm), followed by *P. pseudostrobus* (29 ± 16 ppm), *J. deppeana* (29 ± 2 ppm), *P. devoniana* (14 ± 8 ppm) and finally *P. martinezii* (9 ± 1 ppm).

The results indicate that the Tales of the Tlalpujahua Mining District represent a challenge for its restoration due to the presence of mercury in soluble forms. For the revegetation of this type of sites it is necessary to consider the bioaccumulation in the vegetation, the negative effects that can have on its performance and the possible implications on the dynamics of the mercury in the ecosystem.

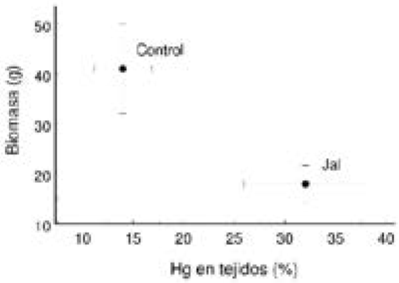
Introduction.- Increasing mining activity to meet human needs has generated large-scale ecosystem problems (Ramos-Arroyo & Siebe, 2007; Ramos-Arroyo & Siebe-Grabach, 2006). One of the consequences is that deposits of mineral residues (mine tailings) are created and can have a high content of heavy metals (As, Cu, Ni, Pb, Hg, Cn and Zn). Of particular importance is mercury, due to its toxicity. The rocks, as well as some extraction procedures, can generate residues with toxic concentrations of this metal. Mercury that is not processed or claimed in mining, as can occur in separation for the obtaining of gold and silver (amalgamation process), can be incorporated into the environment and bioaccumulated in food webs. (Department of Health and Human Services, 1999). As Lacerda (1997) states: "Most of the mercury released into the biosphere through gold and silver mining during the last 500 years, approximately 300,000 t, can still participate in the global Hg cycle through the remobilization of abandoned tailings and other contaminated areas. "

The main objective of this work was to quantify the accumulation of mercury in 5 native species of conifers potentially useful for the revegetation of mine dumps.

Materials and methods. A mesocosms experiment was established, in June 2014, where 5 conifer species were tested: *Pinus leiophylla* Schl. Et Cham., *P. pseudostrobus* Lindl., *P. devoniana* Lindl., *P. martinezii* Larsen and *J. deppeana* Steud. The experiment was a randomized complete block design with 4 blocks, with 10 to 20 mesocosms per block. The mesocosms in turn were divided into two substrate treatments: an organic substrate (sedimentary material mixed with organic matter) and a substrate of mining residue extracted from Los Cedros, in Tlalpujahua, Michoacán (a single substrate per mesocosms). In each mesocosms three species were planted, each represented by a plant (nine months old) from two sources, except *P. martinezii* and *J. deppeana*, represented by a single source. The growth was evaluated for 15 months (2 years of age), one of each two plants was harvested and dry weight and cup cover were evaluated. Also, an evaluation of the plant / root ratio (defined as the biomass of the roots Divided by aerial biomass). Two leaf samples from two species of each species and substrate for mercury analysis were analyzed by means of plasma emission spectrometry (Atomic Spectroscopy Laboratory, USAII-Faculty of Chemistry, UNAM).

Analysis of variance was performed with R (R Development Core Team 2016).

Results.-The results of plasma emission spectrometry analysis indicate that individuals of the species studied accumulate considerable amounts of mercury in their leaf tissues (23 ± 15 ppm), but the accumulation varies between substrates and species. The plants had higher concentrations of mercury in the leaves when they grew in the mining substrate (32 ± 15 ppm) and slightly less than half in the organic substrate (14 ± 7 ppm), these differences are statistically significant (F (1, 10) = 6.4, P = 0.03). The biomass of the plants growing in the mining substrate was lower than that of the plants in the control substrate (Figure 1) and the differences was statistically significant (F (1,10) = 6.1, P = 0.03).



The species with the highest values of mercury accumulation in leaf tissue was *P. leiophylla* (35 ± 24 ppm), followed by *P. pseudostrobus* (29 ± 16 ppm), *J. deppeana* (29 ± 2 ppm), P. *Devonian* (14 ± 8 ppm) and finally *P. martinezii* (9 ± 1 ppm). As regards biomass accumulation, there were considerable differences between species (Figure 2), with P. pseudostrobus being the species that accumulated the least biomass (12 ± 4.5 g) and P. devonian which accumulated more biomass (43 ± 26 g). Because the data of both variables showed a considerable dispersion, no statistically significant differences between species were detected

Fig 1. Mercury concentration in the leaves of five species of conifers and the accumulation of biomass in two substrates, jal and a control mixture.

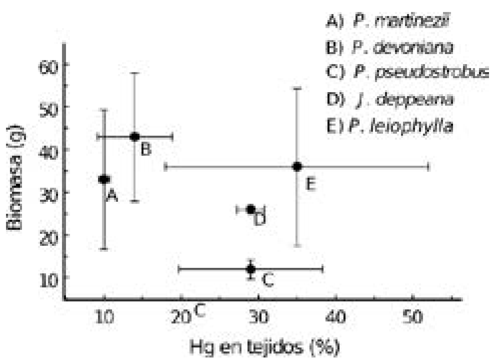


Fig 2.Accumulation of mercury and biomass in each of the five species studied.

Discussion.-The results indicate that in the material from which the tailings of the Mining District of Tlalpujahua are formed there is mercury that can be absorbed by plants and that some species accumulate it in greater quantities. Although the results presented here are preliminary and it is necessary to analyze a larger number of samples, it is clear that some species are able to grow on substrates with high concentrations of mercury without accumulating in their tissues.

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Impacts of artisanal gold mining on soil pollution by trace metals in Komabangou (Niger)

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Key words: soil pollution; trace metals; gold mining; Komabangou; Niger.

Abstract

In Sub-Saharan African countries, gold mining could have major impacts on different environmental matrices particularly in soil due to the use of hazardous chemicals such as mercury and cyanide in gold processing. This study aims at determining the impact of gold mining activities on soil pollution around Komabangou, which is one of the major gold mining sites in Niger. In this context, soil samples were collected from the surface at a depth of 20 cm within Komabangou site and its surroundings and also in a control area isolated from the pollution source. The collected samples were analyzed for 8 heavy metals including arsenic (As), cadmium (Cd), copper (Cu), chromium (Cr), cobalt (Co), nickel (Ni), lead (Pb) and zinc (Zn) by inductively coupled plasma-mass spectrometry (ICP-MS) after acid digestion.

Table 1 presents the descriptive analysis of metal concentrations in Komabangou soils. There is a high variability of concentrations according to the metal. Maximum concentrations up to 6576.70 mg/kg were detected for Pb. Minimum concentrations were detected for Cd (0.04 mg/kg). These results show also that metals concentrations values are very disparate and vary from 0.54 to 555.59 mg/kg for As; 0.04 to 1.43 mg/kg for Cd; 1.24 to 27.15 mg/kg for Co; 18.70 to 257.80 mg/kg for Cr; 3.86 to 175.53 mg/kg for Cu; 5.40 to 126.98 mg/kg for Ni; and 2.71 to 6576.70 mg/kg and 7.56 to 468.96 mg/kg respectively for Pb and Zn. The highest average concentration is obtained for Pb, followed in descending order by Zn, As, Cr, Cu, Ni, Co, and Cd. Average metals concentrations in soil samples from Komabangou gold zone and control soil are given in Table 2 according to site. The eight (8) trace metals sought as As, Cd, Co, Cr, Cu, Ni, Pb and Zn were detected at all sites in gold zone. Zn is not detected in control soil. The concentration values obtained vary according to the sampling site and the metal considered. Compared to control soil, highest metal concentrations were obtained in soil samples collected near Komabangou gold site suggesting an impact of gold panning on soil contamination by metals. The predominance of metal concentration is a function of the site but generally in our various investigation sites, the following metals: As, Cr or Zn have the highest average contents. This result suggests that the soil contamination depends on site and in particular the presence of pollution sources in or near the site.

Table 1: Descriptive analysis of metal concentrations in Komabangou soils (mg/kg)
The data represent the values obtained in soil samples (n = 28) collected in surface horizons (0-20 cm).

	Min	Max	Moyenne	Ecartype
As	0.54	555.59	78.62	156.84
Cd	0.04	1.43	0.19	0.28
Co	1.24	27.15	8.59	7.74
Cr	18.70	257.80	74.10	70.82
Cu	3.86	175.53	41.25	41.10
Ni	5.40	126.98	29.81	34.43
Pb	2.71	6576.70	298.97	1259.83
Zn	7.56	468.96	96.11	103.52

In the absence of national standards, for analysis of our results, we used worldwide limit values for metals in soils used for agricultural purposes. It should be noted that concentrations of all 8 metals detected in control soil are below regulatory guideline values (Table 2).

As concentrations in soil samples analyzed ranged from 0.62 to 392.09 mg/kg. Highest As content is obtained at Cyanidation site. 3 sites out of 7 have levels above world As average concentrations of uncontaminated soils (6 mg/kg) (Bowen, 1976). Guideline values for soil contaminated by As are 20 mg/kg and 29 mg/kg respectively by Italian legislation and by the Dutch agency for environmental protection. Soils sampled from the two gold processing sites (S5 and S6) have a concentration above this standard. Therefore, gold panning seems to affect soils pollution by As.

Cd concentrations in studied soils ranged from 0.04 to 0.41 mg/kg. Cd concentrations are 1.5 to 10.25 times higher than that of control site Soil samples taken at cyanidation site (S5) and Sossoria site (S6) have the highest Cd concentrations. None of the 7 sites had a Cd content above the 1 mg/kg threshold set by the UK Environmental Agency as the baseline for urban soils.

Cr concentrations in soils from Komabangou gold zone range from 19.84 to 254.54 mg/kg. The highest concentrations are detected at site S1, followed in decreasing order of S3, S6 and S5. Cr concentrations in this study, except for S1, are below the reference threshold (150 mg/kg), marking the difference between uncontaminated soils and contaminated soils according to French standard NF U44-041 (Baize, et al. Paquereau, 1997).

Concentration of Cu in our soil samples varies from 3.86 to 94.66 mg/kg. The highest Cu contents were recorded at the S1 and S5 with 94.66 and 68.26 mg/kg. respectively. Therefore, the lowest level (3.86 mg/kg) was observed at control site. For all the 7 sites investigated, no site had Cu levels above Cu limit (mg/kg) in soils.

Ni concentrations in the studied soils vary from 5.40 to 121.95 mg/kg. These values are greater than 5 mg / kg, which is a limit value separating Ni contaminated soil and uncontaminated soil based on guide values (Bowen, 1976) for world average metal levels in uncontaminated soils. Indeed Ni concentrations in our soil samples are 1.08 to 24.4 times higher than the Bowen limit value for Ni. The highest concentrations were obtained at S1, S5 and S6. However, by comparing the Ni content of the present study with the French standard NF U44-041 (Baize, and Paquereau, 1997) fixed at 50 mg/kg, only the site S1 has a concentration above this standard.

Pb concentrations in our soil samples range from 2.71 to 355.44 mg/kg. Pb concentrations in Komabangou soils are up to 131 times higher than control soil. The lowest concentration of Pb is detected at the S5 site. 5 out of 7 sites have Pb concentrations below the world average Pb concentrations in uncontaminated soils fixed to 35 mg / kg (Bowen, 1976). A single site (S5) had Pb levels above WHO limite value of 100 mg/kg in soil (Godin, 1982).

Zn was not detected in control soil. In soils taken from gold site and surrounding areas, Zn concentrations range from 21.72 to 282.83 mg/kg. The site S5 has the highest concentration of Zn, followed by S6, S1 and S3. 3 out of 7 sites revealed concentrations of Zn exceeding the Zn value in uncontaminated soils (90 mg / kg). Compared to the Dutch regulatory standard of 140 mg / kg for contaminated soils, only the site S5 has Zn levels in soils above this standard limit.

Table 2: Average concentrations of metals in soils (mg/kg) at the Komabangou and surrounding sites

Trace metals Sites	Code	As	Cd	Co	Cr	Cu	Ni	Pb	Zn
Control soil Bandjo	T	0,62	0,04	1,61	19,84	3,86	5,40	2,71	< L.D.
Soil Namga pond	S1	10,33	0,08	26,56	254,54	94,66	121,95	15,40	114,42
Soil Zoribi	S2	0,56	0,07	2,35	35,23	36,67	14,39	4,60	22,55
Soil Bouira	S3	4,11	0,07	6,71	92,03	13,53	18,32	6,20	77,38
Soil Kounhou	S4	3,15	0,06	4,37	31,37	11,19	14,69	5,89	21,72
Soil of cyanudation sites	S5	392,09	0,41	9,76	61,96	68,26	26,73	355,44	282,43
Soil of Sossoria sites	S6	140,61	0,23	8,69	70,69	36,99	24,42	48,23	126,99
Limit values	VN	6(1)	1(2)	-	150(3)	100(4)	50(5)	100(6)	300(7)

Concentrations exceeding normal value or regulatory standard

1 World average of uncontaminated soils in As (Bowen, 1976)
2 Reference value for Cd of the British Agency for Soils in Urban Areas
3 Cr limit value (Baize and Paquereau, 1997)
4 Tolerable Level of Cu in Soils (NFU 4405)
5 Ni limit value (Baize and Paquereau, 1997)
6 Pb critical value reported by WHO (Godin, 1982)
7 Zn critical value reported by WHO (Tomgouani *et al.,* 2007)

On most gold sites (S1, S5 and S6), the regulatory limit values were exceeded for at least one trace element. This could pose toxicity for plants, animals, and local population. Adjacent soils are being used for agriculture and the mine polluted materials could contaminate them through hydric erosion or aeolian dust contamination. Therefore the establishment of monitoring and treatment of contaminated soils program would be necessary to reduce human contamination risks by identifying the preferential transfer pathways.

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Adsorptive bioremediation of soils contaminated with organic pollutants

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Contamination of the environment, especially on urban territory, becomes growing modern problem. There are thousands of environmental contaminants, and most of them accumulated in soil. The development of effective approaches for remediation of the contaminated soils is one of the most important goals of modern science. Despite on the evident privilege of soil bioremediation, possibilities of this approach are restricted due to high toxicity and bad properties of the contaminated soils, leading to poor adaptation of indigenous and/or inoculated degrading microorganisms and plants in highly contaminated soils. The main subject of this presentation is to discuss the results of experiments on the use of natural adsorbents and ameliorants for accelerated bioremediation of contaminated soils. Conception of adsorptive bioremediation for soils contaminated with various organic pollutants will be suggested.

Experimental approaches

The experiments on adsorptive bioremediation were carried out with soils historically contaminated or spiked with several individual or mixed pollutants: petroleum and its products (diesel fuel (DF) and spent motor oil (SMO)), 3,4-dichloroaniline (DCA), 4-chlorophenols (CP), explosive 2,4,6-trinitrotoluene (TNT), and polychlorinated biphenyls (PCBs). The initial concentrations of the contaminants in laboratory, semi-field and field experiments deviated from 1000 to 150 000 mg kg^{-1}.

In the experiments with petroleum and products, biopreparations based on degrading bacteria were inoculated separately or in combination with adsorbents of 3 classes (mineral, organic, and carbonic), while mostly granular activated carbon (GAC) was used in the experiments with other pollutants. Their chemical availability was studied through fractionated extraction, and bioavailability was estimated through phytotests and biotests with soil microorganisms and *Daphnia magna.* The degrading bacteria were count by plating on selective culture media. Influence of adsorbents on some properties of pure and contaminated soils were studied. The details are in [1-6].

Results and discussion

The example of ***degradable pollutants*** is petroleum and its products. The main part of those heterogenic pollutants consists of petroleum hydrocarbons (PHC), which are more or less readily utilized by soil microorganisms. The petroleum-contaminated soils often accrue at urban territory: around the refinery plants, gasoline stations, and so on. Microorganisms degrading petroleum hydrocarbons are widely spread in soils, and many biopreparations have been created that are based on microorganisms (mostly bacteria) growing on petroleum hydrocarbons as a sole source of carbon and energy.

Main problems of bioremediation for petroleum contaminated soils are connected to high level of petroleum contamination that is created in places of accidental leakage of petroleum and products (often >5%, w/w). The contaminated soils are usually highly hydrophobic and toxic for microorganisms and plants. Besides, substantial concentrations of some toxic representative of PHC and especially their microbial metabolites - oxidized petroleum hydrocarbons (OPHC), can penetrate to underground water due to their significant water solubility.

In a 2-y semi-field experiment, all the studied adsorbents taken in optimal concentrations (0.2-2% w/w, depending on adsorbent) positively influenced on the rate of bioremediation of gray forest soil contaminated with weathered petroleum (initially 5% PHC). Mechanism of this effect can be explained by their positive influence on soil properties: water holding capacity and soil humidity (due to reduction of soil hydrophobicity), as well as reduction of its phyto- and biotoxicity due to mostly reversible adsorption of the pollutants. In the petroleum contaminated soils amended with the adsorbents, polycyclic aromatic hydrocarbons (PAH) were degraded slower compared to alkanes, however no significant accumulation of those persistent and carcinogenic pollutants (including benzo(a)pyrene) were accumulated there compared to control without adsorbents. Details see here in the other paper [Zinnatshina et al.].

Besides, positive influence of biopreparations (BP) revealed only in the case of severe inhibition of indigenous degrading bacteria. Moreover, the BP were often more effective when added in combination with adsorbents. Fig.1 illustrates the effect of GAC and BP (separately and in combination) on phytotoxicity of gray forest soil contaminated with 5% of DF in the end of the 1st season of bioremediation [1]. In addition, the introduced GAC significantly reduced concentration of PHC and especially OPHC in the lysimetric waters passed through the contaminated soils during bioremediation [2, 3]. Thus, the GAC can localize the contaminated spot giving the possibly to create soil bioremediation *in situ*.

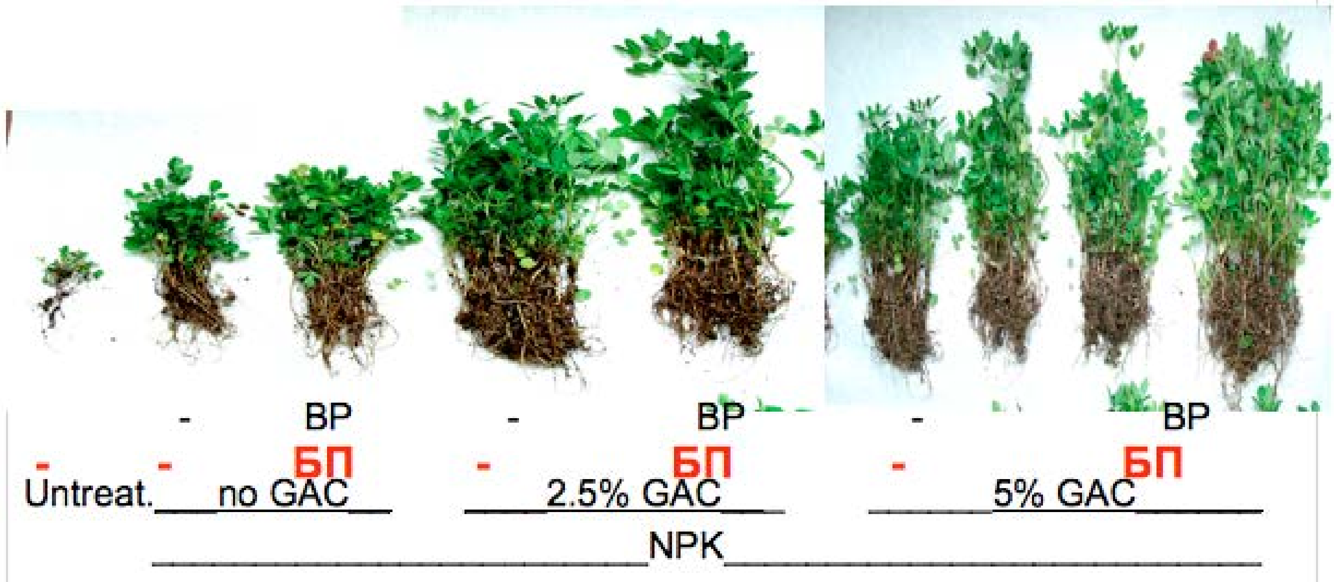

Fig.1. Photo of alfalfa plants grown in soil contaminated with 5%DF after adsorptive bioremediation with the help of biopreparation (BP) as well as GAC (0; 2.5 or 5%), which were introduced separately or in combination compared to untreated control.

The GAC and probably biochar might be the best adsorbents for bioremediation of petroleum-contaminated soils. These adsorbents, especially activated carbon, have high adsorptive capacity to many organic and some inorganic contaminants. Simultaneously many those compounds adsorbed to the GAC are mostly available to microbial degradation. For example, GAC amendment substantially accelerated bioremediation of soils contaminated with chlorinated monoaromatic compounds. That positive effect has been demonstrated for soils historically contaminated with herbicide propanil and its metabolite DCA (2000 mg kg^{-1}), meantime DCA was almost totally available to degrading microorganisms [4].

The adsorbent also accelerated bioremediation of CP-contaminated gray forest soil (initially 5700 mg kg^{-1}), especially when it was introduced in combination with CP-degrading bacteria (DM) (by 40 and 85% respectively), while very low depletion of CP (by 2-5%) was detected as in control soil and in the soil inoculated by DM along. Fig. 2 represents alfalfa plants grown in the CP-contaminated soils treated with DM and GAC (separately or in combination) in comparison with pure soil.

Fig. 2. Photo of alfalfa plants grown in the CP-contaminated soils treated with DM and GAC (separately or in combination) in comparison to the pure soil with the same additives. Unpublished data.

The other approach was suggested for remediation of soils contaminated with ***low degradable and persistent pollutants*** such as TNT and PCB. These soils can be detoxified through the pollutant sequestration in the GAC-amended soils. Mechanisms of that sequestration can be various. In TNT-contaminated soils (up to 2000 mg kg^{-1}), water extractable (readily available) pollutants almost disappeared within 6 h after GAC amendment, while concentration of solvent-extractable (potentially available) TNT decreased by 85% after 4 months incubation. The GAC promoted fast and strong binding of TNT through accelerated microbial reduction of its nitro-groups and catalytic oxidation of the methyl-group. As a result, polymerized and bound TNT products have been formed [4, 5]. Degradation of PCB in historically contaminated soils (1600 and 4200 mg kg^{-1}, primarily tri-, tetra- and penta-chlorinated congeners) were studied in semi-field experiments. Results confirmed PCB persistence; slow reduction of total extractable PCB from unamended control soils was mostly due to biodegradation of tri-chlorinated congeners and formation of a bound fraction of higher chlorinated congeners. The mechanism of PCB sequestration thought to be formation of π–π-bonds between the planar molecules of PCB congeners and graphene-like surface in nanoporous space of GAC. In addition to microbial degradation of less chlorinated congeners, the GAC catalyzed dechlorination of higher chlorinated congeners. The soil amendment with GAC sharply reduced PCB bioavailability without slowing degradation processes. As a result, phytotoxicity of the GAC amended soils reduced sharply but remained high in unamended soils for the duration of a 6-y experiment [6].

These observations indicate the utility of activated carbon and other adsorbents for accelerated remediation of soils contaminated with degradable organic pollutants.

Acknowledgments

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Genesis, geography, soil features and processes in SUITMAs

Genesis of soil physical features of urban soils by traffic load, example Compactosols of construction sites on soil from strong humous loamy sand

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Beside regional ones there are numerous features which are typical for urban soils worldwide. There genesis is due to the everywhere more or less uniform ways to perform constructions. They change particularly the physical properties of soils. Thus beside chemical impacts occur in urban areas also physical impacts on soils. They are at least as common and important as chemical impacts. But investigations about genesis of physical soil properties in urban areas are rare. Particularly physical impacts are from traffic on soils and cut, transport, displacement, deposition and leveling of soils. Primary they occur on areas of building constructions.

Town's extensions happen with development of additional construction areas in gardens within cities and by extension into the fringe of towns. A common feature of urban soils is their increased content of organic matter in old settlement areas and the fringe around towns where garden areas and vegetable farms occur. By the use as vegetable growing areas the soils have not only an increase of organic matter content but also a deep layer of organic matter enrichment which is unusual in natural soils. The question is what will be the genesis by human impact on physical properties of these soils. We will report about the effect of traffic during building construction.

The investigations were carried out on soils from loamy sand to sand at two sites (Bottrop and Herne City) in the northern Ruhr area, Germany which were used as vegetable gardens before. The investigations concern an undisturbed soil profile to a depth of 110 cm at each of the two sites in April. On the soils of each site a skid-steer loader with a contact area pressure of wheels of 43 kPa did drive 20 times. Additional profiles were established underneath the wheel lane to a depth of 50 cm at each site. The trial was repeated in September in Herne. The soil investigation in autumn was restricted to a depth of 30 cm. Location Herne and investigated soil depth were selected for the September trial due to the strong effect observed by driving on soils in spring time. With cups of 250 cm undisturbed soil samples were taken from all 6 profiles for laboratory investigations. At each site and treatments without and with vehicle driving penetration resistance was measured with a penetrologger to a depth of 80 cm.

The soils were in the top soil layer of 30 cm depth strong humous (4-9 % C). Bulk density of top soil was 1.0 to 1.2 g cm^{-3}. Underneath it increased to 1.5 to 1.65 g cm^{-3}. The top soil water content at spring time was at Bottrop 21-29 Vol. % and 30 – 40 Vol. % at Herne. That means the water content was much higher at Herne. The saturated permeability (k_f value) of undisturbed soil layers was extreme high (1 600-81 000 cm d^{-1}). Similar was the air permeability (k_a) in an extreme high the range of 130 000 to 330 000 cm d^{-1}. Soils penetration resistance was for both profiles about 1 MPa in the top soil and increased with depth to 2 (Bottrop) and 3 MPa (Herne), respectively.

The results after driving with the skid-steer loader were the following. The pressure of the used skid-steer loader lowered the surface underneath the wheel by 5.2 cm in Bottrop and 16 cm in Herne under wet weather condition in April. In dry September it was lowered by 3.4 cm in Herne. In the top 30 cm of the soil profiles the bulk density was increased to about 1.30 - 1.40 g cm^{-3} in Bottrop and about 1.40 – 1.60 g cm^{-3} in Herne in April. In September the bulk density increase was about to 1.4 g cm^{-3} in Herne. The soil compression was visible in Bottrop to a depth of 50 cm and in Herne of 60 cm. By compression the water content increased in 0 – 30 cm depth in Bottrop to 22 – 33 Vol. % and in Herne to 31 – 43 Vol. %. The water increase was visible in Herne to a depth of 30 cm and in Herne of 60 cm. In September an increase of water content was only observed in the upper 10 cm. By about only 1 Vol. % the increase was very low. The saturated water permeability and the air permeability were strongly lowered by vehicle driving pressure. In Bottrop it decreased to 60 – 430 cm d^{-1} in 0 – 15 cm depth, underneath to 3000 – 6500 cm d^{-1}. The values for Herne were 1200 – 2000 cm d^{-1} in 0 – 10 cm depth. Below they were 100 – 40 cm d^{-1}. In September the kf values for Herne ranged from 70 – 960 cm d^{-1} for the individual depth segments. The air permeability k_a was 43000-74000 cm d^{-1} in 0-15 cm depth in Bottrop. Underneath it was 110000 – 130000 cm d^{-1}. The air permeability in Herne was 120000 – 150000 cm d^{-1} in 0 – 10 cm depth. Underneath it increased from 33000 – 240000 cm d^{-1}. The September values measured in Herne showed an increase from 2000 to 12000 cm d^{-1} with depth. Penetration resistance increased in 15 cm depth in Bottrop by about 0.5 MPa. Underneath it did not differ much from the soil without vehicle treatment. In Herne the increase was in 0 – 28 cm about 1 MPa and decreased continuously to the depth of 1 m to similar values determined without pressure.

The results show a strong change of physical soil properties by construction machinery. The results showed a strong response of the change of physical soil properties with increasing soil water content. For the investigated humous loamy sand to sand soils they stayed in the range of good quality.

On the other hand the effect of soil compaction by driving vehicles on soils is extreme. Similar, deep soil compaction by deposing soil material in new large multi-store house areas occur in the fast expending cities all over the world. About their properties already reported Chen, Zhang, Sun, Tang, Pan, Jang, Zhao and Burghardt at the 4th SUITMA conference in Nanjing, 2007. Due to their significant properties and dominant occurrence all over the world, it would be important to designate these soils as Compactosols in a separate soil group.

Humus horizons of urban ecosystem soils

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Introduction. Expansion of cities to surrounding areas is inevitably accompanied by partial or complete disturbance of the natural soil cover with subsequent partial restoration of the same. The soil range of every city is rather various: from natural differences that are specific for the given geographical region to anthropogenically transformed and human-"constructed" soils. In most parts of megalopolis territory, the prevailing soils radically differ in their morphological structure and properties from natural soils.

A man cannot create soils in the traditional sense of this word. In urban areas, people must restore the fertile root layer for plants in the areas of disturbed lands, delivering external organic- and-mineral or organic soil materials – the product of a long-term soil formation. For this purpose, one uses generally the humus or peat horizon of natural soils from the adjacent territories. Humus material is mainly applied on an artificially created formation, the so-called "vegetable soil", composed of heterogeneous material.

A fertile organogenic or organic-and-mineral soil layer of natural origin, that is present on the surface, is the reason for including such artificially created profiles into the classification scheme of urban area soils [1]. Such soils are represented by five types of introduced soils: grey humus, dark humus, peat-and-mineral, psammozem, and pellozem soils. Such a variety of introduced humus horizons is due to a number of reasons: inheritance of properties from humus material of natural soils; the techniques that are used to create the root later; permanent enrichment of the material composition as a result of fertilizer mixtures introduction, pollution with urban metabolism products.

The efficiency of the environmental functions performed by soils and soil cover of a megalopolis depends on the humus horizon thickness, the content of organic compounds carbon, and the qualitative composition of humus; the particle size distribution, the formation density; the acid-base reaction of the medium, the degree and type of pollution, the reserves of plant nutrition regime elements.

Objects and methods. For studying the structure, composition and properties of humus horizons, samples were selected from 82 profile pits opened in three functional areas of the city of Saint Petersburg, a typical representative of megalopolises: the recreation, residential and highway ones. The analysis of humus horizon characteristics was conducted using the method described in [2].

Results and discussions. The majority of the studied soils contains anthropogenic inclusions. Most often, the percentage of artifacts in soils does not exceed 5 % both in humus and underlying horizons. A fifth of humus horizon samples is free of anthropogenic inclusions; about a third of them contain only 1 % of artifacts. In 40% of samples, anthropogenic inclusions were 2 to 5 %. Only 3 samples of soil humus horizons contain about 10 % of artifacts.

Underlying layers are characterized by a significant percentage of artifacts. In the tenth part of profiles, the number of artifacts is 10 %, whereas in the fifth parts, 50 % and more. In all other profile pits, the number of anthropogenic inclusion is insignificant. Soils with a high content of artifacts are mainly confined to the residential area and lawns along the roads.

The humus horizon thickness of the studied soils varies within a wide range: 1(2) to 50 cm, rarely more. The most common are soils with a humus horizon thickness of 5–10 cm, and with a formation thickness of 20–30 cm (see Figure. 1).

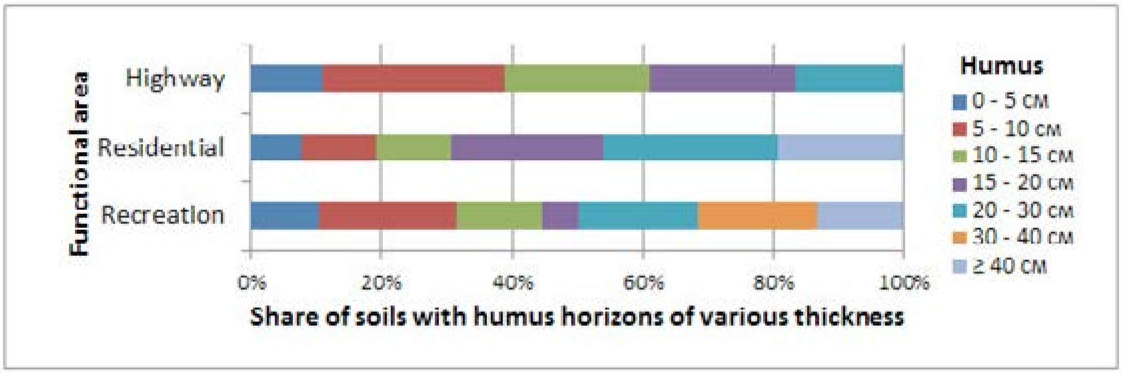

Fig. 1. Distribution of soils with various humus horizon thickness by functional areas

In 45% of all the studied profile pits, the content of organic compounds carbon in humus horizons was within the range of 2–4 %, which, in general, slightly exceeds the value of this parameter in natural soils of the areas adjacent to the city. In 33% profile pits, humus horizons had a high content of carbon, whereas in 6 % of profile pits it exceeded 10 %.

It should be noted that a high content of Corg is observed generally in those soils where, in the course of their morphological description, we detected the presence of coals, coal dust or peat material. There is no clear relationship between the content of organic compounds carbon and a functional urban area.

Between the humus horizons and the underlying layers, we can observe a sharp gradient in terms of carbon content. This indicates the absence of any genetic relationship between the humus horizons and the underlying mineral formation.

It is known that urban soils are characterized by higher values of acid-base reaction, as compared with natural soils of the same area. This is due to a high content of calcium carbonates in anthropogenic underlying formations, and calcium and sodium chlorides that are used as anti-icing agents and that penetrate into the soil.

In 3/4 of samples taken from humus horizons of soils, the values of pHwater are higher than in natural soils. About a fourth of the samples are characterized by a neutral reaction (pHwater 6.5–7.0), about a fourth of them show a slightly acid reaction (pHwater 5.5–6.5). The share of humus horizons with pHwater values over 7.0 corresponds to 75% profile pits. Strongly alkaline reaction is proper to about 1% of samples from humus horizons, whereas 25 % have pH values that are the closest to those of natural soils.

Acid reaction is often characteristic of the soils the upper horizons of which includes peat material. Strongly acid values are common only to soils in the recreation area. In the soils with slightly acid and acid reaction, the percentage of anthropogenic inclusions does not exceed 2–3 % (see Fig. 2).

More than 90% of all humus horizons in the investigated area are characterized by a light particle size composition (59 % belong to sandy soils, and 32%, to sandy loam soils). Generally, underlying layers have also a light particle size composition. The share of loamy and clay soils is about 24 %.

Commonly, urban soils contain a large amount of framework (>1 mm) part, both in humus horizons and in underlying mineral formations. An increase in the content of particles of more than 1 mm is due to the inclusion of construction materials. The framework part composition includes crushed limestone, gravel, brickbats.

52 % of samples from humus horizons includes a small amount of framework part (not exceeding 5 %), 37 %, from 5 to 15 %. Only 11% of samples are characterized by a significant framework content (15–50 %).

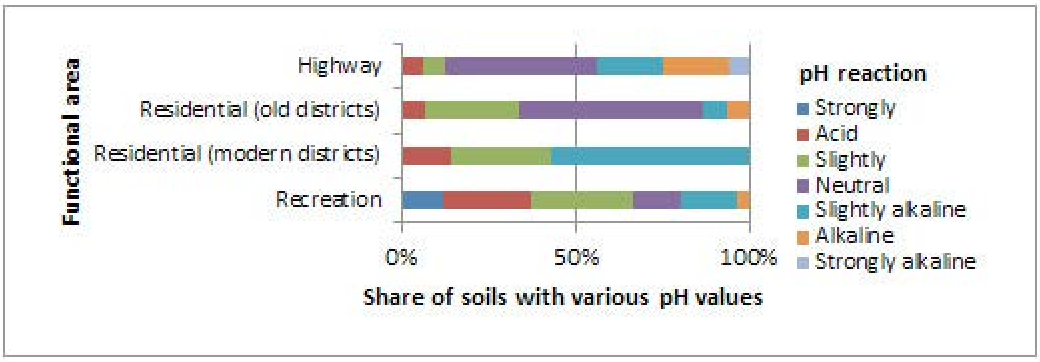

Fig. 2. Distribution of soils with various pH values by functional areas

A large part (44 %) of humus horizons of soils are over-consolidated. In 11% of profile pits, humus horizons feature a low-density structure. The highest share of soils with over-consolidated humus horizons is observed under lawns along highways (63 %).

The efficiency of environmental function performed by urban soils depends on their pollution by heavy metals. 81 % of humus horizons of soils are polluted with mobile forms of at least one heavy metal, the content of which has been studied (Pb, Cd, Zn, Cu, Ni) (see Fig. 3).

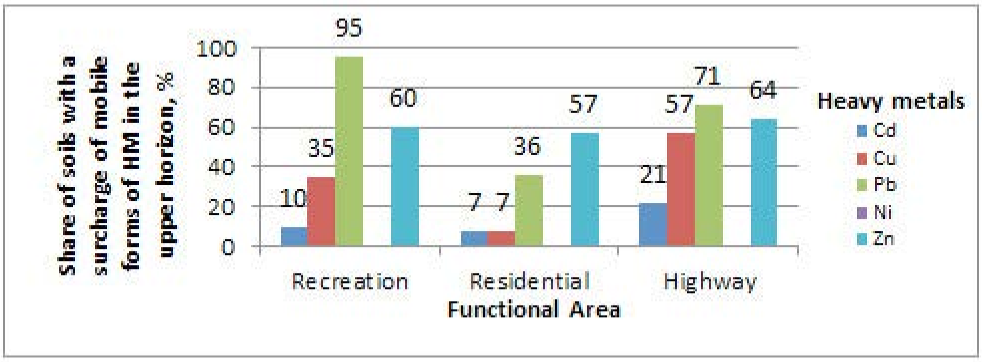

Fig 3. The share of humus horizons of soils in Saint Petersburg, that are polluted with mobile forms of heavy metals in various functional areas

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Soil sealing influence on some microbiological biochemical and physicochemical properties of Ekranic Technosols of Toruń

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Introduction

Soil sealing is one of the main causes of soil degradation in the European Union, together with erosion, decrease in the soil organic matter (SOM) content, compaction, etc. (EC 2006). Soil covering may involve total imperviousness, as caused by solid concrete or asphalt, or soil may be sealed with semi-pervious surface such as cobblestones or concrete paving setts (Nestroy 2006). The sealing of soils prevents the exchange of gases, water, and nutrients between the soil and the atmosphere, which results in a negative effect on their physicochemical properties (Zhao et al. 2012). This, in turn, could negatively influence microbial and biochemical properties causing an irreversible loss of soils' biological functions and loss of biodiversity through landscape fragmentation. Most previous studies have focused on physicochemical properties (e.g. pH, $CaCO_3$, heavy metals, water movement, gas diffusion) as influenced by soil sealing (e.g. Sobocká 2013; Greinert 2013), while its effects on biological components, such as microbial diversity and enzymatic activity, were seldom investigated (Zhao et al. 2012; Wei et al. 2013).

Material and Methods

The aim of the study was to assess the soil properties of Ekranic Technosols and neighboring, reference soils that were not sealed. Generally, 18 soils from different parts of the city of Toruń (NW Poland) were collected and divided into 3 groups according to the degree of soil sealing: (1) soils sealed with semi-pervious concrete paving slabs (A), (2) soils sealed with impervious surfaces, such as asphalt and concrete (B) and (3) non-sealed soils (the control group, C). Soil samples were assayed for (1) physicochemical properties (e.g. organic carbon (C_{ORG}), total nitrogen (N_{TOT}), P available, pH in KCl, (2) the total count of total bacteria (TB), filamentous fungi (FF), ammonifying bacteria (AB) and denitrifying bacteria (DB) and (3) microbial biomass carbon (MBC), nitrogen (MBN) and (3) soil enzymes activity (dehydrogenase, DHA, fluorescein sodium salt hydrolysis, FDAH; urease, UR; nitroreductase, NR). Physicochemical properties were analyzed according to standard methods outlined in Burt (2004). Enzymatic activity were determined spectrophotometrically (Alef and Nannipieri 1995). The total number of bacteria and fungi were carried out using Koch's Plate dilution method. Bacteria isolated on the standard nutrient agar (NA) with soil extract and filamentous fungi on Rose-Bengal agar with streptomycin (Atlas 2010). The selected physiological groups of AB and DB were estimated with the index method, the most probable number (MPN). The numbers of AB and DB were determined with the test tube method.

Results

The data showed the different response of soil properties to artificial sealing in the Ekranic Technosols of Toruń (Table 1 and 2). Significantly higher values of C_{ORG} and N_{TOT} were noted in the reference soils as compared to the sealed soils, whereas there was no differences in these properties between the degree of soil sealing (Table 1). Soil pH_{KCl} as well as the content of P_{AV}, sand and silt did not show any significant differences among studied groups of soils. Water content was the highest in control soils, lower in group of soils B and the lowest in group of soils A. The lowest clay content was noted in the soils under concrete paving slabs (A), while higher and statistically not differentiated in reference soils and in the soils covered with asphalt and concrete (B).

Table 1. Physicochemical properties as affected by the degree of soil sealing

Physicochemical properties	Degree of soil sealing		
	C&	A	B
C_{ORG} (g kg^{-1})	9.22(±6.57*)a	2.95(±1.99)b	3.95(±4.16)b
N_{TOT} (g kg^{-1})	0.65(±0.48)a	0.14(±0.14)b	0.20(±0.19)b
C_{ORG} : N_{TOT}	10.3(±2.08)b	19.6(±7.00)a	17.7(±3.60)a
pH-KCl	7.22(±0.58)a	7.81(±0.81)a	8.00(±0.47)a
P_{AV} (mg kg^{-1})	166(±143)a	126(±61)a	172(±157)a
Water content [%]	5.24(±3.59)a	3.90(±0.86)b	4.26(±1.21)ab
Sand [%]	93.7(±11.4)a	97.9(±3.0)a	96.4(±5.44)a
Silt [%]	2.71(±1.99)a	2.44(±2.07)a	2.00(±2.64)a
Clay [%]	1.10(±2.51)a	0.14(±0.38)b	0.85(±1.57)a

C_{ORG} - organic carbon content; N_{TOT} - total nitrogen content; P_{AV} - available phosphorus content &C - control (non-sealed soils), A - semi-pervious sites, B - impervious sites; *standard deviation; Different letters in the same raw for each property indicate significant effects (Tukey's test; $p<0.05$) of soil sealing degree compared with the non-sealed sites.

The total number of bacteria (TB) and fungi (FF) were the same in both groups of sealed soils and it was over 80% lower in these groups than in the reference soils, while the number of AB and DB did not show any significant differences among studied groups of soils (Table 2). Microbial biomass C (MBC) and N (MBN) content was the highest in control soils and the lowest in the in soils sealed with asphalt and concrete (B), whereas the concrete paving slabs (group A) did not influence their content univocally. The activity of DH and FDAH was statistically higher in soils C and A as compared to the soils B, whereas there was no differences between control soils (C) and soils A. The UR activity was the same in both groups of sealed soils and it was about 60% lower than in the control soils. The highest activity of NR was found in soils sealed with asphalt and concrete (B) as compared to soils sealed with concrete paving slabs (A), while the lack of sealing did not influence the enzyme activity univocally.

Table 2. Microbiological and biochemical properties as affected by the degree of soil sealing

Microbiological and biochemical properties	Degree of soil sealing		
	C&	A	B
TB (10^5 cfu g^{-1} d.m.s.)	40.6(±10.1*)a	9.2(±4.2)b	7.9(±6.6)b
FF (10^3 cfu g^{-1} d.m.s.)	12.9(±10.5)a	2.0(±1.2)b	1.1(±0.97)b
AB(10^4 MPN g^{-1} d.m.s.)	16.5(±17.3)a	7.6(±7.2)a	4.2(±3.4)a
DB (10^4 MPN g^{-1} d.m.s.)	17.6(±19.2)a	1.6(±2.5)a	4.5(±4.8)a
MBC (µg g^{-1})	57.5(±43.6)a	42.4(±24.4)ab	33.3(±10.5)b
MBN (µg g^{-1})	13.8(±10.3)a	9.90(±5.37)ab	7.10(±1.36)b
DH (µg TPF g^{-1} h^{-1})	14.4(±15.7)a	10.5(±15.7)a	3.79(±2.79)b
UR (µg N-NH_4^+ g^{-1} h^{-1})	5.10(±1.66)a	2.21(±0.89)b	1.68(±0.58)b
FDAH (µg F g^{-1} h^{-1})	27.4(±17.4)a	24.7(±25.0) a	16.8(±11.6)b
NR (µg N-NO_2^- g^{-1} 24h^{-1})	2.19(±0.33)ab	1.52(±0.44)b	2.86(±0,69)a

TB, total bacteria; FF, filamentous fungi; AB, ammonifying bacteria; DA, denitrifying *bacteria; MBC,* microbial biomass carbon; MBN, microbial biomass nitrogen; DH, dehydrogenase; UR, urease; FDAH, fluorescein diacetate hydrolysis; NR, nitrate reductase; the abbreviations (C, A, B, a, b, ab) are explained under Table 1; *standard deviation

Conclusions

The study indicated that artificial sealing in urban areas can significantly alter the soil environment by deteriorating some soil properties, while other features remain invariable. Additionally, the results of some properties (even if statistically non-significant) demonstrated that the impervious surfaces, generally more extensive and permanent as compared with semi-pervious surfaces, can result in reduction in soil microbial activity (FF, AB, DB, DH) in urban soils. Thus, semi-impervious surface systems or other materials that allow the exchange of materials and energy between the soil and the atmosphere could reduce the negative effects of soil sealing in urban paved areas.

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Key words: Ekranic Technosols, Enzyme activities, Microbial communities, Physicochemical properties, Soil sealing

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Lead and Zinc status evolution during pedogenesis in a 100 years old Technosol

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Introduction

In the frame of the transposition of the European directive on waste in French law, a national technical committee has been implemented in France since 2009 to set up a methodology of management of excavated lands. The reuse of excavated lands in a lot of city planning and landscaping configurations is designed for long-term uses. Their reuse and deposition on site should lead to the formation of new soils, generally called Technosols (WRB 2006). Although contaminated, these materials present a pedologic interest since they fulfill several functions such as biomass production, storage-filtration and transformation of nutriments, trace elements and water, or formation of ecological niches (Morel et al. 2015). However, the long-term behavior of these materials is difficult to study since the pedological processes exceed the human timescale. Nevertheless, early pedological transformations could sometimes be observed in Technosols (*e.g.,* Séré et al. 2006). The study of these processes needs to focus on "old" Technosols, *i.e.* on materials that have been settled for hundreds of years. The first industrial activities started in Europe in the early 19st century. At this period, the earthworks carried out for factory building led to the backfill of wide areas. These materials are still in place in some old brownfields. Their investigation could highlight several early pedological processes, as well as assessing the status of some pollutants, especially by studying soil profiles where the deeper horizons are considered less evolved than the upper horizons. For this study, a ~2m depth profile was characterized in a 100 years-old Technosol developed on backfills that contain significant concentrations of lead (Pb) and zinc (Zn).

Material and Methods

The study was conducted on a soil profile of the "Union" former industrial site (Tourcoing, France). Historical investigations carried out at the archives of the French railways evidenced that the area of study was not reworked for a century (Coussy et al. 2017). The whole soil profile was sampled as a function of depth (Figure 1). Two types of samples were collected: composite samples for bulk analyses and samples representative of a given depth in the profile for punctual investigations (hereafter denominated "slices"). Composite samples were taken within the following range of depth: 0-10 cm, 30-40 cm, 110-130 cm and 175-185 cm. At each depth range, three replicates were taken on a same horizon. Soil slices were taken at 5 cm, 90 cm and 180 cm deep. The soil structure was preserved (non-destructive sampling using cylinders) and 3 thin sections (30 μm) were elaborated. In laboratory, the soil pH, total organic carbon content, grain size distribution and total elemental concentrations were determined according to standardized methods (Coussy et al. 2017). The release of trace elements was assessed by leaching of the composite samples. The leaching tests were conducted in closed PTFE reactors with continuous stirring during 24h, with a liquid/solid ratio of 10. Pb and Zn status was assessed by bulk analyses such as selective dissolution, and by punctual analyses (scanning electron microscope, electronic microprobe). Selective dissolutions were carried out using both Dithionite-Citrate-Bicarbonate (DCB) and pyrophosphate methods, done in parallel on aliquots. DCB selectively solubilizes pedogenic oxides and hydroxides (Mehra, Jackson 1960). The pyrophosphate method was used to dissolve amorphous complexes and/or very poorly crystalline compounds.

Finally, Zn status investigations were refined by X-ray absorption spectroscopy (XAS) and nuclear microprobe (μ-PIXE and μ-RBS).

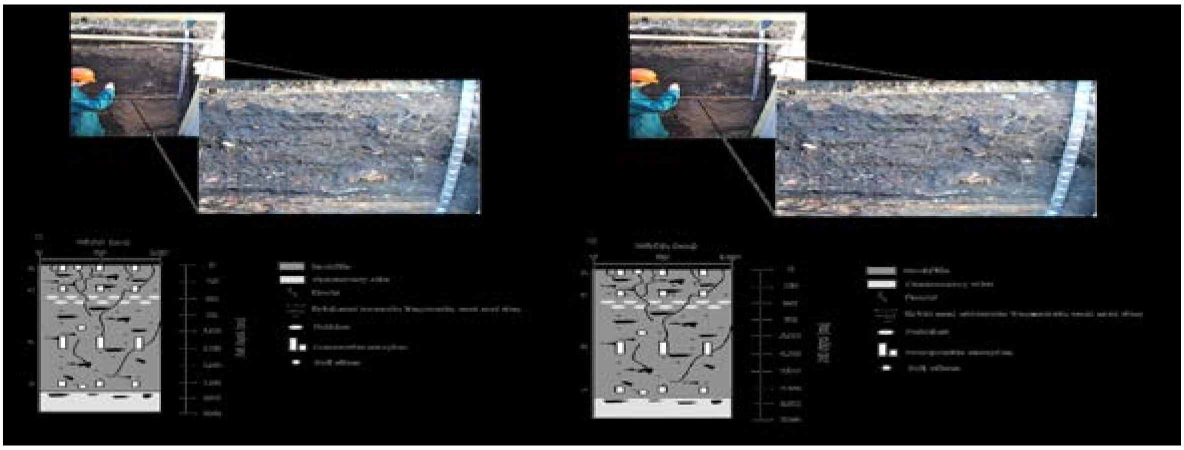

Figure 1. Soil profile. A General overview. B. Details of the central zone of the profile. C. Schematic representation of the soil profile.

Results

A comparison between Pb and Zn behavior after leaching and selective dissolution is shown in Figure 2. Pb and Zn follow the same trends after leaching, indicating that they are very little labile throughout the whole profile (< 0.1 % release). These elements are probably under the form of mineral phases or strongly bound to mineral phases.

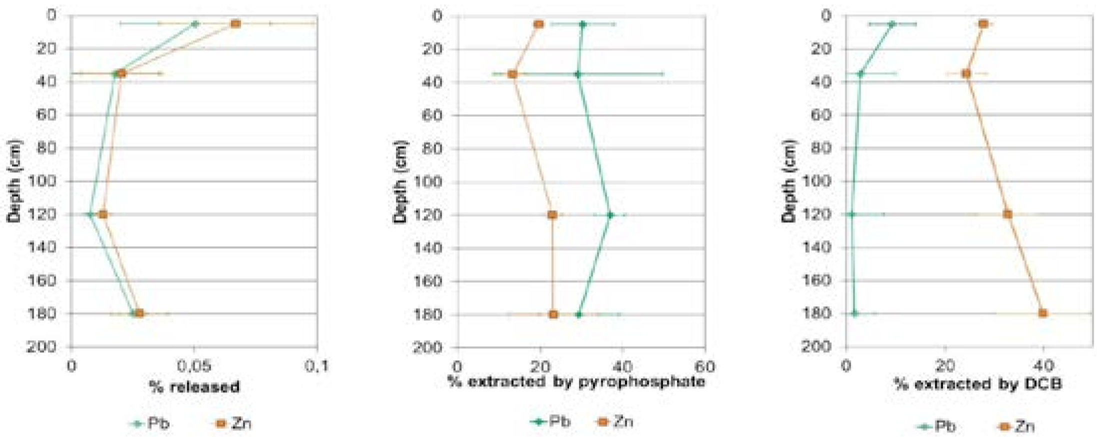

Figure 2. Pb and Zn extracted by leaching, pyrophosphate and DCB, throughout the soil profile (normalized by the total amounts in Pb and Zn of each sample).

Pyrophosphate extractions show that between 20 to 40 % of the total Pb and Zn is bound to organic matter or to slightly crystallized minerals, with no dependence to depth. DCB extractions indicate different trends for Pb and Zn. The Pb associated to Fe (hydr)oxides does not exceed 10% of the total Pb in surface, and this amount decreases along depth. On the contrary, Zn extraction yield (35% on average) is, within uncertainties, constant over the whole profile. However, as Zn concentration in the deepest sampling point is 10 times lower that in the surface horizon, a small quantity of Zn-bearing Fe (hydr)oxides that would have migrated from the upper horizons may have led to such apparent change. Electronic and nuclear microprobe investigations have confirmed that various proportions of Pb and Zn are trapped in Fe (hydr) oxides – mainly identified as ferrihydrite - at the surface of the profile. XAS analyses of the composite samples indicate that Zn coordination is tetrahedral, but in the deeper horizons, Zn is associated to phases having a higher degree of crystallinity than in the surface horizons. The other Pb and Zn minerals identified are sulphides, as well as intermediate phases such as sulphates.

Discussion and conclusion

In the studied Technosol, pedogenesis does not induce a dramatic increase of Pb and Zn solubility since efficient scavengers are concomitantly formed in the system. However, the weathering processes during soil evolution influence Pb and Zn speciation. Primary Zn and Pb bearing minerals have been identified as sulphides. However, these phases have evolved at the surface of this Technosol to form sulphates, not stable in conditions of pH observed here. During this evolution, various proportions of Pb and Zn have been trapped in Fe (hydr)oxides (ferrihydrite) neoformed at the surface of the profile since the initial deposit of the backfills. The input of organic matter at the surface is slightly visible after 100 years of evolution. Technosols are highly heterogenous and widely differ from one place to another because of the variety of their constitutive man-made materials. In this case, 100 years of soil evolution has led to the precipitation of secondary minerals at the surface of the profile. This behavior is similar to pedogenic processes occurring in natural soils, but other specific evolutions due to large thermodynamic disequilibrium can be highlighted, in particular sulphide oxidation and sulphate precipitation.

Acknowledgments

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Influence of technogenic material deposits on the properties of urban Technosols

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Introduction

Anthropogenic soil-forming materials may cause significant changes in the properties of soils in urban areas (Morel et al. 2005; Amossé et al. 2015). The most common anthropogenic materials in urban soils are: building debris, slags, dusts and ashes, translocated rock material, communal wastes, sludges, subgrades and mulches. A number of authors mention consequences of their presence in the soil mass such as changes in the physical, chemical and biological properties of soils in urban areas (Röber et al. 2000; El Khalil et al. 2016), as well as in their functionality (Amossé et al. 2015; Greinert 2015; Morel et al. 2015) and evolution line (Leguédois et al. 2016). They are also key factors for the determination of the systematics of the soils described (IUSS Working Group WRB 2015).

The goal of the paper is to present the properties of anthropogenic materials deposited in the surface soil layers as factors having a direct impact on the properties of soils in urban areas. A theory has been proposed that they play a key role in this matter, regardless of the type of initial soil and its characteristics.

Material & Methods

Zielona Góra is almost 700 years old city in the Polish-German borderland (51°56'23"N, 15°30'18" E). Natural soils of Zielona Góra evolved from different glacial deposits, mainly fluvioglacial sands, but also: marly brown till, gravels and boulders, peat, chalk, gyttja, silt, warp (mud), as well as aeolian sands (Wróbel 1989). In the forests of Zielona Góra and in the immediate surroundings of the city, the presence of Podzols and Brunic Arenosols is a typical phenomenon (Greinert et al. 2013; Greinert 2015). The most soils have a varied content of anthropogenic materials. The soils were examined using soil samples from 104 soil profiles. Their total number was 523. The technogenic materials were collected from anthropogenic deposits covering the soils in 30 sites in Zielona Góra, building their layer from 0-20(40) cm. Their particular kinds were separated in laboratory conditions, mixed up in order to obtain an average, and then analysed using standard methods of soil evaluation. The given content of components is close to the total content. All analyses were carried out three times.

Results

Nearly 800-year history of Zielona Góra has left its mark on the spatial development of the city. This is observed especially in the city center. The altitude of the Old Town is currently ca 1.0-1.5 m higher compared to the ground level of the medieval city, which is caused by accumulation of various technogenic deposits. The undeveloped areas are most frequently covered by Urbic and Ekranic Technosols (Hyperskeletic). New urban zones were established outside the modern, intensive building development. They were located on the least productive soils, which resulted in the removal of all layers from Podzols down to the parent rock. Soils of the new zones are mostly Technic Regosols (Arenic). Soils transformed in different ways are present because of multilateral human impact: Hortic Anthrosols, Technic Regosols, Mollic Technosols, Urbic Technosols and Ekranic Technosols (Greinert et al. 2013).

Table 1. Selected properties of technogenic materials deposited on the soil surface * against the properties of soils of natural genesis, common in the Zielona Góra locality

Material	pH	$EC_{1:2}$	Fe	Cd	Pb	Zn	Cu	Ni
	in H_2O	[$mS \cdot cm^{-1}$]	[$mg \cdot kg^{-1}$]					
neat plaster	11.0	0.6	88	0.2	2.8	26	3.7	6.0
aerated concrete	8.3	0.9	n.d.	0.2	1.7	2.4	1.0	5.0
roof tile	8.1	2.3	306	0.2	n.d.	34	8.3	2.0
clinker brick (factory chimney)	7.8	1.1	3750	0.2	n.d.	41	17	1.3
asbestos-cement roof plank	11.8	4.5	n.d.	0.2	4.6	3.2	5.7	4.3
slag	8.7	9.0	48400	1.0	205	76	33.7	140
ash after biomass combustion	10.2	11.6	18700	4.8	5.8	400	88	43
building sands and gravels	7.4	0.2	2842	0.2	11.4	28.4	8.6	9.0
bed for coniferous plants	4.3	0.2	1160	0.1	6.8	9.1	2.2	1.1
bed for deciduous plants	5.8	0.3	2610	0.1	11.1	10.1	1.2	0.4
compost of green wastes	6.9	0.3	27620	1.1	39.9	258	24.5	6.9
municipal sewage sludge	7.1	0.6	11896	4.1	55.7	313	37.3	12.8
Haplic Podzols	4.4-5.3	0.1	4450	0.1	6.2	23.2	8.0	4.2
Brunic Arenosols	4.1-5.1	0.1	3274	0.2	8.0	18.6	4.1	8.3
Albic Luvisols	5.2-5.6	0.2	2174	0.2	15.2	21.9	6.8	2.3

n.d. – not determined, * Greinert 2015; Hulisz et al. 2016

On the one hand there is a very significant change in the structure of soil profiles but on the other there do not necessarily appear changes in their chemical properties. They largely depend on the presence of other anthropogenic materials with a high reactivity, e.g. neat plaster, asbestos-cement roof plank, slags and ashes. In the general characteristics of urban soils a wider content of the skeleton can be seen, $CaCO_3$, carbon and the pH in comparison to natural soils typical of the area of Zielona Góra (Table 2).

Table 2. Basic properties of 0-100 cm layers of Technosols in the urban area of Zielona Góra ** against the properties of soils of natural genesis, common in the Zielona Góra locality

Soil units	Skeleton (Ø>2 mm)	$CaCO_3$	TC	pH in KCl
	[%]			
Urbic Technosols	7-11	0.0-10	0.4-2.6	6.0-8.3
Ekranic Technosols	0.3-96	0.0-25	<0.1-5.1	4.7-8.6
Regosols Relocatic / Technic subunits of other RSGs	1-19	0.0-3.7	0.2-6.4	5.9-8.2
Haplic Podzols	0.0-4.7	0.0-0.2	0.4-1.0	4.1-4.9
Brunic Arenosols	0.0-2.0	0.0-0.2	0.2-1.3	3.5-4.2
Albic Luvisols	0.0-3.0	0.0-0.2	0.4-2.2	4.9-5.2

n.d. – not determined, ** Greinert et al. 2013; Greinert 2015; Hulisz et al. 2016

Discussion

A characteristic feature of urban regions is the presence of technogenic parent materials of soils made or transformed by man. Technogenic materials are characterized by a high diversity of constituents, a high spatial variability, and a range of temporal discontinuities. Their presence significantly modifies the morphology of soils and their properties. Furthermore, this may be a factor explicitly determining the directions of soil-forming processes and evolution of soils (Greinert 2015, Huot et al. 2015) Materials of technogenic origin, such as construction debris, slag, dust, rock material, lignite, coal, municipal waste and sludge, are currently considered parent materials for Technosols (IUSS Working Group WRB 2015). Admixture of materials found in technogenic soils can be introduced different ways. This induces an effect of heterogeneous soil properties in urban areas (even small ones). Since a significant part of wastes introduced into soils has dimensions of the soil skeleton, they affect the surface soil layers by acting as a drainage medium. Regional and linear introduction of wastes leads to the creation of extensive waste layers, deposited at varying depths. In addition, they change the flow and deposition of soil solution, which results in an unusual variation of the chemical composition of the soils.

Conclusions

The soils of the urban area are geomechanical and chemical transformed, which results in the instability of soil material properties. A disturbing aspect of this phenomenon is high anthropogenic materials content deposited in soils.

Many anthropogenic materials have a high chemical reactivity, which results in a significant change in the properties of urban soils, mainly in terms of pH, the content of $CaCO_3$, carbon, EC, but also in terms of the content of heavy metals.

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The Los Angeles Soil Survey Program; Urban Soil Mapping Concepts and Future Developments.

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Keywords: urban soil mapping, soil survey

The United States Department of Agriculture-National Cooperative Soil Survey program has completed modern soil surveys for several major metropolitan areas including a recently published survey for Los Angeles, California. A soil survey such as the Los Angeles project challenges the principles of soil survey methodology to effectively model current condition of natural and anthropogenic soil properties while maintaining traditional soil mapping standards and devising a valid soil-landscape model that explains soil occurrence. Using urban-oriented mapping unit design, LIDAR derived elevation models, aerial imagery, and on-site soil-landscape observations, the Los Angeles survey describes the spatial relationship between natural and anthropogenic soils as they relate to geomorphic surfaces. The release of this survey data had been highly anticipated for high-demand land use planning projects such as high speed rail, Los Angeles river floodplain restoration, habitat restoration, increasing groundwater recharge, and improving runoff coefficient estimates.

Our presentation will focus on the achievements, limitations, and outcome of using traditional soil survey methods in the urban environment and explain the approach that underlies soil survey mapping conventions. California is home to several densely populated metropolitan areas that clearly need updated and improved soil survey data. Soil surveys for advanced urban soil mapping must include soil descriptions that record soil properties extant in the post development environment and incorporate this data for urban soil interpretation (San Francisco Bay area, San Diego, Orange County, etc.). A brief explanation of future project ideas and goals will be discussed.

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Biodiversity in urban soils: threats and opportunities

Taxonomic structure of microbial communities in the humus horizons of urban soils

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Introduction. Soil is "impregnated with life", according to V.I. Vernadsky, which determines its development and functioning as a holistic bio-inert natural body. The formation of an organic-and-mineral matrix, being an elementary structural unit of soil, is related to the vital activity of microorganisms.

The biochemical activity of microorganisms underlies many of elementary processes occurring in urban soils: decomposition of plant residues, formation of humus substances, destruction of mineral and organic compounds – products of human metabolism.

The aim of the study is the taxonomic structure of microbial communities in the humus horizons of urban soils.

Objects and methods. For studying microbiomes in the city of Saint Petersburg, samples were selected from the humus horizons of two urban soils featuring various degrees of anthropogenic load. Sod-podzolic soil from the park named after I.V. Babushkin has been relatively slightly changed by human activities and has preserved its natural structure (profile pit 5). Introduced grey humus soil (profile pit 4), that has been subjected to strong anthropogenic load, is a typical representative of the megalopolis' soil cover [2]. The profile pit 4 was open on a lawn at the intersection of two highways, 500 m from the park's soil. For comparison of metagenomes of humus horizons of urban soils, we selected samples of sod-podzolic forest soil, that was slightly subjected to anthropogenic impact (profile pit LL). The LL profile pit was open in the Lisino Forestry, at a distance of 40 from the city. This soil was considered as a natural analog of the park's soil.

The analyses of the microbial community (MC) in the humus horizons were conducted using next generation sequencers [1,3].

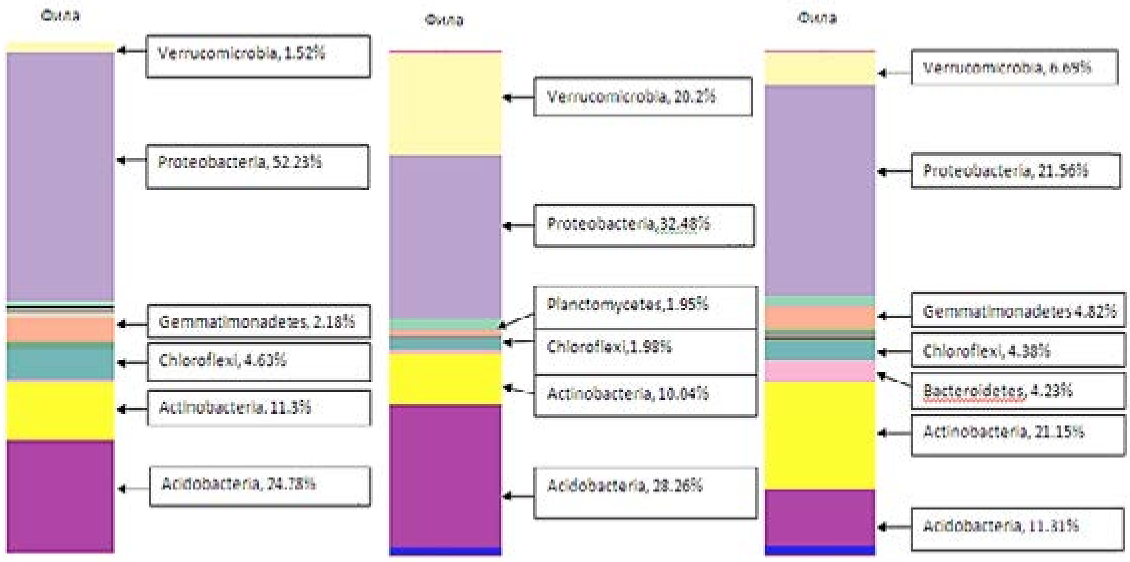
Results and discussions. In terms of the microorganisms' habitat parameters (thermal and water regimes, contents of Ntotal, P_2O_5, K_2O, Corg), humus horizons differ only slightly. The most significant variations were observed in terms of the acid-base reaction parameters (pH) of their habitat. Forest soil has the most acid reaction (pH_{H2O} 3.6), whereas lawn soil was characterized by a neutral reaction (pH_{H2O} 7.0). The park's soil occupied an intermediate position (pH_{H2O} 5.0).

A comparative analysis of the microbial communities' taxonomic structure was carried out at the level of bacterial phyla. We considered the phyla whose share in the microbiome exceeded 1% (see Figure).

The maximum level of biodiversity (the Shannon index) was found in the lawn soil (7.90, profile pit 4), whereas the minimum level was revealed for the forest soil (5.40, profile pit LL). The biodiversity level of the park soil was 6.30 (profile pit 5).

In all samples from humus horizons, we found representatives of five bacterial phyla: Proteobacteria, Actinobacteria, Acidobacteria, Verrucomicrobia, Chloroflexi. The share of the first three MC phyla was 70 to 85 %. Among them, the Proteobacteria prevailed. Its amount varied from 52 % in the forest soil to 42 % in the lawn soil. In the park area, the share of the Proteobacteria phyla decreased to 32.5 %.

The microbiome structure analysis for the series of soil in question revealed a considerable variation of humus horizons both in terms of the bacterial phyla composition and their relative content in different soils, as well as in the terms of position occupied by various representatives of separate phyla in the MC of different soils. In the forest and park soils, the amount of the prevailing phyla (>1%) was equal to 14 units. In the lawn soil, we found 17 phyla.



Phyla LL | Phyla Profile pit 5 | Phyla Profile pit 4

Figure. Taxonomic structure of microbial communities in the humus horizons of urban soils

Differences in the composition of the groups of 6 prevailing phyla in the MC of the forest and park soils were manifested in the substitution of the Gemmatimonadetes (2%) phyla in the forest soil by the Planctomycetes phyla (2%) in the park soil and the Bacteroidetes phyla (4%) in the lawn soil.

Even more significant variations in the microbiome structure were recorded in terms of the ratio of the positions occupied by bacterial phyla in different soils. This concerned primarily the Verrucomicrobia phyla that ranks third in the park soil microbiome and is the most numerous there (20%). The Actinobacteria phyla ranked second in the lawn soil (21%), and third, in the forest soil (11%), whereas in the park soil it ranked fourth (10%). The Acidobacteria phyla, that ranked second in the forest and park soils (24–28%), moved to the third position in the lawn soil (11%). Evidently, the deciding factor in this was the soil alkalization (profile pit 4).

Thus, the taxonomic structure of microbial communities in the humus horizons of soils reflects, at the phyla level, both the genetic specifics of the soils and the anthropogenic factor impact, firstly, the soil alkalization. Probably, an important role is played by various metabolism products that penetrate in the urban soil. The peculiarities of the urban soil microbiome may be used as a sensitive universal indicator of their state.

The analysis of the urban soil microbial community using the pyrosequencing methods provides new opportunities for studying the role of microbial communities in performing their environmental function.

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Biodiversity reserve as an ecosystem service provided by urban soils

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The irregular past and present human activities that alter soils in Urban Areas may induce unusual physical and chemical soil properties because of presence of natural and anthropogenic materials (e.g., bricks, asphalt, sand, pavements, and demolition wastes) (Morel et al., 2015). Urban Soils may indeed have an extremely heterogeneous surface relief (microtopography) that induces a mosaic of microhabitats with different features evolving with time: patches of bare soils, litter or plant cover, big mounts of different contaminated or uncontaminated materials that could be poor or rich of nutrients, acidic or alkaline. In this way, Urban Sites might provide a high level of biodiversity service because they offer a wide variety of habitats.

From an ecological perspective, Urban Soils are of high importance due to the large extent of areas being affected and they can serve as suitable model for integrated ecological studies of communities' assemblage theory across time or soil animals' adaptation to special abiotic features. Human-disturbed sites might be increasingly appreciated as potential refuges for species that are becoming rare in the surrounding exploited landscapes. However because of the complexity of soil biodiversity itself and the low number of below-ground organisms' investigations, (i) the study of Urban Sites as soil biodiversity refuges and (ii) the knowledge of the influence of predominant ecological factors on the colonization success of soil organisms, are still lacking.

With an increasing awareness that soil biota regulate major ecosystem processes such as nutrient cycling or soil structure, soil invertebrates have a role in the process of origin and first development of soils. The inclusion of soil biota as an actor of ecosystem services provision has to be considered in ecological investigations of Urban Sites.

In this context, the aim of our communication is to present results of a taxonomic and functional approach of invertebrates biodiversity sampled in different open and closed French Urban Sites, studied at a local scale.

We characterized the soil biodiversity in spring 2016 in 9 forest sites dominated by birch (*Betula pendula)* in North eastern of France with pitfall traps method (traps for 7 days) to sample the active invertebrates at soil surface (12 replicates by site, one sampling date). The studied Urban Sites were developed on 3 different spoil heap sites, two derelict queries (gravel and sand), three sludge ponds; one unpolluted forest was also studied at the same time for direct comparison. A Multiple Response Permutation Procedure (MRPP; 1000 randomizations) applied to the nine sites showed that community dissimilarity was highly significant ($p = 0.001$). Moreover, a correspondence analysis ordination showed that dominant soil invertebrate taxa are depending on the type of Urban soil. For instance, the activity of Symphypleona springtails is higher in the control site than the Urban ones dominated by Entomobryomorpha or Poduromorpha collembola. Ants are dominant in one spoil heap site that is especially poor in litter at the soil surface. The two queries and a sludge pond site have a dominance of oribatids, woodlice, detritivores coleoptera larvae and adults, some earwigs and slugs that are all detritivores. Furthermore, the difference of community structure is linked to habitat characteristic of each site, the litter quality and physico-chemical soil parameters.

Another study was carried out in the same region in spring 2015 but in 5 open areas with hand sorting in soil blocs and soil cores sampling for MacFadyen apparatus extraction (5 replicates by site, one sampling date): one meadow developed on a soil experimentally constructed 8 years before our study, an inert waste storage facility, two past coke factory sites and one open sludge pond. A difference of soil invertebrates' community structure was also found. The macro invertebrates are dominant in the constructed soil while collembola density correlated with soil calcium concentration was the highest in the sludge pond site.

Macro invertebrates density was the lowest in the two past coke factory soils comparing with the others studied Urban Sites.

These results showed that derelict Urban Sites are biodiversity reserves. In a context of an increasing awareness of soil biodiversity decline as ecosystems and World threat (Orgiazzi et al., 2016), the human pressure on biodiversity in the case of Urban Sites reclamation or in city plan has to be seriously investigated. Today, a major question to answer is which services, Urban Sites have to provide and how man can help the biodiversity provide services through its conservation.

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Enzymatic Activity of Soils in Urban Landscapes and Adjacent Agrogenic Areas of South of Russia

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Enzymatic activity is a specific diagnostic parameter indicating the negative changes at the initial stages of anthropogenic impact on soils. Nevertheless, the effect of urbanization on this parameter is insufficiently understood; therefore, the study of enzymatic activity in soils of technogenic landscapes, especially of urban areas, is of primary importance (Gorbov et al., 2014).

The aim of the study which has been performing at the Southern Federal University since more than 20 years is to investigate thoroughly the specific features of soil cover in the cities of Rostov-on-Don, Aksai, and Bataisk, which are the nucleus of the Rostov agglomeration. The native soils of these areas are Calcic Chernozems (migration-segregation Chernozems according Shishov et al., 2004), which are characterized by a high accumulation of organic carbon and high microbial activity. However, the transformation and migration of soil organic matter associated with its enzymatic transformation developed over centuries undergo significant changes under the influence of anthropogenic factors (Gorbov et al., 2014). Therefore, special attention was given at the current stage of study to the biological activity of natural and anthropogenically modified soils in the park-recreation, residential, and industrial zones of cities and adjacent agrogenic areas. Within the framework of joint research with the University of Ruhr (Bochum, Germany), the enzymatic activity of urban soils and its changes along the soil profile were studied thoroughly.

Soil samples were taken from the soil profile in 0-200 cm depth from the most common soil types of urban landscapes in southern Russia: urbostratozems on buried chernozem (Urbic Technosols Molic (WRB, 2014)); shielded urbostratozem varieties (Ekranic Technosols (WRB, 2014)), replantozems (Urbic Technosols (WRB, 2014)), urbistratified chernozems (Calcic Chernozems Novic Technic (WRB, 2014)), chernozems under woody vegetation (urban parks and protective belt of the city), and chernozems of fallow and virgin areas (Calcic Chernozem (WRB, 2014)). The activity of extracellular enzymes responsible for the C, N, P, and S transformation cycles in soil organic matter (Sinsabaugh et al., 2005) was estimated. Furthermore, activity of two ligninolytic enzymes - phenol oxidase (PO) and peroxidase (PE), and activity of catalase were measured.

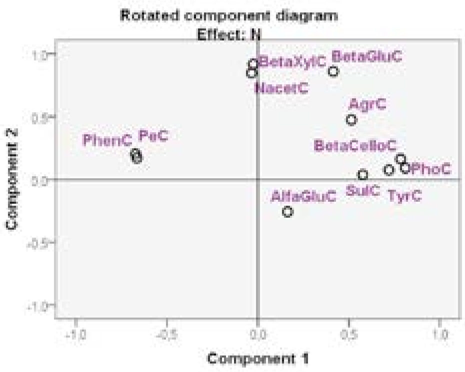
The obtained results showed that under urban conditions, most urbostratozems (both sealed and unsealed ones) were characterized by a low activity of α-glucosidase and a very low activity of ß-glucosidase and N-acetyl-ß-D-glucosaminidase; catalase and polyphenol oxidase behave analogously. The activities of catalase, peroxidase, and polyphenol oxidase in natural urban soils showed the maximum in the upper biogenic soil horizons and decrease with the depth, what could be related to the reduced pool of organic matter and the smaller amount of animals, microorganisms, and plant roots in the illuvial horizons of chernozems. Inversion of enzymatic activity was frequently observed in anthropogenically modified soils, e.g., in buried humus-accumulative horizons of urbostratozems, where the enzymatic activity is higher than in the overlying urbic horizons. In chernozems under woodland vegetation and in urbostratozems, differences in enzymatic activity throughout the profile were clearly manifested. An increase in enzymatic activity is observed in the soddy and humus-accumulative horizons of chernozems under woodland vegetation, as well as its decrease in the middle and lower parts of the profile, while no analogous tendency is revealed in anthropogenically modified soils (Anisimova et al, 2015). The time of sealing significantly affected the enzymatic activity: the longer the time of sealing, the stronger the inhibition of enzymatic activity. The enzymatic activity in the sealed soils has decreased in 1.4 times for catalase and 1.9 times for polyphenol oxidase to compare with unsealed analogue urban soil. The activity of extracellular enzymes in Technosol decreases in 6–8 times.

To understand the role of enzymes involving in the processes of soil organic matter transformation, the conventional coefficient of humification (Khum) was calculated as the PO/PE ratio; Khum > 1 indicates the dominance of humus synthesis; Khum < 1 indicates the dominance of humus destruction (Voznyakovskaya et al., 1990). The obtained results allow suggesting that the PO/PE ratio varies along the profiles of chernozems in forest belts and forest parks and anthropogenically modified soils. The highest variation of oxidase activity was observed in soils of forest belts and forest parks. It is noteworthy that higher parameter values were obtained in the soils affected by intensive anthropogenic impact: the PO/PE ratio varies from 0.94 to 1.31. This effect can be possibly explained by the involvement of these enzymes in the detoxification of pollutants.

Study of soils from different groups revealed that the activity of hydrolytic enzymes in Calcic Chernozem and Calcic Chernozem Novic Technic are almost identical. The highest activity of all nine enzymes was observed in the upper horizons. The highest activity is observed for enzymes responsible for the nitrogen cycle (Arginine Aminopeptidase) and the phosphorus cycle (Acid Phosphatase).The enzyme activity decreases with depth in all investigated soils.

Principal component analysis was performed to reveal the activity distribution features of oxidative and hydrolytic enzymes depending on the profile structure (natural or anthropogenically modified) and the depth.

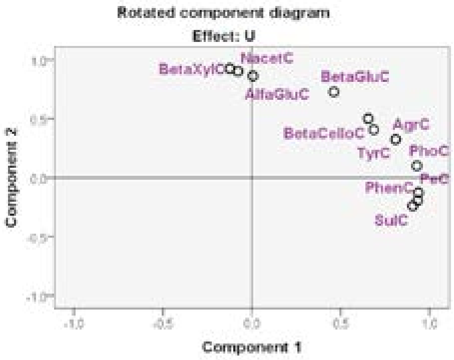
The analysis results showed that the activity of oxidases in native soil profiles was inversely correlated with the activity of hydrolases; oxidative and hydrolytic enzymes are clearly divided into two groups (Fig. 1). Enzymatic activity calculated per unit organic matter was used for principal component analysis.



Native horizons(N)	PC1	PC2
PhoC	0.81	0.09
BetaCelloC	0.78	0.16
TyrC	0.72	0.08
PhenC	**-0.67**	0.20
PeC	**-0.67**	0.17
SulC	0.58	0.04
AgrC	0.51	0.47
BetaXylC	-0.03	0.92
BetaGluC	0.41	0.86
NacetC	-0.04	0.85
AlfaGluC	0.16	-0.26
Explained variance %	**31.65**	**24.57**

Fig. 1. Factor loading (varimax normalized) of two principal components (PCs) for hydrolase and oxidase activities (normalized to SOC) in native horizons: α-glucosidase (AlfaGlu), β-glucosidase (BetaGlu), 1,4-β-cellobiosidase (BetaCello), β-xylosidase (BetaXyl), N-acetyl-β-D-glucosaminidase (Nacet), arginine aminopeptidase (Agr), tyrosine aminopeptidase (Tyr), phosphatase (Pho), sulfatase (Sul), phenol oxidase (Phen), and peroxidase (Pe).

Analysis of two components for urbic horizons has showed a positive correlation of oxidases with hydrolases with a high correlation coefficient (0.94) (Fig. 2). This implies that no clear trend in the distribution of oxidative and hydrolytic enzymes can be revealed along the profile of anthropogenically modified soils, while such correlation can be frequently, although nor always, observed in natural soils: the activity of hydrolases decreases and the activity of oxidases increases with depth.



Urbic horizons (U)	PC1	PC2
PeC	**0.94**	-0.13
PhenC	**0.93**	-0.19
PhoC	0.93	0.10
SulC	0.91	-0.24
AgrC	0.81	0.32
TyrC	0.69	0.41
BetaCelloC	0.65	0.50
BetaXylC	-0.12	0.93
NacetC	-0.08	0.90
AlfaGluC	0.01	0.86
BetaGluC	0.46	0.73
Explained variance %	**47.54**	**32.63**

Fig.2. Factor loading (varimax normalized) of two principal components (PC) for hydrolase and oxidase activities (normalized to SOC) in urbic horizons.

In conclusion, it should be noted that the activity of enzymes is important information reflecting the specifics of the processes of organic matter transformation in soils of urban territories. The enzymatic activity and its change along the profile of chernozemic soils in urbanogenic landscapes affected by anthropogenic impact and differed from activity observed in native analogues.

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Urban and industrial land uses have a higher soil biological quality than expected from physicochemical quality

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Soil quality is defined as the ability of the soil to fulfil functions and provide ecosystem services (Morel et al., 2014). If soil physicochemical parameters are generally considered major aspects of soil quality, soil invertebrates are gaining more and more consideration as soil quality bioindicators. Soil invertebrates and more specifically microarthropods, including Collembola and Acari, are often considered as relevant bioindicators of human activities including agriculture, contamination or urbanisation (e.g. Cortet et al., 1999; Zhu and Zhu, 2015). The modifications of soil characteristics and biodiversity are dependent on humans' land use. However, to our present knowledge, no study has investigated the influence of land use on soil biodiversity across a large range of different land uses. Most studies are focused on forests and agricultural systems (e.g. Ponge et al., 2013) and aren't concerned with urban and industrial soils. A previous work based on chemical properties in France (Joimel et al., 2016) has demonstrated a gradient of soil anthropisation from forest, grassland, arable land, orchards and vineyards, urban vegetable gardens to urban, industrial, traffic, mining and military areas (SUITMA) with an increase in Cd, Cu, Pb and Zn contamination, in pH and available P.

Our objective was to investigate the characteristics of microarthropod communities across various land uses, including urban and industrial land uses, in order to (i) evaluate the effect of land use on biodiversity, (ii) define biodiversity baseline values for each land use and (iii) to determine whether bio-indicators of soil quality follow those based on physicochemical characteristics. The resulting implications for the development of biological soil quality indicators and for the management of French soils according to land use are discussed.

The proposed land use refers to the following types: forest, grassland, arable land, vineyard, urban vegetable garden, SUITMA (urban, industrial, traffic, mining and military areas). A dataset of 3096 replicates from 758 sites, was built by gathering data from different research programmes carried out with different sampling strategies, but always with the same sampling method. To assess soil quality, microarthropod community indices at local scale (specific richness, abundances, Pielou index, ecomorphologic groups), regional scale (beta-diversity), and soil biological quality index were calculated. As the sites are distributed around France according to four major climates (Oceanic and degraded Oceanic, Continental and Mediterranean), the climatic area was considered a random effect. Generalized linear mixed models (GLMM) were used for the comparison of indices between land uses.

A total of 143 species of Collembola were identified. Significant differences in all indices were observed. For collembolan species for example, the number of species decrease along the land use gradient from urban vegetable garden and forest (21.7 and 8.6 species respectively per community) down to vineyard topsoil (3.2 species per community). SUITMA and grassland exhibited intermediate values (4.6 and 7.1 species per community) between grassland and arable land topsoil.

Contrary to the hypothesis derived from physico-chemical indicators, urban soils (SUITMAs and urban vegetable gardens) do not have the lowest soil biological quality. Arable and vineyard cultivation practices clearly appear to be the most harmful land use for microarthropod biodiversity. A better knowledge of topsoil biological quality, as well as its dependence on current land use, should therefore help in the management and preservation of soil biodiversity in urban and in agricultural land uses, thereby increasing ecosystem services to these anthropised ecosystems. For this purpose, the Collembolan Ecomorphological Index and the Acari/Collembola ratio could be selected as indicators.

Our study illustrates the value of aggregated databases concerning soil biological characteristics, even with distinct distribution approaches, in furthering our knowledge about soil quality.

Acknowledgements

This work would not have been possible without the many people, landowners, farmers, gardeners, students and technicians involved in the thirteen research programmes (ACTA, PNETOX, ECOGEN, A. Renaud phD, RMQS – Biodiv, GISFI- open field Lysimeters, Pompey, ANDRA, BIOTECHNOSOL, Bioindicateur 2, JASSUR, Banyuls, Bois de Païolive). The authors extend special thanks to the technical staff of the LSE and especially Alain Rakoto.

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The contribution of soil invertebrates to ecosystem services in urban parks of Lisbon (Portugal)

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Keywords
functional feeding groups, green spaces management, soil ecosystem services, soil invertebrates, urban parks

Background
More than half of world's population lives in urban areas and the increasing urbanization is having significant impacts on ecosystems. Urban soils are strongly influenced by anthropogenic activities, affecting vital key functions at the ecosystem level [1]. The contribution of soil organisms in the provision of multiple ecosystem services (e.g. decomposition, nutrient and matter cycling, and primary productivity) is considered extremely important [2, 3]. However, soil biota ecology is poorly understood in urban spaces, with few studies focusing in urban parks [e.g. 4, 5, 6]. To evaluate soil invertebrates' potential contribution to ecosystem services, and understand their response to environmental changes and management a classification based on functional groups is considered more accurate than only the taxonomic traditionally used [7, 8]. Furthermore, the use of an ecosystem services approach is considered an influential framework for integrating science and policy decisions [9].

Objectives
This study aims to compare soil invertebrate communities in urban parks of Lisbon (Portugal), to understand the importance of these organisms as promoters of ecosystem services in cities, and to provide tools for a better planning and management of green spaces.

Study Area
Lisbon (Portugal), mainland Europe's westernmost capital city, is situated along the Atlantic coast and on the right bank of the Tagus River. The climate is Mediterranean, with dry summers and mild-moist winters. Its urban area covers 958 km^2 (the eleventh largest in the European Union) with about 268.5000 inhabitants [10], and holds "Monsanto Forest Park", a municipal protected forest, with nearly 10 km^2, the largest green patch in the city and one of the largest in Europe.

Materials and Methods
Twelve public parks (four per category) were selected considering their age (more than 50 years old) and location in the city: embedded in the urban matrix, close to another green space, and within the "Monsanto Forest Park". Soil sampling points in each park were distributed in all vegetation types (arboreal, flower bed, herbaceous) and dominant tree species in arboreal assemblages (*Cupressus* spp., *Fraxinus* spp., *Olea* spp., *Pinus* spp., *Quercus* spp., mixed stand), and its number proportional to the respective cover percentage. A total of 112 soil cores were taken, between April and July of 2016. The soil was collected and kept refrigerated until analysis. Samples were hand-sorted and invertebrates (≥ 1 mm length) removed, measured and preserved in 80% ethanol. Specimens were identified to family level and results expressed in density (ind m^{-2}). The taxonomic groups were further classified into functional groups, based on behavioral mechanisms of food acquisition (feeding groups).

Results

A total of 5706 specimens were found, representing four different phyla (Annelida, Arthropoda, Mollusca, Nematoda), and with the five major classes being Gastropoda (72.5%), Insecta (10%), Clitellata (4.8%), Entognatha (3.6%), and Arachnida (3.1%). Soil invertebrate densities varied between vegetation types and arboreal assemblages, being higher in flower beds and mixed stands. Two parks embedded in the urban matrix were amongst the ones with the highest invertebrate densities, while two within "Monsanto Forest Park" had the lowest values. Among the six identified functional feeding groups, saprophagous invertebrates had the highest taxa richness and represented 80% of soil invertebrates (Appendix).

Conclusions

The results reveal that urban parks of Lisbon, independently of their location in the urban matrix, are valuable habitats for soil invertebrates. The analyses of the functional groups suggest that belowground organisms (e.g. saprophagous) contribute to ecosystem services (e.g. nutrient cycling), providing a healthier environment for the public attending the parks. Other variables such as management practices (e.g. irrigation, fertilization, mowing) and soil parameters (e.g. pH, moisture, texture, contaminants) should be considered in future analyses. This study gives new insights on urban soil ecology and provides tools that can help improve soils management and urban parks planning.

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Appendix

Percentage of total density (individuals m^{-2}) (+ SE) of soil invertebrates functional feeding groups on the three vegetation types. The top panel shows values proportional to 100% and the bottom panel allows comparison between the smaller values.

Biodiversity in urban soils: threats and opportunities (on the example of cultivated microorganisms)

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Urban soils have the specific biological properties in comparison with biological properties of natural soils of the same zonal area. This phenomenon is determined by the special conditions of the genesis of urban soils and ecological conditions of urbanized areas. The important factors for the formation the biota of urban soils is the presence in the urban environments of various types of pollutions (caused by building, industry, transport, household waste), special temperature and water regimes, artificial plant cover, type of urban management, etc. Many studies now have been held using molecular techniques which greatly extend our knowledge on the composition of the soil mycobiota. Simultaneously, still remains many tasks which can be solely solved by cultivation, which remains a useful tool for initial characterization of microbial communities' ecology.

At the Department of Biology, Faculty of Soil Science, Lomonosov Moscow State University the long-term studies (since 1996 year) of microbial communities in urban soils are conducted. The goal of investigation is to determine the structure and diversity of different ecological and trophic groups of saprotrophic cultivated microorganisms (microscopic fungi, yeasts, bacteria) in different types of urban soils in field and in laboratory experiments. The main part of the investigation was held in a number of districts of megapolis - Moscow city, with the urban soils of different genesis, age, usage and ecological conditions (plant cover, types of pollutions, etc.). Some studies were carried out in small towns (Pushino, Serpukhov).

The isolation of cultivated microorganisms was performed on the number of solid media: for microfungi on the CzA, MEA, SA, PDA, for yeast on the GPYA, for bacteria on the diluted glucose peptone yeast agar by dilution plate method. Isolation of fungi from different ecological and trophic groups was performed also by bite techniques on cellulose paper (cellulolytic fungi), human hairs (keratinolytic fungi) and linden litter. The species composition of the fungal and yeast assemblages was determined based on the cultural and morphological characteristics using the relevant identification guides and DNA barcoding. The estimation of microfungi and yeasts as potentially pathogenic was performed according to special recommendation of species hazardous to humans (Hoog de et al. 2007). The genera of saprotrophic bacteria was performed using morphological, cultural and phenotypic characteristics. The microbial biomass content was determined by means of fluorescence staining (acridin orange, Calcofluor white, FDA, Ethidium bromide), the ergosterol content, CO_2 emission.

It has been defined that the microbial communities of urban soils differ from those in natural soils in the same zonal conditions by the structure of microbial biomass, by taxonomic structure of saprotrophic microorganisms, by dominating species, by the increasing share of potentially pathogenic fungi, yeast and bacteria. Fungi are recognized as one of the most important groups of soil saprotrophic microorganisms, because of their leading role in decomposition of wide range of organic substances and high biomass content. It has been demonstrated by us that urban soils contain fungi primarily as a pool of spores. The mycelium content is considerably higher in soils of urban forests and parks (Terric Technic Retisols, Albic Retisols), but less in the soils of residential areas (Urbic Technosols). The mycelial biomass varies depending on the seasons and may considerably grow up in urban soils as a result of application of remediation mixtures, wood chips, etc. Maximum content of viable fungal biomass has been revealed in summer in terms of fungal CO_2 emission, as well as FDA hydrolysis. However, it was shown by the ergosterol extraction that the share of viable mycelium could be high also in winter and could be comparable to that in summer or exceed it.

The presence of small (filterable form) bacteria (<0,2 mkm) in the bacterial communities composition could be an indicator of their state . Electronic microscopy demonstrated that these bacteria are present in dormant form. The content of that bacteria are generally higher in urban than in natural soils.

The distribution of microorganisms in urban soils is usually more mosaic than in natural soils.

It is known, that pigmentation of organisms possesses the protective function concerning impact of some negative factors of the environment. It was defined that the share of the saprothrophic pigmented microorganisms in the urban soil could increase. The number of dark-colored melanin containing microfungi could increase in urban soils, exactly at the road-side zone. The third part of yeast species from urban soils has red-colored pigmentation, the most frequent are *Cystofilobasidium capitatum*, *Cyst. macerans* and *Rhodotorula mucilaginosa.* The tendency of increasing the pigmented forms was noted also for bacteria.

Taxonomic diversity of cultivated microorganisms in urban soils also has its peculiar features, which depend from the soils properties. The lowest species diversity of cultivated microfungi has been noted in the long-term used urban soils and in the artificially composed urban soils, e.g., soil-like technogenic superficial formations. Compared to zonal soils, the mycobiota of urban soils is characterized by elevated levels of eurytopic microfungal species. Basidiomycetous yeast group is the most dominant in urban soil under the lawn vegetation in the city of Moscow. Except red-colored yeasts, this group contains wide spread species from genera *Filobasidium, Naganishia, Papiliotrema*, and some psychrophilic yeasts. Typical boreal soil yeast of genera *Solicoccozyma* and species *Saitozyma podzolica* are rarely isolated from urban soils.

Different types of pollutions are an important factor for the formation of microbial communities in urban soils. For bacterial complexes it is manifested by the redistribution of taxa and increasing the abundance of bacteria adapted to certain types of pollution: namely, pigmented *Rhodococcus* to petroleum products, polychlorophenyls; *Arhrobacter*, *Bacillus* to heavy metals; Enterobacteriaceae to house hold pollutions.

The prolonged soil (Urban Technosols) contamination with heavy metals and petroleum products did not significantly decrease the total number of bacteria, but somewhat reduced content of viable bacteria cells (to 55-60%) compared to the undisturbed natural soils (65-70%). The share of the small filterable forms of bacteria was 3-10 times more in urban soils polluted with heavy metals and oil petroleum.

At the same time the microbial communities of urban soil could be more resistant to some stress factors than natural soil microbial communities. For example, the elevated soil temperatures affect assemblages of cultivated microfungi, changing their composition, diversity and microfungal communities compositions during the successions in laboratory experiments. The most pronounced effect of elevated temperatures (30 °C) on fungal diversity was revealed in the natural boreal soil (Umbric Albeluvisol) and the least pronounced in Urbic Technosol. A less pronounced response of microfungal assemblages to some stress factors in the urban soil in comparison with the natural soils may be due to the rather high species diversity as the result of the pronounced heterogeneity of their physicochemical properties and due to numerous sources of fungal spores input.

It is known that in outdoor urban environment temperature is several degrees higher as compared to typical zonal temperatures. Thus, urban soil may include microbial species capable to growth at elevated temperatures. According to our data the share of microfungal species which are typical for areas situated southward, is increased in urban soils. There are some areas in the cities where the raise of soil temperatures could be expressed most strongly. Among of other anthropogenic factors, the influence of the elevated temperature on soil yeasts has not been studied previously. Our results has demonstrated that the temperature increase (for 5ºC) in urban soils located near the outdoor hot-water pipeline results in yeast abundance and species diversity. The number of yeast cells in soils under hot-water pipeline in winter season was 10 times higher and the taxonomic structure of yeast communities was more diverse (2.5 times) than in urban soils located at a distance. Thus, soils under warming impact are a favorable habitat for the soil yeast, and this anthropogenic factor leads also to increase of the mosaic of the microbial populations in urban soil.

The type of urban management is of great importance for the urban microbiota formation. Structural alterations in the organic compounds introduced into urban soils brought the greater incidence of keratinolylic fungi and lower occurrence of cellulolytic fungi. Regular removal of leaf litter in autumn and introduction of remediation mixtures are leading to significant changes in microfungal species composition of urban soils, as well as affect rates and stage peculiarities of successions of cellulolytic fungi.

Some microbial species in urban soil are recognized as dangerous for human health. The increasing of this potentially pathogenic (opportunistic) species in urban soils was recorded in the all groups of examined cultivated microorganisms. The accumulation in urban contaminated soil of the potentially pathogenic (many genera and species of the family Enterobacteriaceae), and allergenic bacteria (some species of the genus *Rhodococcus* and of *Micrococcus*) may constitute a threat to humans. The pathogenic and opportunistic yeast of species *Candida albicans, C. glabrata*, and *C. parapsilosis* were extracted from urban soils near garbage dumps. The most long-term investigations are carried out for the analysis of the presence of opportunistic microfungi in urban soils. Summarizing the results, we have observed the negative effect of the accumulation of potentially pathogenic species among all trophic groups of microfungi. The most frequent potentially pathogenic fungi registered in boreal urban soils of European part of Russia are: *Aspergillus fumigatus, A.flavus, A.niger, Fusarium oxysporum, Scedosporium aurantiacum*. Our results has demonstrated that the temperature increase (for 5ºC) in urban soils As it has been shown in our preliminary investigations, the botanical gardens could serve as the refugiums of natural groups of soil microorganisms in the urban areas.

As a consequence, urban soil mycobiota develops specific features affecting the character of functioning of the soil organic complex, decomposition of organic substances, development of vegetation and thus contributing to the formation of the ecological image of urban ecosystems.

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Factors driving soil Collembola and earthworms in Mediterranean urban parks: feedbacks from Montpellier and Naples

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Within the cities, soil biodiversity is preserved in few sites, still unsealed by cement or paved roads, like urban parks, family gardens, or urban agricultural areas. These areas provide crucial ecosystem services (Haase et al. 2014). Urban parks in particular provide aesthetic and recreational services, regulate the water cycle, modify local climate, produce O_2 and, filtering air pollutants, improve citizens health (Lorenz and Lal 2009). Besides, urban parks are also important habitats for biodiversity (Nielsen et al. 2014), which being valuable by itself provides also a range of other services (Haase et al. 2014). However, soil biodiversity is currently poorly known, especially in Mediterranean cities, and relatively uninvestigated are the environmental factors determining its structure and persistence.

To fill this gap, we explored the environmental factors affecting soil biodiversity of Collembola and earthworms (good indicators of soil biological quality), in parks of two cities: Naples (Italy) and Montpellier (France). The investigated factors were soil inorganic pollutant contents, vegetation cover (with or without canopy) and urban landscape features. In addition, we focused on the effects of management practices, especially of turfs, studying both conventionally managed systems (high energy inputs, including irrigation and regular cuttings with exportation of organic matter) and ecologically managed systems (low energy inputs, with only 1 or 2 cutting per year and mulching).

Collembola communities are both strongly affected by urban park management practices. In particular, the canopy cover was the main determinant of the Collembola community structure, which strikingly differed between areas with or without canopy. Landscape features, followed by soil local conditions, like the presence of litter and soil porosity, also influenced Collembola communities. Abundance of earthworms was greater in ecologically managed systems compared to conventionally managed systems.

Our findings may help city planners to promote soil biodiversity by creating or correctly managing urban parks.

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Policies and strategies to support and maintain urban soils' quality

MAINTAINING AND PROTECTING SOIL RESOURCES DURING URBAN EXPANSION

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Background

Productive soil is critical for the continued existence of humanity. It supplies water and nutrients to plants. It provides support for larger specimens, and it processes and ameliorates waste products.
The first European settlers recognised the essential roles of soil. 'Poor' soil at Sydney Cove resulted in the government being moved to more fertile soils around Parramatta.

You cannot eat harbour views!

Rapid increase in Sydney population is placing increasing pressure on adjacent rural lands. Yet these lands and their soil are critically important providers of Sydney's food supply. For example...fruit and vegetable growing utilises xxx ha, dairying uses yyy ha, poultry farming uses zz ha (ABARE). Additionally urban fringe soils are increasingly used to process and beneficially reuse urban waste.
Urban planners consider issues such as nearness to transport, flood risk, ease of construction and ecological values in determining urban development areas. However there is little consideration of the loss of Sydney's food sources.

Mining proposals need to consider the implications of BSAL (Biophysical Strategic Agricultural Land).

Why does this not apply to urban encroachment into Sydney's food supply?

Options to address this issue:
Include consideration of loss of productive agricultural land in the planning process. Some land is likely to be too valuable a food source.
Consider more infilling of 'difficult' lands within the current urban foot print. Examples include steeper lands in Hornsby Shire.
Emphasise urban development on 'poorer' soils, examples include Hawkesbury Sandstone derived soil and highly degraded agricultural lands.
Consider options for re-establishment of intensive agricultural activities on previously abandoned horticultural properties, e.g. The Wedderburn Plateau. An obvious question is what resources are needed to make these soils more productive?
Actively discourage subdivision of productive agricultural lands into rural residential lots.

Really radical ideas
Are we populating the 'right' areas? Housing can be built almost anywhere. Productive soils are relatively rare in Australia.
Consider Sydney as being 'full'. Where to next?
Consider incorporation of unused military lands south of the Georges River for urban development. These lands are extremely nutrient deficient, but much of the area is relatively flat plateau and ideal for urban development. Additionally these lands are relatively close to Sydney and have several railway lines

that could be readily extended into the area. Further, the lands are owned by the government and their development would assist in reducing the government deficit.

The availability of the Cronulla desalination plant means less emphasis on rainfall runoff and storage. If Warragamba Dam's roles were reprioritised to emphasise flood mitigation, would this increase the reliability floodplain soils for food production?

Should we simply import fresh food from China?

Potential roles of soil science:

Identify BSAL lands on the Sydney Basin and advocate their retention.

Identify lands that could be developed for urban use as substitutes for urbanisation of productive agricultural lands.

Identify the resources needed to convert otherwise low productivity soils for intensive food production. Emphasis should be on areas such as the lower Hunter Valley where the climate and transport links are conducive to intensive production, and the production areas are relatively close to the market place.

What resources are required to convert low productivity soils to soils capable of sustaining intensive agriculture?

Emphasise the importance of considering all values of soil including urban waste processing.

Finally

One of the four key roles of the NSW Branch of the Australian Society of Soil Science Inc is the advocacy of sustainable management of soils. The loss of productive soil to urban development is a significant issue that Soil Science can assist in addressing.

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How to enhance multidisciplinary work between urban planners and soil scientists?

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For many years, urban planning has to reconcile the well-being of city townsfolks and the preservation of resources and landscapes. Development projects increasingly integrate the so-called "sustainable" dimension. As a consequence, co-working with sociologists, ecologists, landscapers, economists or hydrologists has become an expanding practice. The urban project is nowadays multidisciplinary. However, it seems there is still very little cooperation between urban planners and soil scientists despite the fact that there is an increasing interest in integrating the skills of agronomists and pedologists in urban planning choices (Morel et al., 2014). Indeed, to tackle the major environmental issues (e.g. flood, food dependency), every land surface – including cities – should be considered as a potential supplier of ecosystem services. Integrating urban soil quality into urban planning will allow urban soils for participating in mitigation of the major environmental issues (Gómez-Baggethun and Barton, 2013). Moreover, taking into account the urban soils quality could lead to an improvement of the urban development project at different levels: from project conception (e.g. selection of plant species, soil cleaning demonstration) to project implementation (e.g. balance between excavating and refilling, use of fertile topsoil). Hence, cooperation between soil scientists and urban planners should be promoted: this is the principal goal of our work.

Firstly, to facilitate the cooperation between soil scientists and urban planners there is a need to develop a common vocabulary. Our work first aims at promoting a common definition of the soil that is currently perceived in a completely different way by the two professions. Soil scientists focus on the origin, properties, and heterogeneities of the soil in order to express its potentials, notably in terms of ecosystem services. Urban planners present a rather surface oriented approach (e.g. availability of land surface). Urban soils are mainly considered two-dimensionally by urban planners, their volumes are characterized only for geotechnical properties, contamination levels or displaceable resource qualities (e.g. supply of topsoil, excavations). Then, a national survey was sent to the heads of urban planning and environmental departments of the 40 French largest cities and the top 20 French agglomerations. The aim of this survey was to capture the interest of urban planners in the urban soils theme. Indeed, the survey was composed of 5 questions and according the answers a note ranking from 1 (lack of consideration of urban soils) to 5 (total consideration of urban soils) was attributed. Secondly, this made it possible to understand which urban actors were most interested in the subject and therefore which one is the most suitable to interact with soil scientists. More than 300 urban actors received the survey and more than 80 answered. The results showed that on average urban actors have partial considerations of urban soils in their profession (the average note is 3). They also showed that the actors of urban planning departments are the most interested by the survey. Finally, semi-directive interviews are underway with actors from different project scales (elected officials, project managers, site managers). The first results make it possible to reveal that at the planning scale, taking into account the soil is very variable and depends essentially on the sensitivity of the actors. Moreover, the consideration of the urban soils exists at the operational scale but is based essentially on intuitions and returns of non-formalized experiments. To date, there are no scientific and rigorous methods to encourage the consideration of urban soils in spatial planning. Also, our next objectives are to mobilize soil scientists from other countries to do similar work. It will thus be possible to compare the consideration of the soil according to the countries but also to draw the good practices to construct a scientific and rigorous method of taking account the soil in urban planning. Such a method would allow for better cooperation between soil scientists and urban planners. Not only, it will reduce the costs and the carbon footprint of urban projects, but it will also optimize the ecosystem services provided by soils.

Keywords

Urban soil – Urban planning – Soil science – Multidisciplinary – Ecosystem service

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Soil consideration in regional and local planning documents

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Introduction. As other soils in forest and agricultural environments, urban soils provide a wide range of ecosystem services (Morel et al., 2014). They are expected to contribute to face the major urban environmental issues (e.g. food production, flood mitigation, climate regulation) (Dominati et al., 2010; Escobedo et al., 2011; Adhikari and Hartemink, 2016). Because of their high level of anthropization, urban soils are complex ecosystems that are not easily perceived by city managers and operators. This work aims at describing the consideration of soils by urban planners through the study of urban planning documents.

Materials and methods. To understand how urban planners consider urban soils, an original lexical analysis was conducted on more than 100 urban planning documents of the French's 20 largest cities (Local planning document, Local urban travel document, Local housing program, Intercommunal planning document, Regional climate air and energy document, Regional ecological coherences document, Water management document). Among these documents, some relate to the local scale and others to the regional scale. Moreover, each of them relates to a particular theme (e.g. transport, biodiversity, water). This lexical analysis not only focused on the word soil, but also on other words such as water, air, agriculture, biodiversity, vegetation, transport, economy. Tropes software was used to count the number of times each of these words appeared in each of these documents, but also to understand the lexical context in which they were used. So, we were able to distinguish when "soil" was written by referring to a surface idea and when it was considered as a volume, a soil-resource. A further statistical analysis was done on the results that were crossed with demographic data (e.g. % of artificial surface, number of inhabitants, and distance to the city center).

Results. The results revealed that the term "soil" is rather well considered in French urban planning documents, comparable to other words like "biodiversity" and "air". Some planning documents mainly consider the soil as a land surface, whereas others consider it more as a soil-resource. For instance, the French local planning document about soil cover management obviously consider the soil as a land surface rather than a volume (occurrences: 0,12% soil as a land surface, 0,04% soil as a soil-resource). On the contrary, opposite results were obtained for the documents that deal with water management (occurrences: 0,007% soil as a land surface, 0,035% soil as a soil-resource). However, when the term "soil" referred to a volume, a soil-resource, it mainly expresses its geotechnical properties or contamination levels and refers to the agricultural and forest contexts. On the contrary, no demographic data exhibit a correlation with the "soil" occurrences.

Discussion & conclusion

Whereas the properties and services provided by agricultural and forest soils are well known by policy makers and planning operators, urban soils are mostly seen as a land surface by urban planning. They rarely consider them as a living resource, able to fulfill essential ecosystem services. To overcome such a poor consideration and to sensitize city managers and operators, valuable research prospects will be the development of simple and operational tools to evaluate urban soils quality.

Keywords. Urban soil – Soil resource – Ecosystem service – Urban planning – Planning document

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Urban soil pollution, the past, present, tomorrow: a review study

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Abstract
The pollution of soil after urban activity is increasing day by day. For this purpose, the effects of urban wastes on the environment and soil must be determined. As a result of pollution of the land, areas used as agricultural land are depreciating. For this reason, some precautions must be taken both at home and abroad to prevent pollution of the land. In areas exposed to prolonged pollution, some preliminary precautions can be taken first with remote sensing. Later, it is necessary to analyze soil regularly to prevent pollution of the soil.

Environmental impacts assessment, standardization and certification of urban soils

Potential use of dam sediment for soil construction in urban greening: Agronomic fertility and soil structuration

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Keywords: dredged sediment, constructed Technosol, soil structuration, aggregate stability, organic matter, drying-wetting cycles

Sediments are natural materials coming mainly from watershed soils and rocks erosion. They are composed of elementary mineral and organic particles. Each year in France, several hundred thousand cubic meters of sediments are dredged from EDF hydraulic power installations to ensure their correct operation, and returned to the river to respect the sedimentary continuity. In some cases, sediments may not be returned to water.

In order to find a way to reuse the dredged sediments and to preserve natural soil resources, a research program to use sediments, and particularly fine sediments (< 2 mm) as fertile constructed soils in urban green spaces has been developed. Soils built from sediments could be at the same time a way to restore soils functions and ecosystem services in urban areas and a way to prevent natural soil resource destruction and scarcity.

Then the potential fertility of such sediments, and particularly their ability to form aggregates is studied. The objective of the present study is to assess the agronomic fertility of dam sediments located in different geological environments by (i) following the early pedogenesis of constructed soil from sediment mixed or not with exogenous organic material and (ii) understanding the involved aggregation dynamics, leading to soil structuration.

Four sediments contrasted in texture (from sandy loam to silty loam), mineral composition and initial organic matter content (from 29.1 to 224.3 g kg^{-1}) were studied and compared to an agricultural loam soil used as control. The sediments were dredged from hydropower plant reservoirs, air-dried and sieved with a 40 mm screen to eliminate the coarse organic debris and stones.

An *in situ* experiment started in July 2015 where the four sediments and the control soil were put into 50 individual 350-L containers, sown with ray grass (*Lolium perenne*) and placed under natural conditions over a 3-yr period. The sediments and the control soil were used alone or mixed with 40% v/v of a green waste compost. The hydraulic properties (water content and soil matric potential) of the substrates were continuously monitored using dataloggers. Moreover, after 6 (April 2016), 12 (October 2016) and 18 (April 2017) months, we measured the evolution of substrates chemical properties (pH, CEC, OM content, nutrients contents), biological properties (C-mineralization potential, microbial C biomass, plant biomass production) and physical properties (aggregate stability, bulk density, hydraulic conductivity at saturation (Ks), porosity, available water). The aggregate stability was assessed according to Le Bissonnais (1996) to distinguish three breakdown mechanisms: slaking, mechanical breakdown and microcracking and calculate the mean weight diameter (MWD (mm)) index.

Studied sediments presented good initial agronomic properties that allowed plant growth. After 12 months we observed contrasted cumulated plant biomass production, depending on the sediment and on the compost addition, from 522 g DM m^{-2} to 1637 g DM m^{-2}. These results are mainly explained by the different physical properties of the constructed soils and more precisely by the low aggregate stability (MWD under 1 mm whereas a stable aggregate MWD is above 2 mm) of certain sediments leading to slaking crusts and poor hydrodynamic behavior. The addition of compost in sediment changed the soil structure organization by slightly increasing the soil total porosity by 2.5 % to 13 % v/v, increasing the macroporosity (34 % v/v on average) and decreasing the microporosity (10 % v/v on average).

From a chemical point of view, the addition of compost leads to a lower aerial biomass production than for pure sediments after 12 months (from 17% to 89%). These results can be mainly explained by the low nitrogen content of the mixed sediment-compost soil after 6 months (from 2.34 to 16.9 mg N kg^{-1}) and after 12 months (from 0.2 to 11.16 mg N kg^{-1}), leading to nitrogen organization by the microbial communities to the detriment of plant nutrition. Nevertheless, the development of roots is important for all the modalities, which suggests a plant growth potential for next months.

In conclusion, the four studied sediments have contrasted aggregation and plant biomass production capacities but all of them showed a potential use for urban greening of high interest. Results on sediment aggregation showed that some sediments are already mature with strong aggregates that resist to external aggressions and that other sediments with lower maturity should be improved with treatment, such as high organic matter content material addition.

In situ experiment gave interesting results about aggregation dynamics but the main factors favoring sediment structuration (addition of a high organic matter content material, wetting-drying cycles and microbial community dynamics) need to be investigated during a controlled conditions experiment to understand more accurately the aggregation processes in such constructed soils. In parallel, the remaining 18 months of the *in situ* experiments should confirm over time physical properties improvement or conservation and they will allow to assess the impact of the structuration on the hydrodynamic behavior of constructed soils (soil water retention and aeration, and soil water drainage).

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Long-term accumulation und leachability of heavy metals in urban storm-water bioretention systems

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Abstract

Storm water bioretention systems are widely used to treat diffuse infiltration of runoff from paved surfaces and roofs. At present time, many permits of the German water authorities have to be renewed for urban bioretention systems with an operational time >20 years. Substantial questions remain about the hydraulic performance and the accumulation of pollutants in systems over the long term. Data of metal accumulation of systems with operational times of >10-20 years is currently limited. Therefore, this study deals with the accumulation of metals in a variety of long-term operational bioretention systems to derive further operation recommendations for the water authorities. Soil samples from 33 diverse designed systems were collected across the surface and at intervals up to a depth of 65 cm to determine the spatial accumulation of Zn, Cu, Pb and Cd. Leaching experiments of selected bio-retention soils were derived to assess the metal leachability by water.

The hydraulic performance of most bio-retention systems still fulfils the technical guidelines of Germany, even after long-term operation. Considerable metal accumulation occurred mostly in the topsoil (0–20 cm). Concentrations of all metals are highest at the soil surface (0–10 cm), decreasing with depth. High concentrations were determined at the inflow points of the runoff waters, whereas concentrations at more than 1.5 m distance from the inflow were only slightly increased compared to the initial soil concentrations. Leachability tests demonstrate that most of the metals deposited in bio-retention soils are only slightly water-soluble.

Keywords: 1:10 elution. Bio-retention. Hydraulic performance. Leaching potential. Long-term operation time. Metal accumulation

Effect of land use on biological properties of urban soils of Marrakech city

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The health of soils depends widely on its biological and physico-chemical properties, which can heavily be affected by organic and metallic pollutants from human activities. In urban areas, soils constitute a support of many anthropogenic activities and land use types with different successions over periods of time, resulting to their contamination by different technic materials. Land use constitutes the key to soils quality in urban areas and may profoundly influence soil functions due to modifications of their physical, chemical and biological properties (Wong, Gong 1998; Craul, 1999; Brejda et al. 2000; El Khalil et al. 2008; El Khalil et al. 2013). The aim of this work is to evaluate physico-chemical and biological properties of urban soils in Marrakech city according to the type of land use. The following land uses were defined and studied:

Agriculture on soils irrigated with waste water
Agriculture on soils irrigated with groundwater
Gardening on soils of public gardens (parks)
Building activities on soils of residential areas
Spare-time activities on soils of play grounds
Waste management on soils of rubbish dumps

In total, 21 soil samples were collected, and each type of above land use was represented by three different sites and three other samples were taken from non anthropized sites as control samples. A microbial enumeration (Bacteria, Fungi and Actinomycetes) using specific medias, enzymatic activities (Dehydrogenase, phosphatase and urease) were analyzed as well as some physico-chemical characteristics (pH, soil moisture, COT, Olsen phosphorus). A statistical analyses was achieved with (anova1) and PCA by SPSS21 to compare the variation between all measured parameters through the different types of land use

Results showed differences between sites according to the land use type for each measured parameter, but only fungi concentration, dehydrogenase activity and total organic carbon were significantly affected by land use type (anova1; $p<0,05$).

For dehydrogenase activity, soils of public gardens (39.06±9.32 µg TPF g^{-1} soil dwt), agriculture soils irrigated with waste water (49.20±4.73 µg TPF g^{-1} soil dwt) and irrigated with clean wells water (42.24±12.96 µg TPF g^{-1} soil dwt) presented values significantly different to the control samples (13,28±11,60 µg TPF g^{-1} soil dwt), while for TOC and fungi concentration there was no statistically significant difference between control samples and any other type of land use. However, there were statistically significant differences between agriculture soils irrigated with wastewater (20.17±5.38 ‰), playground soils (7.62±5.44 ‰) and soils of residential areas (8.52±4.72 ‰) for COT.

We conclude from this work that the type of land use does not affect systematically all biological and physico-chemical properties of soils. It depends on each parameter and its sensitivity to anthropogenic materials and pollutants.

Key words: urban soils, land use, anthropisation, microbial concentration, enzymatic- activities

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Heavy metals in roadside soils across a highway in Moscow and their effect to higher plants

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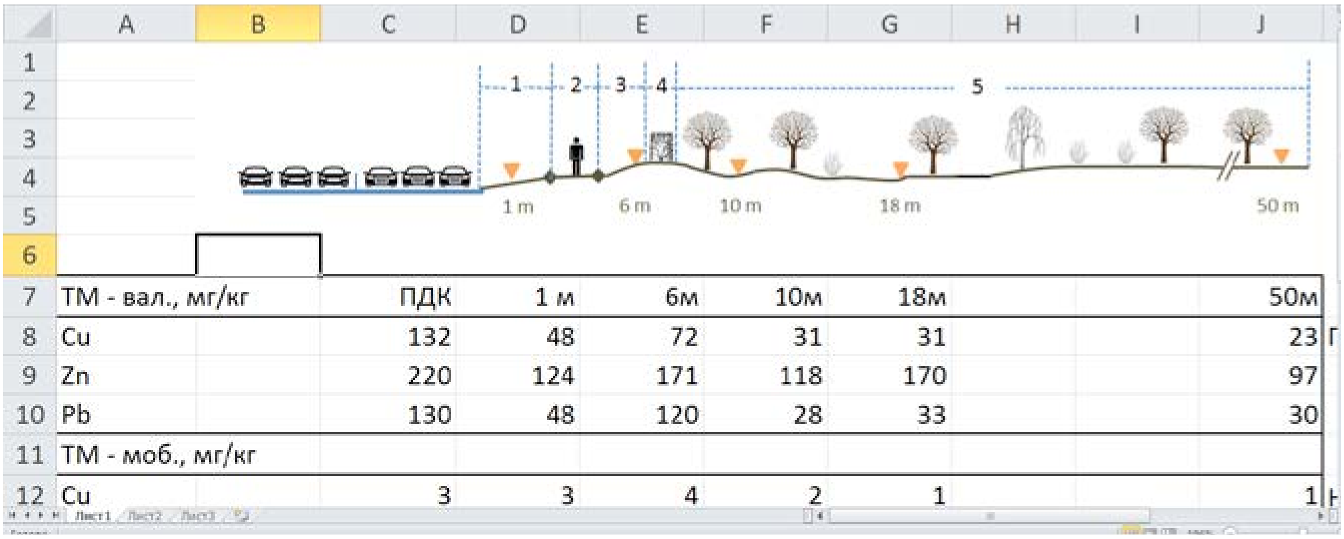
Road traffic is the key source of environmental pollution in cities. Moscow is in the list of top world cities with the highest traffic loads what highlights the need in environmental risk assessment of roadside soils. Motor vehicles originate a wide range of contaminants released to the environment. Heavy metals (HM) are of the greatest concern due to their persistence in soils and health risk exposure. The most common HM presented worldwide in roadside soils are Cu, Zn, Pb, Cr, Ni, Cd (Werkenthin et al. 2014). Objective of this research is to find out the spatial distribution of Cu, Zn, Pb, Cr, Ni, Cd and As in topsoils across a highway in Moscow and to assess their effect to higher plants.

The research objects are soils located along the Minskaya street in Moscow – a 4-km highway with asphalt pavement consisting of three lanes for each direction and traffic intensity of 125,000 vehicles per day. The roadside soils were examined along a 50-m transect perpendicular to the roadbed (Fig. 1). Soil sampling was conducted at the distances of 1, 6, 10, 18, and 50 m from the roadbed in April after the snow melting period. At each distance, three sampling sites (0.5 × 0.5 m) were positioned 10 m apart. The topsoils (0–3 cm depth) were excavated from each sampling site separately. All samples were air dried, 2 mm sieved and stored at 23 °C in the dark.

Fig. 1. Transect across the roadside landscape of Minskaya highway. The numbers 1–5 indicate the following landscape forms: lawn of perennial grasses (1), asphalt walkway (2), the lawn of perennial grasses (3), hedge of shrubs (4), and park territory of standing separately deciduous shrubs and trees (5) (Nikolaeva et al. 2016)

The total HM content was determined by 0.5-g 1-mm sieved soil by microwave acid digestion with 12 ml aqua regia. The digested soil was transferred to 100-ml flasks and filled to the mark with deionized water. Phyto-available HM (Cheng et al. 2011) were extracted from 5 g of 1-mm sieved soil by 50 ml of ammonium acetate buffer (NH4OAc) of 4.8 pH. The suspension was intensively shaken for 1 h and then filtered through ash-free cellulose of 5–8 μm pore diameter. HM were detected by inductively coupled plasma mass spectrometry (ICP-MS) at Agilent 7500a (USA). The detection limit for HM is 0.1 mg kg−1. Plants toxicity bioassay was realized according to the principles of OECD (OECD. Test No. 208) using dicotyledonous plant Lactuca sativa L. and monocotyledonous plant Hordeum vulgare L. Lactuca sativa L. test was realized in 6 replicates (11 seeds per replicate) for each sampling location and Hordeum vulgare L. – in 3 replicates (7 seeds per replicate). Seeds were planted in glass pots of 60 mm diameter filled with 100 g of 2 mm-sieved air dried soil. Distilled water was added initially following the moisture capacity of soils and further every day according the water weight loss. The pots were incubated for 7 days at 24±1 °C and seeds germination rate was assessed. The criterion of test validity was 100% seeds germination in control variant prepared according ISO 11269-2 (ISO 11269-2:2012). Lactuca sativa L. and Hordeum vulgare L. were chosen as their sensitivity to HM is proven by many researches; they are among recommended cultures in guidelines of different regulating organizations; they are suitable for growth in local climatic conditions in zonal soils. Basic techniques were applied for soil properties detection: Following the distance from the road increase pH declined from 7.9 to 7.0, total carbon content – from 5.8 to 3.5 %, electrical conductivity- from 398 to 91 μS cm−1, soil texture varied from loamy sand to sandy loam.

It was found the distribution of total HM declined following the distance from the road increase (Fig. 2a). Cu, Zn and Pb prevailed among detected HM. Concentrations of all HM were below the permissible levels established in Russia (State hygienic standard 2.1.7.2511-09). The highest concentrations were found within 1–6 m of the roadside, and the absolute maximum was detected at 6 m location. We attribute this to road rain water splashes, sprays, and infiltration with contaminated melting snow removed from the road surface to the roadsides in winter; the maximum at 6 m location may be caused by the sedimentation of airborne particles because of the shrubs and trees (Fig. 1). The background levels characterized for Moscow (Kosheleva and Nikiforova 2016) were detected from 10 m location.



ТМ - вал., мг/кг	ПДК	1 м	6м	10м	18м	50м
Cu	132	48	72	31	31	23
Zn	220	124	171	118	170	97
Pb	130	48	120	28	33	30
ТМ - моб., мг/кг						
Cu	3	3	4	2	1	1

Fig. 2. Distribution of total (a) and phyto-available (b) heavy metals (HM) in roadside soils

The distribution of phyto-available HM (Fig. 2b) overall matches the total HM trend. The concentrations of phyto-available HM declined with increasing distance from the road. The highest values were detected within 1–6 m of the roadside. However, in contrast to total HM, the dominant phyto-available HM (Cu, Zn, Pb) were above the permissible levels (State hygienic standard 2.1.7.2041-06). Our findings strongly exceeded the standard for Zn (by 2.5–2.8 times) and Pb (by 3.7–8.5 times). The proportion of this phyto-available HM among total ones is very high (close to 50%), for Cu it is significantly lower (3-7%). Probably due to intense pollution, most of soil sorption positions for HM are busy and new coming portions are of lower interactions with soil (ion exchange, electrostatic interaction, the formation of outer-sphere complexes). High Zn and low Cu mobility is in line with the chemical nature of these elements and their ability to interact with soil components (Lu et al. 2007). High levels of Zn are generally characterized for Moscow urban soils. Pb is known to be concentrated in carbonates which are usual for roadside soils and can be easily extracted by NH4OAc (Cheng et al. 2011).

Environmental assessment of roadside soils performed the strong toxicity related to reference plants. Seed germination rates (mean values compared to control, %) were found as 23 (1m), 17 (6m), 0 (10 m), 18 (18m), 5 (50 m) for Lactuca sativa L. and 14 (1m), 0 (6m), 0 (10m), 0 (18 m), 0 (50 m) for Hordeum vulgare L. No any trend following the distance from the road was observed. The direct correlation between phyto-available HM content and seeds germination rate was not found. Moreover the 1m location performed the highest concentration of HM demonstrated the lowest toxicity among other sampling points. Hordeum vulgare L. was more sensitive to roadside soils contamination than Lactuca sativa L.

The gradual decrease was observed for total HM and for phyto-available HM within the researched 50-m roadside zone. The influence of the road on soil contamination was determined at the distance of 10 m from the roadbed. The highest contributors to HM contamination of topsoils were Zn, Cu and Pb. In contrast to total HM, the dominant phyto-available HM (Cu, Zn, Pb) were above the permissible levels set in Russia. The strong phyto-toxicity of roadside soils cannot be explained by high concentrations of phyto-available HM only and evaluation of other traffic-related contaminants is required for the comprehensive analysis.

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Screening for Bioaccessible Pb in Soils Using a Rapid XRF Analyzer Method

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In recent years, new methods and techniques have been proposed to extend the possibilities of XRF (X-ray fluorescence) to analyze liquid solutions. XRF analysis is a powerful analytical technique to determine a large number of elements present in a sample, spectrochemically (Moradi et al. 2014). Bioavailable Pb, instead of total Pb, in soils is a better measure of the actual health risk posed by this element. EPA method 1340 uses a 0.4-M glycine acid at pH=1.5 under controlled temperature and time to leach the Pb from soil samples, and use the obtained Pb concentrations as a measure of the bioavailable Pb. There are also many other *in vitro* assays used to estimate soil Pb bioavailability, but much of the data are not very consistent.

One of the challenges of these in vitro assay (a.k.a., bioaccessibility) methods is that they need to be done in well-equipped laboratories that are capable of measuring Pb concentrations in leachate solutions using advanced instrumentation such as ICP-MS. Analysis of liquid samples using XRF is problematic because liquid samples have a high X-ray scatter background, which often leads to low signal-to-noise ratio. Several chemical and physical extraction techniques have been proposed to facilitate XRF analysis of liquid samples (Moradi et al. 2015). Eksperiandova et al. (2002) proposed usage of gelatin (agar) to produce preconcentrated thin agar films that could be analyzed for trace metals by XRF with good repeatability due to the homogeneity of the agar films (Kazuhiko et al. 2009). Moriyama (2009) effectively used Ultracarry filter paper and an Ultradry vacuum dryer for sub ppm level analysis of heavy hazardous elements in wastewater and river water with the XRF method.

In this study, we propose a new approach for rapid assessment of soil Pb bioaccessibility that can be conducted in the field. The new method takes advantage of the portable XRF Environmental Scanner that is being widely used for the field screening of total metals in environmental samples. Six urban garden soil samples, with total Pb ranged 376 – 3430 mg kg^{-1} and percent bioaccessible Pb ranged 25 - 48%, were tested in an initial trial. Ten grams of a soil sample were extracted with 10-mL 50% HCl for 30 minutes and the slurry were passed through a 0.45 um filter. Then 1.5-mL filtered extracted solution was thoroughly mixed with 10 g of limestone powder to neutralize the acidity. The extracted Pb was calculated based on the XRF readings on the paste material. The extractant liquid was also directly measured with the XRF analyzer, while another portion was diluted and analyzed with ICP-MS for Pb concentration. Preliminary results showed that the extracted Pb concentrations with the XRF methods (either with the paste or directly on extractant solution) correlate reasonably well to the ICP-MS results, and the calculated bioaccessible Pb are consistent with those determined previously with a modified EPA Method 1340 (glycine extractant of pH 2.5) for these samples. More research is needed to evaluate the variability with different assays, but this XRF method has great potential for use in the rapid assessment of soil Pb risk from urban areas, brownfield, industrial and military sites.

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Modeling and mapping the impact of mining and smelting activities on peri-industrials soils (Wallonia, South Belgium)

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In many countries, atmospheric deposition of pollutants from industrial, mining and smelting activities have strongly impacted soils pollutant concentrations in large areas. Managing the environmental and human risk caused by atmospheric deposition requires first to locate the soils impacted. Here we outline the methodology we developed for modeling the atmospheric deposition of pollutants from mining and smelting activities in Wallonia (South Belgium), and we present the maps we obtained for the topsoil metal enrichment due to atmospheric deposition.

The methodology established for modeling and mapping the impact of mining and smelting activities involves three steps. In the first step, we model the pollutant dispersion from 125 chimneys, considered individually, by a finite volume method. To that end, we assume that each chimney has emitted an identical amount of particles with the same characteristics during one year with representative weather conditions (2008). In the second step, we estimate the enrichment of atmospheric pollutants in 508 control points spatially distributed over Wallonia. In the last step, we calculate the amount emitted by each of the 125 chimneys by fitting the 508 control points using a non-negative linear least squares model.

The results illustrate a promising methodology that can be used to trace the impact of former industrial activities on topsoil metal content. The resulting maps indicate that soils in Wallonia have been impacted on a large scale by trace metal depositions, including Cd, Cu, Hg, Pb and Zn. Moreover in some industrial areas, high levels of metal concentrations are expected principally due to atmospheric deposition of pollutants originating from former base metal smelters.

Assessment of ecological state of urban soils in Saint-Petersburg: case study

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St. Petersburg is a large industrial and transport center located at the eastern tip of the Gulf of Finland. St. Petersburg, situated at the junction of sea, river and land routes, is the Russia's gateway to Europe, strategic center and the closest city to the European Union countries. Inland waters cover about 10% of the city. Area (with administratively subordinated territories) covers 1439 km². Population is 5 million and 225,7 thousand people (as of 1 January 2016 according to Rosstat data). St. Petersburg is the second (after Moscow) largest city of the Russian Federation and the third largest city (after Moscow and London) in Europe. St. Petersburg is the administrative center of the North-West Federal District of Russian Federation, which has significant natural resource potential, highly developed industry and dense transportation network, providing links of the Russian Federation with the outside world through sea ports in the Baltic and the Arctic Ocean.

The ecological status of such a large center reflects the whole range of socioeconomic problems resulting in decline of human health under the influence of various chemical, physical and biological factors. The ecological situation in the city is determined by the emissions from more than a thousand industrial enterprises, large railway junction, seaport and the great motor vehicle fleet – 1 638 183 cars, 20 221 buses and 217 738 trucks as of 2015 (Serebritsky, 2016). All this transport is served by a huge amount of petrol stations and transport companies: currently in St. Petersburg operate 27 fuel operators and 397 petrol stations. Industrial enterprises of the city include high-capacity, resource- and power-consuming ecologically dangerous works. According to the data collected from the automatic air monitoring system of the city in 2015 total emission into the air from both the stationary sources and vehicles has reached 521,0 thousand tons of chemicals, including particulate matter (PM) – 3,1 thousand tons, sulfur dioxide (SO_2) – 4,4 thousand tons, carbon oxide (CO) – 379,4 thousand tons, nitrogen oxides (NO_x) – 61,4 thousand tons, hydrocarbons (CH_x) – 22,3 thousand tons, volatile organic compounds (VOC) – 49,2 thousand tons and 1,2 thousand tons of other pollutants (Serebritsky, 2016). The amount of emissions per capita complies 135,9 kg/year, per unit area – 434,5 t/km^2 (Belousova et al. 2014). Noteworthy that 91,9% of emissions are accounted to the transport activity. Emissions to the air from stationary and mobile (transport) sources are dominant factor of soil contamination in the city due to atmospheric deposition.

Soils of St. Petersburg are characterized by a different genesis and various degree of disturbance – from manmade soil-like formations of the historical center to seminatural soils of recreational zones on the edge of the city. Soils of the sites with high anthropogenic pressure are characterized by modified soil profiles (higher thickness, compared with the natural soil profile type), with abundant inclusions of anthropogenic artifacts in the form of debris and domestic wastes and remains of communications, and have a medium to a strong degree of surface littering, low projective cover of plants and signs of chemical contamination.

Soil ecological monitoring in St. Petersburg has been started since 1991 under the order of Committee for Nature Use, Environmental Protection and Ecological Safety of St. Petersburg (further reference - Committee for Nature Use). Survey of soil contamination is conducted to the moment at the expense of variety of funding sources, with a main contribution of the Committee for Nature Use, with a sampling network of 200×200 meters covering already an area of about 830 square kilometers, which includes the main residential and industrial zones and areas of prospective development. List of priority pollutants includes heavy metals (HMs) and metalloids (As), persistent organic pollutants (POPs – dioxins, polychlorinated biphenyls, organochlorine pesticides), aromatic hydrocarbons (BTEX – benzene, toluene, ethylbenzene, xylene) as well as hazardous organic compounds such as polycyclic aromatic hydrocarbons (PAHs – benzo[a]pyrene, benzo[k]fluoranthene, benzo[b]fluoranthene, benzo[g,h,i]perylene and others). Many years of work has resulted in creation of maps of soil contamination with organic and inorganic pollutants executed at the scale of 1: 40 000. But despite the progress achieved there is still much work, for instance filling of spaces and correction of allocated contours on the map.

Importance of soil contamination control is based on increasing of the potential health risks (carcinogenic and non-carcinogenic), posed to children and adults due to chronic exposure (US EPA SC 2002). It is to be noted that exposure magnitude and dose received from soil contamination are different between the age categories. Children are more susceptible to soil contamination due to higher exposure magnitude (Calabrese et al. 1989; Van Wijnen et al. 1990). Thus the ecological state of urban soils especially at residential and recreational areas of the city needs to be under control.

Therefore, this study is aimed on assessment of anthropogenic load on urban soils of different land use scenarios in St. Petersburg determining the total concentrations of organic (benzo[a]pyrene; sum of PAHs) and inorganic (HMs) pollutants in soil.

Study area included industrial, residential and recreational zones within Primorsky, Vasileostrovsky and Kirovsky administrative districts of St. Petersburg (names of districts are given in order of increasing of location density of potential stationary sources of soil pollution, population density and traffic activity). Potential sources of soil contamination affecting HMs and PAHs levels in soil here are high traffic activity (Western highway and Primorsky prospect), steel and chemical industries (Kirovsky engineering plant, Baltiysky shipyard plant, varnish factory “Kronos”), thermal-power-stations (“North-Western”) and other industries. Soil samples were taken from the topsoil layer – 0-20 cm. A total of 135 grab soil samples were collected diagonally from 25 m^2 sampling plots were combined into 27 composite samples of 0.7 kg each one.

Determination of PAHs in soils was carried out by reverse-phase high-performance liquid chromatography (HPLC). A total of 15 individual PAHs were analyzed. Data on the HMs content in soil was obtained via flame atomic absorption spectrophotometry method. Total concentrations of Pb, Cd, Cu, Ni, Zn, As and Hg were analyzed. Total soil pollution index (*Zc;* Vodyanitsky, 2008) was calculated in order to assess health risk, according to the following equation:

Where, n – is a number of analyzed elements; $K_1 \ldots K_n$ – ratio of actual concentration of the element to its soil background (regional or clarke).

Health risk level is assessed according to 4 categories in order of increasing numerical value of the index: $Zc < 16$ – low; $16 < Zc < 32$ – moderate; $32 < Zc < 128$ – high; $Zc > 128$ – extremely high.

Results of HM and PAH analysis are shown in **Table 1.** Measured sum of PAHs values ranged from 0,17 to 3,77 mg/kg between different land utilization types. Maximal concentration was revealed in Kirovsky district between all studied land uses (2,28-3,77 mg/kg). Soils of industrial and residential zones of Vasileostrovsky district reach high total PAHs concentrations as well, but at the same time soils of residential zone are characterized by higher PAHs level (3,02 mg/kg) than industrial (2,04 mg/kg). There is no standards on the total PAHs content in soil in Russian Federation, regulation is provided only for benzo[a]pyrene, which is equal for all land use and soil types – 0,02 mg/kg (MPC, GN 2.1.7.2041-06, 2006). Comparing with German soil guideline value of 1,0 mg/kg for sum of PAHs in soil, it can be concluded that all studied soils in Kirovsky and Vasileostrovsky districts, excepting recreational zone of Vasileostrovsky district, do not conform to standard limit. Benzo[a]pyrene concentrations have similar distribution pattern as total PAHs. Practically all studied soils have shown concentrations exceeding maximal permissible concentration. Benzo[a]pyrene portion counts up to 30% from the sum of PAHs in studied soils which evidently shows predominant accumulation of this substance.

Heavy metals concentrations in soils of industrial and residential zones between all Districts were found to be higher than permissible levels. Measured total Pb concentration in soil of industrial zone in Kirovsky district exceeded MPC (32,0 mg/kg) for nine times reaching the value of 296,4 mg/kg. Soil of Kirovsky district is generally characterized by higher HMs level comparing with Vasileostrovsky (moderate) and Primorsky (supposed to be the cleanest). However obtained values of total pollution indices refers all studied soils to the high health risk category with except for soil of recreational zone of Primorsky District, which applies to the low health risk category (**Table 2**).

Table 1. Heavy metals and PAHs concentrations in urban soils, mg/kg of air dry soil

	Pb	Cd	Cu	Ni	Zn	As	Hg	BaP	∑PAHs
Kirovsky district									
Industrial	296,40	0,91	74,00	89,00	343,00	7,11	2,57	0,84	3,77
Residential	126,70	0,69	59,10	61,90	96,00	4,91	1,86	0,58	2,32
Recreational	82,04	0,52	64,00	72,10	71,30	5,74	2,05	0,46	2,28
Vasileostrovsky district									
Industrial	237,12	0,64	53,00	74,20	301,40	6,30	2,70	0,46	2,04
Residential	101,30	0,63	23,20	40,00	204,00	6,10	1,53	0,70	3,02
Recreational	120,01	0,49	20,00	33,70	80,00	5,98	1,10	0,11	0,53
Primorsky district									
Industrial	147,00	0,79	52,00	17,20	147,00	6,10	2,43	0,11	0,56
Residential	22,70	0,42	25,50	22,80	116,90	5,60	1,30	0,02	0,17
Recreational	19,10	0,36	22,30	12,20	51,20	4,10	0,37	0,04	0,21
SGV*	**32,00**	**0,50**	**33,00**	**20,00**	**55,00**	**2,00**	**2,10**	**0,02**	**1,0****

* SGV – soil guideline values according to Russian legislation GN 2.1.7.2041-06 (2006)

** - soil guideline value for the sum of PAHs according to German legislation BBodSchV (1999).

Table 2. Evaluation of health risk according to Zc categories

	Zc	Zc health risk category
	Kirovsky district	
Industrial	121,14	High
Residential	87,01	High
Recreational	81,80	High
	Vasileostrovsky district	
Industrial	117,37	High
Residential	64,97	High
Recreational	47,28	High
	Primorsky district	
Industrial	97,10	High
Residential	48,82	High
Recreational	14,24	Low

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Soil ecological monitoring in urban ecosystems

The soil cover of the Voronezh Upland Oak Forests

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The urban environment is a complex open system that maintains its existence and ability to function due to the interaction of its subsystems: natural, technological and social. Natural systems of urban areas have a constant and widespread anthropogenic influence, which is reflected in all their components. The study of soils and soil cover has important place in the ecological studies of the quality components of the urban environment. Urban soils have important ecological functions and are subject to intensive anthropogenic pressure. Their natural counterparts formed outside the influence of the city's infrastructure. In the study of soils of urban areas reveal a mechanical disturbance of the structure of the genetic profile, change parameters of their composition and properties, the degree of contamination with heavy metals. Objective assessment of this component is possible through the study of soils in natural systems of the urban environment. All this gives a high ecological significance to the research.

Voronezh is an example of a complex urban ecosystem. Here a considerable area is occupied by forests of different sizes, which are included in the ecological framework of the city and largely determine the quality of its environment. Forests can be used as a background of areas with natural soil types. City economic objects are within a small woodland. Forest soils within cities are experiencing intensive anthropogenic load. In large forests the anthropogenic factor is sporadic. Therefore, these soils are natural and are considered to be background components of the urban environment.

Forest ecosystems of Right bank's Upland Oak Forest dominate in the natural complex of the city of Voronezh. She stretches as a strip along the right bank of the Voronezh river. Upland Oak Forest is a part of the high fourth terrace and steep slope from it to the river. Ravines covered with forests crossed by a strip of oak. Oak forest is located within a typical forest-steppe of the Oka-Don plain, on the watershed of the rivers Don and Voronezh. The right bank of the Voronezh river is a sandy-clay left bank of the Don river, in which are embedded the valley of the river Voronezh. Therefore, there are growing indigenous types of oak forests on clay soils and mixed forests are on sandy soils. Oak forests account for 85% of the forests. They became part of the green areas of the city and its forested parts.

Our study was conducted in the key area of the Upland Oak Forest - it is Shilovsky forest. Soil cover the key area is specific and complex. This is due to the geological, geomorphological conditions and vegetation. Shilovsky forest located on the southern outskirts of Voronezh. Its area is 1,200 hectares. The study area has clearly defined boundaries. They are on the top of the slope. The slope has considerable slope and crossed by numerous ravines. The difference in relative elevation between the bottom of the slope and adjacent watershed is 40-60 m.

More than 70 % of the forest surface slope of the area occupied by the wet oak forests of III – IV class of bonitet with the different variations of gray forest-steppe soils. High part of the slope has a slope of 1-2°. It is a narrow strip along the highway at the residential area Shilovo. Soil cover is represented by dark gray forest-steppe soils. Humus horizon in them has a capacity of 50-60 cm (A1+A1B). Elongated areas of these soils are replaced by poorly washed away their counterparts on the slope with steepness of 2-3°. In these soils the humus horizon is shorter (A1+A1B = 33-43cm). Some areas in this part of the slope are characterized by a distribution of gray forest-steppe soils. In them the power of horizons A1+A1E is 35-40 cm or from 15 to 27 cm depending on the steepness of the slope. In the middle part of the slope steepness is more than 10-15°, rarely 3-5° or 5-7°. Here the base components are washed out of the soil. Their humus horizon is strongly washed away. In these soil combinations can be observed a regular alternation of soils according to the degree of flushing. The slope at the junction of the slope to the shore of the reservoir is 1-2°. Here is a narrow, weakly expressed in microzone. It formed reclaimed soils. Their capacity reaches up to 70-90 cm. They play a minor role in the soil cover structure of the forest ecosystems of the Upland oak forest.

Complex tree structure of the soil cover is formed by elements of the hydrographic network, such as the ravines. Reclaimed soils distributed at the bottoms of ravines. On the slopes there is a high degree of differentiation of the soil cover. This is caused by the formation within a single slope, soils of different erosion degree. The complexity and contrast of soil combinations is enhanced by high moisture at the bottoms of slopes and groundwater. Below is a description of the base components of the soil cover structure.

A large part of dark grey and grey forest soils formed on the surface loam. They land fluvioglacial sediments at shallow depth. In them morphological and genetic traits are expressed most full. Grey forest medium loam soils contain 35-42 % of physical clay. The proportion of clay fraction is 14-25 % . Humus and humus-eluvial horizons are well-structured. The proportion of structural units with size 10-1 mm is 75-85 %. They have high water stability. The amount of humus in the 0-20 cm layer is 5.1-6.6 % in dark grey soils and is 3.2-4.8 % in grey soil. The humus content gradually decreases to 1.0-1.5% at a depth of 50-60 cm. The sum of exchange bases is in the range 22-30 mEq/100 g throughout the soil profile. The value of hydrolytic acidity is 2-7 mEq/100 g up to 1 m and sharply decreases to 0.4. deeper than 1 m. The degree of saturation of the bases gradually increases with depth from 82-88 % in the layer of 0-20 cm to 90-98% in the layer of 140-150 cm. Reaction of the soil environment is weakly acidic (pH_{KCl} = 4.5-5.5) in the A1 horizon or close to neutral (pH_{KCl} = 5.6-5.8). It changes to sour in the horizons A1E and EB. The reaction of the soil environment is neutral at depths below 120 cm. The number of mobile connections of phosphorus (6.0-9.1 mg/100 g) and exchangeable potassium (16.4-18.9 mg/100 g) corresponds to the average of the high and of their provision in the humus horizon. The content of exchange potassium (K_2O) little changes with depth, and the content of phosphorus (P_2O_5) is increases.

The gray forest washed away soils on the slopes are characterized by a short humus horizon and a pronounced light horizon. The "nut" structure present in the middle part of the soil profile. These soils contain little humus and nitrogen, low availability of the mobile forms of phosphorus and exchange potassium are the unfavourable water-physical and physico-chemical properties. They have low rates of forest properties. Herbaceous and tree vegetation inhibit erosion. However, water erosion is present. This is due to the granulometric composition of low quality. Average dust fraction dominates in the composition of physical clay. Medium sand fraction predominates in the composition of the physical sand. Small capacity well structural layer and poor water stability of structural aggregates contribute to the manifestation of water erosion.

The soils in the bottoms of ravines are formed in conditions of intense inflows of material that washed from the upper parts of the slope. Inflow, transit and accumulation of talus define the basic and additional soil-forming processes. Their profile is characterized by layering, increased humus layer, the lack of structure. Among them are rarely available inwashed (30 cm), medium inwashed (30-60 cm) and strongly inwashed (60 cm) soils. Genetic horizons represented by several layers. These layers vary in power, color, granulometric composition, structure, composition and density. It is a powerful diluvial sediments of different granulometric composition. In their properties they are similar to soils of the watershed. For example, the soil at the foot of the eastern slope (at the reservoir) contain 5.6-7.3 % of humus in the upper part of the profile is still 0.3-0.4 % nitrogen. These soils are well provided with phosphorus, hydrolyzable nitrogen and exchangeable potassium. The sum of exchange bases is 25-31 mEq/100 g. The reaction of the soil environment slightly acidic.

Thus, the results of the research show that the dark gray and gray forest soils loamy granulometric composition are the best for the growth of oak forests. These soils formed on loess loam cover with favourable physical–chemical and chemical properties. Here grow oak forests II–III classes of bonitet. Indicators of the composition and properties of these soils should be used as base when assessing the ecological status of urban anthropogenically-modified soils.

Microbial activity in constructed Technosols for stormwater management system

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Abstract

Green Infrastructure (GI) is a designed environmental feature that usually includes technogenic materials (Constructed Technosols). It employs a multifunctional systems approach that combines natural resources (e.g., soil, vegetation, trees, wetlands) with engineering and technology in built environments. GI provides ecological, economic and social benefits to urban environments dominated by grey infrastructure (e.g., roads, sewers, electrical grid networks, water treatment facilities). In 2010, a Green Infrastructure Plan was developed by the New York City Department of Environmental Protection. The core of the plan was to design and construct green infrastructure to capture stormwater to reduce the burden on wastewater treatment plants and decrease combined sewer overflow, thereby improving the water quality in the harbor. There is also interest in the ancillary benefits of GI, such as effects on local climate, air quality and social factors.

The objective of this work was to characterize soil chemical properties and microbial biomass and activity relevant to carbon and nitrogen cycling processes. In 2016, composite soil samples (0 to 10 cm) were taken at 22 GI sites in New York City. These sites were constructed 5-7 years prior to the sampling. For each site, we measured physio-biochemical properties such as heavy metals, pH, salts, organic matter, texture, bulk density, total organic carbon, total nitrogen, microbial respiration, biomass, N production, and potential denitrification. Results showed that these sites did not have a significant level of contamination by heavy metals. For example, the median Pb concentration was 89 mg kg^{-1} which is lower than the median concentration of 355 mg kg^{-1} measured in 1,652 garden soil samples in New York City (Cheng et al., 2015). The main variables affecting microbial biomass and activity were total organic carbon, total nitrogen and pH and there were significant positive correlations between some heavy metal concentrations and microbial processes. For example, correlation was observed between microbial biomass and, Zn and Cu (P-value < 0.05). Our results showed significant effect of land use (i.e., bioswales and vegetated bioretention areas) (P-value < 0.001) and site location (P-value < 0.001). These

Assessment of soil and vegetation contamination in the zone affected by Middle Timan Bauxite Mine (Komi Republic, Russia)

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Introduction. Open pit bauxite mining causes destruction of soils and vegetation over large areas. Mine production also causes aerotechnogenic pollution of the environment. Since 2002, scientists of the Institute of Biology KSC RAS perform complex monitoring of soils and vegetation affected by Middle Timan Bauxite Mine in the northern taiga subzone of the Northern taiga. Production work on the Mine lead to emission of several toxic substances into the atmosphere. The main pollution source is the red bauxite dust generated at almost all stages of production from blasting to loading ore into railway wagons. This dust contains aluminum, ferrum and silicon oxides as well as residual heavy metals. Pollution agents include also gas substances and solids forming as a result of vehicle work - oxides of sulphur, nitrogen and carbon, heavy metals and aerosols.

Objects and methods. To control contamination and dynamics of accumulation toxic elements in plants and soils, plant (mosses and lichens) and soil (upper horizons A0 litter and mineral A2 (A2B)) samples are collected annually from the Mine area. In plants, we analyzed heavy metals (Cu, Pb, Zn, Mn, Ni, Fe) and Al concentration; in soils – pH, concentration of exchangeable Ca and Mg, mobile forms of oxides of Fe and Al, acid-soluble Pb, Ni, Co, Cu, Zn, Al, Fe and Mn. Analytical studies were performed by ecoanalitycal laboratory of the Institute of Biology KSC RAS. Samples for chemical analysis were collected at five of 15 monitoring plots (MP). All MPs are located on smooth drained watersheds in green moss spruce forests at different distances from production facilities. MP 15 located in 2 km from the open pit № 2 considered as control. MP 1 and MP 2 are located in forests at the border of working pits №2 and № 1, MP 5 and MP 6 - to the south and to the north from the lamination storage.

Standards of heavy metals of maximum permissible concentration (MPC) in plants are missed. So, in comparing analysis, we used normal and maximal heavy metals concentrations in plants from (Melsted, 1973, cited by: Ilyin, 1991). Normalized Al content is given by (Nieboer et al., 1978).

Assessment of soil contamination by heavy metals Pb, Ni, Co, Cu and Zn was made using current regulations (HS 2.1.7.2041-06 maximum permissible concentrations (MPC) of chemical compounds in soil: Hygienic standards; HS 2.1.7.2511-09 Approximately permissible concentration (APC) of chemical compounds in soil: Hygienic standards). We also used scale of ecological ranging of heavy metals concentrations in soils at pH 4.0-6.0 (Ecology and protection…, 2002).

Results and discussion. Chemical analysis showed that, in moss *Pleurozium schreberi* (Brid.) Mitt., only Cu and Zn concentrations were significantly lower than normal level 3-40 mg/kg for Cu and 15-150 mg/kg for Zn. Nevertheless, the highest content of chemicals was found in the area of lamination storage and the lowest - at control MP 15.

In 2014, at all the MPs except for MP 15 and MP 11 Pb concentration exceeded normal level (0.1-5.0 mg/kg according to Melsted); at MP 6, Pb concentration exceeded even MPC (10.0 mg/kg). Pb concentrations varied significantly year by year and depended from the technogenic press level. For example, mining cessation in the northern part of pit № 2 lead to decrease Pb content at MP 1 (2002, - 10.8 mg/kg, 2007 – 6.8 mg/kg, 2014 – 6.5 mg/kg). MP 6 demonstrated high concentration of Pb (6.3-18.0 mg/kg) during all monitoring period.

The most intensive accumulation was noted for Al and Fe. So, their concentrations at the most contaminated site (MP6) increased by 17.1 and 11.4 times during the monitoring period. In 2014, Fe concentration in mosses at all the MPs (except for control MP) exceeded MPC (750 mg/kg) by 3.5 (MP 11) - 32.0 (MP 6) times. Al concentration was also 1.3 (MP 11) - 50.0 (MP 6) times higher than normal concentration. Normal concentration of Al is 150-500 mg/kg (Nieboer et al., 1978).

Similar regularity was traced also by analysis of metal ions accumulation in epiphytic lichens (*Hypogymnia physodes* (L.) Nyl.). 2002-2014 monitoring reveals stable trend of increasing concentration of all analyzed chemical elements. Concentration of Al, Fe, Mn, Pb and Ni are significantly higher than normal and maximal permissible concentrations for plants at almost all the MPs. Maximal concentration of contamination agents was found at sites affected by intensive mining and loading of bauxite. Al and Fe oxides were the main contamination agents.

According to absolute content of pollutants in plants at MPs, all metals can be arranged in a row: Al > Fe > Mn > Zn > Ni > Cu > Pb.

The structure of soils was similar at all MPs. It formed mainly by gley-podzol and peat-podzol-gleyic soils as well as by low mountain podzol soils that are typical for the study area (Rubtsov, 1962).

Soils had acid reaction - water pH varied from 4.1 до 4.8, pHacid – from 3.1 to 3.8, that is also typical for the study area. Soil pH was higher at MP 1 and MP 6 (in A0 horizon). This fact can be explained by dust pollution because of close MP 1 location to the pit and MP 6 location near lamination storage. This fact is confirmed by increased concentrations of Ca and Mg at these sites especially at MP 1. Content of Al oxide mobile forms (0.12-0.49%) and Fe mobile forms (0.12-1.22%) in soils changed insignificantly during the monitoring period. Higher content of Al and Fe oxides in upper mineral horizons in comparison with organogenic horizons is due to their accumulation in form of complex compounds with organic matter that is typical for natural gley-podzolic soils (Zaboeva, 1975).

In 2014, there were no significant changes in total (acid-soluble) Al, Fe and Mn content in comparison with the previous years. It is only should be noted that Al and Fe concentrations decreased in the upper organogenic soil horizon at MP 11. Al, Fe and Mn content were higher in horizon A0 at MP 6 (28000, 26000, 1900 mg/kg).

Concentration of heavy metals in soils in most cases did not exceed MPC and APC (HS 2.1.7.2041-06, HS 2.1.7.2042-06), but exceeded control values (MP 15). According to the scale of ecological assessment of soils by heavy metals content, studied soils were classified as having "low" and "average" concentration level (Ecology and protection…, 2002). In 2014, the trend continued of an increase of heavy metals in soil at MP 6 that is close to lamination storage. Here are the highest concentrations of Zn, Pb, Ni and Co in horizon A0 that can be related with air pollution of soils by production activities.

Higher concentration of heavy metals, Al, Fe and Mn in organogenic horizons in comparison with mineral those can be due to biogenic accumulation of the elements. The soil at MP 5 established in 2011 because of lamination storage expansion was less contaminated. The clearest soil is the soil at MP 15.

According to the state standard, soils can be classified as low and average contaminated (GOST 17.4.3.06-86. Nature protection. Soil. General requirements to soil classification according to affect of chemical contaminants).

Conclusion. Therefore, monitoring of soils and vegetation performed at the territory of Middle-Timan Bauxite Mine showed that the production activities affect mainly vegetation cover that provides barrier functions. Increased concentrations of some heavy metals and acid-soluble forms of aluminum and ferrum in soils were connected not only with geochemical features of the rocks, but also with dust pollution of upper soil horizons especially at the sites located near working pit and lamination storage.

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Alternative microbiological indices for evaluating the ecological state of anthropogenic soils

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Intensive anthropogenic activities within the borders of large cities often lead to significant and irreversible changes in the state of the natural environment resulting in the formation of an intensely damaged urban ecosystem with a modified soil cover. Priority soil contaminants include heavy metals, petroleum hydrocarbons, which being toxic compounds negatively affect the functioning of soil biocenoses (Robert 2010; Gennadiev et al. 2015). As a contributory factor to environmental pollution is gas leakages from artificial gas storages (*Mozharova* 2010), which leads to qualitative and quantitative changes in the soil microflora both at the population level and at the microbial cellular level (Murata et al. 2005; Guo et al. 2012). In our view, an analysis of various microbiological indices can be important in ecological monitoring of soils of urban ecosystems. Microorganisms as compulsory component of every biocenosis can be used as indicators, due to their high sensitivity to changes in environmental conditions, ability to display a variety of reactions and their rapid multiplication, which makes for timely identification of abnormalies which occurs during influence of ecological factors (Martinez-Salgado et al. 2010).

The aim of this study was to microbiologically diagnose the ecological state of anthropogenic soil of the town Mednogorsk and on the territory of Stepnovsky underground natural gas storage (Saratov region.). This research also aims at solving the task of identifying microbiological indices which can serve as perspectives for ecological monitoring of soils with different types of pollution.

Objects of this study were soil samples from the city Mednogorsk, Orenburg region, which is characterized by complex ecological and sanitary living conditions. One of the leading industries of the city is a copper-sulfur plant. Anthropogenic impacts on soil and plant vegetation occurs as a result of gas and dust emissions from the plant and from waste disposal facilities. The major pollutants are copper, iron, manganese and sulfur compounds. In connection with the above mentioned peculiarities, the soil samples were evaluated for the number of heterotrophic microorganisms, iron-oxidizing and manganese-oxidizing bacteria. The coefficient of magnetism (K_{mag}) was also determined – an index which reflects the concentration of iron in the soil. From the 70 soil samples obtained from the city Mednogorsk, 10 soil samples which were characterized by extremely high levels of magnetic coefficient (K_{mag}>3) were selected for microbiological analysis. And 3 samples with low levels of magnetic coefficient (K_{mag}<1) served as control (Ctrl1-Ctrl3).

In soil samples with high levels of magnetism, total number of heterotrophic microorganisms varied from 18.4 to 71.5 $\times10^5$ CFU g^{-1} of dry soil (Table 1). Reduced levels of heterotrophic microorganisms were observed in two samples with high levels of magnetic coefficient. This concurs with previously published researches, where a reduction in the number of prokaryotic microorganisms was observed in different types of soil exposed to the influence of pollution with heavy metals (Murata et al. 2005). The content of iron-oxidizing bacteria in the soils studied ranged from 0.8 to 32.0$\times10^5$ CFU g^{-1} of soil. A significantly high amount was observed in 4 soil samples when compared to other samples (Table 1). In the control soil samples, iron-oxidizing bacteria content was low, ranging from 0.6-4.8$\times10^5$ CFU g^{-1} of dry soil. It was stated that in soil samples with extremely high coefficient of magnetism, the amount of iron-oxidizing bacteria in the microbial biocenosis was higher. The number of manganese-oxidizing bacteria in the soil compared to the iron-oxidizing bacteria was much less in two samples – less than 100 CFU g^{-1} of dry soil and in four samples it ranged from 0.9 to 2.3$\times10^4$ CFU g^{-1} of dry soil. It varied irrespective of high or low values of coefficient of magnetism. The number of manganese-oxidizing bacteria in the control samples corresponded to values ranging from 0.13 to 2.9$\times10^5$ CFU g^{-1} of dry soil.

Table 1. Researched indices of soil samples from the city Mednogorsk

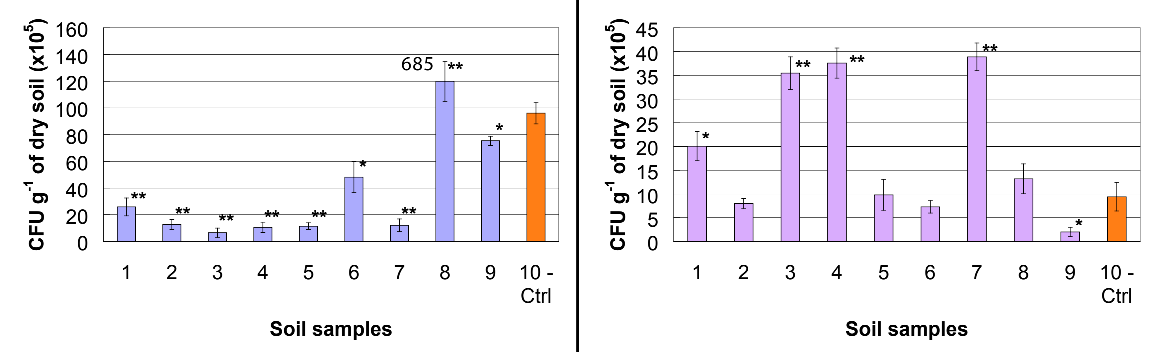
Parameters	Number bacteria in soil samples, CFU g^{-1} of dry soil (×10^5)												
	1	2	3	4	5	6	7	8	9	10	Ctrl1	Ctrl2	Ctrl3
Bacteria: Heterotrophic	6.2	325.0	71.5	24.7	26.5	0.2	26.5	18.4	44.5	68.5	14.9	1.9	34.6
Iron-oxidizing	2.1	74.2	32.0	10.9	1.1	<0.1	0.8	3.3	19.9	17.8	4.8	2.4	0.6
Manganese-oxidizing	0.01	14.15	0.12	2.30	0.88	0.01	0.31	0.001	0.67	<0.001	2.08	0.13	2.89
Index (K_{mag})	6.49	4.10	3.82	3.15	4.97	5.60	3.16	4.64	4.02	3.18	0.33	0.57	0.37

The second group of objects of this study was dark-brown soil samples from the territory of Stepnovsky underground natural gas storage (UGS) in the Saratov region (Russia). Sample 10-Ctrl to Fig. 1 represents the average of the indicators measured in five soil control samples outside UGS. In some samples the amount of heterotrophic microorganisms comprised of about 6 to 26×10^5 CFU g^{-1} of dry soil. In sample № 6 and 9, it was much higher – 48×10^5 CFU g^{-1} of dry soil and 75×10^5 CFU g^{-1} of dry soil respectively (Fig. 1a). The number of heterotrophic microorganisms in sample № 8 was the highest; this could be due to a high level of soil pollution with organic compounds in that sampled area. In connection with the peculiarity of this territory, we evaluated the number of cultivable aerobic hydrocarbon-oxidizing and methylotrophic bacteria. The difference in the number of hydrocarbon-oxidizing bacteria was low; it was at an average of 2 to 39×10^5 CFU g^{-1} of dry soil (Fig. 1b). The methylotrophic microbial content varied in different soil samples from 1 to 60×10^5 CFU g^{-1} of dry soil (Fig. 1c).

Comparing the amount of heterotrophic and hydrocarbon-oxidizing bacteria in the samples, it is observed that in three of the samples (3, 4 and 7) the amount of hydrocarbon-oxidizing bacteria was higher than heterotrophic bacteria. Such an increase in the content of hydrocarbon-oxidizing bacteria can be associated with a selective impact of corresponding substrates, e.g. hydrocarbons. It was discovered that, in three samples (№ 3, 5 and 7) the content of methylotrophic bacteria was higher than heterotrophic. Sample № 3 and 7 also were characterized by a high number of hydrocarbon-oxidizing bacteria. The correlation coefficient (R^2) between the number of methylotrophic and hydrocarbon-oxidizing bacteria in the soil samples was 0.637. Attention should be drawn to the fact that in the soil samples № 5, 7 and 9, the number of methylotrophic bacteria is higher than hydrocarbon-oxidizing, which shows the proliferation of not only facultative methylotrophs but obligate methylotrophs. This serves as an indirect proof of the existence of methane in upper horizons of soil above UGS. The amount of iron-oxidizing bacteria in most of the soil samples was at a range of 1 to 3×10^5 CFU g^{-1} of dry soil (Fig. 1d). Sample № 5 was identified with a low iron oxidizing bacterial content, whose sampling was at the borders of the researched territory. Soil sample № 6 with a high content of iron-oxidizing bacteria was sampled directly above the main trunk of the gas well near the gas distribution station. It is possible that a cluster of bacteriomorphic magnetite had been formed in that area.

Thus, the microbiological analysis of the anthropogenic soil ecosystems reveal a reduced content of heterotrophic microorganisms in comparison with control samples, which may be a reflection of soil microorganisms' reactions to changing environmental conditions, the proliferation of specialized microflora in the soil cenoses due to the presence of different pollutants, as this is important for environmental monitoring.

a b



c d

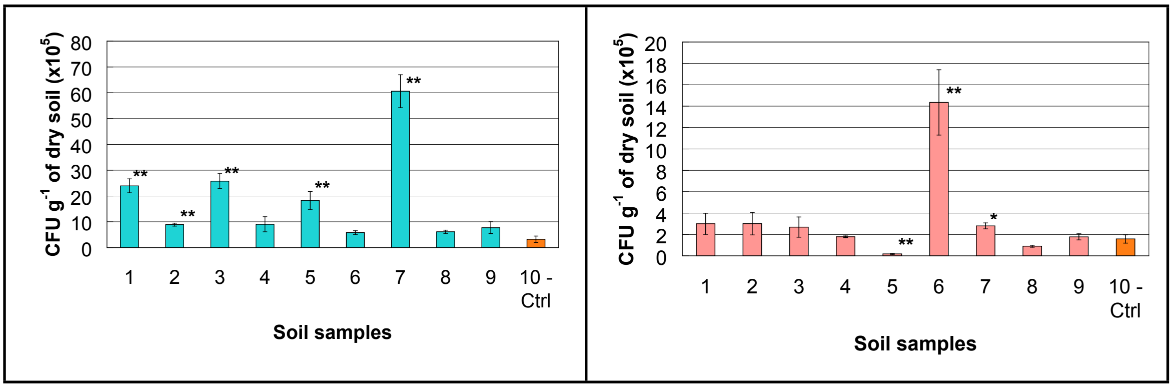


Fig. 1. Number of bacteria in soil samples: a – heterotrophic; b – hydrocarbon-oxidizing; c – methylotrophic; d – iron-oxidizing, error bars (n=8) indicate standard deviations, * and ** – statistically significant differences compared to control for $P<0.05$ and $P<0.01$, respectively.

It was stated that for urban soil samples from the town Mednogorsk contaminated with heavy metals, the number of iron-oxidizing bacteria could serve as a prospective monitoring indicator for pollution. While in areas of UGS, the number of hydrocarbon and methylotrophic microorganisms could serve as significant monitoring indicators and also help find the source of gas leakages.

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Prospects for the use of the species composition of aerobic spore-forming bacteria in the forensic examination of urban soils

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At the present time the world is undergoing an active process of urbanization and the proportion of urban population increases steadily. This leads to an increase of the relevance of urban ecosystems studies, including the research aimed at the study of urban soils. Forensic expert study of soils that emerged at the junction of the general theory of forensic science, soil science, geology, mineralogy, is a new level of knowledge about soil stratifications and other soil and geological objects associated with crime scene and investigation of crimes [5]. At the same time forensics of urban soils is a particularly difficult task due to the extremely high heterogeneity of the urban environment and the impossibility to identify all the factors affecting the soil. The specific urban pedogenetic process based on the disturbance of the natural soil, accompanied by scalping and burial of natural horizons, bringing new material of various origin to the soil surface, artificial creation of horizons in the process of remediation is complicating the problem.

The sole use of the methods adopted in soil science in forensic examination (analysis of the mineralogical composition of the soil, humus content, soil chemistry, color definition) does not always allow unambiguous identification of the soil samples obtained by an expert. The application of additional indicators on the basis of biochemical and microbiological properties of the soil would dramatically narrow the range of possible identifications for the questioned soil samples.

However, there are some limitations that reduce the applicability of additional indicators. For biochemical parameters (activity of soil enzymes, the content of certain classes of macromolecules, etc.), the main limitation is their high spatial and temporal variability. In particular, the activity of soil enzymes depends on many parameters, including the state of the organic matter of the soil, its mineral part, land use type, and so on [7]. In addition, during the long-term storage of samples, which is typical for the process of the investigation of serious crimes, their activity can be reduced in an unpredictable way, which may make it difficult or impossible to interpret the results. Finally, the studies of enzymatic activity of soils usually require samples of about 1-5 g, which is not always possible to acquire without damaging the evidence.

The features of soil microbial communities seem more promising in this case, especially if not quantitative but qualitative composition of the sample's microbial community is defined. In view of the possible disappearance of the non-spore forming bacteria unable of prolonged anabiosis from the microbial community, the most promising group is aerobic spore-forming bacteria belonging to *Bacillales* order. The choice of this group is based on the following properties:

These bacteria can form endospores that can remain viable for decades or even hundreds of years.

These bacteria are widely distributed in the soil of all known types [8].

These bacteria have been observed not only in the upper horizons, but also in the underlying layers, including buried soils [3], as well as the deeper layers down to the depth of 540 cm [6]. At the same time all other groups of microorganisms gradually disappear down the soil profile.

These bacteria are characterized by considerable diversity (over 200 species), and species composition varies not only between different soil types [4], but also between relatively close areas [1].

Our research has shown that in the microbial communities of undisturbed soil (ordinary carbonate chernozem), the share of *Bacillales* species among the culturable bacteria reached 25%. In urban soils a gradual decrease in the proportion of *Bacillales* species with increased level of anthropogenic load was observed (data obtained in the study of anthropogenically transformed soils of Rostov-on-Don, and chernozem of the virgin steppe at Schepkinsky reserve, adjacent to the northern boundary of the city). It has been found that in soils of the marginal areas of the city the share of *Bacillales* species was 5.9% in soils with vegetation cover and 4.3% without it. In the central part of the city it was 1.3% and 0.03%, respectively [2]. Thus, under the conditions of soil anthropogenic transformation a sharp decline in the share of spore-forming bacteria has been observed in comparison to zonal soil types, which can serve as an important identification characteristic of soil samples.

At the same time, the main studies of the species composition of spore-forming bacteria in the soils of our country were held more than 40 years ago by academician Mishustin E.N. These studies covered mainly the soils of agricultural lands, and did not include anthropogenically transformed soils. In addition, over the years the taxonomy of the genus *Bacillus* has undergone radical changes, and new methods and approaches to species identification have emerged, therefore many species described in these papers are no longer valid. Thus, the range of the species of spore-forming bacteria, particularly in urban soils, remains largely unexplored. However, no studies of a similar scale have been carried out since the 50s - 60s of the 20th century. Most of the studies dealing with spore forming bacteria, are aimed at the development of practical methods for their use in biotechnology: in the production of probiotics, biopesticides, enzyme preparations and others.

The shift from fundamental research towards applied aspects in this field seems to be caused not only by the prospects of obtaining practical results. In our opinion, one of the main reasons for this change in research direction, is the existing problem of *Bacillus* species identification. In the analysis of the soil microbial communities identification of a large number of isolates to species level is needed which is quite expensive and labour consuming.

Nevertheless, this kind of research opens broad prospects for fundamental research to fill the gaps in knowledge about the distribution of spore-forming bacteria in different types of soil and climatic zones caused by reclassification. Such studies are also of important practical use, since they allow to obtain additional reliable diagnostic signs for the forensic examination of soil.

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Biogeochemical cycles in urban soils: climate change perspective

Microbial abundance and respiration of urban soils in Moscow, Russia

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Urban areas globally cover around 0.5% (Schneider et al. 2009) and may expand by 16,000 km^2 from 2000 to 2030 yrs. (Angel et al. 2011). Approximately half of the world's population lives in cities and it is projected increase to 60% by 2030 (Pickett et al. 2011). Urban soil research has focused in the past on sanitary quality in the Former Soviet Union, and on content, distribution and migration of contaminants, including heavy metals. Last decades the study of urban soils focuses on the biochemical (Lorenz and Kandeler 2005; Shirokikh et al. 2011) and microbiological (Papa et al. 2010) activities, soil cell morphology (Soina and Lysak 2012) and microbial biomass content (Zhao et al 2013). However, the information about abundance and respiration activity, as well as their spatial variability, in urban soils are still scare. It might be especially intriguingly for very heterogeneous urban ecosystems as Moscow megapolis (the largest city in Russia). This research focused on soil microbial abundance, microbial respiration (CO_2 production) and some indexes of urban soil's microbial community functioning, located in different functional zones of Moscow megapolis, regarding the high spatial heterogeneity and contrasting anthropogenic pressures.

Materials and methods

Moscow city (55°N, 37°E) is located in sub-taiga zone where natural vegetation is dominated by coniferous and mixed forest with Umbric Albeluvisols (WRB 2006). Soil cover of Moscow is very heterogeneous, varying from Technosols (disturbed) to non-disturbed Umbric Albeluvisols (namely natural protected areas). The functional zones were visualized as: recreational (urban parks, natural protected areas and green zones), residential (court yards) and industrial (close to road-sides and industries), totally 52 sites. Soil sampling sites (2 m^2 plot by augering, upper 10 cm layer) were selected randomly in each functional zone (August-October). Soil samples were transported to the lab, air-dried, sieved, and used for chemical and microbiological analysis.

Preparation of soil samples prior to microbiological analysis included moistening to 55% of water holding capacity and pre-incubation (22°C, 7 d, air exchange) to avoid an excess CO_2 production after preparation procedures. Soil substrate-induced respiration (SIR) was measured based on the maximum initial response to glucose addition (Anderson and Domsch 1978; Ananyeva et al. 2008). The rate of SIR (μL CO_2 g^{-1} h^{-1}) was used to estimate soil microbial biomass carbon (C_{mic}, μg C g^{-1} soil). Soil basal respiration (BR) was measured and expressed as μg CO_2-C g^{-1} soil h^{-1}. The ratio of BR to C_{mic} (microbial metabolic quotient, qCO_2, μg CO_2-C mg^{-1} C_{mic} h^{-1}) and C_{mic} / C_{org} ratio (in %) were calculated.

Contribution of fungi and bacteria to SIR at the two sites was measured by the selective inhibition (SI) technique (Ananyeva et al. 2015). The fungi carbon (C_{fungi}) content was calculated as fungi portion (%, SI) from soil C_{org}.

The contents of soil organic carbon (C_{org}), ammonium, nitrate, phosphorus, potassium, and heavy metals (HMs: Cu, Cd, Ni, Pb, and Zn), the pH_{KCl} and the particle size distribution were determined.

Results

The high spatial variability of urban soil chemical and microbiological data was found. The soil C_{org} content ranged between 1.4 and 11.5% with an average of 5.0%, half of the samples contained more C_{org} (>4%) than the reference Umbric Albeluvisols (≤4% C_{org}) dominating in the region. Mean pH_{KCL} was 6.0 for soil in the recreational zone, around one pH unit significantly ($p<0.05$) less was for the residential and industrial zones. No significant difference between functional zones was found in soil nitrogen (ammonium and nitrate) and potassium contents, whereas phosphorous content in the residential and industrial zones was about as double as higher compared to that at the recreational zone. HMs content increased in the order recreational<residential<industrial zones, but the differences were not significant ($p>0.05$). Average HMs contents in Moscow urban soils were below the sanitary thresholds. Sand, loamy sand, sandy loam and loam textures were obtained for 1, 7, 20 and 15 soil samples, respectively.

Soil C_{mic} content in the recreational, residential and industrial zones ranged from 216 to 778, 75 to 662 and 112 to 625 μg C g^{-1}, respectively. Average soil C_{mic} was 382 μg C g^{-1} with a coefficient spatial variance (CV) of 46% for all samples. A high average C_{mic} of 445 μg C g^{-1} was found for the recreational zone, and the difference with other functional zones was not significant ($p>0.05$). The soil BR at the recreational, residential and industrial zones ranged from 0.26 to 2.37, 0.16 to 1.03 and 0.15 to 1.04 μg CO_2-C g^{-1} h^{-1}, respectively. Average BR was 0.61 μg CO_2-C g^{-1} h^{-1} with a CV of 65%. Mean soil BR at the recreational zone (0.78 μg CO_2-C g^{-1} h^{-1}) was significantly ($p<0.05$) higher than in the residential and industrial zones. The qCO_2 values ranged from 0.95 to 3.90, 0.83 to 3.35 and 0.65 to 3.38 μg CO_2-C mg^{-1} C_{mic} h^{-1} for soil at the recreational, residential and industrial zones, respectively (CV=49%). The mean values of qCO_2 were similar for different functional zones. The C_{mic} / C_{org} ratio at the recreational zone was significantly ($p<0.05$) higher (by 1.7-2.0 times) than in the others.

The spatial variation of C_{mic} and BR depended mainly on C_{org} and pH, however the BR variation was additionally explained by NH_4^+, P_2O_5, Ni, Cu (multiple linear regression, $R^2_{adj}=0.56$, $p<0.001$). Considering a very high variability reported for C_{org} in studied Moscow soils and the influence of the value on microbiological properties (C_{mic}, BR) we split the total samples into two parts, regarding C_{org} content above or below 4%. We found that BR and C_{mic} in so-called 'rich' (C_{org} >4%) soils were 1.5-1.6 times higher compared to those in 'poor' (C_{org} ≤4%) soils. On the contrary, the C_{mic} / C_{org} values in the 'poor' soils were double higher from the 'rich' soil. When only the 'poor' soils were analyzed, the significant difference in microbiological properties between the functional zones was found: C_{mic}, BR and C_{mic} / C_{org} in the recreational zone were 1.9, 1.7 and 2.4 times higher than in the industrial zone (Table 1). This might be an evidence of the negative effect of anthropogenic pressures (zoning) on urban soil microbial properties. Otherwise, heterogeneity of C_{org} in urban soils, including artifact with extremely high values, masks the influence of functional zoning on soil microbiological activity.

Fungi / bacteria ratio was estimated for the soils of the recreational and industrial functional zones, representing different level of disturbance and varying in chemical properties (i.e. C_{org}, pH_{KCl} and C / N) (Table 2). Portion of fungi contributed to SIR total (82-84%) and C_{mic} were similar in studied soils. However, the C_{fungi} / C_{org} ratio was significantly 2.4 times higher for Umbric Albeluvisols than for the Technosols.

Thus, the soil values of C_{org} and C_{mic} of megapolis were not significantly differ for various functional zones, however for soils with C_{org} <4% (no amendment of organic substrates) the C_{mic}, BR, C_{mic} / C_{org} were significantly higher in recreational zones compared to those industrial, indicating thereby to anthropogenic influence.

Table 1. Soil microbiological parameters (range / mean, 0-10 cm) of different functional zones in Moscow (n=24, C_{org} ≤4.0%). *Values with different letters significantly (p ≤0.05) differ between zones (ANOVA, Tukey-test)*

Parameter	Recreational (12)	Residential (6)	Industrial (6)
C_{mic}, μg C g^{-1}	216-559 / 397 **a**	110-351 / 242 **b**	130-473 / 202 **b**
BR, μg CO_2-C g^{-1} h^{-1}	0.26-1.07 / 0.57 **a**	0.30-0.55 / 0.38 **ab**	0.15-0.49 / 0.33 **b**
qCO_2, μg CO_2-C mg^{-1} C_{mic} h^{-1}	0.95-2.04 / 1.43 **a**	0.98-3.35 / 1.89 **a**	1.00-3.34 / 1.89 **a**
C_{mic} / C_{org}, %	0.86-2.46 / 1.66 **a**	0.32-2.36 / 1.10 **ab**	0.36-1.39 / 0.69 **b**

Table 2. Chemical properties, microbial biomass carbon content (C_{mic}), ratios: C_{mic} / C_{org}, fungi-to-bacteria (F / B), C_{fungi} / C_{org} in 0-10 cm soil layer (1 - Umbric Albeluvisols, forest park, 2 – Technosols, lawn with trees near road-side) of Moscow. *Values with different letters significantly, p <0.05, differ between soils (t-test)*

Soil	C_{org}, %	pH_{KCl}	C/N	C_{mic}, μg C g^{-1}	C_{mic} / C_{org}, %	F / B, %	C_{fungi} / C_{org}, %
1	2.59 b	3.60 b	16.9 a	538±45 a	2.08 **a**	82±15 / 24±1	1.70 **a**
2	5.75 a	6.83 a	19.1 a	492±19 a	0.86 **b**	84±13 / 26±0	0.71 **b**

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A study of the main factors influencing soil organic carbon stock distribution in urban soils, at French scale

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Key words:
Urban soil, Storage, Organic carbon, Classification, Territory

Soils are the largest pool of terrestrial organic carbon. They can behave as a sink or a source of atmospheric CO2 (Jacobson et al., 2000). The prediction of climate change consequences on ecosystems depends partly on the better understanding of the distribution and control of soil organic carbon (SOC) content. Artificialized areas represent nearly 3% of the World territory (9.3% in France), and by 2050 the proportion of the urban population is expected to reach 66% worldwide (Liu et al., 2014; Service de la Statistique et de la Prospective, 2015; United Nations et al., 2014). However, available data to assess whether urbanization leads to an increase or decrease of SOC and which factors explain the most the SOC distribution in these very heterogeneous soils, are extremely scarce. Hence, the effective role of urban soils in carbon sequestration and greenhouse gas balance is unknown and generally underestimated. Our hypothesis is that the anthropic factors (*i.e.* land use types and management) and vegetation cover mostly explain SOC cartography in urban soils, at a territory scale.

The first objective is to link the urban soil use, management and vegetation cover to their soil organic carbon stock (SSOC), at French territory scale. The second objective is to determine whether these factors explain the most SSOC distribution in urban soils, compared to extrinsic natural factors and soil property variables (*e.g.*, climate, nitrogen content, carbonate content, clay content), at French territory scale.

This work is based on a systematic data collection from different organizations (*e.g.*, research institutes and associated project leaders, cities and urban agglomerations), over the French territory, which have accepted to share their data for this study. More than 10,000 data, displaying environmental characteristics, SOC contents and other soil

properties (*e.g.*, cation exchange capacity, pH, nitrogen and carbonate contents and soil texture), were collected. After SSOC estimation, a statistical treatment was conducted to characterize the different types of urban soils, according to their SSOC and the main factors explaining SSOC distribution. We have tested the effect of extrinsic parameters such as climate, urban land use (a classification of 14 types of uses adapted from Micand and Larramendy, 2014), vegetation cover (herbaceous, horticultural massive, tree or vegetation mix covers), management frequency and age of the site. The effects of the available intrinsic soil properties were also tested. The effects of the anthropic factors (land use, age of site, and type of vegetation) on SSOC were the most significant and allowed to regroup the urban soils in three different categories, according to their SSOC: i) sealed soils; ii) open vegetated and strongly managed soils; iii) open vegetated and near-natural soils. The climate had also a significant effect on SSOC distribution as well as the following soil properties: nitrogen and clay contents.

According to these results, it will be necessary to focus on the three urban soil categories in different cities of France, under contrasted climatic conditions, in order to understand the SOC dynamics, at the soil profile scale.

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Storage of carbon in constructed Technosols: *in situ* monitoring and modelling

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Abstract
With the increase of global population and the threat of climate changes caused by anthropogenic gas emissions, high pressure has been put on arable lands in order to cover the needs for both food and bio-energy production. Conversion of degraded lands for such purposes represents a sustainable solution, implying the restoration of several ecosystem services, which have been impaired. Construction of Technosols on degraded lands has been investigated in order to increase soil fertility and biological activity, using various organic and inorganic industrial by-products (Séré *et al.*, 2008; Rokia *et al.*, 2014). Field trials have demonstrated the interest of this pedological engineering process and remediation technique for the production of non-food biomass and the improvement of soil biodiversity. Moreover, the construction of Technosols with materials rich in organic carbon may also represent a way to store carbon in soils for a long-time, thus alleviating the emission of greenhouse gases associated to the traditional end-of-life of these products. However, the processes of organic matter transformation and mineralization in these newly formed soils are largely unknown.

We have collected data on soil organic C evolution over 12 years on two experimental sites in Lorraine, France, where different Spolic Garbic Hydric Technosols were created from thermally-treated coking plant soil, papermill sludge and green waste compost. Data were compared to the one from natural soils in the same region, and to the available data from other constructed Technosols in the literature (Beesley, 2012; Uzarowicz *et al.*, 2011; Vidal-Beaudet *et al.*, 2012). RothC model (Coleman and Jenkinson, 1996), describing the evolution of soil organic carbon divided in five pools of organic matter, was adapted to the specific constraints of the constructed Technosols (*e.g.* with possible evolution of soil density and soil depth). The adapted model was used to predict the evolution of soil organic carbon on both experimental sites, both at short-term over the last 12 years and on the long-term over the whole 21st century.

Our results suggest that the stock of organic C in the top 30 cm of constructed Technosols significantly surpasses the level usually observed in natural soils under similar climatic conditions and plant cover. The total amount of organic C stored in the whole profile of the Technosol (100 cm) remained five times higher than the corresponding value in natural soils. The initial decrease of the stock of organic C in the top 30 cm was correctly described by the RothC model when taking into account the various types of organic matters introduced in the Technosols, while the observed later increase caused by plant input could only be predicted over a much longer period. Among the tested parameters, the accurate prediction of C input from photosynthesis was the most critical one. Soil construction could therefore be a way to optimize soil ecosystem services associated to carbon storage, e.g. global climate regulation. Further investigations and new modelling approaches are however needed to precise the dynamics of soil organic carbon in these newly formed soils, particularly regarding the influence of climate changes expected in the next decades (Dagois et al., 2016).

Keywords
ecosystem service – industrial brownfield – reclamation –– carbon storage - modelling

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Distribution and factors controlling soil organic C in the Chicago region, IL USA

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Abstract

Scharenbroch et al., (2017) summarized 63 studies on urban soil organic carbon (SOC) storage from across the globe and concluded that urban SOC is variable (0.3 to 135 kg C m^{-2}) and our understanding of the drivers of SOC storage in urban areas is limited. More detailed information of SOC storage and dynamics in urban ecosystems will allow for improved accuracy of global and regional C budgets, sink and source projections of urban SOC with disturbance and climate change and improved soil management for maximization of ecosystem services. A large-scale study of SOC storage and dynamics across a major urban ecosystem was conducted to better understand urban SOC storage and dynamics. Soil organic C (0-100 cm) was measured on 190 (0.04 ha) plots distributed throughout the seven-county Chicago, IL USA metropolitan region. The data collected was analyzed to model SOC distribution across an urban ecosystem. Soil organic C densities in these Chicago region soils (0-100 cm) ranged from 4.13-132 kg m^{-2} with a mean of 34.2 kg m^{-2}. The majority (>75%) of SOC in these soils was found at depths greater than 25 cm and the data suggest that 100 cm may not be deep enough to fully capture the SOC storage in the urban ecosystems (Figure 1). Similar to other urban SOC studies (e.g., Pouyat et al., 2002, Raciti et al., 2011; Beesely, 2012; Vasenev et al., 2013; Edmondson et al., 2014), Chicagoland SOC density was relatively high and variable. The highest SOC densities were observed in the most urbanized landscapes areas (e.g., commercial, industrial, utility, transportation land uses) and lowest SOC densities were found in agriculture lands (Figure 2). A state factor model was used to predict SOC storage. Soil forming factors such as climate, parent material, relief and tree cover were not important predictors of SOC density. The most important predictors of SOC across the Chicago region ecosystem were land-use and other anthropogenic factors, as well as surface soil properties (0-25 cm) (Figure 3). Models that incorporate these factors may useful in predicting spatial variability in SOC across urban landscapes. However, further tests of this approach in urban regions with different characteristics (e.g., bioclimatic setting, parent material, topographic heterogeneity, and historical development patterns) are necessary.

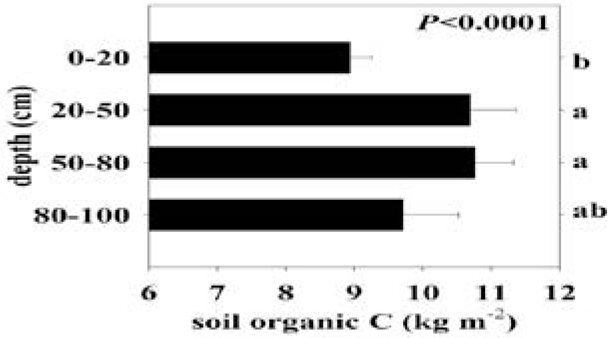

Figure 1. Soil bulk density, organic C concentration and organic C density in 380 soil profiles (0-100 cm) across the seven county Chicago, IL USA region. Significant differences among depths identified by unique letters using Tukey-Kramer HSD test.

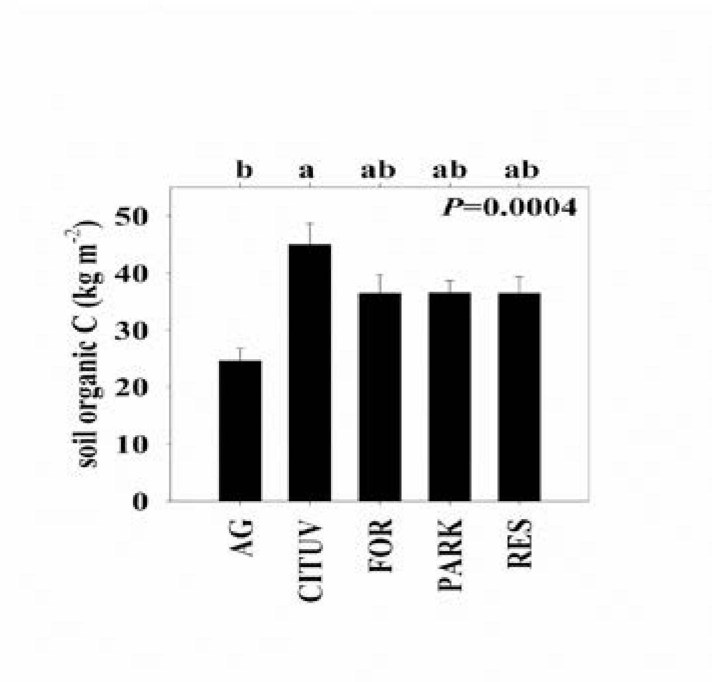

Figure 2. Soil organic C density on 190 plots (0-100 cm) across the seven county Chicago, IL USA region. Means by land-use types: AG (agriculture), CITUV (commercial, industrial, transportation, utility and vacant), FOR (forested lands), PARK (park and other openlands), RES (residential). Significant differences among depths identified by unique letters using Tukey-Kramer HSD test.

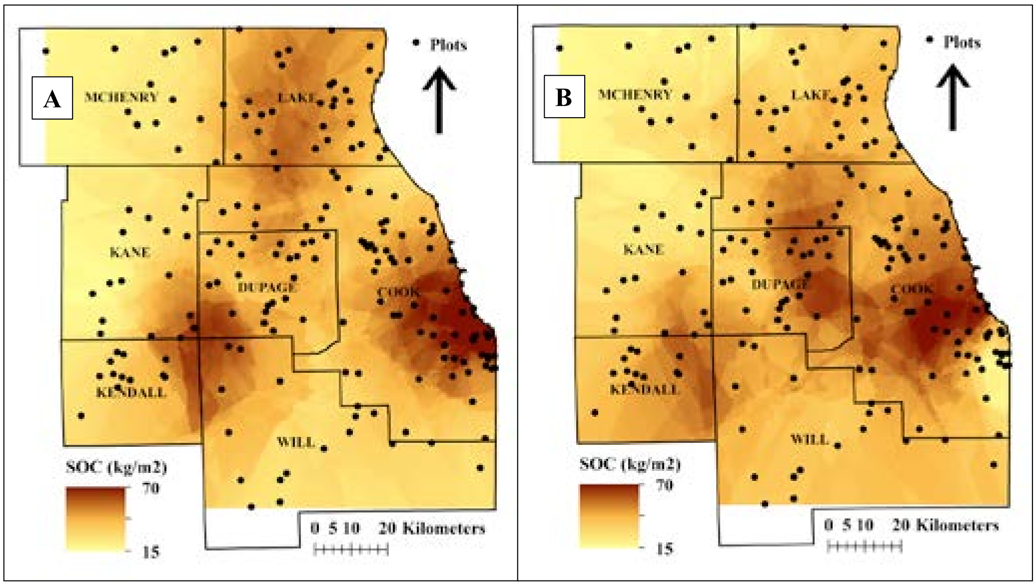

Figure 3. Spatial interpolation of soil organic C density on 190 plots (0-100 cm) across the seven county Chicago, IL USA region. Map A is created from measured plot data and map B is from modeled data from anthropogenic factors and surface soil properties. Map B was produced with a step-wise regression produced a model ($P<0.0001$) explaining 66% of variance in SOC density with these parameters: organic C ($P<0.0001$), pH ($P<0.001$), bulk density ($P=0.0042$), distance to nearest highway ($P=0.0078$), K ($P=0.0096$), Na ($P=0.0126$), particulate organic matter ($P=0.0141$), silt+clay ($P=0.0216$), slope ($P=0.0912$), microbial biomass C ($P=0.1426$), mean annual precipitation ($P=0.2016$), N ($P=0.2079$), C/N ($P=0.3806$), dissolved organic C ($P=0.6708$), effective CEC ($P=0.9052$) and electrical conductivity ($P=0.9091$).

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Carbon stocks for New York City soils

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A 1:12000 scale soil survey that differentiated soils formed in naturally deposited materials from those in human-altered and human-transported materials, the latter separated by artifact content and type, was completed for New York City, USA, in 2014. The map unit design was largely based on land use, and soil components characterized by use dependent properties. Over 100 pedons were sampled for lab analyses, and carbon stocks to a one meter depth were calculated for over 50 pedons. Included were woodland tracts with soils formed in naturally deposited materials and turf-covered areas with soils formed in human transported materials (HTM). Carbon stocks in the former group varied with particle size distribution, while those soils in HTM generally increased with artifact content. In most cases, HTM soils with low artifact content (less than 10 percent) under turf cover had equal or greater carbon contents than comparably textured natural soils in woodlands, while skeletal soils in HTM with high artifact content (greater than 10 percent) had more than twice that amount. Carbon stocks were also calculated for a limited number of pedons under pavement.

The data suggest significant variability and potentially high amounts of sequestered carbon in soils formed in human transported materials. The common occurrence of black carbon, especially in artifacts such as coal, slag, and asphalt, high bulk density values, and the presence of buried surface layers and are among the factors contributing to the high values.

Estimates for total carbon stocks in NYC are presented, as well as comparisons with carbon levels for other important land uses (woodland, agriculture) in the surrounding New York-New Jersey-Connecticut metropolitan area.

Impact of Iron–Manganese Nodules on Geochemical Cycles of Trace Elements in Uncontaminated and Contaminated Soils

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Soils are characterized by a natural capacity for self-purification and detoxification of trace elements (Dobrovol'skii, 1999). The study of modern and potential processes regulating trace elements contents in soils is important for preserving an ecologically favorable environment. One of these specific processes is the formation and growth of organomineral neoformations represented by iron–manganese nodules. Iron-Mn nodules occur in soils of different origins in many bioclimatic zones and act as specific filters for soil self-purification (Cornu et al., 2005; Hickey et al., 2008; Gasparatos, 2013). The nodules consisted of a complex Mn-Fe-oxide matrix, soil mineral grains, and C-rich areas (Timofeeva et al., 2014). The nodules are also characterized by a high exchange capacity and a well-defined sorption activity for trace elements (Gasparatos et al., 2005; Timofeeva, 2008; Cornu et al., 2009). Trace elements differ in their selectivity for sorption by the Fe-Mn compounds in the nodules. Despite extensive studies, little is known about how the levels of trace element accumulation in Fe-Mn nodules vary according to anthropogenic impact on the soils.

The comparative analysis of the different forms of metals in the soil makes it possible to determine the level of anthropogenic soil pollution. Deleting some chemical elements from geochemical cycles and formation of nodules is a protective and ecological mechanism in soil. For understanding reasons for the formation of nodules is necessary to analyze the content of metals in the soil profile and nodules. Usually for these purposes use gross forms of metals. The distribution of elements in soil profile depends on many factors: pH, organic matter content, moisture content, etc. For estimating the degree of soil pollution is best to use background content, as this is takes into account regional geochemical features. For estimating the degree of soil pollution is best to use background content, as this is takes into geochemical features in region (Nesterova et al., 2011).

The objective of this study is to identify the accumulation of trace elements in nodules under natural conditions and under anthropogenic impact.

We examined uncontaminated (located in the Sikhote-Alin Biosphere Nature Reserve) and contaminated soils (located near a polymetallic factory in Rudnaya Pristan) from the west coast of the Pacific Ocean (the Primorye Region of Far East Russia). The experimental soil fields are classified as Udepts according to Soil Taxonomy USA (Soil Taxonomy, 1999). These soils contain hard, brown, spherical nodules of different sizes (Timofeeva and Golov, 2007; Timofeeva 2008; Timofeeva 2014). To understand the cause of the accumulation different forms of metals in soils and the formation of nodules is necessary to use a list of chemical methods. In this work, we collected nodules from Udepts and studied them using energy dispersive X-ray fluorescence spectroscopy, X-ray diffraction analysis, atomic absorption spectrometry, electron probe microanalysis, and field-emission scanning electron microscopy. The enrichment factor (Kx) was calculated from the data for the bulk elemental contents as the ratio of element (x) concentration in the nodules to its concentration in the soil (without considering the nodules): $Kx = C\text{nod}/C\text{soil}$ (Gasparatos, 2013).

One of the important characteristics of the nodule are their morphological characteristics. The Udepts contained abundant rounded and ellipsoid shaped smooth nodules of different sizes. Most nodules exist as hard compact segregations. The outer surfaces of the unbroken nodules were brown to reddish-brown and dark reddish-brown in color. The surfaces were shiny in appearance when the soil matrix was washed off. The quantitative distribution of nodules in the soil was characterized by a consecutive increase from the upper to the middle parts of the soil profile. The peak abundance was observed in the middle part. The number of nodules sharply decreased in the lower part of the soil profile. The analysis of the nodule distribution revealed that the optimum conditions for nodule formation are in the middle part of the Udepts. The mineral grains of nodules are composed of quartz, sillimanite, ferrosilite, hematite, jacobsite, tephroite and bixbyite. Comparative characteristics of the distribution of elements within the soil profile and soil nodules help us to find the cause of loss of some elements of the exchange of geochemical cycles in soils. The average abundance of trace elements in the studied uncontaminated Udepts was as follows (mg kg^{-1}): V (93.8) > Ni (24.3) > Cu (20.8) > Zn (37.7.) > Co (19.5) > Pb (14.3) > Cd (0.4). Investigations of the depth profiles demonstrated that the concentrations of Ni, Cu, Zn, and Co were the highest at surface horizon A. The concentration of Pb, Cd and V increased with depth, and the highest amount was found in the middle part of the soil profile (horizons Btc1, Btc2). The contents of the trace elements increase sharply in the nodules except for Zn and Cd, whose concentration level in the nodules is usually lower than and sometimes identical to that of the soils. The nodules contained high concentrations of Co (*Kx* 2.1–7.5), Ni (*Kx* 1.8–3.2), Cu (*Kx* 1.5–2.4), V (*Kx* 1.5–2.3), Pb (*Kx* 1.2–2.0). The levels of enrichment factor of trace elements in the nodules varied with depth. The accumulation of Co, Ni and V increased for nodules located in the middle part of the profile (horizons Btc1, Btc2). Lead and Cu mainly concentrated in nodules located in the subsurface (horizon AB). An analysis of the relationship between the concentrations of the major compounds in the nodules (Fe and Mn) and the concentrations of the trace elements revealed a complex relationship for nodules. In the nodules of uncontaminated Udepts, concentrations of V ($r_{\text{Mn-V}}$ 0.83), Co ($r_{\text{Mn-Co}}$ 0.92) and Ni ($r_{\text{Mn-Ni}}$ 0.78) were controlled by their strong affinities for Mn. Lead was associated with Mn and Fe compounds. Major compounds of nodules played a secondary role in the accumulation of Zn, Cu and Cd. According to Manceau et al. (2003) and Vodyanitskiy (2005), Zn in nodules is concentrated in phyllosilicates, which were identified in our nodules. The Cu and Cd were concentrated in the C-rich areas within the nodules.

The ecosystem contamination with trace elements is especially strong in the areas of ore mining and industrial activity. The contaminated Udepts were subjected to the trace elements inputs from the industrial emissions. The contents of trace elements in the contaminated Udepts considerably exceed the concentrations of these elements in uncontaminated Udepts (by 1.5–4 times for Co (54.3 mg kg^{-1}), Ni (92.7) and V (138.8) and by 8–31 times for Cu (514.3), Zn (1107.5), Cd (4.1) and Pb(302.6 mg kg^{-1})). Investigations of the depth profiles demonstrated that the concentrations of Cu, Zn and Pb were highest at surface horizon A. Analysis of the V, Ni, Cd and Co distribution revealed increases of these elements in the middle part of the soil profiles. In accordance with the distribution of trace elements in the host soil material, the character of their occurrence in the nodules is governed by a distinct inverse dependency. The nodules of the middle part of the profile show the maximum contents of Cu, Zn and Pb. The highest *Kx* values for the trace elements are registered in the nodules of upper soil horizons. With respect to *Kx* levels, the trace elements can be arranged into the following series: > Pb (6.1–8.7) > Co (5.3–8.1) > Cu (3.6–4.2) > V (1.9–3.5) > Ni (1.7–3.4) > Cd (1.3–2.7) > Zn (1.2–1.8). The relationship of the elements changed with the influence of anthropogenic impact. The accumulation capacity of the nodules that were formed in contaminated Udepts was largely dependent on the Fe compounds. The associations of trace elements in the nodules indicated that the concentrations of Zn, Cd and Pb ($r_{\text{Fe-Zn}}$ 0.98; $r_{\text{Fe-Cd}}$ 0.90; $r_{\text{Fe-Pb}}$ 0.88) strongly correlated with the amount of Fe. Likewise, Fe positive correlated with Co, Ni, and Cu ($r_{\text{Fe-Co}}$ 0.82; $r_{\text{Fe-Ni}}$ 0.79; $r_{\text{Fe-Cu}}$ 0.62). Iron was mainly concentrated in the outer zone of the nodules and was the potential source for accumulation of trace elements.

The trace elements moving along flow vectors in a soil environment encounter a number of migration barriers. One result of their activity is the formation of Fe-Mn nodules, which can selectively uptake trace elements and form microscopic zones with high concentrations in the soil profile. We show that the levels of trace element accumulation and relationships between trace elements and major compound of nodules varied significantly in uncontaminated and contaminated soils. The Fe–Mn nodules in Udepts are characterized by an increase of trace elements accumulation parallel to the increase in the anthropogenic impact. The concentration of Zn and Cd in the nodules is directly related to the soil contamination. The Fe–Mn nodules play the role of specific traps for trace elements, which is confirmed by a decrease in the soil contents of trace elements upon the increase in their contents in the nodules.

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Soil basis for urban farming

Carbon balance assessed by eddy covariance measurement in Moscow urban forest and adjacent urban areas

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In the beginning of the 2014 in northern district of Moscow was installed eddy covariance tower on the edge of Timiryazevskiy urban forest and Timiryazevskiy district of Moscow. Tower 34m high was constructed inside the territory of LOD (Lesnaya Opytnaya Dacha) experimental station in the south-eastern part of the forest. Main tree species of urban forest and neighboring urban areas are *Acer Plantanoides, Tilia cordata, Betula pendula, Quercus robur*, *Pinus sylvestris*. Forest itself is mixed with some small plots dominated only by deciduous or coniferous species, whether trees in urban areas was mainly deciduous. Mean canopy height is about 30m. in both forest and urban areas. The soil cover of the studied sections is represented by sod-podzolic soils with different degree of development of the humus horizon. All soils have well-developed profile of sod-podzolic soil with low power litter (only in forest area) and developed humus-accumulative horizon with high humus content (3,24%)

Carbon dioxide daily fluxes from investigated area was calculated for six months of 2014 (from April till October) utilizing eddy covariance method. Most (90%) of fluxes footprints was no longer than 500m for all wind directions during the time of monitoring. Forest in 500m radius around tower is a zone of active recreation with several roads and wide path network. On the other hand closest to tower urban area characterized by a low-rise buildings (in most cases no more than 5 floors) which are mainly administration ones and have wide green areas around them very few roads and low traffic.

As a result difference in calculated fluxes was not so dramatic, as it was expected. Diurnal carbon dioxide fluxes dynamics was pretty the same for all months except August, due to long period without precipitation and higher soil moisture under the forest canopy. Estimated daily fluxes values was higher in forest areas for the whole period of investigation, except August, and ranged from -2 to 8 g C_{CO_2} d^{-1} m^{-2} with mean about 2,5 g C_{CO_2} d^{-1} m^{-2}.

Safe Produce from Contaminated Soils?Quantifying Sources of Pb Deposition on Vegetables Grown in Urban and Rural Settings

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Abstract

Vegetables grown in urban community gardens in New York City (NYC) have been shown to contain higher Pb concentrations than market-basket vegetables (McBride et al., 2014). While surface particle adherence plays an important role in leafy vegetable Pb-contamination, the relative significance of various sources of surficial deposition have not been sufficiently characterized. This study compared a single variety of leafy lettuce (*lechuga*)grown in Pb-contaminated soil (844 mg Pb kg^{-1}) and clean soil (70 mg Pb kg^{-1}), each under three different conditions: 1) bare soil, 2) mulched soil to limit splash, and 3) mulched soil under hoop houses to limit both splash and air deposition. In addition to the field study in a community garden, the two NYC soils were transported to Ithaca, New York, where the experimental design was replicated at a rural field site. Characteristics of atmospheric deposition were evaluated by passive trap collection through triple BSNE samplers with particle collection at 5, 15, and 60 cm heights above the ground and funnel samplers with cellulosic filters at 90 cm at both the rural and urban sites, as well as active collection by cascade impactorsin NYC. The lettuces grown under differentconditions in the urban and rural settings were further compared to lettuces grown in the same soils in a greenhouse in Ithaca and lettuces purchased from supermarkets in NYC.

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The field assessment of environmental controls and potential of artificial dryness-rewetting cycles for CO2 soil emission in urban farming area (Haplic Luvisols) of the Moscow region

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Field sites and Methods. The assessment of the so called "Birch effect" (the well known effect of short-time strong impulse emission of CO_2 and nitrogen oxides gases into the atmosphere due to rain or other kind of rewetting after dryness events (Borken et al., 2006, Schindlbacher et al., 2012)) has been held in south of the Moscow region (Pushchino, 54° 50'N, 37° 36'E, 185 m asl). The study was conducted under field conditions in Haplic Luvisol urban farming area at (i) grassland (meadow) site, and (ii) at the young (2 yr fallow) bare arable site. Soil respiration fluxes were measured before and after artificial rewetting followed the simulated draughts of different longivity. The experimental design included the artificial simulation of two variants of natural draught within summer period: (A) two short draughts in sequence (SD) equal to 6 and 5 weeks each, separated by 1 week of rewetting period; (B) one long-term draught (LD) 12 weeks long.

The drought was provided by installation of roof of polyethylene over the experimental plots. Drought duration was considered as the time between watering of plots. The watering procedure simulated a rainfall event of 4 mm precipitation. After a six-week drought, watering was continued during seven days (one week) in raw, 1–2 times per day. The total amount of precipitation was 48 mm. Watering was performed between 9 and 10 and from 16 till 17 hours of a 24-hr day time. Rewetting after the second five-week drought and after the twelve-week drought, carried out simultaneously, lasted for 6 days. The total amount of "rainfall" was 28 mm.

The surface soil carbon dioxide fluxes were measured using a portable infrared gas analyzer Li-COR 6400 with a special soil chamber. The rates of CO_2 fluxes were determined after 2 and 8 hours after the soil watering and then daily in the morning hours. Soil moisture at 5 cm depth was measured with electronic moisture meter HH2 (Hanna Instr., with ML2 sensor head). The soil temperature at a depth of 5 cm was determined by an electronic thermometer CheckTemp-1.

Results. Volumetric soil moisture the week before the end of the first short-term drought (end of July) established at the level of 10.2% at the grassy plots and at 5.3% at the bare ground plots (Fig 1, A). The termination of drought (the first watering event) has led to an increase in soil moisture up to 26% and 10% for the grassland plots and the bare arable plots, respectively (Fig 1, B). Maximum soil moisture was observed to the end of the period of watering and reached at the grassy and the bare sites close values of 33–35%. The soil temperature in the upper soil layer of 0–5 cm within the period of drought interruption was changing between 18 and 24°C.

Before moisturizing, during the maximal drying out of the soil, the flux of CO_2 from soils at the grassy plots amounted to 246 ± 53 mgC/m^2/h, while at the bare site the rate of soil respiration was 5 times less and constituted 50 ± 5.5 mgC/m^2/h only. Two hours after the first watering event (4 mm of precipitation) the soil respiration at the grassy plots increased by 1.8 times (451 ± 95 mgC/m^2/h). For the bare arable plots the rise in soil respiration was slightly higher, at some 2.1% (107 ± 4.6 mgC/m^2/h).

Throughout the period, when the watering was carried out, the soil respiration has changed slightly. However, the excess water during the process of rewetting led to some reduction in CO_2 fluxes from the soil, while increasing the spatial heterogeneity of carbon dioxide fluxes.

Termination of the 2nd short and the long-term droughts was conducted in early autumn (September 3 – 8). Soil temperature during this period was noticeably lower than in the first irrigation, and varied from 13 to 17°C. Soil moisture at the SD sites was gradually decreasing within 5 weeks from 32 – 33% to 10.9 and 4.4% at the grassy and the bare arable plots, respectively, taking these values one day prior to irrigation (Fig 2, A). In the variant of LD the soil moisture was maintained during August at 6.8% and 2.5% for the grassy and the bare sites, respectively. After the first watering the soil moisture in the grassland plots under the both variants of management (SD and LD) increased to 22 – 23%, and at the bare sites to 9-10%. After 2 days of intensive watering, simulating the 16 mm of precipitation, volumetric soil moisture in the grassy plots has reached 30%, and at the bare ground plots – 28%, remaining at this level until the end of irrigation.

The carbon dioxide fluxes from the soils under SD management before watering were 387 ± 63 and 51 ± 6.2 mgC/m^2/h at the grassy and the bare arable sites, respectively (Fig 2, B). In the variant of LD the respective values were 164 ± 41 and 36 ± 1.5 mgC/m^2/h. 2 hours after moistening of the plots under the SD variant, the soil respiration in the grassland increased by only 1.05 times (407 ± 46 mgC/m^2/h), while at the bare plots the CO_2 flux increased by 1.6 times (82 ± 3.3 mgC/m^2/hour). In the plots with the prolonged drought, after moistening the respiratory rate of the soil increased by 2 and 2.3 times at the grassy and at the bare arable sites, amounting to 334 ± 53 and 84 ± 2.6 mgC/m^2/h, respectively.

Conclusions. It was found, that the "Birch effect" estimated for Haplic Luvisols in the European south taiga subzone by means of the response of soil respiration to artificial watering after interruption of simulated droughts of varying intensity, is dependent on the presence of vegetation cover (grassland vegetation or bare arable land), and also on the duration of the dryness period, and on soil temperature at which the watering took place. Besides, the "Birch effect" was found to be the maximal after the interruption of the first "short" drought in the summer period and during the prolonged drought in the early Fall, when the soil respiration increase constituted 1.8 to 2.0 and between 2.1 and 2.3 times at the grassy and bare sites, respectively. Soil moisturizing after the 2nd short-term drought occurred at the lower temperatures, as compared to the first one (18 – 24°C and 13 – 17°C) and did not cause a surge of respiratory activity at the grassland site (absence of the "Birch effect"), whereas at the bare arable plots the rate of CO_2 soil respiration flux increased by 1.6 times.

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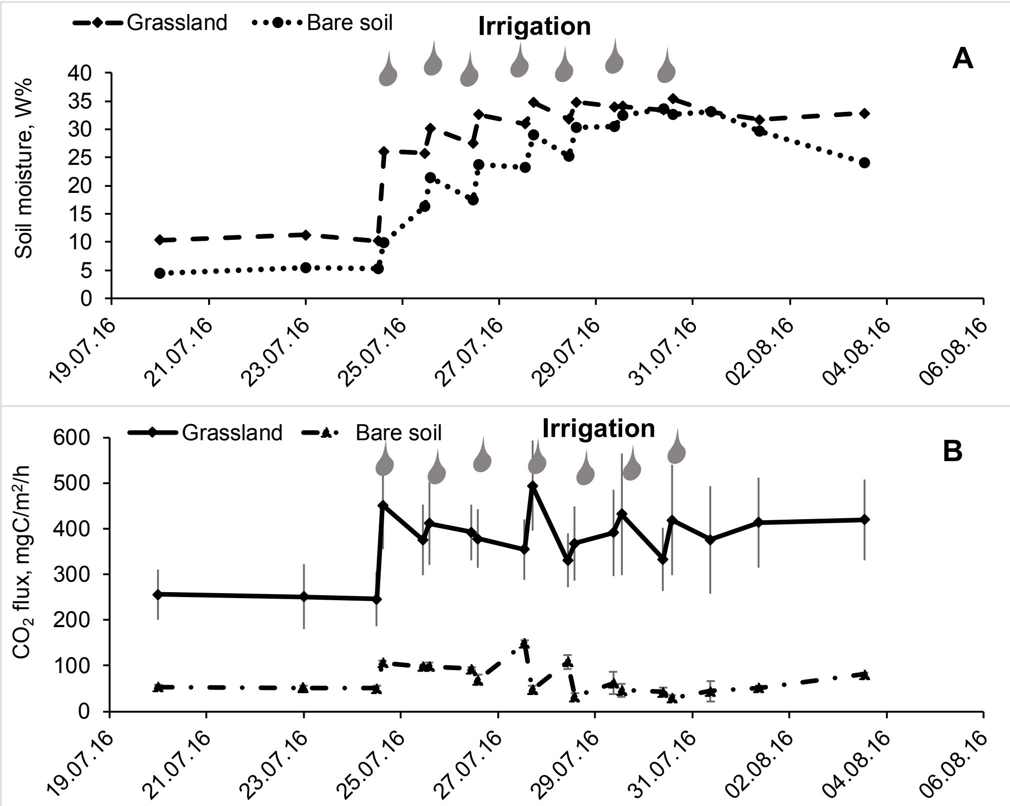

Fig 1. Soil moisture (A) and CO_2 flux (B) for the grassy and bare plots in Puschino urban farming area during the interruption of the 1st short droughts.

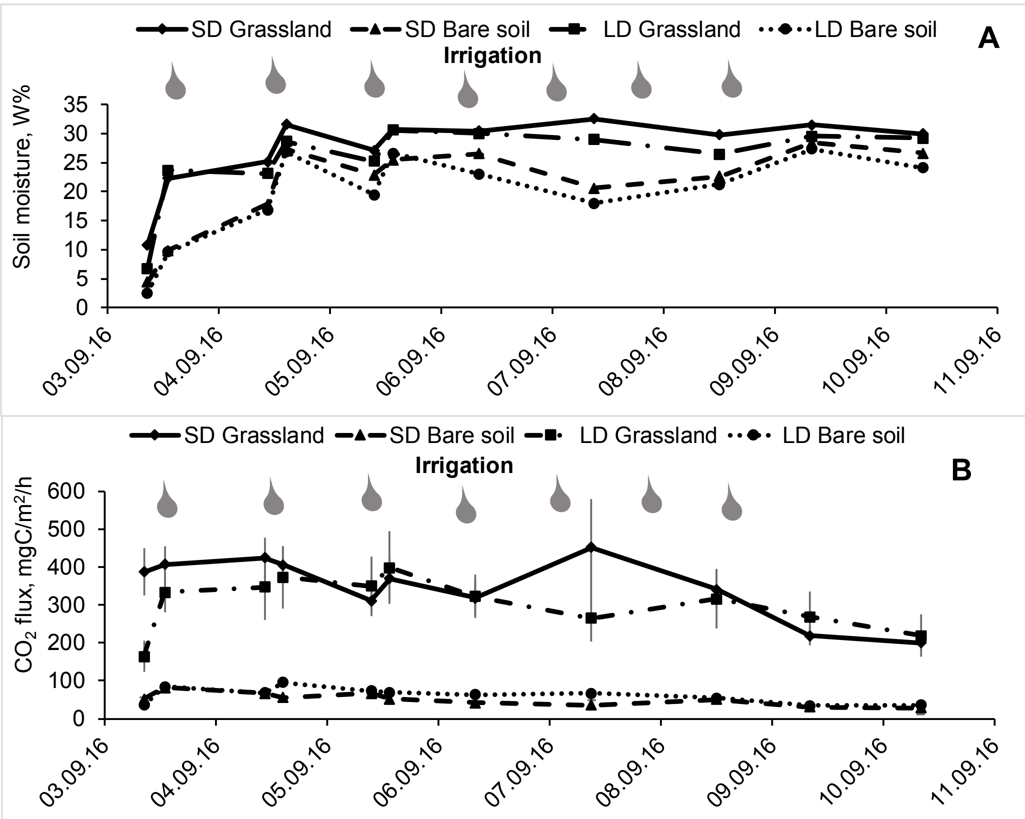

Fig 2. Soil moisture (A) and CO_2 flux (B) for grassy and bare plots in Puschino urban farming area during the interruption of the 2nd short and long-term droughts.

Land management and soil developmental processes under the green-infrastructure in Tokyo

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Introduction

Despite of decrease in domestic population in Japan, the population density in the urban area still increase. Extension of urban area is also still required from the center of the city to the rural area. The urbanization always requires flat lands and covering of ground surface by asphalt and concrete. The increase trend of the impervious area accompanied by road expansion is also confirmed in the worldwide scale (Elvidge et al., 2007; Laurance et al., 2014). Infrastructures using concrete and asphalt, that is so-called gray infrastructure, have been constructed to establish urban areas. The gray infrastructure has brought us urban disasters such as flood, land subsidence and so on as well as convenient life. Water dynamics in soils beneath the gray infrastructure has a key role to protect the urban disasters. The base soil has been compacted to avoid water infiltration, resulting in flooding due to surface runoff after heavy rain. The ground surface with pervious paving is now enlarged to increase water retention in soil.

Furthermore, to extend flat land area in mega cities in Japan, the area along the sea coast has been reclaimed using wastes, demolitions, sludges, dredged sediments and so on since four centuries ago (Fig. 1). The area of the reclaimed ground along Tokyo Bay has expanded for industries and storage spaces of gray infrastructure along with increase in economic growth during 60's and 70's. Greenery area has been installed along the coastal line, river line, and inside the city center to avoid flooding, tsunami, and to reduce heat island effect. The greenery area, so called "green infrastructure", is now addressed to enhance resilience for natural and artificial disaster. The artificial greenery area is constructed taking account of natural vegetation and landscape. However, soils beneath the green infrastructure is not well understood from the scientific point of view. This study tracked change in soil properties after construction of man-made soils in the Tokyo Bay area.

Fig. 1 Land reclamation in Tokyo Bay from 1590 to 2002 (Endoh, 2004). Stars A, B and C on the map are the survey sites.

Materials and Methods

Soils on man-made islands were surveyed along the Tokyo Bay area (Fig. 1). The area of Tokyo Wildbird park locating at the site A has been constructed in the mid '60s by landfill using demolition of constructions and municipal garbage. A pond has naturally formed by rainfall, resulting that wild birds have nested the area around the pond because vegetation consisting of reed grass gradually covered there. The area preserved as a bird sanctuary for over half a century. In the mid '70s, Tokyo Metropolitan government preserved the area as a bird sanctuary accompanying with the urban forest by afforestation using *Quercus sp.*. The second landfill island is the Wakasu marine park at the site C established approx.. 40 yrs ago using urban constructed wastes. After the construction of the man-made island, the area has been covered with lawn over 40yrs. The grass vegetation has been kept by artificial cutting. The third one, Uminomori Park at the site B, has been started planting on 2007 and it continue the planting in 2016. A corn penetrometer was used to get the vertical profile of soil softness. The soil softness test repeated over three times at one plot in the park to confirm the averaged hardness. At the Uminomori park, three sites, which has constructed at different year on 2008, 2012 and 2014, were compared to confirm change in soil physical properties with plant growth. General soil properties including contents of inorganic carbon have been determined for the soil profiles with depth.

Results and discussion

The soil reaction was alkaline over 8.0 at the deeper horizons of all soil profiles. The surface horizons tended to be acidic from 7.3 to 6.6 at the Uminomori park during 6 years after the construction probably due to decrease in carbonates and bases by downward water drainage and/or surface runoff. The surface horizons at Wakasu and Tokyo Wild Bird Park established over 40 yrs. ago showed acidic soil reactions, 5.8 and 6.5, respectively. Materials included in soils were demolitions from constructed debris made from concrete, resulting in alkaline soil reaction. Alkaline soil reaction is common in soils even in a greenery area like as soils beneath paved road mixed with quick lime to enhance stability of road bed. The alkaline soil reaction gradually declined with time mainly due to downward soil water movement.

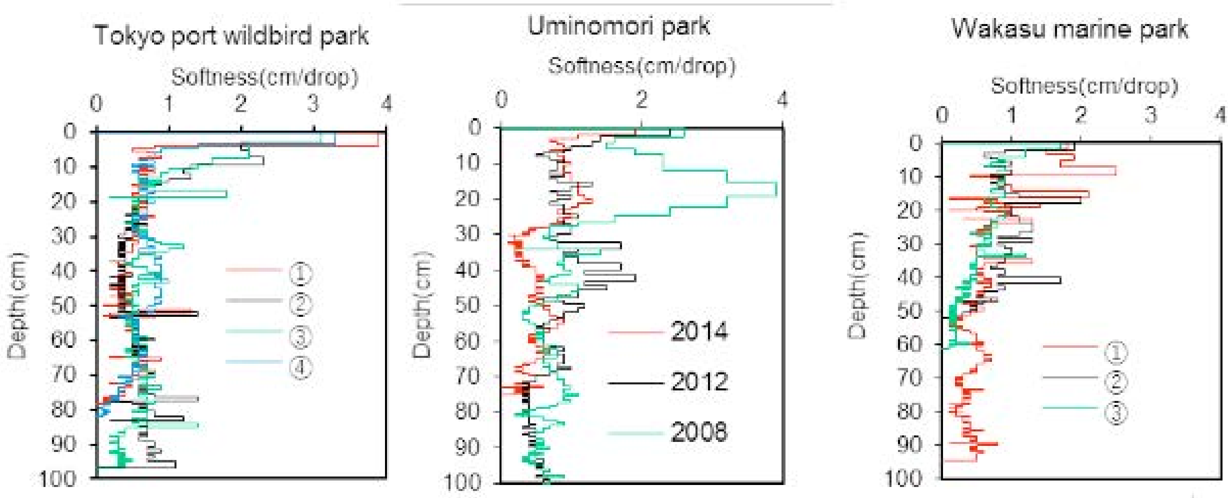

Fig. 2 Profiles of soil hardness using a corn penetrometer. The number in a circle indicates different places in the park to test the hardness. (Matsudaira et al., 2017)

However, deeper soil has kept alkaline soil reaction, indicating that soil water has not been vertically delivered due to prevention of downward water by hard pan layer compacted by heavy machines like as road bed construction. Under the 50 cm in depth, the soil softness below 1 cm/drop indicates the existence of hard pan layers below 50cm of the depth at all sites. Soil bed for tree plantation has been repeatedly compacted during the construction process using heavy machines. After several tens of years, deeper soil regions have kept hard even after the plant growth in Tokyo Wild Bird Park. Although the hard pan basement is not essential for plant growth, the construction process was same as the road bed and the basement of buildings. The growth of tree vegetation seemed not to be damaged due to the hard pan layer. However, limitation of root growth to deeper region will be negative effect to basement strength against earthquake or heavy rainfall in this region.

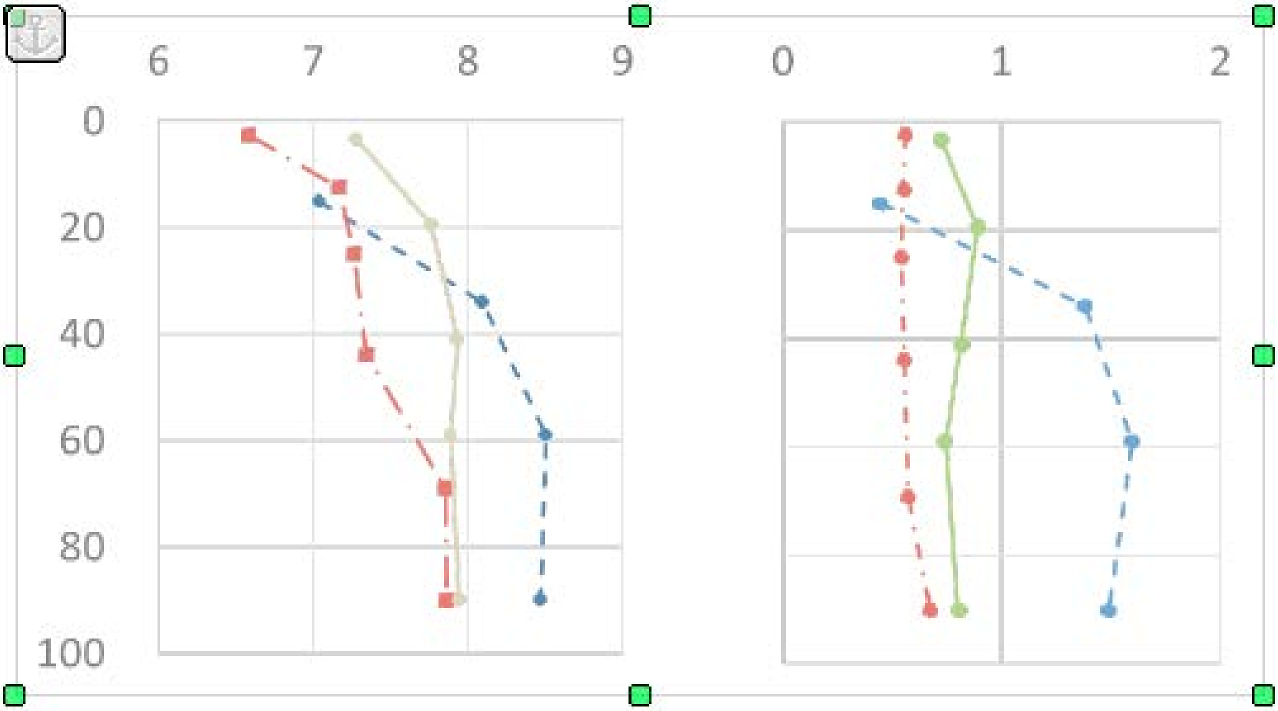

Fig. 3 Values of pH and inorganic carbon with depth at Uminomori Park with time after the plantation. (Matsudaira et al., 2017)

Accumulation of inorganic carbon has been detected at all alkaline horizons even after several years (Fig. 3). The hard pan layer can keep inorganic carbon at the deeper region by locking it up from water percolation. It is also possible that the inorganic carbon has been accumulated due to absorption of CO_2 in the gas phase in deeper soil. Decrease trend in the contents of inorganic carbon even in deeper horizons indicates gradual acidification of the soil. Plant growth probably enables aeration and water infiltration to deeper region, resulting that gradual soil development even after land engineering of the green infrastructure. Soil management is probably necessary to promote the development process of the basement for the green infrastructure.

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Accumulation of As and Pb in Garden-Grown Vegetables: Factors and Mitigation Strategies

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One of the earliest metals discovered by human is lead (Pb) and it has been used for the last 5000 years. Arsenic (As) came to be used by human much later than Pb. The earliest available records indicate the use of As-sulfides in China as early as A.D. 900, and incorporation of As-oxide in ant bait in Europe in 1699 (Shepard, 1939). Lead arsenate was first used as an insecticide in 1892 against gypsy moth (*Lymantria dispar*) in Massachusetts, USA (Peryea 1998). Arsenic and Pb have been used as pesticides (e.g., calcium arsenate, lead arsenate, and copper arsenate) for orchards and farms.

The cumulative contamination of soils by Pb and arsenate beginning in the late 1800s persists today (Schooley et al, 2008), because Pb is quite immobile and As is only very slowly leached through soils (Veneman et al, 1983; Hood 2006). As contaminated lands are converted to residential and farming uses, the potential risk to human health is increased through direct or indirect exposure pathways arising from gardening and further transfer through food chain.

This project includes a combination of laboratory and field experiments. The research objectives are (1) Quantify the degree of Pb stabilization and As mobilization due to addition of varying combinations of phosphates, compost, Fe, and Mn amendments; (2) Evaluate the extent of Pb and As uptake by common urban garden vegetables grown in contaminated soils, and whether the amendments will reduce such uptake.

In the field, plots were developed at Duke Farm (New Jersey) known for elevated levels of As and Pb. Different amendments (TSP, bone meal, manure compost, commercial raised bed, iron, manganese) were added to the plots and common vegetables were planted (carrot, tomato, radish, lettuce). The concentrations of Pb and As in vegetable samples were analyzed to assess the uptake and other factors that contribute to the tissue contaminant levels.

The effects of the different types of plant and amendments were assessed with two-way ANOVA. Differences between treatments were tested with Tukey's honest significance test. Principal component analysis (PCA) (Venables and Ripley, 2002) was applied to assess relationships among response variables (soil and plant tissue metal concentrations, pH, salts, TOC and plant biomass), and the five factors (amendments, plant types, presence/absence of Fe and Mn, and double concentration of amendments). The significance of factors was tested with a Monte Carlo test (Manly, 1991). Linear discriminant analysis (LDA) (Dray and Dufour, 2007) was used to isolate the best response variables separated the different amendment treatments (Venables and Ripley, 2002). The correlation between vegetable concentrations of Pb or As and vegetable Al was tested with General linear model.

The contaminated test plots with silty loam soil in New Jersey have mean concentrations of As at 36 mg kg^{-1} and Pb at 219 mg kg^{-1}. Plant type, amendments and their interaction affect vegetable Pb and As concentrations. The concentrations of Pb and As in vegetable tissues are more dependent on plant type than on amendments. Carrot Pb concentrations were significantly different from other vegetables. Comparing to the control, raised bed soil, manure compost and triple super phosphate decreased Pb vegetable concentrations whereas there was no difference between bone meal and control. Iron increased Pb vegetable concentrations by 45%, likely due to reduced soil pH. Composts increased total organic content and plant biomass, diluting soil Pb and As concentrations in tissue.

Radish had the highest concentrations of As, followed by lettuce, carrot and then tomato. Five percent of radish samples had concentrations of As greater than 0.2 mg kg^{-1}, the standard used by the Food and Agriculture Organization (FAO) of the United Nations/World Health Organization (WHO) (FAO/WHO, 2014) and the National Health and Family Planning of People's Republic of China(NFHPC) (NFHPC, 2012). All other vegetables (carrot, lettuce, tomato) had concentrations of As below 0.2 mg kg^{-1}. Iron addition had no effect on As concentration in the plant tissue. Double the amendments didn't affect Pb or As vegetable concentration comparing to the control. High levels of Mn in soil suppressed plant growth in Mn treated plots.

Correlations of Pb and As concentrations with Al concentration suggest that dust deposition and soil particle entrapment are the main contributors to the Pb and As levels in plant tissue. Therefore, rigorous washing prior to consumption can help reduce the exposure risk. This also suggests that measures to control and reduce the soil dust / deposition can effectively lower the Pb and As levels in vegetable tissues.

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Maximum water content in vegetated green roofs substrate. Effect of substrate thickness.

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Introduction

Increasing development of vegetated green roofs (VGR) in cities implies now a better knowledge of VGR abilities to decrease water runoff volume and peak flow. One of the key issue for accurate estimation of possible amount of water retention with VGR is the assessment of the substrate maximum water content (MWC). MWC is defined as "the amount of water taken up by compacted materials inside cylindrical vessel after total immersion for 24 hours in water which is then left to drip away over a 2-hour period." (FLL, 2008). This quantity is more or less the field capacity of the substrate at a given depth. Once the MWC is reach, water will drain (Sandoval et al., 2015). Generally, manufacturers give a MWC value of their substrates, expressed as a volume fraction. However, normalized protocol for the determination of MWC imposes a 10 cm length substrate sample (FLL, 2008). It appears that on the kind of substrates used for VGR (mainly composed with mineral matter and poor in organic one), this volume fraction can be different with substrate thickness and a decrease of MWC (expressed as a volume fraction) with depth was observed (Mesgouez et al., 2014; Palla et al., 2010). This abstract aims at presenting the methodology developed, based on observations and simulations, to obtain relationship between MWC and thickness of a substrate. The methodology will be first described then results will be presented. A discussion and conclusion will sum up the main points of this work.

Materials and methods

The studied substrate is generally used for extensive VGR (Gromaire et al., 2013) and is composed of a combination of natural pumice, lava, bark compost and green compost. The organic matter represents 3.4 % in mass. First step consists into determination of the maximum water content of the substrate. Objective is to observe how MWC varies with substrate thickness. For that, we followed the protocol proposed by FLL (2008) but with different thicknesses of substrate: 5, 10, 15, 10 and 25 cm. Retention curve was also realized. Relationship between volumetric water content (VWC) and suction (Ψ) was determined till a 160-m suction force. This value correponds to pF=4,2 (pF=log(Ψ) with Ψ in cm) that corresponds theoretically to the permanent wilting point. From these experimental results, modelling works was undertaken in order to have theoretical retention curve paramaters that permits us to assess MWC for different substrate thickness. Retention curve parameters of the van Genuchten model (van Genuchten, 1980) were computed by inverse modeling with RETC code (RETention Curve, Van Genuchten et al., 1991). These parameters are α, a fitting parameter, n and m, dimensionless shape parameters, Ks, the saturated hydraulic conductivity, θr and θs, the residual and the saturated volumetric water content.

From theorical retention curves, it was then possible to calculate the MWC by integration of water content over the whole substrate thickness.

Results

Experimental maximum water content

As shown in Table 1, results point out a decrease in MWC expressed as a volume fraction with the thickness, except for 15-cm depth. Error during experimentation may explain the high value observed. These results confirm those observed by Mesgouez et al. (2014) and Palla et al. (2010).

Tableau 1 : Maximum water content and saturated hydraulic conductivity

Substrate depth (cm)	MWC (% vol)
5	0.49
10	0.41
15	0.43
20	0.37

Retention curve parameters

Retention curve are presented on Figure 1. Six simultaneous values of volumetric water content and suction have been measured. Volumetric water content varies between 0.6 at saturation to 0.08 for a suction force corresponding to the theoretical wilting point. Results of inverse modeling with RETC are presented on the same figure (dashed line, correlation coefficient is 0.96) and van Genuchten model parameters are given in Table 2.

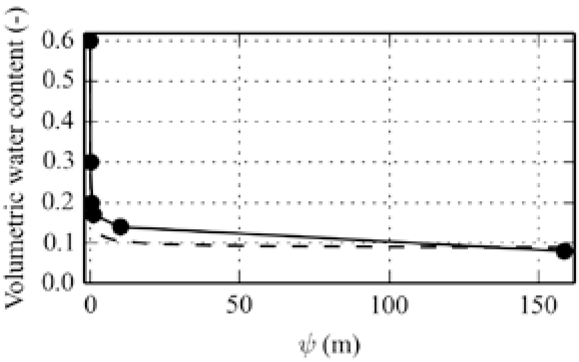

Figure 1 : Retention curves obtained from experiment (black points) and from inverse modelling with RETC code (dashed line)

Table 2 : Retention curve parameters

α (1/cm^{-})	0.38
n (-)	1.52
m (-)	0.34
Ks (cm/s)	0.085
θs (cm^3/cm^3)	0.59
θr (cm^3/cm^3)	0.084

Finally, it was possible from the results to assess MWC of VGR and to extrapolate values for different thicknesses as shown on figure 2 where MWC is expressed as a water depth. Data from van Genuchten model fit well with experimental results (once again except for 15-cm thickess). As, it could be expected from experimental observation, for the studied substrate, the relationship between MWC and thickness is not linear but has a logarithmic shape.

Discussions and conclusion

From experimental observations and modeling work, we clearly show that for some VGR substrates, relationship between maximum water content and thickness is not linear. Thus, for the determination of this key parameter in VGR water retention performance assessment, one single measurment as suggested by most of the protocol like in FLL is not enough. Thus, for a better estimation of VGR performances, a measure for each thickness or retention curve parameter could be useful.

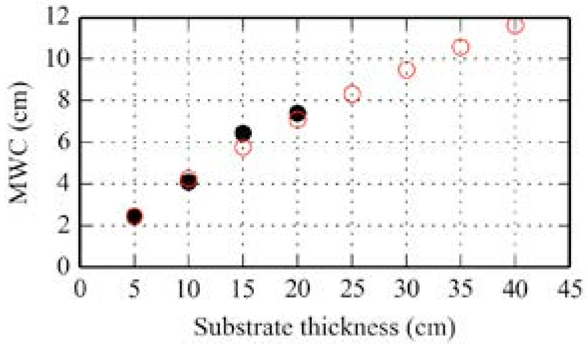

Figure 2 : Relationship between maximum water content (MWC) expressed in water depth and substrate thickness. Black points are results from observations, red points from van Genuchten model

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A trans disciplinary approach for a comprehensive overview of French gardens as complex territorial and environmental systems

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Keywords: collective gardens, urban soil, garden soil, socio-technical characterization, gardening practices, garden production, alimentation, socio-political characterization, governance, management practices, recommendations, soil remediation

Abstract

The French research program "Urban Community Gardens and sustainable cities (Jassur) is a trans disciplinary program studying practices, functions and risks associated with urban collective gardens. These gardens are growing in urban areas faced with the challenges of sustainability. The aim is to better understand these complex and multifunctional systems for a better management. The research is based on a central question: what services provide urban collective gardens? In this regard, a bio-chemical characterization of soils and products from the gardens is required. This is to evaluate soil fertility, their ability to be a support of biodiversity and the environmental and health risks due to potential pollution. All of this is contributing to qualify the food supply service. A socio-technical characterization of gardening practices is needed to evaluate the participation of garden production to alimentation and nutrition of families. In parallel, a socio-political characterization of the governance of these areas is necessary to emerge renewed management practices, recommendations to stakeholders and, if necessary, biological soil remediation processes.

Field investigations are dedicated to an evaluation of gardens combining survey, sampling and characterization of soil-water-plant-atmosphere systems. Twelve partners from research and associations have worked in the territories of seven French cities with contrasting soil and climatic conditions: Lille, Grand Lyon, Marseille, Grand Nancy, Nantes, Paris / Ile-de-France, Grand Toulouse. In terms of governance, the analysis of local public policies complements interviews with actors involved in the management of the gardens. A field sampling approach followed by characterization of soils, plants, water and air is realized to assess ecosystem services (regulation and support), particularly in terms of biodiversity and water regulation. The evaluation of the food supply service is permitted by a soil fertility diagnosis associated to the knowledge of cultural practices, productions and the measurement of consumed quantities and nutrient intake. Based on (i) the representations of the gardeners about the interests and dangers of gardens and (ii) a risk assessment related to the presence of pollutants in soils, treatability tests of bio- and phyto-remediation are made in the laboratory and in situ.

In terms of results, at French national scale, the explosion of forms of collective gardens is due to increasing and more and more diversified social and ecological expectations. At the local level, modes of governance are mixed and mobilize complex networks of actors. At the scale of the garden, the food function is multidimensional and the trend is the development of ecological practices. If the quality of garden soils is very heterogeneous, they remain fertile, they are supporting a considerable biodiversity while having locally high pollution levels due to gardening practices and to the urban environment (e.g. soil contamination, air pollution). For the gardener, food and nutritional interest may be locally challenged by health risks. In thus cases, bioremediation of heavy metal contamination is possible and an in situ demonstration test involving metal accumulating plants is conducted over several years. The overall result is the need to organize gardens nationally and to adapt regulations.

Acknowledgment

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Sorption of humic acids by microbial cell – a promising approach to introduce useful microorganism in environment

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Physiological action of humic acids (**HAs**) was demonstrated on the numerous microorganisms [1,2]. One of the possible mechanism of action is the capability to bond toxic substances by HAs [3]. Besides to decreasing toxic effects, HAs are able to mitigate positive effects too. For instance, HAs were reported to mitigate a positive influence of culture broth of bacteria on the ciliate *Tetrahymena pyriformis* [4]. Therefore, HAs can be considered as substances, mitigating both positive and negative impacts on microorganisms in soils. HAs can be adsorbed on fungi [5] and bacteria [6,7,8] and perform as active filters [9] which protect cells from various disturbances. HAs adsorbed on the cell surface (**a**HA**s**) may be considered as a kind of protecting «clothes», for cells. This effect can be analogized by the effect of granulated seed. An important advantage of aHAs in comparison to free HAs (HAs in solution), is the absence of the effect of decreasing physiological activity of HAs in soils, due to sorption on the soil surface and point stimulation on the curtain strains.

The research demonstrates the ability of aHAs , to increase stability to environmental factors: chemical (active substances clothianidin), physical (UV, drying with subsequent storage in 2,10 and 25 °) and biological (bacteriophages), which have been never shown before.

Materials and Methods:

Microorganism: *Acinetobacter* sp. is an oil breaking down strain, isolated from preparation «Destroil», *Escherichia coli* strain C600 (culture collections of the lnstitute of Gene Biology, Russian Academy of Sciences), *Solicoccozyma terreus* (culture collections of the Faculty of Soil Science, Moscow State University).

Substanses/factors: clothianidin, coliphage T4, ultraviolet radiation (254 nm, Vilber Lourmat), drying (40°C) and storage microbial cell (+25, +10, +2 °C).

HAs: The HAs used (Merck, Germany) had an average molecular mass of 20 kDa and the following composition (%): C, 40; H, 37.8; N, 4.2; O, 18.

The creature of aHAs: Adsorption HAs was carried out following the standard procedure [10]

The effect of clothianidin on the growth of *Acinetobacter* sp. was detected by spectrophotometry method (620 nm), the effect of UV and time of storage was detected by cultivated microorganisms on universal growth agar media, *Escherichia coli* was grown on LB agar.

Result and discussion:

Protection cells *Acinetobacter* sp. against pesticide: Pesticide resistance of *Acinetobacter* sp. was increased in presence of aHAs. The greatest effect of protection from pesticide was observed in terminal adsorption (all active sites were occupied).

Protection cells *Acinetobacter* sp. and *Solicoccozyma terreus* against UV: Control cells and cells with aHAs UV treatment during 1 minute (for *Solicoccozyma terreus*) and 10 minute (for *Acinetobacter* sp.). The aHAs protect cells both of *Acinetobacter* sp. and *Solicoccozyma terreus* against UV. After UV treatment the titer was reduced by two orders of magnitude (for *Acinetobacter* sp.) and one order of magnitude (for *Solicoccozyma terreus*) in control, whereas the comparison titer was reduced twice (for *Acinetobacter* sp.) and in 1,6 times (for *Solicoccozyma terreus*) for aHAs (Table 1).

Table 1. CFU microorganism affected by UV radiation

Variant	*Acinetobacter* sp.	*Solicoccozyma terreus*
Control	$10^7 \pm 10^6$	$4,8x10^7 \pm (1,3x10^6)$
Control + UV	$10^5 \pm (4,3x10^5)$	$4,5x10^6 \pm (6,5x10^5)$
sHA	$10^7 \pm (1,2x10^6)$	$3,5x10^7 \pm (8,7x10^6)$
sHA + UV	$4,5x10^6 \pm (4,5x10^5)$	$2,1x10^7 \pm (4,5x10^5))$

Protection cells *Acinetobacter* sp. against drying and storage: Biomass of culture were dried in 50 ml sterile vilals during 10 – 12 hours at 40 °C, then closed and incubated at +25, +10, +2 °C during 1 year. Counting of colony was carried out at 6 and 12 months. Figure 1 presents the graphs of reducing bacterial titer over time. Reduction of bacterial in control was more rapid in comparison to the aHAs .

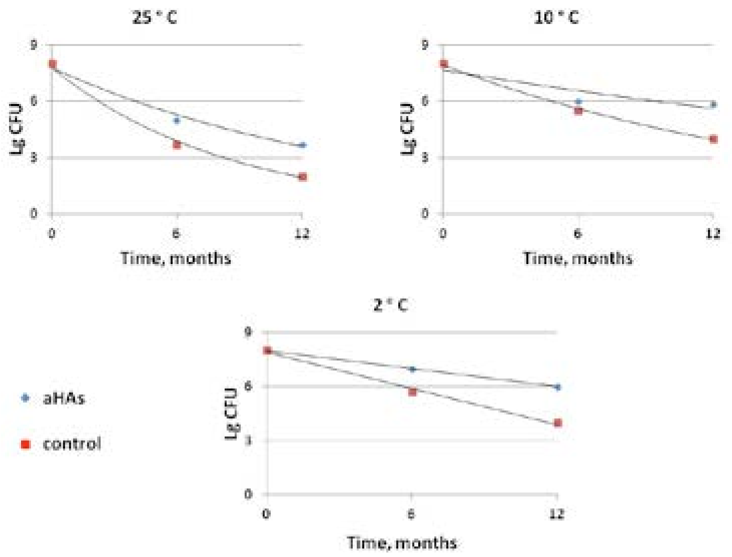

Fig.1. Decrease titer *Acinetobacter* sp. during storage at different temperature.

Protection cells *Escherichia coli* against coliphage: In first part of the study we examined the interaction of HAs with coliphage in solution. For this purpose the purified phage T4 was incubated in solution of HAs with different concentrations during 30 minutes. After that the phage was applied to the surface Petri dish with *Escherichia coli*. In the case of phage infection of cells, there were empty spots on the agar. Control variant and variant coliphage+HAs didn't differ. Thus, HAs in solution didn't affect the sorption phage on cells *E. coli*. In the second part of the study we explored an influence of aHAs on detection cells by coliphage. In this case we treated aHAs and control cells with phage. Finally, on Petri dish with aHAs cells were less empty spots in comparison to control variant. The aHAs prevented sorption coliphage T4 on cells *E.coli*. Apparently, HAs bind cell receptors and coliphage aren't able to detect cells.

Thus, HAs can be considered as a universal adaptogen. Due to the absorption properties of HAs, in our opinion, it would be applicable to create artificial structures with aHAs and various substances for a successful introduction useful microorganism in environment. We have already shown the possibility use of aHAs to eliminate soil contamination by hydrocarbons [10]. The Figure 2 presents the model of protection aHAs microbial cell and the creation of artificial systems with HAs.

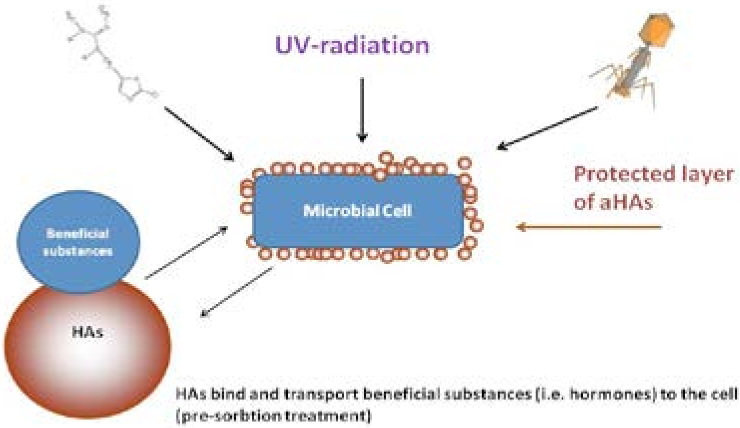

Fig. 2. The model of protection aHAs cell with chemical, physical and biological impact and the creation of artificial systems with HAs before the sorbtion of HAs.

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Urban soil as a cultural heritage

Carbon storage and carbon dioxide emission in urban soils and sediments of ancient cities of European Russia

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Soils and cultural layers of ancient cities are the examples of soil systems strongly transformed by the anthropogenic activity. It is of great interest to study the entire thickness of urban deposits together with the soils buried under them (Alexandrovskaya, Alexandrovskiy, 2000). Such studies have shown significant differences between urban soils and urban sediments of ancient cities and towns (urbosediments, habitation deposits, cultural layers) developed in different landscape zones (Alexandrovskaya et al., 2001; Alexandrovskiy et al., 2012; 2013; 2015; Bronnikova et a., 2003; Dolgikh, Alexandrovskiy, 2010; Engovatova, Goyeva, 2012; Golyeva et al., 2016a, 2016b; Mažeika et al., 2009; Mazurek et al., 2016; Sándor and Szabó, 2014). Over the centuries, layers of habitation deposits (or archaeological cultural layers) of average 3-5 m, in depressions up to 15-20 m in thickness have formed in towns and cities of Europe. These specific deposits partially transformed by pedogenesis and containing the profiles of weakly developed buried soils, as well as the underlying initial natural soils, and may be referred to as urbo-sediments (Alexandrovskiy et al., 2012). They consist mainly of the remains of buildings constructed out of wood, stones, bricks, or other materials and may also include traces of manure and diverse municipal wastes. Their composition and morphology depend on the natural conditions of the territory.

In the humid northern forest regions of Europe, the accumulation of wood remains, manure, and other organic substances is active. Thus, organic urbo-sediments are formed and the decomposition of organic matter in the deposits is hampered due to the high moisture content (Dolgikh, Alexandrovskiy, 2010). Thick urbosediments (habitation deposits, up to 7m in the oldest center) with high organic carbon content (10-35%) were formed in the historic center due to a long history of development of the Veliky Novgorod since the 10th AD (58.52500 °N,31.27500 °E; weak drainage, North-west European Russia). The thickness of organic layer in the periphery of historical center is 0.5-1.5 m and less than in the main area of historical center.). The organic horizons in the urban sediments prior to the 18th AD have the most acid reaction in the entire profile (pH <5.8). The overlying dark gray urbo-organic-mineral layer (1-1,5 m) accumulated during the 18th-20th AD. It is much richer in the mineral mass, although the content of humified organic matter is also high. This layer is relatively dry. The wooden chips in it are strongly decomposed; inclusions of limestone, bricks, sand and clay interlayers, and lime are also present. The reaction is neutral to slightly alkaline (pH 7.5–8.0); the organic carbon content reaches 2–12 %.

We observed similar properties in the urbosediments with high organic matter content in other old urban centers of the forest zone of European Russia- Rostov Velikii, Staraya Ladoga, Staraya Russa. Also in the forest zone, but under better drainage conditions (Moscow and Yaroslavl for example), active mineralization of organic matter and partial humification take place. The thickness of the organic layer is reduced, and the main part of urban sediments is represented by the mineral layer. Well-developed organic layers, similar to those described in Novgorod, can be found in Moscow in large depressions in the relief and in buried river valleys and ravines. They are also present on flat interfluves, where they alternate with plots in which the organic layer is absent. At higher topographic positions in the upland areas, the thickness of the initial organic layer is reduced, transformed into an organo-mineral or a humified mineral layer. In lower organo-mineral layers organic carbon content is 5-15%, in upper mineral layers – 2-5%

On the basis of long-term geoarchaeological research, data of geological drilling (Kushnir, 1960) and archaeological interpretations (Petrov, Tarabardina, 2012) calculation of carbon stocks in urbosediments in historical center of Velikii Novgorod were made. Carbon stocks in urbosediments of historical center (4.5 km2) is 1.95×106 t (4333 t C per ha). It is higher than content of organic carbon in cultural layer of

Moscow – 6-7×106 t (Alexandrovskaya, Alexandrovskiy, 2000) or 10.645×106 t (Vasenev et al., 2014) for full square 1000 km2 of Moscow.

Comparative studies of soil carbon dioxide emissions were held in natural and anthropogenically transformed landscapes of the southern taiga (Novgorod region.). Measurements of emission by closed chambers method were carried out in the natural spruce forest, arable land, post-agrogenic meadow and forest, residential areas of different ages in Veliky Novgorod. The values of soil carbon dioxide emissions in the city are depends on the capacity of the transformed urban deposits and its content of organic carbon. Reduction in soil emissions 2.35 times and decreasing carbon stocks were revealed from the historical center to a modern residential areas. The maximum values the of soil carbon dioxide emissions in southern taiga (Novgorod region) are corresponds to ancient residential areas of the city center, the minimum - agricultural arable lands. Hydromorphic organic layers of urbosediments (10-15th AD, raw organic material, organic carbon 20-35%) in the historic center of the ancient cities can be important storages of adsorbed carbon dioxide. The results of field experiments and modeling of pulsed carbon dioxide emissions from hydromorphic organic urbosediments (Veliky Novgorod) were showed that the thick urban habitation deposits are accumulated significant amounts of carbon dioxide at a distance from the soil surface (Smagin et al., 2016).

In the ancient and medieval towns in the semi-arid steppe zone of Europe, such deposits consist of remains of mudbrick or adobe made of loess. The thickness of urbosediments of Pahanagoria (the largest ancient Greek city on the Taman peninsula 6th BC-9th AD; 45.27694 °N, 36.96611 °E; semi-arid steppe zone; South of European Russia) reaches 5.5 m. Urbosediments accumulated under the impact of anthropogenic activity differ from the natural sandy substrates; urbosediments are mainly derived from the debris of sun dried bricks made of marine clay with some admixture of clay (Alexandrovskiy et al., 2012). The development of soils and urbosediments in ancient cities of European Russia was specified by the continuous accumulation of construction debris and other wastes, anthropogenic turbation of the material, arid climate, and the predominance of steppe vegetation. Under conditions of the dry climate of the Taman Peninsula coupled with good drainage and aeration of the cultural layer, the transformation of organic and mineral substances was very intense. Carbonates are present throughout, although their distribution in the profile is rather irregular. The organic carbon content is low (up to 1 %), with a slight increase in the *Chernic* horizon (2.27 %) developed from the urban sediments. The similar concentration of soil organic carbon are typical of urbosediments of other ancient cities of semi-arid steppe zone (Alexandrovskiy et al., 2015).

Thus, the urbosediments of ancient cities in the humid forest zone is a huge reservoir of organic carbon. Organic carbon and carbon dioxide from low waterlogging organic layers can be available for modern carbon cycle in the case of changing modern soil hydrological conditions in ancient cities. Organic carbon content in urbosediments of ancient cities in the semi-arid steppe zone is less than in topsoil and more than in subsoil horizons of background soils.

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The record of the history of anthropogenic landscape transformation in the actual soil cover of the New Jerusalem Monastery

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Soils of the monastery play the special part of urban soils. They don't play the only important role for the sustainability ecological function of the urban environment and save the memory about historical evolution and the ways of the nature and anthropogenic landscape. The New Jerusalem monastery is the Federal target object and one of the largest cultural and historical monuments. The New Jerusalem Monastery is situated in Istra city, Moscow Region. It was built in 1656 year by Patriarch Nikon. The territory surround of the monastery had transformed and bethink like natural cultural landscape reproducing the topography of The Holy Land according to the conception of «The Russian Palestine». The monastery was one of the most popular center of pilgrimage in the XIX and in the beginning of the XX centuries.

There are several steps which include of the anthropogenic influence on the territory of the monastery. The most important are connected with building and operation of monastery, although the beginning of the agricultural development of the territory dates back of the iron century (Ershov I. N., Aleksandrovskiy A. L., Ershova E. G. et al. 2014). The monastery was built in the bend of the river Istra on the hill of nature provenience congruent to the second terrace above the flood-plain which occur moraine, fluvioglacial deposits and alluvium sediments of the different ages. The investigations of soil cover inside walls of the monastery and on private territory were in 2012 – 2013 years. Soil profiles were described inside walls of the monastery in the different types of the land uses: near the avenue of arborvitae on site of the grave yards of XVII century, under the Apple – trees garden, on the grassplot near the south wall of monastery, although on the north hillslope of monastery from the Inoplementing town to Kedronskiy's flow course.

The territory inside of the monastery walls was exposed to the greatest transformation, which concerned to fills and strengthening for slopes of the hill, the construction and repair of the monastery buildings, several fires, the destruction during the years of The Great Patriotic War, archaeological excavation and etc. The natural soil cover have been completely destroyed and the natural ground in the different historical periods covered by anthropogenic deposits rapidly as a result of this transformation. The anthropogenic deposits are widespread of all the territory of hill and are represented by clay, sand including waste (broken brick and 50 % limestone) and have a thickness from 0,1 to 0,8 meters.

On the territory inside the monastery walls we was investigation the Urbic Technosols on technogenic deposites, bubbling up from HCl, starting from the surface. The soil profiles divided into the densely penetrated by roots sod horizon, urbistratified horizon with inclusions of brickbat and limestone, which is sharply changed to the technogenic sediments. There are not soil formation characters between the separate technogenic horizons. The technogenic horizons underlied stratified alluvial sediments. The upper horizons of soils were characterized of carbonate – argillaceous – humic composite of plasma, the highest biogenesity with wealth coprogenic zones, the aggregated matter, which testified to presence the modern humic – accumulative process according to the results of micromorfologycally studies.

The Urbic Technosols on technogenic sediments was described in the Apple – trees garden, which was newly planted on the territory of monastery in 70st years of XX century. Its profile differed from the above soils of bigger depth of stratification thickness which was necessary for roots system development of fruit trees.

The Urbic Technosols were formed on the steep slope side of the second terrace above the flood-plain, on allochthonous subsoil maked up from outside to strengthened the walls of monastery. The thickness of the filling layer which including brickbats amounted the 90 cm. The humus horizons formed in its upper part. Below its underlay technogenic bed or buried subsoil.

The texture of humus horizon of all the soil which formed on filling layer was sandy – loam. Sandy fraction make up 60 – 70 %. The abundance of limestone in technogenic sediments as a formed of inclusion in soil thickness determined the actually reaction of anthropogenic soil – alkaline, weakly alkaline and neutral reaction. The content of exchangeable calcium and magnesium in humus horizons of anthropogenic soil from 8 to 15 cmoll(eq)/kg, it decrease down to 8- 14 cmoll(eq)/kg. In a majority soils the content of humus was low. The Urbic Technosols were differed of the more humus content – 3 – 5 %. In the technogenic subsoil the content of humus less 1 %. The very higher content of labile phosphorus typical for all soils, it was associated preeminently with the cultural layer.

The anthropogenic soils contaminated of heavy metals. The content of labile forms of zinc and cadmium achieved the MAC in soil of garden, located inside of monastery walls and created on imported soil. The excess MAC of nickel, copper, zinc and specially lead was marked in the Urbic Technosols on technogenic sediments.

The natural alluvial soil outside of monastery walls in the valley of river Istra suffered less anthropogenic transformation. Areas of valley were uses like hay-field, garden and tillage. Haying influenced on the changes in the biological cycle of substances. The soils saved morphological characteristic feature, but the result of the construction Istra reservoir in 1937 year, damming, put off the flood pattern, reduction underground water table in soil was impairing sings of gleying and annual alluvial sedimentation stopped. The studied soils were classified as Distric Fluvisols and Eutric Fluvisols. The soil cover was disturbed during the construction various engineering structure of Bogoyavlenskaya Pustyin (The Cell of Patriarch Nikon) on the particular areas. During the period of Nikon the hydrological regime of soil was essentially changed as a result of the construction the complex hydrological system, which including the complex interrelated partially systems of ponds and «Kedronskiy flow» flume surrounding the monastery on the north, west and south. Later, after the degradation of monasterie's hydrosystem the main role played the highway engineering «Buzharovskoe roadway», which cutting the part of the valley of the complex of monastery. Creation The Gethsemane garden significantly affected on landscape: tree planting near the west walls of monastery (now the park area « The Museum New Jerusalem's»).

In 2009 – 2016 years after extensive restoration works for reconstruction the architectural complex of monastery the top target was preservation natural – landscape environmental of historical heritage, recreation natural – anthropogenic landscape without which it is impossible perceptual unity «The Russian Palestine». Given the prospective tourist development and pilgrimage it was actually of infrastructure development which will be based on complex investigations of soil.

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The soils of Saint Petersburg at the time of Peter the Great

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Introduction and area description. Saint Petersburg is situated in the north-western part of Russia. The climate is humid continental, the average annual temperature is 5,8°C and average annual precipitation is about 660 mm. The city lies on a terraced lowland. The first terrace is coastal lowland (absolute height up to 3, 0 m), gently sloping toward Finnish Gulf. The Littorina Sea (the last stage of the Baltic Sea evolutionary development) flooded the terrace several thousand years ago. The historical part of the city situated on this terrace, divided by numerous rivers (the Neva and its distributaries, the Fontanka, the Moyka and others). The urban soils tend to waterlogging due to the flat terrain and water-bearing surface deposits, combined with the wet climate conditions.

Saint Petersburg is a young city; its history began about 300 years ago, at the epoch of Emperor Peter the Great. Although, poetic utterance of A. S. Pushkin that Petersburg was born "from darkness of forests, from marshy swamps" is not utterly correct. Numerous settlements had been along rivers Neva, Fontanka and others in the 17th century already. The population were engaged in agriculture, so there were areas of arable land. The Swedish town Nyen (fortress Nyenscans) was located at the confluence of rivers Okhta and Neva.

The aim of this paper was to characterize the buried native soils of Saint Petersburg of the epoch of Peter the Great, discovered during the soil and archeological research.

Methods. Soils were identified using Russian soil classification system (2004) considering additions proposed by Prokofieva et al. (2014) and also according the World Reference Base (IUSS Working Group, 2014). A set of traditional analytical methods was used to obtain chemical characteristics of soils (Vorobieva, 2006).

Results and discussion. Archaeological excavations revealed that even the slight rise of water (by 1-2 m) caused flooding of Nevsky avenue and other low places in the 18th century. Impact of periodic flooding is traced in the alternating humus and yellow loamy sand horizons in soil profiles, described in Winter Palace inner yard, on Sredniy avenue of Vasilievsky island, on Aptekarsky island, Nevsky avenue, in Summer Garden. Therefore, the drainage construction and uprising of surface level by addition of earthy materials were priorities at the early stages of Saint Petersburg's development. The burying of native soils occurred during city construction, paving, rising the territory to reduce the excessive moisture, etc.

The thickness of filled-in and cultural layers in the historical part of the city typically is 0,9-2,0 m. Anthropogenic layers contain construction debris and household waste, mixed with loamy or sandy fine earth material. The thickness and composition of anthropogenic layers reflected the history of urban development. The cultural layers formation was intermittent in time. Archeologically significant cultural layer is preserved in Saint Petersburg not more than by 30%.

The rare high degree of preservation distinguished the cultural layer (190 cm in thickness) on the territory of Kasansky square. Here in the excavations the traces of the settlements of the first citizens of Saint Petersburg could be seen: remains of wood flooring, well frame, parts of leather shoes, pottery, etc. The rise of the territory in the city center slowed after granite embankments of rivers Neva, Moyka and Fontanka have been constructed. According to data of soil and archaeological excavations the period of intensive growth of the cultural layer on Nevsky avenue (up to 70 cm) occurred in 1830-1900 and stopped in the beginning of 20th century. It is known from evidence of contemporaries that Nevsky avenue was paved with stone even at the time of Peter the Great. Two cobblestone pavements, one over another, were found near the wall of ancient church in the cultural layer of Kasansky square (fig.1, a). The upper pavement, which was located at the depth of 1 m, was dated by the middle of 18th century. The lower pavement (at the depth of 1,6 m, absolute height 1,29 m) probably dates back to the era of Peter the Great. The pavement, found at such depth, indicates to the grand process of Saint Petersburg formation.

a b

Fig.1. a - Urbostratozem with two buried pavements (Kazansky square); b - Urbostratozem on peat soil (park Ekateringof)

The most abundant native soils in the central part of Saint Petersburg are grey-humus gley soils (Umbric Gleysols), which found under filled layer in Kasansky Square, in Sheremetev's and Derzhavin's gardens, on the 11th line of Vasilievsky island and other places. These soils were formed on Littorina marine loamy sands. The humus horizon characterized by dark grey color with a steel shade, it sometimes contains fragments of roots and stems of marsh plants. The lower horizons are heavily moistened and gleyed. Redoximorphic conditions expressed in the form of rusty ocher and bluish mottles abundance and ferrugination along root traces.

Arable grey-humus gley soils were found under cultural layers, on the depth of 195 cm, on the place of town Nyen. The remains of cereals and ruderal plants have been preserved in these soils. Profile of the ancient arable grey-humus gley soil, which had thick (more than 30 cm) humus horizon, was found under cultural layer (127 cm in thickness) in square of Twelve Colleges. Arable grey-humus gley soils, fertilized by ashes, with ruderal plants remains, occurred also in Summer Garden. All these data evidence that the territory, where Saint Petersburg is located, was inhabited and subjected to human impacts long before arrival of Peter the Great on the banks of the Neva.

In the more elevated drained area, on the 15th line of Vasilievsky island, gleyed iron-illuvial podzol (Albic Podzol) was found on the depth of 112-115 cm. Under the podzolic horizon (4-5 cm in thickness) were the ocher iron-illuvial horizon and gleyed BC horizon with olive spots and stains and ferruginous dendrites along the root hollows.

Soil-archeological investigations in the Sheremetev's garden allowed to find traces of the original layout of an ancient garden, remains of a fountain on the central walkway and the native alluvial grey-humus gley soils (Umbric Fluvisols), buried on the depth of 92-94 cm. In the courtyard of the manor the buried native soil is located on the depth of 175 cm, it has dark-grey with brown shade humus horizon (31 cm in thickness). The soil forming material is bluish gray loamy sand. Several wooden stakes, charcoal pieces, and an iron pin were found in the humus horizon. Presumably, in the 18th century the soil was on the edge of the small harbor where boats moored in front of the main entrance.

Park "Ekateringof", which originated from a country residence of Peter the Great, built in 1711 for the spouse of the Emperor. There were found native peat soil (Histosol) under cultural layer (156 cm in thickness) (fig.1, b). The peat consists from remains of sedge, the degree of decomposition is medium (30-35%).

The soils of Saint Petersburg, both surface and buried, has light texture (sand or loamy sand). This fact in combination with humid climate promotes the deep penetration of solutions through soil profile. As a result, alkaline reaction could be found not only in anthropogenic layers, but also in buried native soils (table 1).

Table 1

Selected properties of surface and buried humus horizons

Horizon	Depth, cm	pH H_2O	Total organic C, %	$CaCO_3$, %
Urbostratozem on buried soddy gleyed podzol (Urbic Technosol over Gleic Albic Podzol) –Sheremetev's garden				
UR1	0-10	7,7	3,80	15,3
[AY]	94-107	8,0	3,96	0,2
Urbostratozem on buried grey-humus gleyed soil (Urbic Technosol over Umbric Gleysol) –Sheremetev's palace, courtyard				
UR1	0-31	7,4	3,30	0,6
[AY]	175-206	7,9	1,39	0,1
Urbostratozem on buried grey-humus gleyed soil (Urbic Technosol over Umbric Gleysol) –Summer Garden, p.1				
URay	0-18	6,7	4,01	8,8
[AY]	118-127	7,8	0,93	1,9
Urbostratozem on buried grey-humus gley soil (Urbic Technosol over Umbric Gleysol)- Derzhavin's garden, p.8				
URay	0-15	7,2	5,37	2,9
[AY]	155-171	7,7	1,94	1,3

The carbonate content in anthropogenic layers varies from 1 to 39%, whereas the presence of carbonates isn't typical for the native soils and soil forming materials. Humus content in the surface horizons of urban soils exceed the humus content in humus horizons of studied buried native soils. The native soil horizons, unlike anthropogenic ones, are not contaminated by heavy metals.

The urban soils of Saint Petersburg, consisting from heterogeneous anthropogenic layers and buried native soils, exist as a single functional entity.

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Urban soils as an indicator of authority's horticultural and environmental level

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Complex of soil-forming factors: parent rock, biota, relief, climate and time forms soils. Moreover, urban soils are formed under the participation of an extra one – an anthropogenic factor. The anthropogenic factor that connected with economic activity can be either universal or specific. Under the universal anthropogenic factor, physical and chemical properties of soils evolve most: soils become denser, its water retention capacity declines, pH of the soil increases to neutral and lightly alkaline, the decomposition rate of organic matter diminishes, and its quantity increases. The amount of phosphorus, heavy metals and persistent organic pollutants increases; impenetrable materials and constructions (concrete, asphalt, and buildings) seal part of soil surface. These specific changes have been observed in all cities, only the magnitude of change differs: in strongly urbanized areas and in the city center changes are greatest, in natural areas they are minimal (Burghardt, 1994, Stroganova et al.,1998).

Specific influence can be connected both with functionality of the territory (for example, organic pollution of soils near gas station, a large amount of Calcium and alkaline reaction of the surface soil horizons near cement and concrete plants), and the history of the territory's development.

In the cities soil profile gradually grows up, the more senior the city is the powerful cultural layer it forms, the more horizons in the soil profile that testify habits and technical progress of citizens. Every era leaves its mark in the buried soil horizon. For this reason during the work in the cities, archeologists usually work together with soil scientists (Chernov et al., 2004).

Construction works leads to deleting history of place written in soil profile. Therefore, sites where the soil profile formed for centuries has remained become more and more valuable. Certainly old gardens and parks are among these valuable sites.

Since the end of the 1990-th we carried out work on studying of soils of historical botanical gardens and parks in Moscow, St. Petersburg and Tver (Stroganova, Rappoport, 2005; Rappoport, 2003). Soil properties (morphological, chemical, biological), the structure of the soil and factors leading to formation of specific soils widespread in old parks have been studied.

It has turned out that specific conditions related to qualify care of plants form the unique soils that we called recreazems (Stroganova, Rappoport, 2005). These soils differ both from well investigated urban soils of residential and industrial areas, and from natural soils of urban forests. Besides informative soil properties, studying of these soils allows to draw a conclusion on high culture of gardening of our ancestors. The formation of fertile horizons 30-50 cm thickness demanded remarkable efforts of import many tons of fertile material by horses (Rappoport, 2003).

This layer is buried at a depth of 40-80 cm from a day surface now, but it has medium amount of available forms of potassium and phosphorus and medium and high microbiological activity (and it at a depth about 1 m and even more deeply!). In these horizons roots of trees which find necessary nutrients and water here, in the uncontaminated buried humus horizons often meet.

Supply of numerous amount of fertile soils by the cartage – huge business, and we admire gardeners of the last centuries who projected and created remarkable landscapes. Nevertheless, very few people understand that competent work with the soil is the cornerstone of these magnificent landscape ensembles. Studying of soils of old parks allows to estimate the speed and the direction of transformation of artificially created soils and soil material and to find useful solutions for modern green urban territories.

As we with interest study artefacts and evidences of horticultural knowledge in the buried horizons in soils of botanical gardens and parks, future generations will study marks that we left today.

There will be certain markers in the soil – symbols of our time that will be able to tell a lot to future generations about us, our relation to soils, to plants and environment.

Among these symbols of our time could be the following:

The top or subsurface humus horizon with the high gross content of lead – for many years, gasoline contained additives with lead (so-called leaded fuel). At the beginning of mass motorization, very few people thought of harm for health of lead.

A large amount of peat in topsoils of green areas. Since 1990-th years, fertile mixes based on peat with small supplement of sand were used for creation of lawns. Destruction of wetland ecosystems, delivery of a huge amount of peat to the city and its further decomposition (or even burning) with allocation of a large number of CO_2 – even bigger, than allocations from motor transport (Smagin, 2012) – all this show low biological and agronomy literacy of the people responsible for horticulture in Moscow. It is also a consequence of lack of environmental laws on protection of wetlands – extremely valuable and fragile natural ecosystems.

Number of compacted humus (or urbic) horizons in soil profile as the technology of creation of green plantings on the residential and green territories practically everywhere is broken and underlying layers of soil do not plough before deposition the following.

The widespread detection of crushed granite and marble (2-5 mm fraction), will become probable a big riddle for scientists of the future who will study the Moscow soils. It is just our modern tradition of use of deicing reagents (https://ria.ru/spravka/20121016/903105508.html).

The increased contents of Zn and Ti in Moscow green territory's soils that is partly connected with trees spring whitewashing (Zn and Ti oxides – are white pigments of paint). The Moscow authorities have ceased to whitewash trees as this procedure is useless for plants and leads to pollution of the soil by chemical compounds of paint only last 3 years.

Small quantity of coprolite in the humus horizons: cleaning of foliage, lack of watering and the wrong lawn care leads to soil mesofauna diversity and number decrease, including earthworms who actively participate in soil structure formation (Stroganova et al., 1998).

It has to be noted that the most part of Moscow territory traces of modern greenery management that remain in soil, does not characterize our time as time of high horticultural level, with any significant achievements in the field of urban greenery agronomy and care of the environment.

In 2015-2017 the "Zaryadye" park on the place of the demolished hotel "Russia" near the Kremlin in the center of Moscow is created. In the park over underground constructions by deposition of sand and a foamglass the artificial relief was formed. On surface plant communities similar to natural tundra, fir forest, pinewood, birch forest, deciduous forest, steppe and subtropical plot were designed. Development of soil layers and the range of plants has been created by staff of MSU Botanical garden and Main Botanical garden of RAS.

According to the experience of cultivation of wood plants in the MSU Botanical garden, it wasg offered to make a fertile layer with power up to 1 m under wood vegetation and up to 0.5 m under perennials. At the same time chemical properties and particle size distribution of soils were selected individually for each zone taking into account requirements of plants and specifics of use of the park – extremely intensive recreational impact as the park has to be open for free visit all the year round.

Certainly, it is a risky experiment, but it will show as far as we understand the processes happening in city soils. As far as we have learned to create artificially the soil and an agrotechnical background which will allow in initially adverse conditions of the city to create nature similar plant communities from extremely different zones from the tundra to subtropics.

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The threat of technogenic soil pollution on the territory of the Museum - reserve “Kolomenskoye”

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The territory of museum - reserve “Kolomenskoye” is a landscape-architectural complex that includes the world-famous monuments. Natural Foundation has the same cultural-historical value as an architectural ensemble. In “Kolomenskoye” grows many age-related plants. Here is preserved the trees of English oak (*Quercus robur*), planted in the 16th century, fragments of the landscape Park “Lipki” and the avenue of limes, planted in the early 19th century, the city’s only grove of European ash (*Fráxinus excelsior*), well known in Moscow gardens of Kolomenskoye.

The proximity of the big city creates a huge recreational load, therefore the pollution of air, soil arises. The conditions of the flora existence and development are deteriorated.

One of the major aims in the environmental activities of the museum – reserve is the maintenance, preservation and restoration of the natural environment.

The automotive pollution produces a special danger. Motor transport moves through Prospekt Andropova road and Kashirskoe road. The ecological condition of the reserve is largely dependent on atmospheric precipitation, especially the left-bank part of Moscow. Here the dust, carbon monoxide and carbon dioxide gases, oxides of sulphur, nitrogen etc. remains the most important pollutants.

In this regard, the objectives of the study were to assess the anthropogenic load on natural objects on the territory of the reserve depending on distance from the highway.

To fulfill environmental studies the method of snow and soil probes sampling was developed. The samples were analyzed for heavy metals (HM) content.

In accordance with the description of soil crust, the territory of the Museum-reserve belongs to the soddy podzolic light loamy deep cultivated loamy clay soils.

Description of the soil unit. Museum-reserve “Kolomenskoe”, Voznesenskiy Garden

Ad (0-8 cm)	brownish-dark gray, small spots of whitish material, medium blocky -grainy-powder-like structure, many roots (sod layer), sandy loam, inclusions of anthracite, dusty crumbs, porcelain, noticeable by color and wavy horizon boundary
A old-arable (8-40 cm)	sandy loam, grayish-brown, crumbly-powder-like structure, packed soil, many small and medium roots, inclusions of anthracite, brick, noticeable by color and wavy horizon boundary
A2B (40-62 cm)	uneven color: there are whitish spots on a light brown background, medium blocky - powder-like structure, medium loam, white silica powder, average number of roots, small worm tunnels, noticeable by color and smooth horizon boundary
B1 (62-104 cm)	uneven color: there are whitish spots on red-brown background, medium loam, the medium blocky structure, whitish and wavy horizon boundary light loamy mottles, roots, inclusions of anthracite, layer of clay, wavy horizon boundary
B2 (104-110 cm)	red-brown, separate whitish spots, prismatic structure, loamy clay, small worm tunnels, layer of clay

Dependences of chemical parameters changes of snow in connection with the distance from the highway are fixed. The HM content in the filtered water is low (table 1), but in solid residue of snow samples is high (table 2). This suggests that the physical state (aerosol, dust, colloidal, etc.) in which they enter the atmosphere, is strongly adsorbed on the surface of the snow and forms large particles.

Table 1. The contents of trace elements in filtrates of snow samples, mg/l

The distance from highway, m	Pb	Cd	Zn	Ni
2	0,0002	0,0014	0,13	0,003
7	0,0002	0,0010	0,02	0,003
25	0,0002	0,0014	0,02	0,003
50				

Table 2. The content of trace elements in the solid residue of snow samples, mg/kg

The distance from highway, m	Pb	Cd	Zn	Ni
2	115,91	0,88	335,19	18,89
7	86,85	0,90	220,90	16,81
15	121,26	3,24	257,04	62,60
150 (control)	173,33	5,33	402,67	18,97

These data indicate a real threat of pollution, not only the territories adjacent to the highway but remote areas. And this is connected not only with the intensity of inflow of pollutants, which is closely related to distance from the road, but also with the ability of HM to stay mainly in the finer fractions, which contributes to their penetration into the territory. The total load close to the road (2m from the fence into the Park) is ~ 470 mg/kg and for the control area (200m from the fence, in the Park) is ~590 mg/kg, almost 20% more.

Environmental status of the study area was also determined by the concentration of HM in soil and by bioassay method of soil samples, from different “signal” or “reference” points on the reserve territory. The results for some used for assessing the total toxicity of the test cultures is illustrated in figures 1-3. The toxicity by bioassay was determined in the samples taken near the Prospekt Andropova road, that was confirmed on the other test objects increasing the lethality of test cultures.

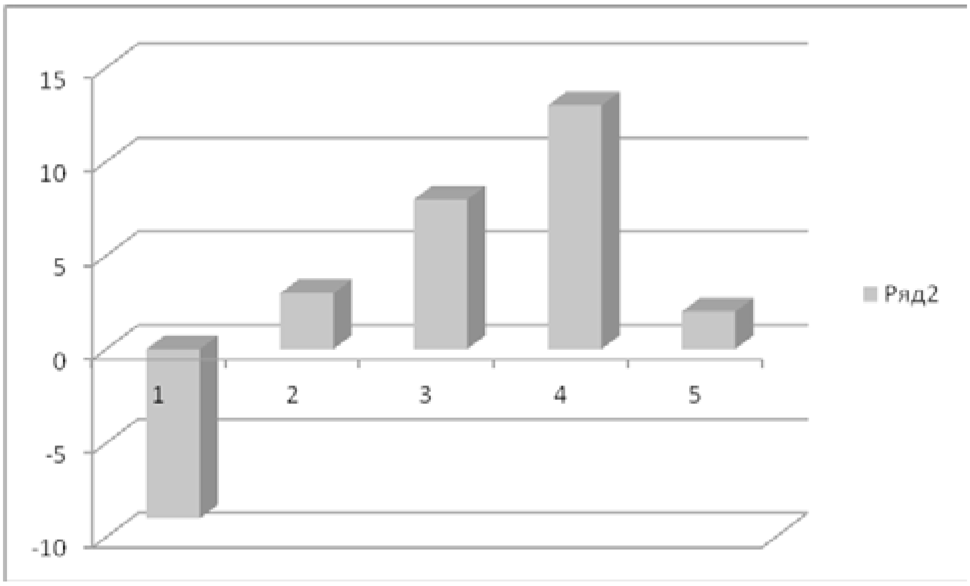

Figure 1. Bioassay (test-object: *Redish seeds*; test-parameter: the length of roots, %).

Notice: 1. Close to Prospect Andropova road.
2. The lawn near the administration.
3. Near the Apothecary garden.
4. Near the Kazanskiy garden.
5. Moscow river descent

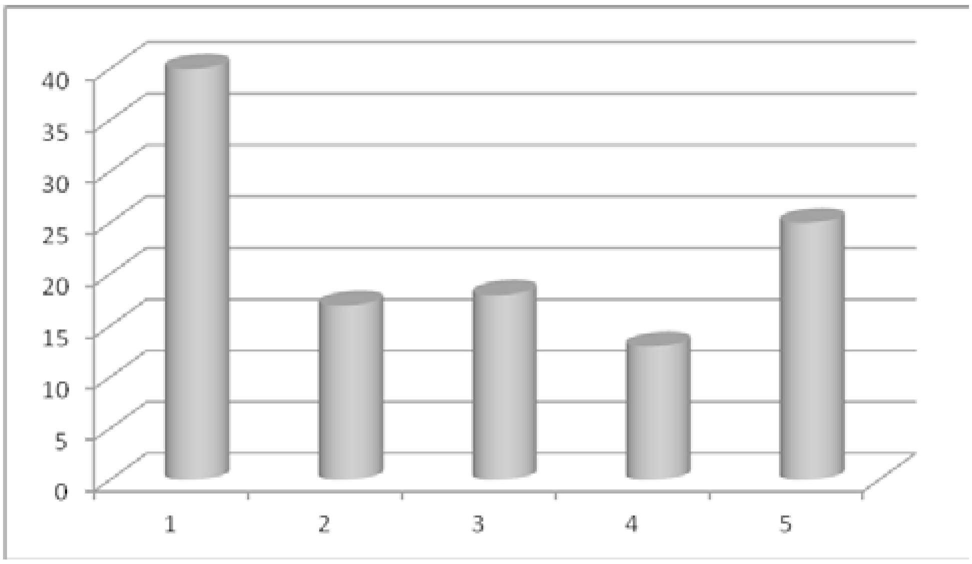

Figure 2. Bioassay (test-object: *Paramécium caudátum*; test-parameter: lethality, %.)

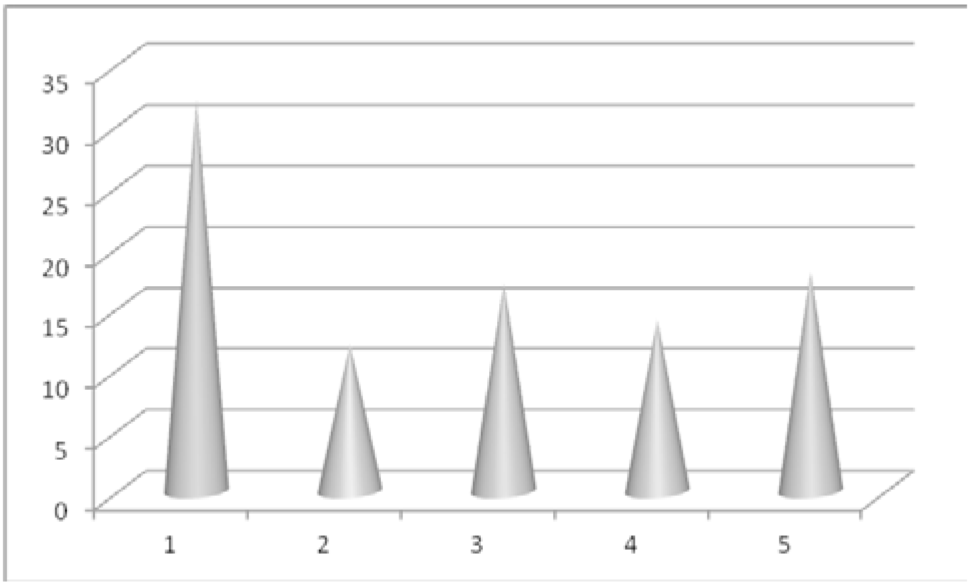

Figure 3. Bioassay (test-object: *Daphnia magna*; test-parameter: lethality, %.)

The exceeding of HM content established only for cadmium. However, the data of the increased content of potentially mobile forms of HM in the topsoil on the territory of the Kazanskiy garden are obtained.

This shows that the territory of the Museum-estate "Kolomenskoe", is a completely independent structure and has its own barriers from urban pollution. Despite this, the intensity of pollution from the road has a real threat. The results of these studies proof this.

Devil in the rubble: The story behind the Teufelsberg mountain of Berlin

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After WW II, about 20-30% of the buildings in the City of Berlin, Germany was destroyed. Today, more than 60 % of the city soils are influenced by WWII rubble. The major part of it was tipped into landfills, while the minor part was deposited outside the city at non-built-up areas, into bomb craters, parks, and backyards. The so-called devils mountain (Teufelsberg) is the major artificial mountain in Berlin, containing of about 25 Mio. m^3 of rubble deposit.

In first part we briefly report on the gypsum, which is a problematic component in the rubble material, leading slowly to high sulphate concentration in the seepage water. As a consequence, the sulphate concentration in the groundwater exceeds since 10 years the trigger value of 240 mg SO_4 l^{-1} and reaches spotwise concentrations of >1000 mg SO_4 l^{-1}. Numerical scenarios show that this sulphate release will continue up to another 1000 years.

In the second part we will report about our suggestion of developing the Teufelsberg area as a site of remembering the consequences of war. The Rubble symbolizes the loss of life of hundreds of thousands of people during WWII. In the rubble lies buried their homes, schools, industry, and cultural values that have been destroyed by war and the failed politics behind it. The present, primary use of Teufelsberg as a site for recreation and leisure does not honor such memorialization in any way. One reason for this is that history is inevitably hidden, embedded in the soil profile. Our task as soil scientists, together with historians, cultural scientists, artists and designers, is to help preserve this place as part of the cultural soil-scape, to make it accessible, and to ensure that historical reference is facilitated.

Urbanization and sustainable development in Europe (Jean Monnet Session)

Spatial-temporal changes of urban and peri-urban soil land-use – A state-of-the-art on measurement, drivers and effects of soil artificialisation

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Introduction

The sustainable use and global management of soils is one of the greatest challenges for the future (MEA, 2005). Soils play an essential role with their functions and provide several ecosystem services classified as provisioning, regulating and cultural services, which are useful to human well-being (European Commission 2010, Dominati et al. 2010, Morel et al. 2015). But the increasing and antagonist demands for habitat, economic activities, infrastructures, food, raw materials, energy and green spaces, threaten this finite and non-renewable resource on a human timescale. Soils, and especially urban soils face the paradox of being of high interest for their properties and building issues, and being subjected to insufficiently coherent urban planning policies.

The artificialisation of soils caused by land use change is a current issue within scientific communities from local to international scales. Within the framework of sustainable development, the European and international communities made the commitment to halt degradation processes, especially erosion, dwelling and flooding. Strong objectives towards sustainable land-use are provided in the European program for environmental actions, one of them being to stop the increase of land occupation by 2050.

It is now necessary to provide a precise lighting on the artificialisation of soils in the process of trying to reconcile the resource scarcity and the conflicting uses within the framework of sustainable soil management. If the environmental impacts of the soil artificialisation are separately well documented, a global vision is missing. An overall perspective is also needed about the social and economic consequences at local and global scales, over the short and long term.

In this context, since the end of 2015, two French public research institutes (INRA and IFSTTAR) were commissioned by public authorities (Ministry of environment, ADEME, Ministry of agriculture) to carry out a pluridisciplinary and collective scientific state-of-the-art on the drivers and the environmental, social and economic effects – positive and adverse- of soil artificialisation.

Methodology

The methodology of the scientific and critical state-of-the-art (ESCO – scientific collective expertise) is based on rules and procedures established by the French national charter of scientific expertise (http://www.cnrs.fr/comets/IMG/pdf/chartenationaledel_expertise_139106.pdf). The requirements specification of the ministries was translated into main topics and scientific cross-cutting issues on the artificialisation of soils by land-use changes. The studied changes of land-use are those defined by the French national observatory of the agricultural area consumption (ONCEA), adapted from the CORINE land cover data base: "effective change of an agricultural, forest or natural area into artificial areas such as residential, industrial and commercial zones, communication networks, mining area and open-pit quarry, landfills and construction sites, urban green areas and leisure and sport areas. The artificial areas are not more able to support an agricultural or forest activity or to be used as natural habitat". The intensification of activity within a specific land-use (e.g. agricultural or industrial area) is not included in the scientific evaluation.

The analysis of the academic literature and grey literature (i.e. parliamentary reports etc.) may be completed by interviews of technical experts, civil society representatives or economical actors if necessary. The leverage actions to control the soil land take and its adverse effects will be identified.

Various actors are involved in the ESCO: 1) the project team with three scientific coordinators; 2) scientific experts in charge of the coordination of the chapters of the final report (appointed on their skill profile and experiences); 3) scientific contributors to the different chapters of the report (appointed by the chapter coordinator); 4) a steering and a stakeholders committees.

Key words for each main topic were defined and a bibliographic survey was conducted within Web of Science and Scopus data bases. Each bibliographic corpus was refined by the coordination scientific experts.. The references were completed by the own references of the contributors. A first overview of the outline of the report was then produced by the experts. Papers reading and report writing are the next steps of the literature evaluation. The global report with a synthesis is to be produced at the end. A public restitution seminar will conclude the ESCO.

Results

Four main topics were defined from the requirements specification: 1) current state and trends of soil artificialisation : definition, measurement tools and methods, differences between methods and their results – A specific focus on soil sealing is expected; 2) drivers of artificialisation processes (regulation, demography, economics, sociology…) : ranking, evolution of factors, relations between zoning policies and soil sealing…; 3) environmental, social and economic effects of soil artificialisation, in particular which impact on food biomass production; 4) leverage actions : which scenarios and models for accurate future estimation of artificialisation? Which equilibrium between positive and adverse effects? Which compensation in case of adverse effect? What about the reversibility of the process? Which cost/benefit evaluation of urban renewal? ; 5) research priorities on measurements, drivers and consequences of soil artificialisation, to support policy-makers.

Twelve working groups constituted by 3 to 8 experts are currently involved in the ESCO. The academic bibliographic corpus has returned 200 to 1800 references, depending on the topic.

Socio-economical evolutions and concomitant land-use planning have triggered the strong increase of land-take. Artificial areas account for 8.4 % of the French metropolitan territory in 2006 and 9.3 % in 2014 (data Teruti-Lucas). Almost two thirds of the surfaces are impervious soils, such as roads, car parks or buildings. As a consequence of various spatial resolutions, the rate of artificial areas was calculated to be 5.6 % from the CORINE land cover data.

A selection of results on the environmental effects of the soil artificialisation is presented, focusing on the impact on physical and chemical properties. Two hundred and fifty references have been distributed between the 5 experts of the group and it appeared that no review paper is available on the topic. However, a lot of papers are presenting results of characterization of specific sites, in various contexts all over the world. Many papers are dealing with soil contamination (mainly trace elements). Agronomic properties are seldom studied in the papers, no more than the soil classification. Hence, a first outline of the chapter is suggested, including 1) the typology of artificial areas and classification, 2) the physical and chemical properties of soils at various scales (physical properties, agronomical properties, organic carbon, trace elements (speciation, toxicity), organic pollutants (speciation, mobility), 3) indicators of physical and chemical quality; 4) remediation and reversibility (e.g. soil construction).

Conclusions

This state-of-the-art on measurement, drivers and effects of soil artificialisation is expected by the end of 2017. Even if a lot of technical reports have already been produced, this report based on academic research will be essential to enlighten the current situation of soil artificialisation. Thus, by improving the science-policy interface, it will improve the decision-making processes and help the authorities to implement a sustainable land-use management at local and national scales.

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From Waste to Soil: A Sustainable Approach for Global Cities

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Waste management is a growing challenge for cities around the world. New York City alone generates approximately 14 million tons of solid waste from residences, institutions, construction and demolition, fill, and commercial businesses each year (NYC DDC, 2003). Historically, solid waste materials have been dumped and subsequently capped in areas surrounding the city, or incinerated, or in the past few decades shipped to landfills at remote locations. Shipping to landfill is becoming unsustainable due to rising cost, diminishing space for landfills, regulatory constraints and environmental concerns. Long distance transportation of wastes consumes energy, and organic waste in the landfill contributes to the release of methane (another greenhouse gas that is twenty times more effective than CO2 to global warming) and H2S (a toxic gas).

On the other hand, green and sustainable movements are gaining momentum. Many emerging projects in urban areas require healthy and clean soil. For example, urban gardening and urban agriculture bring many aspects of environmental, health and social benefits in addition to local organic food. The idea of green infrastructure is to use soil to infiltrate runoff and filter out contaminants and nutrients before going into groundwater or waterways leading to pollution. Urban forest and land restoration not only can beautify the environment but also clean the air, cool the environment, and sequester carbon from the atmosphere. However, it is well known that urban soils are often contaminated, and a large proportion of them are various fill material (e.g., construction debris) – thus lack of nutrients and having soil properties unsuitable for plant growth. One of the main obstacles of mitigation of health risk from contaminated soils is the availability of large quantities of clean soil to replace or cover the contaminated soil.

There is potential to manufacture clean and productive soil from components in the vast quantity of municipal solid waste in the city. In New York City, about 30% of the total solid waste is organic, 20% is from Construction and Demolition industry, and 30% is fill material from development projects. 'Waste' may not be an entirely applicable term in New York since more than 50% of the solid waste is being recycled or reused. Currently, 38% of the construction and demolition waste and 99% of the fill material is being diverted from the landfill. Recycling and reuse have thus become a functional part of the material economies of cities.

This recent era that is approaching full scale recycling offers opportunities to renew soils and to rebuild them at the scale of urban centers. Concrete and brick can be used as potential soil parent materials (Morel, 2014) and could cover about 1/10th of NYC's 130 km2 of open space each year. The Mayor's Office of Environmental Remediation initiated a "Clean Soil Bank" program where pristine glacial sediments, mined from depth beneath construction sites, are diverted and put into beneficial use. In partnership with Brooklyn College, Greenthumb and several community organizations, a pilot study mixed sediments with compost and produced an ideal growth medium (i.e., soil). Organic waste contains abundant carbon and a wide range of nutrients that are necessary for crops and plants. If implemented in a city-wide scale, the volume of such a mix would cover 1/2 of a km2 per year or entirely resurface Central Park in six years. It is important to mention that these sediments, deposited thousands of years ago, have been tested, and are determined to be virtually free of any contaminants that are prevalent in urban soils.

To achieve sustainable goals such as climate resiliency, reduced carbon footprint, clean air and water, innovative beneficial use of solid waste materials should be encouraged. One stone can kill two or more birds in the process. Scientific research agenda should be developed leading to data for informed decisions. For example, research is needed to understand the chemical safety of reused waste material, soil quality, and development of the manufactured soils. Scientists should work closely with agencies, communities and industry in developing policy, programs, logistics and capacity.

Design of Facsimile Yellow Kandosols for Indigenous Vegetation for Barangaroo Point, Sydney.

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Barangaroo Point, Sydney, Australia is a redevelopment of a redundant port into a naturalistic facsimile of Sydney Harbour's indigenous sandstone-derived flora. Crushed sandstone, recycled from excavations, with added recycled compost was the medium used to create an anthroposol mimicking the low nutrient Yellow Kandosol the indigenous flora is adapted to.

Analysis benchmarking natural Kandosols on this Mesozoic sandstone was used to establish the fertility levels likely to be required. It showed total P of 25-30 mg/kg and Ca 60-80 mg/kg in the sandstone samples and 30-50 mg/kg P and 150-250 mg/kg Ca in A horizons of fully developed Yellow Kandosols. Total Mn was around 20 mg/kg. The analysis established P, Ca and Mn as the limiting elements. This floral assemblage contains species known to be sensitive to excess P. At Farm Cove the early colonists in Sydney failed to grow successful food crops on these soils.

In ecosystems on nutrient deficient geology it is often found that most bio-accumulated limiting elements are held in the forest canopy. Analysis of leaf, bark, wood, understory and litter layer, together with estimates of total forest biomass lead to a conclusion: if the limiting minerals in this fire-prone schlerophyll woodland were returned to the "ash-bed" then the topsoil P level would rise to 50-70 mg/kg and Ca 600-900 mg/kg. These conclusions were supported by soil sampling before and after a fire hazard reduction burn in an analogous site.

This work helped calibrate levels of the limiting elements to impose on the concept "Barangaroo Anthroposols" resulting in a calculated estimate that 10% v/v of commercial garden waste compost would provide all the limiting nutrients required for a climax schlerophyll woodland community of this type to develop.

A series of pot trials were then conducted using 5-30% v/v of garden waste compost. Only at the 5% and 10% levels, in the acidic pH treatments, did the most sensitive species grow without pH and P induced Fe and/or Mn deficiency symptoms. Regardless of total soil Mn *Eucalyptus haemastoma* showed foliar Mn inversely correlated with pH ($p > 98\%$) with toxic foliar levels of over 1200 mg/kg occurring below pH 5.

To support the five vegetation communities required by the designers: heath, open Eucalypt woodland, closed tall-woodland, lush closed canopy forest and amenity turf with park trees, three topsoil edaphologies were then specified using compost levels by volume of 5% for heath, 10% for the eucalypt woodlands and 20% for the amenity turf and park tree areas.

A failure rate of <0.5% in a floral assemblage, known for its significant horticultural challenges, was achieved. The work also extended knowledge into the Sydney Sandstone flora, and how it is adapted to soils with levels of P, Ca, and Mn, amongst the lowest recorded.

ID 1521165

Hydraulic properties of technogenic planting substrates - measurements and models

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Purpose-designed Technosols (e.g. as growing media) are employed for several uses, spanning from urban greening in general to food production. Their use/installation offer the opportunity to up-cycle urban wastes such as construction and demolition debris, food residues, green wastes etc. To keep enough plant available water is one of the critical functions that these purpose-designed Technosols should cover. Therefore, a/n wide/deep/accurate knowledge of the hydraulic properties of the constituents of such substrates, and how they behave in mixtures is crucial to allow the correct design of a substrate according to its intended use . The current available knowledge on hydraulic properties of technogenic materials is often derived from low resolution measurements which do not deliver the detailed information needed to understand (and model) the behavior of the pure substrates and its binary (for a start) mixtures.

In our contribution, we present the hydraulic properties of a set of technogenic substrates, which have been measured using a combination of some up-to date measurement techniques delivering high resolution data (Equi-pF apparatus, HYPROP, WP4C, KSAT). Such data is needed when models, mainly developed and tested for soil substrates, should/have to(?) be adapted for technogenic substrates.

We tested mined natural materials along with materials further processed and technically produced such as tuff, pumice, porlith, expanded schist, expanded clay, bricks, ground coffee, compost, etc.

Our results show, that a detailed knowledge on the hydraulic properties of such materials is required to understand their behavior in mixtures and in soils. Thus, we derived a concept how to assess and predict the performance of substrates in mixtures and demonstrate how simulations can help to optimize Technosols constructed from known technogenic substrates prior to production.

A hybrid approach to model land cover dynamics and the feed-backs with soil resources.

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A wide range of societal issues require insight in land cover dynamics including nature conservation, food security, and environmental impact. Examples include the Sustainable Development Goals at the global level, Natura2000 at the European level, and regional development programs. The main challenge in land cover dynamics modelling is that land cover is highly dynamic in contrast to other environmental characteristics like soil and topography at various temporal and spatial scales. Research to land cover dynamics focuses on obtaining insight in the land cover dynamics (including the identification of underlying driving factors) and increasingly on future land cover scenarios. We identified three main underlying factors behind land cover dynamics being history, environment, and neighborhood. Models for land cover dynamics typically focus on one or a combination of these factors: Markov chains focusing on land cover history, regression approaches focusing on the environment, and Cellular Automata focusing specifically on the neighborhood. We propose a hybrid approach in which we first analyze the three factors individually and analyze their relative importance. Subsequently, we run a hybrid model that combines the Markov chains, regression analysis, and cellula automata with their relative importance. The methodology is being illustrated for two very distinct cases from urbanization and ecology. By using a hybrid approach different disciplines can learn and benefit from each other. In both situations we are dealing with a number of interesting features that complicate the modelling. For example, in both cases we are dealing with abrupt changes as a result of e.g., forest fires and policy decisions in urban planning. We specifically focus on the role of the soils as they are typically one of the central driving factors behind land cover changes, but we are also increasingly interested in the impact of land cover dynamics on the soil resources. The study shows that land cover dynamics models need to include effects of environment, history, and neighborhood. Processes underlying land cover dynamics determine the modelling approach that functions best for a particular case study.

Incorporating Soil Science into Urban Planning

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Cities are currently under continuous dynamic pressures and changes, mainly due to the increase in population. The United Nations estimated an increase in the total population of 2.5 billion people by 2050, with 90% of the estimated increase to occur in Asia and Africa (United Nations 2014). Nevertheless, recent studies have shown that urban growth might proceed in more developed countries as well despite population loss (Lauf et al. 2016). To accommodate the urban population growth cities are constantly changing and increasing the urban areas, mostly towards agricultural areas. Such dynamics have impact on the land use change and, therefore, keep presenting challenges to urban planners and policy makers, such as integration of natural resources with new urban areas under climate change scenarios (Hurlimann and March 2012). However, little has been done concerning a rational soil management for food production in urban areas. This problem is particularly evident in the omission of strategies for the food production in local or regional spatial planning tools. The benefits and value of soil remains an unknown and avoided subject for most spatial planners and decision-makers.

This study focus on reviewing and assessing the status, challenges and opportunities of soil in the urban context. In particular it addresses the following research questions: (1) What is the role of soil in Urban Planning?; (2) What are the latest developments in soil knowledge-transfer into practice?; (3) What are the main challenges and opportunities to integrate soil into Urban Planning? In particular, it discusses the use of ecosystem services as a bridge in communication with planners and decision-makers. It is relevant to increase the knowledge on the role of soils in urban areas. This project is on-going, therefore current advances will be presented and will look for a discussion on the contribution of soil ecosystem services for decision-making and land management in urban areas.

Keywords
Soil Ecosystem Services; Agricultural systems; Urban expansion; Land use change

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Modeling and projecting sustainable development of the megalopolises: the New Moscow Project

The contribution of abiotic and biotic factors to the annual CO_2 production dynamics of the artificial soils (Moscow botanical garden)

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Introduction

Urban regions are major sources of atmospheric CO_2, and 78% of global C emissions are attributed to cities. Furthermore, built-up urban areas exert significant influences on their local climates. Human activity in urban development is associated with the construction of artificial soils and sealing of natural soils. In contrast to natural soils, the properties and pedogenesis of urban soils may be dominated by their anthropogenic origin. As urban areas dramatically increase globally, more studies on the effects of urbanization on biogeochemical cycling are urgently needed.

Currently in the world, there are about 2300 botanical gardens and arboreta, which are centers of floristic and geobotanical research, public environmental education. In Russia today there are 99 botanical gardens, most of which belongs to the higher education institutions – universities, agriculture, forestry and medical institutions.

Botanical gardens in the cities are unique artificial ecosystems in which, thanks to continual investment of resources, it is possible to partially offset the negative impact of the urban environment and create a high level of biodiversity.

Research objectives: 1) evaluate the seasonal dynamics of CO2 effluxes and CO2 concentration profiles of soils of Moscow State University Botanical Garden Arboretum planted with Picea obovata (pinetum) and Carpinus betulus (hornbeam forest), 1) estimate contribution of soil properties, vegetation, moisture and temperature conditions in the spatial and temporal variability of the carbon dioxide production.

Materials and methods

The Botanical Garden of the Lomonosov Moscow State University is located 800 meters south-west from the edge of the high right bank of the Moscow River (55.708°N, 37.526°E). The Botanical Garden was founded in October 1950. Arboretum covered an area about 10 hectares, planted more than 20,000 trees and shrubs 700 species. Because of the significant soil disturbance during the construction of the Moscow State University main building, it was necessary carry out work on remediation of topsoil. For this, significant amounts of lowland peat were used.

Moscow has a humid continental climate with severe winters, no dry season, warm summers and strong seasonality. The mean annual temperature is 5°C, total annual precipitation averages 689.2 mm. The terrain is composed of poorly water permeable silty clay and loam, which lies on the moraine.

Soils of Moscow State University Botanical Garden differ from other urban soil and from natural soils near Moscow. According to published data, soils of MSU Botanical Garden are characterized by high fertility and relatively slightly contaminated.

All studies were carried out on the two stationary sites from November 2014 to November 2016. The experimental sites are located in plantations of Picea obovata and Pinus sylvestris.

Air and soil temperatures were measured at each of the two sites six times per day with Thermochron ibutton™ data loggers. Air temperatures were made at 1.5m above the ground. Soil temperatures were measured at 2, 10, 20, 40 and 60 cm.

Carbon dioxide efflux from the soil surface was measured by the closed chamber technique in a triplicate at each site. Measurements were taken every 1-2 weeks from 13 to 15 pm. To measure carbon dioxide concentrations at different depths, sealed tubes were placed in the soil, 1 cm in diameter and perforated on the bottom part. Sampling was conducted with a rubber stopper once a week. CO_2 concentrations were measured with a portable IRGA DX6210.

Results

According to the World Reference Base for Soil Resources, soils of the key sites can be classified as Technosols or Anthorosols. The soils have a thin litter, gray sandy loam surface organo-mineral horizon of 20-50 cm thick underlying brown silty loam mineral horizon. Some soil horizons have artefacts (brick, coal, rubber, metal, glass, and carbonate). The content of total organic carbon was noted from 0.2 to 8.4%. The pH measured in the water ranged from 6.9 to 7.3. The upper soil horizons are characterized by high biological activity, resulting in the high content of the microbial carbon and high potential respiration.

Soils of all plantations are characterized by similar annual temperature regimes. The average annual temperature varies very slightly with depth and it is about 7°C.The observed small differences in temperature conditions among soils are attributed to varying in projective cover degree, canopy density, as well as the depth and duration of snow cover. Soil freezing in winter was limited to the upper 10-20 cm. Soils were in the frozen state only one or two months.

Soil respiration showed a distinct seasonal variation. Carbon dioxide efflux from the soil surface at both sites during the years ranged from a minimum 0 in February to a maximum of July 600-700 $mgCO_2/(m^{2*}hr)$. In winter, about 0 efflux values were observed about only 3-4 weeks. For both soils, sharp increase in carbon dioxide efflux started in April and has reached its maximum in early July. The sharp emission reduction observed since the end of September, and was associated with a sharp decrease in the temperature of air and soil.

There was a significant correlation in the annual cycle of CO_2 efflux for both soils ($r^2 = 0.9$; $p<0.05$). Annual carbon dioxide soil surface efflux of soil planted with Picea obovata was 1370 gCO2/($m^{2*}yr$), soil planted with Carpinus betulus - 1590 $gCO_2/(m^{2*}yr)$. Contribution of the summer season in the annual CO_2 emissions is about 70%, winter-spring-– 20%, autumn – 10%.

Over the year, the CO_2 efflux was weakly correlated with the air temperature ($r^2 = 0.5$; $p<0.05$) and correlates well with the temperature of the soil at a depth of 10 cm ($r^2 = 0.9$; $p<0.05$).

Moisture has little effect on CO_2 emissions ($r^2 = 0.03$) in the annual cycle. However, during the summer period (when the soil temperature above 10°C) moisture plays a more significant role than the temperature ($r^2=0.4$, $p<0.05$).

In the period from May to January, soil profile CO_2 concentrations is relatively stable: the minimum value observed in the upper 10-cm layer of soil (1600-3000 ppm), with a gradual increase in concentration with depth. The CO_2 concentration at the depth of 60 cm from 2 to 4 times higher than that at a depth of 10 cm. At a depth of 60 cm was observed a significant increase of CO_2 concentration since the beginning of June to the end of August, from 7 to 15 thousand ppm. It is associated with the accumulation of carbon dioxide in the soil air during the growing period. The sharp outburst of CO_2 concentration at all depths (except 60 cm) was observed in February, March and April. The sharp increase in concentration is due first to the jamming of gas in the soil profile during the period when the upper 10 cm layer was still in a frozen state.

NYC Urban Soils Institute – A local and global resource for soils

Research, Education, Conservation, Sustainable Solutions

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The formidable task facing all cities is to integrate soils and the life they support into all urban development going forward and to incorporate the development of urban soils into the legacy landscapes that urban centers hope to preserve and sustain. As urban centers embrace green infrastructure for climate resiliency, water resources management, urban heat island mitigation, food security, and long term sustainability, soil is no longer the sole domain of agricultural science.

Green infrastructure – whether for stormwater management, climate change mitigation, or food security – has become common vernacular among government agencies as well as private sector environmental professionals. This shift has resulted in more interactions with urban soils as evidenced by requests for urban soils data, information and training. Although the demand for the knowledge of urban soils has grown, it is clear that our understanding of urban soils has not kept pace and there is a significant gap between the needs and existing resources.

Some emerging and well established fields that require urban soils research and coordination include:
Urban agriculture including community and home gardens as well as commercial operations;
Urban reforestation and restoration projects;
Stormwater management;
Brownfield and soil remediation; bioremedation
Soil survey and mapping;
Climate resiliency planning.
Greening of cities

These are not distinct and independent fields of management but are interrelated and require coordination of information dissemination as well as of planning and implementation. A centralized entity that can facilitate the flow and sharing of information and serve as a "one stop shop" for soils information and services is critical for cities.

NYC Urban Soils Institute

New York City Soil & Water Conservation District (the District) has partnered with Brooklyn College, the Gaia Institute and USDA Natural Resources Conservation Service (NRCS) to create the ***New York City Urban Soils Institute***. The mission of the USI is to advance the
scientific understanding and promote the sustainable use of urban soils through education, conservation, and research for diverse audiences.

The USI achieves its mission through five divisions:
Soils Testing and Technical Services: soil testing, interpretation, and other technical services.
Education and Outreach: A wide range of soil science and conservation training opportunities for all ages and knowledge levels.
Data Depository: A platform for soils data storing and sharing for New York City.

Research: Coordination of an urban soil science research agenda.

International Collaboration: A vehicle for promoting, sustaining, and developing research collaborations that progress the science and sustainable solutions for our cities and beyond through better understanding, conservation and development of soil health.

We believe that the USI will persist and fulfill its mission through the strengths of partnerships and collaborations. We invite you to collaborate with us on this new initiative as urban soil science is growing attention and gaining new research fronts.

Soil and microbiological diagnosis of anthropogenic pollution of forests and forest park landscapes of metropolis Moscow

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Urbanization has caused a significant negative impact on the environment. The growth of urban population significantly enhances (increases) recreational load, which primarily affects greenery of forests and forest park landscapes, playing a crucial role in the wellness conditions of megalopolises. This situation is clearly aggravated by the reduction of the area and deterioration in the quality of green spaces in urban areas (Status of green spaces ... 2003).

One of the factors negatively affecting the functioning of the recreational landscapes is soil compaction. It is caused by unregulated recreation, destroying the complex of plant growing properties of the soil, which in turn affects the state of green areas (Mosina, 2003).

Even more significant is the combined effect of soil compaction and soil pollution. In metropolitan areas, cities, large industrial centers there is a significant contamination of the soil caused by various pollutants, the priority is given to heavy metals (HM). Particular danger is posed by the extent of contamination and the growth coupled with the general increase of recreational load.

In this context, to preserve green plantings, preventing the irreversible consequences of their degradation, early diagnosis of their condition may be required, using sensitive indicators, some of which are microbial ones.

The high display ability of microorganisms indicated by a number of researchers, however, the study of this component in the forest soils in the recreational areas remains insufficient.

Therefore, the purpose of our research was to study the soil and microbial succession in the forest ecosystems and forest parks in a different HM pollution and unregulated recreation in the comparative period of time (about 25 years).

The object of the study were the previously laid down test areas (Mosina, 2003) under the oak plantations: the two age groups of X - XII and VII-VIII-age classes, as well as pine and birch stands IX-XI age classes growing in the unique forest - LOD RSAU -MAA named after K.A. Timiryazev at different distances from the urban environment (5 m - 500 m).

On the laid plots of 0.5 hectares along the perimeter of the crown projection model trees soil samples were selected of the upper 10-cm layer (rhizosphere zones) in 7-10-fold repetition.

Microbiological studies were carried out in dynamics in fresh soil samples by the common methods (Methods of Soil Microbiology and Biochemistry, 1991). Identification of spore-forming bacteria was carried out using the Determinator of N. A. Krasilnikov and Berge (1948). The total content of heavy metals was determined by the X-ray fluorescence analyzer model TEFA 6 W Orteke company (USA). The density of the soil was defined by the gravimetric method.

Research results

As a general pattern, there is a significant increase in recreational pressure, almost completely destroyed the living ground cover. The share of path network of the LOD was 30-35% in 80-90 years, while in 2010-2014 it has increased 1.5-2 times.

A significant part of the stand (more than 40-50%), growing on the border with the territory of the city (test plots № 11, 7, 10), is on the verge of collapse and is characterized by a more pronounced signs of depression: increased dieback and crooked trunk, damage to various diseases, in contrast to stands in the middle of the forest, far from the urban environment of about 500 m (test plots № 6,8,9).

In the forest areas, close to the urban landscape, we can see increased soil compaction coupled with higher levels of HM contamination (Table 1).

Table 1 Soil and ecological characteristics of forest stands of LOD

№ of test area	The main type, class, age	Bulk density, g/sm3 * 1990 2014	Content of HM, mg/kg(1980-1990)		
			Pb	Zn	Cu
Forest areas, remote from the urban environment (~500 m)					
6	Oak, X-XII	0,79±0,03 0,85±0,08	62,2 ±4,1	73,0±7,3	10,0±0,9
8	Oak, VII-VIII	0,74±0,05 0,79±0,08	86,1 ±8,1	97,04±9,08	10,02 ±0,84
9	Pine with birch, IX-XI	074±0,06 0,78±0,07	77,0±7,8	96,0 ±8,9	36,03±2,92
Forest areas, close to the urban environment (~ 5 m)					
11	Oak, X-XII	1,45±0,10 1,8±0,09	120,0±10,4	114,0+-9,82	77,09+-5,6
7	Oak, VII-VIII	1,17±0,08 1,62±0,09	100,0±8,7	100,0+-8,68	108,02+-9,14
10	Pine with birch, IX-XI	1,43±0,09 1,82±0,09	131,0±10,4	211,0+-16,44	92,0+-7,64

* Average during the growing season

Violation of regime of rhizosphere aeration zone in combination with impaired assimilation apparatus of plants in the forest areas with increased soil compaction and HM pollution creates sensitization effects, thereby reducing the biological activity of the soil (Fig. 1).

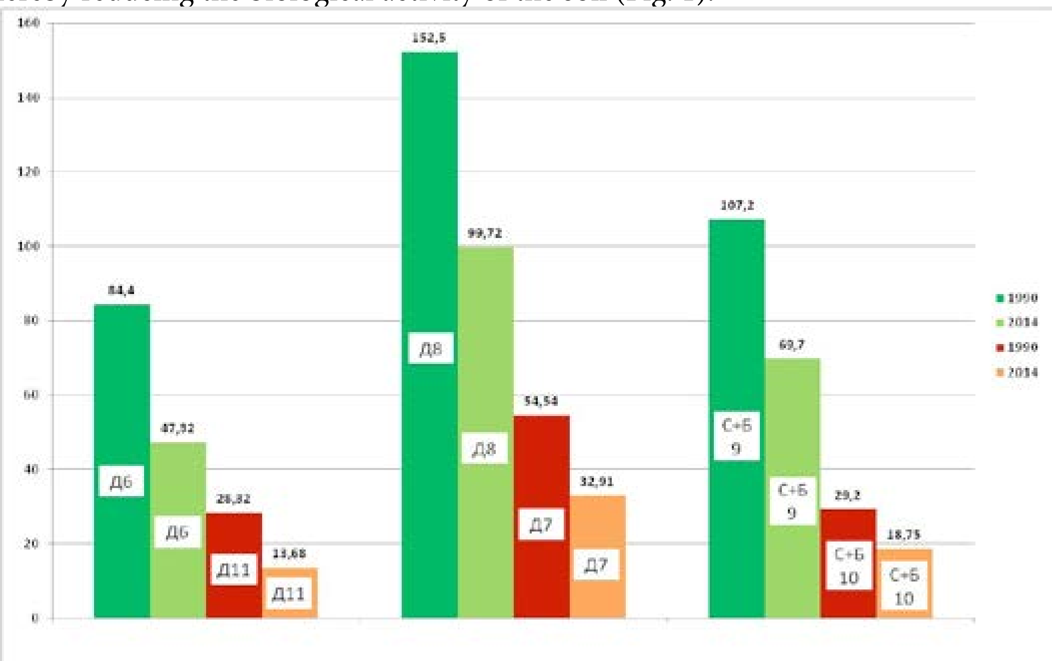

Fig. 1 The total biological activity of the soils in the forest areas with various anthropogenic load (number of microorganisms (million CFU / 1g soil, MPA + SAA)

Along with reducing the number of microorganisms we can observe reducing the intensity of mineralization processes, evidenced by the wider mineralization ratio (the ratio of the number of microorganisms on MPA and SAA), amounted to 1.6 - 1.8 under plantations at a minimum distance from the urban environment (- plantations) compared to the figures 1.1-1.4 in the middle of the forest (+ plantations), and besides, the process is strengthened over the past 25 years (Table 2).

Table 2 Coefficient of mineralization under LOD plantations under different anthropogenic load

№ of test area	Mineralisation ratio	
	+ plantations	- plantations
	1990 г. 2014г.	1990 г. 2014г.
6, 11	1,2 1,42	1,8 2,5
8, 7	1,4 1,6	1,8 2,5
9, 10	1,1 1,2	1,6 2,1

In the forest areas with high anthropogenic load the content of "northern" species of bacilli is increased (Table. 3), which confirms the weakening of the mineralization processes, strengthened under present conditions.

Table 3 Species composition of spore-forming bacteria in the forest areas with different anthropogenic load (% of total on MPA + SA) (average of 6 dynamic observations) in the time interval

№ of test area	«Nothern» species					«Southern» species			
	Bac. cereus	Bac. virgu-lus	Bac. agglo-meratus		Σ	Bac. idosus	Bac. mes-en-teri-cus – Bac. subtilis	Bac. me-gathe-rium	Σ
	Forest areas, remote from the urban environment (~500 m)								
6	14/16	14/16	12/14		40/46	12/15	7/5	2/1	21/21
8	12/13	12/14	13/14		37/41	14/15	6/4	2/-	22/19
9	14/15	12/14	12/14		38/43	14/16	6/3	1/-	21/19
	Forest areas, close to the urban environment (~5 m)								
11	16/18	18/20	14/18		48/56	21/33	5/4	1/2	27/39
7	14/15	14/16	12/13		40/44	21/27	5/-	-	26/27
10	16/17	14/16	13/13		43/46	20/30	3/-	-	23/33

In the numerator -1990. in the denominator - 2014

Ecological conditions of phytocenoses are significantly deteriorated in the condition of megalopolis due to unregulated recreation combined with the HM pollution, which is diagnosed by microbiological indicators, one of which is the biological activity and the intensity of mineralization of organic substances.

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Landfill Salaryevo as an object of environmental hazard within the territory of New Moscow

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The problem of accommodation of human waste is one of the most pressing environmental problems of our time, which is associated with an increase of the rate of population growth and thus the increasing formation of waste. According to the annual report of the UNEP 2006, the European Union produces about 1.3 billion tons of industrial and household wastes yearly. In Russia 5 billion tons of waste was established in 2012, which is 14% higher than in the previous year. Of these, the volume of household wastes was about 50 million tons and industrial wastes - about 10 million tons [1, 2].

According to the Federal Service for Supervision of Natural Resources (Rosprirodnadzor), so far only 30% of wastes is utilized, while the rest is placed mostly on unauthorized landfills, only a small percentage is placed at the legal landfills, covering more than 250 hectares of land and being a real sanitary-epidemiological danger to nearby residents due to the presence in the wastes of various heavy metals, including mercury, medical wastes, etc. Waste disposal and landfill areas are sources of secondary contamination of neighboring environments: air and soil, surface water and groundwater. As a result of this contamination, negative impact of wastes and products of their transformation on human health is possible.

One of the regions with the most difficult situation in the area of waste management is Moscow region, which is the largest industrial hub in the Russian Federation. In Moscow 6,260 million tons of Municipal solid wastes (MSW) was formed in 2013, in Moscow region - 4,789 million tons of MSW [3]. There were 41 MSW landfills with the total area of 689 thousand ha in 2011 in Moscow region. [2]

Recognizing the environmental hazard of landfill, it should be noted that these issues are still poorly studied, particularly the environmental properties of ground soils of the landfill. Therefore, the purpose of our research was to study the properties of the soil landfill "Salaryevo". This landfill is located in the Leninsky district in the south-west of Moscow (since July 1, 2012 - the territory of Moscow) and is one of the largest landfills in the Moscow region. It covers an area of 59 hectares, its height reaches 80 m, slope angle ranges from 40 to 60. 15million tons of wastes were buried here.

The landfill is located in the immediate vicinity of the Moscow Ring Road (1.5 km). Various settlements are located nearby: Village Salaryevo (30 m), village Mosrentgen (1750 m to the East), village Dudkino and collective gardens of the factory "Red October", village Rumyantsevo (1700 m to the North) and village Kartmazovo (1650 m). Nicholo-Khovanskoye Cemetery is located 200 m to the Southeast of the landfill (between landfill and village Mosrentgen). The farmlands of JSC "Kommunarka", JSC "Moscovskiy" are adjacent to the landfill. The airport "Vnukovo" is about 8 km to the West.

Soil and environmental characteristics of the landfill was carried out for the upper 10-cm layer of soil-ground and included the study of agro-ecological parameters, the density (bulk density value), content of pollutants (heavy metals (HM), petroleum products, surfactants), biological activity, including microbiology. Test areas of about 100 m2 size were laid down; samples were taken in a 7-10-fold replication using the method of envelope. The samples were mixed thoroughly, the mixture was analyzed accordingly.

Photo 1 Landfill Salaryevo – one of the largest landfills in Moscow region.

Results

Agrochemical characteristics of the soil correspond to zonal sod-podzolic soils. According to the content of humus (1.49%), the soil is poor in organic substances, as to the degree of acidity (pH KCl 5,1 ± 0,5), it is slightly acidic. The level of mobile P2O5 is 80,4 ± 7,9 mg / kg and K2O is 32 ± 0,3 mg / kg respectively, which is average and very low respectively.

The soil is characterized by unfavorable agro-ecological properties: high density, amounting to 1,64g / cm3 for a layer of 0-10 cm, the content of pollutants was also significant. HM concentration exceeded maximum permissible concentration (MPC) by 2-3 times (Pb-55mg / kg, Cd-1,11mg / kg, Zn 291 mg/kg and Cu 119 mg/kg (Fig. 1), petroleum products 1150 ± 116 mg / kg), - more than 3 - 4 times exceeding MPC (300 mg/kg), surfactant 1,38 ± 0,12 mg/kg.

Photo 2. Landfill Salaryevo – its height reaches 80 m.

Biological activity of the polygon soil is characterized by the low cellulose-degrading capacity, percentage of leaf decomposition was only 7,8 ± 0,8%, which is 2-3 times lower than the appropriate data of the zonal sod-podzolic soil (on a scale of D.G. Zvyagintsev) [4].

Also the microbial activity was weak, as evidenced by the low values of the number of microorganisms-ammonifiers and microorganisms growing on mineral nitrogen sources (a total of 45-50 ± 4-5 thousand KOE/1g of soil on the breeding ground MPA + KAA), which are 1-2 order lower than the control soil.

The above figures reflect ecological condition of the landfill, which is characterized by the complex of negative factors: a substantial density, significant pollution by HM, petroleum products, surfactants, which causes a decrease in the biological, including microbiological, activity and represents a danger for the environment.

Fig. 1 Content of Heavy metals (HM) in the soil of the landfill Salaryevo

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MAJOR FEATURES AND POLLUTION OF SEALED SOILS IN THE EASTERN DISTRICT OF MOSCOW

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Introduction. The terms "sealed soils" refers to urban ones, covered by solid road surfaces (asphalt, bituminous concrete) and buildings. Despite their wide occurrence in the soil cover of Moscow (up to 70-95% of the surface) and other large cities, their properties, functioning and contamination have been poorly studied. In Russia the urban soils were traditionally studied only in exposed areas and the obtained properties have been extrapolated to the whole territory assuming that all urban soils are identical. The current stage of the urban soil research is impossible without paying attention to sealed soils. The first study of sealed soils which included the determination of their physico-chemical, microbiological properties and heavy metal (HM) pollution was conducted in the South-Eastern district of Moscow (Prokofieva, 1998). It was found that the sealed soils buried under artificial coatings continue their operation, they are not transformed into abiotic ground and their moisture content is sufficient for plant growth. This was explained by the permeability of the coatings, which increases with time (the life span of the coating in the humid zone is about 10 years).

The aim of this work is to study morphological, physico-chemical and chemical properties of sealed soils in land-use zones, to assess the level of pollution by oil products (OP), benzo(a)pyrene (BaP) and HMs in comparison with background soils and urban soils exposed to the day surface. We used the results of soil geochemical survey carried out in the Eastern district of Moscow, (EDM) in September 2016.

Study objects and methods. We investigated the southern part of the EDM which belongs to the south-taiga landscapes of Moscow Meschera, a flat outwash plain occupying the interfluve between the Moscow and the Klyazma rivers and made up by glaciofluvial and ancient alluvial deposits. Sealed soils are anthropogenically transformed, often developed within other soil profiles, as well as on the cultural layer and displaced extraneous loose deposits. Soil sampling was performed on the basis of natural and land-use zoning (Kasimov et al., 2013) which allowed us to identify five areas: industrial, traffic, residential, recreational and postagrogenic.

During the field study of the sealed soils we used different stripping pits. Under the layer of asphalt and underlying intermediate sand-gravel layer at depth from 10 to 70 cm a top horizon of the soil was sampled. A total of 32 pits of the sealed soils were sampled and 71 samples collected. In addition, we used the data on 52 samples of the unsealed urban soils and on 12 samples of background soil samples collected in Moscow Meshchera (50 km to the east of the city). Physico-chemical and chemical properties of soil were determined by conventional methods, the contents of OP, BaP and HMs –by luminescent-bitumen, low temperature spectrofluorimetric and ICP-MS methods, respectively. Using field morphological descriptions and interpretation of satellite images the percentage of the sealed soils was defined in the land-use areas of the EDM. Most of the sealed soils (> 70%) occur in industrial and traffic areas, the smallest part (<20%) –in the areas of individual residential development.

Sources of pollution. The main source of the emissions to the atmosphere in the EDM is the transport sector, which contribution amounts to 92-95% (Regions and cities of Russia …, 2014). The district also has various industrial enterprises: power engineering, metalworking and mechanical engineering, chemicals and petrochemicals, construction materials and other. Pollutants get into the sealed soils with emissions of industrial plants and during the abrasion of the road surface, tires and other parts of cars. The priority pollutants of the soils are readily soluble de-icing salts (DISs), OP, BaP (which is a dangerous carcinogen from the group of PAHs) and HMs.

Research results

The main features of the profile structure. The upper horizon in the sealed soils is usually absent (removed) while the rest of the horizons are so heavily modified, disturbed and mixed that their morphogenetic study faces difficulties. Classification of the soils and their designation was carried out on the basis of diagnostic horizons, their presence, thickness and combination (Prokofieva et al., 2011). When distinguishing horizons we took into account also their chemical and physico-chemical properties. The most typical profile of a sealed soil has the following diagnostic horizons and man-made layers: Asp – asphalt, PG – sand-gravel intermediate layer, U – urbic, humus-accumulative horizon; AYur – humus horizon with signs of urban pedogenesis; RAT – remediated horizon with organic residues; RT – organic remediated horizon (peat mixture); TSN – anthropogenic mixed ground.

Physico-chemical and chemical properties. The upper horizons of the sealed soils are characterized by an average content of humus, slightly alkaline pH and loamy texture (Table 1). According to the conductivity (TDS), they are highly saline due to the application of AIRs. The content of soluble salts is 100 times higher than the critical level equal to 3,0 mSm/cm (Environmental ..., 2005). The increased humus content is typical of the sealed soils in recreational areas, and the high alkaline reaction (pH> 8.0) – in industrial and residential areas. Compared to the soils in the exposed areas the sealed soils have lower humus content and lighter texture, higher salinity but comparable pH values.

Table 1. Physico-chemical and chemical properties of the sealed soils in the EDM

Parameter	Depth, cm	Humus, %	pH_{water}	TDS, mSm/cm	Particles < 0.01mm (%)	BaP, mg/kg	Oil products, mg/kg
Industrial (n*=12)							
Mean	3-55	2.90	8.11	173	22.7	9211	21443
Traffic (n=7)							
Mean	4-61	3.85	7.87	752	24.5	0.146	5714
Residential (n=15)							
Mean	5-68	3.64	8.19	260	24.0	1003	679
Recreational (n=5)							
Mean	5-60	6.80	7.28	80.4	20.1	0.204	4012
Sealed soils in EDM (n=39)							
Mean	3-68	3.86	7.99	299	23.2	3220	8399
Min		0.05	6.49	59.1	4.1	<0.001	< 5
Max		12.1	9.37	4500	38.5	25554	68144
Unsealed soils in EDM (n=52)							
Mean	0-20	5.76	7.8	0.48*	33.0	644	4022
Background sod-podzolic soils of Moscow Meschera (n=12)							
Mean	0-25	1.25	4.9	0.03*	12.0	3.4	0.00

*n – number of samples, **solid residual, %

In terms of BaP and OPs contents the sealed soils show large difference from the background and the exposed urban soils (Table. 1) due to considerable heterogeneity and extremely high concentrations of the pollutants in some locations where the norm of BaP (0.02 mg/kg) and its background level on average are exceeded 161,000 times and 947 times, respectively. The MPC of OPs in urban soils is 300 mg/kg (Environmental requirements ..., 2005) however in the studied soils this value is exceeded 28 times, and the background value – more than 8,000 times. The highest level of BaP pollution was revealed in the industrial areas, and maximum of OP pollution – in the industrial and traffic areas. Compared to the exposed urban soils the sealed soils are also rich in the pollutants: they display 5 times higher content of BaP and 2 times higher levels of OP.

HMs contents in the sealed soils are less variable than those of the organic pollutants. Maximum contamination by HMs (particularly Cu, Zn, Pb, As, Sn and Sb) was observed in the industrial area, the minimum contamination was found in the recreational areas and traffic zones (Table 2). In the residential and recreational areas the differences with the unsealed analogues are small and tend to indicate a protective role of asphalt resulting in a decrease of the majority of HMs concentrations by 10-50%. In the industrial zone the sealed soils reveal 2-6.6 times higher concentrations of the HMs than the exposed urban soils. This is especially true with respect to Cu, Sb, Zn, Sn and Pb. When the area of the unsealed soils is very small they might concentrate surface rain and snowmelt runoff from the entire catchment and therefore display higher rates of HMs leaching while the leaching process in the sealed soils is weakly manifested.

Table 2. HMs contents in the upper horizons of the sealed soils in the EDM

Pa-ra-me-ter	Depth, cm	Cr	Ni	Cu	Zn	As	Cd	Sn	Sb	W	Pb
Industrial (*n*=5)											
Mean		63.4	37.1	527	618	6.92	1.35	19.0	6.98	5.15	187
min	3	24.6	9.11	14.5	61.6	1.7	0.42	2.02	0.86	1.38	16.9
max	30	144	108	1315	2439	13.3	3.52	67.2	25.4	12.7	644
P*		0.764	1.19	6.63	2.87	1.71	0.59	2.79	4.11	1.21	1.98
Traffic (*n*=5)											
Mean		30.7	16.7	33.1	125	3.41	0.38	2.32	0.73	1.65	31.0
min	4	15.7	10.9	9.86	46.9	1.61	0.11	1.03	0.26	0.57	14
max	51	49.2	27.3	112	247	4.56	1.07	4.78	1.8	2.95	73.1
Residential (*n*=10)											
Meam		50.9	19.6	32.5	136	4.39	0.799	4.96	1.16	3.57	50.6
min	5	22.5	6.71	9.64	30.7	0.94	0.11	1.12	0.38	0.62	9.16
max	68	153	36.1	108	306	9.27	3.69	20.8	2.79	16.5	131
P		0.93	0.78	0.74	0.56	0.68	0.58	0.77	0.72	0.98	0.92
Recreational (*n*=4)											
Mean		34.8	15.8	23.3	117	3.36	2.02	2.96	0.83	4.38	27.9
min	6	18.1	12.3	16.5	87.8	1.85	0.57	1.45	0.53	2.14	15.7
max	60	58.1	19.4	32.2	133	5.99	5.15	5.03	1.4	9.47	42.3
P		0.41	0.57	0.47	0.71	0.85	0.22	0.48	0.86	1.24	0.63

P – ratio between HMs concentrations in the sealed soils and their unsealed analogs

Conclusions. Morphology, physico-chemical and chemical properties of the sealed soils vary across land-use zones and differ significantly from the unsealed urban soils, consequently, these soils require careful consideration. The results of our research indicate that the coating of a soil by asphalt is not an obstacle for the penetration of technogenic fluxes which contain various pollutants – toxic salts, BaP, OP, and HMs – which are able to accumulate under the asphalt in extremely high concentrations. With the removing of asphalt the toxicants might be incorporated into biological cycle and migrate to the adjacent landscapes creating an environmental hazard for citizens.

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Functional-ecological analysis of soil cover in the RTSAU Forest Experimental Station as reference site of Moscow soil eco-monitoring[1]

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Key element of any soil environmental monitoring is correctreference site. In such big object of monitoring as Moscow megalopolis it cannot be only one reference site but in any case their number must be very limited and each monitoring site have to be very well validated by the previous monitoring investigated data. One of the best candidate for official local reference site of soil environmental monitoring in the northern part of Moscow is the central core of the Forest Experimental Station (Fig. 1) of the Russian Timiryazev State Agrarian University in the Timiryazev district of the Northern County of Moscow (Vasenev, Raskatova, 2009).

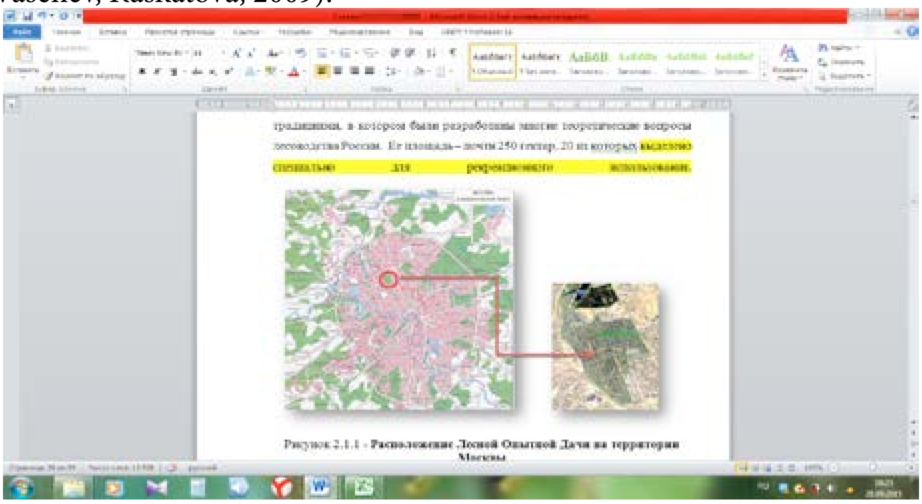

Fig 1 - **Location of the RTSAU Forest Experimental Station in Moscow territory**

Firstly, RTSAU Forest Experimental Station (FES) has well conserved natural vegetation and especially soil cover.FES' soil cover is comparative with soil cover of the principal regional reference site for the southern taiga zone in the European part of Russia – Central Forest Preserve, according to its soil cover patterns and landscape organization, dominant soil profiles, their texture, lithological construction, soil feature and regimes, and even actual soil forming processes and successions (Vasenev, 2008).

Secondly, RTSAU FES is in the territory of the Timiryazev administrative district, which is one of the most environmentally friendly district in the all area of traditional Moscow with comparatively low urban environmental impact, especially on soil cover.

Thirdly, Forest Experimental Station's terrestrial ecosystems are characterized by the increased spatial variability and soil cover patterns with soil subtype/type differentiation due to soft mesorelief forms that is typical for the southern taiga zone and have to be taken into attention in case of man-changed soil environmental assessment in the processes of landscape design or construction environmental impact assessment.

Finally, RTSAU FES is the site of long-term (around 150 years) soil, vegetation and environmental monitoring with hugyvolume of already accumulated data, well developed monitoring infrastructure (including unique for Russia urban forest eddy covariance station) and high-qualified staff up to professors in all aspects of soil environmental investigation.

Forest Experimental Stationhas soft mesorelief with maximum absolute height 175 m and the minimum one 160 mabove sea level. The LOD's relief is result of the processes of glacier accumulation and flows of thawed glacial waters, so the territory is composed of Quaternary sediments, under which lie the Jurassic clays (20-22m thick). Quaternary deposits are represented by low-power silty cover loams (up to 0.5 m -

1 - with support of RF Leading Scientific School Grant NSh-10347.2016.11

Vasenev e. a., 2007), underlain by moraine or fluvioglacial. The level of groundwater varies from 5 to 10 m. In some places, there are harsh conditions of surface runoff and locally close groundwater table, which leads to swamping. Previously a branched drainage system has been developed, with local disturbances of the soil cover.

Thereis dominated woodlands of natural and artificial origin –in approximately equal proportions (in fractions 52/48 forested area). The predominant species is pine (34% forested area). The average age of the stand is about 100 years. Prevailing communities are complex pine forests with participation of linden, oak, elm and maple.

Relatively little disturbed natural soil cover is predominantly consisted of sod-podzoluvisols (Ortho-podzolic soils by Russia Taxonomy, or Alfisols by Soil Taxonomy, or Albeluvisols by WRB, or Podzoluvisols by FAO) with differently developed organic, humus-accumulative, eluvial (podzolic), illuvial (partly textural) and transitional horizons locally modified by surfacehydromorphic and gley processes. In general, they are characteristic of the background southern-taiga ecosystems in the center of the European part of Russia and of the original soil cover in the essential part of Moscow.

Soil heavy metal stocks variation in the central core of the FES has clear correlation with mesorelief forms, HM storks in the early spring snow cover and ones in the ground vegetation (Table 1). This is result of significant natural factor of heavy metal redistribution in frame of FES landscapes that need to be more carefully investigated and taken into attention in frame of Moscow soil eco-monitoring results interpretation.

Таблица1. Ranges of heavy metal stocks variation in case of non-contrast mesorelief of the Forest Experimental Site (average of 5 years data)

Meso-relief	**LNS***		**MNS**		**TMH**		**MSS**		**LSS**	
HM	***Min***	***Max***	***Min***	***Max***	***Min***	***Max***	***Min***	***Max***	***Min***	***Max***
HM in topsoil*(kg/ha at depths 0 - 20 sm)*										
Pb	42,2	112,9	30,9	96,5	20,1	54,1	30,2	56,2	72,2	106,5
Cu	17,9	53,8	15,0	34,9	14,0	33,0	16,0	28,0	16,6	38,0
Zn	110,9	145,1	106,1	126,9	75,3	126,7	82,8	166,1	82,8	166,1
Cd	0,14	0,26	0,10	0,14	0,06	0,08	0,19	0,33	0,30	0,43
HM in the yearly-spring snow cover*(g/ha)*										
Pb	38,9	73,9	22,3	55,6	16,8	55,6	32,7	80,4	37,4	115,1
Cu	3,3	10,9	1,70	3,4	1,5	5,5	2,0	7,4	3,0	11,3
Zn	15,6	70,1	6,0	54,5	3,2	51,4	4,9	51,4	13,8	70,9
Cd	0,3	0,6	0,4	1,7	0,5	1,4	0,8	1,8	0,8	1,9
HM in the background grassy vegetation cover *(g / ha)*										
Pb	28	58	22	50	11	17	34	92	56	122
Cu	96	130	49	76	35	41	84	144	220	290
Zn	734	1027	611	951	487	737	1010	1254	1861	2242
Cd	0,1	2,6	0,3	1,7	0,2	0,4	0,4	1,3	3,0	4,0

* - LNS and MNS – the lower and the middle parts of the northeastern slope; TMH – the top of the moraine hill; MSS and LSS – the lower and the middle parts of the south-western slope.

Comparison of heavy metals stocks mean values in the early spring snow cover allows estimating the daily amount of aerogenous pollutant intake, as well as the current surface trend and the lateral mechanism of its increased accumulation in the accumulative elements of the mesorelief (lower parts of the slopes LNS and LSS - Fig. 2).

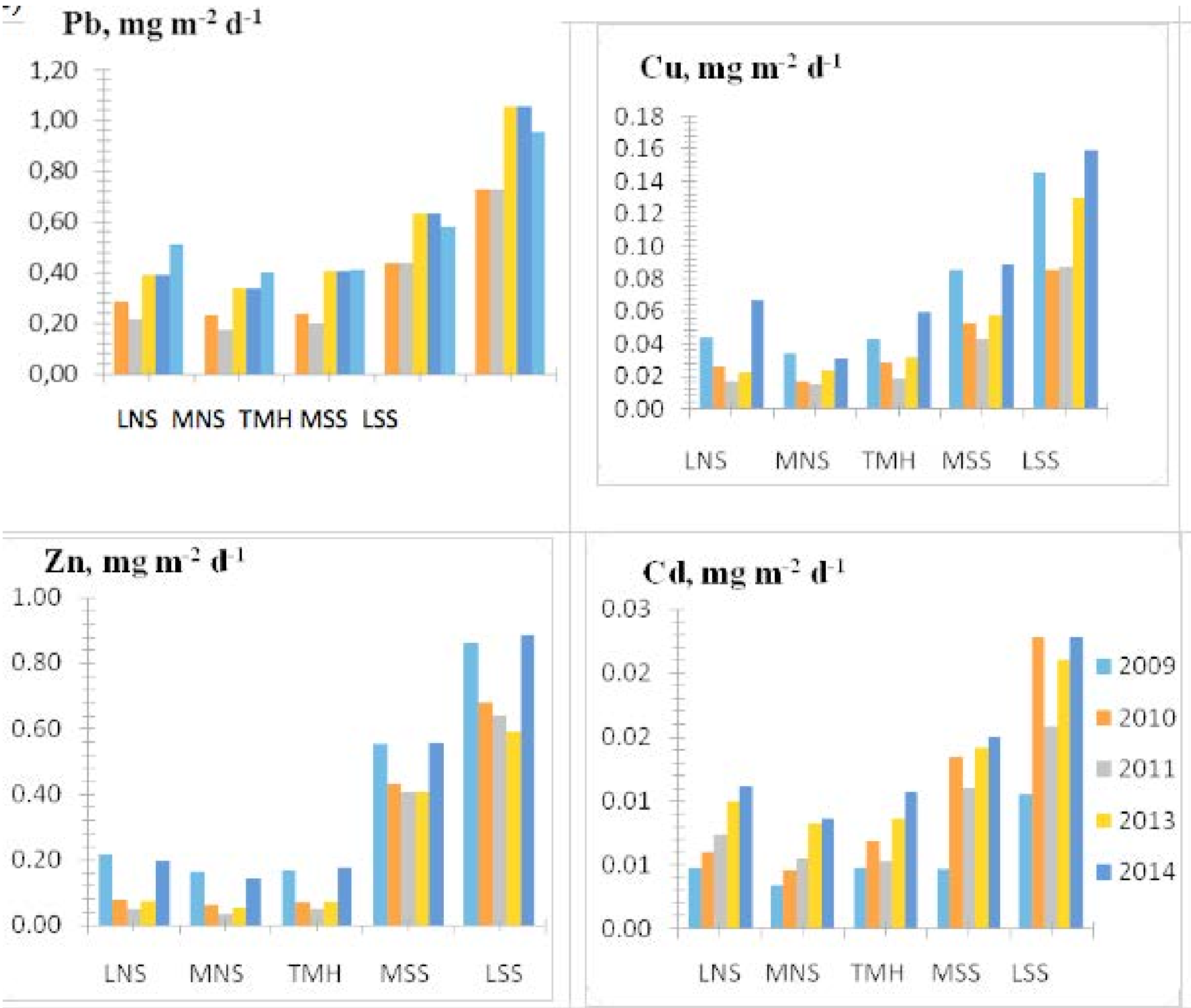

Fig. 2. Distribution of the technogenic input daily modules of heavy metals in the monitoring sites

The heavy metals that got to the soil surface are partially redistributed along the soil profile and partially entered the plants. In the monitoring ofthe changes in the heavy metals balance the grassy vegetation biomass plays a significant role (Avilova e.a., 2015).

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Urbanization in New Moscow: challenges and perspectives for soil resources

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Introduction

Urbanization is responsible for substantial environmental consequences worldwide Urbanization substantially modify vegetation and soils; urban soils vary from slightly disturbed to totally artificial soil constructions, with features and functions different from those of natural soils (Morel et al., 2014) and could play a key role in an ecosystem of a sustainable city. Urban soils are important resources, capable to provide important functions and services, including fertility, carbon (C) sequestration, filtering and purifying surface run-off, performing as habitat of microorganisms and supporting biodiversity. Urbanization coincides with different processes; some of them, e.g. soil sealing or excavation of the fertile topsoil horizon for building construction, have a clear negative effect on urban soils resources. However, establishing urban green infrastructures likely enhance urban soil's functions and services. Both current land-use type (i.e. functional zoning) and land-use history affect functions and properties of urban soils, which shall be considered to analyze urbanization effect on soil resources. This study aimed to predict the effect of urbanization on soil resources in the New Moscow.

Materials and methods

The New Moscow Project, announced in 2012, to address urbanization and environmental problems by moving from a metropolitan city to a mega-region (Argenbright, 2013). This ambitious project expands the legal borders of Moscow City increasing its surface 2.4 times (up to 2500km^2) and attracts investments to develop urban infrastructure. Rapid urbanization is thus expected within the New Moscow Project in the coming decades and the possible consequences for soil resources are not yet estimated. In order to analyze urbanization patterns, land-use maps for two time periods (1980 and 2015) were created based on the available historical data, including topographic maps, satellite images and Open Street Maps. Nine different land-use categories, including urban functional zones were distinguished for each time period and land-use change was analyzed.

The effect of urbanization on soil resources was analyzed based on the existing soil map (Shishov and Voitovich, 2002) and soil data collected in New Moscow in 2015. Soils located in different functional zones and having different land-use history (e.g. parks located on prior forested areas or residential blocks, occupying prior fallow lands) were sampled to the depth of 0-150 cm. Chemical, physical and biological properties were analyzed in collected samples. Data on SOC stocks, pH, nutrient contents, contaminants' concentrations and microbiological activity were analyzed Land-use maps and data on the properties of soils with different land-use history allowed predicting possible effects of urbanization on soil resources in the New Moscow.

Results and discussion

Considerable urbanization occurred in the New Moscow for the analyzed period 1980-2015. The total urbanized area increased on approximately 280 km^2, from which 80% were occupied by new-built residences and public areas, whereas 15% were covered by green zones. Urbanization most likely occurred on agricultural, fallow and forested areas, which total extent decreases 15, 59 and 13% in comparison to 2014 (Fig. 1).

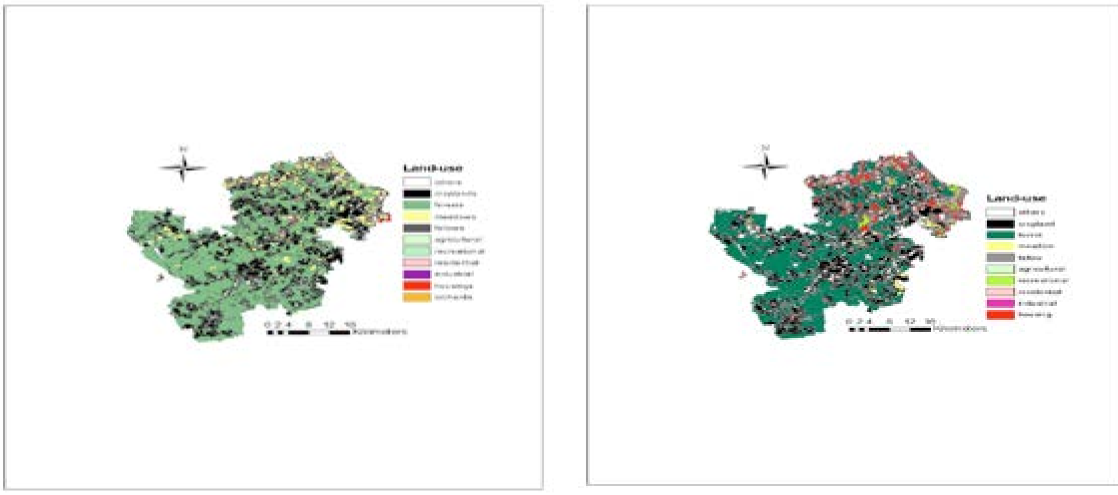

Fig. 1 Land use maps for the New Moscow in 1980 (A) and 2014 (B)

Land-use history of the recently urbanized areas was analyzed to distinguish the most likely urbanization pathways. Conversion of fallow lands and croplands to residential areas was the most expanded urbanization pathway, resulting in extra 62 and 34 km^2 of new residences correspondingly (Fig 2).

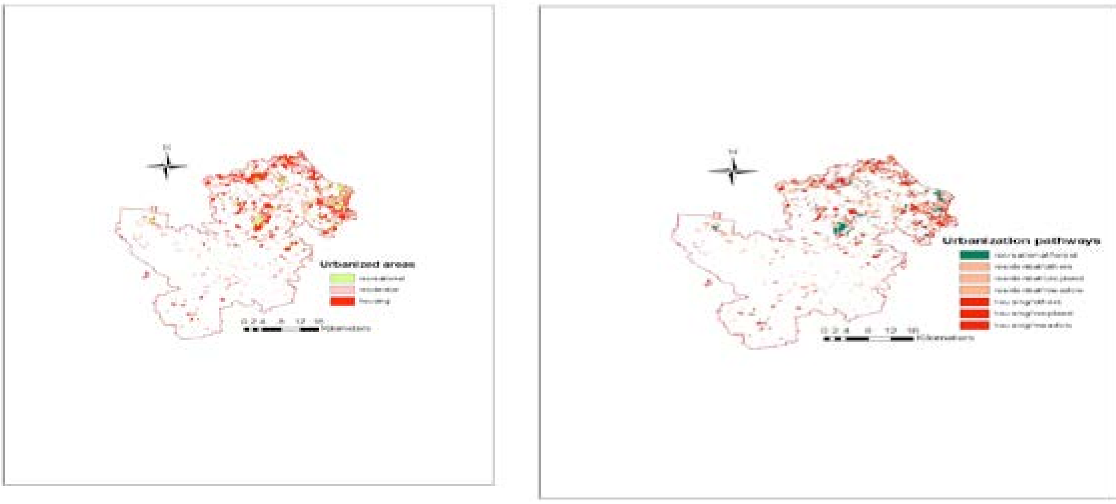

Fig. 2 Current urban functional zones (A) and urbanization pathways (B) in the New Moscow

Soil survey results showed significant difference in primary soil features between urban and natural soils, as well as between urban soils with different land-use history. In general, soils of urban areas possessed lighter texture than natural soils. Soil texture in the areas, urbanized between 1980 and 2015 was on average one grade lighter than those at the areas urbanized before 1980 (sandy loam and loam respectively). Urban topsoils were also slightly over-compacted compared to natural soils. The typical morphological features of urban soils compared to natural ones included contrast colors, higher number of layers and abundance of soil layers (Fig. 3). This outcomes correspond well with the morphological feature of Technosols in accordance with WRB descriptions (Rossiter et al, 2007).

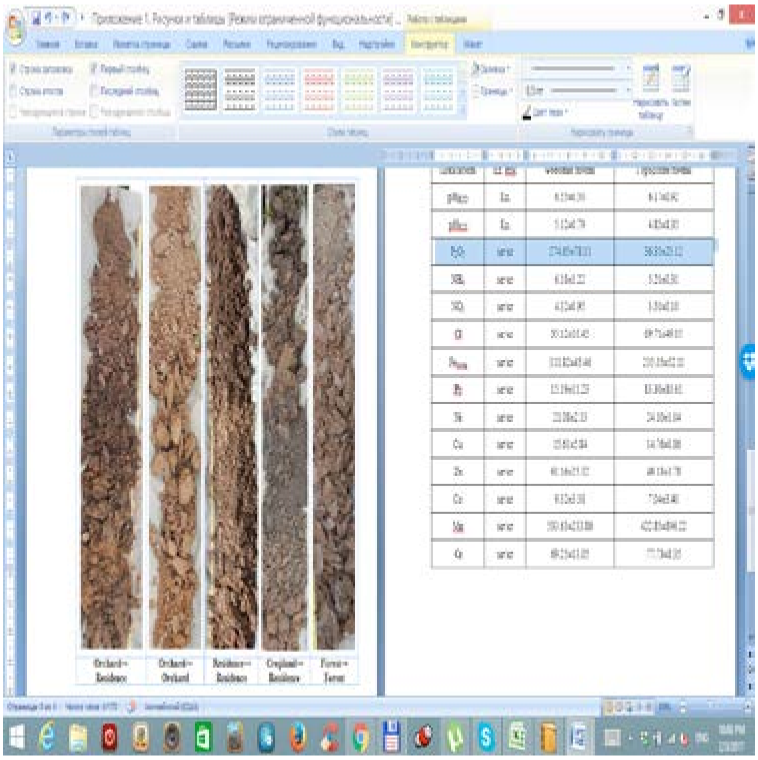

Fig. 3 Urban soils with different land-use history in the New Moscow

Only few data is available by now on soil chemical and biological features (whilst the major part of sample is still under analysis). Preliminary outcomes indicate increased C stocks and P_2O_5 concentrations in urban soils, whereas contamination with heavy metals was insignificant. Microbial biomass carbon and basal respiration were lower for urban soils compared to natural and in more disturbed areas (i.e. industrial areas) compared to residential and recreational zones.

Conclusion

Urbanization in the New Moscow caused conversion of approximately 280 km^2 of croplands, fallow lands and forested areas into urban areas over last 35 years. Versatile effects of the urbanization on soil features included alteration of basic soil features and functions. Extrapolation of the investigated land-use patters will allow predicting possible effects of future urbanization on soil resources in New Moscow.

Acknowledgements

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Poster

A COST action on Technosols

the Scientists of the SUITMA Network

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Being confronted with the numerous ecological and societal challenges of the present, we need to initiate, sustain, and intensify dialogue in general, understanding, and constructive discussions on problems and their solutions.

The existing international network dealing with *Soils of Urban, Industrial, Traffic, Mining and Military Areas* already established a biennial series of scientific conferences. By combining scientific talks and excursions the network offers the opportunity for an intense exchange among the participants, which contributes to understanding and friendship and already led to several international scientific cooperation.

One topic of interest in the SUITMA network is Technosols. These are (i) formed unintended due to means of urbanization such as construction, sealing, erosion etc. or (ii) are constructed and produced and intended to fulfill several of the soils functions in urban or non-urban contexts.

Thus we analyze, classify and map Technosols. We analyze the soil forming conditions, the soil forming processes and begin to understand and conceptually model their geneses. We are interested in their soil functions and are partly able to describe them and their dynamics by the help of mathematical models.

In the same time Technosols are already industrially produced in big scale. In urban areas, they are used as soil-like growing media for all kinds of urban green such as flower-beds, green roofs, filter layers in rain water harvesting devices, as planting substrates for street trees and as well in urban agriculture and gardening for food production. The range of employed materials is spanning from natural, mined sediments like sand, peat, tuff, or pumice, over processed natural substrates like expanded schist, expanded clay or bricks to technically produced substrates like concrete, slags, paper mill sludges or silica gels. We just started to understand how these artificial substrates interact in early soils genesis.

The initiative to be presented intends to broaden the group of scientists and invites other stakeholders to participate in the exchange on all kinds of Technosols in the COST Program.

In this contribution, we will introduce all relevant information about COST actions: their meaning and aims, duration and organization, financial possibilities and how the COST action can be used as a scientific network which is, setting up new topics to the scientific agendas. Being funded by the European Commission, COST actions are open to participants from European countries, Israel and from COST Near Neighbour Countries including Russia, Belarus, Ukraine, Albania, Algeria, Armenia, Azerbaijan, Egypt, Georgia, Jordan, Lebanon, Libya, Moldova, Morocco, the Palestinian Authority, Syria, and Tunisia.

Soils contamination by traces metals in the valley of Gounti Yena (Niamey-NIGER)

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Key words: soil, trace metals; Gounti Yena; Niger.

Gounti Yena valley is a vegetable growing area of Niamey city surrounded by many pollution sources as : roads, wild dumps, raw sewage, burning of tires and waste. All these sources of pollution make of Gounti Yena a zone which could be contaminated by traces metals. These are found in soils and natural water and can reach very high concentrations in some substrates polluted by anthropogenic activities such as market gardening. They pose real environmental and health problems. Gardeners use wastewater from the valley directly to water their crops grown on soils that may be highly contaminated, and these crops are intended to supply local markets with vegetables and fruits. These products are then likely to be contaminated by traces metals. This could lead to a risk of human contamination through the consumption of these products (Tankari Dan-Badjo and *al.,* 2012). This study is therefore based on the soils contamination by the metals on Gounti Yena valley in order to provide data on this contamination and to take the appropriate measures to protect people and the environment. The study area covers an approximately 26 hectares and crosses several districts of Commune II of Niamey. The soils of this valley are of alluvial type, little evolved and rich in humus. The vegetation is very diverse.

The soil samples are taken along the valley so as to cover the entire surface and at a depth between 0 and 10 cm. Along the transect, all sampling points (P) were geolocated with a GPS. The sample is placed in a well-identified plastic bag. The laboratory analysis of the metals was carried out by inductively coupled plasma mass spectrometry (ICP/MS). The results obtained have been treated with the excel software and are expressed in mg/kg of soil. The results of soils average metals concentrations are given in table 1.

Table 1: Average concentrations of nine (9) metals in the soils of the Gounti Yena valley.

	As	**Cd**	**Co**	**Cr**	**Cu**	**Hg**	**Ni**	**Pb**	**Zn**
Gounti Yena	1.19	0.52	3.69	16.91	17.72	0.23	7.98	39.51	278.01
Control	0.23	0	0	0	0	0	0	4.71	7.75

Results show that concentrations of metals in soils of Gounti Yena are very disparate. At the control soil, only As, Pb and Zn were detected among the 9 metals with variant concentrations for As of 0.13 to 0.32 mg/kg, Pb of 4.30 to 5.12 mg/kg and Zn of 5.40 to 10.10 mg/kg. In the soils of Gounti Yena, the results obtained show that the concentrations range from 0.01 to 4.23 mg/kg for As, 0.03 and 3.56 mg/kg for Cd, 0.01 and 50.85 mg/kg for Co, 0.01 and 369.42 mg/kg for Cu, 0.01 and 1.26 mg/kg for Hg, 0.01 and 23.05 mg/kg for Ni, 0.01 and 725.66 mg/kg for Pb and 0.01 and 5546.30 mg/kg for Zn. The highest average concentration is observed for Zn followed in descending order by Pb, Cu, Cr, Co, Ni, As, Cd and Hg. Table 2 summarizes the regulatory standards for metals concentrations in soils according to several authors and also presents the average concentrations obtained in Gounti Yena soils and control soil.

Table 2: International standards and trace metals concentrations in soils of Gounti Yena Valley and the control Soil (mg/kg).

Metals	**Acceptable values (Sezgin and *al.,* 2004)**	**Standard AFNOR NF U 44-041 (1985)**	**French Association for the study of soil**	**Concentrations in Gounti Yena valley**	**Concentrations at the control soil**
Pb	100	100	100	0.01 – 725.66	4.71
Cd	3	2	0.7	0.03 – 3.56	Nd
Cr	100	150	150	1.01 79.91	Nd
Cu	50	100	100	0.01 - 369.42	Nd
Ni	50	50	80	0.01 - 23.05	Nd
Hg	2	1	0.3	0.01 – 1.26	Nd
Zn	300	300	300	0.01- 5546.30	7.75
As	20	20	20	0.01 – 4.23	0.23
Co	50	30	50	0.01 – 50.85	Nd

The concentrations of metals in the Gounti Yena valley exceed in some sampling points the soil limit values reported by different authors, such as Bowen (1996). This relates to Cd, Cu, Ni, Pb and Zn. Also, Cu, Pb and Zn exceed limit values reported by Temmerman and *al.,* (2003) and Kabata and *al.,* (2001). Zn at the sampling points P_1 ; P_2 ; P_3 ; P_4 ; P_5 ; P_6 ; P_7 ; P_8 with 404.29 mg/kg, 312.65 mg/kg, 5546.30 mg/kg, 322.65 mg/kg, 525.56 mg/kg, 2936.44 mg/kg, 2079.30 mg/Kg and finally 415.10 mg/kg of metals levels far exceed the acceptable values according to Sezgin and *al.,* (2004), the AFNOR standard NF U 44-041 (1985) and the French Association for the Study of Soil. Cd also finds itself in very high concentrations at some sampling points and even exceeds the limit set by some authors like Baize (2010). This is the case for the points P_1 ; P_3 ; P_{21} ; P_{14} and P_{11}.

In the soils of the control site, no trace of Cd was detected. For Cu, a very high concentration is detected at P_{10} and P_{21}. By comparison with the AFNOR standard NF U 44-041 of 1985, these contents are 3 and 5 times higher than the norm. It is the same finding at P_1 and P_2, where the Cu concentration is 5 times higher than this same limite value. At P_{10} and P_{21}, the Cu concentrations of the order of 369.42 mg/kg and 143.27 mg/kg respectively detected far exceed French regulations of 100 mg/kg. As for Pb, it is found in high levels at the level of 4 sampling points (P_1, P_8, P_9 and P_{10}) along the Gounti Yena valley. The concentration of Hg in soils of Gounti Yena ranges from 0.01 to 1.26 mg/kg with an average of 0.23 mg/kg. At the control site no trace of Hg was detected. Co was detected on the point P_{10} and the value of 30 mg/kg obtained is higher than the AFNOR standard.

The present study evaluated the metal levels in soils in the Gounti Yena valley. The results obtained showed that the nine (9) elements (As, Cd, Cr, Co, Cu, Hg, Ni, Pb and Zn) were detected in the soils of the Gounti Yena valley. In the control soil only As, Pb and Zn were detected at very low levels compared to regulatory standards. In the valley soils, high levels of Cd, Cu, Ni, Pb and Zn were found to exceed regulatory standards. This poses a problem of contamination of the plants grown in this valley and entails a risk of transfer in the trophic chain threatening the population which consumes these fruits and vegetables. Adequate decisions including monitoring of the soil contamination and the establishment of depollution process have to be taken in order to reduce human risks contamination.

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УДК 631.43

The experience of using tomographic methods for study of city soil properties

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Physic properties and its dynamics under anthropogenic impact data are important for organization of rational city soil using and its fertility management. But standard methods and methodic are hardly usable for modern urban soil science. New methods from other area of knowledge, such as computer microtomography widely used in geology, biology and medicine, are need to searched and adapted.

Objects of the study are soils of Rostov agglomeration and its physic properties, transformed under industrial, residential and recreational zones influence and also city territories margins were under influence of agricultural using. According to researches of city soils since 1998 soils were grouped to morphological classes – 1) natural structure soils without urban disturbance, 2) natural structure soils overlaid with anthropogenic sediments, 3) soils overlaid with not water conductive covers and overs [4].

3D scanning of soil samples was occurred on 3D scanner Bruker SkyScan 1172 in V.V. Dokuchaev Soil Institute. Image resolution was 16 μm/pix for study of inner structure. 16 μm/pix resolution makes possible to detect most of pores that conduct water. We used DataViewer and CTan to analyze the images. The samples had natural water content and structure during scanning. Soil sampled in special plastic containers 3cm diameter with hermetic package after [2, 3, 4]. Modern analysis methods level allows us to analyze separate structure elements, calculate its volume, surface square, amount and orientation inside of the sample without disturbance [1, 2, 5]. Also we can gain pore data (general porosity, open and isolated porosity in mm^3 of %, pore size and volume and its dependence, pore amount, connectivity)(table).

One of the main components of soil degradation in urban conditions is degradation of physic soil properties, what realizes as ecological dysfunction of soil. Soil degradation on horizon level connected with changes of particle size distribution, destruction of typical Chernozem structure, soil pore space deformation, compression, disaggregation, and forming massive block structure.

For urban territories in the steppe zone, a comparison of humus-accumulative horizons (A, Asod, Ap, and buried [A] horizons) made it possible to trace tendencies of changes in surface soils under different anthropogenic impacts and in the buried and sealed soils. Tomographic data allow to gain not only quantity information, but visual too. During data analysis we found that

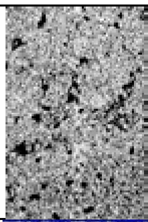
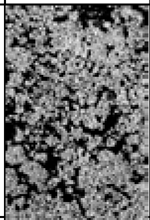
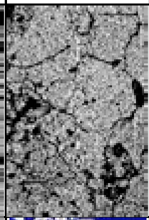
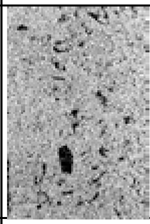
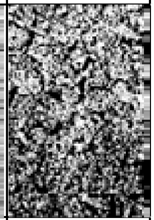
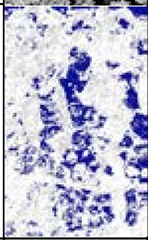
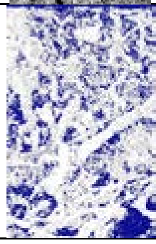
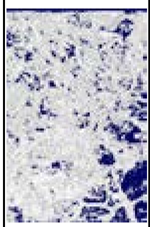
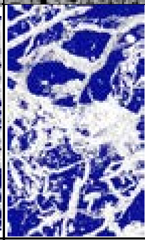
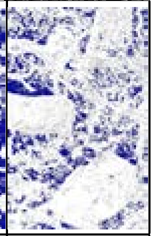
Shielded Urbanostratozem on buried chernozem (Ekranic Technosol (WRB, 2007)) had the most disturbed structure. Differ to undisturbed and park chernozems shielded urbanostratozem on buried chernozem have obvious signs of compression and reduced porosity. Pore space is fractured and produced by roots. Pore space connectivity is less than natural. Drainage properties is not good. Specific chernozem structure is perished (surface square is lessened, the amount of aggregates in the same volume is less, isolated porosity twice more than undisturbed chernozem (Calcic Chernozem, (WRB, 2007)). Water and air conductivity occurs in old root ways.

Shielded carbonated urbanstratificated chernozem (Calcic Chernozem Novic Technic (WRB, 2007)) is close to undisturbed chernozem in spite of high bulk density (~1.8 g/cm^3). Structure disturbance level is much less, pore space introduced by different pore types, connectivity is about 87%. But it has bigger isolated porosity, a lot of isolated little pores and the highest surface square. It can be result of big sand contain in the sample.

Difference between deposit soil samples, especially low pore connectivity can be explained by huge pore with compressed borders in the field of view. The structure is little compressed visually but close to normal.

Soil properties and structure of samples from park and virgin land are close to standard.

Table.
Urban soils. Structure and volume properties according to tomographic data.

Soil	Chernozem with high humus contain (park)	Common carbonated Chernozem, Aqsay town, Yantarny village	Urbanstratified carbonated shielded chernozem, Rostov-upon-Don residental zone	Common carbonated Chernozem, Rostov-upon-Don, park	Common carbonated Chernozem, Rostov-upon-Don, deposit	Shielded urbanstratozem on buried chernozem	Common carbonated Chernozem, Persianovsky village, virgin land
Tomographic (black pores)							
3D model of pore space (white pores)							
Object volume, mm^3	**1826,29**	**1826,29**	**1826,29**	**1826,29**	**1826,29**	**1826,29**	**1826,29**
Object surface, mm^2	**22223,96**	**22562,54**	**32754,82**	**27137,23**	**20932,36**	**17226,97**	**28605,6**
Number of objects (solid phase)	**525202**	**434509**	**246322**	**425803**	**273996**	**176521**	**405349**
Number of closed pores	**2241095**	**4068301**	**4016929**	**2379474**	**3345865**	**3560599**	**2725781**
Volume of closed pores, mm^3	**18,03**	**38,43**	**46,92**	**22,08**	**32,08**	**53,8**	**28,28**
Surface of closed pores, mm^2	**4459,57**	**9354,16**	**11335,74**	**5191,39**	**7719,96**	**10461,97**	**6612,08**
Closed porosity, %	**1,34**	**2,48**	**3,02**	**1,63**	**2**	**3,1**	**1,97**
Volume of open pore space, mm^3	**485,71**	**276,74**	**277,43**	**476,42**	**223,44**	**92,7**	**391,98**
Open porosity, %	**26,59**	**15,15**	**15,19**	**26,08**	**12,23**	**5,07**	**21,46**
Total volume of pore space, mm^3	**503,74**	**315,17**	**324,35**	**498,51**	**255,53**	**146,5**	**420,27**
Total porosity, %	**27,58**	**17,25**	**17,76**	**27,29**	**13,99**	**8,02**	**23,01**
Number of pores	**894493**	**1014702**	**2482612**	**1764102**	**2380397**	**2676946**	**2820511**
Connectedness, %	**97,16**	**39,8**	**87,29**	**96,7**	**88,69**	**58,61**	**94,71**

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Chemical element concentrations in urban soils at the turn of the twenty-first century

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A prevailing part of the world's human population lives nowadays in settlements, and the greatest environmental geochemical transformations occur there. Chemical element concentrations are consequently changing in soils, which are the key accumulating biomineral medium of urban ecosystems.

Geochemical peculiarities of this medium are in many ways linked to the landscape-geochemical conditions of soil formation and subsequent inflow, migration, and accumulation of substances. In the natural (biogenic) landscapes, soils and even plants largely inherit geochemical properties of parent rock materials. As distinct from the natural landscapes, geochemical patterns of urban soils have become dependent on anthropogenic activities in this day and age.

We considered calculating average concentrations and absolute spreads of the chemical elements as the most important task at the end of the 20th – beginning of the 21st centuries. In carrying out this task, we studied soils of over 300 settlements in Europe, Asia, Africa, Australia and Americas using specially developed methods (Alekseenko, 2000; Alekseenko and Alekseenko, 2014). This allowed establishing the average concentrations of 50 chemical elements (Table 1). The list includes such elements as Bi, C, Cs, Nb, O, Sb, Ta, Tl, W, and Yb, which abundances in the Earth's soils were not found by A.P. Vinogradov (1959).

Table 1

Abundances of the chemical elements in the Earth's crust, the Earth's soil cover and in urban soils (mg/kg)

Element	Element number	Abundance in		
		the Earth's crust	the Earth's soils	urban soils
Ag	47	0.07	0.50	0.37
Al	13	80500	71300	38200
As	33	1.7	5.0	15.9
B	5	12.0	10.0	45.0
Ba	56	650	500	853
Be	4	3.8	6.0	3.3
Bi	83	0.009	–	1.12
C	6	–	–	45100
Ca	20	29600	13700	53800
Cd	48	0.13	0.50	0.90
Cl	17	170	100	285
Co	27	18.0	8.0	14.1
Cr	24	83.0	200.0	80.0
Cs	55	3.7	5.0	–
Cu	29	47.0	20.0	39.0
Fe	26	46500	38000	22300
Ga	31	19.0	30.0	16.2
Ge	32	1.4	5.0	1.8
H	1	–	–	15000

Hg	80	0.08	0.01	0.88
K	19	25000	13600	13400
La	57	29.0	40.0	34.0
Li	3	32.0	30.0	49.5
Mg	12	18700	6300	7900
Mn	25	1000	850	729
Mo	42	1.1	2.0	2.4
N	7	19.00	1000	10000
Na	11	25000	6300	5800
Nb	41	20.0	–	15.7
Ni	28	58.0	40.0	33.0
O	8	–	–	490000
P	15	930	800	1200
Pb	82	16.0	10.0	54.5
Rb	37	150	100	58
S	16	470	850	1200
Sb	51	0.5	–	1.0
Sc	21	10.0	7.0	9.4
Se	34	0.05	0.01	–
Si	14	295000	330000	289000
Sn	50	2.5	10.0	6.8
Sr	38	340	300	458
Ta	73	2.5	–	1.5
Ti	22	4500	4600	4758
Tl	81	1.0	–	1.1
V	23	90.0	100.0	104.9
W	74	1.3	–	2.9
Y	39	20.0	50.0	23.4
Yb	70	0.3	–	2.4
Zn	30	83.0	50.0	158.0
Zr	40	170.0	300.0	255.6

As can be seen from the above data, concentrations of B, Ba, Ca, Cl, Hg, Li, P, Pb, Sr, and Zn in urban soils have become significantly higher than those in the Earth's crust and soil cover due to technogenic processes. It is worth noting that abundances of these elements in the Earth's soils are lower than in the Earth's crust. This indicates that the general soil forming processes could scarcely substantially influence the raising contents of these elements in urban soils.

Concentrations of As (9.4), Ag (5.3), Sn (2.7), Mo (2.2) exceed their abundances in the Earth's crust (folds of excesses are shown in brackets). Their abundances in the Earth's soils are also higher the in the crust. Thus, accumulation of these elements in urban soils is affected by both the natural soil forming processes and technogenic activities.

Differences between the chemical element concentrations in urban soils and in the Earth's soils and crust forced us to discriminate the geochemical system of urban soils and to calculate abundances of the elements in order to provide the data for environmental studies.

Technogenic impact on inflow, migration, and accumulation of certain elements in soils is constantly changing. The relation between the natural soil forming processes and technogenesis is also dynamic. It is not possible to find the rate of such changes at the moment. In this regard, it is recommendable to establish the chemical element concentrations for a specific time slice. The calculated contents of the chemical elements in urban soils can be considered as the abundances for the end of the XX century – beginning of the XXI century.

For a detailed examination of urban geochemical patterns, which are highly dependent on technogenic influence, we separated settlements into six groups according to the number of inhabitants:

1. more than 700 thousand;
2. from 300 to 700 thousand;
3. from 100 to 300 thousand;
4. cities with population less than 100 thousand;
5. small towns, villages, hamlets;
6. tourist and recreational areas.

Settlements with such activities as mining, processing, and waste landfilling are considered distinctly. Soils of each group of settlements are different by chemical element concentrations (Alekseenko and Alekseenko, 2015).

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Ecotoxicological state of urban soils of the Arctic with different functional load (Murmansk and Yamal autonomous region)

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The functioning of the polar biome strongly relies on its soils. The geochemical regime directly connects soils with their function as agent for accumulation, migration and transformation. In addition, soils play very significant role for various ecosystem services (Morel et al., 2015).

On the one hand, trace elements are naturally present in parent materials and soils occurring in the form of sulfides, oxides, silicates, and carbonates (Antcibor et al., 2014). At the same time trace metals are considered as the major group of anthropogenic contaminants in soils. Studies conducted earlier, showed that trace metals can reach the Arctic by different paths both anthropogenic and natural origin (Akeredolu et al., 1994; Rahn al., 1997; Rovinskiy et al., 1995; Thomas et al., 1992).

Investigations of pollutant behavior in both urban and natural soils could be used for making accurate risk assessments concerning such aspects as human health and long-term ecological effects. Approaches to establishment of limit values and identifying priorities concerning the remediation of contaminated sites could be also developed (Linde, 2005). Data concerning the trace elements content in soil of the Arctic is limited and should be state as insufficient. Evaluation of anthropogenic impacts on Arctic ecosystems requires not only background levels of trace metals, but also landscape distribution of elements in permafrost-affected soils in relation to soil properties (Antcibor et al., 2014).

This study was conducted on the territory of Yamal autonomous region within the settlements (Aksarka, Kharsaim, Kharp, Labytnangi, Salekhard) and Murmansk. Both regions are referred to the zone of discontinuous permafrost.

Soil classification was conducted according to "Classification and diagnostics of Russian soils" (Shishov et al., 2004) and World Reference Base for Soil resources (FAO, 2014) (Table 1).

Table 1. General field information on studied key plots

Key plot	Geographical coordinates	Functional zone/Landscape description	Name of the soils in WRB (2014); Russian soil classification system (2008)
Aksarka	N 66°33′54,3′′ E 67°48′04,8′′	Recreational functional zone	Urbic Technosol; Urbanozem
Kharsaim	N 66°35′54,7′′ E 67°18′34,2′′	Recreational functional zone	Urbic Technosol; Urbanozem
Salekhard	N 66°33′31,9′′ E 66°34′07,2′′	Residential functional zone	Urbic Technosol; Urbanozem
Labytnangi	N 66°40′01,1′′ E 66°20′59,6′′	Industrial functional zone	Urbic Technosol; Technozem
Kharp	N 66°48′34,0′′ E 65° 47′08,0′′	Industrial functional zone	Urbic Technosol; Technozem
Murmansk	N 68°58′45′′ E 33°05′33′′	Recreational (x2)/Industrial/ Residential functional zone	Urbic Technosol/Histic gleyic Podsol/ Urbic Technosol/Entic Podzol; Torfyano-stratozem/Torfyano-Podzol gleeviy/ Urbo-stratozem/Torfyano-Podbur gleeviy

Ecotoxicological state of Russian Arctic cities is underestimated. That is why this study was aimed to investigate trace metals content in soils of both Yamal and Murmansk urban environments, and to deduce profile trends of distribution trace metals in permafrost-affected soils of studied urban areas. During the investigation 12 sites in Yamal region and 4 sites in Murmansk were studied and samples were taken from a depth of 0-5 cm and 5-20 cm. Soil samples have been collected in industrial (Labytnangi, Kharp, Murmank), residential (Salekhard), recreational functional zones (Aksarka, Kharsaim, Murmansk). Trace elements contents (Pb, Cu, Ni, Zn, Mn) were determined with an X-ray fluorescent analyzer "Spectroscan-MAX" (OST 10-259-2000).The values obtained were compared with the permissible concentrations and maximum allowable concentrations adopted in Russia named in GN 2.1.7.2511-09 (GN 2.1.7.2511-09), GN 2.1.7.2041- 06 (GN 2.1.7.2041-06) and SanPin 42-128-4433-87 (SanPiN 42-128-4433-87).

Results on trace elements content for investigated key plots in urban environments of Yamal region and Murmansk are summarized in Table 2. The highest concentrations for Cu, Zn, Ni were found in the Kharp key plot which seems to be caused by existing chrome-processing factory. The highest median values for Pb were found in soil samples from Aksarka and Labytnangi key plots. Soil samples from Kharsaim and Kharp key plots were characterized by the highest median values for Zn. This can be explained by geological origin and high regional background concentration element for this trace element (Moskovchenko, 2010).

Soil samples collected in Murmansk are characterized by highest medians in Pb, Ni and Mn in topsoil horizons, and Mn in lower horizons (*Mur1 and Mur3* - recreational functional zone); Mn and Zn (*Mur2* - industrial functional zone); Mn and Ni in topsoil horizon, Mn and Zn in lower horizon (*Mur4-residential industrial zone)*. Since soil samples in Murmansk were collected from less-disturbed soils (compared to highly human-mixed soil material in settlements of Yamal autonomous region) profile distribution of trace elements seems to be similar to those in natural soils of the Arctic region reported in previous works (Tomashunas, Abakumov, 2014; Moskovchenko, 2010; Nikitina et al., 2015). It means that the highest contents of trace elements occur in Histic topsoil horizons or on the biogeochemical barriers (which can developed on the active layer-permafrost border or in redoximorphic conditions).

Table 2. Trace metals content in soils of studied urban areas, mg kg^{-1}

ID/Soil horizon (depth, cm)	Cu	Pb	Zn	Ni	Mn
Kharsaim					
Km1 / O (0-5)	10.5	36	143	13	599
Km1 / G (5-20)	8	7	27	16	538
Km2 / O (0-5)	1.6	2.3	5.7	4	339
Km2 / Gtur (5-20)	1.6	2.3	5.4	4.4	87
Aksarka					
Aks1 / O (0-5)	3.8	4	11.6	8.3	262
Aks1 / G (5-20)	9.1	7.6	25	15	392
Aks2 / O (0-5)	5.5	10	17	12	425
Aks2 / G (5-20)	6	150	17	14	419
Salekhard					
Sal1 / W (0-5)	7.1	8,9	27	9	497
Sal1 / C (5-20)	7.5	8,9	25	9	499
Sal2 / W (0-5)	6.3	6,2	20	10	649
Sal2 / C (5-20)	7	6,7	24	11	1520
Kharp					
Kh1 / W (0-5)	73	7.9	56	50	1745
Kh1 / C (5-20)	80	3	46	19	1886
Kh2 / W (0-5)	74	4.2	49	28	1799
Kh2 / C (5-20)	86	3.9	49	30	557
Labytnangi					
Lab1 / W (0-5)	9	9.1	31	13	402
Lab1 / C (5-20)	6	6.1	19	10	449
Lab2 / W (0-5)	6.2	6.6	19	9	1632
Lab2 / C (5-20)	7.4	7	21	12	1432
Lab3 / W (0-5)	9.5	7.3	27	17	456
Lab3 / C (5-20)	11.2	7.7	28	17	476
Murmansk					
Mur1/O-T (0-12)	45	93	43	44	47
Mur1/R (12-24)	3,9	2,8	36	55	110
Mur2/O (0-2)	23	6,8	21	17	35
Mur2/RY (2-34)	13,7	2,1	16	16	40

Mur3/T (0-12)	51	55	51	78	130
Mur3/E (12-24)	2,2	3,5	6,7	3,9	19
Mur4/T (0-11)	52	16	67	90	1400
Mur4/BHF (11-38)	21	4,5	45	23	850
Maximum allowable concentrations (MAcs)	***33***	***32***	***55***	***20***	***1500***

Degradation of permafrost could alter the behaviour of trace elements in soils. It will affect the rates of accumulation, transformation, translocation, leaching and transportation of trace elements and other pollutants within the permafrost-affected landscapes. Consequently, ecosystem services provided by urban soils should be investigated in context of predicted climate change.

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Extreme accumulation of sulfur and other elements in soils and sediments of the cities of Central Russia

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In old cities of European Russia, thick layers of urbosediments have been accumulated under the impact of anthropogenic activity; these layers are considerably transformed by pedogenetic processes and enriched in technogenic elements. Their thickness in central parts of the cities reaches 3–5 m increasing to 10–15 m in some depressions. Their accumulation has led to the leveling of topography and to the rise in the groundwater level; the latter is particularly pronounced in the regions with wet climate and flat topography (Alexandrovskiy et al., 2012). Under these conditions, organic cultural layers (wet layers in terms of archaeologists) are formed. They represent peat-like mass with the remains of wood chips and wooden constructions that are permanently found below the groundwater table (Velikii Novgorod, Staraya Ladoga, Rostov Velikii, Smolensk) (Dolgikh, Alexandrovskiy, 2010). There are also fragments of ceramics, animal bones, and other inclusions. The organic matter content in such sediments reaches 50–70% (in some cases, up to 90%).

Usually, the organic (wet) layers are overlain by mineral layers composed of fine earth with brick fragments and other inclusions. The organic layers correspond to the medieval epoch. The mineral layers have mainly been accumulated in the past two–three centuries. The initial soil underlies the organic layers. This may be a Retisol or Planosol (Velikii Novgorod and Smolensk), or a gray forest soil, Luvic Phaeozem (Rostov Velikii). In Staraya Ladoga, this is a dark-humus soil on lacustrine-bog sediments (Phaeozem). Element concentrations in the samples were determined by the X-ray fluorometry. We also determined the contents of SOM and LOI, pH, and the $CaCO_3$ content.

The results of analyses indicate that human activity leads to the accumulation of many elements—heavy metals, phosphorus, calcium, etc,—in the urbosediments (Alexandrovskaya, Alexandrovskiy, 2000). Normally, they are accumulated in the entire thickness of urbosediments. The content of calcium carbonates is somewhat higher in the upper mineral layer, whereas the contents of copper and zinc are higher in the lower organic layer. Heavy metals, P2O5, and $CaCO_3$ also penetrate from the cultural layer into the underlying buried soil.

The accumulation of sulfur attracts special attention. This element is present in high concentrations in the wet organic layer. Thus, in the mineral (dry) layer, the content SO3 rarely exceeds 1%, whereas in the wet organic layer it may reach 6–10%. In the underlying buried soil, the sulfur content sharply decreases. Thus, the layer with maximum sulfur content is strictly confined to the permanently waterlogged organic layer of urbosediments. Analogous or even higher concentrations of sulfur are often found in the natural lacustrine and bog sediments of the Holocene.

Often, a transitional organomineral layer is found between the mineral and organic layers of urbosediments. In our opinion, it is developed from the organic layer after the construction of drainage systems with an artificial lowering of the groundwater level. As a result of drying of the organic sediments, the microbiological activity enhances, and the fast mineralization and humification of the raw organic matter take place. This is also accompanied by a decrease in the content of many elements. The decrease in the content of phosphorus and heavy metals proceeds slowly, whereas the decrease in the content of sulfur is a fast process. This has been shown for the organomineral layer in Staraya Ladoga.

The rate of sulfur accumulation in the organic layer can be judged from data on a relatively young organic layer in Smolensk, in the park of Blonie. Under the recent sediments, a peat-like layer that accumulated in the 18th–19th centuries AD is found. In 200 years, the SO3 content in this layer has reached 5.8%. The upper part of this organic layer has recently been drained. However, the sulfur content in it has significantly decreased.

The observed phenomenon of the considerable accumulation of sulfur in the organic urbosediments has a complex natural and anthropogenic nature. The direct reason for it is the anthropogenic accumulation of the organic layer of urbosediments; the enrichment of this layer is sulfur has a natural origin analogous to that of sulfur accumulation in the natural lacustrine–bog sediments.

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Role of Multi-Functional Floating Urban Green Infrastructure in Creating Natural Habitats and Curbing Pollution

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Introduction

Rising temperatures due to global warming have lead to innovative strategies to mitigate the rise in temperatures in existing and future cities. There has been an increasing trend in implementing urban green infrastructure (UGI) such as green roofs and green façades to achieve temperature reductions while also delivering other benefits such as pollution reduction, creating habitat for local wild life, beautification and numerous other functions. An interdisciplinary intervention between architecture, engineering, plant biology, ecology, horticulture and soil science needs to be further investigated for the sustainability and proper usage of available space. Considering coastal cities and towns with integrated natural water bodies such as rivers and lakes, there is an opportunity to use these spaces for creating sustainable urban green infrastructure that could supply the surrounding areas with fresh produce as it can be farmed on site.

Methods

The Netherlands has been at the forefront in using the local harbors to integrate systems that not only create a habitat for greenery to grow but also to perform other pollution mitigating services. The 'Urban Green' project launched in September, 2015 which was developed and commissioned by the Municipality of Rotterdam and Public Works, is creating a floating island with two main objectives. First is to improve the water quality in the area for fish habitat and micro-invertebrates. Second objective is to improve the spatial planning of the city of Rotterdam.

A floating island measuring 300m² serves as a habitat for fish and micro fauna both above and below the water. This is also a much welcomed design feature, for it enriches the area with greenery providing over 400 apartments facing the island with a view to enjoy. Another project under the same directive known as the 'Driving Green' project is the first prototype constructed using wooden frames aimed at creating micro fauna and fish habitat, and a second prototype uses only plastic. This project is proposed to be installed in the Nieuwe Maas water way, a distributary of the Rhine River.

Another innovative approach is practiced by the 'Recycled Park' project, which started off as a joint venture between Royal Haskoning DHV, ISI and SK international in assignment of SBIR (Small Business Innovation Research). The project involves an entrapment system used to remove plastic waste from open water. In light of the importance of this innovation, the Dutch government became the primary ordering party, as it turns out that 98% of the plastic waste is concentrated in the upper meter water level, the upper half meter consisting of organic and inorganic waste such as plastic wrapping, bottles, cans, foils, bags etc. In association with HEBO these traps will be placed in strategic positions along the rivers. The plastic visor is comprised of a floating basin 6m wide and 12m long, with separation and shredding installation, a finger sieve which separates large material from small material. After the organic waste is returned to the river, what remains in the big-bag is clean material that can be used to make building blocks for a floating park. This floating landscape designed by the Students of Rotterdam University is comprised of hexagonal plan blocks that can be connected together using a pen.

Similarly, the students of TU Delft are currently further developing these building blocks. The Wageningen University will analyze the plastics taken out from the rivers. Additional materials such as Bio based plastics and Bio based wax which has a reduced carbon footprint and lower exhaustion of fossil raw materials, the top of the building blocks will have a green environment thriving with a wide variety of plants, moss and even trees a few meters high. These building blocks can be attached to each other and a big floating platform can be created. The bottom of the platform where algae and different plants will grow can provide the marine life with a habitat, where they can even safely lay their eggs. The optimum use of this ecosystem can be achieved with the guidance and advice of the ecologists.

The variations of these blocks can be both above and under the water. They could also have height differences resulting in a curved landscape; this variation of building blocks would give rise to a new landscape, new city parks with a unique character. This can be a floating landscape on the river, a public green area that facilitates sport together with water-related programs. The floating characteristics can also allow parks to be relocated if needed. River shores are also going to be softened in comparatively inexpensive way as compared to replacing the hard shores with natural slopes, these floating platforms can provide green areas in and on the water, along these green shores fish, birds and other organisms can nest and breed, while creating attractive public spaces. Another project which is noteworthy is situated in the Gowanus canal, an infamously polluted waterway in Brooklyn, US. This experiment aimed at cleaning water through phytoremediation, desalination and rainwater to irrigate floating gardens was designed and built by Balmori Design firm. The structure features 19 plant species in metal culvert pipes that are filled with plastic bottles. Layered underneath it is a combination of bamboo, woody plant material, water lyacinth rope, coconut matting, oak cork and postconsumer shredded plastic. Like a sponge, it filters water creating a productive landscape and in a bigger scale it would act as a habitat for wildlife and utility island as a floating park or a playground. These islands are composed of solar stills that distill the canal's blackish water and collect it in a reservoir as unsalted water. The plants used in this system include goldenrod, black-eyed Susan, Black rush and bulrush which are efficient in removing contaminants.

The irrigation of such spaces could also be a factor worth considering. The "In search of habitus" project also known as the 'Bobbing Forest' by designer Jorge Bakker is a collection of elm trees planted on decommissioned steel water buoys with a 600 liter water reservoir that requires water to be replenished four times a year. This could be made more sustainable if a passive atmospheric water collection system is also integrated in order to collect moisture from air and amass clean water for irrigation purposes in the above mentioned floating garden systems. The 'Warka Water' system and invention by Aruro Vittori, mainly designed to supply clean drinking water in places where water is scarce such as Ethiopia is a 30-ft high vase shaped low tech design that can provide 25 gallons of water per day. Other variations of such systems are also affective in different environments, as they could provide a sustainable low maintenance solution for collection of irrigation water especially in coastal areas, where there might be abundance of saline content in the water where these floating gardens might be proposed.

Conclusion

Further research must be carried out on the combination of the passive systems implemented into these floating gardens, seamless and sustainable programs that not only provide positively for the environment but also have least amount of upkeep and intervention after the installation. The design in itself must be justified by the advantages if provides the society and environment with the least amount further upkeep, resembling natural systems as much as possible.

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Environmental assessment of the native and man-changed soils in the Pereslavl region of the Yuryev-Polish plain[1]

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Introduction. Man-changed soil cover of the Pereslavl region is especially interesting for research in field of land quality modern state and prediction with Global changes challenges of the XXI century. Firstly, Pereslavl is one of the key elements of so called Gold Ring with more than Millennium history of intensive land-use practice with different inputs on soil cover patterns and functions. Secondly, it is in the northern part of Yuryev-Polish plain with intermediate native soil cover patterns between zonal one with dominated sandy loam Podzoluvisols (Vasenev, 2008) and typical for Opole soil cover pattern with dominated loam Chernic Gleyed Phaeozems (Soil Excursion…, 2015).

Objects and methods. Relief of the study area is presented by hilly-steeply sloping erosion moraine plain. The absolute level of the terrain does not exceed 177 m above sea level. The territory is characterized by finely and gently undulating topography with flat watersheds. Gullies and ravines network is quite active: the thalweg distributed wetlands and meadows with bush encroachment. Moraine ridges slopes have erosion processes. Moraine of Moscow glaciation is characterized by reddish-brown color, high content of boulders and detritus, high-density and low filtration capacity for soil solutions and lysimetric water, sandy and gravel presence. Cover loams are more favorable for soil formation. It makes a fairly uniform soil texture, taken from the parent material. Bioclimatic resources limit the range of cultivating crops in the region. In addition, these climate conditions are favorable for gley and podzol processes development, and soil acidification too. Principal soil forming and degradation processes have been studied in the chrono-sequences, meso-relief- and litho-catena sets with especial attention on soil physic-chemical properties and soil migration processes, analyzed by lysimeter method.

Results and discussion. Common for native and slightly changed soil cover patterns in the Pereslavl region sod-podzolic soils (Sod-Podzoluvisols / Albeluvisols Umbric) have a typical for southern taiga zone principal system of genetic horizons: A – AEL – EL – ELB – B1 – B2 – BC – but with well-developed humus-accumulative sub-profile and local gley features, which are characteristic for Opole soil cover. Long used soil profiles usually have 20-30-cm arable or urbic horizon on the illuvial horizon B, the upper part of which has already been transformed. Some of these soils are rich in available forms of nutrients, humus, nitrogen and exchangeable calcium. These properties are developed in centuries, especially around churches and monasteries. Previously, such soils were referred as monastic. The other ones are poor and degraded due to erosion, dehumification, disaggregation, overconsolidation and gley processes. Often, they are also acid with increased mobility of nutrients and heavy metals in topsoil, geochemical barriers in subsoil and intensive local lateral fluxes of soil solutes including nitrates and colloids of water-soluble organic matter with aluminum and iron. These fluxes can have increased content of heavy metals and often do strong impact on the water quality in the numerous local shallow lakes and old ponds that are typical for these landscapes too.

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Fitoremediation of urban soil polluted by copper

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Was studied availability of using fitoremediation for extraction from soil by plants (method of atomic spectrophotometry). Chitosan was proposed as an effective additive component for double increasing fitoremediation of soil polluted by copper. It was shown that photosynthetic apparatus of wheat plants was stimulated by chitosan (methods of thermoluminescence and slow fluorescence induction).

Fitoremediation is a gentle method of clining up [1, 2] of soils in urban and past factories territories considered by copper.

Was studied migration ability copper in the system plant-soil with effective additive component polysaccharide chitosan. Chitosan is a natural component in soil with complecs properties with metals. Copper was used as a model heavy metal in our inverstigations. The method of vegetative miniatures were studied migration ability of copper ions in the soil-plant system. Investigations were carried out on sod-podzolic srednesuglinistoj soil, (Podzols Entic (Loamic) [4]). As a model plant used wheat Triticum aestivum L. seedlings (variety "Lyubava"). The weight of the soil in pots of 100 g in each pots were sown on 12 germinated grains of wheat.

Copper was added as an aqueous solution CuSO4´5H2O 7 mg per 100 g soil. Oligohitozan was added as a 0.5% solution per 10 ml per 100 g soil. Three variants of the experiments were conducted. In the first embodiment, the soil and copper were added 10 ml of distilled water, and the second oligohitozan copper. Third Embodiment served background, the soil was added 20 ml of distilled water. On the third day after seeding, the seedlings were taken for analysis. Wheat seedlings is adjusted to an absolutely dry weight in an oven for 6 hours at 70 °C. Then the dried sprouts were laid at weighing bottle, poured thereto 3 ml of HNO3, HClO4, and 7 ml ashed on a sand bath. The evaporated precipitate diluted with 5 ml of 1N HCl. The copper content in the wheat seedlings were determined by atomic spectrophotometry. The results are shown in Table 1.

Table 1. The copper content of the wheat seedlings.

Experience	The average weight of dry matter	Confidence interval (α=0,05), mg/g dry matter
Background	0,1273	0,1006 ÷ 0,1540
Copper	0,1701	0,1200 ÷ 0,2202
Oligohitozan and copper	0,3039	0,2069 ÷ 0,4009

It is shown that the presence of chitosan in the soil increases and copper migration ability, respectively, its entry into wheat germ (in the first phase of the sheet) by 1.5 times compared with the control.

There is a question about the need to study the effect of chitosan on plants. A number of studies have shown that chitosan has immunogenic properties and rostostimulyatora.

For the first time the methods termolyuminestsenii (TL) and slow fluorescence induction (SIF) has been investigated the effect of chitosan on the efficiency of the photosynthetic apparatus of plants, which is directly related to plant productivity [5,6].

Slow fluorescence induction measured at a wavelength of 686 nm at room temperature. To standardize the initial conditions were 30 second sheet broadband illumination with blue light, then the sheet was kept in the dark for 5 min. The next time you turn on the blue light were measured fluorescence. The parameter used ratio (FM- FT) / FT, where FM - the maximum value of the fluorescence, FT - its steady-state level.

It has previously been shown [7] that changes in this parameter for different methods of treating plants correlated with a change in photosynthetic activity (O2 release rate) per chlorophyll.

SFI and Measurement TL was carried out on three weeks of wheat seedlings grown under the following conditions. The mixed urban soil samples classified as urbanozëm - replantozëm (Urbic Techosols (Eutric, Loamic, Ochric)) [3,4], weighing 200 g was sown on 20 grains of wheat. The soil sample with 10 ml of 0.05% chitosan solution was made. As a control, the soil in the natural state. Chitosan was added to the soil three times at weekly intervals. The first time was added immediately before planting seeds.

The results of measurements SFI plant leaves treated with chitosan, are presented in Table 2 (the significance level (□) 0,2). In making chitosan in the soil there was an increase of the parameter (FM - FT) / FT MIF, indicating increased photosynthetic activity.

Table 2. Results of measurement SFI plant leaves.

Experience	$(F_M - F_T)/F_T$	Confidence interval $(F_M - F_T)/F_T$ (α=0,2)
Background	0,88	0,83 ÷ 0,93
Chitosan	1,09	1,07 ÷ 0,11

To measure the TL first sample (cutting from the leaves of wheat seedlings) lit at 200C light from an incandescent lamp, passed through water (heat) and an interference filter with ' max = 735 nm for 1 minute, then within

3 minutes at -30 0 C with light from an incandescent lamp, passed only through a water filter. The sample was then cooled to -80 0 C, and heating was performed at a speed of 300C / min. to 80 0 C with simultaneous recording of the curve TL (depending on sample light intensity on the temperature).

There are a number of peaks, the most important of which are the peak of A (with a maximum temperature of about 10 0 C) and peak B (with a maximum temperature of about 30 0 C) in TL plant leaves [8]. The magnitude of these peaks can be judged on the effectiveness of the second photosystem plants.

Soil chitosan resulting in an overall reduction in the intensity TL peak area A (Sp (-30, -3) = - 3.7 ± 1.0 conv) and in peak B (Sp (10; 60) = - 4,0 ± 1,5 standard units) (Figure 2)... It can be assumed that chitosan increases the rate of nonradiative energy deactivation and increases the efficiency of the second photosystem of plants, which leads to an overall reduction in TL.

Based on the data obtained by means of MIF and TL it can be concluded that the introduction into the soil of chitosan increases the efficiency of the photosynthetic apparatus.

Table 3. Temperatures peak maxima TL wheat leaves when applied to the soil chitosan

Experience	peak temperature, ^{0}C.	
	Peak A	Peak B
Background	-6±2	33±2
Chitosan	-19±1	29±6

Conclusion

In the study of soils contaminated by copper treatment possibilities by phytoremediation it has been revealed that the introduction of natural polysaccharide chitosan in the soil-plant increases the mobility of copper ions and their arrival at the plant by 1.5 times.

The methods of thermoluminescence (TL) and slow fluorescence induction (SFI) has been revealed stimulating effect of chitosan on the work of the photosynthetic apparatus of plants.

It seems appropriate to use chitosan to improve the efficiency of phytoremediation method for cleaning urban soils contaminated with heavy metals.

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Soils and soil cover of urban and suburban parks in Saint Petersburg (Russia)

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Introduction. Urban soils are the one of the most discussed topics of modern soil science. Numerous studies conducted also on the territory of urban parks and other green areas but mostly for environmental assessment and contamination control. There are only a few papers where genesis and evolution of park soils were considered (Dolotov, Ponomareva, 1981; Matinian et al., 2008; Prokofieva et al., 2013; Kawai et al., 2015). The objectives of present study were to characterize soils and soil cover of urban and suburban parks of Saint Petersburg and to discuss their distinction from soils of other urban areas.

Study area. Saint Petersburg is located at 59°57´N and 30°19´E on the banks of river Neva and east coast of Finnish gulf. The climate is humid continental of the cool summer subtype – Dfb, according to K' ppen classification (Kottek *at al*., 2006). The average annual temperature is 5.8 °C and average annual precipitation is about 660 mm. The natural conditions correspond to the southern taiga subzone. There are eight landscape regions within administrative boundaries of Saint Petersburg (1439km^2). They distinguished by the stable features of their landform, soil-forming materials and moistening regime (Isachenko, Reznikov, 2014).

Objects and methods. Studied parks were located within the administrative boundaries of the city, at the different distances from the city center. The objects include the urban parks of 18th century located in the central part of the city (Polish Garden, Summer Garden, Voronikhinsky Square, Park of Kamennoostrovsky Palace), urban parks of 20th century (Pulkovsky park, Park of Internationalists, Voronezhsky garden), the suburban parks of 18-19th centuries (park Alexandrino, Shuvalovsky Park, park Osinovaya Roshcha Alexandriisky park, Angliisky park, park Sergievka, Oranienbaum and Pavlovsk).

Soils were classified according Russian soil classification system (2004) considering additions proposed by Prokofieva et al. (2014). Additionally the names of Reference Soil Groups according the World Reference Base (IUSS Working Group, 2014) were given.

The chemical characteristics of soils were determined by traditional analytical methods (Vorobieva, 2006).

Results and discussion. Among areas for park construction were as well natural, as man-altered (mainly agricultural) landscape units. Park development was accompanied by significant purposeful transformation of initial landscape: filling of depressions, creation of artificial hills and terraces, drainage construction, etc. Natural vegetation was partly or completely substituted by deciduous cultivars, ornamental shrubs and lawns. The ways of soil cover transformation depended on initial landscape conditions and architecture style. The purpose of soil transformation was to create appropriate edaphic conditions for park vegetation. Sometimes soil constructions were made for planting certain kind of vegetation, for example, an individual tree or tree group (Semeinaiya Roshcha in Pavlovsk park, the memorial oak in Kolonist park). These constructed soils had thick (50-70 cm) humus layer for the better development of the root systems.

Factors of soil transformation in parks are also altering of moistening regime and vegetation cover. The drainage promotes not only better aeration but also better heating of soils. Therefore, in parks, the litter of deciduous trees is richer in biogenic elements and conditions of its decomposition are preferable in comparison with natural coniferous forest.

Soil cover of urban parks in the central part of the city (Prinevsky landscape region) consists mainly from urbostratozems (Urbic Technosols). The natural soil cover differentiation of this area usually hidden under the cultural layer. Although, urbi-stratified soddy rzhavozem (Entic Podzol) was described in the Park of Kamennoostrovsky Palace. Urbostratozems predominate in urban parks, but their share in soil cover became lesser in large suburban parks, for example Pavlovsk.

Several parks in the southern part of Saint Petersburg (Internationalist park, Voronezhsky garden) were created in the middle of 20th century on the rural lands. The soil cover of Internationalist park included agrozems (Anthrosols) and agrosoddy elluvial-metamorphic soils on varved clay (Stagnosols) along with urbostratozems. Urbi-stratified agrosoddy elluvial-metamorphic soils on varved clay also occurred in park Alexandrino in the southwestern part of the city.

Shuvalovsky Park and park Osinovaya Roshcha are situated in the northernmost part of city (Lembolovsko-Toksovsky kame landscape). The soil forming materials are limnoglacial sands and loamy sands. Natural soils of park Osinovaya Roshcha are soddy rzhavozems.

Parks of Peterhof (such as Alexandriisky, Angliisky, Sergievka) and Oranienbaum park are located in Predglintovy landscape of limnoglacial plains. The soil forming materials are moraine loams and limnoglacial sands. The natural soils here are represented by soddy podzolic and gleyed soddy podzolic soils (Luvisols), soddy podzols (Albic Podzols), soddy and mucky gley soils (Gleysols), peat gleyzems (Gleysols).

Pavlovsk park is situated in the southeastern elevated part of Prinevskaya lowland. The soil forming materials are mainly limnoglacial sands. The soil cover consists from natural and anthropogenic soils. Natural soils are represented by soddy podzols (Albic Podzols), grey-humus sandy soils (Arenosols), soddy alluvial soils (Fluvisols), soddy and mucky gley soils (Gleysols).

Anthropogenically transformed soils of suburban parks are stratified, urbi-stratified, and also turbated soil varieties. Anthropogenic soils of suburban parks are stratozems and urbostratozems. Anthropogenic soils of suburban parks have less amount of artifacts, lower pH in comparison with typical urban soils. Median thickness of anthropogenic layers in suburban parks (52 ±21 cm, n=59) lower than in the urban parks (120±30 cm, n=34). Natural factors of soil differentiation play significant part in the large suburban parks, where share of natural soil could reach 75% and more. Natural soils preserve their typical chemical characteristics. Therefore, heterogeneity of soil cover in large suburban parks reflected as well in soil properties and patterns of vegetation cover. The latter usually combines natural and introduced plant species and communities.

Conclusion. Soil cover of parks, especially of large suburban parks, is unique natural and anthropogenic phenomen. The wide range of intermediate forms between natural and anthropogenic soil varieties could be detected here. The deeper pedological investigation of park soils contributes to soil conservation and resolving of urban environmental problems.

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Evaluation of soil-ecological efficiency of disturbed lands restoration

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Mining activity is accompanied by a transformation of the earth surface and the formation of new technogenic habitats (technogenic landscapes), and at the posttechnogenic period environmental condition of them is mainly determined by the quality of their rocks, made on the surface, as well as the form of the generated terrain. Any rock stored to dumps has the potential, that contribute or hinder to the restoration of damaged ecosystems. Therefore, the extracted minerals should be included to the concept of natural resources. Rock, paved surface, which largely determine the potential recovery and the ecological condition of technogenic landscape are also should be included to this determine. In this sense, rational use and conservation of natural resources must involve a technology for forming a technogenic landscape, which creates the best conditions for the implementation of the self-healing capacity of ecosystems.

Because the soil is the basis of any terrestrial ecosystem, the rate of its formation determines the dynamics of the recovery of all the other components of the ecosystem and the quality of their functioning (phyto-, and mikroby- and zoo- cenoses and so on). However, the rate of soil can also be considered as a parameter characterizing the soil-ecological potential, which depends on the quality of lithologic properties and surface topography created in step technogenesis, and can be controlled by the technology of formation of technogenic landscape

Soil-mapping studies conducted at the technogenic landscapes of Kuzbass based on profile-genetic soil classification of technogenic landscapes, revealed a number of important features of soil formation. Firstly, the soil cover of technogenic landscape is represented by four types of embryozems: such as initial, organic-accumulative, sod and humus-accumulative [Kurachev, Androkhanov, 2002]. Secondly, they all represent a single evolutionary chain that allows to differentiate the initial stages of the recovery of soils into four stages, each stage of development idiogenously to succession biocenosis [Androkhanov, 2003]. Thirdly, the rate of soil formation in the technogenic habitat, depending on bioclimatic conditions, substrate quality and location in the landscape, can be estimated by the type of embryozems, formed on the broken surface for a certain period of time. The results allow to propose a methodology for calculating the rate of soil formation in technogenic landscapes in the number of reliably diagnosed morphologically and analytically stages (phases) of soil and/or stage of succession phytocenosis [Androkhanov, Kurachev, 2010].

It should be noted that the proposed approaches are evaluated soil-ecological state of technogenic landscapes already formed. Meanwhile, it is essential to develop a theory and method for predicting soil-ecological state of the emerging technogenic landscape is still at the stage of feasibility study for field development project and use the most important parameters of the forecast of a technical (ecologically significant) assignments in the working draft of the subsequent reclamation. A procedure of calculations based on the theory of soil evaluation is developed to solve this problem [Gadzhiev et al., 2001]. Compare bonitet score natural soil with a score bonitet technogenic landscape soil allows to quantify the extent of their differences, make a prediction completeness of ecological potential source of natural resource reclamation, determine the prospects for self-healing ecosystem using a particular technology education technogenic landscape.

Direct application developed grading methods of calculation, on technogenic landscapes is not possible. A theory appraisal applies only to natural-historical formations (soils), in equilibrium with soil factors and conditions (climatic, lithological, biological, etc.). When soil formation in technogenic landscapes the technogenesis effects are mail soilforming conditions (property relief and rock), especially when shorter pragmatically reasonable time period (about 20 years) [Androkhanov et al., 2004]. Therefore, a system of analytical methods for the isolation of ecologically significant there is provided to assess the degree of influence of technogenic effects/

With this approach, soil-ecological efficiency (SEE) of used or designed technology of forming technogenic landscape expressed in bonitet score (bs) or as a percentage generally determined by the follow formulas:

a) SEE (bs) rel. = Bs × Cs (s);

b) SEE, % = Cs (s) × 100,

where Bs - bonitet score of natural soil; Cs (s) - the coefficient of specificity of substrate at the technogenic landscape. The numerical value of the coefficient is determined by the parameters of the limiting factors of soil formation. It uses either the analytical method (for existing technogenic landscapes) or settlement (for planned).

Studies have also shown that the relief of technogenic landscape is more important limiting factor in soil formation. Represented formulas (a, b) can be used in the calculation of soil and environmental efficiency of technologies of formation of technogenic landscape reclamation or on a horizontal surface or close to it. However, in reality, a horizontal surface or a slurry dump occurs or the planned areas. In practice, technogenic landscapes are dominated with a high degree of slope surfaces. In this case, we must enter the factor of relief specificity. And formulas (a, b) take the following form:

c) SEE (bs) = Bs × Cs (s) × Cs (r);

g) SEE,% = Cs (s) × Cs (r) × 100

where Cs (r) - the coefficient of specificity of relief of technogenic landscape relatively the natural one.

In cases where Cs (s) = 1, soil-ecological efficiency of formation of technogenic landscape and its reclamation is completely determined by the coefficient of specificity of the relief, while Cs (r) = 1, the efficiency reaches a maximum SEE = 100%, but it is possible only in theory. In practice, when the destruction of natural landscapes and the subsequent reclamation the SEE is much less. This is due to the irrational use of natural resources and effective reclamation technologies, which do not provide rapid recovery of damaged land.

For values of Cs (s) < 0.05 a technogenic landscape is the desert. Higher values characterize different levels of soil-ecological state of technogenic landscapes. Thus, the soil-ecological state of technogenic landscape characterizes the self-healing potential of disturbed lands. Than it is higher, the greater the likelihood of recovery of damaged ecosystems. Therefore, the more the soil conditions in the technogenic landscapes will meet environmental bioclimatic conditions, the soil and their ecological condition will be better and self-healing capacity of the entire complex ecosystem will be higher.

Calculation of soil-ecological efficiency of forming technology or reclamation of technogenic landscape is important for comparative assessment of soil and environmental impacts of mining activities. It is needed when the development of inter-regional environmental policy in the long term, and it is needed in the definition of priorities in the implementation of decisions that have environmental consequences, differentiation of financial resources and technical capabilities in line with agreed priorities.

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Soils consideration in French Evaluation of Ecosystems and Ecosystemic Services in urban areas

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In France, the "Evaluation Française des Ecosytèmes et des Services Ecosystémiques (EFESE)" or French Evaluation of Ecosystems and Ecosystemic Services, is the adaptation of the United Nations Millenium Ecosystem Assessment (MEA, 2005). In order to reach national evaluation's aim, a conceptual frame (CGDD 2016) was validated and specific orientations selected in order to set up the evaluation at national scale. It defines the perimeter of the evaluation and gives a common working base for actors involved in the project. EFESE perimeter goes as far as land and marine ecosystems of metropolitan and overseas french territory. It is organized in six types of ecosystems, including "urban ecosystems" which is presented here.

Urban ecosystem is defined as a system populated and planned by and for humans, made for the most part of living environments, including soil which is the ground for other types of uses (parks, gardens, wetlands, …) and urbanized spaces (roads, buildings, …). Within this complex and highly heterogeneous environment, nature in the city, subject of our paper, refers to unsealed soils on which species and habitats can develop. The major goal of this paper is to present the methodology and approach used to evaluate the services provided by this urban ecosystem, focusing on soils part.

Methodology

In order to demonstrate urban ecosystems ability to provide services at green area scale, we used the "state and transition" model. It was conceived to assess services provided by ecosystems as function of its state. Different states are described for each type of green area as well as transition between the alternative states, due to urban pressure (management, urban planning, soil sealing, …). It also raises the question of state transitions in an historical context (Lavorel 2015 ; McIntyre et al. 2007 ; Zweig et al. 2009 ; CGDD 2016).

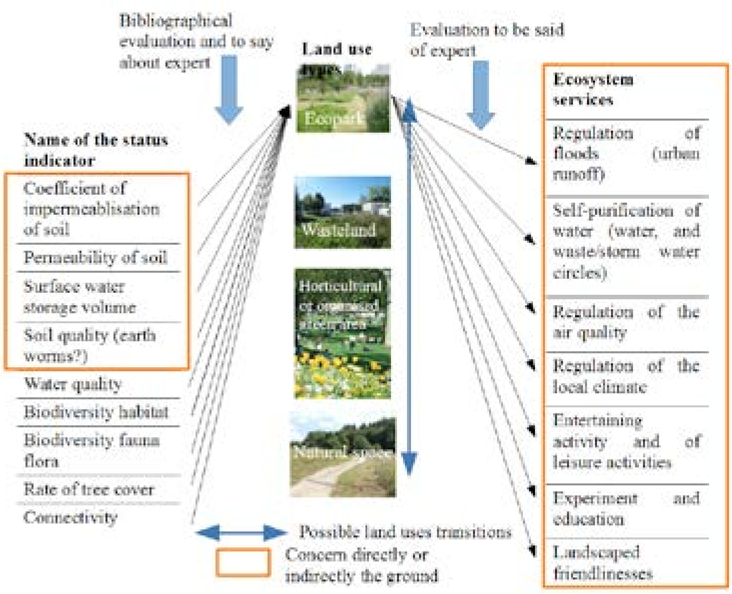

Figure 1: Methodology and place of soil in the evaluation of services

Considering the state of knowledge about ecosystems ecological functions, still being investigated by researchers, the unclear link between functions and services and the lack of data in urban areas, the methodology was simplified to be easily taken-up by urban managers and stakeholders. Its main principle is that a better state will allow higher expression of ecological functions and therefor higher services provided.

The method, showed in figure 1, characterizes the level of services using qualitative marks attributed in regards of land use, management and planning. It is build around a five steps analysis:

Selection and definition of the types of areas (regarding existing typologies and available date, and urban issues) and alternative states for each one considering pressures applied to these areas ;

Identification of services for urban ecosystem (bibliography and work groups) ;

Selection of state indicators defining the alternative states and connected to the services chosen ;

Qualitative evaluation of services provided by each alternative state based on experts knowledge ;

Definition of transitions and their effects on state indicators and therefor services (allows the evaluation of impacts of transitions on urban planning and the identification of bundles of services.

Two different specific type of urban areas providing services were selected. The green areas are the only ones described here, the other one being wetlands. For both types of areas, four alternatives states were defined, from the more natural to the more degraded: "wasteland", "horticultural or organised green area", "Ecopark" and "natural space".

Seven services provided by the selected green urban areas were identified in the literature and will be assessed in this paper: Flood regulation (mainly from urban runoff), Water purification, Air quality regulation, Local climate regulation, recreation services, experimentation and education, Landscape and aesthetic.Finally, considering the selected services, eight state indicators were selected, half of which are characterizing soils state: three characterize hydraulic functions or soils purification (sealed or waterproofed area, permeability, above ground water volume storage capacity) and one soils quality through earthworm abundance; these organisms are important "soils engineers" and their characterization is and indicator of soil state, use and management as well as a first service evaluation (Ademe 2008, Cluzeau 2009, ENVASSO 2008). Each indicator was described regarding its goal, data used, results provided, indirect links to services, and weakness.

Transitions that were assessed at the urban green area scale are related to management, attendance, design and planning, and finally pressure from upstream watershed (connected to soil sealing, loss of natural area, wetlands …). They are defined from the local stakeholders use and management practices

Examples will be shown in the presentation.

To complete the model, qualitative evaluation of services is determined from experts evaluation. For each alternative state, the provided service is given a mark from 1 to 4 (representing the maximum of variability observed for every alternative state). Each mark is given with a description. The following application of transitions shows the evolution of services and allows identification of groups of services with related evolution when use, management or attendance is modified. Regarding soils importance, it is shown in figure 1 that its contribution to flood regulation, water purification is significant and that it also is indirectly significant for vegetation support and associated services.**Conclusion**

This work, still in progress, shows the importance of urban soils condition for ecological functions and direct or indirect services provided for users. Although not considered as such, soils support habitats and land use. It is not central to the methodology but considered all along the analysis.

In the end, the state and transition model could allow a qualitative estimation of impact of various scenarios of land use on services provided. Larger considerations regarding territories evolutions could be implemented in the model according to Rounsevell *et al.,* (2006) who shows contrasted land planning scenarios and its effects on land use

This methodology is based on bibliographic studies and expert evaluation but could benefit from further investigation in order to decrease uncertainties regarding: link between services provided and state indicators, selection of indicators (robustness, applicability, …), evaluation of indicators (larger panel of experts, …), environmental context consideration, …

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Heavy metals in urban soils of Southern Russia

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Under urban conditions, soils fulfil an important protective function: they adsorb pollutants and hamper their input to ground and surface water and the atmosphere. However, urban soils accumulate pollutants and can become their sources for the environment. Therefore, characterization of soil status in urban areas is necessary for adequate decision-making in the management of urban land resources. The high contamination of soils with heavy metals in urbanized landscapes is mainly of local character, because the areas of large cities are usually contaminated nonuniformly, and technogenic fallout anomalies can be observed on the increased general background. They are confined to industrial zones, where the concentrations of zinc, lead, nickel, mercury, chromium, and other metals usually increase further in several times. Lead contamination is observed along motor roads.

The contents of metals in soils of Southern Russia vary in wide ranges and depend on two main factors. The first factor is the natural background dependent on geochemical conditions. The second factor is the anthropogenic contamination of soils with heavy metals from different sources.

According to Gorbov et al. (2003), soil anomalies of zinc, lead, copper, vanadium, cadmium, mercury, and other metals were detected in Rostov-on-Don, the highest concentrations being found for chromium, lead, and zinc. From data for the late 1980s, zinc anomalies (4 MPC and more) covered the entire old center of the city. The Empils paint plant makes the largest contribution to the contamination of the city with zinc. From our 2003 data, the danger coefficient (MPC exceeding) in the upper 10-cm thick layer of soil sampled from a flowerbed near the plant and a heavy traffic road was 49.3 for mobile zinc and 18.2 for lead.

Transport contributes significantly to the contamination of soils with heavy metals. Major highways with traffic exceeding 200 vehicles in hour are the main sources of soil contamination with lead in the city of Rostov-on-Don. The accumulation of this metal reaches 4 MPC and higher in some places.

Soil profiles were established in different functional zones of cities in the Rostov agglomeration, the largest in Southern Russia, in order to study all main types of agglomeration soils: migration-segregation chernozems, urbostratified chernozems, and urbostratozems (including replantozems, chemozems, and shielded urbostratozem varieties). Soil samples were collected from genetic horizons, including urbic horizons. Total chemical composition was determined by X-ray fluorimetry on a MAX-GV spectroscan. The degree of contamination was estimated by comparing with the MPC values and background concentrations reported by Akimtsev et al. (1962). The accumulation coefficient was calculated as the ratio between the element concentrations in the upper accumulating layer and in the rock. The total contamination factor (TCF, Zc) was also calculated from the equation proposed by Saet: $Zc = \sum KCi - (n-1)$, where n is the number of elements whose contents exceed the background values.

The obtained results indicate that the concentrations of most elements in loess-like loams, which are soil-forming rocks in the agglomeration area, exceed the background values (Table 1).This can be related to the migration of metals along the profile and the long-term accumulation effect, which determines the features of loess-like loams. For some elements (Cu, Cr), even the MPC level is exceeded. It should be noted that high contents of these elements in regional rocks are typical not only for urbanized landscapes, but also for the specially protected natural areas (SPNAs). Profiles were established in the SPNAs of the Ust'-Donetsk and Zerograd districts; the mean contents of metals in loess-like loam were as follows (mg/kg): Cr, 108; Co, 23; Ni, 60; Cu, 62; Zn, 87; Pb, 27.5. These high contents of microelements in loess-like loams can be due to their high carbonate content and become a reason for the increased content of these elements in the soil profile. This also explains the high contents of all elements under consideration in virgin and fallow soils, which exceed the background values throughout the profile and in the parent rock.

Table 1 – Heavy metals in loess-like loams of the Rostov agglomeration

Parameter	Heavy metals, mg/kg (ppm)						
	V	Cr	Co	Ni	Cu	Zn	Pb
Background	67	100	8	45	30	65	20
MPC/PPC	150	100*	50*	80**	132**	220**	130**
M_{av}	99,2	108,7	19,4	49,6	54,1	74,0	25,8
σ	12,3	9,4	3,6	5,7	5,1	12,2	6,6
m	2,46	2,22	0,72	1,15	1,02	2,45	1,32

*In Russia, no MPCs are developed for chromium and cobalt in soils; therefore, MPCs for home grounds in Germany are given (Eikmann and Kloke, 1991).

** Hygienic standard #2.1.7.2014-06. Maximum permissible concentrations (MPCs) of chemical elements in the soil. GN 2.1.7.2511-09 Hygienic standard. Provisionary permissible concentrations (PPCs) of chemical elements in the soil.

Although the fallow lands are not used at present, the MPCs are exceeded for chromium, nickel, and, in some horizons, for copper; an exceeding of MPC for lead is also revealed in the surface layer of the profile established on fallow land at 500 m from the M4 Don route. Nonetheless, the TCF does not exceed 8, which classifies the soils of this group into the category of permissible contamination.

In soils under woodlands (forest belts and forest parks), contamination with zinc and lead is observed in the Ad horizon, which can be due to the input of these elements into the soil with tree waste, where they are accumulated during the vegetation because of atmospheric fallouts. Their TCF values are slightly higher than in soils of fallow areas, but they are no higher than 8, which also indicate a permissible contamination level of soils from this group.

The determination of heavy metals in urbostratozems – typical soils of urban areas characterized by the presence of several urbic horizons (diagnostic UR horizon) showed a slightly higher variation in the content of chemical elements in this group of soils. In general, the situation is slightly different from that in soils of natural genesis. The contamination of urbostratozems with heavy metals is estimated to be similar: the TCF varies in the range below 8, and horizons with a contamination level higher than the permissible one (Zc=8.2–8.6) are revealed only in the middle part of the profile established in the old center of the city and on the street with heavy traffic.

Interesting results are obtained for urbostratozems occurring under the layer of shieling material (most frequently asphalt). This layer fulfils a protective function in this case: the lowest contents of heavy metals are found in this group of soils. The highest TCF values are confined either to topmost layers or to the lower part of the profile: buried chernozem horizons, where the accumulation of metals occurred before the burial of soil under the layer of filled horizons. A demonstrative example of such situation is provided by the profile established in an old industrial region of the city, where several large plants were located. In the A_{ur} horizon of this profile buried under an asphalt layer and several urbic horizons (with a total thickness of about 80 cm), zinc accumulation is revealed, because the metal content is equivalent to 7.6 MPC (6.4 background values). The accumulation coefficient is 5.3. Thus, these are consequences of soil surface contamination occurred before the asphalt was laid. The source of contamination is the plant producing paint coats, including zinc white, which has operated until recently at about 1 km from the profile established.

It is believed that the input of heavy metals into soils of urbanized landscapes is mainly due to anthropogenic reasons. However, chemical elements should accumulate in the surface layers in this case. Interesting information is provided by the calculation of accumulation coefficients; average coefficient values for all profiles of the soil groups are given in Table 2.

Table 2 – Coefficients of accumulation of heavy metals in the surface layer of the Rostov agglomeration soils

Chemical element	Calcareous ordinary chernozem		Shielded urbostratozems	
	fallow areas	wood plantations	urbic horizons	buried A horizons
V	1.03	0.99	0.86	1.01
Cr	1.12	1.03	0.91	0.97
Co	0.71	0.65	0.69	0.85
Ni	0.78	1.14	0.87	1.10
Cu	0.85	0.92	0.78	0.91
Zn	1.23	1.55	1.21	1.72
Pb	1.43	1.60	1.47	2.28

Accumulation coefficients higher than 1 indicate accumulation of the element in the surface layer; coefficients lower than 1 suggest the removal of the element to the lower layer. Comparison of chernozems under different plant covers shows that woody plants favors the preservation of water in the soil and the deeper wetting of soil layer and, hence, reduces the accumulation of vanadium, chromium, cobalt, nickel, and copper in the surface soil layer. The accumulation coefficients of these metals in urbostratozems are still lower, which can be due to the looser structure of filled layers and the presence of sandy interlayers, which favor the wetting of soil and the removal of metal compounds to lower layers, down to the parent rock. However, the accumulation of zinc and lead in the surface layer increases under the forest canopy, as well as in urbostratozems. In the urbostratozems shielded by dense coatings, the situation is variable, which can be related to the different times of soil sealing with asphalt.

Thus, the increased content of heavy metals in the parent rock is a reason for their increased concentrations in soils of urbolandscapes in Southern Russia. Another reason is the input from anthropogenic sources, as evidenced by the accumulation of chromium, nickel, zinc, and lead in the surface horizons of soils.

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Analysis of anthropogenic effects on carbon dioxide fluxes from artificial urban soil construction in Moscow

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Introduction

Soil continuously supports the need for life and reproduction of organisms, energy supply, materials and information, which are obtained through the efforts of many generations of organisms(Smagin..,2012). One of the main factors of soil disturbance is urbanization. Urbanization is the recent trend of land use change, coupled with the rapid growth of urban areas, which leads to a qualitative change in the functioning of the soil cover of urban ecosystems. Traditionally, urban soil studies have been focused on highly disturbed and human-constructed soils in megapolis (e.g., Craul and Klein, 1980; Patterson et al., 1980; Short et al., 1986; Jim, 1993, 1998), however urban soil functions were rarely studied. Emissions and sequestration of greenhouse gases, primarily CO2, is a key soil function. Environmental risks of increased CO2 emissions from urban soils are determined by various factors of anthropogenic influence, in particular the use of functional features, the structure of the soil profiles and the presence and degree of anthropogenic load. The research aims to analyze the effect of these anthropogenic factors on CO2 emission from urban soils.

Methods

Two research areas have been studied to analyze the impact of various anthropogenic factors such as heavy metal pollution, salinization, acidification, and by using different substrates of an artificial organogenic soil structures on the CO_2 emissions. One field which has been artificially disturbed by heavy metal pollution, salinization acidification locates in the campus of Moscow State University of Russia on the south-west side of Moscow and the other field where different substrates is situated RSAU on the name of *K.A.* Timiryazev on the north of Moscow. The research work was held from June to August 2015, The measurements of carbon dioxide, soil moisture, soil temperature and the air temperature were taken once in 10 days on each plot by using a gas analyzer (Li 820), a soil moisture meter(HH2), soil thermometer (HI98501). To measure the CO_2 fluxes the gas analyzer is connected to a chamber which a 16cm height and is been stalled in the soil, the pump inside Li 820 will pump the air coming out from the soil to the gas analyzer where the analyzing of the CO_2 fluxes is taking place. This observation takes about 2-3 minutes or till the CO_2 concentration in the chamber gets more than 100 parts per million (ppm) in comparison with the atmosphere. While the Li 820 is measuring the CO_2 fluxes, the soil temperature, soil moisture and the air temperature is measured 3 time repeatedly.

Results

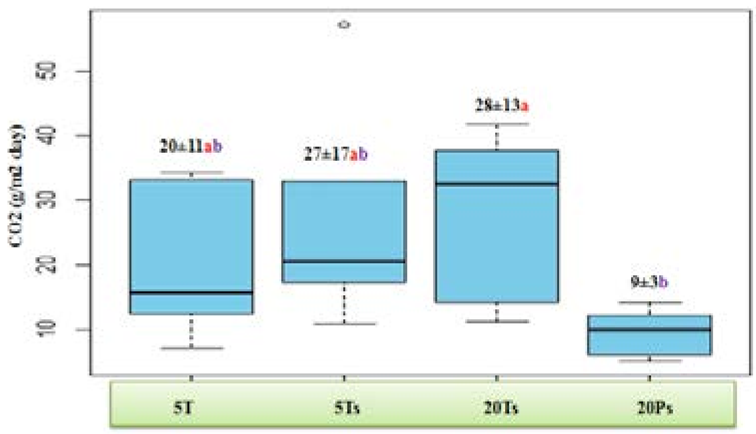
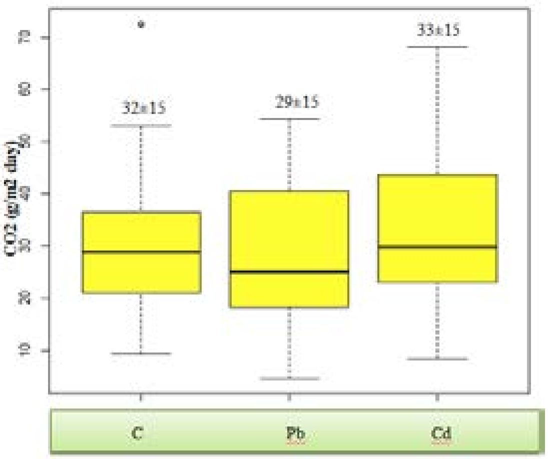


Figure .1. The dynamics of CO2 the contrast soil structures.

Three different samples with 2 different depths have been used to verified the the seasonal of CO_2 on each. As a result the research shows that the lowest seasonal dynamics of CO_2 was for Peat + sand 20 cm, the mean soil temperature was 18.43°c and the moisture was 19.75%. The highest flow rate of the CO_2 was for sandy turf 20 depths and the mean soil temperature was 17.44°c and the moisture was 27.27%. In order to compare the seasonal dynamics of CO_2 2 different substrates (sandy turf and peat+sand) with the same depths have been taken the flow rate had a differences of 24 g/m^2 per day.



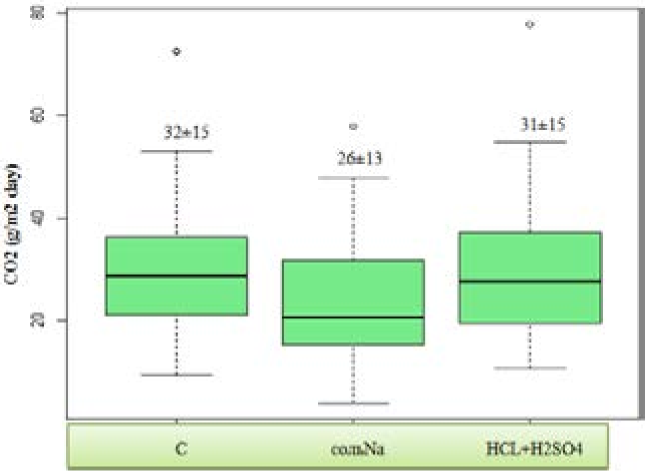


Fig 1 **Fig 2**

Figure 2,3. The dynamics of CO_2 fluxes in polluted, salinated and acidificated soil.

For this research 5 different soil were taken control(C) which is the natural soil in the field, soil which has been artificially polluted with lead (Pb), soil which has been artificial salinated and soil which has been artificially acidificated. C has a seasonal dynamic rate of 32.12 g/m^2 per day, the mean of the soil temperature was 19.2 °c and the moisture was 39.8%. The highest seasonal dynamics of CO_2 fluxes has been monitored for soil which is artificially polluted with cadmium, the mean of the soil temperature was 16.7°c and the moisture was 38.0% by comparing with control site. Soil which is artificially polluted with lead has a seasonal dynamic rate of 39.56 g/m^2 per day, the mean of the soil temperature was 19.6 °c and the moisture was 40.6 %. The salinated soil has a seasonal dynamic rate of 26.3 g/m^2 per day and the acidificated soil has a seasonal dynamic rate of 38.9 g/m^2 per day. By comparing these 5 sample, it can be understand that soil which artificially polluted with cadmium reduce more carbon dioxide than the rest.

Conclusion

These results illustrate the changing dynamics of CO2 fluxes in the presence of pollution, acidification and increased salinity, changes in the soil moisture and temperature. Comparison of CO2 emission of soil structures with a different profile structure allows to develop guidelines for environmentally sustainable design of urban soils.

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Watershed approach as a basis for comprehensive regional environmental monitoring

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An existing monitoring system does not necessarily reflect the exactecological conditions of a studied area. There is no general structure, no uniform methods of observation and analysis, and no integrated network of spatial observations at the regional level. This eliminates the possibility of obtaining comprehensive information about the scale of pollution present in a studied territory (Karpets, 2012).

Some important information to consider regarding the spatial organization of regional monitoring include, but are not limited to: criteria for boundaries of a regional system,location of the territory in the overall national system, the internal structure of the regional system as well as a consideration of the peculiarities present in the organization of a spatial network of observation points. Traditionally, to define a regional system of monitoring borders, researchers propose to take into account phyto-geographical zoning, or a principle of spatial-temporal variability in moisture regimes of a territory (Karpets, 2012). To solve a problem of more consistent regional monitoring we offer a watershed approach because the direction of flowsof elements and nutrients in a "soil-water-sediments" system is linked to the nature of surface runoff in a catchment area.

The content of chemical elements found in natural waters and the magnitude of their migration depends on the various conditions in the catchment area including physical and geographical conditions, human factors, e.g. fertilizers containing certain quantity of heavy metals. Fertilization causes a change in the heavy metal content in soils and as a result, in migration patterns of the elements transporting downhill to the natural waters and bottom sediments. An introduction of chemical inflow into the system affects the pH of thatsystem, which in turn stimulates further change in geochemical processes and reactions (Bluzhina et al, 2016). The negative effects of fertilizer application also include an increase in the mobility of certain trace elements contained in the soil. These trace elements become more actively involved in the geochemical migration, leading to a deficit of B, Zn, Cu, Mn in a plow layer (Golovin et al., 1984).Research through the lens of geochemical migration with regard to environmental issues allows for a more comprehensive approach and gives the possibility of a more accurate forecasting within the framework of monitoring activities.

Based on analysis of numerous literature data, nitrogen and potassium fertilizers contain the greatest amount of impurity with the following levels: Mn, Cr, Ni, Zn, Ti - up to 100-400 mg/kg, and B - 50-60 mg/kg. Some accompanying elements can be found in superphosphate and other types of mineral fertilizers that are widely used in modern agriculture (Belitsyna et al., 1985). The superphosphate fertilizer contains significant impurities of heavy metals that may have an impact on geochemical behavior of elements in soils due to their propensity to migrate into wheat, water and sediments.

According to the Department of State Land Supervision and the Territorial Department of the Federal Service for Veterinary and Phytosanitary Surveillance (Rosselkhoznadzor) in Stavropol Krai, the studied areas in the Egorlyk river basin had nitrogen fertilizers, potash, lime and superphosphate introduced into the soil under winter wheat.As a part of regional environmental monitoring in the Bolshoi Egorlyk river basin, we established three research sites. They are considered catenas of similar geochemical composition and spatial location. A catena is a series of soils on a slope where the differences between them are a direct function of the change in gradient.

For hydrochemical studies, 36 samples of water and sediments were collected. Samples of soil, wheat plants, water and sediment were collected in accordance with Russian Federal Law #102-ФЗ of 26.06.2008 "On ensuring the uniformity of measurements." Collection of natural water samples from the river was done in accordance to P 52.24.353-2012 "Sampling of surface and treated waste water." Quantitative chemical analysis to measure the total content of Cd, Co, Mn, Co, Zn, and Pb in soil, wheat plants, surface water and sediments was performed with an atomic absorption spectrometer with atomization in flame iCE 3300 (Thermo Scientific).

Statistical analysis was performed in R 3.0.3 (R Core Team 2014) software. The PerformanceAnalytics package produced a scatterplot matrix, with histograms, kernel density overlays, absolute correlations, and significance asterisks to determine the relationship between the heavy metals in soil and sediments (Cu, Pb, Co, Zn, Cd, Mn) (Peterson and Carl, 2014). To test a significant difference between samples, Student-test with a p-value of 0.05 was used.

To assess a mutual influence of heavy metals in the studied morphological units in the Bolshoi Egorlyk watershed (grass - arable land - water of the Egorlyk - sediments of the Egorlyk), the heavy metals concentrations, coefficients of water migration, of biological absorption and of bottom accumulation were determined (Table 1).

Table 1. Selected geochemical properties of the heavy metals in the soil, water, wheat plants, sediments in the Bolshoi Egorlyk watershed

Heavy metal	*Soil, mg/kg*	*Water, mg/kg*	*Coefficient of water migration*	*Wheat, mg/kg*	*Coefficient of bio absorbtion*	*Sediments, mg/kg*	*Coefficient of bottom accumulation*	*soil* pH
Cu	7.8	4.5	8.70	4.1	0.79	12.30	2.74	7.59
Zn	67	5.7	6.24	44.82	0.54	4.763	0.836	
Pb	5.3	0.092	5.2	0.23	1.44	6.94	75.43	
Cd	3.1	-	0.45	0.024	17.7	1.97	49.25	
Mn	293	0.029	0.1	30.00	0.3	3.47	-	
Co	5.7	0.027	13.64	0.83	0.46	0.39	14.44	

To confirm the relation between the heavy metal content in sediments and soil of a wheat field, the correlation matrix was composed for the studied landscape geochemical catenas (Figure 1). The correlation coefficients for Cu, Zn, Pb, Co are negative, indicating that with a decrease in the metal content in the soil of the wheat field, there is an increase of its concentration in the river sediments. A soil-sediment relationship for Cu and Mn was described as close, for Cd - close and statistically significant, for Zn - average, for Pb and Co - moderate.

Among established strong binary relationships arising from interaction of the indicators, it is important to note the mutual influence of the following indicators: Cu → Cd, Pb → Cd, Co → Pb. These relations should be considered when developing comprehensive regional environmental monitoring programs.

Using the watershed approach as a basis for development of a regional environmental monitoring program, increased accuracy of data, heightened territorial integrity of an organization and a reduction in maintenance costs was observed; the magnitude of which would vary based on the complexity of representation and observation network.

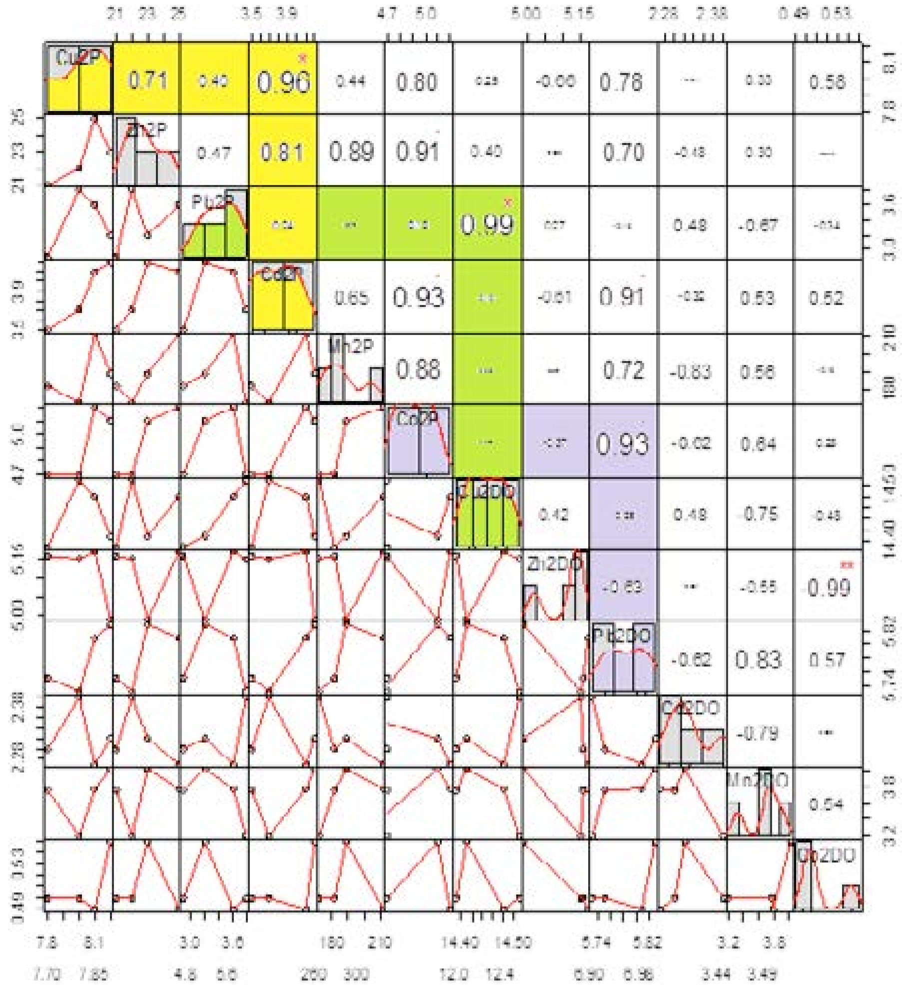

Figure 1. A scatter plot matrix, with histograms, kernel density overlays, absolute correlations, and significance asterisks (0.05, 0.01, 0.001) for Cu, Zn, Pb, Co, Mn in soil (Cu2P, Zn2P, Pb2P, Co2P, Mn2P, respectively) and sediments (Cu2DO, Zn2 DO, Pb2DO, Co2DO, Mn2DO, respectively). Significance codes: * - $p \leq 0.05$, ** - $p \leq 0.01$, ns: $p > 0.05$ - maybe there is a link but not/the least statistically significant.

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The sustainability of nature management on the basis of valuation of ecosystem services of forest and parks

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Abstract

Humanity have a strong negative impact on the environment in terms of pollution, extraction and exploitation of natural resources. The global problem is that the nature conservancy does not fit into a market economy, causing a "market failures" (Bobylev, Zakharov, 2009). Leading ecologists and economists of the present time offer economic incentives for environmental protection, introducing a new concept of "ecosystem services". This concept applies to all parts of the ecosystem and in particular to the soil, which is based on their ecological functions. Parks and protected areas are allocated as the most informative objects for the study of the concept of ecosystem services and their economic evaluation methods.

Ecological functions as the basis for the provision of ecosystem services (for example, soil functions)

Natural ecosystems perform functions which are only potentially ecosystem services. The real value of ecosystem services for human well-being, that is, their actualization as the ecosystem services is determined by the presence of their consumers on the territory of the scale (Bukvareva 2014).

Analysis of typing soil functions shows that their value, both globally and in the biogeocenotic level, can not be overestimated. They determine the quality and quantity of services provided by ecosystems that need to be considered in economic assessments of areas.

Under conditions of increasing anthropogenic load on the biosphere, the impact of this factor on the regional level, the most actively manifested in the form of the degradation of ecosystems. Especially mottled pattern is observed in cities where there is a concentrated consumption of services and the environment is experiencing a strong human impact. Here coexist slightly disturbed territory of protected areas and parks, and medium- and greatly disturbed residential and residential-transport landscapes that differ in the degree of anthropogenic pressure (Kasimov, Perelman, 1995).

Features of protected areas and park areas as the object for the development of ecosystem services assessment scheme

Parks and protected areas are the last reserves of intact ecosystems of the planet, which are constantly at risk. The potential threat of rejection of the area to other uses and increasing recreational load determine the need to create an algorithm of evaluating ecosystem services these areas (Batker, D. et al., 2008)

Firstly, protected areas and forest park ecosystems produce services at all levels of scale - global regional and local. It is worth noting that the natural parks in the city, in this case, occupy a special position, as have high local service - in the most densely populated regions ecosystem services become the most valuable (Bukvareva 2014).

Secondly, parks and protected areas provide a full range of ecosystem services for people (provisioning, regulating, cultural).

Thirdly, in the territory of the city park there are areas with varying degrees of disturbance, each of which provides a different quality that allows us to trace the tendency of reducing the value of ecosystem services. In urban park are found intact parts which have been preserved in almost pristine condition, and greatly disturbed parts. Each of them has its own value and has a certain range of ecosystem services. Intact areas provide regulatory services and this component make significant value in the overall economic assessment. At the same time cultural services make a smaller contribution because recreational load is deliberately limited on such intact areas. Greatly disturbed areas, by contrast, provide cultural services as much as possible, experiencing the greatest recreational load, but input of provisioning and regulating services is minimal. Value for service users is provided by the entire territory of the park, but its distribution within the park depends on the disturbance area.

Fourthly, the need for natural parks in the city is increasing every year due to the general tendency of cities and urban population growth in many countries of the world, including Russia.

In order to take into account the degree of disturbance of the territory in the assessment of ecosystem services it's necessary to use a comprehensive assessment of the ecological status of the territory. Assessing the environmental status gives a more accurate result on the completeness and quality of ecosystem services (particularly it relates to regulating and provisioning services). In turn, this will make a detailed analysis using mapping techniques to create distribution maps of ecosystem services (Puzachenko et al., 2014). In the future, it can be helpful in making decisions about the design of parks, conservation of protected areas and functionality of a given territory in the city and outside it.

Assessment model of ecosystem services intact and park areas

Currently, assessment of ecosystem services does not take into account the quality of ecosystem services, which can be determined by degradation biogeocoenose: undisturbed biogeocoenoses provide higher quality services and at a higher level than the degraded. In this connection, assessment of ecosystem services should take into account the ranking of the territory according to the degree of disturbance on the basis of ecological indicators.

The soil is the most stable component of the ecosystem, performs basic biospheric functions of different scales (global, regional and local) (Dobrowolsky, Nikitin, 2012). At this point, the functions and services of the soil is practically not included in the valuation of ecosystem services. For a more complete and accurate assessment it's necessary to take into account the economic value of soil resources.

We propose the following scheme for assess ecosystem services of parks and protected areas: the definition of a set of ecosystem services, which are provided in accordance with functionality of territory, including taking into account the soil; definition of ecological soil functions; choice of indicators to analyze the ecological state of functions that are responsible for the selected ecosystem services; ecological assessment of the facility, which determine the degree of deterioration of the territory with respect to the conditional standard (intact areas), showing the quality of ecosystem services; economic valuation of ecosystem services (including soil).

In accordance with the above scheme were assessed value of the natural park «Bitsa forest» in Moscow. Integrated ecological assessment of soil showed high biodiversity in this territory (Pe = 4,3-4,9). Each year, the park generated value approximately $ 1.5 million / ha, which is based on the ecological state of soils in different parts of it. The greatest contribution is made by regulating (about 60% of the total) and cultural services (about 25%, respectively).

The concept of «sustainable development» during the entire period of formation has been folded out of interaction and agreement between all stakeholders, involved in the discussions on the main problems of the planet, including pollution and decreasing biodiversity. At the moment it is the main vector of development of human society.

The development and application of valuation of intact natural resources and reasonable biodiversity conservation will determine the sustainability of the human population in the decades ahead.

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Evaluation of total petroleum hydrocarbon contamination of Moscow Ring Road (MRR) roadside soils

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Key words: Total petroleum hydrocarbon (TPH), contamination, road side soils.

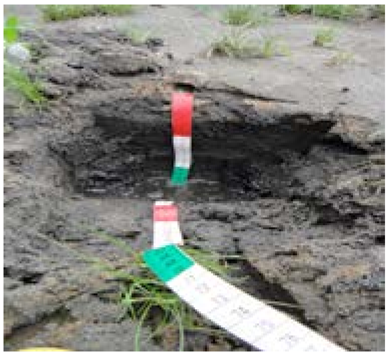
Introduction. The road traffic has become one of the most serious environmental problems in many cities and the main source of pollution of urban soils**.** The widespread use of hydrocarbons in fuels causes their predominance among organic atmospheric pollutants, once deposited to the surface, hydrocarbons may persist and bioaccumulate in environmental media and infiltrate into groundwater aquifers via leaching or into surface aquifers by runoff thus affecting soil biota, plants humans, and animals [1,2]. Vehicle accident can be considered as yet another serious factor roadside soil pollution. Organic contaminants in roadside soils have been receiving considerable attention as a result of traffic intensity. Total petroleum hydrocarbons (TPH) are discussed in literature as one class of substances so far. However, as a diverse mix of numerous individual aliphatic hydrocarbons, components of petroleum products also behave individually in the environment [2,3,6].

The objective of this study was to describe soil pollution with TPH as a result of tanker accident, redistribution of TPF in soil of road slope and background pollution of soil near MRR.

Pic. 1 The place of tanker accident

Pic.2 Soil profile at the place of tanker accident

Pic.3 Accumulation of runoff products near the drainage tubes (wetland)



Pic.4 Soil profile on place of accumulation (wetland)

Materials and Methods. Soil samples were collected at the site of the vehicle accident at distances of 1,5 and 5 m (at the top and the bottom of the slope) from the road. At the same positions of the background slope soils (10-50 m distance from the place of the accident) sampling was carried out. The runoff from the place of the accident flows through the drainage tubes to the other side of the road, where the water flow spreads over the soil surface, forming streams and puddles, and as the result the so called wetland appears. Soil samples were also collected from this wetland (pic.1, 2, 3, 4). Total petroleum hydrocarbon (TPH) concentrations and their fractional composition (medium fraction: n-alkane chain-length C15 to C26) were determined. TPH concentrations in soil were determined gravimetrically after triple extraction of

20 g sieved soil (<2 mm) with 50 mL hexane. TPH and fractional composition of petroleum hydrocarbons of selected samples were further determined using GC-MS. The background TPH concentration in soils of the MRR slopes (depth – 2-10 cm) reached 1110±500 mg kg^{-1} (approximately 9000 vehicles per hour). In the lower sandy layer of background soil (12-25 cm) the concentration of TPH was 35±15 mg kg^{-1}. On the top of the slope (site of accident) TPH concentration reached 5100±230 mg kg^{-1} at the depth 2-7 cm, and 985±443 at the depth 12-25 cm – sandy layer. At the bottom of the slope (5 m from the top) the TPH concentration in the upper layer of soil reached 4850±2180 mg kg^{-1}, and at the depth of 12-25 cm - 1490±670 mg kg^{-1}. The TPH concentration in soil samples from sandy layers (site of accident site) was 30-40 times higher than in background. This horizon contained more TPH, than a similar on the top of the slope, indicating lateral subsurface TPH migration. The TPH concentration in soils of wetland varied from 8470±3810 to 10590±4760 mg kg^{-1}. Wetland accumulates runoff from both sides of MRR, so the reason of soil contamination here is not only due to the accident with the diesel fuel caring tank. This is confirmed by soil analysis on the presence of volatile TPH. In these soil samples there are traces of oil solvent (Nefras A-130/150), this substance was not found in soil samples of the accident site. On the chromatograms of all soil samples set of peaks corresponding to fragment homologous series of n-paraffin hydrocarbons C14-C26 were recorded, the maximum of which falls on the C16 - C20. The number of isoprenoid hydrocarbons peaks were also recorded in all samples, among which pristane and phytane were identified. Such composition and the ratio of components are typical for petroleum products on the basis of middle petroleum fractions. Higher levels of isoprenoids than n-paraffins indicate that TPH were subjected to partial biodegradation (microbiological decomposition). Thus, according to the literature, more prone to biodegradation normal alkane's structure which decomposes primarily to less - iso-alkanes [4,5,6].

Conclusion. Thus, vehicle crashes are the powerful momentary factor causing severe pollution of roadside soils. Road runoff should be arranged properly, in order not to create areas with polluted with TPH.

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Heavy metals in soils of the urbanized agrolandscapes

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The urbanized agrolandscapes playing a considerable role in providing the population with vegetable produce in small towns of Russia make it necessary to estimate the soil quality at this territory.

There is no systemized registration of quality of agricultural soils in cities. At the same time, it is noticed that cities agrolandscapes often suffer from technogenic impact and turn out to be contaminated by heavy metals.

Our objective is to present information about heavy metals concentration in soils of agrolandscapes of some Russian cities (Tula, Kursk, Taganrog), that further can be used for cities agricultural soils monitoring.

Tula – regional city in european part of Russia. In this city there are modern buildings but also significant part of private sector with gardens inside the city. In the studied are was included Kosogorskiy metallurgical plant gardens near Kosaya Gora Iron Works (in periphery of Tula) and in Proletarski district.

Kosogorskiy metallurgical plant produces cast iron and ferromanganese. Iron and manganese compounds are dominated in aerotechnogenic emission. The concentration of manganese were from 7300 to 9000 mg / kg of soil in gardens at the impact area of Kosogorskiy metallurgical plant.

The maximum permissible concentration (MPC) of total manganese in soil - 1500 mg / kg (HS 2.1.7.2041-06). V.V. Kowalski (1974) on the basis of the analysis of soil and plant material has given characteristics within the content of chemical elements in soils and proposed the use of the threshold (limit) concentration. According to his calculations, the normal amount of manganese in the soil is from 400 to 3000 mg / kg. According to V. Kowalski Manganese concentrations in the soil above 3000 mg / kg, are excessive, and they can cause undesired physiological processes in plants. In oxidizing conditions the concentration of manganese in plants decreases, while reducing conditions help to increase concentrations, and they can reach toxic values.

Analysis of regulatory and reference materials allows us to consider the accumulation of manganese in an amount of 7300 - 9000 mg / kg in soil gardens near Kosogorskiy metallurgical plant is high and requiring further control.

Analysis of soil gardens in Proletarian District of Tula, as well as gardens, located near Kosogorskiy metallurgical plant, has shown that, despite the significant differences of soil properties, they share a common pattern: the accumulation in the upper soil zinc horizons, the content of which in some cases even exceeds the MPS. Zinc values from 112 to 604 mg / kg, with an average of 260 mg / kg. The background value of the element in the soil is 60 mg / kg.

The primary role in zinc pollution of gardens, located in the city of Tula, belongs not aerotechnogenic impact. The accumulation of zinc in soils of agricultural landscapes of the city is predominantly agro-technical in nature.

City of Kursk is located in the chernozem agricultural area at the same time has developed industrial potential. In Kursk, as in many cities of Russia, the structure of the use of the urban area is characterized by a one-storey residential building with a private garden plots, orchards, vegetable gardens.

The southern area of the city was studied, which concentrates the major part of large industrial enterprises. The main source of contamination with heavy metals surrounding landscape - Kursk Accumulator Plant (KAZ). Analysis of heavy metals in soils of vegetable gardens and orchards in the impact zone seemed to have fixed the accumulation in them of lead, cadmium, nickel and zinc in concentrations exceeding the MPS.

Analysis of the contents of heavy metals in the soils of urban agricultural areas - gardens, staying away from the industry, showed accumulation of zinc, reaching in some cases 290 - 300 mg / kg. Russian standard is 220 mg / kg (HS 2.1.7.2042-06). In Germany, for agricultural land (private sector), the specification for zinc is 300 mg / kg of soil (Eikman, Kloke, 1991).

Taganrog is a large industrial center of the south of Russia, where the widespread mechanical engineering and metallurgy: There are such major industries as the Metallurgical plant, Krasny Kotelschik, Combine Plant, Tavia others.

Industrial enterprises are concentrated within the three major industrial areas, occupying about 40% of the city. The city is home to about 255 thousand people, and many of them use the products of gardens of the city.

The content of heavy metals in soils is an important indicator of the state of the landscape, as they both excess and deficiency causes the disease organisms.

In the course of the evaluation of soils in Taganrog, gardens within the city limits were surveyed.

The studies found that the major source of contamination of the Western area of the city is the landfill of municipal solid waste, located near the motorway Nikolaevskoe. Agrolandscapes located in the impact area of solid waste landfill and of the Nikolaevskoe highway, was classified as moderately dangerous (aggregated index of contamination). Total content of cadmium and lead in the soils of agricultural landscapes exceeded MPC.

There is risk of contamination of plants in the impact zone of industrial plants and motorways. High intake of heavy metals in plants affect the magnitude and quality of the crop (Ylyin, 1991, Privalenko, 1994).

According Privalenko V.V. (1994) a wide use in road construction metallurgical slags (enriched with heavy metals), which led to the spread of mechanical pollutants throughout the city, largely contributed to heavy metal contamination.

In addition to technogenic input of heavy metals in the soil agrolandscapes of Taganrog, we can not ignore the income resulting from different types of agronomic activity.

Agrotechnogenic impact characterized by the active (often nonnormable) using organic fertilizers (usually a chicken or rabbit droppings). For soils of agricultural landscapes characterized by medium or high content of mobile phosphorus and potassium, high (often exceeding MPC) content of mobile zinc, low content of mobile cobalt.

In the case of use of copper-containing preparations for the spraying trees in agricultural landscapes, soils accumulate increased content of mobile copper concentration that sometimes exceed the MPC.

Some areas are characterized by non-standard use of phosphate fertilizers, which leads to contamination of soil.

In urban agricultural soils of Taganrog, in zones of intensive exposure to industrial enterprises and highways, elevated concentrations (often exceeding MPS) of mobile forms of lead (10 - 21 mg / kg in soil) , zinc (34 - 100 mg / kg in soil), copper (10 - 16 mg / kg in soil), cadmium (0,8 -:6,9 mg / kg in soil) were documented. The degree of security of these soils agrolandscapes basic elements of power depends on the diligence and literacy of owners. Territories are at risk and need special attention. To reduce the effects of anthropogenic charge on the territory of urban agricultural landscapes it is necessary to organize a system of recultivation

Conclusion

High concentration of heavy metals in soils was revealed during sampling analyzis of agrolandscapes in several Russian cities.

The current trend in the accumulation of some heavy metals in the soils of urban agricultural landscapes should be under regular monitoring. Actually, however, there is not even a complete systematization of the available factual material.

Due to agro-technical activity, zinc accumulation processes are going in the upper layers of the soil of orchards and gardens, located within the city limits.

The accumulation of heavy metals dispersed by the aerotechnogenic emissions are going in orchards and gardens, located in the area of influence of industrial enterprises (of manganese - in the impact area of Kosogorskiy metallurgical plant in Tula; of lead, nickel, cadmium - near Kursk Accumulator Plant in Kursk; of cadmium, lead, copper, zinc - in gardens of Taganrog near the zone of solid waste landfill).

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Contamination of urban soils with heavy metals in landscaped area of Lomonosov Moscow State University

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Keywords: contamination; risk elements; soil; urban park

Introduction. The quality of environment and green spaces in urban areas directly related to the state of soil cover which subjected to a number of anthropogenic pressures. Physical and chemical parameters of urban soils are changed under the use of de-icing agents and detergents, air dust settling, proximity to highways and regular overcovering of degraded soils with soil material based on peat. Urban soils contamination and related nutrient imbalance lead to suppression of trees, shrubs and grasses and ultimately degrades the quality of the urban environment. [1]. The objective of this study was to describe the soil pollution levels in landscaped area of Lomonosov Moscow State University. The comparison is done between two localities covered by trees and those of opened lawn areas modified with new soil material.

Materials and Methods. Risk elements in soils of the landscaped area of Lomonosov Moscow State University were examined. The sampling was done in the places located on lawns and under shrubs and trees. (fig. 1). All soils of investigated territory belong according to domestic classification [2] to konstructozems.

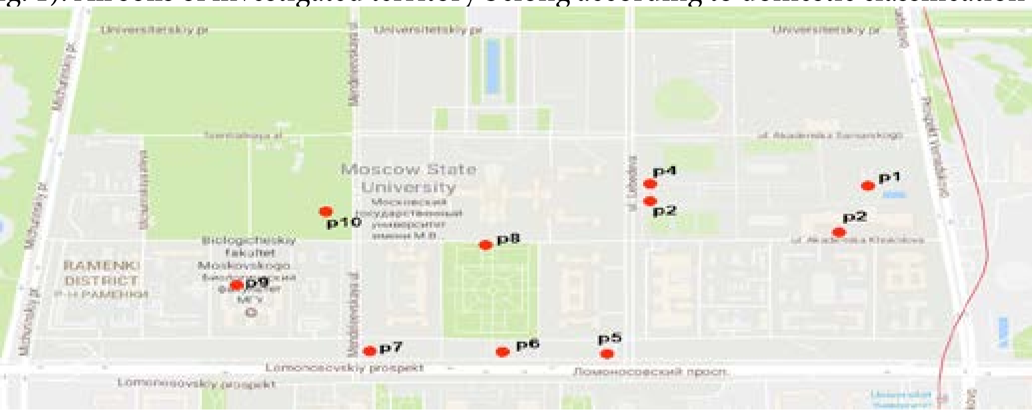

Fig.1. Location of sampling points

Soil samples were collected in august of 2016 from all points marked on fig.1(depth of sampling – 10-20 cm). Points p1-p7 were located on lawns, where in the period from 2010-2013 yy. contaminated and degraded soil was overcovered with new ground, obtained on the basis of uncontaminated peat and sand. Points p8-p10 were located under shrubs and trees on the territory of the Botanical garden of Lomonosov Moscow State University, where soil has not been modified during more than 15 years. The basic soil analyses were done, i.e.: pH_{H2O} potentiometrically; organic carbon content (Corg) by a modified oxidimetric Tyurin method; bioavailable forms of phosphorus and potassium were determined in extraction of 0.2M HCl at the ratio soil:extractant 1:5 (w/v). Bioavailable forms of manganese and iron were determined after extraction with ammonium acetate-buffer (pH=4.8) at the ratio soil:extractant 1:5 (w/v). Heavy metals contents (Zn, Cu, Pb, Cd) in the soil were determined by extraction with 1M HCl at the ratio soil:extractant 1:10 (w/v) and afterwards determined by AAS method under standard conditions.

Results and discussion. Results of soil tests are summarized in table 1.

Table 1 Main chemical properties of the studied soils from different zones of the landscaped area of Lomonosov Moscow State University

	pH_{H2O}	C_{ox}, %	P_2O_5, $mg*kg^{-1}$	K_2O, $mg*kg^{-1}$	Mn, $mg*kg^{-1}$	Fe, $mg*kg^{-1}$	Zn, $mg*kg^{-1}$	Cu, $mg*kg^{-1}$	Pb, $mg*kg^{-1}$	Cd, $mg*kg^{-1}$
	modified soils									
p1	6,4	3,96	304,2	310,3	16,5	11,0	42,0	11,5	21,5	0,100
p2	6,8	2,11	407,3	385,7	18,7	12,0	58,0	10,0	20,5	0,360

p3	6,7	3,75	367,6	200,0	15,6	17,0	65,0	12,5	35,5	0,320
p4	6,3	3,35	394,4	200,0	23,5	11,0	66,4	12,0	21,5	0,250
p5	6,4	2,88	435,3	292,3	26,0	14,0	36,0	11,5	33,5	0,280
p6	6,2	4,18	65,6	115,4	16,2	8,0	46,5	12,5	36,7	0,050
p7	6,4	3,03	208,5	300,0	22,7	13,0	29,5	10,5	16,3	0,280
`	unmodified soils									
p8	6,6	6,96	144,0	492,3	20,7	27,0	70,0	35,0	59,5	0,470
p9	6,5	3,04	347,2	664,0	28,0	11,0	91,0	38,0	63,5	0,540
p10	6,1	3,91	623,4	168,0	25,6	13,0	80,5	32,2	73,5	0,650

Studied soils had close to neutral acidity, high content of organic carbon and bioavailable forms of phosphorus and potassium. According to domestic classifications all soils were characterized by middle and high levels of manganese, zinc and copper content. Al soils are contaminated by lead and cadmium. [3]. The concentration of these elements is 2-10 times higher than the background concentrations in soils of Moscow region. Background concentrations for lead and cadmium are 7 and 0.05 mg*kg^{-1} respectively. Background concentrations for other risk elements are presented in table 2.

Table 2. Background concentration of risk elements in soils of Moscow region (1M HCl extraction) [2]

element	**background**
Cadmium (Cd)	0.05
Copper (Cu)	27.0
Lead (Pb)	7,0
Manganese (Mn)	670.0
Phosphorus (P)	1220.0
Zinc (Zn)	50.0

The quality of modified and unmodified soils is defined by anthropogenic pressure: traffic, urban dust fallout, the application of de-icing agents, detergents (tabl.1). All these factors influence the soil acidity, enrich it with phosphorus and potassium, as well, as heavy metals. Ground materials witch were used for soil modification were not polluted, the mixture of peat and sand was pre-approved with nitrogen, phosphorus and potassium fertilizers (GOST 25100-2011). On the lawn areas, covered with new materials, the content of heavy metals (Zn, Cu, Pb, Cd) is less than on unmodified soils. To compare heavy metals content between two groups of soils, paired t-test was used at alpha 0.05. The significant different was found. (fig.2).

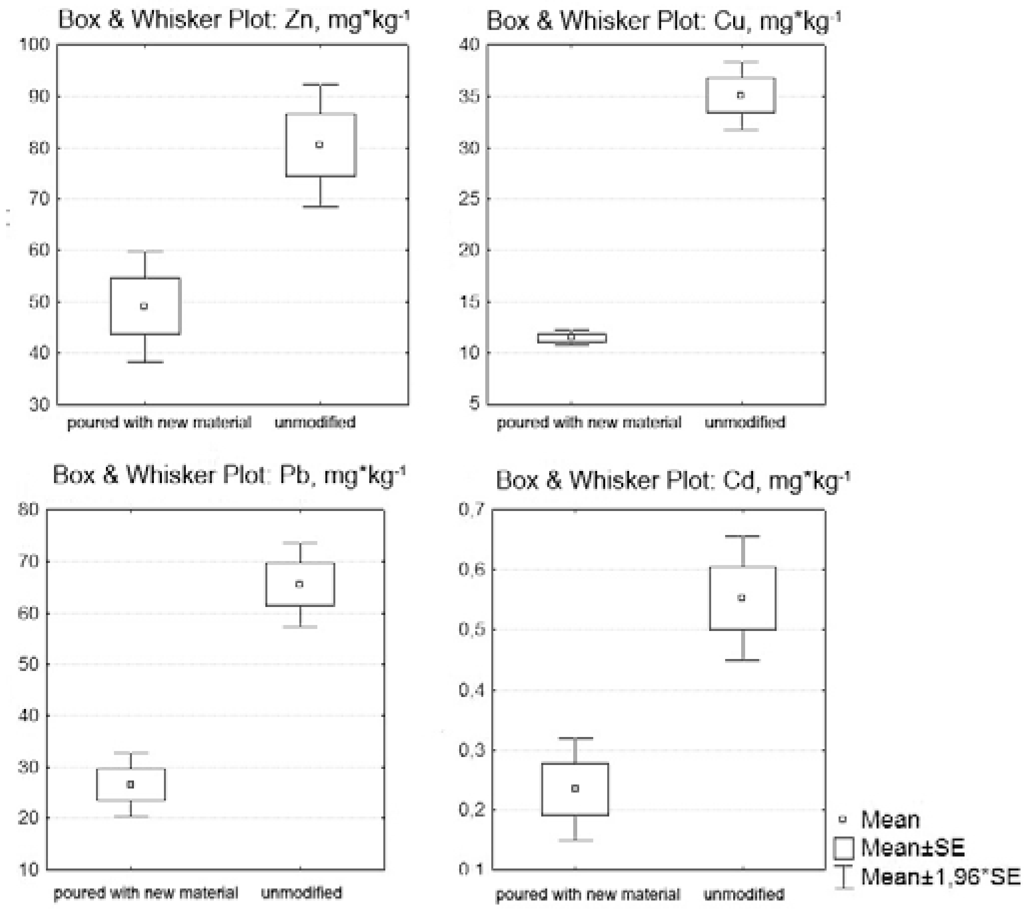

Fig. 2. Diagrams of Zn, Cu, Pb, Cd content in modified and unmodified soils

Conclusion. The formation of uncontaminated layer on lawns and renovation of their plant community is a good, but expansive goal for Moscow environment. This method can significantly reduce the anthropogenic pressure on soils, it also improves the conditions of lawn grasses and ornamental plants growth. But it should be taken in consideration, that peat – one of compounds of grounds, used for lawn renovation has very low levels of trace elements important for plants, thus peat properties, such as high organic carbon content, neutral pH and hitch content of phosphorus can cause the deficiency of Mn, Fe, Cu and Zn. The deficiency of some trace elements was observed on some sites of landscaped area of Lomonosov Moscow State University, thus monitoring of soils properties and fertilizers application is advisable to control nutrient imbalance in urban conditions.

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Role of soil microorganisms in the degradation of oil hydrocarbons

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Oil and products of its processing are the most common environmental pollutants. In terms of adverse effects on the ecosystem oil and petroleum products occupy second place after radioactive contamination. Oil consists of hundreds of different organic compounds (aliphatic, alicyclic, aromatic hydrocarbons and heteroatomic compounds), the ratio between which vary depending on the origin of petroleum sources. Oil composition includes hydrocarbon, fly asphaltene components, as well as sulfur and porphyrins. The hydrocarbon part of the oil consists of alkanes (paraffins), naphthenes (cycloparaffins) and arenes (aromatic hydrocarbons).

Oil pollution caused negative changes in soil biological communities, resulting in sharply reduced productivity and deteriorating economic value of land. In many cases, the process of degradation of oil can be activated by the application of mineral and / or organic additives (biostimulation), as well as the introduction of specific cultures of microorganisms capable of degrading a variety of oil hydrocarbons (bioaugmentation). The natural process of contaminated soils restoring occurs from 10 to 50 years. The use of new biological products and technologies can eliminate contamination within 1-3 years. Recently, for bioremediation microbial associations, consisting of two or more strains are used, since the introduction of monocultures of microorganisms in hydrocarbon-contaminated environment can not completely solve the problem of soil cleaning.

Microorganisms represented by different taxonomic groups are able to absorb petroleum hydrocarbons. They are various kinds micromycetes, yeast and bacteria. More than 20 genera of bacteria, and over 10 genera of fungi capable for different petroleum hydrocarbons biodegradation are described. To date, a vast amount of material about the ability of microorganisms to recycle a wide range of petroleum hydrocarbons is accumulated. It is recognized that an important role in reducing pollution belongs to bacterial genera Rhodococcus, Arthrobacter, Acinetobacter, Pseudomonas (Tanase et al. 2013; Oberoi et al. 2015; Liu et al. 2016).

The aim of this study was to investigate the decomposition of oil by bacteria with different biodegradation potential. The following groups of bacteria were used in the work: 1) bacteria-destructors of a wide variety of aromatic compounds (Rhodococcus opacus 1CP, Rhodococcus wratislaviensis G10, Gordonia polyisoprenivorans 135), 2) a strain of Microbacterium foliorum BN52, isolated from contaminated with chlorinated aromatic compounds soil, but not exhibiting significant destructive activity, 3) the strains Arthrobacter agilis Lush13 and Acinetobacter sp. - typical representatives of the soil microflora. The strain R. opacus 1CP can completely degrade benzoate, phenol, chlorophenols (Gorlatov et al. 1989). Strain R. wratislaviensis G10 is able to grow on chlorobiphenyls (Plotnikova et al. 2006). G. polyisoprenivorans 135 decomposes a number of aromatic compounds (Solyanikova et al. 2015). The strains M. foliorum BN52 and A. agilis Lush 13 and did not show any significant destructive activity against biphenyl, phenol or chlorophenols, however, they were able to maintain their long-term viability under the conditions of prolonged exposure to adverse factors, such as starvation or the presence of toxic compounds.

The ability of microorganisms to degradation of oil hydrocarbons or its components (nonane, decane, hexadecane) was investigated at present work. For this purpose the microorganisms are cultured in flasks for 10 days at 30 ° C in liquid mineral medium (Gorlatov et al. 1989) supplemented with 2% of oil or alkanes as the sole carbon source.

We used oil from the field Aschisay (Kazakhstan) of the following composition: alkanes - 78%, NAFTA - 6.7%, arenes - 3.7%, other compounds - 11.6%. The medium was sterilized with carbon sources at 0.5 atm for 30 minutes before inoculation with bacteria.   Infrared spectrophotometry method was used to determine the residual oil content after cultivation of bacteria. Infrared spectrophotometric method allowes to determine the hydrocarbon content by number of C-C, C-H bonds. Oil hydrocarbons were concentrated for analysis by extraction with carbon tetrachloride from the test sample (1: 1, V/V) and the measurement of the concentration (g / l) was performed on the instrument AN-2 (Saint-Petersburg, Russia). Oil degradation degree was calculated in percentage relative to control (mineral medium with 2% oil without microorganisms). The obtained data are presented in the table.

Table. Degree of oil destruction after 10 d of cultivation with studied microorganisms

Strain	Peculiarities of cells	% of oil destruction
Gordonia polyisoprenivorans 135		43,67
Rhodococcus wratislaviensis G10		10,86
Microbacterium foliorum BN52	Vegetative culture	0,48
Microbacterium foliorum BN52	Cells after dormancy stage (based at colonies' type):	
	Smooth	1,33
	Rough	24,37
	Micro	0
Arthrobacter agilis Lush13	Vegetative culture	20,27
Arthrobacter agilis Lush13	Cells after dormancy stage	4,58
Acinetobacter sp.	Vegetative culture	8,56
Bacterial mixture		32,93

Since the precision of the method for oil hydrocarbon determination is 15%, 4 variants can be considered as significant values. The highest degree of oil destruction was shown in two variants: 1) with strain G. polyisoprenivorans 135 – destructor of benzoate and 3-chlorobenzoate, 2) with bacterial mixture isolated from oil preparation after 2 months storage at room temperature.

Noteworthy is a small destructive activity exhibited by some embodiments of soil microflora - strains of M. foliorum BN52 and A.agilis Lush13. M. foliorum BN52 culturing in liquid mineral medium with aliphatic hydrocarbons (C8, C9, C16) did not lead to the decomposition of these compounds, indicating a lack of vegetative cells oil-decomposing activity (Solyanikova et al. 2017a). However, observed in the variant of cells that germinate after resting stage with formation rough colonies, some destructive activity is quite expected. It can be explained by gene activation that can occur after resting, the induction of whom in vegetative cultures may be difficult.

Vegetative culture of A. agilis Lush13 also showed some oil destructive activity. These data are in good agreement with the results previously obtained for A. agilis Lush13- its ability to survive under adverse environmental conditions (Solyanikova et al. 2017b).

Thus, the present study showed the possible contribution of different groups of microorganisms to remove the oil pollution. Under the conditions of high level pollution the most important role in cleaning up the environment from the oil belongs to a highly adapted strains-destructors possessing broad destruction potential. However, the soil microflora is making an important contribution to the removal of local soil contamination. This may occur after germination of resting forms of survival bacteria at resumption of the vegetative cell growth.

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State and Municipal Land Supervision and Monitoring Over the Soil Protection

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The importance of protecting the soil layer is most acute with regard to fertile lands, including lands within the metropolitan area. The actual problem is the public regulation of supervision and monitoring of soil protection. At the current moment, state and municipal land control over the protection of soil, carried out on agricultural lands and agricultural plots in land settlements. This type of control is carried out by the Federal Service for Veterinary and Phytosanitary Surveillance and its territorial bodies for observing the implementation of measures to conserve and reproduce the fertility of agricultural lands, including reclaimed lands, the requirements for preventing unauthorized removal, transfer and destruction of the fertile soil layer, as well as damage to land in a result of mismanagement of pesticides, agricultural chemicals or other hazardous to human health and to the environment substances and waste. In addition, an important role in the control activities plays the local government, which creates a special unit within its structure, performing general and special municipal control over soil protection.

Federal Service for Veterinary and Phytosanitary Surveillance and its territorial bodies exercise the function of state land supervision and monitoring on agricultural lands and on land plots in zones of agricultural use in populated areas, within their competence in accordance with the Regulations on the Federal Service for Veterinary and Phytosanitary Surveillance, approved by the Decree of the Government of the Russian Federation on June 30, 2004 No. 327171.

The Federal Service for Veterinary and Phytosanitary Surveillance and its territorial bodies perform state land supervision over compliance with: the requirements to prohibit unauthorized removal, transfer and destruction of the fertile soil layer, as well as damage to lands as a result of violation of the rules for handling pesticides, agrochemicals or other dangerous for Human health and the environment substances and wastes of production and consumption; requirements and mandatory measures to improve lands and to protect soil from wind and water erosion and prevent other processes, that degrade the quality of land; requirements associated with the mandatory use of lands from agricultural lands, the turnover of which is regulated by the Federal Law "On the circulation of agricultural lands", for agricultural production or other activities, related to agricultural production; requirements in the field of land reclamation, in violation of which the consideration of the cases of administrative violations are exercised by the bodies of state land supervision; orders issued by officials of the Federal Service for Veterinary and Phytosanitary Surveillance and its territorial bodies within the competence, on compliance with the requirements of land legislation and the elimination of violations in the field of land relations. The unsolved legal problems, arising from such inspections are indicated in the scientific literature. In particular, in the process of exercising state supervision over the conservation of soil fertility, during which the establishment of the fact of its reduction is carried out in accordance with the Criteria for a substantial reduction in the fertility of agricultural lands, approved by the Government Decree on July 22, 2011 No. 612.

As noted the specialists in the field of legal regulation of land-surveillance relations, Krassov O.I. and N.I. Kalinin, the state land inspector should know the initial indicators of fertility and compare them with the indicators at the time of inspection. In most cases, this cannot be done, since soil, geobotanical and other special land surveys are practically not carried out.

In addition, representatives of the legal doctrine highlight the defects in the legal regulation of land reclamation, land improvement and soil conservation. In practice, this also leads to problems of bringing violators to administrative responsibility under Art. 8.7 of the Code of Administrative Offenses of the Russian Federation "Failure to fulfill responsibilities for reclamation of lands, mandatory measures to improve lands and to protect soils", as evidenced by judicial practice.

It should be also mentioned, that scientists, O.L. Dubovik, in particular, mark the problems of delineation of the non-use of agricultural lands with other contiguous offenses in this area, introduced by the Code of Administrative Offenses of the Russian Federation, the unauthorized removal or transfer of the fertile soil layer (Part 1, Article 8.6), the failure to fulfill or the untimely fulfillment of responsibilities for reclamation of land during reclamation works (Part 1, Article 8.7), failure to fulfill the established requirements and mandatory measures of improvement and lands and soil protection from wind, water erosion and prevention of the other processes and other negative impact on the environment, worsening the quality of lands (Part 2, Article 8.7), as well as the administrative offenses, specified in Art. 8.8 of the Administrative Code of the Russian Federation.

The important unresolved legal problem is the coordination of activities between state and municipal authorities in the field of soil protection.

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Legal Support of Soil Resources Protection

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Annotation: In the present article, the authors consider the legal regulation of the conservation of soil quality at the federal and regional levels, the relations between the concepts of "land" and "soil." The authors analyze the experience of the city Moscow in regulating soil conservation in populated localities.
Keywords: soil, land, land legislation, soil resources, land resources, Moscow.

Environmental protection in the Russian Federation today has a legal basis both on the federal, regional and local levels. The theoretical basis of any of the branches of law is its conceptual apparatus. The presence of uncertainty can create difficulties in law enforcement practice or even gaps in the regulation of any spheres.

Despite the fact, that there is a fairly extensive terminology, dedicated to the methods of protecting the environment and its components, the issue of the relations between the concepts of "land" and "soil" is subject to scientific discussion. It is important to understand that the success of regulatory and legal regulation of issues of rational use of land resources and the preservation of a favorable environment for human beings depends on a correct and clear understanding of the relationship of these terms.

Protection of land and soil is under the jurisdiction of environmental and land legislation. The Federal Law "On Environmental Protection" [5] separates such objects as land and soil and, among other things, relates to the components of the natural environment that together provide favorable conditions for the existence of life on Earth. In this connection, according to the law, they are subject to protection from exhaustion, pollution, destruction, degradation, spoilage and other negative effects.

In the Land Code of the Russian Federation [3], soil is already considered as part of the land to be protected. For example, in clause 4 of Article 13 of the Code, it is obliged to carry out measures for conservation or use to improve the condition of unproductive land, when carrying out works that violate the soil layer. Article 42 establishes the obligation of the owners of lands and of the persons who are not their owners, to prevent the deterioration of the state of soils and lands, thereby again separating these concepts in the article. Non-compliance with mandatory soil conservation measures (for example, reclamation), non-elimination of the consequences of negative impacts on land and soil is the basis for termination of the right to permanent (unlimited) use of the land parcels, the right to lifetime inheritable possession of land, as well as lease (Article 45,46) [3].

It should be noted that in the early editions of the Land Code, the soil was considered as a component of both land and land parcel. However, the tendency of increasing attention to land as an object of real estate entailed the exclusion from the land law branch of issues related to the essence of the land as a natural resource and, accordingly, the exclusion from the concept of "land" given in Article 6 of the Land Code, such a component as soil [4]. Now the land parcel is an immovable thing, representing a part of the earth's surface and having characteristics that allow to define it as an individually defined thing [3]. Such view on the land parcel is rather narrow and does not allow to consider it as a component of a natural object.

Protection of lands and soils of settlements is a specialized activity of authorized bodies, which consists in implementing various measures to ensure protection, safety and environmental safety when using them. Important here is a higher level of negative impact on land and soil resources [4].

In the process of urban development, some of the land is naturally vulnerable to negative impacts, therefore, measures to restore damaged land are an integral part of the activities of city authorities. To this end, various kinds of environmental and town planning documentation are adopted, and specialized bodies are created. An example is the Department of Nature Management and Environmental Protection of Moscow.

The Department carries out its activities, based on the Decree of the Moscow City Government and is governed by both federal legislation and legislation, adopted at the city level. Until 2007, there was a law of the city of Moscow “on land use and development in the city of Moscow,” where both the protection of land and soil and the norms for building were determined. Then, two other normative and legal acts were created, they divided this sphere into two: the Moscow City Law “On Land Use in the City of Moscow” [1] and the “Urban Planning Code of the City of Moscow”. The issues of land protection are solved in the first of them, and this is the subject of Chapter 6 “Protection of land in the city of Moscow”.

The law refers to the objectives of land protection in the city of Moscow: ensuring the right of citizens to a favorable environment, preventing pollution, littering and other damage to lands, improving and restoring lands that have been adversely affected by economic and other activities and, as a result of natural processes, leading to depletion and destruction of soils. Returning to the relations of the concepts of “land” and “soil”, it should be pointed out, that in this law the latter is mentioned only in the article on the purposes of protection and is no longer used. The issue of soil protection is not detailed, since there is an independent normative legal act of the City of Moscow Law “On urban soils” [2]. Thus, it is obvious, that only at the level of regional legislation, the notion of “soil” is disclosed and, moreover, “urban soil” is separately considered. Among the important provisions of this law, it is possible to single out the compulsory observance of the permissible values of the quality of urban soils and the impact on them, depending on the functional purpose of the territory, the maintenance of the urban soil register, which contains a collection of data on the types, subtypes, types of urban soils and the quantity and quality of the urban soils, the introduction of the concept of the passport of urban soils, which is a document, containing information on the state of soils on a particular land parcel and changes, occurring in them as a result of economic and other activities.

However, unfortunately, Moscow is the only subject where a separate regulatory legal act is devoted to soils, as an independent natural object. A similar draft of the federal law has not been approved.

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Degradation of Soil Resources in Industrial and Military Facilities

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Annotation: The article deals with the problem of degradation of soil resources in the territories of industrial and military facilities, as well as in zones of military conflicts. Despite the high role of soil resources in many of the human activities and more than a century of the history of the existence of soil science, the problem of soil contamination does not lose its relevance and, even more, becomes more and more important for the ecological state and preservation of human health.
Keywords: soil, land, soil resources, land resources, soil contamination, soil degradation.

The main problems for soils are irreversible losses due to soil compaction, erosion and, of course, due to local heavy metal contamination and acidification. The entire second half of the XX century is characterized by a constant increase in the growth of anthropogenic impact on the environment, including soil. More than half of the arable land, today, has been degraded to some extent. The gradual loss and degradation of the soil resource will continue and even grow due to climate change, land use, ever-growing urbanization, infrastructure development and destructive human activities. In many countries, there is already a policy of preventing the growth of local soil pollution, especially in areas with large industrial complexes and military installations, but the problem of pollution does not lose its relevance. Despite the fact that soil degradation is recognized as a serious and widespread problem, its quantitative assessment, geographical distribution and total area have not been fully studied.

Degradation of soils for the first time received a scientific justification at the end of the XIX century and it was given by Russian scientists Dokuchaev V.V. and Ismailsky A. A. It was their work that later became the basis for the emergence of a new science - soil science. Although the development of this science already has more than a century of history, a clear and comprehensive definition of soil degradation has not been formed, primarily because of its multifacetedness and connection with both natural and anthropogenic factors that change over time [2].

As was already noted, one of the main factors of negative impact is a human and the objects of industrial and military nature that he creates. In many regions of Europe, the soil degrades as a result of loads, created by almost all sectors of the economy. It is important to note that for each region there are different types of degradation of the soil layer (or several species), which is due to the difference in the impact factors.

For example, for Western Europe, erosion is the most common problem, and desertification is for Central Asia. For Central and Eastern Europe, in addition to erosion, the problem of pollution is acute. An incorrect policy regarding the use of mineral fertilizers, pesticides and heavy metals entailed serious contamination of groundwater, deterioration of the soil layer and loss of its fertility.

Increasing the level of ecological literacy and the obligation to implement international legislation contributed to reducing pressure on the soil resource. However, the soil should be considered as a limited resource because of the very long period of its restoration and the huge costs associated with it.

Soil pollution, at the present stage, is the natural result of inefficient technologies and uncontrolled emissions at most industrial enterprises. Existing norms of the legislation on liability for environmental violations are applied on the fact of the revealed violations, and preventive measures are purely effective.

Problem regions include not only operating enterprises, but also more than a thousand former military facilities, industrial facilities, storage facilities that continue to release pollutants into the environment, military conflicts are causing the same irreparable damage.

For example, in Bosnia and Herzegovina, the war caused damage to the soil layer over an area of more than 6,000 hectares, through the destruction of forests, erosion, and waste disposal. An important feature, as well as land minefields and unexploded ordnance, was estimated to have been mined in Bosnia and Herzegovina by more than 27% of the arable land and until their complete clearance, recovery processes are almost not supposed to be possible [1].

Influence of military infrastructure facilities on the ecological situation and on the environment in general and on soils in particular continues in peacetime, and the bulk of military facilities by the nature of pollution differs little from industrial enterprises. At the same time, the impact of the armed forces is much more difficult to assess than industry, since most of the reporting on the event is classified. Today, it is presumed that military activities should be carried out without causing environmental damage and taking into account the consequences for the environment, with a reasonable limitation of the needs of the troops and the fleet, but these restrictions should in no way reduce the opportunities for ensuring security and protecting national interests.

Industrial enterprises also leave serious consequences of their activities directly affecting the state of the environment. All enterprises produce a huge amount of waste, including toxic substances. For example, the activities of the metallurgical industry entail the dumping of salts of heavy metals, the production of plastic products leaves a waste containing phenol and benzene. Among other harmful elements identified by industry can be mentioned - lead, mercury, cadmium, arsenic, and beryllium. All these substances, getting into the soil, inevitably begin to accumulate there, having a toxic effect not only on the earth, but also on the health of people. Separately, we can say about the pollution of oil and oil products. In addition, nuclear power plants unload from the reactors waste, 90% of the products are uranium fission, then it is buried in the soil, causing radioactive contamination.

It is important that, despite the high role of soil resources in most types of activities (including some, contributing to economic growth), which entail their depletion, soil protection, as a rule, is not the subject of separate planned activities, for example, by contrast with water or air resources protection. Soil is protected only indirectly, through measures of environment, water and the atmosphere protection.

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Microbial activity in constructed Technosols for stormwater management systems

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Green Infrastructure (GI) is a designed environmental feature that usually includes technogenic materials (Constructed Technosols). It employs a multifunctional systems approach that combines natural resources (e.g., soil, vegetation, trees, wetlands) with engineering and technology in built environments. GI provides ecological, economic and social benefits to urban environments dominated by grey infrastructure (e.g., roads, sewers, electrical grid networks, water treatment facilities). In 2010, a Green Infrastructure Plan was developed by the New York City Department of Environmental Protection. The core of the plan was to design and construct green infrastructure to capture stormwater to reduce the burden on wastewater treatment plants and decrease combined sewer overflow, thereby improving the water quality in the harbor. There is also interest in the ancillary benefits of GI, such as effects on local climate, air quality and social factors.

The objective of this work was to characterize soil chemical properties and microbial biomass and activity relevant to carbon and nitrogen cycling processes. In 2016, composite soil samples (0 to 10 cm) were taken at 22 GI sites in New York City. These sites were constructed 5-7 years prior to the sampling. For each site, we measured physio-biochemical properties such as heavy metals, pH, salts, organic matter, texture, bulk density, total organic carbon, total nitrogen, microbial respiration, biomass, N production, and potential denitrification. Results showed that these sites did not have a significant level of contamination by heavy metals. For example, the median Pb concentration was 89 mg kg^{-1} which is lower than the median concentration of 355 mg kg^{-1} measured in 1,652 garden soil samples in New York City (Cheng et al., 2015). The main variables affecting microbial biomass and activity were total organic carbon, total nitrogen and pH and there were significant positive correlations between some heavy metal concentrations and microbial processes. For example, correlation was observed between microbial biomass and, Zn and Cu (P-value < 0.05). Our results showed significant effect of land use (i.e., bioswales and vegetated bioretention areas) (P-value < 0.001) and site location (P-value < 0.001). These results suggest that relatively young (< 10 years) GI sites provide significant levels of microbial biomass and activity relevant to carbon and nitrogen cycling. Even with the high influence of human activity, the constructed Technosols show behavior similar to soils that occur in natural areas.

Hierarchical drivers of aggregation in a constructed Technosol

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Abstract

Aggregation is a key process in many soil functions. It is known to be influenced by the amount of organic matter. However, soil biota, especially plants and earthworms, plays a critical role as well. Constructed Technosols represent good models to test the relative importance of these factors since their composition can be easily manipulated by mixing different proportions of parent materials and introducing soil organisms. In this study, we performed a mesocosm experiment, using excavated deep horizons of soils (EDH) as mineral material mixed with green waste compost (GWC) at six different proportions (from 0 to 50%) in the presence or absence of plants and/or earthworms. After 21 weeks of incubation, aggregation was characterized by 1) determining the size fraction and morphology, 2) measuring the distribution of organic in each fraction and 3) testing the aggregate stability. Results showed that organisms accounted for 50% of soil aggregation variance while GWC was responsible for only 5% of the variance.

The total percentage of variance of organic carbon distribution in aggregates explained by organisms was similar to that of the proportion of GWC (28 % and 22% respectively), while their interaction accounts for 26%. Organisms had the dominant (70%) effect on structural stability compared to GWC (2%). The structural characteristics of depend more on biota than on the proportion of organic matter. The effect of earthworms and plants in combination was complex: whereas plants had a dominant effect on the distribution of the size of aggregates by disrupting earthworm casts, earthworms had a dominant effect over plants for aggregate stability under fast wetting only when the percentage of compost was low. This study underlines the importance of the indirect effects of the organic matter: in this case, increasing compost proportion has merely no effect on aggregation in the absence of plants or earthworms.

Dynamics of soil organic carbon of reclaimed lands and the related ecological risks to the additional CO2 emissions

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Introduction

During the recent decades, the world has witnessed an ever-growing concern towards global warming resulting from greenhouse gases, for example carbon dioxide (CO2). The potential soil carbon accumulation ability of human damaged and managed ecosystems roughly the same as the total historic C miss assumed at 55 to 78 Gt. The achievable soil C absorption capacity is only 50 to 66% of the possible ability. In the light of sustainability policy of soil carbon sequestration is examined and cost-efficient. Sequestration of carbon governs transmission of atmospheric CO2 into long-lived pools holds it safely consequently it is not instantly reemitted. Thus, soil C sequestration implies growing SOC and SIC stocks through land reclamation.

The global soil carbon pool assessed as about 2500 gigatons (Gt) includes about 1550 Gt of soil organic carbon and 950 Gt of soil inorganic carbon. The soil C pool is 3.3 times the size of the atmospheric pool (760 Gt) and 4.5 times the size of the biotic pool (Lal, 2004). Mining and quarry exploration results in fundamental changes in all landscape up to its full destruction. These abandoned pits, without soil and vegetation cover, become a large and persistent source of atmospheric CO2 due to reduced vegetation productivity and various soil processes.

Plant-soil interactions play a critical role in regulation of global biogeochemical and hydrological cycles. These two parts of ecosystems regulates the environment sustainability in conditions of climate global change and anthropogenic effect.

In view of the increasing of concentration greenhouse gases in the atmosphere, there is a strong need to investigate the processes of dynamics of soil organic matter of recultivated lands.

Material and methods. The study area is located in the Kingisepp area of phosphorite mining. Reclamation of quarry was carried out by following scheme: dense spoilbanks with high content of stones were covered by two types of substrata – friable carbonate loams without organic carbon and friable carbonate loams with admixture of turf. These flat surfaces were revegetated with use of seedlings of *Picea abies (L.)*, *Larix sibirica Ledeb*, *Pinus sylvestris L.*. On these plots we have established monitoring investigations in 1998, 2004 and 2014 years. The organic carbon content was determined from the oxidizability of the organic matter (the wet combustion method). Here is need to describe the numer of sitesQualitative and quantitative composition of humic acids exctracted from soils of different periods of ripening was investigated bysolid state 13-NMR- spectroscopy method. This methods is a valuable tool for the characterization of soil organic matter and humification processes in soils. The total aromatic content was determined by integrating the signal intensity in the intervals 100–170 and 183–190 ppm, the total aliphatic content was determined at the intervals 0–110 and 164–183 ppm.

Results and discussion.

On the first site with admixture of peat (under *Picea abies (L.)*) organic carbon content of mineral horizons decreases due to mineralization and humification processes (Fig. 1). This contributes to increasing the rate of enrichment of atmospheric concentration of CO2. But at the same time the succession of gross community to forest leads to the intensive accumulation of forest floor and organic matter. On other plots without fertilization by organic amendments organic carbon content slowly increases due to vegetation formation.

Figure 1. Content of organic carbon in soils with admixture of peat

The analysis of molecular structure preparations of humic acids showed that in all samples there was a predominance of aliphatic carbons over aromatic (Tabl. 1). Due to inherent biochemical stability of natural aliphatic biomacromolecules can increase the terrestrial storage of atmospheric carbon dioxide. Usually this type of bio(macro)molecules, for example, waxes, terpenoids and glycerides arise from plants, animals and microorganism. It should be noted that aliphatic components also could be formed in surface during non-enzymatic polymerization of low-molecular-weight lipids.

Tabl. 1. Total aromatic and aliphatic carbons, %

	Site 1		Site 2		Site 3	
	2004	2014	2004	2014	2004	2014
aromatic content	36	33	28	33	35	34
aliphatic content	64	67	72	67	65	66

Solution 13 C NMR spectra of HAs, from the examined soils, are shown in the table 2. Despite 10 years of soil development the samples investigated practically didn't differ in the amount of functional groups and molecular fragments. The distinct peak in the 23–32 ppm region, representing CH2 alkyl structures was observed in all the spectra (Fig. 2). Biochemically recalcitrant SOM fractions are enriched with alkyl carbon (C) structures and resist decomposition due to intrinsic molecular properties. Figure 2 also demonstrated a smaller peak in the methyl group (51 ppm) and carboxyl C regions at all samples. Additionally, samples showed a signal at 68 ppm, indicating the presence of methyl esters of carboxylic groups. Furthermore, the signal at 125 ppm for sites is characteristic of protonise aromatic carbon. Such long lived molecules derived from tissues of plants can promote stabilized aliphatic hydrocarbons to soil organic carbon. High similarity of amount of functional groups and molecular fragments at different sites could be caused by predominance woody species. As is known, tree species as well as underground parts of plants have high proportions of alkyl C, as opposed to grassy species (Lorenz and Lal, 2005). Accordingly, in light of the processes governing stabilization of CO2 into biochemically recalcitrant macromolecules, recovery of woody plants is preferred.

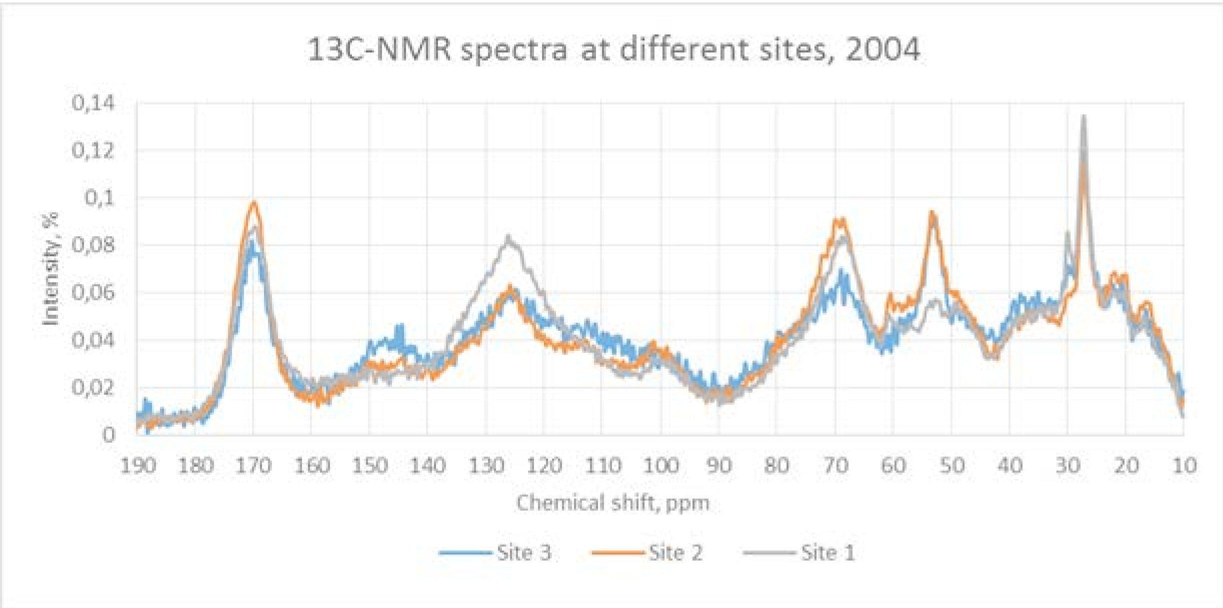

Fig. 2. 13C-NMR spectra at different sites.

Conclusions

The total global emission of CO2 from soils is recognized as one of largest fluxes in the global carbon cycle, and changes in the approach of reclamation of quarries could have a large effect on the concentration of CO2 in the atmosphere and environmental sustainability of ecosystem. The role of the former mining complexes on regulation of carbon stock and carbon dioxide emission were assessed in this context by the number of evaluation and instrumental methods.

Soil organic carbon accumulation is very slow processes. The use of 13CNMR spectroscopy in the study of humic substances has revealed very low levels of temporal compositional variability. High aliphaticity has been considered to be indicative of a higher availability of SOM to mineralisation. Recovery of woody plants could be preferred on quarries because it is potential sources of recalcitrant biomacromolecules in soil and it may contribute stabilization of CO2 into soil organic matter.

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One more challenge for study of anthropogenic pedogenesis: soil change in peri-urban environment (Belgorod case study)

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The beginning of the 21st century marks the first time in history that more than half of the world's population lives in urban areas which occupy about 2% of the land surface. In Europe, more than 70% of the population live in urban areas today. This number is likely to increase to 84% by 2050. Urban areas are likely to increase worldwide due to many factors such as economic growth, population growth, rising living standards, availability of cheap agricultural land, inner city problems, increase in the wealth of household, enhanced personal mobility. In Europe, the urban land increased by 3.4 % between 2000 and 2006 — by far the largest proportional increase in all land use categories. The typical process of urban expansion in Europe is the conversion of the agricultural land to urban land in form of detached single family homes. The same pattern in terms of holiday settlements (dachas) and private cottages are found in Russia, where 64 mln. ha former agricultural land (9% of all abandonments) around the cities are affected. On a global scale about 0.5 mln. ha of arable land is annually being lost to the expansion of urban areas. The conversion of agricultural land to urban land occurs continuously since medieval times and later, well documented for many old cities of Europe and North America. Urban expansion on arable land is a typical pattern of land use change in human history worldwide with increasing impact at present. Thus, a consequence of intense urban expansion and rapid growth of urban-rural transition zone is involvement of agricultural and forest into the peri-urban areas. Peri-urban areas are the transition zone, or interaction zone, where urban and rural activities are juxtaposed, and landscape features are subject to rapid modifications, induced by human activities

Soil formation functioning due to conversions of native ecosystems to agricultural use, and, vice versa, a recovery from agricultural use to quasi-natural conditions, have been relatively well-studied. Unlike to the post-agrogenic restoration to quasi-natural ecosystems, the development of soil properties after conversion of arable land to urban land has received less attention. Our objective is firstly to examine the effects of land use change from arable land to peri-urban area (urban garden and grassland within residential housing) on soil properties and soil formation. We need also to understand the ways in which new ecosystems of peri-urban areas are affected in terms of carbon balance and potential of soil carbon sequestration, soil pattern and soil functions, to create better tools and effective strategies for the planning of sustainable land use systems.

The subject of case study is peri-urban area of Belgorod (50°36' N 36°36' E, 390 000 inhabitants, 550 000 ones - in Belgorod agglomeration) in forest-steppe zone (Phaeozems and Chernozems). Belgorod is a vivid example of one of the fastest growing cities in the Central Chernozemic economic region. Over the past 20 years, the former arable lands within a 30 kilometers zone from the city are actively used for settling and houses construction. A vast territory of individual housing development is being formed here.

Studies of the soils of peri-urban area around Belgorod in place of former arable land were started in 2016. The first data were obtained on two key-sites: on Chernozems and Phaeozems (gray forest soils). The soil cover of the investigated territories is characterized by its heterogeneity. Sealed zone (buildings and paths), residential zone (lawn, playground), garden zone (growing fruits and vegetables) are allocated in peri-urban units. The soils of the residential zone have a thin horizon (<5 cm) with urbic material, which is connected with the primary development of this site. Soils of suburban farming area (gardens) are close to agrogenic soils, but differ in the structure, water regime (due to regular watering) and change in the upper border of secondary carbonates and redox status. Thus, each of them differs from arable and urban soils. These soils are in an intermediate position in the series of increase of the anthropogenic impact.

Biodiversity of algae and cyanobacteria in soils of Moscow

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Introduction. Microscopic algae and cyanobacteria are constant inhabitants of the soil. They form the algal-cyanobacterial communities which are a constituent of any phytocenose. Soil algae and cyanobacteria are very sensitive to transformation of soil properties and response to it by changing the biodiversity, composition and structure of communities. The depth of such changes indicates the degree of integral anthropogenic impact on soils that could be used for bioindication studies.

The study objective was to reveal the parameters of soil algal-cyanobacterial communities in different land-use zones of Moscow and their association with the principal changes of urban soils properties.

Area and methods of study. The study involved the territory of two administrative districts of the Moscow city. The anthropogenic impact on soils results from the activities of industrial enterprises, the motor and rail transport facilities and the use of deicing reagents during winter.

Samples for algological examination were taken from soil layer of 0 to 5 cm in spring, after melting of the snow cover, both at a reference site and in different land-use zones of the city (recreational, residential and traffic). Landscapes with forest vegetation and cultivated landscapes with sown meadow vegetation were studied within the reference site with soddy-podzolic soils. The recreational zone is a city park, where samples were taken 1-3 m from walking roads. In contrast to the forest, shrubs are cut, the grass is regularly mowed and the litter is removed along the walking roads in the park. In the residential zone samples were taken from the lawns near walking paths, garbage containers and parking spaces. Soils are shaded by houses and to a different degree exposed to trampling. In the traffic zone samples were taken from the lawns 1,5-3 m from the highways. In summer the lawns are regularly hosed and mown. In winter the highway and walking roads are treated with deicing agents causing the seasonal salinization of soils. Soils of all land-use zones are exposed to organic and inorganic pollution (least of all in the recreational zone) and alkalinization.

Species biodiversity of soil algae and cyanobacteria is studied by standard methods of soil algology (Gollerbakh, Shtina, 1969). The ecological parameters of species were borrowed from the monograph of S. S. Barinova et al. (2006), that of life forms (ecobiomorphs) of soil cyanobacteria and algae - from the monograph of E. A. Shtina and M. M. Gollerbakh (1976).

Results and discussion. The reference forest soddy-podzolic soils have the algal-cyanobacterial communities, typical to forest soils of the taiga zone. Green and streptophyte algae definitely prevail in them; the ochrophyte algae are quite diverse, while the diatom algae and cyanobacteria have just small number of species (Table). The growth of the diatom algae and cyanobacteria is suppressed by the abundance of organic matter and heterotrophic microorganisms in the forest litter horizon. The result is the low number of species in one sample. The shade-tolerant but non-resistant to soil desiccation species of algae prevail (the C-, X- and H- life forms).

In cultivated soddy-podzolic soils under sown meadows which are annually plowed and periodically limed the algal-cyanobacterial communities, typical of arable soils, are formed. The leading groups are cyanobacteria, green and streptophyte algae, and the role of diatom algae is essential (Table). The number of species in one sample increases as compared to forest soddy-podzolic soils. Among the cyanobacteria the species of arable soils preferring the unsodded sites and highly resistant to soil desiccation and strong solar exposure (the P- life form) are the most diverse.

The algal-cyanobacterial communities of uncontaminated soils of the reference site are characterized by the multispecies complex of dominant species (Table).

Table

Composition of algal-cyanobacterial communities in different land-use zones of Moscow*

Land-use zones / Parameters	Reference		Recreational (park, n = 3)	Residential (n = 10)	Traffic (n = 15)
	Forest (n = 5)	Meadow (n = 3)			
Cyanobacteria	3 / 8,3	16 / 32,7	1 / 3,3	9 / 12,3	22 / 21,8
Algae: Chlorophyta + Streptophyta	22 / 61,1	20 / 40,8	12 / 40,0	28 / 38,4	40 / 39,6
Ochrophyta	10 / 27,8	5 / 10,2	9 / 30,0	13 / 17,8	12 / 11,9
Bacillariophyta	1 / 2,8	8 / 16,3	8 / 26,7	23 / 31,5	27 / 26,7
Total number of species	36 / 100,0	49 / 100,0	30 / 100,0	73 / 100,0	101 / 100,0
Number of species in one sample	7	16	10	7	7
Number of dominant species	11	10	8	2-4	2-9

*The number of species and their percentage of the total number of species are given above and under the line, respectively

In the recreational zone (in the park) the algal-cyanobacterial communities are of "forest" type and have a multicomponent complex of dominant species, like on the reference sites under forest (Table). This indicates the low degree of anthropogenic transformation of soddy-podzolic soils. However the management of the park area increases the sun exposure of soil surface, and the removal of litter, aerogenic pollution and use of deicing reagents on walking roads in winter result in soil alkalinization and seasonal salinization. It leads to the disappearance of many shade-tolerant and salt-nonresistant species of green and streptophyte algae (the C-, X- and H- life forms). At the same time the photophilous diatom algae (the B- life form) appear in algal-cyanobacterial communities. Among them the halophilic species or those idifferent to higher concentration of salts in the soil which prefer neutral or alkaline conditions prevail. There are also unicellular green and eustigmatophyte algae which belong to the Ch- life form, particularly resistant in extreme conditions. The result is the increasing biodiversity of algal-cyanobacterial communities (the number of species in one sample see in the Table).

In the urbanozems of residential and traffic land-use zones algal-cyanobacterial communities are of "meadow" type, the leading groups in them being cyanobacteria, green and streptophyte algae. Pollution of soils, their seasonal salinization, changes of moisture regime and trampling lead to the decreasing biodiversity of photosynthetic microorganisms and changing ratio of cyanobacteria and algae in algal-cyanobacterial communities (see Table). The share of cyanobacteria decreases, while the share of the algae component increases due to the growing diversity of diatom species (the B- life form). Similar to the recreational zone, the halophilic species or those indifferent to higher concentration of salts in the soil, which prefer neutral or alkaline conditions prevail; many species are resistant against trampling. The species of cyanobacteria typical of arable soils disappear; they are replaced by filamentous cyanobacteria extremely resistant to soil desiccation and high temperatures (the M- life form). Among green and eustigmatophyte algae the species belonging to the Ch- life form (including the halophilic ones) are more diverse, while the shade-tolerant and moisture-demanding species (the C- and H- life forms) disappear. Just few resistant species prevail (apart from the algal-cyanobacterial communities of soils along the local road network). The above-mentioned features indicate the medium degree of the anthropogenic impact on soils.

Conclusion. The composition of algal-cyanobacterial communities in the urbanozems of residential and traffic zones reflects the principal lines of habitats transformation, i.e. xerophytization, alkalinization, seasonal salinization and pollution of soils. The biodiversity of the studied groups of soil phototrophic microorganisms in urban soils depends on the intensity of these processes.

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Study of antibiotic and probiotic activities of humic preparations to soil micromycetes

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Introduction

The interactions of humic substances (HS) and microscopic soil fungi are very important for understanding of sustainable soil functioning. Soil fungi are actively involved in the processes of the HS synthesis, transformation and mineralization due to production of extracellular nonspecific oxidative enzymes (Lindahl et al., 2007; Zavarzina et al., 2011). Of note is the unequal ability of different groups of fungi to the degradation of HS and development in their presence. The degradation of lignin and related compounds by fungi from the "white-rot" group occurs only in the presence of an easily metabolisable carbon source, e.g. glucose (Zavarzina et al., 2011). Some species of micromycetes (e.g. *Trichoderma atroviride*) can develop on media with humic acids (HA) and coals using them as a unique carbon source (Gramss et al., 1999; Silva-Stenico et al., 2007). Additionally, HS are also capable of mutual influence on living organisms in general and on micromycetes in particular. Principal direct effects exhibited by HS onto microorganisms include stimulation of biomass growth and biosynthetic activity (Kulikova et al., 2005). A lot of studies have demonstrated that two main fractions of soil native HS, i.e. HA and fulvic acids (FA), are also able to control plant diseases caused by various soil-borne phytopathogenic fungi of various genera (Martin et al., 1990; Moliszewska&Pisarek, 1996; Loffredo et al., 2007, 2008). A wide variety of the observed effects can be explained by the polyfunctionality of HS and variability of micromycetes. Industrial humic products (HP) obtained from natural sources largely inherit the HS properties of an initial material and therefore act as ameliorants and medications for detoxification, remediation and restoration of degraded and polluted soils and as plant growth stimulants (Yakimenko&Terekhova, 2008). The objective of this work was to investigate the interaction between micromycetes and HP for estimation of antibiotic and probiotic activities of HP. We attempted to prove whether these activities were dependent on the carbon richness of the growth medium.

Materials and methods

In the model experiments, we investigated responses of *Alternaria alternata* and *Trichoderma harzianum* to HP of different origin (leonardite and lignosulfonate) in two concentrations (0.1 and 0.02%) in liquid and agar Czapek medium. *A. alternata* is phytopathogenic dark pigmented species, for which synthesis of melanin was observed. *T. harzianum* is capable to control development of pathogenic fungal cultures and therefore plant diseases caused by them. Also, antagonistic soil-borne fungi are of great interest (Loffredo et al., 2007, 2008). We measured growth parameters (accumulation of mycelium biomass, growth rate of fungal colony and spore production) at various sucrose concentrations (0.3 and 30 g/L). To characterize spectral properties of HP and their changes due to fungi growth we used a number of indices: the fluorescence emission maximum position and its variation upon changes of the excitation wavelength (so called "blue shift" of humic-type fluorescence, (Patsayeva&Reuter, 1995), fluorescence intensity of protein-type emission band taken at 350 nm with excitation at 270 nm F_{350} (Khundzhua et al., 2017), and the indices calculated from the absorption spectra and their second-order derivative.

Experimental results and discussion

The obtained results have proven the existence of significant relationships between the extent of the inhibitory/stimulation action of various HP and:

- experimental conditions, namely the carbon status of the growth medium;
- and some features of the tested micromycetes.

The carbon status of the growth medium influenced a possibility of the HP transformation and consumption by micromycetes and hence a degree of intensity of micromycetes' responses to HP. Biomass indices in liquid media were in a direct relationship with the sucrose concentration (available carbon) and the ability of HP to stimulate the biomass gain depended on the capacity of micromycetes to utilize them. At large, the most active utilization of 0.02% HP occurred with *T. harzianum* and *A. alternata* at 30 g/L sucrose in the nutrient medium. It is possible to activate intensity of the HP utilization by *T. harzianum* in lower sucrose concentration media by preliminary growth without HP addition when fungal metabolites are actively generated by this strain.

There is no doubt that the tendency of influence and the extent of the inhibitory/stimulation action depend on analyzed HP concentrations. Within the concentration range that we selected and that in general corresponded to the range of HS concentrations (10, 100, and 300 mg/L) in (Moliszewska&Pisarek, 1996; Loffredo et al., 2007, 2008), it is possible to detect correlations between the extent of the inhibitory/stimulation action of various HP and some their chemical and functional properties. We can assume that the most significant inhibition of mycelial growth of *A. alternata* and *T. harzianum* by HP on the agar medium with 30 g/L sucrose is due to the negative influence of excess nutrients. HP addition stimulated sporulation, which was more clearly seen on the agar medium with 3 g/L sucrose: the higher concentration of the added HP, the more active sporulation (Figure 1).

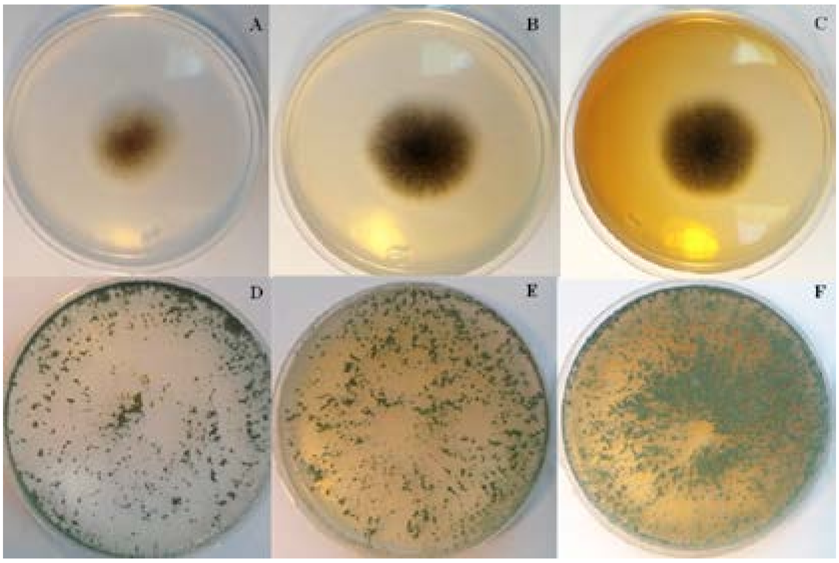

Figure 1. Fungal colonies of *Alternaria alternat*a (A-C) and *Trichoderma harzianum* (D-F) with the sporulation area on the 5^{th-} day of growth on the Czapek agar medium with: A,D) 3 g/L sucrose; B,E) 3 g/L sucrose and 0.02% HP; C,F) 3 g/L sucrose and 0.1% HP

The other studies of HA and FA isolated from soils have confirmed that the relationships between the extent of the inhibitory/stimulation action of HS and some features of micromycetes exist (Moliszewska&Pisarek, 1996; Loffredo et al., 2007, 2008). In general, HS had a more stimulatory effect on species-antagonists as compared to representatives of plant pathogens, although *T. harzianum* was less sensitive than *T. viride* in the presence of HS in the growth medium (Loffredo et al., 2007, 2008). *A. alternata* was very sensitive to all kinds of HS (Moliszewska&Pisarek, 1996). We have not found that HP had more inhibiting effect to *A. alternata* than *T. viride.* Perhaps this is due to the fact that HP activity is still less specific compared to natural HS.

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Influence of plants on pollutants mobility in soils

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Soil is a multicomponent and multifunctional system characterized with different conditions for root system led to differences in plants availability of nutrients, metals etc. The upper-layer soil horizon (first 10 sm) commonly presented in ecosystems as a humus-accumulative horizon, is the main source of plants pollutions, related with such factors as plants root localization and source of pollutants (Cheng 2003; Ciarkowska and Gambuś 2005). On the other hand, root system influence on microbial activity of soil and hence on transfer of elements in plants by forming of specifically space in the soil – a rhizosphere. The results of rhizosphere studies suggest that vegetation potentially could be managed to facilitate biological remediation of waste sites (Anderson et al. 1994; Abou-Shanab et al. 2005)

Our research was aimed to determine the role of plants on pollutants mobility in the soil and transfer in plants in case of different sources of contamination.

Soils (luvisolic soil according to FAO) were sampled from surface horizon (0-20 cm) in Vladimirskaya Region (Russia), characterized by well-developed structure and high nutrients content. In the research was used radionuclide 90Sr as an indicator of pollutants mobility and transfer. Using of isotope method allow to obtain results directly by Geiger–Mueller STS-13 counter without applying of chemical methods. Case study of 90Sr is also relevant because of its high danger and high concentration in some regions damaged after accidents on NPP (IAEA 2006).

To investigate the influence of different source of pollution on transfer factor were modeled two pot experiments. The first pot experiment was done to evaluate the role of plants in the 90Sr transfer – 90Sr introduced into seedlings planted in "clean", not contaminated soil (Figure 1). The second pot experiment aimed to explore transfer of 90Sr from soil to plant with initially soil contamination – radionuclide was applied in soil by water-soluble form.

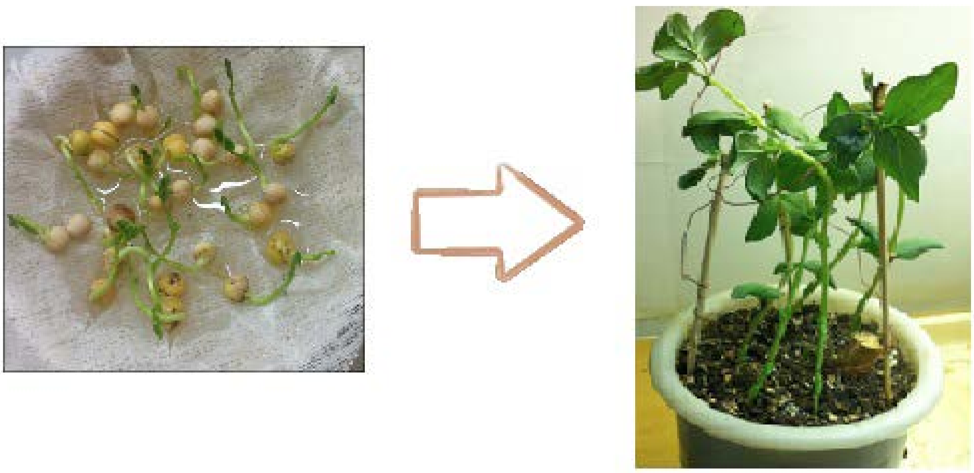

Fig. 1. Scheme of the first pot experiment - ^{90}Sr introduced into seedlings planted in "clean", not contaminated soil

At the end of the vegetation period, was determined uptake of radionuclide in plant. The pea (*Pisum sativum*) and bean (*Vicia faba*) were selected as the test plants. The choice was justified by the simplicity of planting, caring for plants, a short growing season and a relatively high accumulation of ^{90}Sr. Simultaneously to evaluate abiotic factor in migration process have been studied diffusion of ^{90}Sr in the soil by using experiment where a sample of ^{90}Sr contaminated soil contact with a "clean" soil in saturated conditions through the permeable barrier (Mattigod et al. 2001).

Table 1

Distribution of ^{90}Sr among root system and soil mass, pulses/(g s). 1 – Per total mass; 2 – Per 1 g of organic matter

Component	Vegetation of pea with the introduction of ^{90}Sr into roots		Vegetation of pea and bean with the introduction of ^{90}Sr into the soil	
	1	2	1	2
Plants' roots	330±200	350±210	55±5	58±5
Soil with partially removed roots and detritus	14±5	280±100	14±4	280±80

In the first vegetation experiment activity of roots was visible exceeds the activity of soil with partially removed roots and detritus (Table 1). The results of compared activity of the aboveground and root mass of plants revealed that ^{90}Sr was evenly distributed throughout the plant. In the second pot experiment distribution of ^{90}Sr in the soil and roots was less in compare to first experiment.

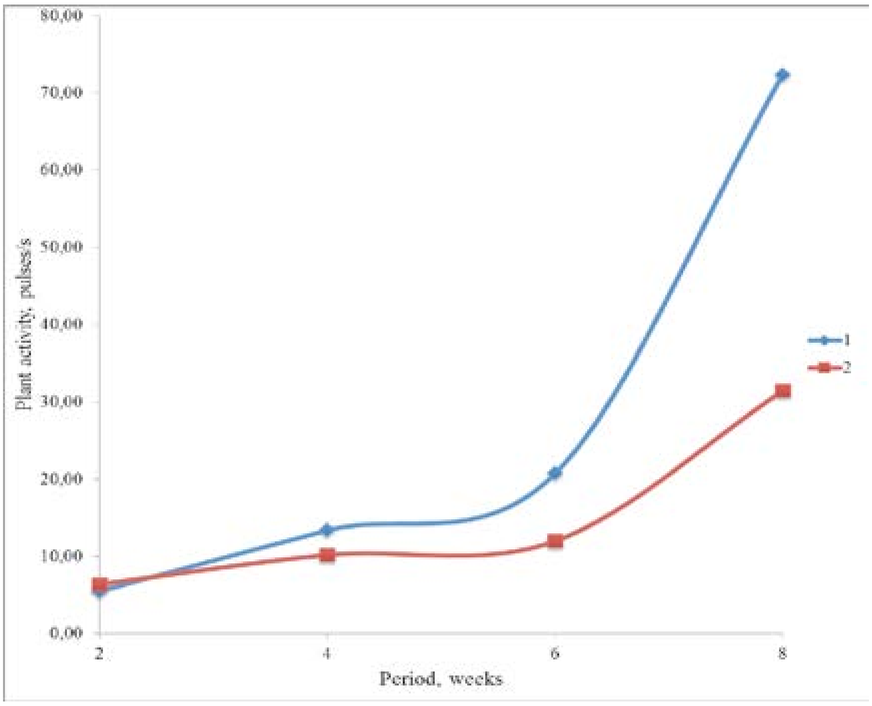

Fig. 2. Activity of plants during the second vegetation. 1 - Vegetation of pea with the introduction of ^{90}Sr into roots; 2 - Vegetation of pea with the introduction of ^{90}Sr into the soil.

The results of the second vegetation showed preferential transfer of ^{90}Sr to plants from the plant residues (Figure 2). Reduction in the rate of diffusion, as well as high bioavailability contributes the main role of root system in mobility of pollutants. The data allow adjusting existing model of pollutions mobility in soils and availability for plants. Also, obtained results provide an opportunity to develop recommendations for areas affected by radioactive contamination.

Acknowledgements

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The impact of Oil and Petroleum Products to the Condition of the Soil

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There are various geochemical changes in the soil which are the result of accidental spills of oil and oil products, and drilling and oilfield wastewater. These negative processes lead to the degradation of soil, degradation of fertility, disruption of landscapes and soil ecology. Then the ingredients that entered into the soil, such as heavy metals, salts, hydrocarbons, various components of the drilling mud, penetrated into the plants and reduced the quality of agricultural products.

Agricultural production losses range from several tons to tens of thousands of tons, as a result of leakage of oil pipelines. Accidents are a great threat to the soil, because oil with associated produced water penetrates into the deeper layer of soil and it is not always possible to detect during land monitoring.

Also, if there was a dumping of raw or crude oil, there is a strong contamination by different chemical elements. If drilling fluids spilled into the ground, severe pollution does not occur but in this solution contains large amounts of chlorides, salts of sodium and magnesium - and this is the main cause of soil salinity, which already has a negative impact on the ecosystem of the area. Contamination zone extends to a distance of several kilometers from the scene of oil spills to the environment. After the oil spilled, before starting work on localization and liquidation of oil pollution, distribution of petroleum products around has usually already completed.

Another problem is the hit of oil in produced water. Such accidents and oil spills occur not only at the site of oil production, but also, on pipelines for various purposes. The cause of this is corrosion of the pipes, their failure to replace or skip sanitary measures for the protection of pipes. Corrosion of pipes, replacement of pipes later than necessary, or not doing sanitary measures to protect them, there are the treasons for occurrence of such situations. [1]

Highly mineralized formation water quickly goes under ground to a great depth, causing the death of vegetation and living organisms, which leads to soil degradation. We need to consider that, if the soil was flooded with reservoir brine, it will take 20 years, during which she will be self-cleaning.

In addition, there is a mechanical soil disruption in all enterprises of the oil industry. Mechanical infringement of soils are associated with construction and reclamation works. The properties of the soil are radically changing, negative processes are taking place in it, because of the removal of fertile top layer.

Contamination of soils with oil and oil products is making tremendous changes in all its components. Serious and often irreversible effects occur in morphological, physical, chemical and microbiological properties of the soil, which leads to reduction of productivity of natural and artificial ecological communities, which leads to reduced productivity of natural and artificial ecological communities, in particular to reduce crop yields, and, in particular to reduction of crop yields.

The change of the microbiological properties of the soil also affects all living organisms in the soil. Bacteria, invertebrates, microorganisms and animals, who poisoned with tiny particles of oil, lose their ability to perform certain functions. This imbalance leads to disruption of the ecosystem. Harmful substances will accumulate in the soil, in groundwater, and then it will appear in the human body, which is dangerous for his health and life. In addition, the crop that has grown on such soils, can not be eaten, because it contains a lot of harmful bacteria and other hazardous to health substances.

Permissible concentration of oil products in soil is determined by a combination of many factors. Such factors include climatic conditions, type and composition of soil, type of vegetation, composition of petroleum products and the type of land use. The normative content of these factors in the soil are not defined in many countries, including Russia, because such rules should be set separately for each district, given the type of soils, based on analysis of data on the impact of oil on various ecosystem components and, in addition, on people's health. Moreover, the allowable concentration level of oil and oil products in soil are not established by the normative documents in the Russian Federation. The same for all regions level of the maximum concentration of soil pollution in Russia can't be adopted due to the complex composition of petroleum products as biodegradable pollutants, and also because of the diversity of climatic, landscape and natural biogeochemical conditions. [2]

The company requires raw materials and energy, so contaminants can occur even at the stage of preparation of production. When using the finished oil products, transportation or other activities, also appear related types of pollution. When we look for the best ways to prevent the harmful effects of production on the environment, it is necessary to explore the solution in the complex, analyzing them from both an environmental and economic perspective. This is the essence of one of the basic principles of "clean production" - which says that pollution prevention is beneficial. [3]

Based on the scheme of contaminating streams, including both internal and external sphere of the technological process, using the economic and technical possibilities of the enterprise, you can gradually reduce the harmful environmental impact of production in general. It is obvious to everyone, that the whole complex of works on cleaner production can be performed by a team of engineering professionals only, with the full support of the company's management. [4]

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Distribution, contamination and potential ecological risk assessment of heavy metals in tropical urban soils

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Introduction

Urban population is increasing rapidly and approximately half the total world population and two-thirds of people in developed countries live in urban areas (Linde 2005; de Kimpe and Morel 2000). Urbanization leads to substitution of natural ecosystems by artificial ones, which may exert effects on human health (Davydova 2005). Urban soils play an important role in maintaining the environmental quality as they can act as both source and sink for pollutants. These soils are generally less characterised than agricultural soils and highly variable due to diverse human activities which influence soil composition (Ghosh et al. 2016).

There is a growing concern over the potential accumulation of heavy metals in tropical urban soils as heavy metals are considered as one of the main pollutants responsible for environmental contamination (Jozic *et al*., 2009). Heavy metals naturally exist in the Earth's crust, but due to uncontrolled development, urbanization and increased anthropogenic activities such as vehicular emissions, waste water sludge and industrial wastes have resulted in accelerating input of heavy metals in urban soils over the years (Irvine et al., 2009).

The present study was conducted in two vacant lands in west Singapore which were occupied (about 20 years ago) for various farming activities; however, there was little confirmed historical data as to the exact usage and prior developments. Also no information is available on the soil properties before and after the occupancy period. Therefore, a baseline study on the soil conditions was required in order to determine the suitability of the land for future landscape operations, as well as allow to make an informed decisions on remediation measures. The objectives of the study were to assess the principal soil quality parameters and determine the presence of any soil contaminants and assess their potential ecological risk.

Materials and Methods

The sites were located in the western part of Singapore (Figure 1). Each study site was divided into five sub-plots and the soil samples were collected from 0-100 cm depth with subsequent divisions of 0-10, 10-20, 20-50 and 50-100 cm. Duplicate core samples were collected for *in situ* bulk density determination. The soil samples were analysed for bulk density, soil texture, pH, electrical conductivity (EC), cation exchange capacity (CEC), organic matter, nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and heavy metal [Arsenic (As), chromium (Cr), cadmium (Cd), lead (Pb), copper (Cu), nickel (Ni), zinc (Zn) and mercury (Hg)] concentrations.

Potential ecological risk index (RI) of heavy metals for the sites was evaluated followed by Hakanson, 1980-

(1) = x (2) = / (3)

where, referred to potential ecological risk individual coefficient; was the toxic response factor of a certain metal (e.g., Cd = 30, Hg = 40, As = 10, Pb = Cu = Ni = 5, Cr = 2 and Zn = 1); was individual pollution coefficient; was the actual measured data and was the reference value of heavy metals.

Soil environmental quality of the study sites were also evaluated by single-factor pollution index (P_i) and Nemerow multi-factor index (P_c).

$P_i = C_i / S_i$, where C_i is the measured value of soil contaminant i and S_i is the background value of soil contaminant i in mg/kg. $P_i < 1$ denotes non-contamination and $P_i > 1$ denotes contamination, and the higher the P_i, the more serious the soil contamination.

$P_c = \{[(C_i)/(S_i)^2_{ave} + (C_i / S_i)^2_{max}] \times 0.5\}^{1/2}$, where, $(C_i / S_i)_{ave}$ is the average value of the pollution index of soil contaminants, and $(C_i / S_i)_{max}$ is the maximum value of the single contamination index.

Figure 1 Study sites and soil sampling locations

Results and Discussion

Heavy metal distributions showed similar pattern for both site A and site B across soil depths. The results showed that the mean concentrations of the heavy metals were higher in the top (0-10 cm) and lower (50-100 cm) soil layers (Table 1) for both the study sites; but the values were comparatively lower than the standard allowable limits. Considering the soil depth up to 100 cm, the toxicity levels at site A were low and the degree of contamination ranged from < 0.00001 to 25.63.

Table 1 Mean concentrations of heavy metals in the study sites

Site A	Heavy metal concentration (mg/kg)			
	As	Cr	Cu	Zn
0-10 cm	17.1	15.7	13.5	114.9
10-20 cm	11.9	7.3	9.5	41.3
20-50 cm	9.8	5.6	5.6	59.0
50-100 cm	16.0	23.8	-	62.3
Site B				
0-10 cm	23.5	15.7	13.5	70.4
10-20 cm	11.0	7.3	9.5	46.2
20-50 cm	8.0	5.6	5.6	44.9
50-100 cm	15.1	23.8	-	50.7

Similarly, observations from site B showed that the lower toxicity levels and the degree of contamination ranged from < 0.00001 to 7.55. Arsenic concentrations of both the sites were significantly higher and ranged from 8-23.5 mg/kg up to 1 m soil depth. Higher concentration of As might be due to the dumping of waste materials found on site or indiscriminate use of pesticides during farming (Pan and Wang, 2012).

The potential ecological risk levels of the heavy metals of the study sites were in the order of As>Cu>Cr>Zn>Pb. However, ecological risk assessment showed low ecological risk index with RI values of 9.76 and 8.44 for site A and site B respectively (Table 2). The Nemerow multi-factor index (Pc) and contamination degree of each sampling site calculating from the single factor index of heavy metal (Pi) in 0-100 cm soil depth are presented in Table 3. The Pi values ranged from 0.0001 – 0.85; higher Pi values were observed in 0-10 cm and 50-100 cm soil depths. As heavy metal contamination is often found to be combined and concomitant, therefore a comprehensive pollution index (Pc) was used to provide a concrete evaluation of the overall pollution. The result showed the heavy metal element pollution degree was in the sequence of As>Cu>Zn>Cr>Pb in the studied region.

Table 2 Assessment of potential ecological risk index (RI)

		As	Cu	Cr	Zn	Pb
Site A	Observed values (mg/kg)	13.71	20.13	23.92	69.39	0.46
		6.85	2.01	0.48	0.35	0.07
	RI	9.76				
Site B	Observed values (mg/kg)	12.21	9.35	13.09	50.86	1.84
		6.11	0.93	0.26	0.25	0.26
	RI	8.44				

Table 3 Assessment of single factor (P_i) and Nemerow multi-factor (P_c) pollution index

		As	Cu	Cr	Zn	Pb
Site A	Observed values (mg/kg)	13.71	20.13	23.92	69.39	0.46
	P_i	0.69	0.40	0.24	0.35	0.01
	P_c	0.46				
Site B	Observed values (mg/kg)	12.21	9.35	13.09	50.86	1.84
	P_i	0.61	0.19	0.13	0.25	0.05
	P_c	0.45				

Conclusions

Anthropogenic activities changed the associated geochemical concentration ratios and increased the metal concentrations of soils. Although the soils of the study sites were not severely contaminated with heavy metals, the results can be used as background data for future studies. The study emphasized the importance of proactive measures for systematic and continuous monitoring for heavy metal concentrations, where certain remediation steps could be carried out to minimize the rate and extent of pollution in future.

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The stability of urban and technogenic soils of cryolithozone to chemical pollution

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Introduction. Currently in the domestic and world science has accumulated extensive material on the problem of the effect of chemical pollution on state of soil and ecosystems. However many problems are still not solved. Many regularities, mechanisms and possible effects of chemical pollution on the ecological and economic functions of soil are not disclosed, the limits of their stability, the exceeding of which leads to ecological crisis or disaster are not installed; quantitative methods for assessing execution by soil of the environmental, establishing of thresholds their sustainability, predicting on their the basis of environmental consequences of chemical pollution, its of rationing etc. are not designed (Kolesnikov 2013). Especially acute problem on the territories of northern ecosystems. Exactly they are characterized by more weaker resistance to various forms of human activity, which is based on its two main characteristics: the average annual temperature and ice content permafrost.

Objects and methods of research. The study area is located on the territory of the Republic of Sakha (Yakutia) where are widespread the frozen soils. The author selected the following objects of research:

- urbanozems were selected on the territory of medium-taiga landscapes residential territory of Yakutsk city. For they are characterized superficial of 50-cm and thicker layer "urbik" obtained by mechanically stirring, burial or contamination of initial natural soil by not soil material.
- cryozems were selected on the territory north-taiga landscapes at the industrial site of Nurbinsky mining plant. The characteristic features of these soils are undifferentiated or faintly differentiated mineral stratum into genetic horizons, close underlain icy permafrost, non flushing water regime.

Research were performed accordance with generally accepted methods in pedology. Analysis of mobile forms of microelements in soils were performed by atomic absorption spectrometry on a multichannel gas analyzer in 1 normal extract of nitric acid. The content of oxides were measured on a mass spectrometer with inductively coupled plasma.

Results and discussion. The stability of soil cryolithozone to chemical contamination is determined by the criteria of sorption capacity (Dyagileva 2013). Frozen soils with high sorption capacity holds and accumulates harmful compounds and elements for many years. Consequently, these soils have a low resistance to chemical contamination.

Frozen soils with low sorption capacity holds element in a state of exchange absorption or easily "miss" through the soil pollutants that during impact do not have time to have a harmful effect on the very soil. Such soils are characterized by high resistance to chemical contamination.

In the table 1 shows the integral indicators sorption capacity of soil materials studied frozen soils which determine resistance to chemical contamination.

Urbanozems have uneven distribution of basic physical and chemical properties by soil profile (Sivtseva 2010). Distribution of granulometric composition discontinuously and unevenly in depth. In contrast to the natural soils in urbanozem of Yakutsk city are contained quite a lot of large fractions (1-0,25).

Table 1

Integral assessment of the sustainability of urban and technogenic soils of cryolithozone to chemical pollution

Criteries of sorption capacity		Cryozem	Urbanozem
Morphological and genetic	Granulometric composition	Two-term profile (Loamy / Sandy loamy)	Profile is jumbled / bulk
	The content of the fractions, % size, mm (>0,01/<0,01)	22/78	19/81
	Density	Dense	Slightly compact
	Power of the organic horizon (AB), sm	6,0	5,0 (adscititious / bulk)
	The presence and nature of the permafrost (the depth, cm)	Icy permafrost (65)	Dry permafrost (125)
Functional	Acid-alkaline conditions of soil	5,5	8,0
	Humus content, %	2,8	5,0 (adscititious / bulk)
	Capacity cation exchange, meq / 100g	29,0	6,0
	Humidity (hygroscopic moisture, %)	2,7	0,7
	The content of basic oxides	SiO_2>>Al_2O_3>Fe_2O_3>K_2O>Na_2O, MgO>CaO>TiO_2>P_2O_5>MnO	SiO_2>>Al_2O_3>Fe_2O_3> CaO >Na_2O>K_2O>MgO> TiO_2>P_2O_5>MnO
The level of sorption capacity		High	Low
The stability of soil of cryolithozone to chemical pollution		Low	High

The reaction of soil environment in the profile with the depth varies irregularly and fluctuates by layers within the pH 7,5-8,1. The humus content is very low, but in the upper layer reaches 5%, due to the conduct of greening activities. The cation exchange capacity is low. Urbanozem has chaotic distribution in soil profile by composition of basic oxides and mobile forms of microelements and is the result of the specificity of the formation of layers urbik in urban soils. The tendency of accumulation of mobile forms of Pb, Zn and Cu are observed in the surface layers urbanozem.

Cryozems are characterized with a two-term profile by the granulometric composition (sandy and loamy), with weakly acidic conditions of the soil medium in the upper organic horizons and close to neutral in the mineral part of the soil profile, by high humus content in throughout the soil profile, with medium capacity cation exchange, undifferentiated or poorly differentiated soil profile by the composition of the major oxides and the presence of icy permafrost.

Microelements by content of mobile forms and by characterization of intraprofile distribution are grouped into three clusters. The major criteria for the elements I (Mn, Cu, Zn, Cd) and II (Co, Cr, Ni) clusters which affect sorption are the contents of physical clay and capacity of cation exchange. The main sorbent for elements III (As, Pb) cluster is organic substance.

Conclusion. Urbanozems have a low sorptive capacity and high resistance to chemical contamination. Cryozems are characterized by high sorption capacity and, therefore, by low resistance to chemical contamination.

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Transformation of Chernozem morphology under urban conditions

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About 5% of global chernozems occur in Russia, and a major part of them is in the Southern Federal District (SFD). The SFD is also an industrial region of Russian Federation; the degree of area urbanization was 70.8% in 2002; at present, the district almost reaches the average level of urbanization for Russia (74.2%), despite its agricultural specialization.

The Rostov agglomeration is one of the largest highly urbanized area in the chernozemic zone of Russia; this is the fourth most important interregional center. The urban soils of the Rostov agglomeration mainly develop from calcareous ordinary chernozems or migration-segregation chernozems according Shishov et al. (2004). These soils are characterized by different depths and different degrees of humification, which underwent some transformations under the effect of urbotechnopedogenesis. It should be noted that urbotechnopedogenesis involves a complex of soil-forming processes occurring under the effect of technogenic impacts in urban conditions (Zamotaev et al., 2012).

The most typical way of chernozem transformation under intensive exploitation of the industrial and residential regions in the old city is complete (to the BC horizon) or partial (A horizon) removal of the upper soil layer, or 'decapitation' according to the terminology of French soil science (Kovda and Gerasimova, 2000) followed by the stagnation of the remaining profile under anthropogenic layers. This is an urbostratozem developed on chernozem, with a thick urbic horizon as a diagnostic element. At the current stage of Russian soil science, a collective opinion has been formed about the morphogenetic characteristics of this horizon. Prokof'eva et al. (2014) indicate that the urbic (UR) horizon is a synlithogenic diagnostic horizon, which gradually forms due to the input of different substrates onto the day surface under conditions of urban and rural settlements.

In the Rostov agglomeration, it was identified the following anthropogenically modified soils derivative of chernozems.

Urbostratozems (urbanozems) on buried migration-segregation chernozems have a UR–[A–B–C] profile or, in the case of the complete stripping of chernozem, a UR–[C] profile, where the UR horizon is >40 cm thick. The soil is defined as an urbostratozem (urbanozem) according to the 2004 Russian classification of soils or an Urbic Technosol Molic according to WRB (2014).

The UR horizon is frequently subdivided into the subhorizons UR1, UR2, etc., which differ in morphology, composition, and properties. Because of the changed conditions of soil formation and sedimentation and the related features of the profile structure, these soils should be classified into the trunk of synlithogenic soils and the division of stratozems (Prokof'eva et al., 2014). Urbostratified chernozem subtypes of migration-segregation chernozems (or urbochernozems) are also widely distributed; they also have a UR–[A–B–C] profile, but the thickness of their UR horizon does not exceed 40 cm and frequently lies within the range from 10 to 25 cm. These soils are denoted as Calcic Chernozems Novic Technic according to the WRB classification. In our opinion, these soil types should find their place in the trunk of postlithogenic soils in the current classification of Russian soils.

Soils frequently include the upper recultivating (RAT) humus horizon, which is specially created for the law cover; this is a filled surface organomineral layer of urban soil, dark in color, with crumbly structure, containing more than 4% humus. Such recultivating horizons are diagnostic horizons for soil-like bodies: technozems (replantozems and constructozems) (Prokof'eva et al., 2014). Prokof'eva et al. (2011) consider them as the potential basis for future urban pedogenesis. The chernozems buried within them are characterized by alteration of important processes for chernozem formation like humus accumulation and carbonate migration. The both processes decelerate or cease, and, hence, the content and dynamics of total organic carbon (TOC) and inorganic carbon (IC) vary little in these components, except the cases when the covering material contains increased amounts of calcium carbonates.

The sealing of soil by covering with impermeable substrates like asphalt or concrete is another significant transformation of soil cover in urban landscapes. In this case, chernozems are eliminated during construction operations or isolated from the surface with the formation of a peculiar group of sealed soils: ekranozems (Prokof'eva, 1998), or Ekranic Technosols Molic (WRB, 2014). Thus, the conservation of chernozem under an impermeable cover is an alternate evolution of chernozem morphology under urban conditions. The soil profile can almost retain its natural thickness, and the contents of the main components remain on the level typical for chernozems in their native state. An exception is provided by humus, whose content decreases and then stabilizes on a relatively low level of 2–3% (Gorbov and Bezuglova, 2014).

Such conservation of chernozem profile under the current intensification of urban development is frequently of temporary character; after the release of the cover, the sealed soils automatically become objects of study as a sort of bio-abiotic reserve of the urbosystem. This is related to the fact that the soil retains its main properties under stagnation or conservation conditions and is capable of restoring its potential after release (Gorbov et al., 2015).

In the Rostov agglomeration, migration-segregation chernozems (Calcic Chernozems Aric according to WRB (2014) on the plots under city forests, parks, gardens, and old lawns occur in the natural state. The accumulative function is one of the main functions of soil cover on these areas; in this case, this is related to the accumulation of specific organic matter (Gorbov and Bezuglova, 2014). Artificial forest areas prevail in cities of the steppe zone, and the Rostov agglomeration is characterized by significant transformation of plant cover and change of its floristic composition: the steppe vegetation gives place to forest plants. According to Gudzenko (2016), the total area of tree plantations in the city of Rostov-on-Don and adjacent landscapes is 10 000 ha, including 184 ha of parks, squares, and boulevards; the resting area is occupied by the forest-park belt beyond the urban area, although it is included in the Great Rostov.

Our studies (Gorbov and Bezuglova, 2014) show that the content of humus in the upper 0- to 10-cm layer of soils in the planted urban areas is higher than in native chernozems. During the more than half-century history of the forest park belt, the content of humus in its soils becomes equal to 7.0% on the average, with the typical range from 5.9 to 8.5%.

It is known that the input of plant waste under woody plantations differs from that in the steppe zone, which affects the distributions of humus and water in chernozem profiles. The soil water regime also changes: the shielding of soil surface by tree crowns favors the conservation of water during the hot season and the prevalence of descending water flows over the ascending flows during the year. This primarily affects the distribution of carbonates, which are leached to the BC and sometimes C horizons.

Thus, in-site urbotechnopedogenesis determines three ways for the morphological transformation of chernozem within the city: stagnation under a covering layer, conservation under an impermeable solid surface, and intensification of humus accumulation and carbonate leaching under forest vegetation.

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Dynamics of microorganisms in hydroponic system of cucumber in response to Agrobacterium bv1 (root mat) infection

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Hydroponic culture provide several advantages for growers. However, new diseases specific to hydroponics have been reported, including "root mat" caused by Agrobacterium bv1 strains (Weller et al. 2000). Since 2013 many hydroponic cucumber (*Cucumis sativus*) and tomato (*Solanum lycopersicum*) crops in the Russian Federation have been affected by this root disorder (Khodykina e al. 2014a). In 2014–2015 it has spread across many regions of Russia and became one of the most serious problem of vegetable cultivation in glasshouse (Ignatov et al. 2016). The symptom is extensive root proliferation within the rockwool propagation cube and across the rockwool slab surface. This disease is common in the UK, France, Japan, Greece, Switserland, and New Zealand, causing significant loss in marketable yield (Weller et al. 2006; Sawada and Azegami 2014). The causal agent of this disease was shown to be wild-type Agrobacterium biovar 1 strains harboring a Ri-plasmid (Weller et al., 2000). Agrobacterium biovar 1 strains have high resistance to many antibacterial chemicals and antibiotics (Khodykina et al. 2014b). Soil-borne microorganisms such as Agrobacterium spp. are well adapted to aquatic environments, and their growth in mineral substrates is favored by the absence of normal soil microbiome (Ignatov et al. 2016). We compared rock wool mat and coco fiber mat microbiome under cultivated cucumber plants at the stage of fruit bearing by NGS analysis of 16S rRNA gene fragments. 16S rRNA gene fragments were PCR-amplified from total DNA using 3 multiplex pairs of consensus primers. Four amplicon's libraries were obtained and analyzed on the Roche/454 Life Sciences GS JuniorGS sequencer.

Analysis of 16S rDNA profiles placed the bacteria into 9 groups: Flavobacteriales (17.4% in average), Rhizobiales (16.7%), Pseudomonadales (12.9%), Sphingobacteriales (12.9%), Burkholderiales (8.7%), Alteromonadales (8.1%), Xanthomonadales (6.8%), Enterobacteriales (0.18%), and an unclassified bacterial clade (16.3%). The percentages of Rhizobiales clones (including *Agrobacterium* spp.) were greater in the rhizosphere of plants grown on rock wool mats (infected - 25.9% and control -26.1%) than on coco fiber mats (6.6 and 8.1%). Rock wool mats had smaller part of unclassified bacteria (12.9%) comparing to coco fiber mats (19.6%). Agrobacterium spp. was a predominant part of Rhizobiales clones in infected rock wool mats (72.7%), while infected coco fiber mats had only 32% of Agrgrobacterium spp. in total number of Rhizobiales clones. Root mat disease significantly increased population of Flavobacteriales – 21.9% against 12.8% in control, and population of pectolytic Enterobacteriales (0.36% against 0%). Root mat disease significantly decreased population of Xanthomonadales – 2.25% against 11.4% in control. These results suggest that hydroponic mat bacterial community may play an important role in the changes of cucumber rhizosphere biological conditions during the infection caused by Agrobacterium spp. bv1.

The pathogen has extremely high rate of spreading, survival in infected soil, water and substrate, and easy establish new local populations in infected glasshouses. Within 4 months after their first observed symptoms on some 0.5% of plants, the pathogen was recovered from 95% of plant, soil, and substrate samples collected across the glasshouse with 12000 plants (Khodykina et al., 2014b).

Different lineages of rhizogenic Agrobacterium strains are able to form biofilms, which may pose a high risk in hydroponic recirculating systems used in the cultivation of cucurbits and tomato. Biofilms protect microbes from biocides. Various strains of *Agrobacterium* spp. were able to tolerate hydrogen peroxide, even at concentrations of 600 ppm (in practice, in general concentrations of maximum 100 ppm are used) (Bosman et al. 2015). Additionally, strains were found that possess catalase activity, enabling them to survive hydrogen peroxide exposure. We have described before a high resistance of the pathogen strains to nearly all tested antibiotics of different activity mechanisms (Khodykina et al. 2014b). Meanwile, suppressing of the pathogen spreading on the crop is possible by applying disinfection of drain water with 240 mJ/cm2 UV radiation (99% efficiency), application of Na-hypochlorite (5ppm) or peroxide (15ppm) at dripper, lowering pH (pH 5.0 drip) (bacteria are suppressed by low pH), prevention root damage during transplantation, control of *Pythium, Pseudomonas* and *Pectobacterium* infection sources. Phytosanitary measures must be strictly followed to reduce initial level of contamination. A number of biocontrol agents has been tested (Khodykina et al. 2014a, 2014b), and they can improve plant tolerance to the disease, but unable to clearn the glasshouse and prevent infection on new plants in installation once infected by this new harmful pathogen. Maintenance of proper microbiotic composition of hydroponic substrate might be a choice of plant growers in "root mat" control in glasshouses.

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Rare and Protected Plant Species as an indicator of recreational load on the city forest environment: Bitsevsky Forest Natural and Historical Park

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Being the largest mega polis Moscow has one distinctive feature that is different from other major cities in the presence of a relatively well-preserved natural forest arrays in a green part of the city. Many forest species of plants, including rare and endangered species, which are in need of protection, grow in these urban woodlands. These kinds of plant species are the most susceptible to various environmental factors changes and are the indicators of anthropogenic load associated with the growing population. Thus for a rare plant status reason or reduction in number of species we can judge about the recreational load degree on the woodland park environment and set up protection requirements for these species and community as a whole. In the context of a big city, such environment-related factors figures as light, humidity, composition and soil drainage are obviously far from ideal for plants. In this regard, the tree growth rate is declining; herbaceous plants are changing their magnitude and population structure (Kuznetsov et al. 2015). We present research findings on the structure of rare and protected species populations, included in the Red Data Book of Moscow and the Moscow region, due to the increased recreational load in the forest belt of Moscow city (Nasimovich, Romanova 1991). In order to identify and describe certain stages of ontogenesis for species under discussion there we used ontogenic condition criteria for herbaceous plants, described in details in many sources. The concept of the discrete ontogenesis of plants, by the first, was carried out by T.A. Rabotnov (1950). Detailed ontogenetic researches of plants has already begun since 70th by T. I. Serebriakova (1976). An important characteristic of plant populations is ontogenetic spectrum, as it related to the biological characteristics of the species. When we build the ontogenetic spectra of model species we rely on the representations of Spectra base types by L.B. Zaugolnova (1994). Widely used criteria for studying the ontogenesis of plants were applied in this work, and for the coenopopulation ontogenic structure investigation – the method of discount areas by M.G. Vakhrameeva., L.V. Denissova (1990). For the first time, the ontogenic structure of coenopopulations has been described and analyzed on the basis of the characteristics of ontomorphogenesis in the Bitsevsky Forest Park for such species as May lily (*Convallaria majalis L).*, Eurasian Solomon's seal *(Polygonatum multiflorum L., All.),* European sanicle *(Sanicula europaea L.).* Comparing the structure of the protected species coenopopulations, we showed their different types of dependence on anthropogenic stress. Under the influence of recreational load the spectrum of coenopopulations for listed species is being modified, the systematic organization of coenopopulations is being broken. The separate stages of ontogenesis for mentioned above species were identified and analyzed, as well as for individuals of different ontogenic conditions on sampling areas were counted, the ontogenic spectra for coenopopulation were composed in general. The findings were based on the premise that weed response to external forcings, both natural and man-made, is the changing nature of growth, their life and age condition. On the basis of the foregoing, when comparing age structures of coenopopulations for three protected species, you can see different dependence on anthropogenic press. Under the influence of recreational load and anthropogenic press the age range of coenopopulation is modified for *Sanicula europaea*, *Convallaria majalis* and *Polygonatum multiflorum*, the number of individuals in a young age conditions are reducing, so as systematic organization of coenopopulations, some of the materials are transferred to the category of regressive. However, subject to the certain security measures, sometimes quite minor associated only with environmental awareness, it is possible not only to maintain but also to increase the number of these species in the natural-historical "Bitsevsky Forest Park ".

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Predicting lead and zinc concentrations in soils of an urban catchment (Sydney, Australia)

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Introduction

As urbanisation and population density increases, areas once used for industry are being repurposed and redeveloped into housing for the growing urban population. In urban areas with a history of, or currently containing industrial activity, soil contaminant concentrations can be elevated to potentially harmful levels. For the benefit of urban planning and human health, it is therefore essential to observe where the contamination lies and to gain a mechanistic understanding of the drivers of soil contaminant content in urban areas. In terms of heavy metal content in soils, mapping is relatively simple; however it is harder to identify key drivers of heavy metal distribution, such as proximity to roads, and map this with known uncertainty.

Using the Sydney estuary catchment located in Sydney, Australia, as an example, this study sought to predict the distribution of two heavy metal contaminants (lead and zinc) in the soil with known uncertainty, and determine the main drivers of these distributions using Linear Mixed Modelling.

Methods

Compared to alternative predictive methods, Linear Mixed Modelling (LMM) is able to account for both fixed and random effects by incorporating the response variable and a number of covariates into the model. Key drivers are determined through backwards elimination of non-significant covariates and the uncertainty is assessed by observing the model's prediction intervals.

As the response variables within the modelling process, 1522 soil samples were collected and analysed for lead and Zinc (herein Pb and Zn, respectively) using aqua regia digestion using ICP-OES (USEPA Method 200.8 modified) spectrometry. Following log transformation the data were separated into model calibration (n=1122) and validation datasets (n=400).

Covariates included digital elevation and its derivatives (slope, aspect, curvature, MRRTF, MRVBF, TWI), population density, distance from sample point to roads, type of roads near sample point, land use, soil landscape and underlying lithology. Any skewed numerical covariates were transformed depending on the degree of skewness.

Covariates and calibration soil data were then fitted as linear mixed models using Residual Maximum Likelihood estimation (Patterson and Thompson (1971)eB and elaborated upon by Stein (1999) and Marchant and Lark (2007)). Following calibration, the model was validated using the earlier derived validation dataset using leave-one-out cross-validation. Once the model was deemed valid, the predictions were mapped using the Empirical Best Linear Unbiased Predictor (EBLUP).

Result

Mean observed concentrations of Pb within the calibration and validation datasets exceeded the most conservative guideline value of 300mg kg^{-1} provided in the National Environment Protection (Assessment of Site Contamination) Measure (NEPM 1999). There were only two sites at which Zn concentrations exceeded the guideline value of 7400 mg kg^{-1}. In terms of guide value exceedance for each land use, enterprise corridors had the highest proportions of points exceeding the guide value (50%), closely followed by residential areas (46.2%), industrial (33.5%) and environmental uses (20.1%).

Following model calibration, significant covariates for Pb included x, y (Eastings and Northings, respectively), log-transformed elevation, population density, main road type, cube-root-transformed distance to main roads, and soil landscape. Zn had similar predictors in the final model, however population density was a non-significant predictor and land use was a significant predictor.

Validation proved the model to be suitable, and so Pb and Zn distribution were mapped. Predicted Pb exceeded the NEPM (1999) guide over a large portion of the study area; predicted Zn also exhibited elevated concentrations over a large proportion of the catchment, but did not exceed the guide. Relatively higher concentrations for both Pb and Zn were located in the south-east of the catchment.

Discussion

The high proportion of guideline exceedance for lead is a concern for low- and medium-density residential areas as inhabitants are more likely to come into contact with the soil. In contrast, those living within high-density residential settings (i.e. apartments and high-rise buildings with little or no exposed soil) are less likely to be exposed to soil contaminants and are therefore of less concern.

Understanding key drivers allows for better management of urban soils and risk assessment. Numerous studies have determined traffic and roads as important influencing factors of heavy metal soil contamination (Birch et al., 2011; Luo et al., 2015; Sun et al., 2010). Previous studies have also linked land use to elevated metal concentrations in the soil (Atapour, 2015; Facchinelli et al., 2001; Guagliardi et al., 2015; Lin et al., 2002; Snowdon and Birch, 2004). The significance of population density is most likely a reflection of the longer history of industrial activity in areas closer to the Sydney CBD which also have a higher population density.

It is concerning that Pb exceeded the guide value over a large proportion of the study area. As more people are residing within the catchment and more land use change is occurring, there is heightened risk of human exposure to soil contaminants such as Pb. This study could prove advantageous though as it has provided a more precise map showing areas of interest in which further investigation may be undertaken, and where caution may need to be taken in terms of reducing risk of exposure.

Conclusions

Main drivers included x, y (Eastings and Northings, respectively), log-transformed elevation, population density, main road type, cube-root-transformed distance to main roads, population density and soil landscape.

Maps presented areas of lead concentration that exceeded the guide value and areas where zinc is elevated. Mapping the distribution of contaminants assists in management of suspected contaminated soil, especially in residential settings.

The findings of this study would assist in improving soil management in urban areas, provide more precise modelling techniques and increase awareness of soil contamination in urban areas.

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Is biodiversity homogenisation a reality in urban vegetable gardens ?

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Urban gardening is a very common practice in many industrialised and developing countries. However, the functioning and the ability of garden soils to support vegetation and biodiversity are underrated. Understanding the effects of the urban vegetable garden land use on soil biodiversity could have implications for the management of urban soils. Biodiversity is often estimated as lower in urban ecosystem compared to more natural ecosystem. Indeed, urbanisation involves modifications of soil characteristics (e.g. pollution) and fragmentation and reduction of habitats. Moreover, urbanisation is a major cause of biodiversity homogenisation, which implies a diminution in native species and an increase in exotic species (McKinney, 2006). However, this relationship between homogenisation and biodiversity patterns in urban ecosystems is not so obvious for all taxa groups (Clergeau et al., 2006; Kaltsas et al., 2014). Most studies exploring this relationship have focused on taxonomic diversity of avifauna and vegetation and do not take into account soil biodiversity, which is a relevant bioindicator of human activities (e.g. Cortet et al., 1999). Moreover, few studies have questioned the relationship with a trait-based approach in order to highlight the effects of urban ecosystems on functional diversity. A functional approach could be better adapted and more robust because traits are properties of individuals which govern their responses to their environment (Pey et al., 2014). Our objective is to investigate the biotic homogenisation in French urban allotment sites with comparison between vegetation and soil biodiversity responses to urbanisation.

The study focuses on allotments sites in three French cities, situated in contrasted climatic areas (continental, oceanic and mediterranean): Grand Nancy, Nantes and Marseille. The present study was carried out in 15 urban vegetable gardens which are representative of the French urban vegetable gardens. This selection come from 104 urban vegetable gardens previously studied for physicochemical characteristics and gardening practices. To assess soil biodiversity, Collembola were sampled in March-April and September-October 2013. Twelve replicates of intact soil core (5 cm depth, 6 cm diameter) were randomly sampled. Vegetation has been also identified in quadrat of 1m². Taxonomical community indices (e.g. specific richness, abundances, Pielou index, ecomorphologic groups, beta diversity), and Functional community indices (e.g. body size, presence of furcula) were calculated.

Our results demonstrated a differentiation of vegetation communities on the basis of taxonomical structure but a biotic homogenisation was observed according to functional structure. For vegetation, the same functional traits were observed in each urban vegetable garden of each cities. In contrast, for collembolan taxonomical or functional structure, no homogenisation was observed between urban vegetable from the three different cities. Further studies need to discriminate the importance of homogenisation for others soils fauna groups and for others urban habitats in order to help urban sustainable management.

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Anthropogenic pollution of big cities and its realization in soil-plant system (by the example of Saint Petersburg)

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Soils (urbanozems) are an important and integral part of urban environment. They largely determine the possibility of creation and functioning of greenery. In urban environment the superposition of anthropogenic factor on the natural processes of soil formation takes place. On the territory of St. Petersburg natural soils have been destroyed or have undergone fundamental changes during its construction and development. They differ significantly from forest and agricultural lands. Soil formation in the city has some specific features: the processes of addition and cutting of soil, mixing of soil horizons, accumulation of waste products in the surface layers take place. The soil cover is characterized by fragmentation and pollution.

In actual conditions of a big city with a diversified industry the accumulation of pollutants in soils is characterized by significant complexity and heterogeneity and is heavily dependent not only on emission points – industrial enterprises and transport, but also on such soil indicators as organic matter content, cation exchange capacity, medium reaction, grain-size classification. In the issue of atmospheric scavenging some substances are accumulated in soils, the other practically do not stay in them and migrate in soil profile, others undergo degradation and (or) transformation. The behavior of contaminants in soils is strongly influenced by the natural conditions of the area: amount of precipitations, water regime type, local topography, anthropogenic activities.

In the city under the influence of emissions of industrial enterprises and transport, increased recreational loads, unfavorable hydrological conditions there is a gradual loss of fill-up fertile layer structure, reducing the content of organic matter and humus, accumulation of pollutants. Soil porosity reduction entails a deterioration of the water-air regime, reducing of permeability. The reduction of hydrophilic properties takes place, which is related primarily to the loss of organic matter and considerable accumulation of aero-anthropogenic dust in soil, that gives hydrophobic properties, distinctly registered in the soil surface layer. In some areas, particularly in dividing strips of green highways, the surface flow starts to prevail over the vertical filtering.

Over a period of growth and development of green spaces the reduction of nutrient elements in root-inhabited layer of soil takes place due to the wash-out (wash water regime) and their carry-over with the mown grass, fallen foliage of trees and shrubs. Concurrently the natural cycles of nutrient cycle characteristic of natural forest and meadow communities are violated. These factors lead to the gradual degradation of the fill-up fertile layer, reducing of the stability of greenery, fall of cultivated grass on the lawns, that require higher level of cultivation agrotechnology, and the emergence of weedy species. There is a deterioration of decorative and aesthetic qualities of green plantations, their oppression and abatement of sanitary and hygienic functions performed by them. Such landscaping objects require major repairs, which is lifting of 10-centimetre layer of the upper depleted and polluted soil ground, delivery of clean fertile land and recreation of lawns, as well as the replacement of landings if necessary. The execution of these works is an essential measure for enhancing of plant resistance in urban environment and the main way of improving of landscaping system in megalopolises [2.3].

An integrated ecological and agrochemical soil assessment of objects of greening in St. Petersburg has been conducted [1]. The content of heavy metals, arsenic, oil products, including benzo(a)pyrene, pesticides (plant protection products), as well as environment reaction, content of humus and basic elements of plant nutrition and other indicators have been determined. Biotesting of soil samples on organisms at various levels of the organization has been effected. When sampling soil the state of woody, shrubby and grassy vegetation has been recorded.

In most cases a neutral or alkalescent environment reaction (zonal natural soils reaction Wednesday slightly), high content of carbonates and sulfates are characteristic of the soils of St. Petersburg. The soils adjacent to highways have an increased chloride content because of the application of sleetproof funds. The content of organic carbon in soils of industrial districts depends not only on soil processes, but also on settling dust, including soot, oil, remnants of burnt fuel and other carbonaceous compounds of industrial and transport emissions. Unfortunately, this factor is not always taken into account, and increased amounts of carbon (humus), registered in urban soils, are taken for an indicator of soil fertility. Actually anthropogenic carbon is not associated with the natural processes of soil formation and perverts the real assessment of soil fertility.

Conducted studies have shown that between the degree of soil pollution and the state of the green space at the object of landscaping there is usually no direct correlation dependence. The soils of high fertility, although polluted, have less tangible negative effect on plant growth. Important factors are specific stability of woody plants to atmospheric pollution, degree of soil preparation when creating green spaces, timeliness and quality of conducted care arrangements.

Evaluation of the soil quality based on the determination of physical and chemical indicators of soil and their degree of pollution requires a lot of time and considerable resources, though it is not always a reliable criterion of assignment and conducting of repair (reconstruction) of the landscaping object. Current practice of visual assessment of habit of the green object, its aesthetic appearance, carried out by specialists, based on an integrated accounting status of green spaces (trees, shrubs, herbaceous plants), their decorative effect is a more reliable indicator in determining the reasonability of conducting of current or major repairs of the object.

Questions of quality soil preparation, their nutritional status and environmental conditions are determining factors for the issue of greening of megalopolises. Our demands for urban soil and artificially prepared land mixtures – substitutes for soil to create green spaces shall meet the following requirements:

1) contain sufficient organic matter and nutrients necessary for long-term growth of lawn grasses, trees and shrubs;

2) ensure the creation of optimal water-air regime for plant growth;

3) do not contain substances toxic for plants and urban environment.

The heterogeneity of the ecological situation in different areas of the city, the multi-level negative impact on trees, their different resistance in urban environment and other factors require detailed research on each particular facility in order to ascertain the causes of premature loss of greenery and development of measures to improve the planting works.

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Micromycetes of urban soils in Syktyvkar

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Introduction

Microscopic fungi (micromycetes) are integral components of terrestrial and water ecosystems. High resistance to various environmental conditions enabled micromycetes to adapt to a broad range of ecological niches and resulted in diversity of life forms (Hawksworth, 2001). Soil micromycetes perform important functions, including mobilizing nutrients, forming soil structure and humus accumulation (Kurakov, 2001, Sizonenko et al., 2016). Soil micromycetes include ecological groups, regarding sustainability to environmental factors: acidity, temperature, moisture, light, oxygen regime and substrate features (Khabibullina, 2001). Specific and generic structure of micromycetic communities differ for various climates and ecosystems. In comparison natural soils, features and structure of micromycetes in urban ecosystems remain poorly studied. This research studied diversity and structure of micromycetic communities in Syktyvkar town, located in taiga zone of Russia.

Materials and methods

With the population of approximately 250 thousand citizens Syktyvkar is the largest town of Komi Republic and its political center. The town extents 162 km^2, including 70 km^2 of built-up areas and 55 km^2 green zones. More than 30 industrial factories locate inside the town boundaries. Climate of the areas is temperate continental with mean annual temperature + 0,4 ° C and annual precipitation of 670 mm. Natural soils are dominated by Podzols and Podzolic soils with high acidity (pH=3.8-4.4) and low humus content. Urban soils of Syktyvkar include three aggregated groups: i) anthropogenic soils with surface transformations; ii) anthropogenic soils, transformed over profile and iii) soil-like bodies (Mitiyshov et al., 2008). Soil sampling was organized in spring and autumn and covered tree different areas: i) recreational areas (two urban parks); ii) an urban square with limited transporting and iii) a central street with intensive transport. A natural area located 17 km from the town was studied as a reference. Micromycetes in the collected soil samples were quantified in soil suspension, sown at the Agar growth medium (Zvyagintsev, 1991) and micromycetes from different taxonomic groups were identified (Egorova, 1986; Domsh et al; 2007).

Results and discussion

The effect of recreational and transport load on micromycetic structure was studied. The impact of recreational load was examined in soils of walk paths in comparison to adjacent undisturbed plots. We found 28 species of micromycetes in the undisturbed plots, including 20 species from *Moniliaceae* and 3 species from *Dematiaceae* and *Tuberculariceae* families. The communities of micromycetes identified in soils of the walking paths included only 17 species. Likely, the reduction in biodiversity was caused by exclusion of some species from *Moniliaceae* and *Dematiaceae* families (Table 1).

Table 1 Structure of micromycetes' communities in soils under different recreational load (points 1, 2 and 6 refer to walking paths and 3, 4 and 5 refer to undisturbed plots)

Species	Soil sampling points					
	1	2	3	4	5	6
Division *Zygomycota*						
Mortierella sp.			+	+	+	
Division *Ascomycota*						
Aspergillus clavatus	+				+	
Asp.fumigatus	+	+		+	+	
Asp. niger						+
Acremonium sp.			+		+	
Acr. strictum			+	+	+	
Gliocladium roseum				+	+	
Geomyces pannorum			+			
Monilia geophila	+	+		+		
Penicillium citrinum				+	+	
P. granulosum			+	+		
P. brevi-compartum			+	+		
P. corymbiferum			+			
P. fellutanum		+		+	+	
P. frequentans		+			+	+
P. funiculosum	+	+		+		+
P. lanosum		+	+		+	
P. nigricans			+	+		
P. purpurogenum	+	+	+	+	+	
P. thomii	+		+	+		
P.Zaleskii			+		+	
Trichoderma harsianum		+		+		
Tr. lignorum		+				
Семейство *Dematiaceae*						
Alternaria alternata	+				+	
Alternaria tenuis	+	+		+	+	+
Cladosporium cladosporioides			+	+	+	
Culvularia tuberculata	+	+				
Helminthosporium gramineum		+				+
Семейство *Tuberculariaceae*						
Cylindrocarpon sp.		+				
C. candidum			+			
Fusarium oxysporum					+	
F. moniliforme					+	
Порядок *Mycelia sterilia*						
Mycelia sterilia			+		+	

The effect of transport load on micromycetes included decreasing of fungi mycelia content and changes in contents and structure of microbial community, depending on the proximity to the roads. The most evident changes in micromycetes' communities were found in soil of the roadside lawns, adjacent to the motorways. The structural changes in micromycetes' likely were caused by the complex influence of transport

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ANTHROPOGENIC TRANSFORMATION OF URBAN SOILS OF THE MINING REGION

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The development of civilization and the growth of urbanization causes increased human intervention in the natural complex. Due to the violation of natural landscapes, pollution of the city's territory and extensive suburban areas by a variety of solid, liquid and gaseous waste, the city's supply with natural resource potential is diminishing, the sustainability of the territories is decreasing, the abioticity of ecosystems is increasing, and the environmental risk for all components of the environment is increasing (Forest ecosystems ..., 2008), including for soils. A powerful anthropogenic factor of soil degradation is contamination by heavy metals as a result of mining enterprises (Dobrovolsky, 1983).

Some problems of chemical degradation of soils in the Trans-Urals region of the Republic of Bashkortostan in connection with the spread and accumulation of heavy metals have been reflected in a number of works (Yanturin, Singizova, 2007; Ilbulova, Semenova, 2009; Semenova et al., 2013). However, studies on the study of physical degradation of the soils of the Bashkir Trans-Urals were fragmentary.

The work was carried out in the industrial center of Bashkir **Trans-Urals region** in the city of Sibay, in the territory of which there is a large deposit of copper pyrite and a large ore mining and processing enterprise that has been functioning for half a century.

Objective: to study the nature and assess the degree of physical degradation of the main soil groups in Sibay.

The objects of research were soils located in different parts of the city's territory and beyond, to varying degrees subject to anthropogenic impact without reference to a particular geographic area. In total, 25 full-profile cuts were laid. For a comparative analysis of anthropogenically transformed soils with initial soil (common black chernozem), a full-profile incision of the virgin analogue of this soil was also laid. To measure the degree of degradation and deterioration of physical and hydrophysical properties, soil profile disturbances, indicators and criteria for physical degradation of soils described in the literature (Snakin et al., 1992, Degradation ..., 2002), as well as scales for assessing the physical properties of the soil (Kachinsky, 1958, Garifullin, 1984).

As a result of research the following main categories of soil have been identified: 1) the virgin soil - not affected by soil (part of the territory of the old town cemetery and the city park), 2) arable, including horticultural soil neighborhoods with a constant and intensive agriculture, 3) wild land - former cropland that is currently withdrawn from economic circulation, 4) anthropogenically transformed soils recreational areas (city parks, buffer strips of industrial zones of the city, etc.), 5) recultivated soils, 6) soil remaining rock dumps under extracted from quarries.

The results of determining the general physical properties and thickness of soil horizons are given in table.

Table. Change in the thickness and general physical properties of soils

Horizon	Power, cm	General physical properties		
		Density, g / cm^2	Density of solid phase, g / cm^2	Total porosity, %
Virgin soil (soil profile cut 3-1-09)				
A_{sod}	7	0,96	2,61	63,2
A_1	22	1,08	2,61	58,6
AB	16	1,21	2,65	54,3
Soil with partially preserved or newly formed sod horizon (average of 8 similar sections)				
A_{sod}	3,9±0,40	1,09±0,019	2,62	58,4
A_1	21,8±1,64	1,18±0,017	2,61	54,8
AB	16,8±2,44	1,26±0,024	2,61	51,7
Wild land (average of 6 similar sections)				
A_1	25,8±1,45	1,22±0,017	2,60	53,1
AB	17,3±1,89	1,33±0,011	2,62	49,2
Garden soil (soil profile cut 3-13-09)				
A_{arable}	27,5±0,99	1,12±0,014	2,59	56,8
A_1	15,5±1,31	1,16±0,028	2,62	55,7
AB	15,0±1,18	1,23±0,011	2,64	53,4
Recultivated soils (soil profile cut 3-7-10)				
A_{sod}	2,3±0,33	Не опр.	Не опр.	Не опр.
A_1	19,0±1,57	1,31±0,011	2,60	49,6
AB	14,7±1,63	1,39±0,010	2,61	46,7
Regenerated soil (soil profile cut 3-1-10)				
A_1	51,0±5,34	1,19±0,034	2,58	54,6
B	59,2±4,57	1,29±0,020	2,63	51,0

From table it can be seen that all the categories of soils under consideration for equilibrium density are higher in comparison with virgin soils. According to the scale of F.Sh.Garifullin (1984), the density of garden soil is estimated as "optimal", in the horizon A1 of the wild land soil - goes to the category of "compacted". The horizon A1 of the buried soil corresponds to the category "dense". By the density change in the wild land soil, the first degree of degradation (weakly degraded) is noted, in the buried soil - the 1-2 degree of degradation (weakly and moderately degraded). The remaining groups of soils by density change are classified as ungraded.

The porosity of the horizon A1 virgin and Asod garden soil according to the scale of N.A. Kachinsky (1958) is classified as "excellent." Significantly, it decreases in soils with sod, as well as in the restored and wild land soil, passing in the horizon A1 to the "satisfactory" category. The porosity of the humus-accumulative horizons of buried soil is estimated as "unsatisfactory".

The results of the determination of the structural-aggregate state of the studied soil categories of the Sibay city indicate that the virgin soil has an "excellent" (in the Dolgov and Bakhtin scale) structure in the horizons A1 and AB with very high water resistance of the aggregates. Recovered after construction works and garden soil is much inferior to the indicators of virgin soil and are evaluated on the structural state of "good." Soil deposits, in particular horizon A1, are characterized by "satisfactory" indicators of structural and waterproof aggregates, reliably yielding soil to the sod horizon. Analysis of samples of buried soil showed a "good" structural state with "satisfactory" water resistance of the aggregates.

Thus, under the influence of anthropogenic factors in Sibay soils, with the exception of garden crops, phys-

ical degradation occurs: deterioration of the structural-aggregate state, compaction, reduction in porosity and a decrease in the thickness of humus-accumulative horizons. The formation of the sod horizon in the wild land soil contributes to the improvement of its structural-aggregate state.

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FACTORS WHICH MODIFY BIOGEOCHEMICAL CYCLES IN URBUN SOILS

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Anti-Icing reagents (AIRs) are chemical artificial means, most of them are different salts. They are part of the control technologies winter slipperiness on streets and roads, to prevent it or eliminate. Under their influence the snow becomes wet, containing brines. There is a possibility of mechanical snow removal from the surface of the road facilities and objects or sidewalks pedestrian areas in procedural terms.

Some highway maintenance activities, especially in the cities and towns have the potential to cause serious negative physical, chemical and biological impacts to the surrounding environment. These impacts to water, air and soil quality, to plants, domestic, wildlife habitats and species can be significant and leading to their degradation. Site-specific factors, the scale of the work, the types and volumes of used materials can influence to the level of risk of natural sites functioning.

Uncontrolled proliferation of substances (salts) are distribution losses anti-icing reagents, drains brines into storm sewers, splashing when driving and pollution of the vehicles, "salty" aerosols, rotary handling snow reagents on roadside landscaping facilities, temporary storage of his lawn, "dry" snow storage, the use of soluble salts in the pedestrian areas, sidewalks and stops of public transport in cities and towns. How we can choose alternatives? We must consider and compare not individual reagents (substances), as various water-soluble salts and the friction materials (gravel, sand and other), but specific technologies street or pedestrian areas maintenance during winter period. The solutions are used in pre-treatment prior to the snowfall. During heavy snowfalls solutions are used in combination treatment with solid salts. This method allows for the timely mechanical cleaning and has a minimum salt load in the urban area.

Preventive treatment of solid reagents to snowfall is ineffective. Up to 80-85% of total AIRs amount is carried away during the distribution and from the surface as a result of air streams from a moving vehicles and the wind. They should normally be used in 30-40 minutes after the start of snowfall, when the road is already with snow mass. It is impossible in a metropolis. 75-80% anti- icing liquid reactant remains on the surface of the road during the distribution on dry asphalt even in conditions of heavy traffic. This is optimal in terms of process safety and to prevent the uncontrolled spread of salts in the city.

Snow mass from the road contains reagents, waste and other pollutants. Its accumulation, temporary storage and further utilization with full sewage treatment have principal ecological value. From 1994 to 2000, on the roads and streets of Moscow had been distributed about 350 thousand tons of solid sodium chloride (technical salt) annually. Salt had been used when the snow was already fell. There were difficult and bad conditions for intensive cars traffic.

In that time practiced temporary storage of snow from the roads on the lawns. We found processes of soils degradation, the destruction of utilities and contamination of natural waters. Urban vegetation is affected by salt stress.

Since 2001, this technology has not been used, the experiments were conducted, new solutions were found. In the period from 2004 to 2011 in Moscow (without new annexed territories) is used annually not more than 232.0 thousand tons of liquid AIRs in the amount of 65.0 thousand tons of salt, and 83.0 thousand tons of solid AIRs - ratio of about 3: 1. The liquids (brines) is used in average about 90 times in the winter season, the solid salt - about 30 times. The normal calculated amount of distribution of 42 g / m^2 solids and 40 g / m^2 of liquid AIRs. We used for the winter season of 148 thousand tons of salt, enough for 12-15% melting of snow in average. The annual balance in 2009-2011: calcium chloride - for about 90 thousand tons; sodium chloride – about 56 thousand tons; the other salts - not more than 2 thousand tons.

Snow accumulates on the side of the road, then transported to 56 fixed melting stations and 146 mobile.

Since 2011 in Moscow have been used technology of winter cleaning of the carriageway of highways, streets, roads and squares (road facilities of Moscow) with the use of anti-icing reagents and rubble of fraction 2-5 mm. Decision of 28.09.2011 N 05-14-650 / 1 (Department of housing and communal services and improvement of the city of Moscow).

Liquid reagents replaced by a solid, physical blends of different salts, including sodium chloride, calcium chloride, potassium chloride and sodium formate.

Total allowable salt load has reached more than 387 thousand tones in the winter season in terms of dry matter (in 2011 - 423 thousand tons). There is the resolution to using of 200 thousand tons of solid anti-icing reagents on roadways, 150 thousand tons - on sidewalks and pedestrian areas.

For the period of 2004-2011 years on the city territory in the middle fell 147 thousand tons of salt per winter season, and for 2011-2017 - already 311.4 thousand tones.

The city balance in winter 2009-2010 on calcium chloride accounted for about 107 thousand tons of sodium chloride - about 36 thousand tons, and the other in the amount of salt - no more than 2 thousand tons. There have been changes in the chemical composition, now the balance of sodium chloride again prevails.

Established standards for "acceptable content of chemicals that are not related to the active substance in the composition of anti-icing reagents." There are 12 especially dangerous chemical elements, potential environmental pollutants: fluorine, zinc, lead, mercury, copper, molybdenum, chromium, arsenic, cadmium, selenium, nickel and cobalt. For solid AIRs total concentration of these pollutants is 668.0 mg / kg, and for liquid - 238.2 mg / kg. Total annual possible entry (supply) into the environment of the city increased to 250-300 tons.

Potassium chloride forms a eutectic with ice at a temperature of 10.6 degrees Celsius below zero. This salt is mineral fertilizer for agriculture. It is inappropriate to use this substance as a reactant (AIRs). The content and distribution of potassium chloride in the environment is controlled and regulated.

The use of combined anti-icing reagents is allowed (KR tv.) in the pedestrian areas, parks and yard areas. It is a mixture of chlorides of alkali and alkaline earth metals, sodium formate and marble chips. The amount at a single treatment is 80-200 g / m^2.

During the winter workers can use from 4 to 15 kg of salt per square meter. Sodium chloride is one-half that amount. Sodium formate (NaHCOO) in the environment is gradually becoming (oxidized) to sodium bicarbonate or carbonate - $NaHCO_3$ or Na_2CO_3. The negative impact of sodium formate on the soil and the plant at equal concentrations greater than that of sodium chloride, but the melting capacity is much lower.

Marble chips included in the composition of these reagents. With such high volumes of applications it inevitably falls into the storm drains and accumulate there, causing flooding in the streets during of the period of abundant rainfall. Now the total annual salt load, due to the winter maintenance of the road network and pedestrian areas, increased an average of 2.1 times. We must take into account and assess the likelihood of environmental and technological risks. We need measures to prevent them.

The behavior of the reagents in the environment, their impact on regional objects of hydrosphere, landscapes, vegetation, urban soils need to be considered in the characterization of geo-ecological situation, when making development plans and building of the cities.

Establishment of Phyto-available Arsenic Standard in Rice Paddy Soil

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Rice that is a staple food in the Republic of Korea (ROK) has been occasionally cultivated near abandoned mines. Leaching of heavy metals such as arsenic (As) from the mines may contaminate the paddy soils, in which the rice produced have distributed to the local market. Therefore, rice potentially absorbing As from the paddy soil may be hazardous for health safety. In ROK, soils contaminated with As have been managed according to the As concentration determined after aqua regia digestion (total As). Many soil scientists reported that management of As in soils by phyto-available As is more effective than that by total As since As concentration in crops has a significant correlation with phyto-available As. Therefore, this study was carried out to establish standard for phyto-available As in paddy soil using transfer function of As. As contaminated soil samples were collected from agricultural soils nearby 65 abandoned mines, and were used to cultivate as substrate for pot experiment in a greenhouse. The soils contained highly variable concentration of total As (6 to 1701 mg kg^{-1}) and also chemical properties; soil pH (4.4 to 8.2); organic matter content (2 to 148 g kg^{-1}); and available phosphate (6 to 1701 mg kg^{-1}). After cultivation of rice, phyto-available As concentrations in the cultivated soils was analyzed using four extracting methods such as 0.1M $(NH_4)_2HPO_4$, 0.05M EDTA, Mehlich 3, and 1M $NaHCO_3$. Concentration of As in polished rice also was analyzed. Transfer function of As in Polished rice was estimated by four extracting methods. Three extracting methods except $NaHCO_3$ method showed significant relationship between As in soil and that in polished rice ($p < 0.05$). Phyto-available As standard was estimated using As transfer functions and permitted quantity of residual As in polished rice (0.2 mg kg^{-1}) (Table 1).

Table 1. Phyto-available standard on Arsenic in Soils using transfer function.

Permitted quantity of residual As in Polished rice (mg kg^{-1}, FW)	Extracting solution	Transfer function	Phyto-available standard (mg kg^{-1})
0.2	0.1 M $(NH_4)_2HPO_4$	$Log(As_p)=1.03+0.27Log(As_{DAP})$	50.99
0.2	0.05 M EDTA	$Log(As_p)=1.11+0.25Log(As_{EDTA})$	58.09
0.2	Mehlich3	$Log(As_p)=1.04+0.28Log(As_{Mehlich3})$	38.52

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ORGANIZATIONAL AND LEGAL ASPECTS OF ANTHROPOGENIC HUMAN ACTIVITIES IN TERMS OF URBANIZATION (ON THE EXAMPLE OF THE CONSTITUTIONAL BASES OF THE ENERGY SPHERE)

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Abstract: *In this article, the author examines current issues of legal regulation of anthropogenic human impact on the environment. The author pays special attention to energy issues. In conclusion, the author makes scientifically based conclusions on the basis of the analysis.*

Key words: *Constitution, sphere of energetics, constitutional bases, alternative power engineering.*

Introduction.

The energetics is one of factors of sustainable development of a certain territory of the state, all country, the region. It is a factor having significant effect on ecology and level of the favorable environment, as a result - an element of worthy life and free development of the person. The sphere of energetics is the field of realization of human rights and interaction of institutes of civil society as interests not only collective subjects, but also individuals are affected. The modern constitutional legislation of many states, in the majority, considers energetics as an element of safety of the state, profitable budget expenditures, a component of domestic and foreign policy. Meanwhile the energetics, from the point of view of the author, is the sphere of risk requiring special attention through a prism of the constitutional bases of any state for the decision modern a task not only state but also international, world-class.

Results of a research.

The analysis of the constitutional legislation which is carried out by the author has allowed to note that constitutions of foreign countries do not pay much attention to the sphere energetics.

The constitutional bases of the sphere of energetics can be defined as set of the constitutional principles and norms, directly and indirectly affirming rights, duties, responsibility and system of guarantees of the state bodies and officials of the public power, society, the person, subjects of fuel and energy complex at his formation, and also by production, distribution and consumption of products of his activity; planning of use and restoration of natural fuel and energy resources [1. P. 3].

It is possible to divide the constitutional norms into the groups fixing the sphere of energetics on various bases. For example, on degree of a specification of the adjustable sphere: on directly and indirectly regulating the sphere. Classification by bases of the constitutional system is possible: a) the norms of bases of the constitutional system establishing base for the sphere of energetics; b) the norms defining the rights, freedoms and the citizen's duties; c) the norms affirming the rights and obligations of public authorities in the sphere of energetics [2. P. 1055].

It shall be noted that the constitutional norms in various countries are directed to fastening and regulation of various types of energetics, usually priority for this or that state: atomic, water, electric, alternative. For example, regulation of nuclear power at the constitutional level can be seen in constitutions of the Republics of Germany [8. P. 164-245] and India [6], People's Republic of Bangladesh [3. P. 465-552], Republics Union of Myanmar [3. P. 553-614], Islamic Republic of Pakistan [3. P. 615-744]. The power industry is enshrined in constitutions of the Democratic Socialist Republic of Sri Lanka [3. P. 866-1021], Federations Malaysia [3. P. 328-464], Republics Union of Myanmar. The water power (hydropower) is enshrined in constitutions of the Republic of Korea [3. P. 983-1010], Federations Malaysia, Republics of Sri Lanka, Republic of the Philippines [3. P. 922-976].

The nonconventional energy sources and alternative power engineering standards are devoted the Constitution of India on November 26, 1949, Brazil on October 5, 1988 [5], the Kingdoms of Thailand [3. P.

789-912]. The attention in the Constitution of Philippines is paid to potential resources of energy.

The constitutional norms fix the sphere of energetics by means of regulation of property. It can be seen in constitutions of the Republics China [7], Italy [8. P. 270-80.], Philippines. The constitutional provisions are enshrined by obligations of the state in the sphere of energetics. For example, the constitutional norms fix competence of public authorities of the sphere of energetics in Brazil, Colombia, Thailand. As a rule, it is exclusive and the competing competences. Exclusive competence of the sphere of energetics is enshrined in the Constitution of Brazil, the competing competence fixed by standards of the Constitution of Germany. The competing legislation in the sphere of energetics is reflected in the Constitution of Italy, India. The sphere of energetics is the competence of the Union of Miami, Federation Malaysia. The constitutional norms fix competence and powers of the state of the sphere of energetics. In the Constitution of the Republic of the Philippines concrete powers of the president are fixed in the sphere of energetics. The constitution of the Republic of Korea fixes licensing in the sphere of energetics. Special attention is paid by exclusive ways and methods fixing with the constitutional norms of the sphere of energetics. For example, sources in the sphere of energeticsare enshrined in the Constitution of Brazil; in the Constitution of the Republic of China the purpose of use of energy resources is established.

It is possible to carry to features constitutionally fixed obligations of the state in the sphere of alternative power engineering. They are enshrined in the Constitution of Thailand on August 24, 2007 and Constitutions of Cambodia on September 21, 1993 [3. P. 179-208].

Researching the Constitution of the Russian Federation within the designated subject, we see that federal power systems, nuclear power, defense and safety are under authority of the Russian Federation. The author conditionally divides the norms of constitution of Russian Federation into two groups depending on participation in fixing and regulation of a basis of the sphere of power:

the first – to directly devoted energetics relations (Art. 9, Art. 36, the cl. «i» of Art. 71 of the Constitution of Russia);

the second – indirectly participating in their regulation (Art. 2, 17 and 18; Art. 1 and 7; Art. 8; Art. 45 – 48; cl. «a» of Art. 71; cl. «a» of Art. 72; cl. «k» p.1 Art. 72; Art. 76 of the Constitution of Russia).

According to the authors point of view, the majority of bases of the constitutional system is the base for a regulation of the sphere of energetics:

democracy – influences participation of the people, institutes of civil society in the solution of questions within the energetics sphere;

the principle of division of the authorities and federalism influences on regulation sources (on the subject, the territory of action, a subject);

the rights and freedoms of the person – the supreme value are base for work of all bodies of the public power, the principle of activity of institutes of civil society;

the social state is designed to solve effectively problems of social and economic development, satisfaction of pressing needs of society and legitimate interests of citizens;

the constitutional fundamentals of market economy – a legal regime of property in the sphere of energetics and specifics of the rights of the owner in this sphere; civil, tax, antitrust law, etc. [4].

Conclusions.

Summing up the result it is possible to draw the following conclusions: the constitutional norms of direct regulation of the sphere of power in modern constitutions don't differ in the width and variety. In the sphere of energetics creative treating indirect regulation, it is possible to carry statehood bases; legal status of the person; bases of the economy, property, commodity turnover, nature protection and so on. The factors influencing the volume of the constitutional regulation in the sphere of energetics from the point of view of the author it is possible to carry date and time of adoption of the Constitution of the country: the basic law is younger, the more attention is paid to various aspects of life of society and factors providing his sustainable development namely the sphere of energetics. It is possible to refer dependence of the country on a power complex to the factors influencing the volume of the constitutional regulation of the sphere of energetics. One of ways of improvement of ecology and preservation of the environment it is possible to call the alternative power engineering using renewables. Unfortunately, this question is regulated by the constitutional standards of the majority of the explored states insufficiently.

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Impact of building parameters on accumulation of heavy metals and metalloids in urban soils

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Introduction. It is known that the quality of the urban environment is determined by the allocation of pollution sources, in addition, a significant influence has relief, urban development features and also meteorological factors, which determine the diffusing and concentrating ability of the atmosphere (Baklanov et al, 2008, Regions ..., 2014). Urban districts, especially with high-rise buildings, represent a complex system of surfaces with different slope gradient located at different levels and blown by air fluxes. Buildings greatly alter wind patterns in the surface layer of the atmosphere, creating the locations where dust deposition takes place. These locations are usually restricted to closed yards while the effect of "canyon" occurs along the major highways. Such effects create a considerable heterogeneity of the pollution of urban environment.

However, consensus on the role of an artificial relief in the distribution of pollutants does not exist. Some researchers believe that urban buildings represent mechanical barrier screens that protect residential areas from pollution. According to other data, a sharp decrease in the wind velocity in areas with dense block patterns contributes to the deposition of harmful atmospheric impurities. In this paper, a first attempt have been made to evaluate the barrier function of urban development through the integrated analysis of the data on the heavy metal and metalloid (HMM) concentrations in the topsoils, their physical and chemical properties that define the fixing ability in relation to the HMMs, and the parameters of the artificial terrain (orientation and height of buildings, building density). The application of multivariate statistical analysis helps to determine the conditions of the pollutants precipitation from the atmosphere and to identify the location of geochemical anomalies in soil cover.

Objects and methods of the reseach. The object of the study is Ulan-Ude, a city with a population of over 400 thousand located in Ivolginsky-Uda intermountain basin, drained by the Selenga river and its right tributary, the Uda river. The climate is severely continental with the prevailing western winds. The topography patterns and composition of parent rocks as well as anthropogenical impact causes the variability of soil cover. Mechanically transformed soils, with modified structure of the soil profiles, include urbanozems, ekranozems, necrozems and culturozems. Chemically transformed soils incorporate industrizems and intruzems. According to the classification proposed in (Ilyin, Syso, 2001), the urban soils are characterized by low buffer capacity. They have relatively low level of physical clay (the particles less than 0.01 mm in diameter) (on average 5.8%), being formed on light textured parent rocks and man-made deposits. The pH reaction changes from alkaline (pH 8.5) to weakly acidic (6.1) in the sandy soils of the outskirt areas. The average humus content is rather low, equal to 2.5%.

Ulan-Ude is included in the priority list of the cities with air pollution index API ≥ 14 and has 35 potential pollution sources (plants on repair of locomotives and wagons, rolled metal products, aircraft and shipbuilding, etc.). However the main contribution to air pollution is made by coal-fired thermal power plant and vehicle emissions.

Soil-geochemical survey of the soil cover in the residential area of Ulan-Ude was held in summer, 2014. As a result 106 mixed (with 3 duplicates) soil samples from the surface (0-5 cm) horizons were taken. Samples were collected at grid points with grid size equal to 1000 m in the outskirt areas and 700 m in the central part of the city. The pollutant's fallout rates were evaluated using the data of snow survey conducted in winter 2014, as a result 27 samples were collected. 11 background soil samples and 4 samples of snow were taken in the reference sites, located 20-30 km to the south-west and east of the city. The solid and liquid phases of snow were separated by filtration.

The total contents of the HMMs in the snow solid fraction and in soils were determined by ICP/MS and ICP/AES analyses using "Elan-6100" and "the Optima-4300 DV" equipment. Conventional methods were applied to define the properties that affect soil ability to fix pollutants (pH, humus content, grain-size analysis, the contents of Fe, Mn, Al oxides). The priority pollutants of the soil and snow covers were identified on the basis of calculation of enrichment (*EF)* and fallout (*FF*) factors relative to reference (background) values. Fallouts of HMMs were derived from their concentrations in the solid fraction of the snow and the daily dust load *P*. The total geochemical load on soil or snow cover was evaluated using integral index of pollution Z_c and immission Z_d, respectively. These indices were calculated as $Z_c = \Sigma EF-(n-1)$; $Z_d = \Sigma DF-(n-1)$, where *n* – the number of chemical elements *EF* or *FF* > 1.0, *n* = 14 (Environmental ..., 1990).

The contours of buildings were obtained from the OpenStreetMap database. The heights of buildings (*H*) were determined by visual interpretation of GeoEye-1 satellite image (2015) using the database 2GIS. The area occupied by the buildings (*S*) was determined by a special tool for calculating the geometry in the software package ArcGis 10.0. The sum (ΣS) was used as a parameter to evaluate the density of the building patterns. The distance (*L*) from the sampling points to the buildings was measured using a distance tool which allowed also to identify the directions of the lines connecting the sampling points and the buildings.

Building parameters were determined in the zones with different radius where the central point was represented by a sampling point. To select the optimal radius we used the data derived from the snow survey. It corresponded to the distance at which the correlation between dust fallout *P* or the HMMs concentrations Z_d and the building parameters reached the maximum. The building parameters averaged („) for each point across major directions using one-way ANOVA analysis of variance.

The building parameters were grouped in north-south and east-west directions and averaged for each point.

To describe the geochemical heterogeneity of soil cover in relation to building parameters and a complex of soil factors, the method of regression trees (SPlus package) was used. This approach allows to predict the levels of pollutants in soils with different combinations of factors, and to assess their significance.

Results and its discussion

Determining the radius of impact zone. For all the radius of the impact zone the daily dust load P and the integral index of immission Z_d *increase with the growth of the building area (S) and a decline in the distances L (Table 1). The height of the buildings is not so important factor, as the city is dominated by low-rise (two- or one-storied) buildings. The greatest impact of the building patterns was identified in an area with a radius of 150 m in the south-west and north-east direction, which is consistent with the highest repeatability of the south-west winds in winter (Sutkin, 2010).*

Table 1. The coefficients of Spearman rank correlation between daily dust load *P*, integral index of immission Z_d and building parameters

Building parameters	Correlation with *P*					Correlation with Z_d				
	Radius of the impact zone, m					Radius of the impact zone, m				
	50	100	150	200	250	50	100	150	200	250
*	–0.51 (1)		–0.55 (2)	–0.56 (2)	–0.51 (2)		–0.53 (3)	–0.50 (2)	–0.48 (2)	–0.44 (2)
			–0.55					–0.56	0.43	
*	0.52(1)		0.58(2)	0.45(2)	0,57(2)			0,56(2)		0.51(2)
			0.51	0.43	0.44		0.46	0.55	0.40	
			0.40	0.44	0.43					
Σ*S**	0.61(1)					0.56(1)				

*across major directions: SW (1), NE (2), SE (3)

The building impact on the accumulation of HMMs in soils. The priority pollutants of soils in Ulan-Ude are Sb, Pb, Sn, Cd, Cu. In some areas of the city, in the vicinity of industrial enterprises and along major highways, geochemical anomalies of Mo, Ni, W, Zn, Cr, Bi were also identified (Kasimov et al., 2016). Multivariate regression analysis has shown the impact of the building parameters on the accumulation of almost all of HMMs (Table 2). With the dominance of low-rise buildings in the city the main factor which defines their function as barriers to the atmospheric transfer of HMMs is their surface area: its growth leads to an increase in topsoil concentrations of W, Bi, Zn (1.5-1.6 times), As, Sb, Mo, Sn (1.3-1.4). With the increasing building density (Σ*S*) the levels of Cd, Pb, Cu and Mo increase 1.4-2.2 times. The vicinity of the buildings to a sampling point in the north-western sector, contributes to the fallout from the atmosphere and accumulation in soils of Bi, Zn Cu (1.3-1.5 times). The exceptions are building density in north-western sector and vicinity of the buildings in south-western sector, whose growth decrease concentrations of Cr and Zn (1.4-1.6 times). This can be explained by the relative arrangement of the emission source of these elements and artificial relief features, which protect the soil in this case from the atmospheric Cr and Zn flux.

Table 2. The impact of building parameters and sorption properties of soils on accumulation of HMMs and integral pollution index Z_c of topsoils in Ulan-Ude

Factors	Cd	Pb	Sn	Sb	Zn	Cr	As	Cu	Mo	W	Bi	Z_c
			2+ NE	3+ SW	3+ NE		4+ SW		3+SE 4+SW	2+ NW	4+ SE	4+ SW
Σ*S*	3+	3+NE				2- NW		2+	1+ SW			
					1+SW 3-NW			3- NW			2-NW	3- NW
Fe_2O_3			2+			1+	1+		3+	1+		
Clay							2+			2+		
Humus	2+		1+		2+			2+	2+	3+	1+	1+
MnO						2+		1+				

Note: Ranks from 1 to 4 show a decrease in the factor significance, and the signs "+" or "-" positive or negative correlation, respectively. If the building parameters influence the accumulation of pollutants in a certain sector of the impact zone, it is specified by letters.

Integral soil pollution by HMMs (Z_c) is 1.6-2.0 times higher in the areas with high surface area of buildings and their proximity in prevailing NW, SW wind directions. The impact of sorption properties of the soils on the HMM content is more pronounced due to their low buffer capacity. The growth of Fe_2O_3 and humus contents lead to a significant increase in the accumulation of almost all of HMMs (Table 2).

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Destruction of oil hydrocarbons by microorganisms associations in the soils of the Kola Peninsula (field model experiment)

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Nowadays, oil products (OP) belong to the most toxic substances. Potential hazardous sources of contamination with oil products in Murmansk region include oil tank farms, facilities of fuel and power sector, major industrial plants with their own vehicle fleets, petrol filling stations, facilities of the RF Ministry of Defense which operations involve petroleum products (storage, transport, shipping, bunkering). When discharged to environment, oil hydrocarbons have suppressive effect on ecosystems and significantly affect the habitat.

It is known that bacterial microbiota (Bilay, Koval, 1980; Myazin, Evdokimova, 2012) is essential for decomposition of oil hydrocarbons, however, the fungi greatly contribute to soil self-cleaning against hydrocarbon contaminants (Bilay, Koval, 1980; Kireeva et al., 2005), especially in acid soil with unfavorable conditions for bacterial growth. Process of degradation of oil hydrocarbons in soil aided by microfungi in climatic conditions of Murmansk region is still unexplored. Low potential of self-cleaning of arctic ecosystems characterized with short vegetation period and low temperatures calls for the need to find a technology of environment clean-up from oil contamination to practicable level of recovery of disturbed northern ecosystems.

Environment clean-up efficiency depends on factors including the appropriate choice of a microbial decomposer. To respond to regional oil contamination, it is preferable to use the microorganisms - decomposers adapted to specific conditions (Evdokimova, Masloboev, 2011). The focus is on creation of microbial communities which oxidize oil products more efficiently as compared to other individual types (Smirnov et al., 2002).

This paper objective is investigation of hydrocarbon destruction in soil by microbial communities in the conditions of field model experiment.

OBJECTS AND METHODS

Experimental plots per 1 m^2 were formed based on cultivated Al-Fe humus podzol on the site of Russian Crop Research Institute Branch Polar Pilot Station (POSVIR) located 1.5 km from Apatity town in Murmansk region (67°34' N, 33°22' E). Diesel fuel in the amount of 10 l/m^2 was inserted as contaminator. Variants of the experiment: control – soil without OP; OP; OP + bacterial inoculum (OP+B); OP + fungal inoculum (OP+F); OP + bacterial and fungal inoculums (PP+B+F). The most active strains of micromycetes (*Penicillium canescens* st.1, *P.commune*, *P.simplicissimum* st.1) and active hydrocarbon oxidizing bacteria, previously isolated from the soils of the Kola Peninsula (*Pseudomonas fluorescens, P. putida, P. baetica, Microbacterium paraoxydans*) was used (Evdokimova et al., 2009, 2012). Bacterial biomass was grown in meat-peptone broth in the laboratory fermenter Sartorius Biostat A-plus. The fungal biomass was grown in Erlenmeyer flasks with the liquid medium of Chapek's following composition (g/l): $NaNO_3$ - 3.0; KH_2PO4 - 1.0; $MgSO_4$ - 0.5; KCl - 0.5; $FeSO_4$ - 0.01. The density of the bacterial suspension is 10^9 cells per ml, the fungal suspension is 10^5-10^6 CFU in 1 ml. At 1 and 30 days biological inoculums were injected into the soil in an amount of 1.2 l/m^2 (for 3 plots) and a complex mineral fertilizer of azofoska (NPK) in an amount of 60 g/m^2 (for all plots). The top layer of the soil in all variants was loosened to a depth of 5 cm.

The residual content of oil hydrocarbons in the soil was determined by IR spectrometry methods on the AN-2 analyzer.

RESULTS AND DISCUSSIONS

In the field experiment, three microbial inoculums showed approximately the same behavior (Fig. 1). In case of inoculum based on bacterial fungi community, after 30 days oil product content reduced to 29 g/kg (oil product removal was 57% vs. initial level), after 120 days - 12 g/kg (oil product removal was 82% vs. initial level). In cases of bacterial and fungal inoculums, after 30 days oil product content reduced by 55%

and 51% respectively, after 120 days - by 77% and 79% vs. initial level, respectively (Table 1).

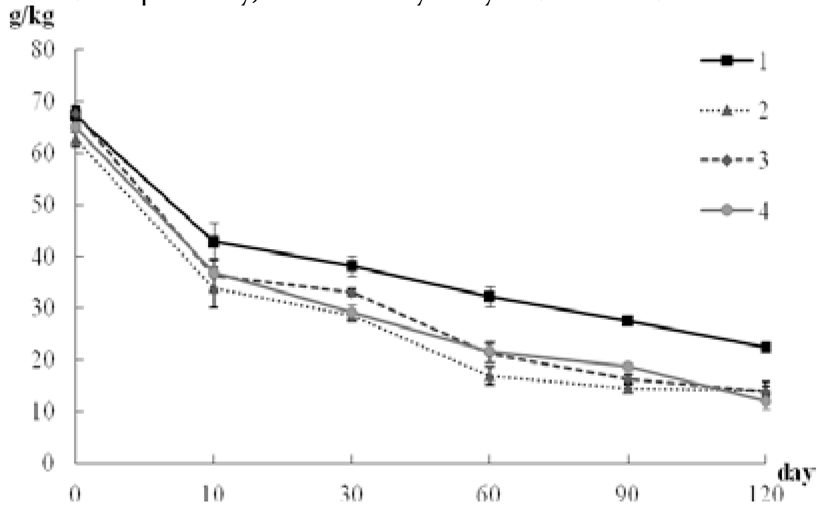

Fig. 1. Dynamics of OP content in the soil of model experiment:

1 – PP; 2 – PP + bacterial inoculum; 3 – PP+ fungal inoculum; 4 – PP+ bacterial and fungal inoculums.

During initial 30 days of experiment, oil product content reduces most intensively due to evaporation (Myazin, Evdokimova, 2012). Introduction of microbial inoculums accelerates the oil product decomposition process by 10-15%.

Table 1

The loss of the content of OP (% of the original) in a certain period of time

Variant	Day				
	10	30	60	90	120
OP	36	43	52	59	67
OP+B	46	55	73	77	77
OP+F	46	51	69	76	79
OP+B+F	46	57	68	73	82

The rate of oil product reduction in soil changes with time of experiment (Table 2). During initial 10 days the rate was maximum due to the most intensive evaporation. Thereafter, the rate of oil product decomposition decreased. In case of OP+B+F, the most significant decomposition rate was observed during 10-30 days of the experiment, in cases of OP+B and OP+F - during 30-60 days.

Table 2

The average rate of loss of OP from the soil (g/kg) for 1 day in a certain period of time

Variant	Time period				
	1-10	10-30	30-60	60-90	90-120
OP	2.43	0.23	0.20	0.16	0.17
OP+B	2.87	0.27	0.39	0.08	0.01
OP+F	3.12	0.16	0.39	0.16	0.08
OP+B+F	2.81	0.39	0.25	0.10	0.20

After assessment of performance of microbial inoculums in cultivated Al-Fe humus soil of Kola Peninsula during different periods, it can be stated that their best effect was observed during 30-60 days of the experiment, however, the case of bacterial fungi community maintained its efficiency even during 120 days.

Thus, use of microbial inoculums based on native microbes in cultivated Al-Fe humus podzol of Kola Peninsula accelerates the oil product decomposition in soil and can be advised for environment post-cleaning from oil hydrocarbons. In the field experiment conditions, the microbial inoculums based on bacterial fungi community demonstrated the best effect: during 120 days oil products content reduced by 82%, oil products decomposition rate after 30 and 120 days was maximum as compared to other experiment scenarios. It is noteworthy that Kola Peninsula soil is acid soil and, therefore, the efficiency of using the microbial inoculums based on microfungi will likely be higher than that of bacterial inoculum.

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Properties of ekranic technosolsin the town of Zielona Gora under different surface covering

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Introduction

One of the main forms of soil degradation is soil sealing [SWD (2012) 101 final /2]. An impermeable layer, like asphalt or concrete, strongly reduces the infiltration of rainwater into the soil profile and interferes with gas exchange between the soil and the atmosphere. Today these phenomena are regarded as the more formidable ones as far as sustainable urban development is concerned [Nestroy 2006, Vanderhaegen et al. 2015].

The morphology of the covered soil presents varied characteristics resulting from the construction of various soil covers. Therefore,urban soil can be further differentiatedas soil covered with solid surfaces: bitumen, concrete, large and small concrete slabs, concrete paving stone and porous materials (concentrated slags of different origin) [Greinert 2003, 2013].

The paper presents the physico-chemical properties of ekranictechnosols overhung under various types of solid soil cover.

Key words:ekranictechnosols, urban soils, anthropogenic soils

Materials and methods

The research site is located in Zielona Gora, in the western part of Poland (51°56'07"N, 15°30'13"E). The research was carried out in the town and in the administrative commune of Zielona Gora. Particular locations were selected in areas with different soil surfaces: bitumen cover, concrete slabs and concrete paving stone – 5 soil profiles at a depth of 150 cm (samples from each of the morphological layers or genetic horizons). Sorption properties were determined by the Kappen method, pH in 0.01M $CaCl_2$ – by the potentiometric method, TOC content using a Shimadzu analyser, particle size distribution – using hydrometer method.$CaCO_3$ content wasdetermined by weight loss and the total content of heavy metals by ICP-MS after mineralisation in aqua-regia.

Results

Averaged results of soil properties are summarized in Tables 1 and 2. A characteristic feature of the sealed soils is the impairment of the physical properties in at least some of the layers and levels. This is because of the compaction of the material to ensure the stability of the solid surface. The described density of tested soil ranges between 2.63-2.86 g cm^{-3} in layers below the sealed surface and 2.54-2.79 g · cm^{-3} of less than 20 (35) cm. The bulk density varies from 1.36 to 1.68 g cm^{-3} in layers below the sealed surface and 1.54-1.71 g · cm^{-3} below 20 (35) cm.

Table 1. Physical and chemical properties of tested soils

	TOC	$CaCO_3$	$pH\text{-}CaCl_2$	Ha	TEB	CEC	BS
	%			cmol · kg^{-1}d.m.			%
Soil surfaces: bitumen cover							
Min.	0.08	0.00	6.85	0.10	2.18	2.38	88.67
Max.	1.50	1.50	7.32	0.35	7.47	7.70	98.56
Mean	0.59	0.56	-	0.24	5.14	5.38	94.59
S.D.	0.52	0.59	-	0.08	1.98	1.98	3.16

Soil surfaces: concrete slabs							
Min.	0.16	0.00	5.80	0.12	2.62	3.20	81.94
Max.	1.08	0.60	7.36	0.58	11.89	12.01	99.00
Mean	0.51	0.13	-	0.24	7.19	7.43	95.62
S.D.	0.30	0.21	-	0.14	2.78	2.66	6.53
Soil surfaces: concrete paving stone							
Min.	0.12	0.00	6.87	0.17	3.68	3.85	92.67
Max.	0.89	0.60	7.43	0.65	17.05	17.27	98.74
Mean	0.48	0.13	-	0.38	9.89	10.27	95.74
S.D.	0.28	0.27	-	0.19	5.14	5.15	2.39

The effect of compaction of top layers is visible. The bulk density of other layers also indicates strong compaction. Total porosity reaches values of 16.7-34.6%. Capillary water capacity is 9.9-15.1%. The pH of the soils was acidic to alkaline, 6.85-7.32 for soil sealed with bitumen, 5.80-7.36 for soil sealed with concrete slabs and 6.87-7.43 concrete paving stone.

Table 2. The content of heavy metals in the tested soils

	Cd	Cu	Ni	Pb	Zn
	mg · kg^{-1}d.m.				
Soil surfaces: bitumen cover					
Min.	0.22	10.08	5.36	9.40	22.00
Max.	0.42	28.58	15.40	56.80	71.40
Mean	0.31	17.04	12.22	22.77	43.71
S.D.	0.06	5.90	4.21	14.86	17.55
Soil surfaces: concrete slabs					
Min.	0.18	7.04	1.88	5.95	12.80
Max.	0.64	19.78	15.74	30.80	154.40
Mean	0.35	11.18	7.54	13.73	55.85
S.D.	0.13	3.72	5.28	7.39	42.95
Soil surfaces: concrete paving stone					
Min.	0.26	8.10	2.44	7.00	16.40
Max.	1.12	38.60	12.80	35.80	116.60
Mean	0.46	19.01	7.69	16.59	58.90
S.D.	0.30	9.79	4.33	10.10	35.29

Discussions

Soils of urban areas show a significant mechanical transformation that affects their physical, chemical and biological properties [Gerasimovaet al 2003, Greinert 2015]. The top layers of the tested soils can be characterized by a lack of humus or residual levels of occurrence (3-10 cm thick) at a depth of 10 to 80 cm, where the content of organic carbon range of 0.75-1.50%. The low level of humus and organic matter in urban soils (urbanozems and ecranozems) can be explained by the disturbance of the soil–vegetation relationships [Gorbov and Bezuglova 2014].However, changes between soil sealed with permeable and nonpermeable material can be seen in the long term [Piotrowska-Długosz and Charzyński 2015].

Sorption properties depend on the particle size distribution and organic matter content and the content of anthropogenic porous materials. Profiles in ZielonaGóra were built with sand, with a low content of TOC which occurs in low sorption capacity.

One of the most commonly observed differences between the urban soils and soils of natural genesis is their pH. Soils sealed with concrete elements showhigher reaction in the top layers of the profiles, which is not unusual forekranictechnosols (Hulisz et al 2016).

The layers under the sealed surface showed a lower content of some heavy metals (mainly Cd, Cu, Pb, Zn) than the layers below.However, in some cases the opposite situation can be seen (Zn, Ni, Pb). There were no significant differences in the content of trace elements under different soil covers.

Conclusion

1. The organic matter content was very low. A higher content of TOC was noted only in layers directly under the cover material.
2. Heavy metals were present in the tested samples in quantities similar to other parts of Zielona Gora. This content can be regarded as 'safe for the environment'.
3. Physicochemical properties may not differ significantly between soils representing different sealing categories or changes can be seen in the long term.

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Hydrocarbon Status of Oil-gas Field Soils under Different Ages of Oil Contamination

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The hydrocarbon status (HCS) of soil is a specific property of soil manifested through peculiar ratios of hydrocarbons occurring in the soil in different forms and in different states. It includes (a) the total content and qualitative composition of bitumoids (substances extractable from soils by neutral organic solvents); (b) the composition and content levels of individual hydrocarbon compounds present in bitumoids (PAHs); and (c) the content and individual composition of free and fixed (adsorbed and entrapped) hydrocarbon gases (methane, ethane, propane, n-butane)

The soils of the produced hydrocarbon fields are often characterized by very sharp discontinuity in their HCS. It is associated with the location of many natural and technogenic HCS forming factors on the small area.

In this text the results of study of parameters of HCS of soils of old oil-gas field are provided. This fields are within the Volga Upland. They have been in operation since the late 1940s. The next soils were compared:

soils on the site which has no technical object (background soils);

soils on the site with a fresh (about half year before the soil sampling) oil contamination. The contamination occurred because of the mechanical damage of pipeline at a depth of about 1.0 m;

soils on the site with an old oil contamination, which happened because of pipeline fractures and mine accidents in the preceding decades.

The hydrocarbon composition in all horizons of the background soils relatively uniform and consists of almost only methane. In the free gas, the concentration of methane is in the range of 1.9–3.0 ppm throughout the soil profile. The retained gas also includes almost only methane, although in a larger amount. The concentration of methane is 3-7 ppmv in the topmost throughout the profile. Ethane, propane, and butane (no more than 1.0 ppm) are detected in some horizons.

Butane, the heaviest gas, becomes the predominant hydrocarbon gas in the freshly contaminated soils. According to its concentration in the free gas phase, the soil profile is clearly divided into three parts. The content of butane in the soil air is 250–480 ppm at depths higher than 75 cm; it decreases to 24–27 ppm in the depth range of 24–75 cm and to 2–3 ppm in the topmost (0- to 24-cm) layer. The appearance of butane in the gas component of the freshly contaminated soil is related to the

In the retained gas, the concentration of butane shows no clear trend: its profile distribution is determined by not only the location of the hydrocarbon source, but also the sorption properties of the soil. The maximum amounts of butane in the retained gas (more than 720 ppm) are observed at a depth of 45–75 cm, where the maximum oily impregnation and the highest compaction of soil are observed. The second maximum of butane concentration (about 140 ppm) is confined to depths higher than 100 cm. Oil in the pipeline was degassed to a wide extent; therefore, lighter hydrocarbon gases arrived into the soil in insignificant amounts.

Free and retained methane was the dominant gas in the old contaminated soil; its content almost corresponded to the background level (2–3 ppm). A single sample of free gas from a depth of 46–58 cm contained about 8 ppm butane and 0.2 ppm propane as traces of the former oil contamination. Thus, oil in the old contamination site was almost completely degassed and devoid of permanently evaporating light fractions for several decades.

The soil bitumoids of the background soils belong to the light type. The maximum value (up to 120 mg/kg) is found in the lowermost (140- to 145-cm) horizon. The bitumoid carbon makes up 0.1–0.2% of the total organic carbon with a maximum (up to 5%) in the lower part of the profile.

The content of PAHs in the soil is low and shows a clear tendency toward an increase in the upper and the lowermost parts of the soil profile: to 0.13 and 0.32 mg/kg, respectively. Naphthalene homologues prevail in the PAHs of the background soil (60–100%); diphenyl and fluorene are found in the upper horizons (up to 40%), and about 15% phenanthrene is present in the lower horizons. The maximum concentration of PAHs and bitumoids is found in the D horizon. This can be related to the the effect of light hydrocarbons from the lithosphere.

The proportion of bitumoid carbon in the total organic carbon of the freshly contaminated soil is very high: up to 40–80%. Bitumoids consist almost only of pure oil. Their concentration is in the range from 15000 to 85000 mg/kg and is distributed throughout the profile in accordance with the sorption capacity of soil horizons. In the D horizons composed by carbonate sands, a lower content of oil is retained: 8000–12000 mg/kg. Bitumoids are of the same (oily–tarry) type in all horizons.

The total content of the studied PAHs in the freshly contaminated soil increases compared to the other soils by more than 100 times (up to 95 mg/kg). Naphthalene homologues are mainly identified in the soil horizons with high oil contents; they make up 98–100% of the total PAHs.

The content of bitumoids in the upper part of the old contaminated soil is higher than in the background soil by an order of magnitude, but their content in the lower part of the profile is almost similar. The proportion of bitumoids in the organic carbon is higher than in the background soil by 2–3 times.

The composition of PAHs in the soil with old residual contamination is more diverse than in the soil of the background plot. Along with naphthalene homologues, diphenyl, fluorene, phenanthrene, pyrene, and chrysene are detected throughout the profile. Benzo[ghi]pyrene is identified in a horizon. Neither benzo[ghi]pyrene nor chrysene were found in the background soil.

Thus, despite the significant change all of parameters of the HCS of soils before the oil contamination, HCS of old contaminated soils are very close to the HCS of native soils. It is characterized by nonuniform trace accumulation of bituminous substances in the upper horizons of the soil profile. Lower horizons are affected probably by the emanations of the hydrocarbons from the deep geological horizons. As a result of this work the value of HCS of soils parameters which characterize the various kind of the hydrocarbons technogenic contamination were obtained.

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ACTIVITY CONCENTRATION OF RADIONUCLIDES IN NATIVE AND ANTHROPOGENIC SOILS IN ROSTOV AGLOMERATION

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The investigation of pollutants entrance into soil and the mechanisms of their accumulation and movement in soils help to reduce further detrimental effects on ecosystems (Bezuglova et al, 2016; Gorbov et al, 2015, 2016). The intensification of urban processes sets a necessity of indicators elaboration to assess the human impact on the soil cover. Inclusion of radionuclide activity in the monitoring indicators list is absolutely necessary.Moreover, it is important to implement comprehensive monitoring of soils, as the degree of load on the soil cover determines the change of physico-chemical properties of soil, which in turn affect the accumulation and migration profile of the radionuclides. The aim of this work is to study the radioactivity of native and anthropogenically transformed soils of Rostov agglomeration, as well as the study of the dependence of radionuclide content from the of degree of soil humus.

The objects of study were selected Urbic Technosol Molic (WRB) of Rostov-on-don and its satellites and also Calcic Chernozem (WRB) of recreation areas of agglomeration. Soils were divided into four groups: herbaceous and woody vegetation (native), as well as sealing and unsealing urban soils for objective results.

Average values of specific activity of natural radionuclides in the soil horizons, including sod horizons and parent rocks in native soil are at approximately the same level regardless of the type of vegetation (tab. 1).

Table 1 – specific activity of radionuclides in Calcic Chernozem

Radionuclide	Horizon	specific activity ± Error, Bq/kg		
		Minimum	Maximum	Average
Chernozem under grassy vegetation				
^{226}Ra	Ad	14,7 ± 1,5	38,9 ± 3,9	23,5 ± 2,4
	C	20,5 ± 2,0	28,1 ± 2,8	25,2 ± 2,5
^{232}Th	Ad	30,5 ± 3,0	33,3 ± 3,3	32,4 ± 3,2
	C	21,3 ± 2,1	34,6 ± 3,5	30,6 ± 3,1
^{40}K	Ad	427,0 ± 42,7	628,0 ± 62,8	490,5 ± 49,1
	C	326,0 ± 32,6	571,0 ± 57,1	425,4 ± 42,5
^{137}Cs	Ad	8,9 ± 0,9	11,3 ± 1,1	9,8 ± 1,0
	C	0,0 ± 0,0	0,0 ± 0,0	0,0 ± 0,0
Chernozem under wood vegetation				
^{226}Ra	Ad	14,7 ± 1,5	28,3 ± 2,8	23,0 ± 2,3
	C	13,3 ± 1,3	30,9 ± 3,1	25,7 ± 2,6
^{232}Th	Ad	23,6 ± 2,4	41,6 ± 4,2	32,1 ± 3,2
	C	26,2 ± 2,6	33,6 ± 3,4	29,5 ± 3,0
^{40}K	Ad	399,0 ± 39,9	643,0 ± 64,3	473,0 ± 47,3
	C	360,0 ± 36,0	562,0 ± 56,2	423,4 ± 42,3
^{137}Cs	Ad	17,0 ± 1,7	85,8 ± 8,6	34,5 ± 3,5
	C	0,0 ± 0,0	8,6 ± 0,9	2,43 ± 0,2

At the same time, the accumulation of artificial radionuclide ^{137}Cs was obtained in sod horizons with very low values in the parent rock. The cesium activity was increased in sod horizons of soils under woody vegetation in comparison with its activity in soils under grassy vegetation. This is due to the high content of humus in these soils (tab. 2) because the cesium is actively absorbed and delayed by the soil humus (Udintseva, Gulyakin, 1968).

Table 2 – the dependence of specific activity of ^{137}Cs by the content of humus

Chernozems	Horizons	^{137}Cs	Humus, %
1205 (under grassy vegetation)	Aarable	9,7	2,62
	A	2,2	2,22
	B1	0,0	1,48
	B2	0,0	1,14
	BC	0,0	0,68
	Cca	0,0	0,57
1203 (under wood vegetation)	Ad	21,3	4,22
	A1	2,7	2,68
	B1	2,8	2,34
	B2	2,4	1,65
	BC	3,5	0,97

In anthropogenically transformed soils, the ^{137}Cs activity values of of natural radionuclides also differ only by the magnitude of the error (tab. 3). As for ^{137}Cs, in shielded soils it occurs throughout the depth of the profile, in contrast to unshielded soils, where its activity approaches zero at a depth of 20-30 cm. Perhaps this is due to the fact that in shielded soils the processes of penetration into the soil layer of radionuclides are impossible and their migration along the profile is also difficult.

Table 3 – Specific activity of radionuclides in Urbic Technosol

Radionuclide	Horizon	specific activity ± Error, Bq/kg		
		Average	Maximum	Minimum
Urbic Technosol Molic				
^{226}Ra	UR	20,0 ± 2,0	31,7 ± 3,2	7,9 ± 0,8
	A	18,1 ± 1.8	29,4 ± 2,9	7,1 ± 0,7
	C	24,8 ± 2,5	33,6 ± 3,4	13,4 ± 1,3
^{232}Th	UR	27,7 ± 2,8	38,6 ± 3,9	11,2 ± 1,1
	A	38,2 ± 3,8	45,0 ± 4,5	32,9 ± 3,3
	C	32,1 ± 3,2	34,9 ± 3,5	29,6 ± 3,0
^{40}K	UR	436,8 ± 43,7	707,0 ± 70,7	257,0 ± 25,7
	A	487,7 ± 48,8	525,0 ± 52,5	440,0 ± 44,0
	C	417,4 ± 41,7	448,0 ± 44,8	379,0 ± 37,9
^{137}Cs	UR	6,4 ± 0,6	16,4 ± 1,6	0,0 ± 0,0
	A	0,0 ± 0,0	0,0 ± 0,0	0,0 ± 0,0
	C	0,0 ± 0,0	0,0 ± 0,0	0,0 ± 0,0
Ekranic Technosol				
^{226}Ra	UR	20,3 ± 2,0	30,4 ± 3,0	4,1 ± 0,4
	[A]	24,5 ± 2,5	33,2 ± 3,3	15,6 ± 1,6
	[C]	21,8 ± 2,2	28,3 ± 2,8	7,2 ± 0,7

^{232}Th	UR	26,3 ± 2,6	40,1 ± 4,0	0,0 ± 0,0
	[A]	29,6 ± 3,0	39,5 ± 4,0	15,0 ± 1,5
	[C]	31,4± 3,1	45,1 ± 4,5	9,2 ± 0,9
^{40}K	UR	412,3 ± 41,2	644,0 ± 64,4	110,0 ± 11,0
	[A]	455,2 ± 45,5	811,0 ± 81,1	208,0 ± 20,8
	[C]	515,5 ± 51,6	777,0 ± 77,7	123,8 ± 12,4
^{137}Cs	UR	1,2 ± 0,1	8,6 ± 0,9	0,0 ± 0,0
	[A]	0,7 ± 0,1	8,9 ± 0,9	0,0 ± 0,0
	[C]	2,0 ± 0,2	7,3 ± 0,7	0,0 ± 0,0

Thus, the behavior of radionuclides is determined primarily by their origin. The natural radionuclides were distributed relatively evenly in the soil profile. The artificial radionuclide accumulates in the sod horizon, thus indicating the source of the intake – atmospheric transport. There is a correlation between the humus content in the sod horizon and cesium activity.

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Technogenic geochemical evolution of chernozems in the sulfur coal mining areas

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Transformation of soil properties in sulfur coal mining areas is one of the causes of soil degradation, and it is considered as a factor of very active local alteration of soil cover. The most intensive mining of sulfur coal in Russia was carried out in the XIX-XX centuries in the densely populated Central economic region in the European part of the country (Novomoskovsk brown coal deposit). The deposit is located in the chernozems' subzone of the East European Plain under the northern forest-steppe. Now there is no coal mining in this area, but the existing waste heaps still have negative impact on the surrounding landscapes.

On the territory of the Novomoskovsk brown coal deposit destruction and degradation of chernozems is due to: (a) the output to the surface of large masses of rocks with high content of sulfides, mainly in the form of pyrite and marcasite; (b) the formation of rocks' subsidence over the coal pits, which leads to changes in surface topography and water regime of soils.

Waste heaps of the Novomoskovsk deposit are very heterogeneous in texture and mineralogical composition. The toxicity of the wastes is determined by the high content of sulfides (total content of sulfur can reach 9%). On the surface the waste heaps are exposed to rain and melt waters. Dissolved oxygen, in conjunction with microbiological activity, causes the active oxidation of sulfides. This process results in the converting of sulfide sulfur to sulfuric acid and iron sulphates ($FeSO_4$ and $Fe_2(SO_4)_3$). As a result, both the properties of the waste rocks and the composition of the waters filtered through the wastes change.

The complexity and heterogeneity of the material composition of waste rocks determines significant variation of all chemical indicators. For example, the content of organic carbon (of coal origin) ranges from 3 to 25%; the amount of water-soluble salts is from 0.7 to 3.5%.

Filtration waters, seeping through sulfide rocks of coal mining wastes, are of variable composition, very acidic (pH ranges from 2.2 to 3.0) and highly mineralized. The salts mainly comprise of aluminum and iron sulphates. Continuous and long-term (dozens of years) supply of filtration waters to the environment leads to substantial transformation of the geochemical properties of chernozems though they are quite sustainable to acid loadings.

Patterns of soil properties' transformation vary in space and time and are determined by:

(a) the distance from the source of exposure;

(b) the composition and mass of technogenic substances incoming to the soil;

(c) the dynamics of soil transformation processses (whether technogenic fluxes keep coming or they have stopped);

(d) the structure and composition of technogenic deposits and their impact on soils (alllocation on the surface in separate soil horizons and (or) admixture to the soil mass).

There are several different situations of technogenic transformation of the chernozems' soil profile in this area:

A relatively heavy technogenic deposit (> 50 cm) with specific chemical, mineralogical and particle size distribution has been already formed on the surface of the soil. Active incoming of the technogenic material stopped more than 15 years ago, so processes of primary soil formation at such sites can be traced;

Technogenic deposits on the surface of the soils are fragmentary, and the soil horizon (usually arable), overlapped by them, is mixed with technogenic materials;

There is no technogenic deposit on the soil surface, but there is a supply of mineralized and acid filtration waters seeping from the waste heaps. In this case, the structure of the soil profile generally matches the profile of the natural soils, but it has some specific morphologic features: carbonates disappear or the depth of their presence decreases; sinter films, composed of carbonaceous particles, are allocated; mealy dotty gypsum formations appear in the humus horizon.

Supply of waste materials to the landscapes (even if the process has already stopped) causes change in the qualitative composition and increasing salt concentrations in soils, influenced by the technogenic fluxes. The anionic part of aqueous extracts of contaminated soils is characterized by the domination of sulfate ion; practically there are no other anions (in natural soils hydrocarbonate salts prevail). Average content of soluble salts in natural chernozems leached (Voronic Chernozems Pachic (WRB, 2006)) and chernozems podzolized (Luvic Phaeozems Albic (WRB, 2006)) of the East European plain, usually does not exceed 0.1% (usually it is lower), while in the soils of the sulfur coal mining areas the content of the soluble salts can be significantly greater than 1%.

The specific feature of the newly formed salt composition of soils is the presence of soluble aluminum sulphate in appreciable concentrations (up to 2.2 mmol(+)/100 g) which is never observed in natural chernozems.

Subsequently, the following changes in the salinity status of technogenically transformed chernozems, depending on the secondary anthropogenic soil formation conditions, appear on this territory:

Desalinization of soils, occurring if seepage of filtration waters coming from the waste heaps terminates. Leaching of salts is higher in soils that occupy subsidences and therefore receive additional amount of water due to changes in runoff conditions. Loss of salts from the soils of flat surfaces with conventional moisture regime is some slower. In these cases, soil horizons with heightened contents of water-soluble salts retain for a longer time.

The increase in soil salinity. In this case, the additional salt loadings are generated due to connections with contaminated soils which are located upslope, or are the result of the continued income of saline waters from the waste heaps.

Incoming to soils of acidic technogenic fluxes with large amounts of aluminum and iron sulphates determines the appropriate changes in cation-exchange capacity (CEC). CEC is saturated by H^{+} and Al^{2+} that displace Ca^{2+} and Mg^{2+}. The singularity of the newly formed structure of CEC determines the emergence of unsaturated chernozems. The degree of unsaturation in the upper horizons, that are mostly transformed, can reach 50% and more. The most essential transformation of the CEC is inherent to upper horizons, taking the bulk of the pollutants. As a result of ion exchange the concentration of calcium sulfate in soil solution increases resulting in its deposition as gypsum.

As a result of the considered processes, the acidic saline and gypsified variations of chernozems leached and podzolized are formed in the soil cover of the northern forest-steppe of the East European Plain in sulfur coal mining areas.

So, in the forest-steppe landscapes of the East European plain, under the impact of technogenic fluxes from sulfide rocks' waste heaps, the chernozems with base-saturated soil are replaced by soil variations with properties that are typical for more humid soil formation (acidic reaction, availability of exchangeable hydrogen and aluminum) along with the specific features of arid soils (high content of easily soluble salts, as well as gypsum formations in soil profile).

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Emission and sink of greenhouse gases in urban soils formed on the buried landfill grounds

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Introduction. One of the city's problems is the formation of spontaneous landfill bodies, posing a threat to the environment due to grounds lithification processes, leading to the formation of filtrate and biogas. According to the Environmental Center, studied the gasgeochemical conditions of spontaneous landfill bodies in Moscow, 40% of these formations consist of dangerous and fire hazardous household waste, 43% - from potentially dangerous construction and household waste, and only 12% - from not dangerous construction waste (Environmental atlas of Moscow, 2000). Twenty years ago the city had about 900 ha of spontaneous landfill bodies, most of which are reclaimed now. But the danger of such objects remained, as many of them were buried and now they are sources of methane and carbon dioxide, which can accumulate in the soils and emit to the atmosphere.

The aim of this research is to identify the methane and carbon dioxide emission, sink of methane in urban soils, formed on made grounds containing fragments of landfill gas generating bodies, depending on the composition of the grounds, their thickness, the degree of flooding and sealing of the territory.

Materials and Methods. Most of spontaneous landfills has been concentrated in a part of city which is a sloping-hilly moraine plain strongly dissected by gullies and ravines. To a lesser extent they were formed on the dissected fluvioglacial and alluvial plains. The relief planning occurred during urbanization. As a result ravines and gullies were filled with a material containing construction and household waste. Urban soils formed in such areas were the objects of our study. The studied areas differed by gasgeochemical danger of buried landfill bodies, flooding the bulk thickness and the degree of sealing. They were divided into three groups, discussed below.

Soil, gas, emission and microbiological survey were carried out at the study sites. Samples of soil air were taken from the holes at a depth of 60-80 cm. The CH_4 and CO_2 emission to the atmosphere is determined by the static chamber method. Gas concentrations were measured by gas chromatography. The activities of bacterial formation and oxidation of methane in soils are determined by kinetic methods. Physical and chemical properties of soils have been analyzed by conventional methods.

Results and Discussion. The first type of objects is represented by soils formed on made grounds up to 10 meters with not flooded thickness and without sealing of the surface, located at the highest, initially most dissected by gullies and ravines city areas. The dependence of greenhouse gases content and the intensity of their utilization and emissions from gasgeochemical condition of buried landfill body, the thickness of the made grounds and from degree of their pollution by waste has been revealed. For example, the maximum methane content is ten times more, and the carbon dioxide content is twice more in the soils above gasgeochemical dangerous buried landfill bodies compared with potentially dangerous. Among the same type of landfill danger the largest soil methane concentration is observed in Urbic Technosols Transportic (UTT) on areas with the thickest (7-10 m) and most contaminated (> 25% of waste) made grounds with organic inclusions of wood, cardboard and buried humus soils horizon. At these sites we also found the highest activity of the bacterial methane oxidation at a depth of 60 cm (20 ng $CH_4/g{\cdot}h^{-1}$ or more), totally recycled methane in the warm months due to the formation of a very capacious biogeochemical barrier. In cold seasons without methane oxidation the highest CH_4 emissions to the atmosphere and increasing its concentration there may be at these sites. The maximum carbon dioxide concentrations in the soils and in the atmosphere are also typical for the areas with the thickest and most contaminated made grounds. In regions with the same thickness of made grounds, but without the inclusion of organic materials soil methane content in UTT is reduced by 2 times, methane oxidation activity is reduced by 10 times, the emission does not occur and concentration in the atmosphere falls. Likewise, content of carbon dioxide in the soil and in the atmosphere reduces. In areas without made grounds in Urbic Albic Luvisols all the features are minimal. The annual greenhouse gases emission to the atmosphere from the first type objects is 1,3 kg CH_4/ha·$y^{-1}$and 4830 kg CO_2/ha·y^{-1}, a total is 4860 kg CO_2 eq/ha·y^{-1}. The maximum sink of methane in soils is 3590 kg/ha·y^{-1}.

The second type of objects is represented by soils with signs of gley formed on the made grounds 0,5-6,8 m thick, with the periodic flooding of their lower layers and partially sealing of the territory. These sites are located on the fluvioglacial plains dissected by bottoms of the small rivers valleys and ravines. Gasgeochemical state of buried landfill bodies with construction and household waste is potentially dangerous and dangerous. Sealing determines the differentiation of the studied characteristics at these sites. In summer the highest methane concentrations in soils (5 ppm - 1,8%) is observed at the territories which are completely sealed and recently retired from this condition because of changing in land use. This is due to accumulation of methane migrating from gas generating layers, and formed in Ecranic Technosols under anaerobic conditions, high methane generation (more than 0,6 ng CH_4/g·h^{-1}) and the low oxidizing ability of soils (3-6 ng CH_4/g·h^{-1}). In case of asphalt destruction, for example, during the drilling, methane emits to the atmosphere with an extremely high intensity from 3 and up to several hundred mgCH_4/m^2·h^{-1}, thereby increasing the concentration in the atmosphere to 100 ppm. The carbon dioxide content in the soil air and in the atmosphere at these areas is also high (tenths of a percent). There is the much lower methane content (2,5-5 ppm) in Urbic Technosol Eutric Humic (UTEH) and in Urbic Technosol Folic (UTF) which surround the sealed parts. The bacterial methane oxidation activity increases here, sometimes significantly (more than 25 ng CH_4/g·h^{-1}). The sink of methane coming not only from the gas generating layer, but also due to the lateral transfer from the sealed areas occurs. Methane emission to the atmosphere is absent or poorly expressed (to 0,05 mg CH_4/ m^2·h^{-1}). The methane concentration in the atmosphere is not more than an average of 3 ppm. The carbon dioxide content in the unsealed soils remains high (tenths of a percent). Emissions to the atmosphere are significant at soils covered by lawns (300-1900 mg CO_2/ m^2·h^{-1}) due to respiration of roots and it's very low or absent at the UTT without vegetation, because of the CO_2 dissolution in humid conditions. In autumn the bacterial methane oxidation decreases in 1,5 times, and other parameters changes slightly. The annual greenhouse gases emission to the atmosphere from the second type objects is 1081 kg CH_4/ha·y^{-1} and 9540 kg CO_2/ha·y^{-1}, a total is 36450 kg CO_2 eq/ha·y^{-1}. The maximum sink of methane in soils is 4580 kg CH_4/ha·y^{-1}.

The third type of objects is represented by soils with signs of gley formed on the made grounds 5-17 m thick, but with stable flooding of their lower layers and without sealing of the territory. These sites are located on the slopes of alluvial plains, dissected by gullies and ravines. Gasgeochemical state of buried landfill bodies with construction and household waste is potentially dangerous with the possible pollution of groundwater. In a similar geochemical condition of buried landfill bodies the seasonal dynamics of bacterial methane oxidation, greenhouse gases concentrations in the soil and in the atmosphere are well expressed.

The methane content in UTEH, UTF and UTT is the least in summer (2-15 ppm). This is due to the maximum bacterial methane oxidation during this period (15,5 ng CH_4/g·h^{-1}). These values are lower than at the first type objects because of moisture increasing here, but are larger than at the second type of sealed objects which are characterized by stronger anaerobic conditions. Methane emissions during the summer there is no or low (up to 0,02 mg CH_4/ m^2·h^{-1}) and associated with autochthonous methane formation in soils (0,010-0,070 ngCH_4/g·h^{-1}). The methane content in the atmosphere is 2-3 ppm. The carbon dioxide concentration in soils varies up to 0,20%. Its emission to the atmosphere corresponds to the natural level and it slightly larger in soils with lawns (on average about 500 mg CO_2/ m^2·h^{-1}). High CO_2 accumulation in the atmosphere is not observed due to its use in the photosynthesis process.

Reducing bacterial methane oxidation activity at least 2 times in spring and autumn leads to a strong increase of methane concentrations in soils in these seasons. The average concentrations of soil methane in spring rise up to 70 ppm while varying from 2 to 400 ppm. They increased to 1100 ppm in the clay underlying grounds at a depth of about 5 meters under waterlogging and extremely low activity of bacterial oxidation. Low activity of bacterial methane oxidation (<10 ng CH_4/g·h^{-1}) is insufficient to utilization its flows. Weak emission to the atmosphere (0,02 mg CH_4/ m^2·h^{-1}) occurs from UTEH, the increased methane emission occurs from UTT (up to 2 mg CH_4/ m^2·h^{-1}). The methane concentration in the atmosphere above the UTEH is 2-3 ppm, and it increases above UTT to 2-5 ppm. The carbon dioxide content in the gas generating horizon at a depth of 5 m is an average of 0,58%, it is released rapidly into the overlying layers where summed with own gas. Therefore, the CO_2 content in the profile of UTT increases, and it is the highest (average 0,65%) in the UTEH with maximum methane oxidation. Emission of carbon dioxide to the atmosphere is lower than in summer (an average about 300 mg CO_2/ $m^2 \cdot h^{-1}$), but its concentrations there are very high (0,50-0,59%), as it has not actively used in the photosynthesis processes yet.

In autumn there is an even greater increase of soil greenhouse gases content than in the spring. This is probably due to stronger wetting during this season, slowing diffusion coupled with low bacterial methane oxidation. There is strong variation in methane concentrations from 4-5 ppm to tens, hundreds and several thousand ppm. Emissions to the atmosphere are connected with the soil concentrations (varies to 38 mg CH_4/ $m^2 \cdot h^{-1}$). Bacterial filter doesn't work practically. The greatest concentration of soil carbon dioxide corresponds to the points of maximum methane concentrations and it is 0,67-0,76%. At the rest territory the soil carbon dioxide ranges from 0,12 to 0,57%. CO_2 emissions are the lowest among the studied seasons (up to 115 mg CO_2/ $m^2 \cdot h^{-1}$); it's associated with waterlogging and decreasing of soil respiration. The annual greenhouse gases emission to the atmosphere from the third type objects is 396 kg CH_4/ha·y^{-1} and 20940 kg CO_2/ha·y^{-1}, a total of 30850 kg CO_2 eq/ha·y^{-1}. The maximum sink of methane in soils is 980 kg CH_4/ ha·y^{-1}.

Conclusions. Urban soils, performing ecological functions, prevent emission of greenhouse gases from gas generating buried landfill bodies to the atmosphere. The most effective methane utilization is in summer in automorphic soils, its emission to the atmosphere does not occur. The deterioration of soil aeration at flooding and sealing, cold temperatures reduce soil oxidative activity and increase the probability of methane emissions to the atmosphere. The carbon dioxide emission is connected with its generation in made grounds and soils, moisture conditions, soil and plant respiration.

Structure of pore space in humus horizons of urban soils

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Introduction. Ecological bases of the urban population life standards are closely related to the soil functions. The latter include absorbing solid, liquid and gaseous substances from the atmosphere; various products of megalopolis' metabolism, transformation and transport of the same. Due to their pore structure, humus soil horizons act as a kind of biogeomembranes. Tomographic methods of research offer great opportunities for studying the structure of pore space, which determines, first of all, the properties of humus horizons and the efficiency with which the soils perform their environmental functions.

Objects and methods of the study. The range of humus horizons of megalopolis soils is varied. They differ both in terms of their origin and formation mechanisms (natural, anthropogenically modified, introduced soils), and in terms of their structure, composition, and properties. Humus horizons of urban soils, on the one hand, inherit the properties of natural soils, and, on the other hand, are related to human activities. To investigate the pore space structure, we selected samples from a depth of 2–10 cm in the humus horizons of Saint Petersburg's soils in two functional areas (recreation and residential ones).

Tomographic analysis of soil samples was conducted using a Skyscan 1172 microtomograph in the "Geomodel" Resource Center of the Saint Petersburg University. Images were obtained under the following conditions: voltage on the tube = 100 kV, current = 100 μA, resolution: 5–6 μm, rotation angle = 0.5 °, averaging over 4 images.

The data for quantitative analysis of porosity were obtained with the help of the CTAn software (ver. 1.15.4.0+); the density distribution in the sample, the qualitative analysis of pore shape and distribution in a sample, the qualitative analysis of pores shapes and distribution in the samples were visualized with the help of CTvox software (ver. 3.2.0).

Results and discussions. The main results of the survey are shown in Tables and Figures 1–6.

Table. Characteristics of the pore space in humus horizons

No of the profile pit. No of the samples	Functional area. Soil	General porosity, %	Description
5. B10	Residential areas. Introduced grey humus soil	23.7	Mostly elongated channels with a diameter less than 1 mm
4. B31	Recreation area. Sod-podzol soil	53.5	Pores are unevenly, randomly distributed, oriented cracks with a width of up to 0.5 mm. A small number (up to dozen units) of channels with a diameter of up to 0.2 mm
9. B202	Recreation area. Agricultural soil	31.9	A large number of small cracks with a width of up to 0.1–0.2 mm. A small number of elongated channels with a diameter of up to 0.2 mm

7. B239	Recreation area. Grey humus stratozem	40.3	Pore space is formed by large cracks with a width of up to 0,8 mm. Single channels with a diameter of up to 0.2 mm
6. B273	Residential area. Introduced grey humus soil	25.3	Voids in the sample are represented by small cracks with a width of up to 0.15 mm
1. B296	Recreation area. Introduced grey humus soil	20.9	Predominantly elongated channels with a diameter of up to 0.3 mm. Cracks can be observed with a width of up to 0.2 mm

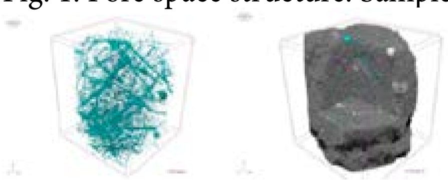
In terms of their shape, cracks in the samples investigated are divided into 2 main types: a) predominantly flat-shaped cracks, and b) round-shaped cracks surrounding inclusions of rocks and minerals. Probably, cracks were formed due to drying of samples.

Hollow channels were formed mainly due to degradation of the plant root system. This is evidenced by the ramified shape of some channels. It is possible that a part of such channels was formed by soil invertebrates.

Based on the data on quantification of open and closed porosity and the qualitative analysis and distribution of pores in the samples, all samples can be divided into 3 groups:

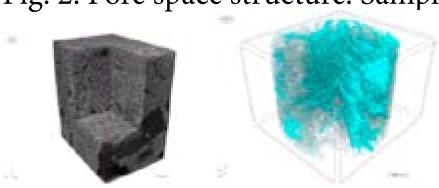
1. In samples No. 10 and No. 296, pore space consists essentially of hollow channels formed as a result of plant root degradation.
2. In samples No. 2 and No. 273, we can observe predominantly cracks with a width of up to 0.2 mm that form a system of intersecting flat-shaped and round-shaped cracks.
3. In samples No. 31 and No. 239, the main feature of the pore space structure is a system of large and round-shaped cracks with a width of up to 0.8 mm, and hollow channels with a diameter of up to 0.2 mm.

Fig. 1. Pore space structure. Sample B10. Profile pit 5.



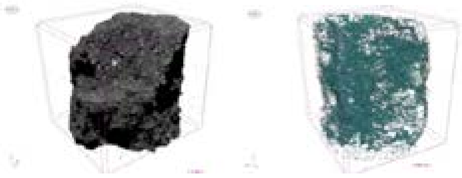
Internal structure Pore structure

Fig. 2. Pore space structure. Sample B31. Profile pit 4.



Internal structure Pore structure

Fig. 3. Pore space structure. Sample B202. Profile pit 9.



Internal structure Pore structure

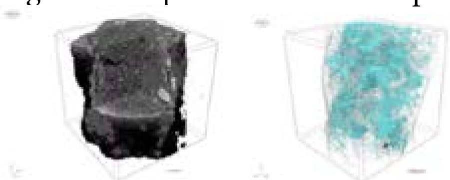
Fig.4. Pore space structure. Sample B239. Profile pit 7.

Internal structure Pore structure

Fig. 5. Pore space structure. Sample B273. Profile pit 6.

Internal structure Pore structure

Fig. 6. Pore space structure. Sample B296. Profile pit 1.



Internal structure Pore structure

Geographic specificity of soil cover of technogenic landscapes in Kuzbass

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Open-mining activity accompanied by the destruction of the soil and vegetation, disturbance of the natural topography, climate change and the removal to the surface large amounts of primary rocks. As a result, the new in their genesis landscapes with a specific relief, the climate and the composition of the parent rocks are formed. Currently, as a result of prolonged intensive exploitation of natural resources of Kuzbass amount of industrial waste is accumulated as hundreds of millions of tons, which occupy an area of about 100 thousand ha.

Any technogenic landscape has two phase in its development, they are technogenic formation and posttechnogenic development. At the technogenic phase the foundation skeleton peculiar landscape is laid for the posttechnogenic development: such as the main characteristics of the relief, the material composition and properties of rocks. At the posttechnogenic phase the formed basis of the skeleton is converted by the natural landscape-factors. Technogenic landscape is gradually transformed into a natural one. The length of time required for such transformation for each technogenic landscape is different. It is determined by the properties and modes of specificity frame framework laid down at the technogenic phase and by the features bioclimatic conditions of the area. In the extreme and very common cases it would take many thousands of years. Conversely, in the best possible but less common cases it is needed by decades.

The transformation processes of the landscape become natural despite anthropogenic nature of such basic factors of soil formation in technogenic landscapes as topography and soil-forming rocks, and as a result of the gradual transformation of supergene and the simultaneous development of the habitats formed biocenoses. The consequence of these processes is the formation of technogenic landscapes, soil and living communities.

The use of profile-genetic classification of soils [Kurachev, Androkhanov, 2002] for mapping the composition of the soil cover of technogenic landscapes of Kuzbass has shown that it is based on four types of embryozems: initial, organic-accumulative, sod and humus-accumulative. All these soils are soils of automorphic formation direction. Embryozems types of half-hydromorphic and hydromorphic formation direction occupy a small area. Because slope surfaces are dominated in the terrain of technogenic landscapes. The dominance of automorphic soil formation can be considered the geographic specificity, even in positions of trans relief. This specificity is firstly due by the fact that there isn't a constant horizon of the soil-groundwater at the technogenic landscapes of the Kuzbass, because of their relative youth, and it is secondly due by the strong stony soil-forming rocks, no aquitard in strong intralandscape drainage ensure their high filtration capacity.

Almost the same composition of the soil cover different bioclimatic zones should be considered as another geographical specificity of the soil cover of technogenic landscapes Kuzbass. Some of the differences there are only in the degree of prevalence of a particular type of embryozems. In particular the composition of the soil cover of technogenic landscapes in the mountain-boreal zone a large proportion of organic-accumulative embryozems are recorded than in forest-steppe and, consequently, a smaller proportion of initial, turf and humus-accumulative are recorded [Sokolov et al, 2012.]. This feature is due to the fact that embriozems are syngenetic reflect varying stages of succession phytocenoses being young biogenic soil formations. Stages of the succession phytocenoses in all areas are the same: from pioneer to complex closed communities [Androkhanov, 2003].

The genetic similarity of same type embryozems formed in the various zones suggests their morphological similarity. However, this does not exclude some differences and appearance, which are particularly noticeable in the composition and the nature of the organic substance in the organic horizons. For example, organic matter of humus-accumulative embryozems of boreal landscapes differ from those of forest-steppe zone by coarser humus. In the southern boreal it leads to the formation of even a particular type of embryozems coarse-humus-accumulative [Androkhanov et al., 2004]. In the northern boreal subzone coarse-humus-accumulative embryozems are gradually replaced peat-accumulative. In addition, sod embryozems begin to fall from the soil medium and northern boreal zones, it is very widespread in southern natural areas. The zonal differentiation of the composition of the soil cover of technogenic landscapes is quite clearly expressed, though not match those of natural landscapes. However, despite the differences in genetic structure of embryozems profiles of different bioclimatic zones, and in the composition of the soil cover, listed four types of embryozems are the most common and reflect the most important stages in the self-healing soil ecological functions in technogenic landscapes.

In morphological respect for all types characterized by a very small thickness of the soil profile (up to 30-40 cm) and a weak degree of morphological differentiation of the mineral part of the soil profile into genetic horizons [Androkhanov et al., 2004; Sokolov et al., 2015]. There is also a common feature of all embryozems types include the formation of a kind of oxidation zone in the upper part of the technogenic landscape rocks. Morphologically, this area is different from the underlying color of silt and a high degree of physical disintegration of coarse. Since the genetic affiliation of the oxidation zone to the horizons B and BC of embryozems is not always obvious, in some embryozems we distinguish it as a specific horizon C. Differ same types listed embryozems mainly on the morphology and genesis of biogenic horizons. In initial embryozems any organic horizons are absent; litter of wood or herbaceous origin must be present in organic-accumulative horizon; in sod litter can be absent, but one must have the sod; in the humus-accumulative is always a humus-accumulation horizon. Embryozems profiles difference recruitment and severity of organic horizons firstly reflects the leading role of biological processes in the formation of the soil profile, and secondly reflects the subordination of all other genetic profile-forming biological processes. Biological processes in embriozems are specific compared with those of normal soil. In the normal climax soils synthesis processes of accumulation, mineralization and humification of organic matter are balanced, and in the young soils, which are the embryozems, processes of synthesis and accumulation of organic matter clearly prevail over the mineralization and humification. For this reason the litter in embriozems persists much longer than in conventional soil, fine earth in the sod horizon is dyed little humus, and a nucleating processes are weakly expressed.

Thus, the specificity of embryozems formation is determined by the characteristics of biogenic processes. The prospects for the development of the latter are controlled by environmental conditions generated in the technogenesis phase. Ttechnogenesis rock formation (technogenic lithogenesis) is considered the most environmentally significant element.

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Influence of recreation on vegetation and the soil in the conditions megalopolis

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Forest parks play an important role in the maintenance of favorable ecological environment in cities. The recreational load increases with the growth of the cities that negatively influences forest parks. In the conditions of megalopolis the forest parks are exposed to atmotechnogenic deposition as well as to recreation. Quantitative data on the change of the main characteristics of various components in forest ecosystems at different levels of recreational load is necessary for forecasting the dynamics of the condition of forest parks and the choice of optimum control.

The purpose of this work is to comprehensively and quantitatively assess the change of indicators of vegetation, mesofauna, characteristics of ground litter and the change of physical, chemical and biological properties soils of forest parks in Moscow depending on the level of recreational influence. The research was conducted in the territory of two large Moscow forest parks: "Losinii ostrov" and "Bitsevskii forest", actively used for recreation. Fir-tree linden-forest on sod-podzolic sandy loam soils and oak-linden forest on sod-podzolic easy and medium loamy soils were respectively studied in "Losinii ostrov" in "Bitsevskii forest" (Album Retisols on WRB, 2014).

5 plots (25×25м) corresponding to the 5 levels of the recreational load determined by the area of footpath network were put in each forest park in the same geomorphological conditions in the watershed, in accordance with OST 56-100-95. At each plot geobotanical description of all tiers of the wood by traditional techniques was performed. For the characteristic of the trees condition the complex indicators by E.G.Mozolevskoy was used (2004). Illumination was defined by the photo-electric light meter Yu-117 at the level of the soil surface and at the height of 1.5 m with 36 multiple frequency at each trial square. The integral stability indicator of development small-leaved linden (PSRL) was determined by the size of the fluctuating asymmetry of lamina (Zakharov, Chubinishvili, 2001). Tackling of ground litter and soils (samples were selected from layers of 0-5, 5-10 and 10-20 cm) was carried out taking into account their biogeocenose space variability and irregularity of distribution of recreational load within the trial areas. Slightly disturbed "core" of forest ecosystems at the I digression stage (DS) was selected as the background. The characteristics of the ground litter, properties of soil and the condition indicators of soil invertebrates were determined by the conventional techniques in soil science. The statistical analysis of data was carried out on the basis of the "stratified sampling" made taking into account ratio of the areas of footpaths, near footpaths zones and the least disturbed core in each DS. Data processing was carried out in STATISTICA package. The chosen level of significance was 0.05.

According to the obtained data in the studied forest parks indicators of condition of the main components of the forest ecosystems depending on the recreational load level change the similar way. Distinctions in the character of vegetation and particle size distribution in the soils influence the extent of change of the studied parameters.

<u>The changes in the condition of vegetation.</u> The recreation impacts all the tiers of vegetation mantle. With the growth of its level (to the V DS) by 4-5 times the share of trees in the good condition decreases. In oak and linden forest of "Bitsevskii forest" more than a half of trees are in the good condition up to the IV digression stage, and in fir-tree linden-forest "Losinii ostrov" already at the III stage their share makes only 44%. It is attributed to the smaller resistance to recreation of coniferous breeds compared to deciduous breeds. The indicator of stability of development of linden is the highly sensitive indicator of change ecological conditions. It increases from 0,028-0,030 for the I stage of digression to 0,039-0,045 for the V digression stage. All stages of digression statistically significantly differ on average values of this indicator. As a result of deterioration in condition of the forest stand crown density of the trees decreases (from 70-80% to 20-30%). It leads to the increase in illumination which increases in forest parks by more than 30 times at the V digression stage. Its change affects the number of undergrowth and species diversity of herbs.

The abundance of underbrush at the digression stages I-IV is rather constant, and to V - sharply decreases (by 3-4 times). At the same time shade-enduring types disappear and filbert bushes expand. The abundance of shoots and undergrowth of trees increases (twice) at the average levels of recreational load, and at the high levels – sharply decreases for the mechanical damage.

At weak recreational load 9-11 species of the plants related generally to forest ecologo-cenotic group are allocated in herbaceous layer. At its average level owing to increase in variety of habitat conditions at average loading species diversity of herbs increases. This can be explained by the implementation of forest-meadow, meadow and weed types. The maximum quantity of species of herbs (23) is noted at illumination of 25%: in "Losinii ostrov" on III stage, and in "Bitsevskii forest" on the IV stage DS. Further increase in loading leads to decrease in species diversity of herbs.

The changes in condition of complex of soil invertebrates. Soil invertebrates form a very vulnerable component of forest ecosystems. Under recreation conditions, they are exposed to both direct influence, which is expressed in their mechanical destruction, and to mediated – as a result of change of habitat factors. On background sites the complex of soil invertebrates in the studied parks is characterized by close values of the main indicators. The density and the biomass are respectively 430-490 pieces/m^2 and 150-170 g/m^2 as an average. These indicators decrease by 2-2,5 times for the digression stage V. Especially strong oppression is experienced by litter mesofauna where the number and biomass decreases twice, already at the III stage, and at the V – by 4-7 times. Increasing the recreational load leads to decrease of the variety of soil invertebrates. In their structure the share of oligochaetes increases from 17-22 to 53-77% and the share of myriapods and insects decreases by 2-3 times.

The changes of ground litter and soils. Maximum load within plots is accounted for footpath soils. The load weakens when removing from them to "core". Therefore for correct evaluation of properties of soils at different digression stages stratified samples were compared. The results are shown in the Table 1.

The increase of load changes the ground litter type. At the first two digression stages they are humified, at the later stages – destructive. Litter stocks decrease by 1.4-1.5 time for the IV-V DS. In its particle size distribution as a result of crushing and mastication when trampling the share of active fraction decreases by 1.7-2 times, and the share of crushed fraction increases by 3.5-7 times.

The most noticeable changes of properties of soils are traced in upper mineral 0-5 cm layer. When the recreational load rises up to the digression stages III-V density, hardness, concentration of Corg, pH of water, electroconductivity the substrate-induced respiration of soils increase and the structure coefficient decreases. Going deeper, at the depth of 5-20 cm the influence of recreation on properties of soils is weakened.

Table 1. Characteristics of laying and property of soils at different stages of digression

Digression stage	**I**	**II**	**III**	**IV**	**V**
«Losinii ostrov»					
Sample size (n)	18	22	24	29	54
Underlayer					
Forest ground litter reserve, kg/m^2	1,31±0,19	1,66±0,45	1,47±0,42	**0,94±0,2**	**0,88±0,08**
Crushed fraction (< 1cm)., %	5,6±4,0	9,7±5,0	13,4±4,5	**15,2±3,3**	**19,1±2,8**
Active fractions, %	73,1±9,1	65,2±9,6	**55,9±8,0**	**51,5±6,6**	**43,6±5,9**
0-5 cm soil layer					
Density, g/cm^3	0,97±0,05	1,02±0,05	1,07±0,07	**1,18±0,06**	**1,25±0,05**
Hardness, MPa	1,10±0,33	1,80±0,36	**2,51±0,28**	**2,61±0,29**	**2,92±0,23**
Structure coefficient	3,92±0,38	**2,71±0,43**	**1,52±0,29**	**1,12±0,24**	**0,95±0,22**
Concentration of Corg, %	1,77±0,25	1,92±0,29	**2,56±0,39**	**2,62±0,26**	**2,92±0,38**
pHwater	4,26±0,16	**4,66±0,15**	**4,66±0,14**	**4,95±0,14**	**5,05±0,11**
Electroconductivity, mSm/cm	0,28±0,03	0,35±0,04	0,37±0,07	**0,46±0,08**	**0,56±0,1**

Substrate-induced respiration, μg C-CO_2/ml*h	7,95±0,89	8,42±1,59	8,44±1,87	9,63±1,07	**9,88±1,0**
«Bitsevskii forest»					
Sample size (n)	17	21	22	31	42
Underlayer					
Forest ground litter reserve, kg/m^2	1,05±0,15	1,18±0,29	1,15±0,18	0,95±0,15	**0,78±0,1**
Crushed fraction (< 1cm)., %	3,4±2,5	**13,0±3,5**	**13,5±4,1**	**15,3±3,6**	**23,9±4,4**
Active fractions, %	81,9±6,2	**60,1±7,4**	**59,3±7,5**	**56,7±7,3**	**38,9±9,3**
0-5 cm soil layer					
Density, g/cm^3	1,08±0,05	1,09±0,06	1,11±0,06	1,16±0,05	**1,29±0,05**
Hardness, MPa	1,8±0,37	2,50±0,33	**2,66±0,38**	**2,85±0,32**	**3,80±0,31**
Structure coefficient	4,88±0,45	**3,29±0,44**	**3,13±0,43**	**2,07±0,24**	**1,02±0,22**
Concentration of Corg, %	2,01±0,25	2,45±0,30	**2,73±0,22**	**3,1±0,40**	**3,29±0,41**
pHwater	5,2±0,09	5,26±0,10	5,33±0,12	5,37±0,10	**5,62±0,10**
Electroconductivity, mSm/cm	0,20±0,02	0,22±0,03	0,23±0,03	0,33±0,12	**0,48±0,12**
Substrate-induced respiration, μg C-CO_2/ml*h	5,62±0,77	5,99±1,17	6,47±0,96	**7,4±0,97**	**8,92±1,04**

*Note: **fat** - averages statistically significantly different from background (α=0,05).*

The obtained data confirm various sensitivity of soil properties to recreational load. As shown by the results of the step-by-step discriminant analysis the soils at different digression stages most greatly differ in the coefficient of degree of structure. Single influences of the other variables are small. Only their total contribution is important when soil discrimination for stages of recreational digression is considered. Instead five-step scheme we propose three-stage scheme to characterize the changes in the properties of soils parks under the influence of recreational load is proposed, since in latter case the proportion of correct classification for independent data increases to 75%.

Trace elements in soils and vegetables from market gardens of (peri)urban areas in Marrakech city

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Marrakech is located in one of the main agricultural area of Morocco. This region is characterized by a strong and rapid evolution of urbanization rate which heavily impact the quality of urban ecosystems and specifically urban and peri urban soils by inputs of metallic pollutants (El Khalil et al. 2008; El Khalil et al. 2013; El Khalil et al. 2016; Haut-Commissariat-au Plan 2017). The consumption of vegetables grown on soils polluted by heavy metals can cause a serious threat for animal and human health and disturb the functioning of ecosystem (El Hamiani et al. 2010; El Hamiani et al. 2015). The aim of this work is to determine the concentrations of As, Cd, Co, Cr, Cu, Ni, Pb, Mn and Zn in soils and different vegetables collected from 9 zones and 2 other zones located respectively in three different urban market gardens and two rural areas used as control (C). The three urban market gardens were located in and near Marrakech city. The first one is located near residential areas (UA1) irrigated by clean wells water. The second area was used for spreading of industrial and urban wastewater for many years (UA2). The third one was recently irrigated by wastewater (UA3).

The concentrations of Zn (40.82-131.43 mg kg−1), As (5.13 - 11.87 mg kg−1), Co (7.47 - 14.29 mg kg−1), Cu (18.88 - 40.95 mg kg−1) and Ni (12.93 - 27.07 mg kg−1) in the garden top soils were within the range of standard concentrations in soils, but Cr (23.6 - 86.09 mg kg−1), Pb (8.12 - 58.68 mg kg−1), Cd (0.18 - 0.36 mg kg−1) and Mn (361.89 - 825.67 mg kg−1) concentrations exceeded by two times the concentrations found in rural areas in the region.

The concentrations of Zn, Co, Mn and As in the vegetables were within safe limits. However, in UA3, Cd (0.4 mg kg−1) in cheese weed (Malva parviflora) and in turnip (Brassica rapa) (0.25 mg kg-1), Cr (20.10 mg kg−1) in Malva parviflora, and in Brassica rapa ; in UA1, Cr in lettuce (Lactuca sativa) and in cardoon (Cynara cardunculus) were high, reaching 40 times the value of standard limit in Coriander. The concentration of Ni in Coriandrum sativum (14.10 mg Kg-1), Cu (27.9 mg kg−1) in Brassica rapa (C) and in bean (Vicia faba) (UA3), Pb (15.68 mg kg−1) in Malva parviflora (UA3), were relatively high for vegetables according to Kabata Pendias (2011). In general, the highest concentrations of heavy metals were found in vegetables collected from the area currently irrigated by wastewater, followed by the zone previously used for spreading wastewater for many years and the zone irrigated by clean water comparatively to the rural area.

The soil-to-plant transfer factors (TF) for these 9 metals in edible parts of the 7 vegetables collected from the different zones varied between 0.01 and 1.35. The classification of plants according to their TF is as follows: Cu>Zn>Cd>Ni>Cr>Pb>Mn>Co>As. The maximum value was recorded in the bean (Vicia fabia) and the cheese weed (Malva parviflora) and the minimum value was recorded in turnip (Brassica rapa).

These results confirm that some vegetables can accumulate heavy metals in their tissues at high levels, exceeding acceptable limits depending on the concentrations of heavy metals in the soils. It may cause health risk for human population. Thus, the monitoring and prevention of environmental risks associated with gardening in (peri)urban and industrial areas are necessary and essential to propose recommendations both to gardeners and decision-makers.

Keywords: garden soils; wastewater; heavy metals; transfer factor; metal uptake; health risk

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Generation, sink and emission of greenhouse gases by urban soils on technogenic grounds at different stages of development of the floodplain in Moscow

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Introduction. Currently great attention is paid to the problem of growth of greenhouse gases'(GHGs) concentration in the atmosphere. Carbon dioxide and methane are the most important GHGs. Urban areas are an important source of greenhouse gases and produce 70% of total anthropogenic emission (Cities and Climate Change, 2011). If there is a stringent control of industrial emissions and vehicle exhausts (IPCC, 2006), the processes of formation, consumption and emission of GHGs from urban soils and grounds are still little-known. Rapid urbanization and expansion of city borders leads to development of new areas, e.g. floodplains with peat alluvial sediments. Technogenic grounds with domestic and construction waste are used for water table decreaseduring construction at these territories. Decomposition of organic matter in natural and technogenic grounds is a source of methane and carbon dioxide. Gases moveby pore space to overlying layers forming the near-surface gas anomalies, change soils' properties and release to the atmosphere. Intensive generation and accumulation of CO_2 and CH_4 into grounds may cause a fire and explosion risk for constructed objects. Gases'emission to the atmosphere changes the global balance of GHGs and negatively influences on people health.

The aim of this investigation was to study the gasgeochemical characteristics of soils on technogenic grounds, underlain by organogenic alluvial sediments at different stages of development of the floodplain of Moscow river.

Materials and methods. The study area was located in Moscow region in the floodplain of Moscow River. This territory was covered with technogenic grounds during land use engineering for water table decrease. Technogenic grounds are 2-7 meters of man-made heterogeneous loamy material with inclusion of construction and municipal waste (fragments of bricks and concrete, armature, wood, broken glass, plastic, polyethylene and others), underlain by alluvial sediments often with peat layers. Folic Albic Retisols (Cutanic) and Histic Gleyic Fluvisols were distributed on the floodplain before land use engineering. Urbic Technosols (Arenic, Transportic) and Urbic Technosols (Humic, Transportic) were formed after covering with technogenic grounds. Urbic Technosols (Folic) were created at adding of the fertile horizon with high content of organic matter during the improvement of territory after completion of construction.

Concentration of carbon dioxide and methane at 60 cm depth was determined using subsurface soil air equilibration tubes. CH_4 and CO_2 emission was determined by chamber method, CH_4 microbial production (MP) and oxidation (MO) - by kinetic method. Gas samples were analyzed at chromatograph. Physical and chemical properties of soils were studied by standard techniques (Vadyunina, Korchagina, 1986, Vorobieva, 2006).

Statistical data processing was carried out by using the StatSoft Statistica 10.0. The results are presented as mean±standard error.

Results. The main source of methane in natural soils is bacterial generation into soil profile. It occurs even in well-aerated soils due to the presence of microzone suitable for existence of anaerobic methanogenic bacteria, e.g. inside the soil aggregates. In aggregates microorganisms are situated depending on their needs of oxygen: anaerobes occupy the center of the aggregate, aerobic bacteria – peripheral zone (Smith, 1980; Stepanov, Manucharova, 2006). The ratio of anaerobic and aerobic microzone is regulated mainly by soil moisture and organic substrate available for microorganisms.

In Histic Gleyic Fluvisols microbial production of methane varies along the soil profile, decreasing from 0.18 $ng \cdot g^{-1} \cdot h^{-1}$ in upper horizons to 0.02 $ng \cdot g^{-1} \cdot h^{-1}$ - in lower. Activity of microbial methane oxidation also falls down the profile from 33.0 to 6.7 $ng \cdot g^{-1} \cdot h^{-1}$. Low methane oxidation activity in the lower layers is caused by low redox potential and lack of oxygen. Disbalance of methane production and oxidation leads to accumulation of methane in the profile to 10.5 ppm. Excess of CH_4 released to the atmosphere (0.11 $mg \cdot m^{-2} \cdot h^{-1}$).

Methane formation and oxidation cycles are closed in the automorphic Folic Albic Retisols (Cutanic). Activity of methane production is lower in order in upper humic horizon (0.07 $ng \cdot g^{-1} \cdot h^{-1}$), in lower horizon MP is equal (0,02 $ng \cdot g^{-1} \cdot h^{-1}$). Methane concentration is near 2.5 ppm. Emission of CH_4 to the atmosphere is absent or weak.

Carbon dioxide concentration at 60 depth is 0.30±0.02 and 0.25±0.01%, emission of CO_2 is 265.1±24.0 and 151.9±37.2 $mg \cdot m^{-2} \cdot h^{-1}$ from Retisols and Fluvisols, respectively.

Gasgeochemical condition of Technosols formed after filling the floodplain varies depending on the properties of parent technogenic grounds and flooding of the territory. CH_4 concentration in Urbic Technosols (Arenic, Transportic) and Urbic Technosols (Humic, Transportic) has a lognormal distribution with predominance of low values (the median is 2.65 and 2.90 ppm, respectively). If there are peat alluvial sediments under technogenic grounds CH_4 concentration in Technosols greatly increases (up to 1-2%) due to migration of gas from the lower layers. Content of methane in soils underlaying by organogenic alluvial sediments is significantly different that in areas where alluvium doesn't contain organic matter ($p<0.05$).

Flooding is often recorded as a result of violations of land use engineering technologies and increases activity of methanogenesis. Median activity of MP is 0.015 и 0.059 $ng \cdot g^{-1} \cdot h^{-1}$ in Urbic Technosols (Arenic, Gleyic, Transportic) and Urbic Technosols (Humic, Gleyic, Transportic), respectively. Maximum values reach 0.62 $ng \cdot g^{-1} \cdot h^{-1}$. There is a significant growth of methane production rate with increase of organic matter content in Technosols ($r=0.52$, $p <0,05$).

The biogeochemical barriers are formed in Technosols at 50-60 cm depth. Methane produced in soil profile (autochthonous) and migrated from lower layers (allochthonous) is oxidized by methanotrophic bacteria. Methane emissions are not predominantly observed. There are local increases of emission up to 2.9 $mg \cdot m^{-2} \cdot h^{-1}$ due to heterogenous distribution of municipal waste in the grounds.

Carbon dioxide content in Technosols varies greatly mainly depending on decomposition of organic matter under aerobic conditions. Average CO_2 concentration is 0,29±0,03%. Emission of carbon dioxide to the atmosphere from Technosols are smaller than from natural soils and equals 91,7±12,7 $mg \cdot m^{-2} \cdot h^{-1}$.

During accomplishment Urbic Technosols (Folic) are created on the lawns. Active methanogenesis (0.098±0.031 $ng \cdot g^{-1} \cdot h^{-1}$) occurs in Folic horizons with high content of organic matter (5.0±0.6%). Presence of the intra-aggregate production of methane stimulates methanotrophic microorganisms which exist on the surface of soils' aggregates.

Biogeochemical barrier is formed in Folic horizons of Urbic Technosols (Folic) where bacterial oxidation of autochthonous methane occurs and oxidation of allochthonous methane moving from lower layers is completed. MO activity reaches high values (46.9 $ng \cdot g^{-1} \cdot h^{-1}$). Thus, a system of biogeochemical barriers is formed in Urbic Technosols (Folic) on technogenic grounds underlain by alluvial, often organogenic, sediments: the first barrier – in Technic horizons at 60 cm depth where allochthonous methane is oxidized and the second barrier – in Folic horizons where autochthonous and allochthonous methane are oxidized together. Concentration of methane in soil profile is low (4.0±0.5 ppm), CH_4 emission to the atmosphere is not observed.

Migration of allochthonous carbon dioxide from natural and technogenic grounds, CO_2 generation during methane oxidation on biogeochemical barriers and mineralization of organic matter in Folic horizons lead to accumulation of CO_2 in soil profile to high values (0.38±0.02%, up to 0.9%) and significant increase of its emission (317.6±41.9 $mg \cdot m^{-2} \cdot h^{-1}$, maximum values are more than 1000 $mg \cdot m^{-2} \cdot h^{-1}$). As a result CO_2 concentration in the atmosphere reaches 0.25±0.01%, that exceeds the global background in order and is dangerous for human health.

Conclusions. Thus, in natural soils activity of bacterial methane oxidation is caused by methanogenesis and depends on the redox conditions. It is maximum in the upper humus horizons of Retisols and Fluvisols and decreased down the profile, that corresponds to distribution of methanogenesis activity in the soil profile. Emission of methane to the atmosphere is associated with disbalance of its microbial production and oxidation, and therefore appears mainly from Fluvisols. Retisols are the sink of atmospheric methane.

In Technosols methane production inside the soil aggregates stimulates its oxidation. As a result, biogeochemical barriers with high capacity are formed. In Urbic Technosols (Arenic, Transportic) and Urbic Technosols (Humic, Transportic) barriers are located at a depth of 60 cm and consume methane migrating from lower layers. In Urbic Technosols (Folic) a system of biogeochemical barriers are formed in Technic and Folic horizons. As a result of barriers' work the emission of methane to the atmosphere is not observed, but is an active generation and emission of carbon dioxide to the atmosphere.

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Geochemical features of formation urban and technogenic soils in Cryolithozone

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Abstract. One of the specific features of soil formation processes in cryolithozone, distinguishing it, including and from of the geological (geochemical weathering), lies in the fact that in permafrost soils is migration microelements only to a certain extent are regulated by living organisms, and in conditions of the harsh extreme continental climate of Yakutia predominantly by plants. The most important factor - the presence of frozen horizon in the soil profile, servant by aquitard and is forming a suprapermafrost geochemical barrier.

Objects and methods. The complex soil and geochemical investigations were conducted in Western and North-western Yakutia in the period 1994-2014. Per values of regional background were accepted statistically significant (n=1241) the mean geometric parameters of the content of microelements in soil cover of natural undisturbed landscapes by long-term data to our research and with the involvement of results of known geochemical surveys in region (Zinchuk et al. 2003; Yagnyshev et al. 2006).

Results and discussion. Formation of the modern soil cover of Western and North-western Yakutia is occurs on a background preceding period of prolonged denudation in result which at the level of modern erosional shear, a dominant position were acquired by carbonaceous rocks of early of Paleozoic. They act as a soil-forming of substrate, thereby determining the "carbonate" directionality of existing geochemical processes during of dominant position Ca-Fe-Mg of components of natural environments.

Soils are acquire characteristic of them content and profile distribution of microelements in the result of transformation of the original rocks of soil formation processes. So association of elements were marked in modern undisturbed soils of the study area, which reflect the geochemical specifics of sedimentary rocks of Ordovician and Cambrian, elements of typomorphic for kimberlites - Cr, Ni, Co, for dolerites - V, Cu, Pb and indicators-elements of influence waterbearing of highly mineralized of brines - Li, Sr .

High values of lithium, beryllium, titanium, chromium, cobalt, nickel, yttrium and niobium were marked relative of parameters of the background (Table. 1). Concentration ratios (CR) relatively of the regional background are varied in widely. Lithophil elements which mark the impact water-bearing of highly mineralized brines, as well as of rocks the basic structure Li, Be, Ti and the Y are present in the soil cover of the territory of study in high concentrations with a factor of 1.2 to 2.03. Group of chalcophile and siderophile elements typomorphic to kimberlites - Cr Co Ni - are noted in the soils of the study area with a sufficiently high concentration ratios exceeding the regional background from 2.5 to 10.9 times. Nb relating to lithophils and characterizing influence of rocks basic composition of territory with CR= 7.9 is allocated. It must be noted the existence of separate local areas of the location of kimberlite pipes of bang, confined, as a rule, to the zones the increased fractured, where are occur unloading on a day surface of highly mineralized brines, and are observed anomalously high concentrations of many of the studied chemical elements.

Thus, in the distribution of microelements in the soil cover are allocated its own distinctive features, reflecting the geological and geochemical specifics of the underlying rocks within the territory under consideration.

In the soil cover of the territory of a study on level of technogenic transformation are exists following various of soils: soils natural landscapes, anthropogenically transformed soils, which include, inter alia, and urban soils, formed in the city of Mirny, Udachny and in the settlement Aikhal, chemically-contaminated of the soils and technogenic surface formations.

Table 1

The total content of microelements in the dominant types of permafrost soils of Western and North-Western Yakutia (In the layer 0 - 30 cm)

Element, multiplier	Types of soil											
	Cryozem, homogenous humus gley		Cryozem, homogenous over-cryogenic gleyish		Cryozem, homogenous non-gley		Cryozem, thixotropic		Cryogenic soils, turf carbonate not fully developed		Cryogenicsoils, alluvial	
	n= 119	*CR**	n= 120	*CR*	n= 112	*CR*	n= 118	*CR*	n= 115	*CR*	n= 110	*CR*
Li, 10^{-3}	3,08	*0,4*	6,11	*0,7*	6,67	*0,8*	8,50	*1,1*	8,00	*0,9*	5,70	*0,7*
Be, 10^{-3}	0,25	*0,9*	0,26	*0,9*	0,31	*1,1*	0,25	*0,9*	0,24	*0,8*	0,25	*0,9*
B, 10^{-3}	1,83	*0,5*	1,89	*0,6*	2,50	*0,7*	2,50	*0,7*	2,50	*0,7*	2,00	*0,4*
P, 10^{-2}	3,42	*0,7*	3,74	*0,8*	3,92	*0,8*	3,00	*0,6*	4,50	*1,0*	4,00	*0,9*
Sc, 10^{-3}	2,83	*1,4*	2,58	*1,3*	2,83	*1,4*	1,50	*0,7*	2,75	*1,4*	2,00	*1,0*
Ti, 10^{-1}	4,20	*1,1*	4,58	*1,2*	4,25	*1,1*	3,50	*0,9*	5,50	*1,4*	3,40	*0,8*
V, 10^{-3}	7,50	*0,8*	6,82	*0,8*	6,60	*0,7*	5,00	*0,6*	3,75	*0,4*	7,30	*0,8*
Cr, 10^{-3}	6,83	*0,8*	7,07	*0,8*	5,96	*0,7*	7,50	*0,9*	4,00	*0,4*	8,00	*0,9*
Mn, 10^{-3}	13,17	*1,3*	11,84	*1,1*	10,08	*0,9*	8,50	*0,8*	10,0	*0,9*	11,70	*1,1*
Co, 10^{-3}	1,28	*0,3*	1,67	*0,4*	1,31	*0,3*	1,10	*0,2*	0,93	*0,2*	1,65	*0,4*
Ni, 10^{-3}	2,67	*0,7*	3,95	*1,0*	3,42	*0,8*	5,00	*1,3*	2,38	*0,6*	5,50	*1,4*
Cu, 10^{-3}	2,42	*0,7*	2,48	*0,7*	2,25	*0,7*	2,50	*0,7*	2,25	*0,7*	2,20	*0,6*
Zn, 10^{-3}	3,92	*0,7*	5,42	*1,0*	4,88	*0,9*	7,00	*1,3*	4,75	*0,8*	5,20	*0,9*
Ga, 10^{-3}	1,03	*0,7*	1,26	*0,8*	1,24	*0,8*	1,25	*0,8*	1,00	*0,6*	1,20	*0,8*
Ge, 10^{-2}	0,83	*1,0*	0,95	*1,2*	1,00	*1,2*	1,25	*1,6*	0,88	*1,1*	1,05	*1,3*
Y, 10^{-3}	3,75	*1,0*	4,16	*1,2*	4,54	*1,2*	4,00	*1,1*	4,50	*1,2*	3,15	*0,8*
Nb, 10^{-3}	0,67	*0,7*	1,03	*1,1*	0,83	*0,9*	0,75	*0,8*	0,87	*0,9*	0,80	*0,8*
Mo, 10^{-4}	1,33	*0,8*	1,29	*0,8*	1,42	*0,8*	1,50	*0,9*	1,50	*0,9*	1,60	*1,0*
Ag, 10^{-5}	1,08	*1,1*	0,82	*0,8*	0,67	*0,7*	0,50	*0,5*	0,75	*0,7*	1,05	*1,1*
Sn, 10^{-4}	1,17	*0,6*	1,87	*1,1*	1,83	*1,1*	2,00	*1,2*	1,63	*0,9*	1,80	*1,1*
Yb, 10^{-3}	3,33	*1,2*	3,42	*1,2*	3,33	*1,2*	2,50	*0,8*	3,13	*1,1*	2,75	*0,9*
Pb, 10^{-3}	0,70	*0,7*	0,68	*0,7*	0,66	*0,7*	0,50	*0,5*	0,58	*0,6*	0,72	*0,7*
Bi, 10^{-3}	0,50		0,53		0,63		0,50		0,50		0,50	

Note: * CR – concentration ratio relative to the regional background

Chemically contaminated soils are a particular case of anthropogenically-transformed types. Technogenic superficial formations - it is as a rule, soils of technogenically-transformed landscape of industrial sites - waste rock, tailings and others.

Of greatest interest with the ecological and geochemical point of view is migration of mobile forms of microelements in the soil profile. The spectrum of analyzed of microelements are selected from the calculation that Cr-Ni-Co - elements II class of hazard, typomorphic for kimberlites that form the natural geochemical anomaly and accumulation of which was noted in all components of the ecosystem territory of research. Cu and Mn - elements II and III class of danger, also related with kimberlite magmatism is actively accumulate in the contact zone of kimberlite pipes and the host rocks and characterize geochemical the specificity soils of Western Yakutia. Pb, Zn, As, Cd - are elements I hazard class, marked in high concentrations in within residential areas cities of Mirny, Udachny and of Aikhal settlement. (Legostaeva, Martynova 2011).

In the the surface horizons of soils in the study area are predominantly elements of iron group - Mn and Cu, which are accumulated by humic and fulvic acids of soil organic matter. And lead, which accumulates on the surface of urban and technogenic soils, especially on plots close to the residential areas (Table 2).

Table 2
The content of mobile forms of microelements in soils of Western and North-Western Yakutia, (mg/kg)

Elements	Regional background for mobile forms of microelements		In soils of natural landscapes		In urban and industrial soils	
	Content, n=75	%	Content, n= 122	%	Content, n=34	%
Cr	4,02	5,0	1,21	1,1	1,76	1,8
Mn	357,09	34,7	195,70	34,9	188,26	12,8
Ni	8,98	23,6	3,91	6,2	7,87	20,0
Cu	8,17	25,5	6,86	25,3	8,49	24,3
Zn	9,96	18,4	9,11	13,0	9,42	13,2
Pb	10,07	100,7	1,74	31,0	1,50	11,7
Co	4,45	31,8	2,90	21,0	3,59	26,2

In technogenic and nature soils affected by anthropogenic impact, is a redistribution in the composition of of the mobile forms of trace elements. And on the first place are act the elements typomorphic kimberlites - Ni and Co. The percentage content of mobile forms of almost all determined microelements also in general are increases.Therefore, at disturbance of of the soil cover, of the integrity of soil profile, of removal upper of organic horizon, "denudation" of mineral part of the soil profile are changed geochemical conditions, resulting in most of microelements goes into a mobile state - water-soluble forms, acid-soluble forms and etc. That is becomes more available to plants, including and wild herbs which are directly used as food, by soluble in water, which creates tension in the overall environmental situation on the territories of industrial influence, for example of mining and processing plants. Similar processes are going in the case backfill of surface, outing on surface material of parent rocks, which are mainly are characterized by prevalence finely dispersed of clay fraction and of increased content of associations Cr-Ni-Co and Cu-Mn, what is manifested in high concentrations of mobile forms of these elements.

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Variability of Infiltration Rates at Selected Bioswales in New York City

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Abstract

In New York City Green Infrastructure such as bioswales are designed to capture stormwater by diverting runoff from flowing into municipal sewer systems. Stormwater entering bioswales infiltrates into the subsurface, evaporates back into the atmosphere, or is retained in the soil. This reduces the burden on wastewater treatment plants during a storm and decreases the combined sewer overflow – which is the leading cause of water quality problems in New York Harbor. Infiltration rate is the most important measurement of a soil's capacity to capture stormwater for a green infrastructure system. Many factors can affect the rate of stormwater infiltration through engineered soils, such as sand content, compaction, plant root development, and fine sediment deposition at the surface. The objective of this study is to investigate the variability of infiltration rates and the factors controlling infiltration rates in these bioswales among twelve built sites in the Jamaica Bay Watershed. Infiltration tests will be conducted using three different types of infiltrometers, each serve different purposes. The double ring infiltrometer is used to measure infiltration rates under common flooding situations during a storm event; the amoozemeter is used to measure infiltration rates when the soil surface layer (0-5cm) is removed; and the Cornell Sprinkle Infiltrometer can be used to measure saturated infiltration rates but without ponding. The combination of these three different methods can help understand the degree to which surface soil and ponding depth control overall infiltration rates of a bioswale system. Data from these tests will be compared to double ring infiltrometer test rates measured during the first three years of operation (2011-2013). Preliminary results obtained in 2016 indicate a high variability for infiltration rates among different sites, within each site and for different types of infiltrometers. Results from this study can be used to inform design modifications and maintenance requirements that may be necessary in order to achieve and maintain optimal infiltration rates.

Biodiversity of bacterial communities in urban soils

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Urban soils are an essential component of the urban environment and significantly differ from the zonal natural soils in a number of chemical, physical and biological properties. This is reflected in the performance by important ecological functions of urban soils: the conservation of microbial diversity, the self-cleaning from pathogenic microorganisms, participation in the absorption and emission of greenhouse gases and many other properties.

The goal of our work was to give a characteristic of bacterial communities of urban polluted soils in the Moscow region, formed under the influence of different types of anthropogenic pollution by using modern methods of soil microbiology.

We researched samples of urbanozem of roadside areas (polluted by petroleum products, heavy metals), selected on the territory of Moscow near the main roads and intruzem (petroleum products pollution) on the territory of the petroleum depot (Kapotnya and gas station area), as well as kulturozem and replantozem on the Botanical Garden of Moscow State University (Lenin' Hills) and of the old Botanical garden of Moscow State University ("Apothecary garden", Prospect Mira).

Long term soil pollution by heavy metals and petroleum products (urbanozem and intruzem) did not significantly decrease the total number of bacteria (staining acridin orange), but few reduced content (%) of viable bacterial cells (staining L7012) comparing to undisturbed natural soils. The proportion of viable cells in the polluted soils was 55-60%, which is slightly lower than in the undisturbed natural soils (65-70%) (Lysak et al., 2009). This demonstrates the high stability and the adaptive capacity of a large part of the soil bacteria to the action of environmental factors, like heavy metals and petroleum products.

In urban soils polluted by heavy metals and petroleum hydrocarbons, the number of small (< 0.2 mcm) filterable forms of bacteria was comparable with the number of filterable bacterial forms in natural soils and amounted to about 50 million cells per 1 g, but they were higher content (3 – 10 times), than in natural unpolluted soils of the same natural zones (Lysak et al., 2010). The study of the potential viability of filterable forms of bacteria indicates a high potential viability of small cells (85 - 92%) than among the bacteria of normal size (55 - 60%). The high content of filterable forms of bacteria in urban soils (pollution heavy metals and petroleum hydrocarbons) confirms the hypothesis of the transition the bacteria in such a state as a possible mechanism of preservation of cell viability in adverse environmental conditions.

Using electron microscopy studies confirmed the presence of filterable forms of bacteria in the urban soil suspension filtrate (Soina et al., 2012). It can be assumed that some small bacterial cells are in resting cyst-like state. There are no signs of division, revealed the presence of large capsule layers, the structural state of the membrane and the cytoplasm, typical to dormant forms of bacteria.

The taxonomic structure saprotrophic bacterial complex (level of genera) was studied on glucose-peptone-yeast agar. By researching taxonomic structure of bacterial complex in urban polluted soils revealed that in urbanozem with different types of pollution bacterial communities have specific features and differ from the natural undisturbed soils. Saprotrophic bacterial complex strong polluted soils manifested in the redistribution of bacterial taxa in favor of increasing the proportion of bacteria that are adapted to certain types of pollution: genus Rhodococcus – petroleum products, polychlorphenols, genus Arthrobacter – cement dust, genus Bacillus - heavy metals, family Enterobacteriaceae – complex household pollution. Such changes should be regarded as indicative. There is the accumulation in polluted urban soils potentially pathogenic (many genera and species of the family Enterobacteriaceae), and allergenic bacteria (some species of the genus Rhodococcus and Micrococcus). This fact testified about a violation of the ecological functions of soil as "bacterial filter" and may represent a danger to humans.

The study of soil bacterial communities of Botanical gardens in the territory of Moscow ("Apothecary garden", Prospect Mira and Botanical Garden on Lenin' Hills), revealed that the main genetic horizons kulturozem and replantozem were characterized by the total number of bacteria (staining acridin orange) and bacteria of saprotrophic bacterial complex (glucose-peptone-yeast agar) over the investigated profile (Rozanova et al., 2016). Down the profile there was revealed a slight decrease in the number of bacteria, the high number of bacteria fixed in buried soil horizons. This feature distinguishes garden soils from the natural undisturbed soil of the same natural zones, where there is quite a sharp fall in the total bacterial quantity and generic diversity down the profile. The garden soils are characterized by active development of cellulolytic bacteria throughout the profile. This fact is connected with favorable terms of the botanical garden for plants, and reflects the dynamic process of organic matter decomposition (Rozanova et al., 2016). There was also a significant species diversity of Bacillus and bacterial penetration inherent in the upper horizons, down the profile. A significant diversity of bacterial complexes in the buried horizons replantozem and kulturozem and can be considered as one of the optional feature botanical gardens offering protection not only plants, but also the bacterial pool.

Results of the study of the integral (the number, the viability of the bacteria and the share of filterable forms) and differential characteristics (the structure of the saprotrophic bacterial complex) show significant transformations of bacterial communities in urban polluted soils, which affects the implementation of the ecological functions of soils and can be used for bioindication of anthropogenic influences.

Under the influence of anthropogenic factors in urban soils (pollution with heavy metals and petroleum products) are significant transformation of the bacterial communities of the soil, which manifest themselves in a change in size, physiological condition (decrease viability, increase in the content of filterable forms of bacteria) and taxonomic structure of the bacterial complexes, the appearance of bacterial taxa inherent natural undisturbed soil. The soils are formed in conditions of prolonged agricultural practices (botanical gardens) are characterized by high quantity and other specialized distribution of bacteria in comparison with natural undisturbed soils. Structure saprotrophic bacterial complex shows similarities with the soils of more southern regions. Urban garden soils require particularly careful treatment of it as performing the function of the preservation and maintenance of microbial diversity, especially in the buried horizons

In polluted urban soils as compared with the natural undisturbed soils microbial community changed significantly. They are characterized by a decrease in the content of viable bacteria cells and differ from community undisturbed zonal soils ratio range of potential dominant. In soils polluted petroleum products and polychlorphenols potential dominant is genus Rhodococcus, complex household pollution – genera of family Enterobacteriaceae (Escherichia, Enterobacter, Klebsiella), the cement dust – genus Arthrobacter. In urban soils (heavily metals pollution) trend of accumulation of hazardous bacteria to humans - potentially pathogenic (genera of Escherichia, Enterobacter, Klebsiella, Alcaligenes) and allergens (genus Rhodococcus, Micrococcus) (Lysak, Sidorenko, 1997; Lysak et al., 2000).

The data on the change of the integral (the number, the viability of the bacteria, the proportion filterable forms) and differential characteristics (the structure of the saprotrophic bacterial complex) indicate a significant transformation of bacterial communities of urban contaminated soils, which affects the performance of soil ecological functions and can be used for bioindication of anthropogenic influences.

The results of the study of the specificity of formation and functioning of bacterial communities of urban soils are of great interest not only from the point of view of fundamental science, but also in practical terms, owing to the important role of bacteria in the preservation and sustainability of urban ecosystems, the management of the important ecological functions of the soil, using the properties of the "key " bacterial populations in biotechnology. Studied patterns enable to outline approaches to management of important populations of soil organisms to preserve the "health" of the soil and prosperous population living in urban ecosystems.

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Effect of organo-mineral amendments and inoculation with Plant-Growth Promoting Rhizobacteria on growth of Ryegrass on the Kettara mine tailing

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Mining sites (e.g. Kettara mine in northwest of Marrakech, Morocco) constitute a major source of metallic contamination that can potentially cause health risks as well as disturbances of the dynamics and functioning of ecosystems (Boularbah et al. 2006a, b; Benidire et al. 2016). Phytoremediation, is an emerging technology used for revegetation of soils contaminated by heavy metals. However, using plants alone for bioremediation is subjected to different constraints such as high metal content, acidic pH and low nutrient content. Thus, the application of organics and minerals amendments could constitute an effective method to reduce the effect of those environmental stresses (Pardo et al. 2014). Moreover, the application of plants growth promotion rhizobacteria (PGPR) which tolerate heavy-metal in association with plants called metallophytes may decrease the availability of contaminants and promote plant growth under stressed conditions (Dary et al. 2010).

The objective of the present study is to evaluate the potential effect of organo-mineral amendments and inoculation with rhizobacteria on the growth and development of ryegrass on Kettara mining tailing.

Due to the highly acidic condition of tailing, before any treatment, we have mixed the mining waste with agricultural soil in equal proportions (½ agricultural soil, ½ mining waste). The mixture obtained was then amended with compost at 10% and with natural phosphate at 6% or by lime at 3%. Subsequently, we carried out ryegrass cultures on these treatments inoculated or not (control) with *Tetrathiobacter kashmirensis* BKM20 and *Mesorhizobium tamadayense* BKM04. These two bacteria were chosen among forty bacteria isolated from the rhizosphere of the main metallophyte plants growing on the contaminated soil of Kettara mining site for their ability to tolerate high metal concentrations and their plant growth promoting traits (Benidire et al. 2016). All cultures were carried out in vegetation vase under controlled conditions.

The evaluation of the efficiency of amendments and PGPRs was carried out by physicochemical analyzes, biological analyzes and by the determination of the plant biomass.

Results of the physical and chemical analyzes showed that addition of amendments to the mixture (½ agricultural soil, ½ mining waste) increased pH values significantly (4.7- 6.42), organic matter content (0.18-1.09 %) and available phosphorus content (0.16-0.72 mg Kg^{-1} of dry soil). The inoculation with T. *kashmirensis* BKM20 was also significantly increased ($p < 0.05$) assimilable phosphorus content (0.14 mg/Kg – 0.20 mg/Kg) and organic matter (1.13- 1.55%) compared to the uninoculated control. However, M. *tamadayense* BMK04 strain showed no significant effect on physicochemical characteristics. The highest assimilable phosphorus concentration was observed after inoculation with a mixture of the both strains (0.27 mg/Kg), which was significantly higher than individual inoculation ($P < 0.05$).

The improvement of physicochemical properties of tailing by the organic and mineral amendments lead to an increase in urease, dehydrogenase and phosphatase activities as well as growth and development of ryegrass. The incorporation of amendments have significantly increased urease activity (<detection limit value-18.22 µg NH_4-N / g dry soil / h) and dehydrogenase activity (<detection limit value-34.58 µg TPF / g dry soil / h). On the other hand, these activities were significantly more improved after inoculation with PGPRs. Individual inoculation with T. *kashmirensis* BKM20 strain was increased urease and deshydrogenase activity by 1.24 and 2.5 fold respectively compared to the control. The inoculation with M. *tamadayense* BMK04 exhibited the same tend with an increase in urease activity by 1.61 fold and déshydrogénase activity by 2.0 fold compared to the control. Furthermore, the results showed that the inoculation with the mixture of the both bacteria improve significantly the urease and déshydrogénase activity reaching 2.9 and 2.73 fold respectively compared to the control.

In comparison to uninoculated control, results showed that shoot biomass of rye-grass were improved significantly ($p < 0.05$) by up to 1.14 fold after individual inoculation and by 1.16 fold after inoculation with mixture of both two rhizobacteria. Furthermore, the maximum root biomass produced was obtained in the presence of inoculation and was 1.33 fold higher after individual inoculation and 1.46 fold higher after inoculation with mixture of both rhizobacteria.

This work showed that the treatment of mining waste by organo-mineral amendments and the inoculation of plants with PGPRs could be used as tool for the phytostabilisation of metals contaminated mining waste.

Key words: Mines, Tailing, heavy metals, organo-mineral amendments, PGPR, Phytostabilisation.

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Sustainable development of forest ecosystems in cities as a way of wildfire control in Russia

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Wildfires are the most dangerous exogenous violation of natural ecosystems in Russia. Climatic changes of the last decades significantly increase a threat of forest fires. Weather variability significantly increases, which is expressed in the alternation of showers and long warm and dry periods, sometimes with a heat wave, like in the summer of 2010 at the center of European Russia. Such specifics create a threat of forest fires high, especially of high severity, so-called catastrophic wildfires. These fires result in serious ecosystem degradation, cause considerable damage to the economy and infrastructure and also negatively influence on living conditions and population health in the regions of wildfires distribution.

Wildfires are one of the most serious unsolved problems of Russian forests. The fact that they cause a huge damage is recognized even by a management of the federal agency that is responsible for forestry (Federal Forestry Agency). The forest resources of Russian Federation are under authority of three ministries – Natural Resources, Agricultural Industry and Defense. Therefore it is these ministries that should pay special attention on forests conditions and fire conditions.

The maximum density (frequency) of wildfires is characteristic for densely populated regions of European part of our country (fig. 1), and the maximum percent of area affected by fire is be accounted for by multiforest regions of Siberia and Russian Far East with poorly developed infrastructure (fig. 2) [1].

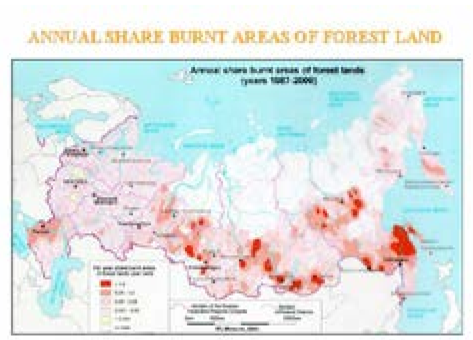

Figure 1. Number of wildfires in different regions of Russia

Figure 2. The share of the burnt forest area

Abnormally dry and hot 2010 year has provoked numerous forest fires across the European part of Russia: there was 34.8 thousands of wildfires, which have passed 2.0 million hectares of forest area, in July and August in Russian Federation. It has become a global environmental disaster as it has completely changed a functioning of forest ecosystems.

Especially complicated situation was in Samara region near Togljatty city. According to Uniform interdepartmental information and statistical system data a sharp increase of number of wildfires (tab. 1) is observed in 2010 in comparison with 2009 and 2011. About 1.5 thousands (20-25%) from 8475 hectares of city forest vegetation were destroyed by wildfire in July-August near Togljatty city. It became a local environmental disaster as completely changed functioning of forest ecosystems. How it was? Regular surface fires were taking place in June-July of 2010 in the city forests of Togljatty. Separate crown fires were beginning to appear at the end of July in certain places. People are forbidden to be in city forests of Togljatty on 30th of July, 2010 according to the resolution of the mayor of Togljatty, and the city situation was became extraordinary. Then the situation begins to develop in a way that there were no light and water in houses on 31th of July in Portposelok and mobile communication was not work. Together security service and population coped with wildfires in Togljatty city by 9th of August: the open fire sources were not revealed.

Table 1. Number of wildfires in 2009-2014 according to Uniform interdepartmental information and statistical system data

Region	2009	2010	2011	2012	2013	2014
Russian Federation	23245	34812	21074	20238	10249	17058
Moscow region	548	2332	475	55	28	47,4
Leningrad region	237	265	250	92	143	504
Samara region	511	792	38	39	32	63

According to Federal Forestry Agency a damage from wildfires in Togljatty city of 2010 was 85.5 billion rubles. It exceeds expenses of the federal budget on forestry in more than four times. Probably Federal Forestry Agency data of a wildfires damage are repeatedly underestimated; it takes into account only direct losses of forest resources, but doesn't consider losses of environmental-forming and natural values by forests and especially doesn't consider a damage caused by fire and fume to life and human health.

Wildfires 2010 in Togljatty city resulted in deterioration of ecological situation in the city - a fire has destroyed the whole forest ecosystem. The soil as an integral part of forest communities is influenced by diverse effects of wildfires.

There were 35 wildfires during fire danger period 2010 in forests within the boundaries of Togljatty city. A total area affected by fire was 2087 hectares. According to results of forest pathology survey carried out on 2665.7 hectares area, it has been suggested to carry out the following activities: sanitary final harvesting – 1059.6 hectares, selective sanitary harvesting - 791.6 hectares, wastes cleaning – 470.9 hectares [2].

Forest areas in Togljatty city belong to forest-steppe zone, where boreal forests are in contact with south of forest-steppe ecosystems.

A tree layer survived after surface fires, but the fire damaged trunks in different degrees. Herbaceous and shrub layers have more suffered by wildfires, however, they have not completely burned, but some areas remained unaffected by fire.

A different picture is in forest communities affected by crown fire. Tree layer has completely burned, as well as herbaceous and shrub layers, spontaneous postpyrogenic successions began there.

Cut-down and fell burned trees are laying on a surface in some places, and nobody is going to remove them and use it in some kind of industry.

A reforestation is planned on a damaged territory of city forests in Togljatty city of more than 700 hectares. Works of reforestation are conducted by 19 contract organizations on the territory of the Togljatty city forests. In 2010-2011 forest planting was carried out on the 85 hectares area. In 2012 spring planting was carried out on the 56 hectares area, in autumn – on 295 hectares area. 250 hectares of city forests were cleared for restoration at the moment [2]. However, there are huge territories which are not even prepared for planting and still someone burns out debris.

Funds for purchase of transplants, soil preparation, planting and agrotechnical tending are allocated from the Samara region budget [3].

However, natural forests regeneration is preferable since vegetation close to undisturbed ecosystems is formed in this case. These plant communities will be more tolerant to local ecological and climatic conditions, and diversity will be higher, than in case of communities that will be created by human.

Catastrophic wildfires in urban forests of Togljatty city have led to a formation of pyrogenic-transformed soils in 2010, these soils significantly differ from unburned according to morphological characteristics and basic chemical and physical properties.

The first stage of vegetation restoration after wildfires is a distribution of ruderal vegetation. Tree and shrub vegetation begin to develop later due to natural regeneration.

Pyrogenic processes are widespread phenomenon, that has a huge impact on soil formation processes, and that fact makes to pay special attention to the study of natural ecosystems. A significant amount of publications are devoted to wildfires role in the natural dynamics of forest cover, since wildfires are the most powerful environmental factor among other factors that determine forests structure and dynamics and also the ecological state. Meanwhile, a problem of post-fire soil formation occasionally attracts the attention of scientists, and it is necessary to recognize that this is happening less frequently. Fire destroys soils and forests for a moment, but nature is restored for years, decades, centuries. Therefore, the results of postfire functioning of forest soils studies in relatively homogeneous climatic and geological and geomorphological conditions are of a great interest for an objective environmental assessment of forest ecosystems current state. It is important for understanding ways of forest ecosystem components recovery dynamics and for prediction of their condition at different pyrogenic impact. Thus, postpyrogenic soil formation is an interesting model for soil and vegetation recovery after catastrophic natural impacts studying. Carrying out a monitoring of postfire areas and predicting what will happen to our soils in future, we will be able to save correctly our forest resources, to create conditions for sustainable development of forest ecosystems and to carry out measures to prevent the loss of land productivity.

A problem of wildfires fight is difficult, comprehensive and very actual. Unfortunately, government is unable yet to cope with the situation arising annually during the fire-dangerous period. A decision of this problem requires involvement and cooperation of specialists in various disciplines such as ecologists, foresters, economists, firefighters, specialists in preserving a biodiversity and health protection, etc.

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Urban biological soil crust: a case study from pedestrian zones and building foundations in Moscow

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The Moscow city has experienced recently a tremendous reconstruction and expansion of pedestrian areas with the new stone pavements established. They represent a vast area of exposed natural hard rock mainly of granitic origin or concrete paving slabs both ready for establishment of biological soil crust. Along with heterotrophic component the biocrust comprises various combinations of cryptogamic and microbial photoautotrophs "pumping" the newly established substrates with organic carbon in epilithic, endolithic and hypolithic ecological niches.

Various types of microbial biofilms and cryptogamic biocrusts formed in urban environment have been extensively studied worldwide in terms of biodeterioration of cultural heritage objects such as monuments, memorials, churches, etc (e.g. Gorbushina et al. 2002; Scheerer et al. 2009). In Russia it is the St. Petersburg city that has received during last few decades the most of research activities addressing biodegradation and conservation of stone surfaces (e.g. Panova et al. 2016). Biological soil crust in general has also attracted a lot of in interest in various regions of the planet with natural extreme environment (Weber et al. 2016). In urban areas the biomimicry exercises comprising greening of roofs or even facades are the main focus of application of cryptogamic soil crusts concept (e.g. Lundholm 2006), however naturally occurring biocrusts on the stone pavements and building foundations are far less studied (Rindi 2007) especially in terms of associated soil-like profiles.

The area of stone surfaces on the streets of contemporary cities including Moscow (especially in pedestrian zones) is dramatically increasing due to implementation of the new principles of friendly urban environment. Following this trend we expect the new habitats for biocrust to appear along with the well-studied ones on the cultural heritage objects and common buildings. Besides that the pavements contain vast and regular network of inter-block pore spaces filled with autochthonous but mainly allochthonous fine earth conductive for pedogenic processes. Unlike sealed soils under asphalt the pedestrian stone pavements including underlying bedding are much better permeable for elements and energy flows. The change from the asphalt to the patchy stone pavement leads to 2-15% increase in the spatial share of loose soil-like bodies or even initial soils. However the stone surfaces still represent extreme conditions for biota caused by lithological factor and also the impact of trampling, reagent treatment, regular cleaning of the surface, and other factors. The surfaces in many urban habitats are exposed to full sunlight and organisms growing on such surfaces are often subjected to extremely high light irradiance, elevated UV radiation and dehydration (Rindi 2007). Thus, opportunistic biological soil crust including simple varieties like cyanobacterial biofilms adapted also to various extreme environment are the first to establish far in advance to vascular plants. Even in the heartland of anthropogenic activity – the cities – the newly established surfaces will be occupied firstly by the most ancient communities of the planet (cyanobacterial biofilms), just like in many other cases of initial soil formation.

The main objective of this study is to reveal diversity, distribution and composition of soil-like bodies with microprofiles (soloids) formed under various types of biological soil crusts on the stone pavements of pedestrian zones and foundations of buildings in Moscow, both in the pore space of consolidated substrates (granites, concrete), and the inter-blocks space of pavement filled with fine earth. We studied pavements of pedestrian zones which represent several time series according to the year of their construction starting from 2005 (residential areas in Kurkino district), 2010-2014 (central district) and up to 2015-2016 (recent renovation of Tverskaya and adjacent streets). We also studied biological soil crust on granite building foundations established in 1950 and 1954. The first data on spatial distribution, microprofile structure, meso- and submicromorphology, carbon and nitrogen content of soil-like bodies formed under various biocrusts (bryophytic, cyanobacterial) at stone pavements and building foundations will be provided in the presentation.

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Ecological and geochemical assessment of soils in vicinities of the solid waste landfill

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Keywords: *solid waste, Luvic Chernozem (Novic), microbiological soil indicators, heavy metals contamination, ecological and geochemical assessment*

Introduction. The problem of regulation of the solid waste is considered to be one of the most vital in the world. In the system of municipal economy it takes the second place on cost and investment after water supply and sewerage system. According to the figures of the Russian Ministry of Natural Resources the bulk of the municipal solid waste is transported to landfills, 7% and 2,4% of the total waste is recycled at recycling and incineration plants accordingly. In spite of the fact that in Russia the system of legislation in the field of waste regulation is relatively developed (Yakovlev, 2007), many solid waste landfills do not correspond to the environmental and sanitary requirements due to the current implementation of the technology of waste deposit. Many of them were established without taking into consideration the landscape, geological and hydrological conditions. The complex multi-stage processes of waste decomposition take place at solid waste landfills during a considerable period. They are accompanied by emissions of biological gas and formation of filtration water. A large amount of dissolved and weighted organic and non-organic compounds, pathogenic microorganisms and bacteria is present in the filtrate. As a result of the inter-landscape migration of polluted substances from landfills, transportation of waste particles by wind, insects and birds the components of the neighboring landscapes (soil, flora, surface and undersurface water, atmospheric air) are affected. It directly or indirectly effects the health of the people living in the neighbouring regions (Bezuglova et al, 2007; Vaisman et al, 2007; Eroshina, Lisukho, 2007; Guman, 2008; Namazova, Romanova, 2008; Zomarev, Zaitseva, 2009; Poputnikova, Terekhova, 2010; Kazdim, 2012; Aleshina, Chernishev, 2012; Kazdim, 2012; Dubrova, Podlipsky, 2014; Ivanova, Gorbachev, 2014; Pavlov et al, 2014, Bekk et al, 2015). It proves the importance of the ecological and geochemical assessment of the state of landscape components in the regions where solid waste landfills are located. First priority is given to soils as they are the main depositor of pollutants and implement the major ecological functions in relation to biodiversity conservation (Dobrovolsky, Nikitin, 2000).

The placement of solid waste landfills at watersheds, slopes of various steepness, terraces, floodplains, hollows and closed basins could have vitally important consequences from the ecological and sanitary point of view. It determines the conditions of accumulation, transformation and migration of contaminants, the state of soils in the zone of influence of the above-mentioned technogenic formations.

Objects and methods. We studied loamy Luvic Chernozem (Novic) on Colluvic material (40 cm thickness) over buried initial dark colored soils in the trans-accumulative position (in the bottom of a local balka). They are located close to the solid waste landfill on the territory of 3,5 hectares (within the town of Lgov, Kursk Region, forest steppe). About 25 thousand m^3 of waste are transported here annually. The gray forest soil was studied as a natural reference. Amylolytic microorganisms and actinomycetes were counted on the starch-and-ammonium agar; micromycetes, on Czapek's medium with added lactic acid; and oligotrophs, on starvation agar (A practicum…, 1976). Fecal indicator bacteria were counted on Endo agar and milk-inhibitory nutrient medium. The total amount of heavy metals in the air-dry soil samples was defined by the X-ray fluorescence method on the TEFA-6111 (XRF-analysis).

Results. The functioning of the solid waste landfill has complex technogenic influence on the adjoining territories which affects its morphology, physical, chemical and biological characteristics. On the one hand, the Luvic Chernozem (Novic) on Colluvic material of the bottom of the hollow preserves in its morphology and characteristics the features of natural soils (neutral reaction of low horizons, sharply declining quantity of fungi and actinomycetes). No increase in concentration of heavy metals of the 1st and 2nd class of danger is registered in the Luvic Chernozem (Novic) as compared to background analogues (table). The coefficients of the techogenic concentration of heavy metals vary from 0,7 to 1,2.

Table. Concentration of heavy metals (mg/kg) in Luvic Chernozem (Novic) of the bottom of the hollow near the solid waste landfill (Lgov, 2016)

Horizon	Depth, cm	Ni	Cu	Zn	Pb
Luvic Chernozem (Novic) on Colluvic material (40 cm thickness)					
Ah	0-8	26	19	53	15
Ahb1	8-15	22	15	44	15
Ahb2	15-30	31	24	46	15
2Ahb3	30-40	26	20	49	17
3ABtkb	40-60	36	19	37	11
3Btkb	60-70	29	21	39	14
Background content		30	23	62	25

Technogenic alkalization of the top soil, anthropogenic inclusions (broken bricks, construction and household debris) can be noted in Luvic Chernozem (Novic) on Colluvic material as a result of deluvial and aeolian particles transfer from the "body" of the landfill compaction. The reaction of the bacteria community is manifested in the increased quantity of saprophytic and oligotrophic microorganisms (up to 4,3 – 5,7x10^6 KOE/g in the upper layer of the soil) and a large quantity of this bacteria up to the depth of 60-70 cm (3Btkb). Microorganisms – the indicators of fecal contamination of the soil are registered. The total amount of coliforms and species of the genus Enterococcus in the surface layer of the soil is 10-30 KOE/g. A great amount of spores *Bacillus cereus* (up to 6,0x10^4KOE/g) which are the causative agents of food poisoning is emitted from the soil.

Conclusion. Microbial complexes of Luvic Chernozem (Novic) on Colluvic material in the trans-accumulative position near the solid waste landfill are characterized by a number of differences from natural gray soils. The reaction of the bacteria community to technogenic influence is manifested both at quantitative and qualitative levels. It indicates the violation of the ecological functions of the soil as "bacterial filter" and is dangerous for people.

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Surface mining and our soil

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Introduction

This study analyzed the relationship between urban ecosystem and soil ecosystem involving the mining sector specifically surface mining.

Mining has been one of the major sources of income in the world due to the fact that vast quantities of the world's priceless natural resources are embedded in the soil.

Surface mining, one of the mining techniques is however rapidly gaining round because access to the minerals is relatively undemanding.

There is no question that surface mining generates a large proportion of income in the world especially in the developing countries that have discovered rich deposits of various mineral ores in theirs soils. However, this process is leading to the destruction of a substantial proportion of the earth's landscape especially the surface.

Are we to turn a blind eye to the negative environmental impact?

Can the income that is made from surface mining be sufficient to compensate the damage it is causing our soil?

Can we confidently say that we are making economic success considering the financial benefits surface mining provides at the expense of the environment?

How can we strike a balance between the economic benefits surface mining (a tool of urbanization) provides, and the sustainability of the soil ecosystem?

Surface mining as the name rightly puts it, is the process of obtaining minerals that are located near the earth's surface. In mountainous areas, the Mountaintop removal mining is used. In areas where the ore deposits are in large quantities, open-pit mining is used. Open-pit mining scrapes off the portion of the earth that does not contain ore and deposits it aside, in order to gain access to the ore deposits. This non-ore containing soil is called the overburden. Accumulation of the overburden results in piled heaps known as spoil banks. Sometimes a long strip of overburden is removed in order to reach a layer of ore deposits of coal. This is known as strip mining.

These spoil banks clearly suggests that the landscape and soil profile have been tempered with, vegetation is eliminated, living organisms whose natural habitat is the soil are destroyed and the soil is some cases is almost permanently damaged due to the ore extraction process.

According to Dr. Thomas Akabzaa, University of Ghana, Legon (quoted in Sticker, 2006, 7), the surface area of land used for surface mining is approximately six times the surface area mining. As a result, farmland and forest are lost.

Fig. 1.1 https://www.thinglink.com/scene/703613084530376704

It is therefore crucial that the relationship between urban ecosystem and soil ecosystem be established. This will enable easier assessment and hence the ability to strike a balance between the challenges and opportunities of urbanization in the surface mining areas.

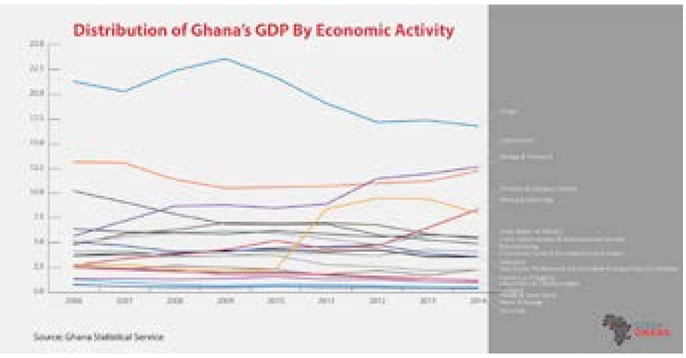
Method

Surface mining projects require the acquisition of large tracts of land by mining companies. The method of study is narrowed down to Ghana, a vibrant mining country in West Africa. It is estimated that about 25% of the total land area of Ghana (some 58,167 km2) is currently under concession to mining firms; most of this land is situated in the forest belt of western Ghana and includes some of the best farmland in the country (Hutchful, 2002, 92).

A comparison is made between the economic contribution made by the Agricultural sector and Mining sector in Ghana. Values for the country's Gross Domestic Product (GDP) from 2006 to 2014 were recorded graphically analyzed.

The aim is to identify the relationship between both economic activities and to decide whether they are mutual or not.

Results



Graph1.1 Source: Ghana Statistical Service

From graph 1.1, an increase in mining activities corresponds to a decline in agriculture. An imaginary projection of the graph 1.1, into a future where mineral ores will be greatly or completely depleted, will show a decline not only in mining activities but also in agriculture because of the damage done to the soil.

Discussion

Surface mining, which employs the cheap and effective, but highly risky, cyanide heap-leach method for exploiting low-grade ore, has been predominant in the sector in the last two decades since the implementation of the neoliberal policy reforms of the mid 1980s (Akabzaa & Darimani, 2001). Butler et al. (2004) estimate that, on average, surface mining requires more than four metric tons of rock to be mined in order to produce just one gram of gold. By the time AngloGold Ashanti Company (AGC) and Goldfields Ltd. (GGL) mine out their concessions in the Tarkwa area (i.e., Iduapriem/Teberebie, Tarkwa, and Damang), a total of 16 ridges ranging from 120 to 340 meters in height will have been turned into huge craters. Each of the companies has admitted in its Environmental Impact Assessments that environmental reclamation and restoration of these sites will be impossible (Akabzaa & Darimani, 2001, 48).

Two ways to help solve the challenge of soil degradation will be

to establish the right policies at the onset of the process and

to put strict measures in place to check the ongoing process and ensure proper treatment of the overload.

As the saying goes "Prevention is always better than cure". Biodiversity banking is a broad term that includes all aspects of conservation. Biodiversity banking seeks to place monetary value on the ecosystem. Ability to estimate the value on soil ecosystem will serve as a guideline to making actual policies and healthy contracts with mining industries.

In order to turn around the challenges of the urbanization that surface mining creates into opportunities, there is the need for a strong mindset for sustainability.

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The Spatial Extent of Evolved Soil Architecture Along a Bioturbation Sequence on an Engineered Cover for Uranium Mill Tailings Containment in New Mexico, USA

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ABSTRACT

The long-term disposal of uranium mill tailings in the United States relies on the sustained functioning of engineered soil systems (technogenic soils) responsible for isolating wastes from surface fluxes of energy and matter that could alter intended engineering properties and allow for the mobilization of contaminants into the environment (DOE, 1989). Composed of a stratigraphy of weatherable materials at the earth's surface, these soil systems are both open and dynamic, and receive and redistribute energy and material fluxes on a recurring daily basis (DeJong, 2015). In natural soil systems, such fluxes are known to drive cumulative changes to physical, chemical and biological soil properties (Lin, 2011). While initially intended to perform uniformly, many individual disposal cell systems are now composed of process dependent assemblages of emergent soils, with distinct properties, that may exert a non-uniform influence on long-term system performance (Benson, 2011). Herein, we show that divergent trends in the development of soil architecture systematically emerge on decadal time scales as a function of ecological succession and topography. We also describe patterns to the vertical and horizontal dissipation of evolved soil architecture.

As part of an ongoing study, a series of soil profiles were excavated in the rock armored clay radon barrier at the Bluewater, New Mexico uranium mill tailings disposal cell. Profile locations were selected across a bioturbation gradient representative of 20-years of ecological succession and landform evolution. These conditions include fourwing saltbrush (Atriplex canescens), perennial squirreltail grass (Elymus elymoides), siberian elm (Ulmus pumila), a harvester ant mound (Pogonomyrmex), and unvegetated ground. Prior to profile excavation, field saturated hydraulic conductivity (Kfs) measurements were taken with a Decagon Devices DualHead Infiltrometer in a horizontal gradient away from surface feature. Profiles were then excavated and a grid established for spatial measurement of structure, roots, crack density, shear stress, total organic C, total inorganic N, and $CaCO_3$. With exception to the unvegetated control, all profiles visibly displayed evolved soil structure through the depth of the clay barrier (60cm), with horizontal impacts dissipating to a shared background Kfs in gradients not exceeding 400 cm. The expression of all measured features varied systematically by surface condition, with the harvester ant mound resulting in the greatest modification to physical engineering properties as quantified by Kfs, crack density, and shear stress. Efforts to characterize the impact of observed soil change to cover system performance criteria including radon flux, hydraulic conductivity, and water balance through evolved evaporative demand from encroaching vegetation are ongoing.

In addition to connecting processes of soil change to long-term performance in an engineered soil system, this study offers a unique opportunity to measure the spatial extent of single biological factors, as evolved from uniform starting conditions, across a well-characterized initial landform.

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Phytoremediation of technogenic wasteland using mineral sorbents and ion exchangers

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In the areas of influence of the enterprises of the JSC "Kola MMC" (Murmansk region) the scattering of heavy metals (HM) in the environment led to the formation of the technogenic landscapes. Their water and soil objects are sources of an uncontrolled secondary pollution of the hydrosphere. To restore the territories subject to anthropogenic pollution, the works on the creation of the vegetation were performed, in which the materials with ion exchange and sorption properties were used.

In the conditions of the Murmansk region, the phlogopite production waste (LLC "Kovdorslyuda" Kovdor) is an appropriate base for the substrate, protecting the plant roots from the negative factors. The waste contains sungulite neutralizing the excess acidity of the soil solutions [1], and vermiculite, which serves as a hydroponic basis for the creation of a grassy turf during the reclamation of the technogenic soil [2].

Experiments on the creation of artificial phytocenoses were performed in the impact zones of the industrial sites of Monchegorsk (MS) and Zapolyarny (ZS) of the Kola MMC. The influence of the climatic conditions on the growth of the artificial phytocenoses was characterized. The effect of sungulite on the redistribution of HM is presented and compared to the results for termovermikulite.

In 2013-14, a 5 cm-layers of sungulite wastes were formed on a plots of wasteland, and the seeds of 4 species of Gramíneae were sown into the layer of vermiculite. The data on the biometric plant indicators (Fig. 1) and on the content of the available forms in the mineral substrates (Fig. 2) indicate a high degree of the grass heterogeneity and the increase of the ameliorant toxicity in the contact with highly contaminated peat. In contact with highly contaminated peat, both the average height of the plants and their biomass are in Monchegorsk two times larger than in Zapolyarny. Thus, a biometric analysis suggests that the plants develop better in the climatic conditions of Monchegorsk than in the vicinity of Zapolyarny.

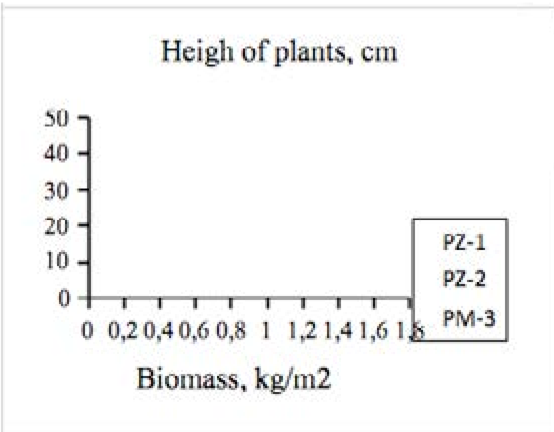

Fig. 1. Biometric plant indicators

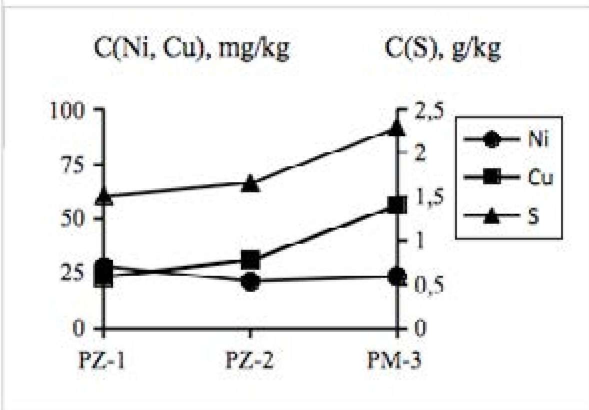

Fig. 2. The content of bioavailable forms of pollutants in the ameliorant

An assessment of the impact of sungulite and vermiculite on the reduction of mobility of HM was performed using the peat without the addition of mineral substrates (Peat), as well as with the addition of sungulite (Sung) and vermiculite (Verm).

In the first series of experiments the peat sample was wetted by 0.01N H_2SO_4 and maintained in a sealed plastic container for 6 days at +20, +3 and -22 ° C.

Then 100 ml of distilled water was poured into the material. The solution was incubated for 2 h and then filtered through a mem<brane filter with a pore size of 0.45 μm.

The concentration of the components in the solution was determined, and the content of water-soluble compounds in the peat was calculated. The experiments with the addition of sungulite and vermiculite are similar.

After separation of the water-soluble compounds, 100 ml of ammonium acetate buffer solution with different ratios of NH4CH3COO and CH3COOH were poured into the vessel and maintained 6 hours. The solutions were filtered through a membrane filter and analyzed.

The sorption of water-soluble forms of copper and nickel by sungulite differs slightly and increases with the temperature decrease, indicating the physical adsorption of the HM on the surface of sungulite. The sorption of nickel by vermiculite is 2-3 times higher than the sorption of copper. In addition, the value of the HM sorption by vermiculite decreases with temperature decrease, which is typical for an ion exchange.

The data in Figure 3 indicate the interaction of the sorbents with HM of the soil. The content of available forms of HM in the technogenic peat exhibits an extreme dependence on the pH of the leaching solution with a maximum at pH = 4.5 for copper and pH = 5 for nickel. The experimental conditions model the contact of the peat with the mineral phases, which occurs in the acidic medium.

Then the formed phases were dissolved in buffer solutions of different pH values. The neoplasms on sungulite are unstable in acidic medium, but at pH>5.5 there is a reduction of the available parts due to the sorption. Nickel absorbed by vermiculite does not pass into the solution in an acidic medium. The sorption of nickel by vermiculite is more effective than by sungulite. In contrast, the largest sorption of copper with the pH increase is made by sungulite.

The content of the available forms of HM slightly increases with the temperature decrease, which leads to the aforementioned increase of the HM concentration in the water unit, which shore is composed of a peat soil. For the water purification from HM the use of a magnesium-silicate reagent based on serpentine minerals is proposed.

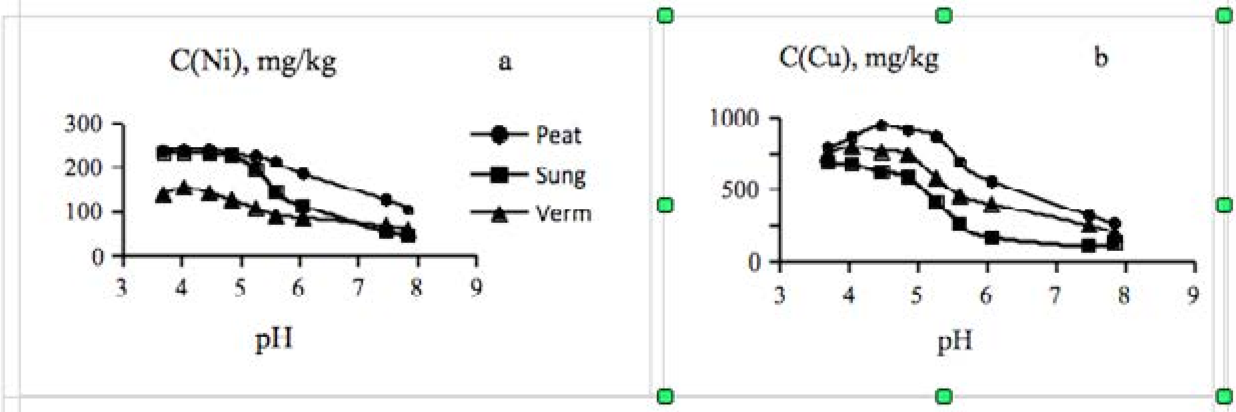

Fig. 3. Dependence of the content of bioavailable forms of nickel (a) and copper (b) at technogenic peat (Peat) and with a mixture of peat with sungulite (Sung) and termovermikulite (Verm)

The data showed that the proposed mineral substrates are valid and promising for the rehabilitation of technogenic landscapes contaminated by HM in the Arctic and Subarctic areas, by reducing the geochemical mobility of the toxicants.

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Spatial variability of urban soils biogeochemical features

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First vaguely mentioned in the 1970 MIT report, the concept of ecosystem services was popularized by the Millennium Ecosystem Assessment (MA, 2005), at the instigation of Kofi Annan in 2000. Thus, like the concept of "sustainable development", it's now used and claimed by many researchers: the concept became in fashion. Four main categories were identified by the MA (2005): provisioning services, regulating services, cultural services, and supporting services. These categories can also be studied in urban environments (Yengué, 2016). Several ecosystem services are in fact provided by ecosystem functioning and especially soil functions.

The main thrust of this work was to improve the knowledge concerning soil biodiversity and related ecosystem services in soils from urban parks. It was made within the framework of a research program, SERVEUR (Ecosystem services of urbans greens spaces) financed by the region Centre Val de Loire (France) The biodiversity of urban soils and the drivers that control this microbiodiversity are in fact poorly known (Sapijanskas *et al*, 2016) . In this work pedological, geochemical and microbiological characteristics of surface soils were investigated in several urban parks of the major cities of the region Centre Val de Loire, France. Biomass, community structure and activity of micro-organisms were determined the MicroRespTM system (Limam, 2014).

Results from this study showed that the soil ecosystem has significantly influenced the microbial abundance and structure of soil microbial community and hence probably soil functions (Motelica *et al*, 2016 ; Bourderie *et al*, 2014). Except for one site it appears that the microbial biomass for all studied urban soils was high compared to natural systems. More generally, catabolic diversity of soil microbial community is variable under the influence of various anthropic and natural factors.

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Microbial concentrations, enzymatic activities and trace element contents in urban soils of Marrakech city according to an anthropogenic gradient

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Soils in urban areas constitute the main connecting element between water, plants, air and Man. For this reason, urban soils receive more attention considering their socio-economic importance and their influence on human health and wellbeing. Due to their close proximity with the population, urban soils are heavily altered by anthropogenic activity and they receive considerable pollution from industry, traffic and refuse (El Khalil et al. 2008; El Khalil et al. 2016). This may affect strongly their biological and physico-chemical characteristics. The contaminated soils may pose a serious human health risk via direct (*e.g.*, contamination of crops of urban gardens) and indirect contamination (*e.g.*, inhalation, ingestion of soil particles) of the population of cities (El Hamiani et al. 2015; Ren et al. 2006; Stanek et al. 1998). Despite their importance, soils in urban areas are still poorly known regarding to their biological functioning.

The aim of this work is to determine (i) the microbial concentration (bacteria, fungi and actinomycetes) and enzymatic activities (dehydrogenase, urease and phosphatase) and (ii) total metal concentration (aqua regia extractable fraction) and water extractable fraction in 9 urban topsoils collected from different sites in the city of Marrakech, Morocco. The studied sites were chosen following an gradient of anthropisation from the peri-urban area of the city (soil 1) toward the historical center (soil 9) according to El Khalil *et al.*, (2008) methodology. The analyses for metal contents concerned the following elements: As, B, Cd, Co, Cr, Cu, Ni, Pb, Zn. A PCA analysis for all parameters, Anova1 for biological parameters and Pearson correlation coefficient were realized by SPSS statistics 21.

The results show that the microbial concentration varies significantly between sites, this variation being directly proportional and statistically significant ($p<0.05$) to the anthropogenic gradient for bacteria (222.6157 - 1627.257 10^2 UFC/g soil dwt), while it is independent from this gradient for fungi (4.5 - 69.76 10^2 UFC/g soil dwt) and actinomycetes (69.78 - 170.64 10^2 UFC /g soil dwt).

For the enzymatic activities, there is a significant decrease for dehydrogenase activity ($p<0.05$) with the anthropogenic gradient (463.05 - 4.45 µg TPF/g soil dwt), while phosphatase and urease activities do not show any significant variation with it, even if their variation between sites is significant ($p<0.05$).

In general, heavy metal concentration showed an increasing trend following the anthropogenic gradient, except for B and Cd, The aqua regia extractable fraction concentrations vary between 45.22 and 126.25 mg kg^{-1} for Zn, 10.04 and 73.69 mg kg^{-1} for Pb, 14.16 and 71.69 mg kg^{-1} for Cu, 12.75 and 20.42 mg kg^{-1} for Ni, 21.39 and 42.21 mg kg^{-1} for Cr, 6.65 and 10.18 mg kg^{-1} for As, 7.49 and 11.89 mg.kg^{-1} for Co and 0.21 and 0.28 mg kg^{-1} for Cd, while the concentration of B varies between 9.31 and 22.13 mg kg^{-1}.

The trace elements water soluble fraction concentrations are very low: <0.001 mg.kg^{-1} for Zn, <0.007 mg kg^{-1} for As, <0.004 mg $kg^{-1}$for Cd, and <0.001-0.0023 mg $kg^{-1}$for Cr, 0.0046-0.0316 mg kg^{-1} for Cu, <0.001-0.0038 mg kg^{-1} for Ni, <0.0015-0.0036 mg kg^{-1} and 0.0046 - 0.011 mg kg^{-1} for Pb.

The trace elements contents in urban soils of Marrakech are approximately in the same range of those measured in agricultural and garden soils in and around Marrakech (data not shown) and very low compared to those measured in mining soil in the vicinity of Marrakech (Benidire et al. 2016). They do not exceed the international limits except for As and Pb (Kabata-Pendias 2011).

Metal concentrations have a positive impact on bacteria, fungi, and actinomycetes concentrations except for B and Cd as well as for urease and phosphatase activities. On the opposite, dehydrogenase activity is negatively impacted by metal concentrations, except for B and Cd.

In conclusion, the results confirm that anthropisation causes a wide spatial diversity of soils in urban and peri-urban environments regarding to their biological and physico-chemical properties. Some of them (*e.g.* dehydrogenase activity) can be used as an indicator of anthropization.

Key-words: urban soils, trace elements, microbial concentration, enzymatic activities, anthropisation

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Ecological condition of soils in small towns of the Republic of Karelia

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Karelia's enterprises annually discharge more than 130 thousand tons of various pollutants to the environment (Gosudarstvennyi doklad… 2010, 2015). A noticeable contribution to air pollution is made by the non-point pollution sources – railway transport and cars. Emissions from stove heating of small private houses occupying a considerable part of residential areas aggravate the environmental situation in towns (Pochva, gorod… 1997).

Heavy metals (HM) have become the leading environmental contaminants in industrialized towns according to toxicity assessments and impact on public health (Saet et al. 1990; Plyaskina and Ladonin 2009). Chemical pollution and degradation of soils in settlements pose a serious environmental problem. Soils, Although they have a capacity to bind many substances to make them immobile, poorly mobile or unavailable to plants, soils themselves gradually get contaminated and toxic (Tayson 2002; Shirinskiy 2003).

The aim of this study was to assess the ecological condition of soils in various land use categories in urban areas depending on their prevalent industry. The following tasks were addressed for this purpose:

determination of acid-alkali indexes, levels of HM, carbon, sulfur and nitrogen, labile phosphorus and potassium compounds in soils of the towns of Kondopoga and Kostomuksha;

assessment of the impact of various industries on the ecological condition of urban soils.

The investigation is concerned with soils in various land use categories (built-up lands – urban and rural type; general-use lands – industrial zone, plants, roads, railways; natural and recreational lands – urban forests, parks) (Pochva, gorod… 1997) in important small towns of Karelia (Kondopoga and Kostomuksha). Soils of strict nature reserves Kivach and Kostomukshskyi were used for reference.

In the territory of Kondopoga and Kostomuksha we made soil pits, 3 for each land use category in the study. Soil samples were taken at different depths (0-5, 5-10, 10-20 cm). The following agrochemical indexes were defined in the samples: salt pH, hydrolytic acidity, total exchangeable bases, base saturation, bulk carbon, nitrogen and sulfur content, labile phosphorus and potassium (Agrohimicheskie… 1975), as well as AquaRegia digested heavy metals and their active forms (Cu, Zn, Ni, Co, Cr, Mn – CH_3COONH_4 extracted; Pb – NH_4Cl extracted) by atomic absorption spectrophotometry in the Equipment Sharing Centre "Analytical laboratory" of FRI KarRC RAS. The resultant data were compared against current Russian hygienic standards (GN … 2006, 2009), and the natural regional background as represented by the average content of heavy metals in the mineral (underlying the forest litter) horizons of Karelian soils (Fedorets et al. 2008).

The town of Kondopoga lies on the shore of Kondopoga Bay, Lake Onego. Its northern part is washed by Lake Nigozero. According to the Federal Statistics Agency (ROSSTAT), resident population of Kondopoga as of January 1, 2016 was 31203 persons. The main industrial facility within the limits of the town adversely affecting the environment is the Kondopoga pulp and paper mill (JSC «Kondopoga»). It is known that the pulp-and-paper industry is one of the most water-intensive, and its major negative impact is on the hydrosphere. The pulp-making process also involves gas-dust emissions that pollute the air and subsequently soils.

AquaRegia-extracted concentrations of lead, copper, nickel and zinc exceeding maximum allowable concentration or tentative allowable concentrations (MAC/TAC) were detected in all the represented land use categories. Specimens from general-use lands showed accumulation of both labile forms of elements and those extracted by AquaRegia at a depth of 5-10 cm, with further decline down the profile. The highest heavy metal concentrations were revealed in the soil samples taken near the railroad, where MAC/TAC were exceeded 16-fold for bulk zinc content, 12-fold for copper and 6-fold for lead. Depth-wise distribution of heavy metals in soils of built-up lands was uneven. The samples from a steep slope in the southern part of the town featured high levels of lead, zinc and copper. Cobalt distribution across the profile was approximately at the same level in all land use categories. In the natural-recreational zone the accumulation of the most labile element, manganese, increased down the soil profile. The levels of labile zinc in the town's topsoil exceeded TAC.

Soils in Kondopoga in general are acid and subacid, locally neutral. Hydrolytic acidity is maximal in topsoil and decreases with depth. Base saturation is the highest in soils of general-use lands and natural-recreational areas throughout pit depth. Urban soils generally feature a high content of labile phosphorus and potassium, the amount of carbon and nitrogen evenly decreases with depth and is maximal in built-up areas.

The town of Kostomuksha is situated in the north of the West-Karelian Upland. on the eastern shore of Lake Kontokki. Population as of January 1, 2016 was 29511 people (ROSSTAT). The town's major industry is iron ore mining, resulting in high pressure on the environment. According to the State-of-the-Environment Report of the Republic of Karelia, the local economic mainstay JSC "Karelian Pellet" is one of the biggest producers of industrial wastes; its contribution to total point-source polluting emissions in 2014 was 61.3% of the gross emissions volume in the republic (Gosudarstvennyi doklad… 2015). Industrial wastes such as overburden, non-recyclable wastes and tailings from the dressing plant contaminate soils and waters around the waste dumps with heavy metals (Fe, Cr, etc.) (Doklad… 2014). The dominant heavy metal in dust emissions from the enterprise is iron (Panteleeva 2015).

Generally speaking, concentrations of labile forms of elements extractable by AquaRegia decrease with depth. In built-up and general-use lands bulk lead content in top layers of soils (0–5, 5–10 cm) exceeded MAC, but labile lead concentration was within normative values. AquaRegia extract from the soil samples taken from a suburban forest on the eastern side of the town contained elevated levels of lead, nickel, copper and zinc (1.5-2 MAC/TAC) at a depth of 0-10 cm.

Kostomuksha soils are acid, with a pH index similar to that of natural soils. Some alkalinization of soils was revealed in general-use lands, the reaction being close to neutral. Hydrolytic acidity was high for soils on rural-type built-up land and in the natural-recreational zone; these soils also had high carbon content in the topsoil. Base saturation was the highest in soils of general-use lands. Urban soils were rich in labile phosphorus and potassium across the entire profile in all the land use categories.

Soils in small towns of Karelia with large industrial production are not contaminated with heavy metals. However, high sulfur concentrations were found in soils of Kondopoga. This is probably connected with activities of the pulp-and-paper mill, which is situated within the town boundaries, since gaseous emissions from the pulp-and-paper industry are known to contain the sulfur compounds that contaminate the environment. Soils of Kostomuksha demonstrated the lowest levels of pollutants, which did not exceed the regional background. The reasons for that are that Kostomuksha is a young town (founded in 1977), and lies quite far (13 km) from the industrial premises of the mining and ore-dressing enterprise JSC "Karelian Pellet". Top layers of the town's soils are base-saturated and rich in labile phosphorus and potassium. Soils of Kostomuksha are characterized by a higher content of carbon, and their acid-base properties are near natural.

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Assessment of soil magnetic susceptibility in a urbo ecosystem by the example of the industrial zone of Khimki near the Leningrad highway

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In today's world there is a constant change in ecosystems due to human activities. With the increasing number of urban areas rises and the level of pollution, affecting the livelihoods and health of the people.

One of the possibilities of determining the degree of contamination is to assess the condition of the soil. Technogenic areas of contaminated soil in urban areas are often zonal character, dedicated in particular to the industrial zone. In these conditions is actual express method of measuring the magnetic susceptibility in the preliminary examination of the site to assess the degree of transformation of the soil and brings the magnetic particles of anthropogenic origin in the soil. Property of oxides and hydroxides of iron to be sorbents and carriers of heavy metals in the soil is important. Due to the fact that the presence of iron oxides and hydroxides can be determined by the value of the magnetic susceptibility, which in turn can be an indicator of pollution of heavy metal compounds, it decided to hold kappometriya.

The purpose of research is to assess the soil magnetic susceptibility in a urbo ecosystem by the example of the industrial zone of Khimki near the Leningrad highway.

For her achievement the tasks have been set:

- studying of a method of measurement of a magnetic susceptibility,
- carrying out kappometriya,
- identification of the most polluted sites of the chosen territory by the received results,
- the analysis of relationship of cause and effect of pollution of the soil in the revealed sites.

The object is the territory of the industrial zone of Khimki near the Leningrad highway.

The subject of the study is the anthropogenic transformation of soils of industrial areas used in the future for housing construction.

The measurements were performed with kappametr CT-5 by the method of transects perpendicular roads (Leningrad - 30m and Vashutinskoe highway - 20 m away from the roadway) and area method at the grid points 400 * 400 m2. Near the industrial area in a forest area has been taken to the point of the background index.

As a result, the areal method it was found that the magnetic susceptibility varies from -0.12 to 0.8 * 10-3 units SI. And the maximum values are located near the intersection of the Leningrad highway and the railway line (Fig. 1.1).

Figure 1.1 Map of the level zones of the magnetic susceptibility of the former industrial zone near the Leningrad highway, Khimki by the method areal, units SI

Method of transects revealed the same pattern at values of from 0.05 to 0.83 units SI.

The received data and analysis of maps allow to state that the maximum contamination of oxides of iron located on site at the intersection of Vashutinskoe and the Leningrad highway and railroad Leningrad direction. This once again confirms that the value of the magnetic susceptibility of soils can be used to highlight areas that require inspection on heavy metal pollution in the first place.

Solid atmospheric precipitation of technogenic origin provide one of the most significant contributions to the magnetic properties of the soil. The sources of pollution can be a vehicle, as well as nearby offices and warehouse buildings. To confirm the assumption was made of dust measurement on the foliage. The scale of relative units was used to characterize the relative dust – points. As a result, the maximum scores were obtained dustiness - 5-6.

As a result of the analysis of pollution of the soil in the revealed sites it is offered to make disembarkation of green plantings. Vegetation is intended not only to ensure comfortable stay of the population, but also to reduce the intake of dust and aerosols from the highways. As is known trees can capture almost half of the total amount of contaminants (including heavy metals, 3,4 benzo (a) pyrene) present in the atmosphere.

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Urban and Industrial Waste Streams as Feedstockto Maximize Biogeochemical Interfaces: Incorporating Vernadsky's Framework in RegionalSoil & Ecological Development.

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The earth has a biogeochemical surface area of about the same scaleas the giant plants of Saturn and Jupiter. This multiplied interfacial cover, however, is produced by the biota: plants, microbes, and animal life. Urbanized and industrial landscapeshave been dysfunctionally structuredto greatly diminish suchinterfaces and their functional capacities, diminishing air and water filtration while simultaneously dropping biodiversity by orders of magnitude. Since every major city produces quantities of waste material each year large enough to hold all of the precipitation and runoff from average to large storm events, a design and construction algorithm has been constructed which allows scaling soil development and plant growth from the waste streamto approach zero discharge for precipitation events.Using such a metric, urban, industrial, and transportation infrastructure can be constructed and/or retrofit with locally available waste stream materialsto capture carbon in urban centers at rates commensurate with surrounding natural, pre-industrial landscapes. Ecological/biogeochemical capacitiesdeveloped through thisdesign and construction strategy allows urban and industrial centers to reverse urban heat island, dropping operating costs for buildings, as well as energy use and peak load requirements.

Earth Science Museum of Lomonosov Moscow State University - base of active formal and non-formal learning in the field of the soil sciences and environment

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Museums as cultural and historical heritage have high evaluation by the local communities. Reconsideration of ideology of world community development becomes actual for all countries, demands updating of the contents and education forms at the end of the XX century. Now there is an active formation of system of continuous education and integration of activity of museums into this process (Mikhailova et al. 2013). Museum playing an important role in the cultural life, it is a unique educational environment that allows to learn directly the original objects, increasing the motivation and cognitive interest of visitors. If every guest of the Lomonosov Moscow State University at Lenin Hills would have chance to visit the Earth Science Museum at the seven top floor levels of the Main University Building, he may have possibility to see the significant role of soils in ecosystems and to get an impression of the enormous variation of the soil types from all over the world.

The Earth Science Museum was founded in 1950 as the teaching museum for MSU students of the Geological, the Geographical and the Soil Science Faculties (http://www.msu.ru/en/info/gz-history.html). The main principle of the Earth Science Museum is based on using the dialectical approaches in order to show the diversity of nature on our planet and the history of its development. The museum's name shows that the Earth sciences comprises a wide range of interrelated braches of science, which deal with the structure and composition of all geospheres and their complex includes the study of the environment soils.

The museum's activity is undertaken in three main directions: conducting classes, furthering research work and disseminating scientific knowledge. The combination of researches with teaching, educational and scientific work makes the possibility for the greatest extending the practical knowledge. Every year more than 2500 academic hours are held in the museum for students. University scientists and teachers conduct classes with students of geographical, geological and biological faculties and faculty of soil science. During seminars on biogeography, geology, mineralogy, soil science and other disciplines they have the opportunity to study full-scale samples. Practical work of students in the museum allows them to get good knowledge and experience of working with natural objects and to prepare for the field research. Students of Soil Science Faculty learn in the museum such disciplines as geology, mineralogy (28 and 27 floors), total soil science and special courses, trainings are held on the 25 floor of the museum at the exhibition "Natural geography zones". The principal theme of this division is physical-geographic zonality and the resources of nature with special emphasis on the complex character and relation of all landscape features. Much consideration is given to soils, which appear to be a "mirror" of the landscape. The division comprises 54 displays, and includes 230 soil profiles, from tundra soils to red soils. There are also hundreds of samples of soil-forming rocks and 15 three-dimensional exhibits showing genuine fragments of ecosystems from various zones. The division contains three terrestrial globes, which depict the distribution of vegetation, animals and soils on our planet. There are more than a dozen displays with animals from various zones and hundreds of herbarium and individual specimens of plants, including those which are landscape-forming, relict or endemic or in some way useful for man. There are also cast models of fruits, sections of trees and so on. Natural exhibits form the basis of this division.

In all zonal displays there are original complex profiles, which show visually the interdependence of the climate, relief, soils and vegetation in the zone. The principle of constructing there profiles may be regarded as a contribution of the Museum to the methodology of complex geographic presentations.

The role of the teacher is not reduced to a mere transmission of knowledge, and is aimed at encouraging independent search for solutions. How can be implemented this approach? The answer is - it can be reached through various interactive methods (Amador, Görres 2004; Ruzavin et al. 2015). What is interaction learning? First of all, it is the interaction of the learner with the educational environment. The diversity of interactive learning methods include: development and implementation of creative tasks; work in small groups; the use of educational games (role-playing, simulation, business, education); involvement of public resources (experts invited practitioners, excursions); work with visual aids, video and audio recordings; organization of discussions; the creation of exhibitions, performances, stories and more. The museum is the most favorable learning environment for the implementation of the interactive teaching methods, the museum exhibition - itself educational environment.

It's hard to imagine the modern development of the Moscow museums without the cooperation with schools and other educational organizations for an increasing the learning motivation of pupils, for the increasing the life's knowledge, for the receiving and applying this knowledge in the ordinary life. For example, there was prepared lesson «Adaptation of organisms for the environmental conditions» The age of participants must be more than 7 years old. Our recommendation was - the participation of the 5-7 classes-pupils.

Tasks for pupils

In itinerary sheets are suggested 3 types of tasks:

1 *type* — to describe the climatic features of the tundra (or taiga, steppe, desert) as habitats.

2 type **—** to write out in the table animals and plants: inhabitants of the tundra (or taiga, steppe, the desert).

3 type — list plant's and animal's morphological adaptations, living at the tundra (or taiga, steppe, desert).

Case: analyze features of habitat (humidity, temperature) and adaptations at such animals as a polar fox and a fennec fox or fennec (Vulpes zerda). Whether expansion of an area of their distribution is possible — whether they can meet in one territory?

Programs of formal education were realized together with the Lomonosov Moscow State University Ecocenter (Educational scientific center on retraining and professional development of shots in the field of ecology, rational environmental management and conservation) constantly since 1983. Over 2000 heads and specialists of various branches studied the short-term professional programs of development: "Ecology and a sustainable development", for teachers -"Investigation activity of pupils in the field of sciences about Life and Earth", regular interuniversity seminars, such as "Ecological environment" and "Education methodology for a sustainable development". The training introduces in practice modern treatment of the concept "sustainable development" with possession of bases of environmental protection and steady management.

Non-formal learning at the Earth Science Museum for longlife learning includes: excursions, Science Festival, Ecological games, Ecology Olympiads, Ecology Cases and Summer Schools. Every year more than 16000 people visit our Museum.

Learning the Soil Sciences in the Earth Science Museum is deep concerning the soil processes, involving exchanges at active surfaces, and follows the great traditions of V. Dokuchaev, first describer of evolutionary development of soils over time in the late 19th century (Winiwarter 2014). The Earth Science Museum playing an important role in the cultural life as a unique educational environment and participates in the active formation of the continuous education in the field of the Soil Sciences.

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Features of phytoremediation and phytomelioration using on polluted and depleted urban soils

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Phytomelioration and phytoremediation may become powerful factors in urban soils' recovery to a state preceding the impact of degradation processes on the soils.

It is necessary to distinguish between the target phytomelioration in urban areas, based on the cultivation of seasonal or perennial plants for the recovery of the upper layer structure, the formation of natural turf and grouting in landscapes with high erosive danger (soils around highways, bridges, artificial reservoirs) and the method of phytoremediation, the essence of which lies in the effective reduction of the various pollutants' concentrations in the root layer in urban soils of different degrees of contamination.

What can the phytomelioration provide in areas of urban landscapes, depleted from nutrients?

The results of three-year experimental studying the comparative assessment of white mustard's (*Sinapis alba),* narrow-leafed lupine's (*Lupinus angustifolius)* and safflower's (*Carthamus)* green manuring are presented. The aim of survey was searching and complete interpretation of the green manure crops range expansion using the comparative agro-ecological assessment of studied techniques. Firstly in the Moscow area cultivated as a green manure crop safflower showed high agro-ecological effectiveness of this method. In this method the safflower variety Shifo was used. In research seven variations were studied. As a control was used clear fallow. The effect of green manure was explored by the influence of different tillage options studied cultures on alkaline nitrogen (N), available phosphorus and potassium content in the soil arable layers. During the effectiveness of green manuring on 1 hectare calculations defined that after plowing top mass of safflower in the soil entered 189 kg of nitrogen, 45 kg of phosphorous. When the narrow-leafed lupine and white mustard were used in the soil returned 138,4 kg on hectare of available nitrogen and 84,2 kg on hectare of available nitrogen accordingly. Marking the microbiological activity of the soil by the experimental options the best results were obtained using as a green manure narrow-leafed lupine and safflower because linen-canvas loss was 48 and 60% respectively [1].

The scientific and practical interest concerning possibilities of phytoremediation emerged quite recently, and it is necessary to recognize, that this particular scientific field as an independent block of applied agriculture, crop production and plant ecology is developing fast and there are obvious successes as well as problems. The authors conclude [5;7;8] that phytoremediation is becoming an important element in strategy of development of ecological technologies in different spheres of industrial activity.

Phytoremediation of soils and grounds, based on phytoextraction, is cultivation of certain plants which uptake heavy metals from contaminated soil and accumulate them into plant tissues. Using this method the plant biomass is harvested [5] and consequently utilized (burnt), when the produced ashes are supposed to be used in recycling of metals.

Scientific sources inform that commercially comprehensible technology of phytoremediation has not been developed yet, as for the time being there is no full understanding of complex interactions in rhizosphere and mechanisms of translocation and accumulation of metals in plants [2;4]. Therefore, no comprehensible technology of phytosanation process of polluted with heavy metals soils is developed yet. Until now, only possibility of some plants to absorb heavy metals from soil has been displayed.

In conditions of urban soils in Moscow we carried out a special experiment to study the phytosanation properties of peonies *(Paeonia lactiflora L.)* [6].

In soil samples collected from the experimental plots the soil's properties were as follows: pH_{KCl} - 6,15;

organic matter - 2,4%; P_2O_5 - 34mg/100 g of soil; K_2O - 30,5 mg/100 g of soil.
Below the results of soil samples' analyzes before and after the three-year cycle of growing peonies in the urban landscape are presented.

The content of heavy metals (after a 3-year cycle of *(Paeonia lactiflora L.)* cultivation) in the soil of the experimental plot (mg / kg of air dried soil)

Chemical element	Soil 0-15 cm			Soil 15-30 cm	
	0,1 N HCl			0,1 N HCl	Ammonium acetate buffer solution
	original content	the final content	as a percentage of the original		
Iron	-------	2017,0		1916,0	11,85
Manganese	-------	207,0		186,0	22,15
Zinc	67,35	53,0	77	43,0	13,2
Copper	22,77	18,95	83	14,96	0,15
Lead	24,55	22,395	91	12,945	0,08
Cadmium	0,73	0,58	79	0,56	0,231

It is necessary to clarify that the use of *(Paeonia lactiflora L.)* refers to passive phytoremediation (annual mowing only the above-ground mass of the crop and removal of roots at the end of the completed cycle of phytosanation). When using annual plants, the plants are removed completely from the soil, and this refers to the active phytoremediation.

Nevertheless there is **the strategic fallacy** in this process.

The existing harvesting technology does not allow complete removal of shoots and roots from soil. Therefore, after decomposition of this parts of hyperaccumulators contaminants remain in the soil.

There is a solution - creation of technology which would allows removal of the basic part of root system together with above ground parts of plants.

It is necessary to underline, that phytoremediation technology includes the elements of traditional technologies applied in traditional crop production, but there are some peculiarities in phases of its realization, which are:

Special preparation of site with anthropogenous pollution of root layer planned for phytoremediation.

2. The plants-phytoremediators should have specific phytosanitary properties in conditions of complex pollution (biological and chemical) – i.e. ability to produce and release specific root exudates – organic acids for inactivation various pathogenic organisms;
3. Sowing the phytoremediator;
4. Removal of hyperaccumulators from soil together with their roots and shoots (complete phytosanation).

On the basis of long-term researches which were carried out by authors [3;6], has been established, that peony (*Paeonia lactiflora L.*), mustard *(Sinápis alba L.)*, safflower *(Cárthamus tinctórius* L.) plants are suitable for remediation and phytoremediation.

In conclusion, it should be noted that phytomelioration and phytoremediation have the potential as ecological solutions for conservation and restoration of urban ecotopes when they are affected by negative manifestation of technogenesis.

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Transfer of Development Rights strategy for enhancing ecosystem services of urban soils

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Introduction

Cities play a key role in the rise of greenhouse gases emissions, which is considered to be one of the main causes of global warming and climate change. An important role in reducing the effects of climate change can be played by Non-Urbanized Areas (NUAs). NUAs are open green spaces characterized by soils with amounts of vegetation that represent the last remnants of nature scattered within urban areas (La Rosa, Privitera 2013). NUAs provide multiple urban ecosystem services such as carbon storage and sequestration, regulation of microclimate and mitigation of urban heat islands, and cultural and recreational opportunities (McHale et al. 2007). Despite their importance, NUAs suffer from surrounding urbanization pressures and are often neglected by local spatial planning practices especially in Southern Europe urban contexts. On the contrary, NUAs should be protected and designed as new public urban green spaces and enhanced in terms of ecosystemic potential through increasing the amount of vegetation cover. Nevertheless, implementation of new public urban green spaces implies to deal with land acquisition of those NUAs private plots where a new green infrastructure is designated to be located. Effectively, public acquisition of land is often economically unsustainable for local administrations and faces resistance from private landowners.

Material and method

This paper proposes a method for enhancing carbon sequestration of NUAs through the implementation of new public green spaces while ensuring the related economic feasibility based on the incentive-based approach of Transfer of Development Rights (TDR) (Brabec, Smith 2002). A TDR program defines an area to be protected from development and transferred to public property (sending area) and another area to be developed by private developers (receiving area). Landowners of sending area parcels can transfer the Development Rights (through a sales and purchase agreement) to the receiving area parcels (Fig. 1). As a consequence, the formers are compensated for leaving their property, the latters take advantage of new development opportunity while public administrators can acquire land with no financial efforts. As a first step, large patches of NUAs are appropriately selected as sites for new public green spaces. Development Rights are assigned to the private land parcels included within these areas and transferred from the parcels designated for green spaces to the adjacent ones designated for new urban development. As a result, new buildings within a limited amount of parcels can be built and the majority of NUAs parcels are transferred to public property. Amount of Development Rights to be assigned to land parcels is identified according to an Economic Feasibility Assessment Tool. This Tool allows to quantify the equitable Development Rights to be assigned to each private landowner in order to ensure the economic feasibility of the urban transformation. The second step of the method takes into account the potential of the public acquired NUAs to both store and sequestrate carbon. A characterization of NUAs by different land covers is conducted in order to assess the contribution of different land cover types to carbon uptake (Nowak et al. 2013).

Fig. 1 – Urban green zone and Developments zones within a NUAs patches compound.

A Land Cover Analysis allows to identify three land cover types: herbaceous vegetation, shrubs and trees. The contribution of NUAs in terms of carbon uptake is evaluated through the application of a carbon sequestration rate (kgCO2/m2y) for each land cover type. Properties of carbon sequestration and storage of herbaceous, shrubby and arboreal species are collected from literature and respectively applied with an average value to the three selected land cover types. Evaluation of enhancement in terms of carbon sequestration is assessed through the comparison between the current no development scenario and the TDR scenario.

Results and discussion

The method has been tested within a municipality at the heart of the Catania metropolitan area. Economic feasibility assessment Tool allowed to verify the minimum net profit ratio for the project investment (P% ≥ 25%) quantifying the amount of development rights and defining the size of the three Development Zones (Fig. 1, red boundaries) and Urban green Zone to be acquired for public property (Fig. 1, green boundary). Land cover analysis has been conducted within a compound and allowed to identify, through visual interpretation and manual extraction, five different current land cover types. Results show that Herbaceous vegetation and Shrubs covers are the most prevailing land cover types (respectively 58% and 31%). Trees and Bare Soils cover about 7% and 4% while Buildings represent less than 0.5 % of the total land parcels area (Tab. 3). According to the literature average values (Nowak et al. 2013), Herbaceous vegetation covers provide the most relevant carbon sequestration with almost 60,000 kgCO2/m2y. After the urban development, a total area of 18,237.04 m2 is built up at the expenses of Trees, Herbaceous vegetation and Shrubs. At the same time, the plantation of new trees allows to add 52,187.29 m2 of Tree cover and provides a supplementary carbon sequestration of 53,231.04 kgCO2/m2y. Summing up this contribution to the existing Herbaceous vegetation and Shrubs potentials, a final amount of 125,762.22 kgCO2/m2y carbon sequestration potential can be provided. According to this new layout, the total carbon sequestration potential enhancement is more than 30% when compared to the current layout. Even though the relevance of these results, the proposed method and TDR scenario shows some limitations. Firstly, the methodology doesn't take into account carbon emission potential of new buildings within the compound. Secondly, the proposed tree plantation strategy represents a scenario aimed at maximizing carbon sequestration and other ecosystem services but could be appear highly theoretical. Indeed a total tree coverage is not realistic because designing urban green spaces implies to identify different zones for leisure such as lawns, pathways, bike lanes, water bodies, and playgrounds.

Conclusions

Results of this study show that it is possible to implement new public urban green spaces and enhance their carbon sequestration potential at reduced costs for the local administrations through the allowance to private landowners of a very limited amount of new development and soil consumption. This represents a reasonable trade-off for the free of charge transfer to public property of their land parcels designated for green spaces. Applying Transfer of Development Rights strategy would help to develop new public urban green spaces throughout the city, implement climate change adaptation strategies, create a more liveable and healthy urban environment and obtain economic benefits for landowners and developers of areas designated for green spaces and local administrations that may implement public services with no or limited financial efforts.

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Mesofauna of Saint-Petersburg soils

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Introduction. In modern cities, natural vegetation communities degrade, being replaced with artificial plantations of tree species and lawn grass mixtures with a limited species diversity. At the same time, the soil cover is transformed, which results in the changes in the functioning of the soil biota. Being an integral component of urban biogeocoenoses, soil invertebrates actively affect the organic and mineral parts of the soils, determining the elementary soil processes occurring therein [1-3].

The aim of the study is to give the characteristic of the soil mesofauna in different functional areas of Saint Petersburg, having a various degree of anthropogenic load. In the assessment of the mesopedofauna contribution to the performance of environmental functions by urban soils, great importance is given to the identification of the soil invertebrates' biocenosis structure: the species and group composition, the composition of environmental groups, the ratio of life forms, and trophic groups.

Object and methods. The studies were conducted in the Nevsky District of the city of Saint Petersburg: in the territory of the Park named after I.V. Babushkin and on the lawn near the intersection of two highways: Babuskina and Dudko streets. According to data of soil scientists [4], the soil in the Park named after I.V. Babushkin is a sod-podzol, urban stratified one, that is classified as an anthropogenically transformed natural soil. The humus horizon has a thickness of 28 cm. The lawn soil is an introduced grey humus one (according to Russian soil classification and diagnostics, 2004 – the urban quasi soil). The soil profile is shortened; the humus horizon has a low thickness (10 cm).

The studies of mesopedofauna were conducted in late September – early October 2016. To count the number of invertebrates, we used the method of manual sample analysis, that is common in soil zoology [1]. We considered as dominants the classes that represented 25 % and more of the total number of invertebrates, and as subdominants, those representing 3–10 %. The information about the group composition, the average number and the share in the population of soil invertebrates in the park and the lawn are provided in the table.

Results and discussions. The average number of invertebrates in the park soil is 2,306.7 units per sq.m. We found representatives of eight mesopedofauna classes. The class of of oligochaetes is characterized by the largest share in the population (the dominant class): their account for 88.2 % of the total number. Among them, the most numerous are pot worms. The classes of insects and millipedes are subdominants. A layer-by-layer counting of mesofauna allowed us to conclude that the absolute majority of invertebrates are concentrated in the 0–10 cm layer of the soil (see Table 1).

The average number of invertebrates in the lawn soil is 376 units per sq.m, which is 6 times lower than in the park. The mesopedofauna is represented by 6 classes. There are no representatives of such classes as gastropods and bugs. The largest share in the soil population is that of the class of oligochaetes (the dominant one), accounting for 85.8% of the total number. Among them, the number of earthworms is significantly higher. Subdominant classes are insects and millipedes. As well as in the park, the majority of invertebrates (78.7%) are concentrated in the 0–10 cm soil layer. Among the lawn soil invertebrates, the share of predators (chilopodans, araneids) is much higher. The low number of pot worms in the lawn soil, as compared with the park, is most likely due to lesser thickness of the humus horizon and higher anthropogenic load.

Conclusion. It has been found that the main mass of mesopedofauna in urban soils, unlike natural biocenoses, is concentrated in the upper 10-centimeter layer. Such a distribution is due to regular removal of plant residues and litter. The lower number of soil invertebrates in the lawn is due to a high anthropogenic load on the soil. The ratio of the number of small animals to that of larger animals in the dominant group (the number of pot worms in the park is 4 times larger than the number of earthworms) can serve as an indirect indicator of the soil compaction degree: with increasing soil density, the number of small forms decreases.

Table 1. Group composition, average number and share in the population of soil invertebrates (Park named after I.V. Babushkin and the lawn (Babushkina Street))

Groups of soil invertebrates	Average number by layer (units per sq.m)/park		Total number (units per sq.m), (share in the population, %)/ park	Average number by layer (units per sq.m)/ lawn		Total number (units per sq.m), (share in the population, %)/ lawn
	AO	0-10		AO	0-10	
Insects (Insecta)	1.3	98.7	100 (4.3)	2.7	13.3	16 (4.3)
Bugs (Hemiptera)	-	1.3	1.3 (0.1)	-	-	-
Entognathous insects (Entognatha)	-	4	4 (0.2)	-	4	4 (1.1)
Chilopodans (Chilopoda)	-	28	28 (1.2)	-	13.3	13.3(3.5)
Millipedes (Diplopoda)	-	101.3	101.3 (4.4)	-	17.3	17.3 (4.6)
Arachnids (Arachnida)	1.3	10.7	12 (0.5)	-	2.7	2.7 (0.7)
Gastropods (Gastropoda)	12	14.7	26.7 (1.2)	-	-	-
Oligochaetes (Oligochata), including:	14.7	2018.7	2033.4 (88.1)	77.3	245.4	322.7 (85.8)
pot worms (Enchytraeidae)	9.3	1589.4	1598.7	73.3	66.7	140
Earth worms (Lumbricidae)	5.4	429.3	434.7	4	178.7	182.7
Total number and share in the population	29.3 (1.3)	2277.4 (98.7)	2306.7 (100.0)	80 (21.3)	296 (78.7)	376 (100.0)

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Analyzing the effects of heavy metals on ecosystem services of urban soils in different functional zones of Moscow megapolis

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Introduction

Urbanization is a global trend with important environmental consequences. Features, functions and key components of urban ecosystems differ considerably from those of natural ecosystems. Urban soils provide important ecosystem services, like purifying surface and ground water, buffering contaminants and supporting greenery. The absorption and neutralization of pollutants is one of the key regulating services of urban soil. Urban soils are polluted with heavy metals (HMs), oil products and poly-aromatics hydrocarbons (PAH). The main sources of urban soils' pollution include industry, transport and waste disposal. Urban areas include different functional zones (i.e., industrial, residential and recreational), resulting in high spatial diversity of urban soils and services they provide. Analyzing spatial distribution of HMs in urban soils is needed to evaluate the regulatory services in various functional areas of the city.

Materials and methods

The research focused on urban soils in Moscow city (Russia). Soil survey was carried out in 2015-2016 and covered recreational (parks, squares, urban lawns), residential and public zones. Samples were taken by depths 0.0-0.2; 0.2-1.0m and 1.0-2.0m, and both topsoil and subsoil layers were involved into analysis. The following chemical properties were measured in collected samples: pHKCl and HMs' content (Ng, Ni, Cu, Zn, Pb, Cd, As, Cr, Mn, Co). The results were processed using the R studio to analyze and were mapped the distribution of pollutants using geostatistical methods.

Results

The HMs' content in the topsoil of various functional zones were measured and compared to the health threshold (approximate permissible concentration (APC)). APC for comparison was used considering the texture and acidity of the soils (Table 1). Most of the investigated soils had neutral and slightly alkaline reaction; however, urban forest soils were acid. Subsoil texture on average one category lighter than topsoil texture. Loamy soils dominated parks and urban forests, whereas sandy loam was typical for other zones.

Table 1

The texture and acidity of the top soil

Functional zone	Lawn	Park	Urban forest	Residential zone	Construction site
pH	6.72	6.97	4.30	7.11	7.53
texture	sandloam	loamsoil	loamsoil	sandloam	sandloam

The concentration of all pollutants exceeded APC for sandy loam soils of lawns. However, the greatest excess of the APC was shown for the construction site. For example, 5 times surpass of the APC was observed for Zn and Pb content and 2 times excess– for Cu and As. Urban forest areas were the least contaminated - the excess of APC was observed only for As and only for the soils with pH< less than 5.5.

The HMs' contents were interpolated in QGIS software to map soil pollution and analyze the patterns of its spatial distribution (Fig.1). Areas of excess of the APC were shown for recreational and residential zones along highway in the 0-20 cm layer. For example, high Cu contents were detected for construction sites in central of Moscow along the entire profile, reaching 262 mg/kg (for example Fig.1). The average value of Hg exceeded the APC throughout the profile. The average content of Zn in the 0-20 cm layer exceeded the APC for light and acidic soils. Exceeds of the APC are noted for lawns and residential areas. The average lead content did not exceed the APC for loamy soils. The largest excess (up to 277 mg / kg) of the APC was found on the Bolotnaya and Sofiyskaya embankments.

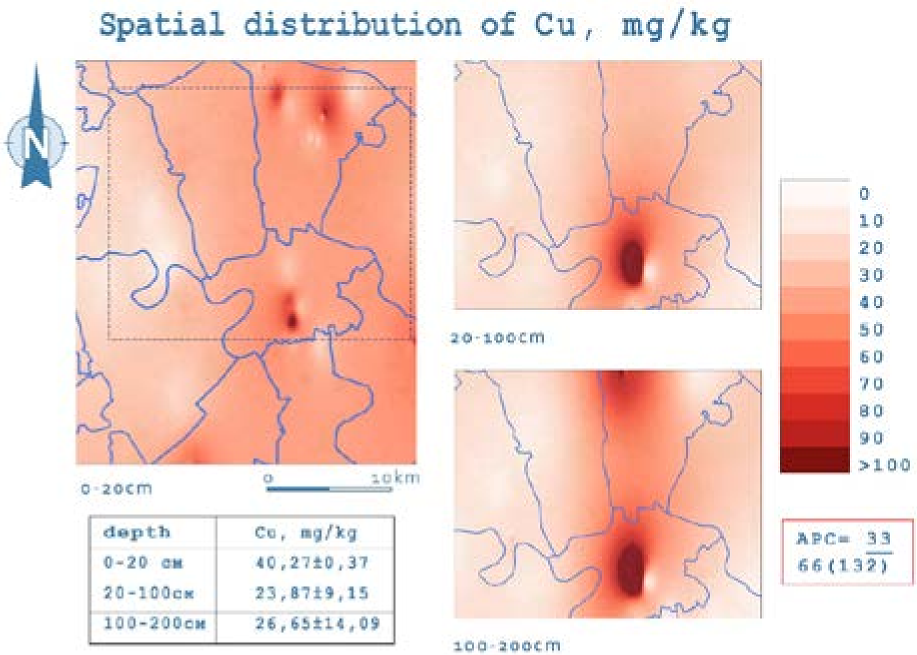

Fig. 1 Schematic map of spatial distribution of cuprum

The ecosystem service's performance by urban soils was evaluated considering the total HM-contamination index HMs (Zc) , acidity and texture, since these properties directly affect the buffering of HM and their release.

Zc was estimated as $Zc=\sum Kki-(n-1)$,$Zc=\sum Kki-(n-1)$, where Kki is the coefficient of the concentration i-th element's; n – number of elements, as pollutants. An integral performance of the ESs was evaluated as a product of Zc (from $Zc < 16$ for non-dangerous to $Zc > 128$ for extremely dangerous), acidy (from pH<5.5 for acid to pH>7.5)

A harmonic mean was calculated to standardize the scale (Fig. 2). It was revealed that the greatest dynamics of the regulatory service was shown for the 0-20cm layer. The Central Administrative District and the South-east Administrative District differ of the smaller implementation of the servicein connection with the high transport and industrial load on these districts. The greatest efficiency is presented in recreational areas.

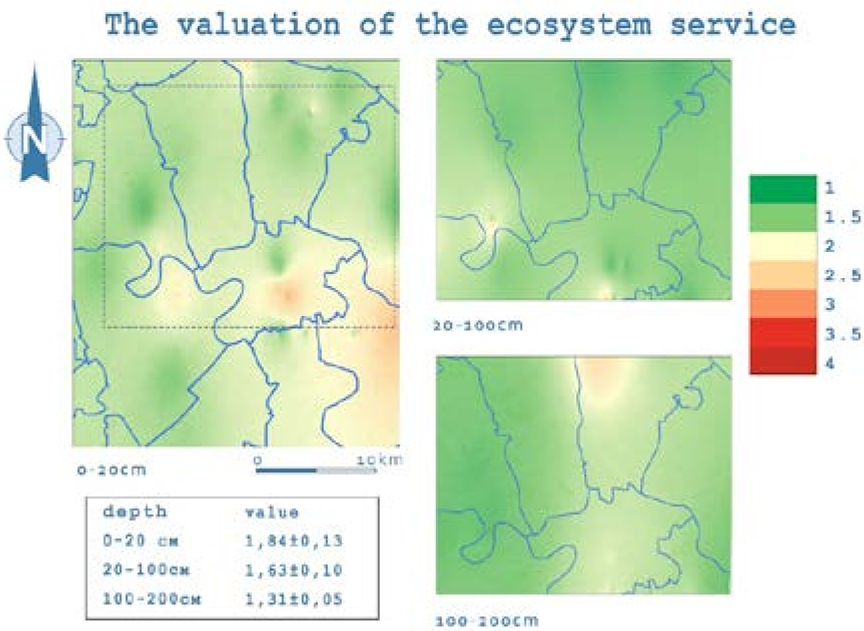

Fig. 2 Schematic map of the valuation of the ecosystem service

Conclusion

The presented approach estimated urban soils' regulatory service by overlaying the maps of pollutants' distribution (HMs, BP and Petroleum product) related to corresponding health thresholds (APC) with maps of soil properties, determining their resistance to contamination - acidity and texture. The presented method can be used to assess the planning of the territory and more efficient functional zoning in the field of civil engineering and environmental assessment. It can be used not only to detect areas with increased risk, but also to search for promising areas for residential development and recreational areas.

Acknowledgements

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Spatial distribution of heavy metals concentration in urban topsoils, Bydgoszcz, Poland

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Introduction

Urban soils are these elements of the environment which are most exposed to heavy metals contamination. It is mainly due to their sources associated with roadside environments, interior and exterior paints, refuse incinerators, industrial stack emissions, management and industrial waste. Moreover urban soils are usually disturbed or transported soils due to ordinary city activities. Such a situation leads to a heterogeneous distribution of heavy metal concentrations in urban-influenced soils (Yesilonis et al. 2008). Finally, this diversity is also the result of A variety of soil factors that determine the binding and transformation of heavy metal compounds (Alloway 1995; Kabata-Pendias 2011). Despite the small share in the area of lands in agricultural (allotments) or recreational use (parks, squares, green areas), the risk of direct contact with contaminated soil or plants is relatively high (Yamamoto et al. 2006).

The aim of the investigation was to determine the spatial distribution of selected heavy metals in the surface horizon of urban soils on the background of some physico-chemical properties.

Material and methods

The research concerns the total content of selected heavy metals in soils of parks, squares, playgrounds, and sport facility areas of a medium sized city in Poland. Composite soil samples of mixed 15-20 cores from 0-20 cm deep were collected from 36 objects of the Bydgoszcz city (53°07'26.5"N 18°00'12.4"E; Fig. 1.). The following analysis was conducted: pH using a glass electrode in H_2O and 1M KCl (ISO 10390:2005), total organic carbon content – TOC on LECO analyzer, cation exchangeable capacity (CEC; ISO 11260:1994), and soil texture on Mastersizer 2000 acc. USDA. The total content of Cu, Zn, Ni, Cr and Co were determined by XRF method. All analyses were conducted in three replicates and the validation of the results was based on the certified materials (reference soil sample TILL-3 and SO-4; Canada Center for Mineral and Energy Technology).

In order to analyze the spatial structure of the data and to calculate semivariograms, the Isatis (Geovariance Co.) geostatistical software was used. Semivariograms were prepared using the following formula $\gamma(h) = 1/2N(h)\,\Sigma[z(x_i + h) - z(x_i)]^2$ (Isaaks, Srivastava 1989) where $\gamma(h)$ is the experimental semivariogram value at distance interval h; $N(h)$ is the number of sample pairs within the distance interval h; $z(x_i)$ and $z(x_i + h)$ is the sample value at two points separated by the distance interval h. The mixed spherical/linear or linear models were fitted to the empirical semivariograms. The spatial variability of the properties studied was categorized into classes based on the percentage of total variance present as random variance: $[Co/(Co+C)]\cdot 100$, as proposed by (Cambardella et al. 1994). When the ratio was less than 25%, the variable had a strong spatial dependence; if the ratio was between 25-75%, the variable had a moderate dependence; if the ratio was over 75%, the variable had a weak dependence; otherwise, the variable was considered randomly correlated (100% - pure nugget effect). Maps displaying the spatial variance of the properties determined were drawn on the basis of the semivariograms.

Fig. 1. Location of research area (53°07'26.5"N 18°00'12.4"E).

Results and discussion

The total content of metals ranged as follows: Cu 20-57.4 mg·kg^{-1}, Ni 1-19 mg·kg^{-1}, Cr 14-46 mg·kg^{-1}, Zn 10-146 mg·kg^{-1}, and Co 1.2-174 mg·kg^{-1}. According to Polish regulations, the analyzed soils were classified as uncontaminated by the determined metals.

Table 1. Analyzed soil parameters.

	pH_{H2O}	pH_{KCl}	TOC	CEC	Sand	Silt	Clay
Min	6.14	5.33	0.97	4.24	57.5	15.9	0.8
Max	7.94	7.78	6.71	22.71	82.9	38.9	3.7
GM	7.46	7.19	2.33	9.27	70.5	26.4	1.9
AM	7.47	7.21	2.58	9.95	70.8	27.1	2.0
V	0.10	0.22	1.62	16.90	44.8	37.4	0.5
SD	0.32	0.47	1.27	4.11	6.7	6.1	0.7
M	7.52	7.34	2.31	9.36	71.6	26.6	2.0
CV(%)	23.67	15.43	2.03	2.42	10.6	4.4	2.9
Rku	9.22	7.78	3.05	3.60	-0.5	-0.5	-0.1
SK	-2.62	-2.59	1.60	1.63	-0.3	0.3	0.7

Min-Minimum; Max-Maximum; GM- Geometric mean; AM-Arithmetic mean; V-Variance; SD-Standard deviation; M-Median; CV (%)-Coefficient of variation; Rku-Kurtosis; SK-Skewness.

The analysis revealed the existence of different geostatistical spatial relationships of the analyzed elements on the investigated area. This diversity is described by the parameters of semivariogram models made on the basis of empirical semivariograms. For calculations for all analyzed metals the complex model was used which included spherical and nugget model. The most of the analyzed elements (Cr, Ni, Zn) were characterized as moderate spatial dependence, which was confirmed by the intensity of the nugget effect within the range of 25-75% (Tab. 2.). Only Co indicated strong spatial dependence (NE - 16%) and poor Cu (NE - 83%). A weak spatial dependence of copper in the study area was also confirmed by a very small value of range - 560 m. Other elements indicated the range value from 1200 to 1650 m. The values of nugget effect obtained for the majority of the analyzed elements showed domination of short range dependence, which is not determined by structural factors or those of local range.

Table 2. Parameters of variogram models.

Metal	Model	Sill (Co+C)	Nugget (Co)	Nugget effect Co/(Co+C)	Range	MSDR	Spatial dependence
		$(mg/kg)^2$		%	m		
Co	Sf, NE	2270	360	16	1250	1.104	S
Cu	Sf, NE	70	58	83	560	0.911	W
Cr	Sf, NE	63	26	41	1200	1.091	M
Ni	Sf, NE	12.2	4.9	40	1410	1.041	M
Zn	Sf, NE	1400	750	54	1700	1.052	M

Sf – spherical, L –linear, NE – nugget effect, MSDR – mean squared deviation ratio, S – strong, M – moderate W - weakly

Conclusions

The results of this investigation indicate that soils of Bydgoszcz had metal concentrations on natural level or elevated above background levels, but not exceeding the limits set by the Regulation of the Polish Minister of the Environment. Traffic is one of the largest sources of enriched concentration of the metals in the city. All objects located in close vicinity to heavy traffic roads showed higher level of contaminants. Moreover, the potential contamination by these metals was also due to soil parameters, like pH, organic matter content or texture what was statistically confirmed. These relationships were possibly responsible for binding these metals onto soil particles and subsequently getting redistributed by air and water movement throughout the city area.

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HEAVY METALS IN CONTAMINATED SOILS IN THE TRANSURALS REGION OF THE REPUBLIC OF BASHKORTOSTAN

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Soils may become contaminated by the accumulation of heavy metals and metalloids through emissions from the rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition (Khan et al., 2008).

Due to the disturbance and acceleration of nature's slowly occurring geochemical cycle of metals by man, most soils of rural and urban environments may accumulate one or more of the heavy metals above defined background values high enough to cause risks to human health, plants, animals, ecosystems, or other media (D'Amore et al., 2005.).

The Bashkir Trans-Urals is located in a biogeochemical province with an elevated level of some heavy metals in environmental objects (Semenova et al., 2016). In this territory there are mining enterprises engaged in mining and processing of polymetallic ores. The prolonged and intensive activity of quarries, mines, concentrating mills also contributed to soil contamination with heavy metals.

The work was carried out in the industrial center of Bashkir Zauralye in the city of Sibay, in the territory of which there is a large deposit of copper pyrite and a large ore mining and processing enterprise that has been functioning for half a century.

Objective: to study the degree of soil contamination in Sibay city with heavy metals.

The objects of research were soils located in different parts of the city's territory and beyond, to varying degrees subject to anthropogenic impact without reference to a particular geographic area.

Investigations of the content of heavy metals were carried out on sites laid by the method of transect in homogeneous areas with a slight anthropogenic impact of a mechanical nature, taking into account the directions of the prevailing winds - north-west and south-west.

The sites were located at different distances from the Sibay concentrating factory, which is a source of pollution: in the east, at distances of 0.5 km (S1), 5 km (S2), 10 km (S3), in the southeast - 5 km (S4), 10 km (S5), 15 km (S6) and north-east - 5 km (S7), 10 km (S8), 15 km (S9). Sampling of soil samples (in 3-fold repetition from the 0-30 cm layer), preparation and analysis of samples were carried out according to the appropriate methods.

The content of heavy metals was determined by atomic absorption spectrometry.

Ecotoxicological assessment of soils was carried out using the maximum permissible concentration of heavy metals for their total contents and mobile forms (extracted with ammonium acetate of pH 4.8). Soil contamination was assessed by the total Zc value, calculated according to the formula:

$$Z_c = \sum_{i=1}^{n} K_c - (n - 1),$$

where *n* is the number of ingredients to be determined; *Kc* is the coefficient of concentration of the element, determined by the ratio of its content in the contaminated soil to the control soil which is not affected.

The results of studies of the content in heavy metal soils are given in the table.

Table. The content of heavy metals (mg / kg) in the soil in the zone affected by the Sibay concentrating factory (above the bar - the total content, below the line - the content of mobile forms)

The sites	Cu	Zn	Cd	Pb	Zc	Pollution category
S1	786,8 73,5	553,8 150,2	4,4 0,18	33,3 0,3	47	Highly dangerous
S2	203,1 13,3	583,9 15,9	5,2 0,1	21,9 2,6	40	Highly dangerous
S3	40,9 6,4	104 3,2	3,9 0,16	18,1 0,01	25	Moderately hazardous
S4	57,5 35,6	446 74,2	2,7 0,01	9,8 2,3	19	Moderately hazardous
S5	49,9 6,5	108,2 2,6	4,9 0,01	17,3 4,6	32	Moderately hazardous
S6	60,1 7,9	124,1 1,2	3,6 0,01	20,9 0,01	24	Moderately hazardous
S7	81,5 22,9	215 17,2	2,9 0,08	19,2 3,8	20	Moderately hazardous
S8	68,8 19,6	142,2 28,4	5,0 0,01	17,1 0,01	32	Moderately hazardous
S9	62,5 12,3	106,5 13,1	4,1 0,08	13,7 5,3	27	Moderately hazardous
Maximum permissible concentration	55	100	2	32		

Thus, in the soils in the city of Sibay there is an increased content of Cu, Cd and Zn. The general regularity of the change in the content of heavy metals is their decrease with distance from the source of pollution.

The level of soil contamination in a radius of 0.5 km from the source of pollution is classified as highly dangerous. The main "contribution" in this case is made by copper, cadmium, zinc. The soils of the rest of the studied territories refer to the moderately hazardous category of pollution.

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LITTER AS THE INTEGRATED INDICATOR CYCLE RATE OF ORGANIC MATTER IN URBAN ECOSYSTEMS.

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One of the tasks of the monitoring of urban areas is to determine the ecological condition of soil and plants. The characteristics can be obtained through the study of classical indicators of biological cycles. One of the most important components of biological cycles of both forest and urban ecosystems include litter, largely determines the functioning of soils and ecosystems in general. Functions of litter are varied, however, as the integrated status indicator biogeocenosis properties litter reflect a ratio the processes of accumulation of carbon in the system and processes of decomposition of organic matter that provide element input to the soil , biota and atmosphere. In the context of the problem of global warming, in the capacity of depositary the role of organic matter and carbon at the outset immeasurably increases and the study of litter are of special ecological importance.

Feature functioning urban ecosystems is the use of different systems of care for plans, including park regime actively used on all types of urban land (residential, transit, recreation, etc.). Park mode of care includes a set of measures such as the removal of undergrowth and underwood, periodic mowing grass, foliage picking, etc., that apparently leads to a change in environmental conditions, and can have an indirect influence on the rate of decomposition of litter. Analysis of the status of the litter helps diagnose a particular biological cycles in urban ecosystems, what determines relevance study of litter on the urbanized territories.

The aim of the study was to assess the state of litter typical woody plantings in urban green areas of the city of Moscow.

Research has been conducted on the territory of the Moscow State University M.V. Lomonosov. The objects of research are trees such as betula pendula, tilia cordata and acer platanoides. Select the data types of tree plantations was determined by dominant tree species in Moscow. The study was carried out on the territory of litter with conditional reference biogeocenoses from the MSU botanical gardens without gardening care regime and landscaped parkland of MSU, where a system of park greenery care, however, in the past 5 years was not litter picking.

Selection of litter is conducted in two terms: the end of vegetation period and after defoliation. Litter were selected in three times the recurrency with square 50 x 50 cm and determined their composition (branches, leaves, fruit, bark, rags and detritus). To determine the fractional composition of detritus he sifted through sieves, 8 were received fractions. Active fraction of litter was determined as a percentage of the sum of the fractions of less than 5 mm of the total stock of litter. [1]. Reserves of easily degradable litter components is calculated on the sum of fractions of litter-leaves and rags. The amount of organic matter implemented annually, calculated as the difference of the number of easily degradable components in litter after defoliation and mineralization at the end of the period [2]. All stocks of litter should be absolutely dry hitch. These materials were processed with statistical methods using standard deviation as a measure of variation in symptoms.

Studies have provided data on indicators of litter typical tree plantations botanical gardens and parkland. Field studies have shown that the power of litter stands of betula-tilia-acer park zone varies within 0, 5 to 5 cm and litter have the same plantations botanical gardens-from 3 to 11.5 cm, which corresponds to the literature on litter forest biogeocenosis and slightly exceeds the data on the Park territory. [3.4] power of litter increased among woody plantings betula-tilia-acer in all stages of the selection as for botanical gardens and parkland, with plantings of Botanical Garden bedding capacity higher than litter plantings of parkland.

Litter studied sites primarily destructive, however, on the territory of the Botanical Garden in 35% meet destructively-enzymatic, as evidenced by the presence of horizons as destructive and transitional destructively-enzymatic. The structure of litter is typical for sites of betula and acer in botanical garden.

As expected, total reserves after defoliation in nearly 2 times higher stocks of litter to the leaves. For plantings of Botanical Garden litter stocks higher in all stages of selection, compared with parkland. Common stocks of litter typical woody plantings ranging for shareware reference territories Botanical Garden-from 0.6 to 1.9 kg/m2 for maximum stock of litter acer for parkland, from 0.2 to 1.5 kg/m2 for minimum stocks from betula litter. The average values of the received data correspond to the literature [5].

Analysis of the data showed that stocks of easily degradable components (leaves and rags) increases by the end of the autumn after leaves. Maximum easily degradable reserves part of the litter are defined in mats tilia plantation of the Botanic Garden-37% of the total stock of forest litter. In acere and betula litter easily degradable components occupy an average of 25% and 8% respectively. In the park area also falls on the stocks maximum litter tilia-45%, and the minimum to 5% betula litter.

The data obtained on annually implemented organic substance showed, that there is a general trend to increase organic matter implemented annually in litter row betula-acer-tilia for two territories with different modes of care. The largest amounts of litter have biogeocenosis tilia parkland-88% of the total stock of litter. Sites have the smallest reserves of betula annually implemented organic substances-6-25%. first of all it is connected with the fact that betula is a finely leafy breed trees , litter in its large number of twigs, betula also secretes substances, inhibitors slow the processes of decomposition of organic matter. Litter have parkland amounts annually implemented organic matter are higher than in the Botanical Garden, which is indicative of a higher intensity of decomposition processes and increased speed of biological cycles.

Study of the fractional composition of litter found features of litter of different types. In mats betula fraction prevails as branches in the Botanical Garden and parkland (up to 70%), while the percentage of tilia litter of leaves (up to 50%) when comparing the fractional composition of litter before and after the fall of the two territories with different modes of care, you may notice that there is a general trend towards an increase in the fraction of leaf, rag, detritus and fruits.

Detritus is a deeply transformed plant residues, shredded to an extent which does not allow for further Division. The data obtained by the fractional composition of detritus showed that share of fines above the mats parkland than at the Botanical Garden of approximately 10%. For the detritus of betula and acer of the Botanical Garden is characterized by a relatively high share of fine fractions 1-2 and 2-3 mm in relation to the fractional composition of the detritus of tilia, dominated by fractions above 3 mm

The active portion of the litter (particles whose size is less than 5 mm) is predominant in the litter sampled until the leaves. The maximum share of the active part of the litter in the betula forest is about 33% of the total stock of litter. There is a general trend towards an increase in the active fraction of litter in a row of tilia-acer-betula as the botanical gardens and parkland. The proportion of active fractions of litter parkland mostly lower than in the Botanical Garden, which may indicate increased speed of biological cycles in these ecosystems.

Analysis of the status of the litter showed that litter the verdant greenery of the urban territory of mostly primitive very low, suggesting a high speed destruction of organic matter of litter.

In relation to litter betula stands of litter and tilia-acer biocenosis of the Botanical Garden and parkland are characterized by elevated shares easily degradable part of the litter and annually implemented substances, as well as a reduced proportion of the content of the active fraction of the litter, reflecting the high rate of biological cycles in these ecosystems. Found that in the midst of the Park regime power and total reserves are declining, litter decomposition rate of organic matter easily degradable, which expresses in increase of annually implemented organic matter from the general reserves of the litter.

However, in the context of a systematic care for destructive litter plantings of acer and tilia noted deposits of organic matter into smaller fractions of litter, as evidenced by the increase in the total equity content 2 times detritus, as well as a trend towards an increase in the content of its fines.

Studies indicate that litter are integrated urban ecosystem status indicator and an important object in the context of the monitoring of the ecological state of urbanized territories.

Analysis of the status of litter urbanized territories showed that park care mode affects the intensity and decomposition processes and deposit ratio of organic matter to urbanity systems, increasing the speed of biogeochemical cycles in urban environments.

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Gas and geochemical condition and ecological functions of soils of filtration fields 30 years after reclamation

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Introduction.

Soils and technogenic surface formations of wastewater filtration fields are a powerful source of greenhouse gases in the atmosphere, such as carbon dioxide and methane. The main mechanism of methane generation is its microbiological formation and subsequent oxidation to carbon dioxide in a high content of organic matter in anaerobic conditions. On the one hand, it presents a risk of the enhanced greenhouse effect and climate warming as a consequence. On the other hand, there is the danger of fires and explosions as well as the deterioration of sanitary and toxicological situation due to existing standards (tentative safe exposure level (TSEL) and maximum permissible concentration (MPC)).

The purpose of the work is to reveal the gas geochemical condition and ecological functions of soils and technogenic surface formations of reclaimed Lublin filtration fields in Moscow in conditions of urbanization.

Research problems (research tasks):

1. Revealing the factors of ecological danger of soils and surface atmosphere contamination based on GIS analysis of several maps (soil, hydrological and geomorphological maps) of Lublin filtration fields and form a complex view of the territory;
2. Assessment the geochemical and ecological functions of soils and technogenic surface formations by the investigated parameters based on the received data;
3. Performing GIS analysis of the results obtained within the investigated territory based on various environmental factors;
4. Assessment of potential technogenic danger and sanitary and toxicological situation of investigated territory based on the performed analysis.
5. **Practical significance.**

Study of gas and geochemical conditions of reclaimed filtration fields is a part of system of greenhouse gases emission monitoring. The study of ecological properties of soils allow to reliably determine the quality of remediation works at Lublin filtration fields including the identification of the potential danger of this territory with the sanitary and toxicological point of view and also to evaluate the contribution to the enhanced greenhouse effect.

Objects and methods.

As object of investigation was selected the area of reclaimed Lublin filtration fields which is currently built up by residential buildings of Marino district in Moscow. Sampling of soil and air was conducted by static cameras; also air sampling from a height of 2 and 30 meters was carried out. All air samples were taken in penicillin vials filled with brine. Analysis was performed on a gas chromatograph CRYSTAL LUX 4000M. Soil samples selected for laboratory studying of physic-chemical properties (density, specific surface area, pH, organic carbon content) as well as for the study of bacterial oxidation and bacterial generation of methane.

Results and Discussion.

The main factor of geochemical danger of reclaimed filtration field's soils is the presence of biogenic layers at a certain depth and the formation of surface organic and mineral horizons during the reclamation. Organogenic horizons and layers contain a high content of organic carbon and characterized high specific surface area;

Methane generation in soils and technogenic surface formations of reclaimed filtration fields dominates in areas with a high content of organic carbon;

Bacterial oxidation of methane at the depth 60 cm in general correspond to its bacterial formation, but in some cases bacterial oxidation of methane is higher than its formation that indicates to additional flows of allochthonous methane from depth;

Urbic technosols (folic) characterized by increased concentration and activity of methane bacterial formation while in urbic technosols observed lower values of these indicators. Maximum activity of the methane bacterial oxidation corresponds to its maximum bacterial formation. Elevated concentrations of carbon dioxide in soils and technogenic surface formations at a depth of 60 cm associated with the maximum methane oxidation zone;

At low content of organic carbon flooded urbic technosols (folic) characterized by higher rates of bacterial formation of methane and low levels of oxidation than not flooded urbic technosols (folic);

Areas occupied by residential buildings and roads have higher concentrations of methane and carbon dioxide at an altitude of 30 meters: carbon dioxide - less than 1/2 MPC, methane - higher planetary level of 1.5 times. Over the territory occupied by woody vegetation concentration of carbon dioxide is less than 1/4 MPC, methane concentration is almost unchanged. Over the territory occupied by trees, concentrations of carbon dioxide are reduced that seem to be associated with its consumption by vegetation during photosynthesis;

Soils and technogenic surface formations of reclaimed filtration fields correspond to the norms of fire danger by their content of methane and carbon dioxide and refer to the “safe” category. However, according to the literature data, these concentrations can cause breakouts of methane in the winter with an increase in its concentration to 1/2 of TSEL.

Conclusions

Geochemical condition of different soil are evaluated and also identified environmental functions, consisting in limiting the emission of methane into the atmosphere due to the bacterial oxidation of own autochthonous methane and allochthonous methane coming from the lower layers.

Analyzing carbon stocks and fluxes of urban lawn ecosystems in Moscow megapolis.

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Urbanization results in irreversible transformations of vegetation and soils. . Urban lawn is an important part of urban ecosystems, providing several principal ecological functions, including . participation in global carbon (C) cycle. C stocks and fluxes in urban lawns are diverse due to the different functional use (residential, recreational areas, etc.), and different morphogenetic and physico-chemical properties of soil and their components.

The research was focused on C stocks and fluxes in urban lawns to assess their function of regulating atmospheric air composition. The following parameters were studied: soil CO2 emission (summarized for a year and growing season), soil CH4 fluxes (summarized for summer period); soil organic C (SOC); below and aboveground biomass. C emission by soil respiration and C sequestration in biomass were considered to estimate C balance.

Soil CO2 fluxes were measured by by infrared gas analyzer Li-820. The measurements were carried out every 20 days. Soi CH4 fluxes were measured by the exposition chambers method with subsequent gas samples analysis in the gas chromatograph. Air temperature and soil moisture and temperature were observed in parallel to flux measurements.

The research sites located at the Russian State Agrarian University and included plots with different functional use and level of anthropogenic load. High level of anthropogenic load was represented by lawns of the Central parterre (P-Wops) and Golf course (S-CEM). A standard level of anthropogenic loadwas represented by ornamental lawns in the territory of the meteorological Observatory (L-St) and Park (St). The grass stands of the studied plots were dominated by cultivated grasses, except the meadow urban ecosystems (L-St), which consisted of native grasses with the sowing of cultivated cereals. The following subtypes of urban soils were identified at the research plots (based on the classification by Prokofieva et al., 2011): 'recreazems' - for at the L-St plot, 'culturozems' – at the St and P-Wops plots, and 'constructozems' – at the POV plots.

.Significant seasonal dynamics of C fluxes was observed for all investigated plots. We observed the highest soil CO2 emission in summer period (June to August) with the maximal 50,3 64,7 gCO2/m2 / day obtained for the P-Wops in June 2014 and 2015 respectively. . Seasonal dynamics of CO2 emissions was positively correlated with soil temperature (R=0,77; p>0.05). The largest flow of carbon dioxide wastypical for summer (3,73 kg/m2), summer carbon dioxide flux is 47.8% of the annual CO2 emissions. In autumn the flow is less. Thus, the value of the total flux decreases in a series of summer>spring>autumn>winter.

Comparing seasonal dynamics of CO2 emission for lawns with different anthropogenic load revealed the highest CO2 fluxes(8,63 kgco2/m2 / year) for lawn urban ecosystem with a high level of anthropogenic load . Comparing annual CO2 emissions by type of lawn urban ecosystems revelaed the maximal 10.04 kgCO2/m2 / year at the P-Wops and the the minimum 4.75 kgCO2/m2 per year at the L-St plots.

These differences in carbon dioxide emissions can be attributed to two factors, which determine the flow value for various types of ecosystems (Kudeyarov, 2007): the content of organic substances and mechanical impact. The maximum SOC concentrations of 4% were obtained for P-Wop plots) for which the highest annual CO2 emission was also reported. The minimum value (1,92%) was observed in meadow urban ecosystems (L-St), which corresponds to the minimum value of CO2 emissions per year. A positive correlation between annual emissions of CO2 emission and SOC in soil was found (R=0,92; p>0,01). The minimal mechanical disturbance of the soil cover that was observed in the urban ecosystems with the standard anthropogenic load level (no machining, rolling, etc.) was characterized by minimal flow of carbon dioxide, whereas the maximum value was observed in the variants with periodic mechanical irregularities of the soil surface (P-Surface and C-Surface). Therefore the CO2 emission was also related to the intensity of anthropogenic load and lawn management.

In contrast to CO2, CH4 absorbtion by the studied soils was shown. It was found that increasing of the soil moisture decreased the flow of methane (R = 0,78; p> 0.05), and with an increase of humidity more than 40% the emission of CH4 was observed. This process can be explained by the fact that increase of the soil moisture decreases the oxygen concentration in the soil air, that increases anaerobic niches, which are occupied by methanogens.

The highest absorption of CH4 during the study period (June-August) was observed in lawns of the-meadow type - 44.4 mg CH4 / m2, and the smallest in sports (11.4 mgCH4 / m2).

Considering CH4 flows in terms of areas with different levels of operational stress, it was revealed that the plots with larger standard load absorbed methane more then with average load on 58.6%.

At the same time, the methane flow is characterized by very low values, and its contribution to an average is 0.02% and no significant influence on the total C flux.

Carbon sequestration in the studied lawns were measured based on the biomass growth. The maximum gainof the ground biomass was observed in May at all study sites, while the maximum increase was observed in the sports turf urban ecosystems with high level of load (222,7 ± 7,2 g / m2), and the minimum in the meadow with a standard level load (155,2 ± 12,4 g / m2). The minimum increase on all types of studied urban ecosystems was observed in August. Average maximum value of grass growth during the growing season were observed on urban ecosystems with high load level (779,9 ± 12,4 g), that was more than the growth of herbs with a standard operational load level (482,4 ± 15,2 g) on 61.7%. This can be explained by the the difference in the maintenance and operation. In urban ecosystems with a high level of treatment conductive frequent mowing, regular watering and mechanical tillage (aeration, combing), which contributes to the activation of growth of the ground and root biomass due to the optimal conditions of soil moisture and air supply. Lawns with a standard load levels differ with rare mowing, watering and lack of machining (Tyuldyukov et al., 2002; Abramashvili, 2006).

Loosing of the root biomass and, as a consequence, minimum connectivity of sod were observed in all studied areas after the winter period. The maximum losses were observed on urban ecosystems meadow type (93,4 ± 5,9 g / m2), the minimum - on sports (13,9 ± 1,6 g / m2).. For all types of the studied lawns root biomass decreased in July, which was associated with summer herbs depression (Shkarin, 2009; Sokolov, 2014). On the basis of the research it was established a positive correlation between the increase in above-ground and root biomass ($R = 0,74$; $p > 0.05$).

Carbon balance was estimated based on the comparison between CO2 emission from soil and C sequestration in biomass.. Flows of CH4 were not taken into account, because their contribution was negligible. For all the plots the flow of carbon into the atmosphere prevailed over the fixation with the difference between the flow and absorption ranges from 1.09 to 2.31 kg C / m2 per year. The greatest carbon losses were observed at the plots with lawn parterre (P-PIW), where they amounted to 2.74 kg C / m2 per year, whereas the lowest - in the meadow (1.29 kg C / m2 per year). It was also revealed a significant prevalence of carbon emissions for areas with a high level of operational load. This is due to the fact that on these areas regular mechanical tillage occurs (aeration, vertical cutting, and rolling), which largely affects violates soil cover and ground vegetation (Laptev, 2006; Sokolov, 2014).

Influence of natural adsorbents on properties and bioremediation rate of petroleum contaminated soils

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Petroleum and its products are priority modern pollutants of soil in many developed countries. Microorganisms degrading petroleum hydrocarbons are widely spread in many soils. Annually, more than 40 ha of soils in Russian Federation are contaminated with those pollutants [1]. Bioremediation *in situ* is the most perspective approach for reclamation of petroleum contaminated soils. It is based on activation of soil degrading microorganisms through regular agronomic practice and amendment of soil microflora by specific microorganisms with the help of biopreparation.

However, in RF the bioremediation is used less often compared to mechanical approach, which is based on excavation and transportation of the contaminated soils to company accredited for their utilizing. The reason of low application of the bioremediation is high toxicity of the highly contaminated soils and their bed quality that inhibits activity of degrading microorganisms and plant growth. Besides, there is a risk for penetration of toxic compounds into the ground waters during the process of soil bioremediation *in situ*. Earlier we demonstrated that activated carbon could positively influence on bioremediation of petroleum-contaminated soils [2-4]. There are positive examples of using other adsorbents for soil bioremediation. However, mechanisms of their influence have not been understandable totally.

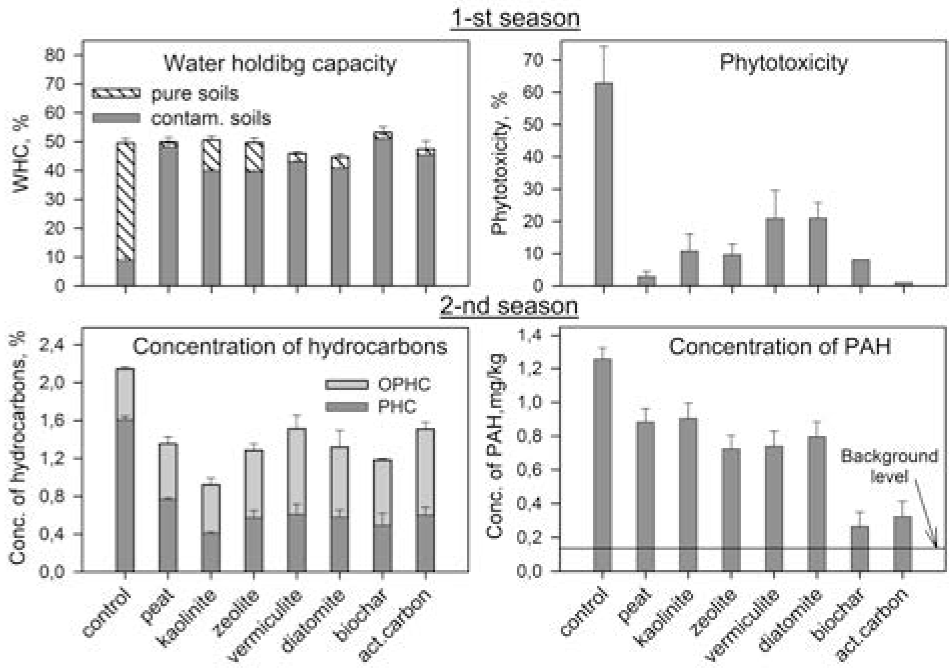
The main goal of this presentation is to study the influence of various natural adsorbents on properties of petroleum-contaminated soils and the rate of their bioremediation. The experiments started on June of 2015 and carried out in semi-field conditions on an experimental place in Moscow region. Plastic square pots without bottom with surface area 0,1 m^2 were embedded into the soil and 10 kg of pure gray forest soil was placed on the surface. The soil was contaminated above ground by petroleum of medium density (taken from Moscow petroleum refinery). In 2 days (just before the treatment), the initial concentration of PHC in soil was about 5%.

The soil was treated in according to protocol of biorecultivation described in the directory document of the company «Transneft» [5]. The soil was periodically mixed just before sampling (4 or 2 times per year) and watered with low mineralized water. Dolomite lime, mineral fertilizer ammophos, as well as biopreparation "Microbac" (developed at the IBPM RAS) added into the soil in according to the protocol. Permanent grasses sawed the soil in the middle of the seasons. In addition, the soil in some pots (except the control) was amended with natural adsorbents of 3 classes: mineral (kaolinite, zeolite, vermiculite, diatomite) in doses of 0,2 and 0,5%, as well as organic (high-moor peat) and carbonic (biochar and granular activated carbon) in doses of 0,5 and 2%. Those values correspond to optimal doses estimated in preliminary laboratory experiments with the same adsorbents taken in several doses in the interval from 0,1 to 5%.

Total concentrations of petroleum hydrocarbons (PHC) as well as total concentrations of oxidized petroleum hydrocarbons (OPHC) in the soil samples were determined by the method of IR-spectrometry certified in RF [6]. Concentration of polycyclic aromatic hydrocarbons was determined by HPLC after PAH extraction from the soil samples with the new developed method of supercritical water extraction [7]. The hydrocarbon degrading microorganisms in soil were counted by sawing on minimal agar medium with diesel fuel as a sole source of carbon and energy. Phytotoxicity of soil samples was determined through a new developed express-method on seed germination of white clover (*Trifolium repens*) as well as on biomass of plants growing in the experimental pots. Water holding capacity (WHC) of soils and other physical soil properties were determined by regular methods [8]. Comparative economic evaluation of the suggested method of adsorptive bioremediation was made in according to the approaches adapted to real prices in Russia.

The results are partly presented on Figure. It was shown that all the studied adsorbents introduced in 2 optimal doses positively influenced on the soil properties as well as on the rate of bioremediation. To the middle of the 2nd season, residual concentrations of PHC in the soils with adsorbents reduced to 0,4-0,8% compared to 1,6% in the control. In addition to hydrocarbons, substantial amount of oxidized petroleum products were determined in the soil to that time. Their relative amounts deviated from 30% to 80-110% of PHC in the control and amended samples accordingly.

It is important that no significant accumulation of PAH was indicated in the samples with maximal doses of adsorbents compared to the control sample. Total amount of PAH in the soil samples with carbonic adsorbents exceeded background level in pure soil only in 2 or 2,5 times, in the samples with other adsorbents – in 5 or 6 times, while those values in the control was 8 times higher then their background in pure soil. In addition, concentrations of benzo(a)pyrene in the amended and unamended soils were higher in 0,7-1,5 and 4,0 times then its maximal permissible level (MPL) accordingly.



Figere. Influence of adsorbents on the resides of PHC/OPHC and PAH in the petroleum contaminated soil in the end of the 2nd season, as well as water holding capacity (WHC) and phytotoxicity of the soil in the end of the 1st season of bioremediation.

Studding the influence of adsorbents on properties of petroleum-contaminated soils can explain mechanisms of positive influence of adsorbents on soil bioremediation. The petroleum-contaminated soil was rather toxic to plants and degrading microorganisms during the 1st season of the treatment when significant amounts of toxic petroleum products (particularly OPHC) formed due to microbial degradation of PHC. As it follows from the Figure, the phytotoxicity of the adsorbent amended soils reduced to 20% and less during the first months of the treatment while control soil remains rather toxic, and up to 60% of seeds died. It was earlier shown in experiments with activated carbon (AC) that maximal count of hydrocarbon degrading bacteria during the 1st season of the soil bioremediation was significantly higher in the AC amended soil compared to unamended control. Besides the AC amendment reduced risk for penetration of toxic compounds (particularly OPHC) to underground waters [3,4].

Study the influence of adsorbents on hydro-physical properties of petroleum-contaminated soils accounts for the other mechanism of adsorptive bioremediation. The WHC of the soil sharply reduced after the petroleum contamination due to formation of hydrocarbon film on the surface of soil aggregates. As it is seen on the Figure, the WHC of the contaminated soils amended with the adsorbents become similar to pure controls with the same amount of the adsorbents while that value for the contaminated control was still 11% compared to 50% in pure soil. In addition, the water-soaking rate of the amended soil samples also become normal compared to the control soil, which remained highly hydrophobic up to the 2nd season.

Thus, it was indicated that introduction of some natural adsorbents substantially accelerated soil bioremediation that was explained by their positive influence on soil properties due to reduction of soil hydrophobicity. Besides, soil toxicity reduced due to reversible adsorption of toxic compounds to the adsorbents, that created better conditions for degrading bacteria and plants.

Economic calculations indicates that price of mechanical approach of recultivation of petroleum contaminated soil deviates highly – from 4 to 62 million rubles/ha. Those values for biological recultivation is the lowest – only 1 or 4 million rubles/ha, depending on dose and price of biopreparation. Use of mineral, organic and carbonic adsorbents increases the price of biorecultivation to 1-3; 3-4 and 5-18 million rubles/ha respectively. Among the organic adsorbents/ameliorants the less expensive can be use of agricultural waste products like rice or buckwheat husks or wheat bran – abbout 1,3 million rubles/ha. However, these calculations do not take into account effectiveness of the approach. In some cases, use of inexpensive approach will not give any positive results. Moreover, use of adsorptive bioremediation (e.g. with carbonic adsorbents) can be useful in some cases when regular bioremediation will not be effective.

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Monitoring of urbanozem on the territory of Yakutsk

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Abstract. The soils of large cities are experiencing intense anthropogenic pressure, which often leads to their degradation and, consequently, to disruption of normal functioning that have both a direct and indirect negative impacts on living organisms.

The environment of large cities is typically evaluated as separate components: atmospheric air, surface and ground waters, soils, and vegetation. Monitoring studies of soils of Yakutsk is a system of continuous observations for their condition, to assess and forecast changes in the status of urban soils under the influence of natural (climatic) and anthropogenic factors.

Man-deep soil transformed itself form a group of urban soils - urbanozem where urbikovy layer has a capacity of more than 50 cm.

On the territory of Yakutsk as a result of anthropogenic transformation formed URBO-soils with different character education urbik layer, generally having the following structure: U1-U2-U3-AB-C; U1-U2-U3-U4-U5-C (Sivtseva, 2013).

Objects and methods. In 2009, the Institute of Applied Ecology of the North, laid the permanent monitoring of soils in Yakutsk system currently observing network for soil quality includes 65 points, evenly distributed on the administrative districts of the city within the various applications. In selected samples of soil the basic physical and chemical characteristics, the movable mold 9 microelements (Pb, Ni, Mn, Cd, Co, Cr, Zn, Cu, As), atomic absorption using a 1 HNO3 as the extractant, the obtained results calculated total index of soil contamination Zc.

To determine the level of contamination of the soil used sanitary norms level of maximum permissible concentration for the mobile forms, regional background, calculated according to previous studies on the territory of the Yakutsk, which in the located within of valley Tuymaada.

Results. Studies of the chemical composition of soils in Yakutsk shows that the intensive anthropogenic load occurs alkalinization of the environment and reduction in organic matter content and, as a result - there is fertility loss and inhibition of plant growth (Table 1.). Analysis of variation of pH over the years research has revealed fluctuations mainly within a weakly alkaline and alkaline pH, which is associated with high salt content. And, in particular, an increase in the content of carbonates associated with the destruction of various construction debris, excess present in urbanozem profile.

Table 1

The average content of some indicators of the composition of soils in the city of Yakutsk on years of research

Index	Research years							
	2009 (n=34)	2010 (n=28)	2011 (n=59)	2012 (n=69)	2013 (n=61)	2014 (n=34)	2015 (n=41)	2016 (n=64)
pH	8,3	8,3	8,1	8,2	8,2	8,0	8,3	8,8
Humus, %	0,6	1,8	0,9	0,6	3,6	2,1	1,5	2,9
HCO_3, mmol/ 100g	-	-	0,37	0,32	0,35	0,47	0,36	0,32

The humus content is low and very low. The degree of salinity of the city of Yakutsk is very mosaic, with a predominance of sulfate-chloride type up to 47% of the total area of the city.

Home geochemical feature of industrial, transport and municipal environmental impact of the city - is the formation of technogenic geochemical anomalies in the various components of the urban landscape (Kasimov, Perelman1993). On the territory of Yakutsk fixed point high and middle contrast gross anomalies of lead, copper, tin, and boron (Legostaeva, Sivtceva et al. 2011). According to the analysis of mobile forms revealed high concentrations of copper, plumbum, chromium, zinc and nickel. Over the years, marked by the highest standards for of mobile forms in the surface 10 cm layer of lead urban soils - up to 59, Zn 20, Cu 10, Ni and 2 times the maximum permissible concentration. Average contents data are shown in Table 2. The relatively fixed regional background excess plumbum up to 3 times, 3 times, zinc, copper, up to two times.

Table 2
The content of elements in urbanozem Yakutsk on years of research

Research years	The mean values, mg/kg								
	Pb	Ni	Mn	Cd	Co	Cr	Zn	Cu	As
2009	5,61	0,84	55,49	0,02	0,60	1,07	9,78	5,43	0,10
2010	12,05	2,46	76,09	0,06	0,79	1,59	15,30	15,91	0,26
2011	8,62	2,35	100,94	0,05	1,83	2,35	19,55	3,28	-
2012	5,12	1,54	40,10	0,03	0,93	1,40	8,31	3,71	0,25
2013	9,35	1,26	70,24	0,05	0,75	1,14	11,20	2,87	0,18
2014	4,48	2,05	133,06	0,02	1,32	1,28	3,86	5,14	0,20
2015	3,31	1,60	50,91	0,03	0,96	1,80	10,60	2,85	0,28
2016	3,12	1,43	71,98	0,05	0,91	0,99	16,90	3,88	0,10
content background (n=112),	3,36	2,51	122,26	-	1,95	2,11	5,58	9,39	-

As the value of the occurrence factors (Hi) in soils and subsoils territory of Yakutsk absolutely dominate zinc and plumbum. In general, the integrated assessment of geochemical parameters can be determined with precision argued that the main environmental risk trends represent the accumulation in soils of Yakutsk plumbum, zinc and copper. Over the years a number of studies of accumulation in the city of Yakutsk corresponds to the following scheme: Zn> Pb> Cu> Mn> Cr> Ni> Co.

Regarding the contents of the background elements, the average values of the total index of soil contamination are within the permissible levels of contamination (Table. 3).

Table 3
The average content of the total index of soil contamination by years of research

	Research years							
	2009 г. (n=34)	2010 г. (n=28)	2011 г. (n=59)	2012 г. (n=69)	2013 г. (n=61)	2014 г. (n=34)	2015 г. (n=41)	2016 г. (n=64)
Zc	11,4	10,5	8,6	4,9	9,5	11,7	5,3	5,4

In assessing the city on the total index of soil contamination (Zc) we can say that in 2016 about 79% of the surveyed points corresponds to an acceptable level of contamination, 12% are moderately hazardous area pollution and 7% refers to the dangerous levels of pollution. There confinement areas with high levels of pollution in the north-eastern part of the city.

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Differentiation of soil cover of man-caused landscapes in Siberia as reflection of their ecological status

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If regard ecological status of landscape as extent of balance between inner properties and outside situation, estimation of ecological status can be done on base of parameters reflecting this balance. It is considered that soils have such features, and morphologic are most informative and easy recognizable among them. It caused by stability of soil properties, from one side, and by their reflexivity to outer factors changes, from other side. Aforesaid characteristics determine priority of morphology in case of soils of man-caused landscapes, because of time deficit for fundamental transformation of other properties. In this connection, methods of ecological status based on the profile-genetic soil classification are wide spread [1]. According to this classification, each soil type occupies a specific habitat, characterized by a specific set of parameters of the ecological status, and the assessment of whole landscape in general performed through the mapping. This approach allowed assessing the ecological status of man-caused objects in a number of regions of Russia [2, 3]. However, such work is carried out on the objects, the differentiation of the soil cover of which is defined by specific field conditions. Research in a wider range of lithogenetic or climatic conditions today are few. As a consequence, in theoretical terms the development of ideas about common patterns of the functioning of man-caused landscapes and the forecasting of their ecological condition is constrained, in practical terms the development and implementation of effective reclamation is complicated.

Thus, the research of the differentiation of the waste dumps soil cover of coal deposits in Siberia was carried out with the purpose of comparison of the ecological status of man-caused landscapes formed in different climatic and lithogenetic conditions.

As objects were selected man-caused landscapes, presented 30-year-old coal-mine dumps of coal deposits of Siberia. Only horizontal sites of the landscape, occupying automorphic and autonomous position studied. The selected sites were organized in two series s of objects: 1. by the principle of the increasing climate aridity; 2. by the principle of increasing the degree of metamorphization of rocks composing the dumps.

Soil cover of coal-mine dumps formed under sub-humid climate of the Kemerovo region (Listvyanskiy), semi-arid Khakassia (Chernogorskiy), arid and arid extracontinental Tuva (Chadanskiy and Kaa-Khem coal) studied. The commonality of geological conditions of occurrence of coal led to the similarity of the soil-forming substrates represented by a mixture of different sizes of fragments of solid sedimentary rocks (claystones, siltstones, sandstones).

In addition, the sites were selected on dumps of anthracite deposits in the Gorlovsky coal mine (Novosibirsk region), which are composed of fragments of the same, but more metamorphosed rocks. Dumps in Nazarovo brown coal mine (Krasnoyarsk region) are composed of mainly unconsolidated sedimentary rocks. Both coal mine, as well as Listvyanskiy, located in the forest-steppe zone. The similarity of climatic conditions of soil formation is determined by the ratio of the values of annual precipitation and mean annual temperature. Thus, the second series looks as follows: Nazarovskiy – Listvyanskiy – Gorlovskiy.

Differentiation of the soil cover estimated by detailed soil mapping the survey sites. For a quantitative evaluation of the ecological status were used gradation proposed by Androkhanov V. A. and by V. M. Curachev [2] with the only difference that for each category was assigned a certain interval of scores. So, a site with a total score from 0 to 20 points is considered as unsatisfactory environmental condition, 20-40 points - satisfactory, 40-60 – good, from 60 to 80 points - a very good, from 80 to 100 points - excellent. If 100% of the site area occupied by the initial embryozems, its ecological status is 0 points, if by organo-accumulative embryozems - 33 points, if by sod embryozems – 66, and if by humus-accumulative embryozems - 100 points.

It is known that the differentiation of the soil cover of the selected objects is determined by the speed of evolution of the embryozems from the initial to organo-accumulative and later in sod and humus-accumulative [1, 4]. So, in the geographical series the degree of differentiation of the soil cover decreases with the increasing aridity of the climate (see table). It was noted that during over a 30-year period soil formation does not reach the stage of the humus-accumulative embryozems in the steppe regions, and in the dry steppe even the sod embryozems. It is noteworthy that in the latter case, noted soil types were not found by us on the excavation of medieval coal tunnel, older than 500 years.

Table

The composition of the soil cover of the studied man-caused objects, %

Name of coal-mine	**Embryozems**			
	initial	organo-accumulative	sod	humus-accumulative
Climatic series				
Listvyanskiy (sub-humid climate)	12	25	48	15
Chernogorskiy (semi-arid climate)	25	60	15	–
Chadanskiy (arid climate)	51	49	–	–
Kaa-Khem (arid extracontinental climate)	43	57	–	–
Lithogenetic series				
Gorlovskiy (anthracite dumps)	20	65	15	–
Listvyanskiy (coal dumps)	12	25	48	15
Nazarovskiy (brown coal dumps)	–	–	22	78

In lithogenetic series the greatest differentiation of soil cover is characteristic of the coal-mine dump, component composition of which is represented by all the stages of young soil formation (see table). Dump of anthracite field is heterogeneous to a lesser extent. Here the evolution of the soil only comes up to the sod stage. A more favorable situation evolves on the dump of brown coal mine, where the composition of the soil cover is represented by two types of embryozems of the last stages of soil formation.

Analysis of the obtained results on the composition of the soil cover leads to the conclusion, that in the arid regions the environmental condition of coal-mine dumps, is assessed as unsatisfactory (see figure). Satisfactory environmental condition is typical for landscapes formed in a semiarid climate, where in the composition of the soil cover organic-accumulative embryozems dominate and sod embryozems occur. In the forest-stepe environmental condition of man-caused landscapes is assessed as satisfactory at the site of anthracite deposits, as good at site of coal deposits, and as great at site of brown coal deposits.

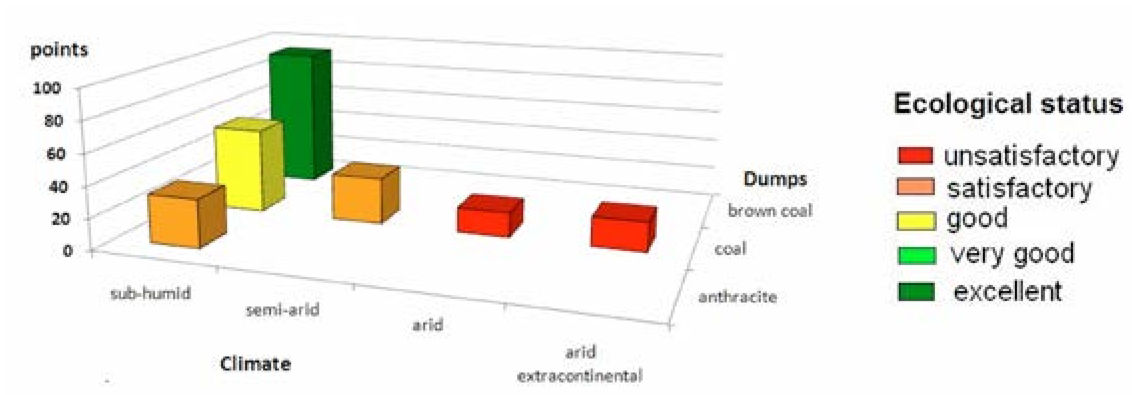

Figure. Ecological status of man-caused landscapes under research in points

Thus, research have shown that the differentiation of the soil cover of man-caused landscapes is defined both climate conditions and degree of metamorphization of rocks composing the dump. A certain component composition of the soil cover of man-caused landscapes, which reflects their ecological status is typical for each climatic zone. With the increasing of the climate aridity differentiation of the soil cover of man-caused landscapes is decreasing, and their environmental condition is deteriorating. Lithogenetic differentiation of soil cover impact on the environmental condition of the landscape through the rate of evolution of soils: the lower the degree of metamorphization of rocks composing a landscape, the higher the rate of evolution of the soil cover and better the environmental condition.

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SOIL FACTOR AFFECTING THE ACCUMULATION OF RADIONUCLIDES IN VEGETABLE CROPS

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The plant-soil trophic system is the original link for the agricultural chain migration of radionuclides (Ratnikov et al., 2004). The accumulation coefficient of ^{90}Sr is different about production of the same plants from 5 to 15 times on various types of soil from the north taiga to the semi desert and desert zones (Alexakhin,1991). During radioactive contamination of agricultural lands, radionuclides precipitated on soil and vegetation cover are initially in the uppermost soil layer 0-2 cm. Soil treatment leads to a redistribution of radioactive substances in the plowing horizon, but most of them remain in the 0-5 cm layer. Therefore, 80-90% of the radionuclides are concentrated in the active root zone. In uncultivated lands, virtually all the radioactive substances are in the upper layer (5-10 cm) of the humus horizons. Consequently, the deeper plant absorbs mineral nutrients; the minimal concentration of radionuclides will be absorbed from the soil.

The main and important soil properties affecting the dynamics of ^{137}Cs and ^{90}Sr in the “soil - plant” systems are:

mechanical and mineralogical composition,

soil solution acidity,

degree of base saturation,

organic matter content.

Based on their strength of radionuclides, soils fixation can be ranged as following: chernozemic soils (black soils) > middle loamy sod podzol soils > sandy sod-podzol soils. Hence, based on their radio resistance, they can be arranged in the following order: sod-podzolic soils (sandy < sandy loam < loamy) < grey forest soils < meadow alluvial soils < chernozemic soils (Gogmachadze, 2010).

The flux of radionuclides in plants depends on the basic agrochemical parameters controlled by the soil fertility that could be arranged in the following descending order: humus > exchangeable potassium content > pH > labile phosphorus content.

Given the behavioral similarities of ^{137}Cs and potassium, ^{90}Sr and calcium in biological systems, and based on investigating the genetic control of the potassium and calcium absorption, we can hypothesize on the genetic control of radionuclides’ absorption and use potassium and calcium model for pre-selection of genotypes based on accumulation of radionuclides (Brewers et al., 1994).

Using contaminated land in the national economy becomes more and more difficult year by year, because environmental pollution is going to be increased. In this regard, modeling the radionuclides accumulation in important vegetable crops is desirable and practical to produce environmentally friendly products (Mitchell et al., 2013; **Gaffar** et al., 2014).

General principles of radionuclides accumulation related to the soil properties are known; however, the degree of plants reaction is not still completely obvious. In present study, we considered the levels of chemical elements accumulation to determine optimal soils to produce vegetables such as lettuce with environmental safety requirements for enhancing whole element contents. We found out that sod podzolic soils are characterized by the highest content of Cs, K, Na, Sr, Cr, Co. Thus, everglade contains more Fe, As, Br than other soils in our study, and, High-moor peat was notable for its highest content of Sr and Ca. It is significant that K, a chemical analogue of Cs, was in greater extent in soil containing a great amount of Cs. The situation is similar for Ca and Sr, and, accumulation of soil micronutrients revealed a clear uniformity of the chemical composition.

The content of Cs, K, Na, Sc, Cr, Co decreased in studied soils as following order: sod-podzolic soils > high-moor peat > everglade.

Concerning the content of Sr reduced in a slightly different order: high-moor peat > sod-podzolic soils> everglade. We distinguished an everglade with less content of Cs and Sr, as well as K, Na, Sc, Cr, Co of the three investigated soils.

The elemental compositions in these soils have their own characteristics:

Sod podzolic soil – K> Ca> Na> Sr> Cr> Sc> Co> As> Br> Cs> Fe

Everglade – Ca> K> Na> Sr> Br> As> Cr> Fe> Cs> Co> Sc

High-moor peat – Ca> K> Na> Sr> Cr> Br> Co> Sc> As> Cs> Fe

In mentioned soils only one macro- (Na) and a microelement (Sr) keep the same order, they stably occupy the 3-4 places out of 11, the remaining elements are more variable. Sc most stably depends on the type of soil with the highest content in Sod podzolic soil followed by high-moor peat and everglade. In all cases, soil content of Cs is considerably inferior to that of Sr. Everglade is characterized by the smallest content of Sr and Cs.

The elemental composition in the lettuce product does not coincide with those in the soil:

On sod podzolic soil: K> Ca> Na> Cs> Sr> Fe> Br> Cr> Sc> Co> As

On everglade: K> Ca> Na> Sr> Cs> Fe> Br> Cr> Co> As> Sc

On high-moor peat: K> Ca> Na> Cs> Sr> Fe> Br> Cr> Co> Sc> As.

Regardless of the type of soil the order of the content of macro and microelements in the salad is hardly varying. Basically, the order of microelements' content levels is the following: sod-podzolic soils> high-moor peat > everglade. Concerning the elements is favorable that Cs which is at the last place in the soil elemental composition takes the 4-5 place in the elemental composition of lettuce. For Sc, Cr, Co the order in the elemental composition is similar both in soils and plants. On the other hand, the order is different for Ca, Fe, Br.

The order of the elemental composition in plants was different compared to the soils. It is obvious that flux of cesium in plants is poor about soils with the heavy texture, and on those with proper texture, it accumulates in large quantity compared to strontium. In our study, we noticed the lettuce ability to absorb less cesium on heavy loamy sod podzolic soils than strontium, only under additional background application of $Sr(NO_3)_2$, this might be due to the leveling effects on plants of sod-podzolic soils, and in addition the introduction of $Sr\ (NO_3)_2$ gives the destabilizing effect of genotype – environmental relations.

Cs in plants was higher than Sr about the lightest soil (high-moor peat) according to all illustrated variants. The transfer rate of several radionuclides in the soil-plant system depends on the number of isotopic or non-isotopic carriers of radionuclides, accompanying the process. It primarily relates to carriers linked to the transport of two leading long-lived radionuclides - ^{90}Sr and ^{137}Cs, which are major non-isotopic carriers and biologically important macronutrients - respectively Ca and K. To measure the coupled transport of ^{90}Sr - Ca and ^{137}Cs – K, a new term was introduced "Discrimination coefficient of radionuclide microquantity relatively to carriers macroquantity "(DC). For ^{90}Sr – Ca, DC= (^{90}Sr / Ca) -acceptor / (^{90}Sr / Ca) - donor.

The highest DC for Sr - Ca (1,9) characterized everglade soil, and for Cs - K (5,5) – sod podzolic soil. These are the least suitable soil for the cultivation of lettuce, contaminated with radioactive cesium and strontium lands, as the plants will out take the largest quantity of Cs and Sr. The lowest DC for Sr - Ca characterized sod podzolic soil, for Cs - K everglade soil. In our case, they are the optimal soil for plantation in the contaminated lands by these elements. However, the most optimum soil is high-moor peat soil, which combines the average DC value for both Sr - Ca, and Cs - K.

As the result of the complex evaluation, the influence of edaphic factor on the level of chemical elements accumulation by lettuce, in which we applied $CsNO_3$ (cesium nitrate) and $Sr(NO_3)_2$ (strontium nitrate) in 100-fold excess the standard permitted on the plant, the highest absorption Cs and Sr, made by us to simulate an extreme situation, happened on the sod-podzolic soil, evidently the least suitable soil for growing environmentally friendly products. Studies showed that the optimum soil for that is high-moor peat soil.

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Deep incorporation of organic matter can improve compacted urban soils to support establishment of deep rooted woody plants

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Abstract

Tree establishment and growth may be hindered by the compacted soils found at many urban sites, due to reduced root exploration and growth, and reduced water availability.

Six soil treatments were replicated three times and applied to compacted and degraded urban soils at three sites. The treatments were: 1) an untreated control, 2) shallow tillage to 250 mm, 3) shallow tillage plus 50% organic matter, 4) deep tillage to 500 mm, 5) deep tillage plus 50% organic matter, and 6) addition of 100 mm topsoil. A single *Corymbia maculata* (Hook.) K.D. Hill & L.A.S. Johnson was planted in the middle of each 2 m x 2 m plot.

Mechanically loosening compacted soils increased the water infiltration rate, the soil water content, and reduced bulk density. Adding organic matter further improved these characteristics. However, the addition of organic matter may have lead to a short term nitrogen immobilisation as indicated by reduced plant growth, and the development of anoxic conditions as demonstrated by corrosion patterns on inserted metal rods, and surface methane exchange measurements. Pre-dawn leaf water potential was regularly measured demonstrated the hydrological benefits of the treatments to the plants.

This study showed that degraded urban soils can be improved by a simple amendment strategy that will help the establishment of deep rooted woody plants.

This inexpensive technique can be easily implemented by councils and contractors. It can use the waste products of municipal green waste collections to improve challenging urban green spaces and to help convert grey and brown field sites into spaces where deep rooted woody plants can get established.

Are Collembola flying onto green roofs?

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The surface dedicated to green space is decreasing despite its major role in functionality and stability of urban ecosystems. As 32% of cities' horizontal surfaces (Frazer, 2005), green roofs are a great opportunity to create green space in cities. In parallel, urban agriculture is expanding worldwide, especially in industrialised countries where news forms of farming inside and on top of buildings (called Zero-Acreage farming) are developing (Thomaier et al., 2015). Rooftop gardens represent 64% of the Zero-Acreage farming surface. Among the many questions raised by this development, their potential positive effect on biodiversity support needs to be studied. Indeed, this soil service is often cited but rarely studied (Lin et al., 2015). Studies on biodiversity support will allow improvements to the design of productive rooftops, for example concerning the type of soil or plants, and further their functional role in urban ecosystems services. Among the biodiversity, soil invertebrates and more specifically Collembola are relevant bioindicators of soil quality (e.g. Cortet et al., 1999). Some previous studies have highlighted a low diversity and abundance of Collembola in extensive green roofs due to high constraints of anthropised solum, like for example low organic matter contents and low water retention (Rumble and Gange, 2013; Schrader and Böning, 2006). However, Technosol characteristics depend on many constraints such as roof characteristics, economical cost and aims of the project. We hypothesise that rooftop gardens could favor colonisation by microarthropods compared to the extensive green roofs previously studied, thanks to their improved soil characteristics.

Our objective was to investigate the taxonomical and functional characteristics of microarthropods communities (collembolan and acari), using a trait based-approach, across various rooftop gardens and extensive green roofs in order to evaluate the collembolan biodiversity in the two types of green rooftops.

Based on existing classification, we distinguished two kinds of green roofs (The Roof Greening Working Group, 2002). First, extensive roofs were characterised by a 5 to 15 cm-depth pozzolan substrate, mostly covered by *Sedum* species. On the other hand, rooftop gardens are intensive green roofs presenting deeper soils (15 to 30 cm) constructed with organic substrates (e.g. compost, coffee grounds, potting soil).

The present study was carried out in 8 extensive green roofs and 8 rooftop gardens located in Paris (France). To assess soil quality, Collembola were sampled in April 2016. Six replicates of intact soil core (5 cm depth, 6 cm diameter) were randomly sampled in each extensive and rooftop garden, paying attention to avoid border effects. Microarthropod community indices (specific richness, abundances, Pielou index, ecomorphologic groups), and soil biological quality index were calculated.

Our results showed a surprising collembolan biodiversity in extensive green roofs and rooftop gardens. Despite various soils characteristics (organic matter and water avaibility), no difference between extensive roofs and rooftop gardens concerning the taxonomical structures of collembolan communities (e.g. species richness, abundances) or soil biological quality are demonstrated. In contrast, there are differences concerning the taxonomic and functional compositions. Two specific community types lived in each rooftop type in function of practices. In rooftop gardens there is a higher intensity and frequency of human interventions, such as organic inputs which involve an increase in euedaphic species compared to extensive green roofs without organic inputs.

These later differences are induced by different ways of colonisation according to the type of green roof. In extensive green roofs, collembolans mostly come from passive dispersion through the air: the "flying" collembolans. In rooftop gardens, collembolans also arrived by annual compost inputs. Further studies need to more accurately discriminate between the importance of landscape and soil habitat on collembolan communities.

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Effects of recreational load on soils of footpaths and their impact zones in the Moscow forest parks

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Forest ecosystems in urbanized areas perform the important ecological function, supporting favorable natural habitat. Stability of their functioning depends on features of ecosystems, the status of all tiers of vegetation and soil properties. When using forest parks as an object of recreation formed by road and path network which breaks the integrity of natural components forest park. According to the level of recreational influence footpaths, near footpaths zones (impact zone) zones and the least undisturbed "core" are allocated. Each of these areas has specific characteristics, and their ratio is reflected in the general ecological condition of forest parks. In the conditions of the city influence of recreation is supplemented with the general atmotechnogenic deposition, containing carbonates, and local – carbon-containing connections and readily soluble salts.

The purpose of work was assessment of changes in the soil properties of footpaths and their impact zone depending on the level of recreational load and features of biogeocenoses.

Two large Moscow forest parks ("Losinii ostrov" and "Bitsevskii forest") which are actively used for recreation served as objects of research. In each forest park 9 areas, on three with different degree of manifestation footpaths are chosen (slightly, moderately, well-defined types). The last was estimated on their width (to 50, 50-80 and> 80 cm), to projective covering of live ground cover (to 5, 5-10 and> 15%) and consolidation depth (to 5, 5-10 and> 10 cm). On gradient from footpaths to the forest area (directly on them and at distance of 20, 50 and 100 cm from their edge) on layers of 0-5, 5-10 and 10-20 cm selected samples in 12 multiple repetition. The areas characterizing a little disturbed biogeocenosis "core" at the I digression stage (DS) served as background. Fir-tree linden-forest on sod-podzolic sandy loam soils on the integumentary loams spread by fluvioglacial deposits and oak-linden forest on sod-podzolic medium loamy soils on the integumentary loams spread by a moraine were respectively studied in "Losinii ostrov" and in "Bitsevskii forest" (Album Retisols on WRB, 2014). On footpaths their superficially gleyed differences prevailed. Characteristics of litter and properties of soils estimated by the standard methods. Data processing was carried out in STATISTICA package. The chosen level of significance was 0.05.

The type and specifics of the wood defined distinctions of characteristics of litter, and different particle size distribution of parent rocks - soil properties. In "Losinii ostrov" in comparison with "Bitsevskii forest" soils have smaller capacity of humus horizons, content with organic matter, less favorable structural state and bigger acidity. Patterns of change of litter and soil properties from footpaths to the forest area in forest parks are identical, and some differences are connected with features of biogeocenoses.

The underlayer of the litter. Under the influence of recreation in forest parks degradation of litter is observed. In comparison with the background its power on footpaths decreases from 2-4 cm to fragmentariness, type – with humified on destructive. Reduction of stocks of litter and width of formation of impact zones correlate with the degree of manifestation of footpaths. On sites with low of manifestation level footpath there is litter stocks reduction (in 1.8 and 1.6 times) which is fixed only on footpaths, with average level (at 1.4-1.9 time) extends to 20 cm from their edge, and well-defined types footpath (at 1.4-2.3) - to 50 cm. More intensively it is shown in "Losinii ostrov".

Crushing and grinding during the trampling organic material of litter lead to the reliable decrease in share active, to increase in the passive and crushed fractions. At the initial stage of recreation in oak and linden forest change of share structure of fractions (1.3-6.5 times) is less in comparison with fir-tree linden-forest (1.4-7.4 times). As much as possible process is shown on footpaths with width of impact zones before 50 cm. On sites with moderately and well-defined types footpaths on the contrary: in "Bitsevskii forest" change of fractions of laying is more essential, than in "Losinii ostrov" (in 1.3-13 and 1.3-7.7 times, respectively). The impact zone extends to 100 cm. It is caused by bigger pliability for decomposition by microorganisms of sheet litter in comparison with coniferous and sheet.

The humidity of litter as a result of transformation of its structure and decrease in water permeability of soils increases from background 20% up to 22-36%. Its statistically reliable increase in "Losinii ostrov" is noted on moderately and well-defined types footpaths and in impact zone of the last to 50 cm, and in "Bitsevskii forest" - only on their well-marked options.

Changes in soil properties under the influence of recreation

Density (ρ_b). The recreation promotes compaction in all 0-20 cm of layer soils. Directly on footpaths (except slightly defined types footpaths) size ρ_b (1,40-1,74 g/cm^3) exceeds optimum ranges. In "Losinii ostrov" reliable consolidation (on 0.17-0.35 g/cm^3) is fixed in all studied layer of the moderately defined types footpaths and in 20-50 cm from them. In "Bitsevskii forest" it is less (on 0.07-0.15 g/cm^3) and is also shown only directly on footpath. At intensification load increasing ρ_b extends to 50-100 cm from edge of footpaths in the first case and only to 50 cm in the second. More deeply ρ_b is in "Losinii ostrov" already on slightly defined types footpaths and in 20 cm from their edge, and in "Bitsevskii forest" only on moderately defined types footpaths. Possibly, it is caused by "exhaustion" organic the profile and approach to the surface of the facilitated eluvial horizon.

The hardness of soils. Regularities of its change under the influence of recreation are similar to the density of soils. However, increase in hardness in comparison with the density of soils in upper layer is shown quicker: statistically significant distinctions (at 1.3-1.7 time) are fixed already on slightly defined types footpaths.

The structural condition of soils negatively reacts to recreation. The coefficient of structure degree (Kstr.) in layer of 0-5 cm authentically decreases at 2-13 times concerning background in all points of approbation, as much as possible - on footpaths. In "Losinii ostrov" on slightly defined types footpaths the structure quality is still "good" (Kstr.=0,81), and on moderately defined types footpaths is already "unsatisfactory" (Kstr. <0,67). Deterioration in structural state (Kstr. <1.5) is shown in 20-50 cm from edge of footpaths. In " Bitsevskii forest " the structure of soils is steadier against recreation. The process of its degradation proceeds more slowly: "unsatisfactory" state (Kstr. =0,39-0,44) is fixed only on moderately defined types footpaths. In impact zones, despite falling Kstr. by 1,6-2 times, its size > 1,5, quality of structure of soils is characterized as "excellent".

The humidity of soils in upper layer significantly increases (by 2-14%) on footpaths and in 20-100 cm from them; most in "Losinii ostrov". Enrichment of underlying layers of soils moisture is less (for 2-6%). In "Bitsevskii forest" it is noted on footpaths and in 20 cm from its edge, and in "Losinii ostrov" – in 20-100 cm. Distinctions are caused by water retention power, the moisture movement conditions, particle size composition.

The maintenance of organic carbon in 0-20 cm layer of soils changes in different directions and is defined by balance of its receipt and losses.

In upper layer of soils of forest parks identical consistent patterns of enrichment of Corg (by 1.4-2 times), proportional to the level of recreational load are determined. Enrichment is connected with the introduction in it the incorporated fragments of litter and increased of biochemical destruction of litter and anthropogenous contribution. In "Losinii ostrov" reliable increase is shown on slightly defined footpaths types, and in "Bitsevskii forest" only on moderately defined types footpaths. Width of impact zones on moderately defined types footpaths makes 20-50 cm and on sites with on well-defined types footpaths - extends to 50-100 cm. As a result of the accumulation of humus and "compression" organic the profile more deeply the maintenance of Corg changes in different directions.

Reaction of the environment. Reliable increase pH of water on 0.4-1.4 on footpaths and along them to 50-100 cm in upper layer of soils of "Losinii ostrov" depends on degree of recreational load. In underlying layers process is not certain. In "Bitsevskii forest" in layer of 0-5 cm the shift of reaction in the neutral party is less (0.3-0.8 pH of water), and impact zones already (at all footpaths - 20 cm). Regularities remain in deeper layers. On urban areas intake of the atmotechnogenic deposition containing calcium carbonates and magnesium and effects of application of anti-icing connections is the main reason. It is confirmed by increase of pH of water (on 0,7-1,1) and turbidity (at 2-12 times) snow melt-waters in comparison with background.

Electroconductivity (Ec) of soils in upper layer increases (by 1.25-3.9 times) as a result of use of anti-icing connections on highways and the yards which with eolian transfer and at winter recreation come to forest parks. This fact is confirmed by the Ec of thawed snow, increasing in comparison with background by 2 - 10 times. At the low level of recreation reliable differences it is fixed only on footpaths, and at its intensification the impact zone 20-50 cm wide forms. Deeper size of the Ec of soils 2-3 times lower. Dependence of its change on gradient in "Losinii ostrov" is absent, and in "Bitsevskii forest" remains with expansion of impact zones to 100 cm. Distinctions are caused by easier particle size distribution of soils of "Losinii ostrov" strengthening the descending migration of electrolytes.

Biological activity of soils at recreation can both amplify, and to go down. As the reason serves transformation of ecological conditions that promotes change of physiological condition of microorganisms and reorganization of their complex. Significant distinctions of size of basal breath of soils is not established. There was a only the trend of its decrease concerning background at weak recreational load to 20 cm from footpaths is tracked, and increase while enhancing recreational load. The substrate-induced respiration (SID) is more indicative. In soils of "Losinii ostrov" its reliable increase (by 1.6 times) is shown only on well-defined types footpaths. In "Bitsevskii forest" the microbial community of soils reacts to stressful situation more quick outbreak of his activity. Reliable differences of SID from background (at 1.2-2,2 time) are fixed already on slightly defined types footpaths, and further and in 20-50 cm impact zones.

The condition of complex of soil invertebrates at recreational load also changes. In comparison with background in layer of 0-20 cm their number (by 1.3-4 times), biomass (1.1-16 times) and variety decreases (by 1,5-4 times) up to formation of monodominant communities (earthworms dominate). Width of impact zones increases from 20-50 cm up to more than 100 cm. Most negatively react soil invertebrates of litter complex .

The conducted researches showed existence of dependence between the level and depth of change of soil properties, width of impact zones and degree of manifestation of footpaths. Density, hardness, structure of soils and condition of complex of invertebrates are the most sensitive to recreational influence. Chemical properties of soils are less informative. Soils of forest park "Losinii ostrov" in comparison with "Bitsevskii forest" as less rich in organic matter, more acid and more light granulometric composition are more vulnerable to recreation.

SOIL COVER OF UFA CITY (genesis, evolution, pollution, degradation)

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One of the most important features of today is urbanization, which covers more countries and territories. This problem affects both the Russian Federation, where cities and towns is home to about 3/4 of the population (more than 100 mln. people) in the territory is 0.65% of the area. Only in the XX century of the total number of Russian cities about 2/3 have received the status of city, 1/3 of them - since 1945. In turn, global environmental changes, such as aridity, greenhouse effect, pollution, acid rain, soil and vegetation degradation, observed primarily in urban areas (Soil ..., 1997).

Environmental pollution, increased anthropogenic impact on biogeocenosis lead to a deterioration of the ecological system, which ultimately leads to the deterioration of health of people, reduce their efficiency, the growth of diseases, reduction in life expectancy and, in general, economic losses to society. To the greatest extent this is reflected in the cities, and especially in large cities, metropolitan areas (Savich et al., 2007).

Numerous studies conducted in various cities in the world, showed that that the main substances that cause pollution of soil urbanized areas are heavy metals and toxic organic matter. And they accumulate in high toxic concentrations and that subsequently leads to their migration to the ground and surface waters and the accumulation of plants (Kadar, Koncz, 1993; Sucharova, Suchara, 1995; Chladna, 1997; Lavado et al., 1998; Marr et al., 1999; Tambasco et al., 2000; Krauss, Wilcke, 2002; Niedzwiecki et al., 2004; Bartminski et al., 2012; Voevodina et al., 2015).

One important factor to optimize the environmental situation is to optimize the properties of soils. City soils perform important ecological functions and are indispensable in this regard. They are a medium for plant growth, a filter for percolating water, absorb toxic products from water and air environment. That is, urban areas are particularly unique type of natural-technical geosystems, which are concentrated within the maximum diversity of interaction between man and the soil. In the practice of conducting environmental research in urban areas the role of soils in urban ecosystems are largely ignored, and many of the specific problem of "urban soil" remain insufficiently studied. Weakly developed questions to study their genesis and evolution in the urban environment conditions, properties, ecological functions; There are no generally accepted taxonomy of urban soils and methods of their mapping, accounting, environmental, resource and economic assessment (Kimpe, Morel, 2000; Takeda et al., 2006; Klementiev et al., 2006; Savich et al., 2007).

The studies of soils cover were carried out in the city of Ufa (Russia). Soil samples from the main genetic horizons were analyzed in a laboratory by routine methods (Agrochemical…, 1976). Also determined the contents of toxic elements – toxic metals (cadmium, copper, arsenic, nickel, mercury, lead, zinc) and persistent organic compounds.

The capital of the Republic of Bashkortostan, Ufa, a major industrial metropolis (oil refining, chemicals, mechanical engineering, energy) with a population over 1 million people, is located in the east of the Russian plain within Belsko-Ufa watershed plains of the rivers Belaya and Ufa (north-steppe subzone temperate zone). The city occupies the southern extremity of this plain and adjacent low-lying spaces beyond the rivers. The main part of the city is located on the watershed, which has the form of strongly dissected plateau, which is significantly elevated above surrounding it on three sides by the river flood plains and valleys and stretched from south-west to north-east for about 50 km.

Soil distribution within the city is closely connected with the nature of the vegetation, the composition of rocks, climate, topography and degree of development of the territory of the man. Zonal soil types in Ufa are dark gray and gray forest, chernozems podzolized and leached. According to I.P. Kadilnikov (1969), the first and second developed mainly in watersheds, terraces and gentle slopes of the left bank of the Belaya River and elevated parts of the relief on the left bank, and the last - on the left bank of the terraces above the floodplain. In the natural form of the soil formed under the primary vegetation. Under the same gardens, parks and gardens, they have undergone a change.

Dark gray and gray forest soils are formed under deciduous forests. Gray soils are almost continuous distribution area north of the refinery and to the east of the river Shugurovka, and dark gray - developed to the south, although it is often found in conjunction with the first. Large areas occupied by them and on the left bank in conjunction with the chernozems.

The structure of the gray forest soils is not very different in different parts of the district. Dark gray forest soils in contrast to the darker gray wood painted, have a more powerful humus horizon (up to 30 cm thick), contain more humus and minerals, sometimes did not have a silica powder that is not podzolized. Chemical properties of soils are presented in the table.

Table. The chemical properties of the main soils of Ufa city

Horizon, depth, cm	pH H_2O	Humus	H^+	Ca^{2+}	Mg^{2+}	N			P available
		%	meq/100 g soil			total	NH_4	$N0_3$	
				%	mg/100 g soil				
Dark gray forest soil									
AU, 0-20	6,0	3,88	7,3	29,4	7,8	0,25	1,92	3,50	15,86
AUel, 20-28	5,9	2,85	7,0	28,4	8,8	0,18	1,23	2,20	10,32
BEL, 30-40	6,2	1,93	5,5	28,4	6,9	not determ	not determ	not determ	4,30
BT, 47-57	6,7	not determ	4,5	31,3	6,9	-	-	-	0,6
C, 60-80	7,6	-	1,0	27,6	8,4	-	-	-	11,55
Gray forest soil									
AY, 0-16	7,3	4,49	1,3	41,6	7,8	0,27	1,09	1,58	14,19
AEL, 16-26	7,0	4,26	2,8	43,1	7,8	0,27	0,88	0,72	5,12
BEL, 28-38	7,0	2,49	3,4	45,1	5,8	not determ	not determ	not determ	1,0
BT, 45-55	6,9	not determ	2,5	48,0	5,9	-	-	-	1,0
Urbic soil									
AH, 0-2	8,1	9,20	not determ	20	11	not determ	0,6	2,5	18,0
AU, 2-10	7,3	3,77	-	46	17	-	1,4	2,6	17,0
BT, 10-85	8,1	2,80	-	15	18	-	1,0	0,8	11,4
C, 85-100	8,1	1,56	-	8	17	-	0,3	0,5	2,7

Chernozems embedded in dark gray forest soils on the right bank of the river Shugurovka. They occupy the free forests, now built up, portions of the lower parts of gentle slopes and sometimes have traces of excess moisture. In addition, these soils are widespread on the left bank of the Belaya River near Dema station, Zaton and on terraces and gentle slopes.

Floodplain soils include various soil formations, developed on alluvial deposits of modern floodplains. Floodplain soils as it is surrounded by a horseshoe of the area of the gray forest and sod-humus-carbonate soils Bielsko-Ufa interfluve. The formation of floodplain soils greatly influenced by the spring floods. During flood a significant part of the flood plain is covered with water, which brings with it, and puts a different weighted material. Due to the heterogeneity laid by river sediment, vegetation, micro-relief and moisture, floodplain soils are very diverse.

In built-up areas (the space between buildings, lawns, landscaping elements, reclaimed areas) soil cover is represented by Urbic soil. Urbic soil are soil-like humus formation with consists of upper layer - is added humus horizon background soils (gray forest or chernozem) and the bottom layer - mineral substrate, the cultural layer, urban garbage. Their chemical composition quite varied and depend on the initial properties of the constituent materials (Table).

All the soils in the last decade been subjected to significant changes in the process of human economic activity. Within Belsko-Ufa interfluve they were under buildings, roads, green areas and maintained their original form only under forest parks. The deforestation in the city led to a revival of the process of erosion of soil and bedrock. Erosion of bedrock activity was shown on the steep slopes of ravines and river valleys, especially in the areas of unconsolidated quaternary sediments. It observed the formation of soil, devoid of humus horizons, leaching and a significant part of the illuvial horizon. Our studies have shown that in the conditions of Ufa soil cover is subject to significant changes, heavy pollution and soil degradation is observed even in parks territories. Among pollutants dominated by heavy metals, including mercury, nickel, cadmium, lead, copper and persistent organic compounds. Also, their distribution maps were made. Maximum hot spots are found near large industrial enterprises and along the highways.

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Potential Impacts from Road Salt Applications on Soils

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During the winter season, the safety and mobility of drivers requires using the best winter maintenance practices and materials currently available. Today and likely into the foreseeable future, that means using chloride-based snow and ice control chemicals, which are the most effective and cost efficient de-icers.

Despite all the benefits for traffic safety, there are also many adverse effects with respect to salting to the surrounding environment. Details on the distribution and concentrations of de-icing salt in soils would help indicate both the geographic extent of de-icing salt impacts and the relative importance of different pathways, including surface runoff, leaching through soil, and retention in soil (Cunningham et al., 2007). The purpose of this soil interpretation is to identify soils that have the potential to be at risk or vulnerable due to the application of road salts.

Soil survey interpretations are predictions of soil behavior for specified land uses and management practices. They are based on the soil properties that directly influence the specified use of the soil. Soil survey interpretations allow users of soil surveys to plan reasonable alternatives for the use and management of soils. They are used to plan both broad categories of land use such as cropland, pastureland, woodland, or urban development, as well as specific elements of those land uses (for example, irrigation of cropland, equipment use in woodland management, or septic tank absorption fields).

When soil interpretations are used in connection with delineated areas on soil maps, the information pertains to the soil for which the soil area is named. This is called the major soil component of the soil map unit. Other soils too small to map but observed within the delineated area are called minor soil components or inclusions.

Salt effects on the physical, chemical, and hydraulic properties of soils are very complicated processes and can be influenced by many factors. These factors are soil type and texture (Greene et al., 1978; Quirk and Schofield, 1955), concentration and proportion of monovalent and divalent cations in the soil solution and on exchange sites (Gillman and Sumner, 1987; Schofield 1947; van de Graaf and Patterson, 2001), clay mineralogy and content (Frenkel et al., 1978; Goldberg et al., 1988; Nelson et al., 2009), pH of soil solution (Chorom and rengasamy, 1997; Chorom et al., 1994; Suarez et al., 1984; Sumner 1993), the initial water content in soil (Rengasamy and Sumner, 1998), organic matter (Barzegar et al., 1995; Nelson and Oades, 1998), soil permeability (or saturated hydraulic conductivity), soil structure, cation exchange capacity, mineralogy, extractable cation exchange capacity, slope, bulk density, and restrictive layers (Ramakrishna and Viraraghavatan 2005).

There is strong and consistent scientific evidence showing adverse reactions of soils associated with road salt applications. Balancing public safety with protecting soils and the environment could become a significant challenge. Using best practices for salt management and understanding the vulnerabilities of soils may help minimize the adverse environmental impacts of road salt.

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Soil CO_2 emission and microbial respiration of various soil layers in Moscow megapolis

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Urban areas globally cover around 0.5% (Schneider et al. 2009) and may expand by 16,000 km^2 from 2000 to 2030 yrs. (Angel et al. 2011). Moscow is the largest city in Europe, its area extended almost 9 times in the last 50 years. The role of urban soils for fluxes of greenhouse gases (especially carbon dioxide, CO_2) remains understudied (Lorenz and Lal 2009). Urban soils are often ignored in the local and regional assessments of carbon stocks and fluxes (Houghton 2003; Kudeyarov et al. 2007). It is unclear, whether urban soils are net carbon sinks or sources (Pataki et al. 2006). Our study was focused on the estimation of soil CO_2 emission from surface and subsoil layers, the relationship between soil CO_2 emission and soil chemical and microbiological parameters.

Materials and methods

We studied Umbric Albeluvisols of forest park (pine, oak, maple), meadow (motley grass, near meteorological station), arable (potatoes) and Technosols of public garden near road-sides (linden, maple) in the north of Moscow megapolis (area of Moscow Agrarian University named by K.A. Timiryazev). For each location in five spatially distributed sites (2-5 m from each other) soil CO_2 emission was measured from soil surface (above-ground vegetation removed) since May to October 2015 yr. (in the end of each month). For this a plastic "collar-base" (diameter 20 cm) was cut into the soil at a depth of 2-3 cm, after half an hour the chamber (volume 0.5 L) was placed on the "collar-base" and connected to infrared gas analyzer (LI-820) then, the CO_2 flux was measured and expressed as CO_2 g m^{-2} d^{-1}. Additionally, in the three sites of each location soil CO_2 emission was measured after consistent removing two upper soil layers of 10 cm thickness (the measurement was carried out no less than 0.5 h after the layer removing). The soil temperature (T, °C) and moisture (W, %) were measured at 10, 20 and 30 cm depth. In the five sites of each location the soil samples were taken from 0-10, 10-20 and 20-30 cm layers then (totally 360). In the soil samples the microbial biomass carbon content (C_{mic}, substrate-induced respiration method), basal respiration rate (BR), soil organic carbon content (C_{org}), pH_w value and C/N ratio were determined.

Results

Soil CO_2 emission of various locations ranged from 0.2 to 87 g CO_2 m^{-2} d^{-1} for studied six months, the difference of these values was 437 times (Figure). Soil CO_2 emission was significantly high in meadow, it was low in arable (on average 33.5 and 3.8 g CO_2 m^{-2} d^{-1}, respectively), in forest park and public garden it amounted on average 20.5 and 28.4 g CO_2 m^{-2} d^{-1}, respectively. It was found that the soil CO_2 emission after removing upper 10 cm layer was higher than the corresponding surface in public garden and forest park, the excess was 48-789% (six months) and 44-219% (July, October), respectively. However, in the meadow and arable the excess of soil CO_2 emission after removing upper 10-cm layer was not found, it was even by 28-480% and 13-54% less, respectively, compared to that of surface. Soil CO_2 emission after removing upper 20 cm layer was up 66-499% (six months), 13-66% (excluded September) and 13-250% (June, July, October) higher than those of corresponding surface in public garden, forest park and arable, respectively. However, in meadow it was 35-545% lower compared to corresponding surface since May to September. In other words, the removing upper 10 and 20 cm soil layers in woody vegetation sites (forest park, public garden) led to an excess of soil CO_2 production, but a such effect was found in arable soil (grassy vegetation) only after removal of upper 20 cm soil layer.

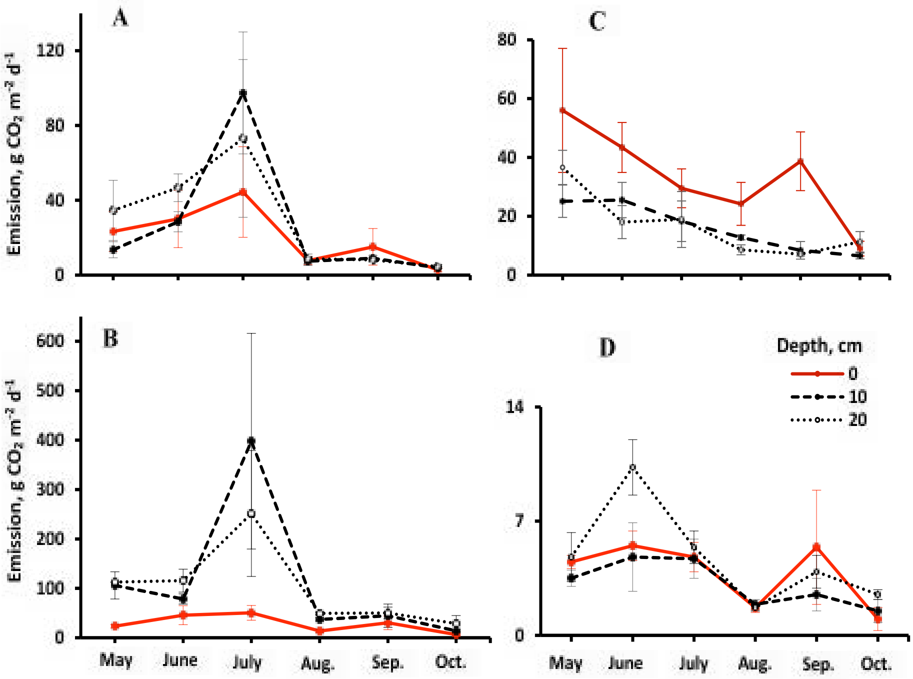

Fig. Soil CO_2 emission from the surface and after removal of 10 and 20 cm soil layers in forest park (A), public garden (B), meadow (C) and arable (D) of Moscow city (since May to October 2015)

The topsoil C_{org} (0-10 cm) of forest park, public garden, meadow and arable were found on average 2.2, 3.0, 3.3 and 1.0%, respectively, it was on average 10-52% less in subsoil layers (10-20 and 20-30 cm), it was excepted arable (the same content in studied layers). The topsoil pH value and C/N ratio were reached on average 4.7, 7.6, 5.9, 5.1 units, and 14, 16, 12, 11 for forest park, public garden, meadow, arable, respectively, and the parameters of subsoil layers were not significantly differed from the corresponding topsoil.

The topsoil C_{mic} of various locations were ranged from 60 to 1294 μg C g^{-1} soil for studied period of time, the difference between these values was 22 times. The topsoil C_{mic} of meadow and public garden was on average 549 and 517 μg C g^{-1} soil, respectively, it was higher that forest park and arable (331 and 110 μg C g^{-1} soil, respectively). The C_{mic} subsoil (10-20, 20-30 cm layers) was found on average 3-2 times less than topsoil (0-10 cm).

The topsoil BR were varied from 0.14 to 2.23 μg C-CO_2 g^{-1} soil h^{-1} for studied period, the difference between these values was reached 16 times. It was found that topsoil BR of forest park and meadow was on average 0.87 and 0.92 μg C-CO_2 g^{-1} soil h^{-1}, respectively, that was almost 2 times higher than public garden and arable (0.47 and 0.42 μg C-CO_2 g^{-1} soil h^{-1}, respectively). Moreover, the subsoil BR of studied locations was on average 30-62% low than corresponding topsoil (0-10 cm).

It was revealed that in studied locations the soil CO_2 emission from surface was significantly correlated with T, W, C_{org} and C_{mic} of 0-10 cm soil layer (r = 0.44, 0.45, 0.60 and 0.59, respectively, p <0.001). However, the correlation between the subsoil CO_2 emission and soil T and W was weak (r = 0.29-0.42 and 0.13-0.14, respectively), and C_{org}, pH, C/N and C_{mic}, opposite, was stronger (r = 0.60-0.69).

Multiple linear regression analysis showed that soil surface CO_2 emission of studied locations was explained by 52% spatial and temporal variation of C_{mic}, BR, C_{org} and pH, of 0-10 cm layer, and after removing upper 10 and 20 soil layers it was explained by 62 and 66%, respectively, variation of C_{mic}, BR and C/N (p <0.01).

Thus, soil CO_2 emission of woody and grassy vegetation sites in Moscow was significantly varied for studied period of time, wherein in meadow it was high and in arable it was low. It was found that subsoil of woody vegetation sites might be an additional CO_2 source in case of soil mechanical disturbance. It shown the dependence of CO_2 emission from various urban soil layers on soil microbial biomass content, microbial respiration, soil organic carbon content, as well as soil pH and C/N ratio.

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Accumulation of Heavy Metals in Dandelion Taraxacum officinale
with Regard to Urban Land Use

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Contamination of soils with heavy metals is a widespread phenomenon on urban lands which are intensively transformed and managed by humans. These lands are characterised by increased emissions of contaminants originating from industrial processes and combustion of fuels. Transformed structure and chemistry of soils, resulting from urbanisation processes, may lead to serious disturbances in their biological activity and impoverishment of vegetation cover. The problem of contamination of urban soils, due to the homogenisation of urban environment, may concern the entire urban centre, including urban allotment gardens and recreation areas. As cities intensively develop, their recreational areas, including allotment gardens lying typically at their peripheries, are nowadays within their centres. That is why, the state and quality of urban environment and changes occurring therein are thoroughly monitored. One of the well-known and recommended techniques is bioindication with the use of phytoindicators.

The present study on the contamination of urban soils with heavy metals was conducted in Kielce (Poland). It is a medium-sized city with almost 200 000 inhabitants, which is an administrative, cultural and business capital of the Świętokrzyskie Province. Kielce is a city with a very rich industrial past. Nowadays, it has a well-developed network of transportation routes and commercial services. As an indicator of the state of the natural environment, a dandelion plant *Taraxacum officinale* was used. It is characterised by a high capacity to accumulate contaminants, including heavy metals. The advantages of using dandelion as a phytoindicator are its widespread availability and very good adaptation to adverse environmental conditions. It is a plant which is widely used in herbal medicine as well – it is gathered seasonally by people, also in urban areas.

The aim of the study was to assess the content of heavy metals in the urban soils of Kielce with regard to land-use types. In the area of the city, 21 samples consisting of dandelion roots and leaves as well as soils were collected. The samples were collected and divided into land-use groups, i.e. industrial areas, urban parks and forests, urban allotment gardens, and urban green areas. In each sample, the total content of selected heavy metals, i.e. Pb, Cd, Cr, Cu, and Zn was determined, after mineralisation in *aqua regia*, by the flame atomic absorption spectrometry (FAAS) method. Moreover, such physicochemical properties of soils were analysed, as: grain-size composition by Cassagrande's method, pH_{KCL} by the potentiometric method, total organic carbon, and sorption properties.

The study indicated that the average values of the analysed heavy metals were not conditioned by the land-use types. This concerned not only the dandelion roots and leaves, but also the soils. Only in the case of samples collected from the urban parks and forests, the average values were lower than in comparison with those collected from other types of land use (fig. 1-4).

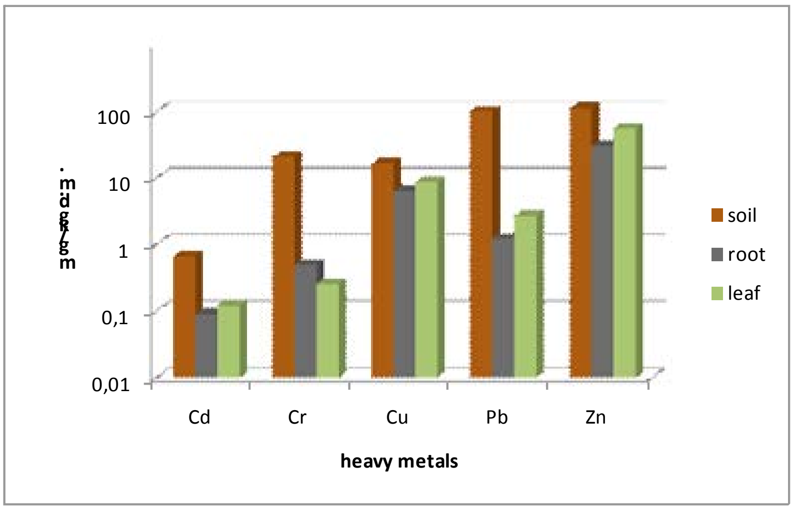

Fig. 1. Average content of the analysed heavy metals in dandelions and soils from industrial areas

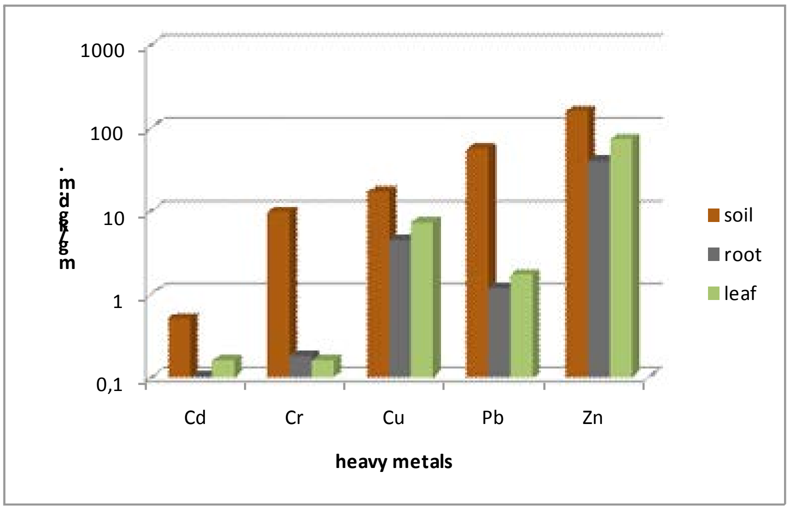

Fig. 2. Average content of the analysed heavy metals in dandelions and soils from urban green areas

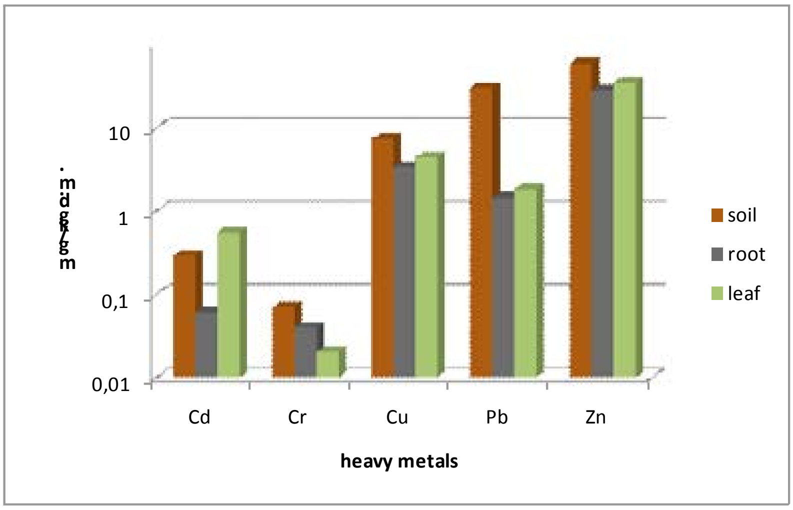

Fig. 3. Average content of the analysed heavy metals in dandelions and soils from urban parks and forests

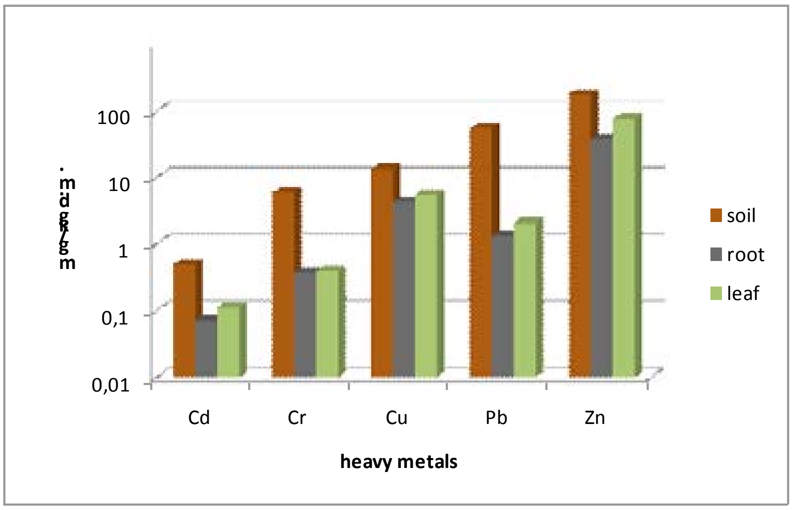

Fig. 4. Average content of the analysed heavy metals in dandelions and soils from urban allotment gardens

The highest content of heavy metals were reported for the soils. These values were relatively higher than those noted for the dandelion roots and leaves. Moreover, it was found that the dandelion leaves had higher content of the analysed heavy metals than the roots. This may indicate that the dandelion leaves, in contrast to the roots, accumulated heavy metals directly from the air. The analysed soils were characterised by varied physicochemical properties. They belonged to the grain-size group of medium sandy loams and sandy loams, and were characterised by the share of silt fraction at the level of 10-36%. They had either neutral or slightly alkaline pH. Three of the analysed samples were characterised by acidic pH (pH_{KCl} values: 3.94, 5.38, 5.95). The present study indicated the variability of soil sorption properties which may be related to both urbanisation and agricultural transformations of soil profiles in urban areas. No visible trends concerning the changes in the values of the analysed physicochemical properties with regard to each analysed land-use type were found.

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Stabilisation of Heavy Metals in Municipal Sewage Sludge from Urban Sewage Treatment Plants by Halloysite in Pot Cultivation of Agropyron elongatum (Host.) Beauw.

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Sewage sludge from sewage treatment plants belongs to a group of hazardous waste. Due to having heavy metals, toxic organic compounds, pathogenic bacteria and viruses in its composition, as well as its persistent odour, it is difficult to manage sewage sludge effectively. An alternative for management of stabilised sewage sludge seems to be a conception of its natural use. Sewage sludge, because of high concentrations of biogenic nutrients, facilitates the growth and development of plants, which is especially useful for conducting agrotechnical treatments on lands intended for reclamation. The use of stabilised sewage sludge in a land reclamation process may foster the minimisation of financial outlays and, at the same time, maximisation of effects for previously assumed goals. Additions to growing substrates, which optimally allow conducting land reclamation processes with using plants, are becoming increasingly important. Phytostabilisation is one of these techniques which are recommended in remediation treatments of soils contaminated with heavy metals. This technique may seem to reduce the risk of incorporating heavy metals into the trophic chain by limiting both the availability of metals for plants and their leaching due to soil erosion as well as overland flow. The phytostabilisation process may involve only these zeolites which belong to the group of clay minerals with proven properties of absorbing heavy metals from soils.

The present study was conducted in order to assess the usefulness of halloysite [$Al_2Si_2O_5(OH)_4 \bullet (H_2O)$] – a natural clay absorbent in stabilisation processes of heavy metals accumulated in sewage sludge intended for land reclamation. The study was conducted in the form of pot experiment with the use of a test plant – tall wheatgrass (Agropyronelongatum L.). It is a species of grass which has been commercially used for cultivation. The species has relatively low habitat requirements and is characterised by rapid growth and increase in biomass which prevents chemical compounds from leaching back into soils.

The study involved eight-week pot cultivation in a phytotrone chamber under controlled vegetation conditions, i.e. identical circadian parameters of light, temperature and humidity. The study involved three variants with a different percentage of halloysite addition, i.e. 10%, 30% and 50%. A control cultivation with a growing substrate based on light soil without the halloysite addition was also established. The pot experiment was conducted in two independent cycles. During the experiment, considerable variability in the rate of seed germination and then the growth of biomass was observed. After the experiment, the biomass was collected, weighed and dried. The total content of heavy metals, such as Pb, Cd, Cu, Ni, Zn, and Hg in the biomass and soil was determined by the method of atomic absorption spectroscopy (AAS). The study results showed that the halloysite addition differentiated the plant's rate of seed germination. The most efficient seed germination was reported for the variant with the 10% addition of halloysite. It was almost two and three times more efficient than the variants with the 30% and 50% addition of halloysite, respectively. The most efficient growth of biomass was reported for that variant as well. During the fourth week of experiment, the germinated seed in the variants with the 30% and 50% addition of halloysite began to wither. The study indicated that the addition of halloysite modifies the level of sorption of heavy metals by contributing to the reduction or intensification of sorption of selected elements by the test plant. According to the study results, the plants growing on the substrates enriched with the 10% addition of halloysite accumulated relatively less Ni and Hg than other heavy metals (fig.1÷4).

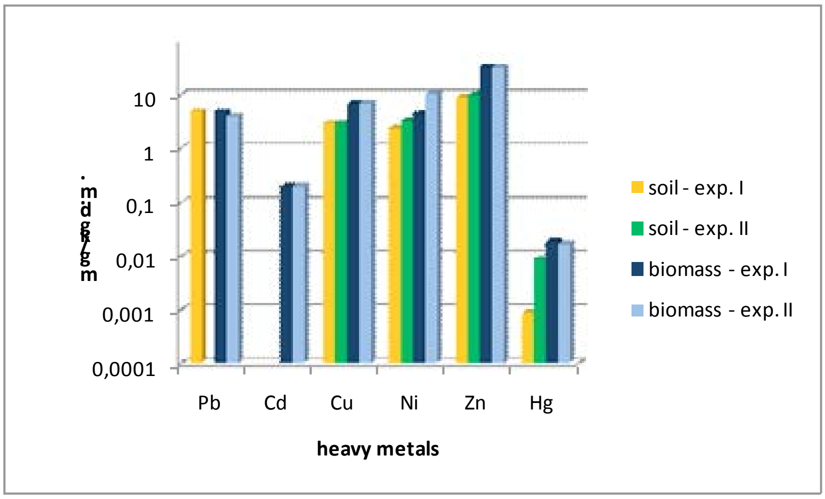

Fig. 1. Content of the analysed heavy metals in the soil and biomass of the pot cultivation – control variant

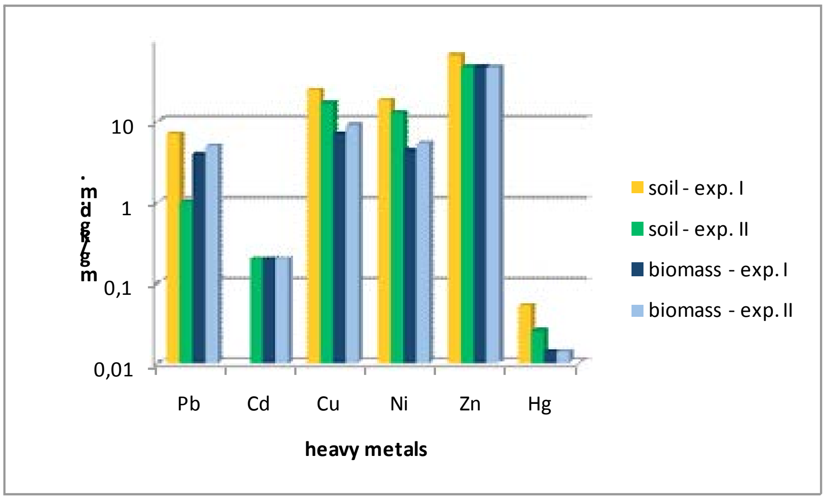

Fig. 2. Content of the analysed heavy metals in the soil and biomass of the pot cultivation –10% halloysite addition variant

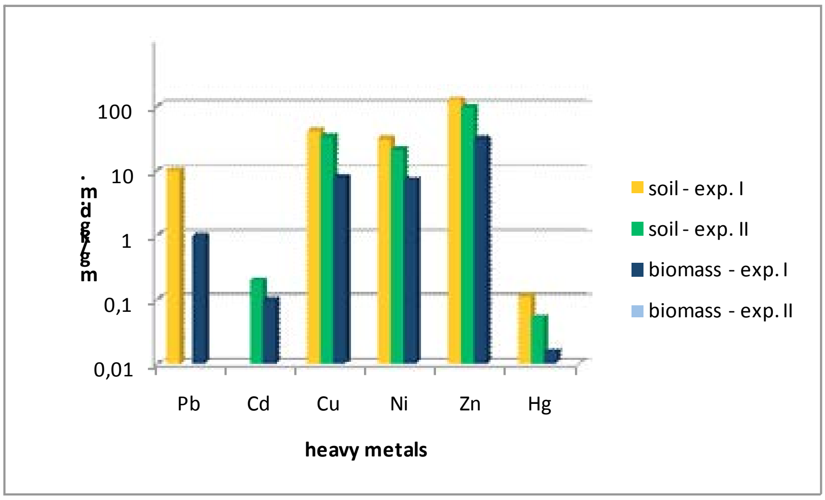

Fig. 3. Content of the analysed heavy metals in the soil and biomass of the pot cultivation – 30% halloysite addition variant

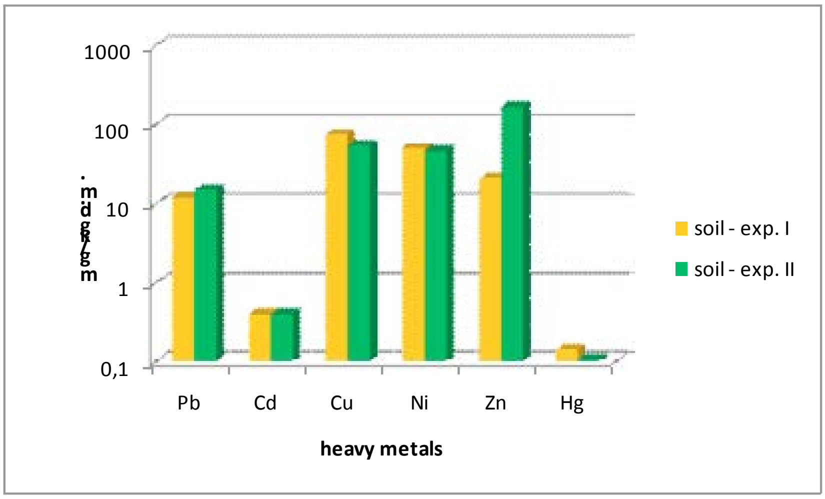

Fig. 4. Content of the analysed heavy metals in the soil and biomass of the pot cultivation – 50% halloysite addition variant

A significant increase in heavy metal sorption was, in turn, observed for Zn. The variants with the 30% and 50% addition of halloysite were not submitted for further analyses because of low growth of biomass (dry mass <1 g). High content of heavy metals in those variants probably contributed to the low efficiency of seed germination and growth of biomass. The initial results of the study indicated that the addition of halloysite, according to its amount, to growing substrates enriched with sewage sludge from urban sewage treatment plants differentiates the level of sorption of heavy metals, rate of seed germination and growth of biomass. The variant with the 10% addition of halloysite proved to be the most efficient, thus it may be analysed in further more detailed cultivation studies.

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Transformation of chernozem physical properties under urbopedogenesis conditions

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The soil cover of urbolandscapes is a complex combination of different soil types functioning within the highly intricate and relatively small city area. This multiplicity of classification varieties is due to the different natures and rates of anthropogenic impacts related to the functional use of the area. All anthropogenic impacts directly or indirectly affect the properties of soils, including such conservative properties as texture. In this work, we studied the main trends of changes in physical properties of chernozems under the effect of urbopedogenesis. Studies were conducted in the center of the Rostov agglomeration: Great Rostov, which includes the city of Rostov-on-Don and the Aksai and Bataisk satellite towns located in the 10–12-km zone. Changes occurring at three levels of structural organization of soil solid matter (elementary soil particles, structural units, and soil consistency) were studied. Particle size distribution was determined by the Kachinskii method with sodium pyrophosphate; the structural status of soil was determined by the Savinov method (dry and wet sieving); bulk density was determined by the cutting ring method. A total of 25 full-profile pits were dug, including 13 in anthropogenically modified (urbostratozems) and 12 in natural soils (migration-segregation chernozems).

Particle size distribution and humus status form the soil matrix, which directly or indirectly affects all soil properties. Therefore, particle size distribution is an important parameter of any soil study. Student test values for particle size fractions are given in Table 1; horizons of migration-segregation chernozems were compared to the corresponding buried horizons of urbosoils.

Table 1 – Comparison of particle size distributions in migration-segregation chernozems and buried analogues of urbosoils: actual and empirical Student tests

Horizons compared	Fraction size, mm							
	1–0.25	0.25–0.05	0.05–0.01	0.01–0.005	0.005–0.001	< 0.001	<0.01	>0.01
t_{cr} = 2.01 at a confidence probability of 95%								
AU,AJ–[AU,AJ]*	4.06	0.45	0.03	0.97	0.67	0.09	0.38	0.43
t_{cr} = 2.03 at a confidence probability of 95%								
BCA – [BCA]*	3.93	0.25	0.29	0.63	0.44	0.08	0.25	0.33
t_{cr} = 2.06 at a confidence probability of 95%								
C – [C]*	5.08	0.93	0.27	0.38	0.62	0.13	0.02	0.02

*Buried horizons are given in brackets (Prokof'eva et al., 2014)

The obtained results indicate that reliable differences are observed only for the total content of coarse and medium sand (1–0.25 mm). It should be noted that under urban pedogenesis conditions, particle size distribution most frequently varies due to the anthropogenic input of particles. For example, migration-segregation (calcareous ordinary) chernozems have no coarse–medium sand fraction (Gavrilyuk, 1955; Zakharov, 1946; Gorbov et al., 2016); however, this fraction is found in all of the studied soils, because it is used in construction operations and deicing sand mixtures. Thus, particles of 1–0.25 mm in size are indicators of anthropogenic impact on migration-segregation chernozems. Urbohorizons (UR) were conventionally subdivided into two groups: heavy horizons containing 0 to 60% physical sand and light horizons containing 60 to 100% physical sand. This division is based on the physical sand-to-physical clay ratio in native soils. It is found that 12 out of 31 urbohorizons are light, and 19 urbohorizons are heavy; thus, the buried native profile forms the basis for more than half of urbohorizons.

The structural status of soil is a fertility parameter, which affects the water–air and thermal regimes and thus significantly affects the living conditions of soil organisms. We estimated the structural status of soils in different land-use zones by different methods. For this purpose, the soils were conventionally divided into three groups: group 1, migration-segregation chernozems under forest vegetation; group 2, migration-segregation chernozems under steppe vegetation; and group 3, urbostratozems. Urbohorizons were considered separately; they were subdivided into light, heavy, and rehabilitating compost–humus (RAT) horizons. Data are given in Table 2.

Table 2 – Estimating the structural status of soil horizons in different land-use zones

Group	Horizons	Structural status estimation on the Dolgov–Bakhtin scale				Agrophysical Institute test		Estimation on the Kuznetsova	
		air-dry		water-stable					
		%	estimate	%	estimate	%	estimate	%	estimate
1	AU, AJ	66.1	good	61.5	good	179.4	good	61,5	exc
2	AU, AJ	57.9	good	66.6	good	223.8	good	66,6	exc
3	[AU, AJ]	51.7	sat	62.1	good	261.5	good	62,1	exc
1	BCA	60.6	good	54.1	sat	193.7	good	54,1	good
3	BCA	53.9	sat	59.1	sat	241.7	good	59,1	good
3	[BCA]	48.1	sat	59.4	sat	287.1	good	59,4	good
1	C	61.0	good	33.9	unsat	113.0	good	33,9	sat
2	C	49.0	sat	38.8	unsat	221.1	good	38,8	sat
3	[C]	46.9	sat	56.9	sat	271.0	good	56,9	good
Heavy UR		50,9	sat	51.4	sat	237.6	good	51.4	good
Light UR		47,5	sat	57.8	sat	247.8	good	57.8	good
RAT		40,4	sat	65.7	good	297.0	good	65.7	exc

(sat) satisfactory; (exc) excellent; (unsat) unsatisfactory.

The presented data show that the Agrophysical Institute test is unsuitable for estimating the structural status of soil, because the scale has wide ranges and all the horizons fall into the same gradation, while the Kuznetsova test overestimates the water stability of aggregates. Thus, the Dolgov–Bakhtin scale is best suitable for the objects under study.

Comparison of the structural statuses of air-dry aggregates in natural horizons of all soil groups shows that the values decrease in the series: soils under forest vegetation > soils under steppe vegetation > buried horizons of urbosoils. In our opinion, this tendency is related to the features of organic matter input into the soils under forest vegetation. The determination of the water stability of aggregates gave some unexpected results. In the upper part of soil profile, the highest water stability is expectedly observed in soils under herbaceous vegetation, because fallow soils under grasses have a stable structure typical for steppe conditions, and the high water stability is its distinctive feature. Water stability parameters of urbistratified chernozems are slightly worse, although they are higher than in chernozems under trees, where microbocenosis is altered under the effect of vegetation and climate changes, and all this is accompanied by a gradual reorganization of aggregate shape and, hence, a decrease in the water stability of soil structure. For anthropogenically modified horizons, the total content of agronomically valuable fraction decreases and their water stability increases in the series: heavy Ur horizons – light UR horizons – RAT horizons.

Bulk densities of the studied soils are given in Table 3. Fallow chernozems are characterized by values typical for zonal soils. The mean bulk density in the 0- to 25-cm layer is 1.1 g/cm3 for soils from this group; its value in the subsurface horizons is generally lower: 1.06 g/cm3. The bulk density of chernozems in the group under forest vegetation is higher; it does not vary throughout the depth under study and is 1.23 g/cm3 on the average. This can be due to the loosening effect of tree roots, because no trenching was performed before tree planting. The mean bulk density of the buried humus-accumulative horizons [AU] and [AJ] in urbistratified chernozems is 1.5 g/cm3, which usually corresponds to the BCA horizon of native chernozems, probably due to the compacting effect of the covering layer; the degree of degradation is estimated at 3 on the 4-mark scale. The compost–humus horizons of replantozems have the highest bulk density, because these soils are confined to the residential zones of high-rise districts, where the surface horizons are subjected to heavy traffic, which causes regular anthropogenic overcompaction.

Table 3 – Bulk density of urban soils

Soils, land-use zone	Horizons	Bulk density, g/cm^3, M±m	Difference with the arable analogue	Increase in equilibrium soil bulk density, % of the initial / Degree of degradation
Chernozems of forest parks	AU, AJ	1.23±0.02	+0.10	8.85 / 0
Urbistratified chernozems	[AU] [AJ]	1.5±0.01	+0.37	32.74 / 3
Replantozems of residential zone	RAT	1.65±0.09	+0.52	46.02 / 4
Fallow migration-segregation chernozems	AU	1.13±0.05	0	0 / 0
$LSD_{0.05}$			0.31	

The degree of degradation of the studied replantozems is 4. A tendency of increase in the density of the AU and AJ horizons is observed in chernozems of forest parks compared to fallow chernozems; the bulk density in the buried [AU] and [AJ] horizons of urbistratified chernozems and in replantozems is reliably higher than in the old arable soil.

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SPECIFIC FEATURES OF THE HUMUS ACCUMULATION IN TECHNOGENIC SOILS OF THE KURSK MAGNETIC ANOMALY

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The global mining industry is currently among the leading sectors of the world economy. As a result of quarrying activity only in Russia the total square of the post-mining areas are more than 1 million hectares.

For more than 40 years scientists of our university have carried out investigations concerning the rehabilitation of the technogenic landscapes of the Kursk Magnetic Anomaly (KMA).

Post-mining areas of the KMA are represented by the immature soils (protosoils) developing on the clay and loam, and chalky-clay rocks.

Our experimental findings shows that one of the most effective way of reclamation is the planting of perennial grasses, some shrubs and trees species (Treschevskaya et al, 2016). Among them are: Hippophae rhamnoides L. (sea-buckthorn), Alnus incana Moench. (alder), Betula pendula Roth. (birch), Caragana arborescens Lam. (acacia), Elaeagnus angustifolia L (elaeagnus).

Due to the planting content of organic carbon in soil increased significantly. The amount of carbon varied widely, depends on annual litter and total stock of detritus.

Soil and plant detrital carbon are significant components of terrestrial ecosystems and sources of heterotrophic respiration. The rates of their accumulation and turnover not only determine the changes in carbon storage, but also control net ecosystem productivity (Janisch & Harmon, 2002; Law et al., 2003).

In this paper we provide the data on studying specific features of humus accumulation and humus composition at the initial stage of soil formation under the different plant species (plantation age is about 15 years).

The most intensive humus formation were recorded under a canopy of alder (the percentage of organic carbon is up to 1.40 in the upper 0-5 cm layer). At the same time here was taking place biogenic accumulation of calcium and, on the contrary, under the influence of humic acids – removal of magnesium from the horizons penetrated by plant roots.

Less intensively humus formation were recorded under the plantings of acacia and elaeagnus (the percentage of organic carbon is up to 0.88 and 0.78, respectively).

The lowest content of the organic carbon were recorded under a canopy of sea-buckthorn and birch (0.66 and 0.55 percent, respectively). Here was the smallest biogenic accumulation of calcium as well.

Total nitrogen content is closely related to the leaf and woody debris. The maximum of total nitrogen we observed under alder, sea-buckthorn and acacia. Tne minimum was under the elaeagnus.

According to C:N ratio, fragmentation pattern of plant debris, changes in its color, structuring of organogenic horizons we suggested that the type of humus under all species was the Mull type.

The basic humus types in the series mull →moder →mor are arranged in order of decrease in the activity of soil invertebrates in transformation of plant remains, the average rate of litter decomposition, and the stock of nutrients in the soil; the zone of predominant carbon accumulation in this series shifts from organomineral soil horizons to the litter (Korkina, Vorobeichik, 2016)

It should also be noticed that under elaeagnus and birch plantations the process of humus formation was observed only in topsoil (0-20 cm), while under other plants it was in subsoil as well (0-50 cm).

The analysis of humus showed that the quantity of humic acids (HA) was more than fulvic acids (FA). Humic and fulvic acids ratio (HA/FA) was approximately 1.2-1.6. The exception were humus under sea-buckthorn where the ratio was less than 1.0. The percentage of mobile HA were insignificant. Moreover, most of them were found in soils under sea-buckthorn. The maximum of calcium humates were recorded under perennial grasses, the minimum – under sea-buckthorn.

Under the influence of HA in the upper soil layers, there was an intensive process of magnesium leaching, resulting in sharply reduced the alkalinity of protosoils. Thus, in the upper topsoil (0- 5 cm), the pH was approaching to the neutral from 7.0 to 7.2.

When we compared the same plant species on clay and loam, and chalky-clay rocks it turned the big difference between them. The impact plantings on the property of chalky-clay rocks was less significant. Humus formation were more slowly with low nitrogen content, organic carbon stocks were two times less in comparison to clay and loam rocks. In humus of immature soils formed on chalky-clay rocks FA were prevailing (under acacia and sea-buckthorn from 5 to10 cm and others species below 40 cm).

These results demonstrate the vital role of plantings in the rehabilitation of post-mining areas of the KMA. Further investigations of the processes of humus and humic substances accumulation in immature soils will contribute to the development of a model of soil formation on technogenic soils. Due to this model it will be possible to restore the natural biodioversity of post-mining landscapes in short-term period.

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Hydrological balance and water transport processes of partially sealed soils

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Keywords: urban evaporation, soil moisture, TDR, soil sealing

With increased urbanisation, soil sealing and its drastic effects on hydrological processes have received a lot of attention. Based on safety concerns, there has been a clear focus on urban drainage and prevention of urban floods caused by storm water events. For this reason, any kind of sealing is often seen as impermeable runoff generator that prevents infiltration and evaporation. While many hydrological models, especially storm water models, have been developed, there are only a handful of empirical studies actually measuring the hydrological balance of (partially) sealed surfaces. These challenge the general assumption of negligible infiltration and evaporation and show that these processes take place even for severe sealing such as asphalt. Depending on the material, infiltration from partially sealed surfaces can be equal to that of vegetated ones. Therefore, more detailed knowledge is needed to improve our understanding and models. In Berlin, two partially sealed weighable lysimeters were equipped with multiple temperature and soil moisture sensors in order to study their hydrological balance, as well as water and heat transport processes within the soil profile. This combination of methods affirms previous observations and offers new insights into altered hydrological processes of partially sealed surfaces at a small temporal scale. It could be verified that not all precipitation is transformed into runoff. Even for a relatively high sealing degree of concrete slabs with narrow seams, evaporation and infiltration may exceed runoff. Due to the lack of plant roots, the hydrological balance is mostly governed by precipitation events and evaporation generally occurs directly after rainfall. However, both surfaces allow for upward water transport from the upper underlying soil layers, sometimes resulting in relatively low evaporation rates on days without precipitation. The individual response of the surfaces differs considerably, which illustrates how important process orientated studies for different types of sealing material are.

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Heavy Metals and Metalloids in Soil Catenas of Mining Areas

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Introduction. A considerable part of heavy metals and metalloids (HMMs) is redistributed in soil catenas, dependent on local landscape-geochemical conditions. There are only few special studies of HMMs' distribution in soil catenas of natural and urban landscapes (Gennadiev and Kasimov 2004; Ruan et al. 2008; Avessalomova 2009). The aim of this study was to determine the features of the HMMs lateral distribution in soil catenas of Dzhida W-Mo (DTMP) and Erdenet Cu-Mo (ECMP) plants influence zones. Particular tasks were as follows: 1) to determine the concentrations of HMMs in soil of conjugate elementary geochemical landscapes of the ore-mining centers; 2) to reveal the major soil and landscape-geochemical factors of the accumulation of HMMs in the catenas and to diagnose lateral geochemical barriers (GBs) according to particular combinations of these factors. GBs are parts of the Earth's crust where intensity of migration of elements decreases sharply within short distances, leading to a concentration of elements (Perel'man and Kasimov 1999; Glazovskaya 2012).

Study objects. Ore-mining centers Erdenet (Mongolia) and Zakamensk (Russia, Buryat Republic) are found in the area of extremely continental climate with cold winter and warm summer. Erdenet territory represents a hilly plain in the zone of expositional forest-steppe with sagebrush-motley grass-grasses plants on haplic kastanozems chromic soils. Gleyic kastanozems chromic soils are common for the floodplains in the narrow strips form. Larch forests are presented at the top of the northern slopes. Zakamensk is located in the mountainous area with a strongly rugged topography, in the taiga zone with larch and birch forests on haplic umbrisols hyperdystric and rendzic leptosols eutric soils. Umbric fluvisols oxyaquic and haplic gleysols dystric soils are common for the lower parts of the smooth slopes and river valleys under the meadow and meadow-marsh vegetation.

The natural soils were anthropogenically modified in the ore-mining centers. The upper soil horizon contains construction and household wastes. Technogenic impact has led to acidification and increase of the content of the physical sand in Zakamensk soil profile and the clay in Erdenet. Artiindustrat and toxicindustrat are formed in the tailings and surrounding areas. Profile of these anthropogenic soils consists of the artificial bulk horizons of toxic and non-toxic materials.

Technogenic impact. Mining plants are developing hydrothermal sulfide deposits. The ECMP was put into operation in 1976. Waste products are stored in the tailing which occupies more than 1500 ha in the Zuna-Gol valley. The DTMP operated from 1934 to 2001. In Zakamensk, 44.5 million tons of waste are stored in Dzhida (filled) and Barun–Naryn (sludge pond) tailings and in the emergency tailing.

Materials and methods. The soil-geochemical survey of Erdenet was performed in summer 2012. We studied six soil catenas with eighteen profiles. The soil pits along the catenas excavated in places characterizing four different landscape-geochemical positions (Perel'man and Kasimov 1999). The soil-geochemical survey of Zakamensk was performed in summer of 2013. Seven catenas with thirty-one soil profile were examined.

The total content of 54 HMMs in the soil samples were identified by mass spectrometry and by atomic emission spectrometry with inductively coupled plasma (ICP-MS and ICP-AES) in the Fedorovskii Institute of Mineral Ores on Elan-6100 and Optima-4300 devices. For the detailed analysis, 16 priority pollutants belonging to the first (Zn, As, Pb, Cd), second (Cr, Co, Ni, Cu, Mo, Sb), and third (V, Sr, Ba, W) hazard classes (GOST 17.4.1.02–83 2008) were selected, as well as Sn and Bi. The properties identified: actual acidity (*pH*), organic carbon content (method of I.V. Tyurin), soil texture (method of laser diffraction, Analysette 22 device).

The obtained data on HMMs concentrations in the background samples C_b were grouped according to their position in the catenas and compared to the elemental percentage abundance (Kasimov and Vlasov 2015) in the lithosphere C via calculation of their relative amounts (clarkes of concentration) $CC = C_b/C$ and reciprocal (clarkes of dispersion) values $CD = C/C_b$. Distribution of HMMs in the catenas and degree of its contrast were characterized by the coefficients of lateral differentiation *L* equal to the ratio of the concentration of a given pollutant in the considered landscape position to its concentration in the autonomous landscape. Location of accumulation zone determines the type of lateral-migratory differentiation HMMs (Gennadiev and Zhidkin 2012): (1) non-accumulative – without significant differences between the element concentrations in the subordinate landscapes, (2) footslope – characterized by the concentration of the elements in the soils of geochemically subordinate landscapes, (3) midslope – showing accumulation of HMMs in the middle part of the catenas; and (4) summit – characterized by the lower element concentrations in the subordinate landscapes in comparison with the autonomous landscapes.

Natural and anthropogenic factors of the accumulation of HMMs in the surface soil horizon and in the soil profile were represented by both quantitative and qualitative variables determined by the method of regression trees using SPLUS software (MathSoft 1999). Mechanisms of developing of the accumulation zones of pollutants can be studied on the basis of the theory of GBs (Saet et al. 1990; Perel'man and Kasimov 1999). Lateral GBs were diagnosed according to the criteria suggested in the study of Perel'man and Kasimov (1999).

Results and discussion. Soil background catenas near Zakamensk and Erdenet have acidic, slightly acidic (*pH*=4.9) and slightly alkaline, alkaline (7.2-9.2) reaction, respectively; organic carbon content 0.2-7% and 0.8-4.1%; light loamy composition with clay fraction 2-2.8% and 2.8-3.5%. The geochemical specialization of soils is greatly affected by the widespread distribution of the volcanic rocks. In the autonomous and subordinate positions, the soils contain increased concentrations of W, Mo, Cd, Bi, and Sr (CC = 1.5–9.2) near Zakamensk and of V, Co, Sr, and As (1.5–3) near Erdenet. Different types of the lateral distribution of the elements are related to the differentiation of the physicochemical properties and the proximity of parent rocks occurrence. In the background catenas HMMs have different types of lateral-migratory differentiation: for the summit accumulative near Zakamensk – Cu, As, Sb, Mo, Pb, V, Co, Ni, Ba, Cd, Sn are common, while V, Cr, Co, Ni are common for those near Erdenet; for the non-accumulative – Bi, Cr, W and Cu, Zn, Sr, Mo, Cd, Sn, W, Ba, Pb, respectively; for the mid-accumulative – Sr, Zn near Zakamensk and footslope-accumulative – As, Sb, Bi near Erdenet.

The contrast in the lateral differentiation of HMMs along soil catenas shows tenfold increases in Zakamensk (*L*=6-47) and several-fold (2-8) – in Erdenet. In both ore-mining centers technogenic impacts have transformed the types of lateral-migratory differentiation of Cu, Sb, Mo, Pb, Bi, W along the geochemical catenas: summit and non-accumulative types in the background catenas changed to footslope-accumulative in the urban. Elements Cr, Ni, Sr have the mid-accumulative distribution. The distribution of the remaining HMMs depends on the individual characteristics of the centers: in DTMP influence zone V, Co, Sn have summit-accumulative type, Ba – mid-accumulative, As, Zn, Cd – non-accumulative; in ECMP influence zone Co – mid-accumulative, Zn, As, Cd, Sn, Ba – footslope-accumulative, V – non-accumulative.

Technogenic impact resulted in the formation of natural-technogenic sorption-sedimentation barriers in subordinate landscapes of the ore-mining centers. In the DTMP impact zone this barrier shows as the increased content of sand (up to 95%) derived from the tailings through water and sulfurous erosion. As a result, concentration of HMMs increases relative to background soil for W, Mo, and Bi 80-fold to140-fold, Sb, Pb, and Cd – 19 to 32-fold, Cu and Zn – 6,5 to 7-fold. In ECMP area the amount of clay fraction increases up to 5-6% and the contents of ore elements Mo and Cu – 7-13-fold. The remaining elements in DTMP area are mainly precipitated on the chemisorption diagnosed by the presence of direct dependence of the concentration of V, Co, and Ba on the contents of Fe, Mn, and Al oxides in the soils. The organomineral barrier specifies the accumulation of Sn, which concentration in the soils is directly correlated with the organic matter content. The concentrations of Mo, Cd and Sb are inversely proportional to the contents of Mn and Al oxides – an evidence of the formation of a gley barrier under conditions of the increased soil moistening with the transformation of Mn^{3+} oxides into less mobile Mn^{2+} protoxides.

In Erdenet, the major role belongs to the chemisorption (V, As, Cr, and Ni) and alkaline barriers. The last one is diagnosed by the positive correlation between *pH* and the concentration of the elements, and is most significant for Sr, W and Sn. Concentrations of the chalcophile elements – Zn, Cd, Pb, Bi and Sb – depend on the nature of parent material; they are higher in the soils developed from the Quaternary deposits and from granodiorite and granite of the Permian intrusive complex.

Conclusion. Technogenic impact has transformed the types of the lateral-migratory differentiation of

HMMs along the geochemical catenas: their accumulation in the subordinate landscapes has become more pronounced. Chemisorption and sorption-sedimentation in conjunction with the acidic and alkaline lateral GBs have the greatest distribution in ore-mining centers. In the DTMP impact zone the organomineral GBs form the local area on the slopes of Modonkul' river valley, and gley GBs – an area along the river course in the form of narrow strips.

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Contamination of heavy metals in soil and vegetation of forest ecosystems in Natural-Historical Park "Kuzminki-Lyublino"

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Natural-historical park "Kuzminki-Lyublino" is one of the largest parks in Moscow city. A crucial task is to conserve its territory. Studied park is the site of high conservation, recreation, environmental education, historical and cultural interest as valuable protected natural area. The park represents large and integral natural territorial complex (geographical landscape), characterized by high natural diversity, presence of rare and vulnerable species of plants and animals and facilities for recreation in natural surroundings.

The aim of the current study is to examine special aspects of pollution in soil and vegetation of forest ecosystems in Natural-Historical Park "Kuzminki-Lyublino".

Line transect sampling method were used to estimate the pollution of the urban forest (759,35 ha). Two transect lines were laid down. First line was directed from the South to the North (1,67 km). The second from East to West (1,78 km). Soil and plant samples were collected from quadrate plots (10x10m) each 300 meters along the line. Soil samples were taken in the corners and the center of each plot, so composite samples were analyzed. In total 12 surface composite soil samples and 12 grassy plants samples were collected. The concentration of following heavy metals in soil were assessed: Zn, As, Pb, Cu, Ni, Co. The concentration of following heavy metals in plants were assessed: As, Pb, Cu, Ni, Co, Fe, Cr. The analysis was made on the SPEKTROSKAN-MAKS device, based on a X-ray spectral method of the analysis. Also total organic carbon (TOC) and pH were analyzed.

Measurements of total content of zinc (first class of danger) in the soil samples showed that its concentration exceeds both background level (28mg/kg) [Motuzova G.V Ecological monitoring of soils // G.V Motuzova, O.S Bezuglova. - M.: Academic Project; Gaudeamus, 2007. - 237 p.] and approxible permissible concentration (APC) – government standard (55mg/kg) [Hygienic standards 2.1.7.2042-06 //Approximate permissible concentration (APC) of chemicals in the soil.].

Soil samples collected at the periphery of the forest were characterized by higher pH values (from 6.7 to 7). Apparently, such values can be explained by the influence of the systematic use of anti-icing agents on the surrounding roads, which shifts the pH towards neutrality.

The content of TOC in the central part of the studied urban forest are within the normal values for Brunic Arenosols.

Study of heavy metals (HM) contamination in the surface soil samples of the Park "Kuzminki-Lyublino" revealed the following regularities. Analysis of total content of zinc, arsenic and lead (first class of danger) in the soil samples revealed that its concentrations widely exceed both the background level as the APC.

The concentration of Cu, Zn and Pb in soil decreases from the periphery to the centre of the forest. There was an elevation Co and Ni content in the soil samples collected in the central part of the forest. The presence and distribution of pollutants denote the aerogenic migration of pollutants. The main sources of HM pollution of soils and vegetation of the forest zone of the Park are Volgogradskiy avenue, Moscow ring highway, Central Heating and Power Plant №22, oil refinery (Kapotnya).

In the analyzed plants, the content of iron, nickel, copper, and chromium didn't deviate from the standard. It is difficult to determine a clear dependence of HM content along the transect due to the influence of many different factors. The content of lead, arsenic and cobalt were measured as well but their presence in the plants in the pronounced amounts has not been revealed.

Thus, the vegetation of the Park does not accumulate in substantial amounts of polluting HM.

We can conclude that "soil-vegetation" system investigated the forest zone of the Moscow park is quite stable. Vegetation is adapted to existing soil conditions.

Conclusions

Despite the significant size of the park's forest zone, soil heavy metals pollution is observed in the entire territory. It indicates aerogenic nature of transit shift of pollutants. West air masses transfer contributes to the pollution of the studied forest.

High concentration of toxic compounds of arsenic in the soils of the park can be explained by dumping of wastes of the military-industrial landfill and by the storage of oil refinery waste; more detailed researches for that issue are required.

A decrease in concentration of Zn, Pb, Cu in soil were observed from the periphery to the center of the park's forest. The concentration of Ni is distributed proportionally across the forest.

The absence of high concentration of HM in plants indicates that their adaptation to the environmental conditions of urban forest.

It is necessary to maintain the existing territorial boundaries of the forest zone of the Natural-Historical Park "Kuzminki-Lyublino" since it is a green filter for the entire South-East district of Moscow, which is considered as an intense anthropogenic source of pollutants.

HEAVY METALS IN SOILS AND PLANTS OF ARID ZONES OF RUSSIA

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The present study analyzes the content of heavy metals and their accumulation in the light-brown soils of the arid zones of Russia. The authors also report the data on the accumulation of heavy metals in the biomass of medicinal and forage plants cultivated in arid conditions. The selective capability of different plants to accumulate heavy metals is also discussed in the paper.

Keywords: *Light-brown soil, heavy metals, pharmaceuticals and forage plants, phytomass, arid zone.*

The Caspian region is one of the most complex agro-ecological regions of the semi-desert southern region in Russia. It's in this arid zone, where are concentrated unique reserves of chemical, fuel, energy, and minerals, but productivity of natural and cultivated plants in the zone continues to diminish due to a small amount of precipitation, high moisture evaporation, frequent cases of drought, increased disinflationary area, salinity and loss soil humus [1-3].

Every year the chemical contamination extends to all environments, creating an entirely new environment for existence to which plants, animals and humans are not adapted. Considering the danger of the accumulation of heavy metals by plants, it is necessary to estimate the reaction of plant vegetation to dangerous elements present in the environment [4-9].

Light brown middle loamy soils were studied both with and without irrigation. The analyses of active forms of zinc, lead and nickel, their dynamic and radial distribution, showed that in irrigated light brown soils active forms of lead and zinc are predominant in the humus-accumulative, transition and gypsic-illuvial horizons. Irrigation leads to zinc redistribution in the upper horizons and layers of the soil.

Active forms of nickel in the upper layers of light-brown soils of non-irrigated soils were virtually absent and irrigation greatly reduced nickel mobility.

Concentration of Fe, Mn, Zn, Cu, As, Sr, Ni, Co, Cr, Pb and Cd, elements conventionally combined into a group of heavy metals in foot end and aerial parts of cultivated on light chestnut irrigated soils forage and medicinal plants were analyzed by atomic absorption spectroscopy [8]. The total content of Fe in phytomass samples of different plant species ranged from 407.2 mg/kg (*Leonurus Cardiaca*) to 40.8 mg / kg (*Silybum marianum*) with an average of 143.6 mg/kg. The total Fe content in a phytomass samples correspond to natural background concentrations. Total Mn concentration in plant samples ranged from 84.9 mg / kg (*Lolium perenne*) to 4.0 mg / kg (*Silybum marianum*), average – 30.0 mg / kg, which is lower than in the same phytomass from other regions (101.5 mg/kg). A direct dependence was found between the Fe and Mn content in plant biomass: increased total content of one entails increased concentration of the other.

Total Zn content varied from 48.6 mg/kg (*Salvia officinalis*), to 4.58 mg/kg (*Galega orientalis*). The average total Zn concentration was 18.1 mg/kg, which is 2.0 times lower than the average content of heavy metals in other regions (36.8 mg/kg). It was revealed that most of the studied plants can accumulate Zn in increased amounts, mainly in foot end biomass.

The content of Cu in plant raw samples varied from 4.1 mg/kg (*Sanguisórba officinális*) to 15.8 mg/kg (*Leonurus Cardiaca*), with an average of 9.5 mg / kg, lower than the average Cu concentration values (12,2 mg/kg) in plants.

The highest concentration of Cr in the phytomass was observed in the studied species *Calendula officinalis* – 2,54 mg kg and the lowest – 0,14 mg/kg in *Silybum marianum*. The average concentration was 0,83 mg/kg. In all plant samples Cr concentration was below the average index.

Ni concentration in the investigated phytomass samples varied from 0,69 mg/kg in *Galega orientalis* to 3,40 mg/kg *Phleum pratense*. Average total Ni concentration does not exceed the approximately permitted concentration (20,0 mg/kg).

The Co content in the biomass of plant samples was minimal in *Salvia officinalis* - 0,010 mg/kg. High levels of Co were found in the biomass of *Calendula officinalis* - 0,121 mg/kg.

Determination of Pb and Cd content in plants, elements of the 1st category of toxicity and the main components of the environment chemical pollution, allowed us to estimate the degree of plants' contamination.

The content of Pb in the samples varied from 0,06 to 16,0 mg/kg and was at minimum *Silybum marianum*, and maximum in *Phleum pratense*. The average lead concentration in the vegetable raw material was 4,8 mg/kg, which is below the maximum permissible concentration by 1,2 mg/kg.

Cd – element extremely high toxicity. Cadmium salts have mutagenic and carcinogenic properties and pose a potential genetic danger. Cd content in the phytomass samples of medicinal plants varied from 0,03 mg/kg in *Salvia officinalis* to 0,27 mg/kg in *Phleum pretense*, with the maximum allowable concentration at 1,0 mg/kg.

The results of these studies showed, due to agrogenic exposure, qualitative and quantitative changes in the distribution and content of heavy metals.

Zinc, manganese, nickel and chrome are accumulated in the upper layers of soil, strontium - in carbonate-illuvial horizons, lead is distributed uniformly over the soil profile. Irrigation in those lands decreases the active forms of lead and nickel and the active form of zinc moves from the upper layers in the middle lays.

Different plant species have the selective ability to accumulate heavy metals, which enabled us to divide them by the total concentration of heavy metals into 2 groups:

Species – accumulators of very high concentrations of heavy metals - Fe, and Cu - *Leonurus Cardiaca*, Mn - *Lolium perenne*, Zn - *salvia officinalis*, Co, Cr - *Calendula officinalis*, Ni, Pb, Cd - *Phleum pretense*;

Species containing low concentrations - Pb, Fe, Mn, Cr - *Silybum marianum*, Cd, Co - *Salvia officinalis*, Zn, Ni - *Galega orientalis*, Cu - *Sanguisórba officinális*.

Despite the selective absorption characteristics of heavy metals in various plant species, their concentration in, the grown on light chestnut arid soils in the Russian zone (Caspian), forage and medicinal plants does not exceed the allowed concentration. Therefore, these plants and their raw materials are not harmful to human and animal health, and can be recommended as ecologically clean.

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Urban transformation and reduction of the use of fertile agricultural land in urbanization

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Abstract

Most of the agricultural land in the world still cannot be used with wrong practices. In the near future, this can lead to very important problems for humanity. In this review study, it contains recommendations on urban transformation and the reduction of the use of fertile agricultural land during urbanization. Since urban transformation is usually done in the old settlements, it is of special importance within the human population. Urban transformation can prevent urban pollution and prevent environmental pollution. With the decrease in the use of agricultural land in urbanization in this way, the importance of urban transformation arises.

Key words: Urban transformation, agricultural land, Land use,

Assessing the effect of soil metal concentrations on terrestrial organisms and on human health in urban and peri-industrial areas in Wallonia (Belgium)

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High levels of metal concentration can be found in urban and peri-industrial soils due to smoke and dust fallout emanating from pollution sources. These soil metal concentrations may constitute a threat to both terrestrial organisms and human health. Assessing the risk due to metal concentration for these two receptors is thus necessary for land contamination management purpose even if terrestrial ecosystems are not systematically considered in the derivation of soil screening values (Carlton, 2007).

This study aims to assess the effect of soil metal concentrations on human health and terrestrial organisms in 8 urban and peri-industrial areas in Wallonia (South Belgium). In these 8 areas, about 800 topsoils has been sampled and analysed for trace metal contents and classical soil parameters (organic matter content, clay content and pH).

The methodology for assessing the effect of metals on human health has been performed with the equations and exposition parameters of S-Risk© software (Cornelis *et al*, 2016). The toxicological reference values selected for the study are those intended to be recommended in the Walloon guidelines for health risk assessment. For terrestrial organisms, the methodology of the PNEC Calculator© (Predicted No Effect Concentration, Oorts K., 2015) has been used, which relies on chronic toxicity data for terrestrial organisms and Ageing/Leaching factors derived from EU RAR (*Risk Assessment Reports*) following the application REACH legislation (ECHA, 2006). Exposition parameters and tolerance criteria specific to land use (natural, agricultural, residential, commercial/recreative, industrial) were taken into account in both methodologies.

The results show that some areas contain metal concentration above the maximum threshold values computed for both terrestrial organisms and human health. The results also show that metals leading to a threat for human activities (such as Pb and As) do not systematically represent a threat for terrestrial organisms and vice versa, as it was observed for Cu and Zn.

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Heavy metals and fluorine in soils of Minusinsk basin

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Heavy metals are priority industrial pollutants that significantly affect the environment and human health. The soils and carbonate neoformations are the storage medium for heavy metals. The purpose of this study is to identify the factors, which determine the content of heavy metals in soils soil solutions and carbonate pendants in soils of the Minusinsk Basin. Three study sites were investigated: Sayanogorsk aluminum smelter area, and the lake Khankul and Khakass National Museum Kazanovka, selected as the background. The study area is characterized by grasslands with Castanozems soils. The climate is sharply continental. The total content of major and ininor elements in soils, soil solutions and carbonate neoformations was measured with ICP-MS, the content of mobile forms of some heavy metals in soils was measured with atomic absorption spectrometry, for extraction from soils ammonium acetate buffer was used. Most of studies of anthropogenic pollution in the aluminum industry zone of influence are related to F and Al content, as well as Na, Ca Mg [2, 5, 10]. Since Sayanogorsk aluminum smelter is not the only source of anthropogenic influence in the Minusinsk Basin, the contents of heavy metals (HM) in soils is also an important indicator for the ecological assessment. The lithology of Minusinsk Basin is heterogeneous, and we consider that not only human-made anomalies are important but also the sources of HM, which are parent rocks and especially locally exposed Devonian rocks [4]. The pollution is estimated by hygienic standards adopted in the form of maximum permissible concentration (MPC) of compounds [3, 4]. In soil minor elements absolute values Ba, Sr, V, Cr, Zn, Zr, Rb, Ce, Ni, Nd, La, Y prevail, Sayanogorsk content of Ba, V, Cr is greater relatively to the two other sites, Sr and Zr content is the highest in soils of Lake. Khankul ares. The highest clarkes of concentration [6] of elements in comparison with natural abundance of elements in igneous rocks by A.P. Vinogradov [8] are marked for Bi (14-26), Se (14-20), As (2,2-7,9) , Hf (1,75-5,01), Yb (4,4-7,4), Cd (in the lower soil horizons in Kazanovka CC=2), Sb (1,4-2,4 except lake Khankul). Minory exceeded MPC for soil are noted for V, in Sayanogorsk the content in soils is 161 ppm as MPC is 150 ppm. In general, in soil solutions Sr, Ba, Zn, Al, V prevail, and the content of Sr, Ba, V, Al is the highest in Sayanogorsk soils. In soil solution from Sayanogorsk the Al content is 129 ppb 14.8 ppb and in Kazanovka the content of V is 19,6 and 4.6 ppb, respectively.

In the area of influence of the Sayanogorsk aluminum smelter a number of heavy metals - specific pollutants for the area is identified. They are elements such as zinc, lead, cobalt and nickel.

Background Zn content in soils is 100 ppm. The maximum total concentration of Zn in the soil reaches 270 ppm, the maximum value of the content of mobile forms of Zn 33.9 Zn ppm observed in the impact zone of the Sayanogorsk aluminum smelter. MPC for total Zn in soil is 100 ppm, for mobile forms of Zn it is 23 ppm. Spatial distribution of lead in the soils of the study area sufficiently can be differentiated according to the remoteness from the industrial complex. The highest concentration of total forms of Pb observed in the vicinity of the smelter and is up to 80 ppm. Background concentration of Pb in soils is 35 ppm. The maximum Pb content of mobile forms in soils is 1.5 ppm. MPC for total Pb in soils is 32 ppm, for mobile forms of Pb it is 6 ppm. In the area of influence of the Sayanogorsk aluminum smelter maximum nickel concentrations in soils are up to 140 ppm. Background values of total Ni concentrations is 60 ppm. The maximum content of mobile forms of Ni is 1 ppm. MPC for total Ni in soils is 85 ppm, for mobile forms of Ni it is 4 ppm. The maximum concentrations of total forms of cobalt in soils is up to 50 ppm. Local background cobalt content in soils is 18 ppm. The maximum value of the content of mobile forms of cobalt reaches 2.4 ppm. MPC for mobile forms of Co is 5 ppm.

The fluorine content in the soils in the area of the Sayanogorsk smelter impact reaches maximum concentrations of 10-12 ppm at a distance of 1.5 km from the plant in the direction of the prevailing western and south-western winds. The background content of water-soluble forms of fluorine for the study area was 1.5 ppm. MPC for water-soluble fluorine in soils is 10 ppm for the water it is 1.2 ppm. In soil solutions fluorine content is from 0.1 to 0.3 ppm in the Chernozems soils of Sayanogorsk study area. The water-soluble fluorine content in Kazanovka in Castanozem soils is low: 1.2-2.0 ppm while in the soil solutions fluorine content ranges from 0.1 to 0.75 ppm. The high fluorine content in soil solutions in Kazanovka compared to Sayanogorsk is probably due to the higher content of fluorine in groundwater and parent rocks.

In carbonate pendants strontium and barium prevail. The content of these two elements is maximum in the saline landscapes of lake Khankul, exceeding the content of the Sayanogorsk and Kazanovka 2-10 times. Zr, Ce, Zn predominate in absolute values in Kazanovka and Khankul, while in Sayanogorsk - Ni, Zn, Cr, V prevail. Also Sayanogorsk area compared to other areas is characterized by higher Cu content, as well as Sc and Y content. Highest CC of elements in carbonate neoformations compared with natural abundance of elements in carbonate rocks [1] in the three key sites are observed for Pb (60-302,5), Ba (17-262), Tl (30-350), Co (32-261), Hf (11- 48), Nb (5,3 - 10,4), the content of Sr is also high (273-810 ppm) in absolute values and it is close to the natural abundance of this element in carbonate rocks. The conclusions are the following: 1) The high content of V, Cr, Ba in soils and carbonate pendants compared to clarkes and the MPC in Sayanogorsk, is probably due to the anthropogenic factor, 2) excess of Al and V relative to the background content in soil solutions also shows the human impact 3) high content of Hf and Nb compared with clarkes in carbonate pendants and in soils may be associated with Devonian rocks, some of which are enriched by these trace elements [9] high Sr content but not exceeding clarke is also associated with lithogenic factor. 4) The fluorine content in the soils in the area of the Sayanogorsk smelter impact reaches maximum concentrations of 10-12 ppm at a distance of 1.5 km from the plant and also zinc, lead, cobalt and nickel are identified as major pollutants in the vicinity of the plant 5) The fluorine content in soil solutions is higher in the background area due to the lithogenic factor.

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Comparisons of agricultural incidents during urbanization

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Abstract

One of the most important problems in the world is the nutrition problem. For this purpose, achieving maximum efficiency from the smallest area is very important. The necessary precautions must be taken to minimize the effects of urbanization on the agricultural areas. In this review study, the negative effects of the urban waste on the agricultural land were evaluated by comparing. The wastes arising from urbanization cause agricultural areas and irrigation water to be affected in the negative direction. On the basis of urbanization, firstly, measures should be taken against the pollution that can be gathered and formed regularly in urban wastes. It is important to carry out the most stringent legal applications for the protection of agricultural land and for the elimination of the problems that may arise through urbanization.

Key words: Urbanization, agricultural area, pollution

A study of abiotic, biotic and functional parameters of six derelict soils in the north-east of France - towards a potential use of derelict soils as a ressource.

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The intensification and closure of industrial activities led to large surfaces of derelict lands. The derelict soils remain unused because they have often a low fertility and could be contaminated. However, soils are limited resources, and derelict soils might be considered for potential re-use, with or without remediation and restoration phases, such as for non-food biomass production. Since soil biodiversity and biological activity play a key role in ecosystem functioning, their study may be an indication for a potential use. The objective of our study was to characterize the taxonomic and functional belowground biodiversity (microflora, fauna, flora) of derelict soils and to link their physico-chemical and biological parameters.

Six derelict soils - three constructed soils and three industrial wastelands - located in north-east of France were sampled using a gridline strategy. Firstly, they were characterized for their physico-chemical properties. The abiotic parameters of the studied soils were measured through fertility and contamination proxies. Then, three main biotic components were quantified (abundance and diversity) - microflora (bacteria and fungi), fauna (collembola and macro-invertebrates) and flora - at the same time and in a same square. Finally a functional approach was carried out through decomposition function (percentage of meso- and macro-decomposers, mineralization capacity, enzyme activities and percentage of polycyclic aromatic hydrocarbon degrading bacteria).

In order to compare the co-structure of abiotic and biotic parameters for the 6 derelict soils and find relationships between abiotic and biotic parameters, a co-inertia analysis was done. A second co-inertia analysis based on abiotic and functional parameters was carried out too. We noticed that biodiversity levels in the derelict soils were rather high but depended on the considered biotic component. Several biotic parameters should then be considered to characterize soils for potential reuse. According to the multivariate analysis, the biotic parameters were more linked to fertility proxies than to soil contamination proxies. Similarly, the functional parameters were significantly linked with abiotic parameters. For instance, we found that the compost amended constructed soils that had the highest fertility level showed the highest decomposition level, and the contaminated constructed soil with the highest pollutant concentration had the lowest decomposition level.

Our study showed then that derelict soils could provide ecosystem services such as biodiversity reserve and decomposition process. Considering biotic and functional soil parameters, such as biodiversity and the potential decomposition processes, could help to identify the derelict soils that could support the biomass production ecosystem service.

Influence of urban environment on the complex of soil micromycetes

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Microorganisms play an important role in soils functions both in nature and urban landscapes. City growth, industrial and infrastructure development result in significant increase of anthropogenic influences, which affects soils strongly. Technogenic impact on the environment promotes development of negative processes reducing soil quality and decreasing soil buffer capacity (Gerasimova et. al, 2003). Under the influence of technogenesis, there is a reduction of soil microorganisms and invertebrates diversity. Damages of soil functions result in appearance of zones with critical ecological state in the city (Lysak, 2010) that breaks the normal life of soil biota.

Aim of our study was to assess species diversity and taxonomical structure of micro fungi in soils of the city with low level of technogenic pressure.

The study was conducted in the Syktyvkar – administrative centre of the Komi Republic. Syktyvkar is situated in the middle taiga subzone. Unlike the other cities of the republic (Vorkuta, Uhta, Sosnogorsk etc.), Syktyvkar have low level of technogenic pressure due to the absence of mining and processing industry. The main pollution sources are timber industry and transport. To study chemical properties and structure of soil mycocoenosis, samples were collected from upper (0-10 cm) soil horizons in different city areas (recreation RC, residential RS and transport TR) in summer 2013. Microbial biomass was determined by the luminescence microscopy method. Qualitative and quantitative composition of micromycetes were studied using seeding soil extract to the Hetchinson medium and acidic Czapek's medium (pH=4.5). Taxonomy of microscopic fungi was determined using guides, interactive "keys" and internet recourses (http://www.indexfungarum.org). Shannon index (H), Jaccard index (Kj), Sorensen-Czekanowski coefficient (Ks) and occurrence frequency indicators (Kurakov, 2001) were used to characterize micromycetes complexes.

As a result, 48 species of microscopic fungi from nine genera including one "species" of sterile mycelium form were found in the soils of the Syktyvkar. The most of them (40 species from five genera) belongs to the group of anamorphic fungi (fungi imperfecti). *Zygomycota* contains eight species from three genera; the most abundant of them are *Umbelopsis ramanniana* and *Mucor circinelloides.*

Anamorphic fungi comprise 83 % of the total species list and contain classes*Hyphomycetes (*39 species from five genera)and *Agonomycetes* (light colored sterile forms). *Hyphomycetes* class has the highest level of species and genus diversity. Maximal species richness was registered in genera P*enicillium* (29), *Trichoderma* (7)and *Mucor* (3 species). Genera *Aspergillus, Mortierella* and *Cladosporium* are presented by single species.

In comparison with the zonal podzolic soils (Khabibullina et al., 2014), Syktyvkar fungal communities are characterized by disappearance of dominant species. The base of fungal communities is often composed of random (23) and rare (20) species. Species of genera *Mucor, Umbelopsis* and *Trichoderma* that are prevalent in the zonal podzolic soils relate to the category of rare and random species in urban soils. *Penicillium camemberti, P. canescens* and *P. thomii* were the most sustainable to the anthropogenic pressure and prevailed both in the zonal and urban soils.*Trichoderma aureoviride* was also classified as frequent species in the Syktyvkar. The species composition of urban soilsfungal communityis far from the zonal soils (Ks 8.5 %).

20 species from five genera of micromycetes were found in soils of the recreation zone including opportunistic species *Cladosporium cladosporioides, Geomyces pannorum, P. canescens* and *P. simplicissimum.* Residential (rban soilslocated near the transport main lines have higher species diversity – 31 species from eight genera. The most abundant species in these soils were *Penicillium notatum* (5, 9 %), *P. corybiferum* (9,7 %), *P. wortmannii* (6,33 %) and *Penicillium sp.* (13,5 %). Opportunistic species are presented by *Mucor circinelloides, Cladosporium cladosporioides, Geomyces pannorum, Penicillium canescens, P. notatum*and *Trichoderma viride.*

Urban soils of transport area have the highest level of the microscopic fungi diversity – 38 species from eight genera. The most prevalent species here belong to genus *Penicillium* (56%). Proportion of toxigenic species increased to 24 % including *Mucor hiemalis*, *M. plumbeus* and *Cladosporium herbarum*. The dominant species here are from genera *Penicillium* (56%), *Mucor* (16%), *Trichoderma* (13%), *Cladosporium* (5%). Genera *Umbelopsis*, *Geomyces*, *Aspergillus*, *Mortierella* and *Mycelia sterilia* c/o comprise 3% from the total species number.

So, in the series from recreational to residential and transport zones, there is an increaseof the micromycetes population and their diversity as well as opportunistic species diversity that is typical for many urban soils (Svistova, 2003; Kuimova, Shumilova, 2014). Up to 66 % decrease of the micromycetes diversity in urban soils in comparison with the zonal soils are caused by changes in structure and properties of urban soils and high technogenic pressure (toxic pollution).

The impact of contaminants with the absence of a sufficient number of green plants causes an increase of toxigenic species of micromycetes in transport zone soils (up to 24% of the total species) and development of adaptive reactions that may increase their aggressiveness (active toxic production) forming the secondary toxic pollution of urban soils.

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Chemically contaminated subaqueous soils: A challenge for Soil Taxonomy

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Subaqueous soils that have been heavily contaminated with synthetic chemicals such as oils, greases, and tars present a challenge to soil classification and taxonomy. While the concentration of these chemicals may be reduced after initial contamination, a refractory fraction can remain that will affect soil properties and morphology for decades or longer. These pollutants can coat particles, fill pore space, or occur as layers either on top of or within a soil profile. Within *Soil Taxonomy*, these contaminants can be interpreted to qualify as artifacts. Even so, their presence does not result in the classification of an anthropic epipedon in many subaqueous soils because an anthropic epipedon is required to be nonfluid. Many subaqueous soils, particularly those found in estuarine channel and similar landforms, are moderately to very fluid. Unless these contaminants are considered to be soil material or parent material, they do not fall clearly within the definition of human-transported or humal-altered materials materials. No extragrade subgroups exist that adequately describe such a contaminated soil. Present Soil Survey Manual description of such contamination is limited to noting a petrochemical smell or including general notes on observed contaminants. These contaminants can be both chemically and physically hazardous to human health and the health of aquatic organisms, and in high concentrations these contaminants can be the deciding factor in soil use and management. The presence of morphologically evident chemical contamination may indicate a broad history of other pollution in a subaqueous landscape, as is the case in Bear Creek, a heavily urbanized tributary of the Patapsco River near Baltimore, MD. Several pedons of contaminated subaqueous soils were collected and described from this estuary. It is reasonable to expect that some other industrialized regions will contain such contaminated subaqueous soils. For the time being, we have no appropriate way to capture some of the most significant features of these soils in their taxonomic names. In *Soil Taxonomy* these soils would classify as Sulfic Hydrowassents, Grossic Hydrowassents, or Fluventic Sulfiwassents. In the *World Reference Base for Soil Resources*, these soils can be given much more descriptive names that reflect their toxic character. A new *Classification of South African Anthrosols* also allows for the description of chemically contaminated and even radioactive soils, in addition to other anthropogenic soils. The recognition of these materials in *Soil Taxonomy* is increasingly important as increasing areas of chemically contaminated SUITMAs are discovered, described, and mapped.

Arsenic Transfer Function in Bean and Sesame Cultivated in Soils near Abandoned Mines

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Crops such as rice, bean, and sesame have been cultivated in soils near abandon mines in the Republic of Korea (ROK). The soils have used to be contaminated with toxic heavy metals such as arsenic (As), but crop products in the areas have often distributed in market. There is a concern of crop contamination that would be detrimental to public health via the consumption. Accumulated As content in food plants vary highly, but little is known about the mechanism of As transfer to the plants, particularly to the edible portion. This study aimed to identify a proper extraction method for As in soil in the context of investigation of the metal transfer function in crops. A hundred of agricultural soils were collected from the area around 65 abandoned mines across the ROK, and were used for pot experiment in a greenhouse. Bean and sesame were sowed and were cultivated for about 4 months until the edible portion of them could be harvested. After harvest, soil properties such as pH, organic matter, and available phosphorus were determined. Total As concentration in soil was analysed after digestion with aqua regia. Extractable As concentrations were determined with four different solutions including 0.1M $(NH_4)_2HPO_4$, 0.05M EDTA, Mehlich 3, and 1M $NaHCO_3$. Concentration of As in edible portion of each crop was also determined. Soils in the pots showed widerange of chemical properties: soil pH (4.4 to 8.2); organic matter content (2 to 148 g kg^{-1}); and available phosphate (6 to 1701 mg kg^{-1}); and total As (0 to 1638 mg kg^{-1}). Sixty-two pot soils were exceeded the Korean concern thresholds for As; of those, thirty-nine soils were over the Korean action thresholds (75 mg kg^{-1}). Concentration of As extracted with Mehlich 3 was more likely to be associated with total As concentration, followed by EDTA, $(NH_4)_2HPO_4$, and $NaHCO_3$. Arsenic was not detected from 34 bean and 63 sesame samples. However, As concentrations were from 0.02 to 1.59 mg kg^{-1} for bean and from 0.01 to 7.43 mg kg^{-1} for sesame, respectively. Correlation coefficients between As concentrations of plants and soil extracts were not high. Among the extraction methods, Mehlich 3 showed the highest correlation coefficient (r= 0.13 for bean; r= 0.19 for sesame). These results may indicate that the Mehlich 3 would be a suitable extractant understand in the context of transfer function for As in crops.

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ENVIRONMENTAL-CHEOCHEMICAL ASSESMENT OF THE SOIL COVER OF NIZHNIY NOVGOROD CITY

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This paper is dedicated to the memory of F.M. Bakanina

Nizhniy Novgorod is the largest city of Russia. This city forms the huge agglomeration which is assessed as the most urbanized area in Russian with developed military complex strongly related to economical and industrial potential (Korrektirovka General'nogo plana …, 2008). N. Novgorod became the trade and industrial city at the beginning of 19th century. During the 20th century the industrial development of the city was expressed in creation of the industry giants – Gorkovskiy auto holding and related facilities. During this period, strong alterations of landscapes were evident: homogenization of the relief, drainage of peat lands, water regulations, redistribution of the contaminants in different landscape components. The mistake planning of the cities functional zones result in depletion of ecotoxicological situation (Bakanina, Voronina, 1994; Dabahov et al., 2014).

During the 1980th institutional mechanisms of territory and landscape planning became more environmental-oriented. Environmental assessment became important part of environmental management before the planning of the territories. At the beginning of 1990-th this work was at the first time conducted in N. Novgorod. In the period 1991-1993yy in the frames of N. Novgorod development plan the scientific project "Environment assessment of N. Novgorod" was implemented. On of the main chapter of this project was "Geochemical assessment of soils and bottom sediments of internal water reservoirs" (Geohimicheskaya…, 1992). The head of this project was F.M. Bakanina, ecologist and soil scientist (1937-2010). Bakanina F.M. active and long studied the urban soil. In the 70 years of 20th century, she studied modern state of land cover in the city of Gorky and technological changes. In the 80 years she led the work on the mapping of selected urban areas (Bakanina, 1974; Bakanina, 1990).

Works on geochemical survey of N. Novgorod were based on the classical methods of soil science. More than 1400 soil pits were described for the city and more than 2000 soil samples were analyzed. Data of soil chemical and agrochemical analyzes (soil acidity, humus, N, P, K, S), particle size distribution and available for of the trace elements (Pb, Cd, Cu, Zn) were collected. The integral index of soil contamination was calculated. The main results of study were the revealing of the huge geochemical anomaly on the city territory (Bakanina, Glebova, 1994), which was considered as main reason of deterioration of the ecological state in some districts of the city. Latest work had confirmed theses data (Dabahov et al., 2014).

According to previously published data (Karta…, 1991; Geohimicheskaya…, 1992) the highest concentration of the trace elements were revealed for over the river part of the city. Here the areas with the most dangerous degree of contamination formed. The most critical situation was in internal and central parts of the city – the degree of contamination here assessed as abnormally dangerous.

The green zones of the city were also assessed on the levels of integral contamination rates. It was shown that the green zones of south and western parts of the city are low contaminated, while green zones from north-east and east suburbans are more contaminated (table 1)

It was also shown that the acidity of the soils due to antropogenic activity became lesser: initially acid soils (pH 4.5-5.0) became slightly of even strongly alkaline (pH values up to 8.5). At the same tine high content of available forms of phosphorous and potassium were fixed for majority of the soils investigated.

Table 1. The content of trace elements mobile forms some city parks soils

Soil profile	pH_{CaCL2}	Content of trace elements, mg / kg				Integral index of contamination
		Pb	Cd	Cu	Zn	
Botanical Garden (south part of city), Umbric Luvisols						
251	6.2	6.5	0.22	4.99	11.9	8.5
253	4.5	4.6	0/16	5.45	7.7	6.74
266	4.7	2.7	0.13	2.15	3.4	3.93
Pribrezhnyj park, (City central part), Transported Antrosols						
693	7.2	57.1	0.4	14.1	51.8	71.29
694	7.9	7.2	0.3	3.6	14.1	21.93
The recreation area on the banks of the Volga (city eastern part), Eutric Fluvisols						
1008	6.8	4.1	0.21	5.17	13.4	20.69
1033	6.6	10.6	0.91	6.71	13.3	28.34
1034	6.7	10.5	0.18	7.62	20.5	29.05
Forest Park «Striginskij bor» (city western part), Umbric Albeluvisols						
44	3.4	4.1	0.01	0.76	0.6	3.4
47	4.9	5.8	0.10	2.63	4.8	10.37
54	3.3	4.0	0.02	0.79	0.8	3.59

The research conducted were the first time for N. Novgorod. As result we can summarize few methodical and applied issues of environmental assessment of the city investigated: (1) data of high resolution soil mapping were adopted for N. Novgorod agglomeration; (2) the serious of soil geochemical maps were created with special reference to trace element distribution; (3) the peculiarities of soil cover transformation in urban landscape were investigated in details, namely the overheating of soil and deficit of water urban soil processes show trend to move to semi arid type; (4) it was substantiated that formation of alkaline reaction of the fine earth can be positive factor in stabilization of main contaminants – trace elements in urban soils; (5) main practical issue is that the data base of parameters of technogenic soil transformation was created and the fragment of ecological carcass for city development plan was elaborated. The results of implemented project "Geochemical assessment of soils and bottom sediments of internal water reservoirs" give the start point for development of environmental and geochemical surveys in N, Novgorod region. (Glebova, Kolomyc et al., 2000; Glebova, 2001; Gelashvili, Ohapkin et al., 2005; Sotkina S.A., 2008; Dabahov, Chesnokova, 2010; Sidorenko, Yunina, 2010).

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Soil-like technogenic formations of soccer fields in European Russia: factors, properties, and processes

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Soccer fields are complex artificial soil-like technogenic formations (STFs) in the sport-oriented recreational landscapes of Russia, which develop under the joint impact of natural and technogenic elementary soil-forming processes (ESPs) (Belobrov, Zamotaev, 2014; Kutovaya et al., 2014). The latter actively operate between the organic and mineral components in the upper, artificial part of the STF profile, as well as between the upper part and the lower part, which includes residual soil horizons and/or parent rock. The high activity and short characteristic times are specific features of ESPs under intense sport and agrotechnogenic impacts. The concept of ESPs determining stable features in the soil solid phase occupies an important place in different aspects of soil studies (Gerasimov, 1975; Duchaufour 1982; Arnold 1983; Mueckenhausen 1985; Kozlovskii 1991; Karavaeva and Zonn 1992; Gerasimova et al. 2005; Targulian 2005; Simakova nad Tonkonogov 2006; Blum 2007; Blume et al. 2010). The ESPs are essential components of the neo-Dokuchaev triad: factors–process–properties. The ESPs include a large group of natural soil-forming processes with characteristic times of tens to thousands of years and highly active technopedogenesis processes directly or indirectly regulated by human activity (Glazovskaya et al. 1986; Solntseva 1998; Belobrov et al. 2002; Lebedeva et al. 2005; Targulian 2005; Tonkonogov 2001; Belobrov and Zamotaev 2007). Technogenic processes significantly contribute to the recent Holocene evolution of soils and soil cover (Solntseva 1998; Aleksandrovskii and Aleksandrovskaya 2005; Lebedeva et al. 2005; Zamotaev and Belobrov 2007).

The empirical study of natural and technogenic processes usually involves the investigation of temporal trajectories of some parameter/property in dated soil sequences. Dated soil-like technogenic formations (STFs) of sports constructions with structures similar to those of natural soils are suitable for the investigation of ESPs. Soccer fields are the most common constructions of this type throughout the world. These are specific sport-oriented recreational zones subjected to regular and intense technogenic impacts resulting in the significant decrease of the realization time of long-term ESPs. The stages and intensities of the main ESPs may be thus studied in time.

Soil-like technogenic formations of professional soccer fields are developed under specific natural-technogenic conditions. According to their biological properties, they have no analogues among the background natural soils, urban soils, and other technogenic soils. The microbial communities of the STFs and their mesofauna are greatly affected by agrotechnogenic loads. The response of the bacterial community and mesofauna to technogenic impacts is seen not only in the numbers of the organisms but also in the changes of their species composition, the inversion of the major ecological niches, and the longer period of active functioning. Soil-like technogenic formations of soccer fields are characterized by a combined natural-technogenic pedogenesis model. Irrigation; additional heating; input of solid-phase (sanding), chemogenic (mineral fertilizers), and organic (earthing) materials; technoturbations; and sport impacts largely determine higher rates of ESPs in the STFs than in the natural soils. The combination and specificity of ESPs vary even within the same group of STFs; they acquire traits corresponding to one of the pedogenesis trends (progradational or degradational), or signs of both trends are present in the profile.

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Radiocesium hyperaccumulation by plants as the basis for their use in phytoremediation of soil contaminated with radionuclides

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Introduction. Nuclear energy use, active nuclear weapon testing and major radiological accidents in XX and XXI centuries led to the pollution of vast areas with long-lived radionuclides. Since for many years to come soil is considered to be a dominating radionuclide storage in ecosystems, soil remediation has become the most important line of research after Chernobyl NPP accident in 1986 (Zhu, Smolders 2000). The progress in phytoremediation of soils contaminated with one of the most toxic technogenic radionuclides – ^{137}Cs – is defined to a large extent by the results of search of plants - hyperaccumulators that are able to absorb ^{137}Cs by roots and to translocate its to the aboveground organs.

The aim of the present work is to explain the ^{137}Cs hyperaccumulation mechanism based on the study of accumulation of ^{137}Cs and ^{40}K (which are the elements with similar chemical properties but fundamentally different biophile characteristics) by plants of forest ecosystems of the East European Plain.

Materials and methods. The study area is located in the south-west of the Meshchera lowland (the center of the East European Plain) and belongs to the zone of coniferous-deciduous forests. Soil and biogeochemical assaying was carried out in 2013 - 2015. ^{137}Cs specific activity in sod-podzolic soils of the study area varies within 6,6 – 138,6 Bq/kg.

Discrimination factors (DF) K/Cs have been calculated on the basis of gamma-spectrometric analysis of ^{137}Cs and ^{40}K specific activity in phytomass and soil samples (Zhu, Smolders 2000):

$DF = (\mathbf{K_{plant} / Cs_{plant}) \div (Cs_{soil} / K_{soil})}$,

where K_{plant} and K_{soil} – specific activity of ^{40}K (Bq/kg) in a fraction of phytomass and soil respectively; Cs_{plant} **and** Cs_{soil} **is the same for** ^{137}Cs.

DF gives an indication in what way and how much the K/Cs soil ratio changes in the plant organism. DF >> 1 indicates an active selective absorption of K by the plant in comparison to ^{137}Cs. The value of DF close to 1 is an indicator of passive K and ^{137}Cs absorption. The value of DF < 1 reflects more active ^{137}Cs accumulation in biological objects compared to the soil.

Results. Table 1 represents the K/Cs DF values calculated for biological objects of the study area. From the table 1 it can be seen that values DF >> 1 are usually typical for the aboveground phytomass while values DF < 1 are typical for the root systems. Thus, for the most plants biophile element K intensively translocates to the shoot while translocation of toxic ^{137}Cs is restricted by root barrier.

However with regard to phytoremediation of polluted soils, plants - hyperaccumulators accumulated ^{137}Cs in the aboveground organs are of special interest. As it is seen from the table 1, ^{137}Cs hyperaccumulation tendency is typical first of all for fern *Pteridium aquilinum* and green mosses (DF < 1) and secondly for bioobjects with DF values close to 1 namely oak and aspen leaves and thin branches.

Discussion. Increased ^{137}Cs accumulation by mosses is linked to their simplified anatomic differentiation. They lack the organs and tissues that act as anti-concentration physiological barriers (Kovalevskii 2010). From our point of view, ^{137}Cs **hyperaccumulation by fern fronds would be due to low selectivity of K-transport mechanisms at the stages of root absorption and xylem transport as well as due to restricted** ^{137}Cs **involvement into phloem transport.**

Table 1 – Values of K/Cs discrimination factors (DF) for bioobjects of the South Meshchera's mixed forest communities

Plant species	Phytomass fraction	DF	Plant species	Phytomass fraction	DF
Quercus robur (81 years)	Wood	4,397	*Pinus sylvestris* (88 years)	Wood	10,193
	Thin branches	1,877		Bark	3,070
	Leaves	1,926		Thin branches	6,313
	Wood of thick roots	1,139		Needles	3,159
	Bark of thick roots	0,070	*Picea abies* (55 years)	Wood	9,369
	Fine roots	0,719		Bark	2,912
Populus tremula (45 years)	Wood	3,013		Thin branches	3,097
	Bark	0,679		Needles	3,138
	Thin branches	1,529	*Pteridium aquilinum*	Shoots	0,388
	Leaves	1,853		Roots	0,029
	Wood of thick roots	0,808	Green mosses	Gametophyte	0,418
	Bark of thick roots	1,911	*Convallaria majalis*	Shoots	33,222
	Fine roots	1,190		Roots	3,059

Notes: the table includes the most representative data for 26 of the 92 analyzed biological objects.

Attempts to explain ^{137}Cs hyperaccumulation by angiosperms are commonly associated with K-philic properties of plants. K-philic species accumulate ^{137}Cs (that is **element - analogue K)** more actively (Wiesel 2010). Performed analysis and summation of literature data make it possible to conclude that plants which are ^{137}Cs hyperaccumulators should meet the following conditions:

1. The intensive absorption of ^{137}Cs by root transport systems. This requirement is fulfilled if nonspecific type of K-transport system, LATS (low-affinity transport systems), is functioning in plant roots (Coskun et al. 2015). LATS, having a low affinity for ion, absorb not only K but also its geochemical analogues including ^{137}Cs. LATS function in plant roots under conditions of high ion concentration in the environment.
2. The intensive translocation of ^{137}Cs to aboveground organs. This requirement is fulfilled in case of low selectivity of element transport at the stages of xylem loading and input to photosynthesizing organs.
3. The effective mechanisms ^{137}Cs detoxication in shoots. A possible mechanism for this detoxification may be ^{137}Cs compartmentalization in vacuoles, similar to sodium.

Plants that are intensively feeding on nitrate nitrogen and reducing it in the phytomass of aboveground organs meet all above requirements. According to the model of internal circulation of ions in plant vessels (Coskun et al. 2015) plants that reduce NO_3^- in shoots use K^+ as a counter-ion for NO_3^- transport in the xylem. In shoots, the fate of these ions differs: NO_3^- is reduced, while K^+ can enter the roots through phloem transport and may participate again as a counter-ion in NO_3^- transport to the shoots. **However in**

nutrient-rich conditions consistent absorption of K^+ and NO_3^- by roots of plants that reduce NO_3^- in shoots is typical; in this case K^+ is accumulated in the vacuoles of shoot's cells in complex with organic acids. Organic acids are synthesized by PEP-carboxylase for neutralization of OH^- ions that are formed as a result NO_3^- reduction (Liu et al. 2015).

From this standpoint, the fact can be explained that the vast majority of currently known ^{137}Cs hyperaccumulators are aridanite plants characterized by active absorption of anionic elements (including NO_3^-) and adapted to growth in high salinity soil and arid climate of tropical and subtropical regions. Primarily it concerns the representatives of an order *Caryophyllales* (*Amaranthaceae* and *Chenopodioideae*) which are the especially strong ^{137}Cs hyperaccumulators (Wiesel 2010) as well as plants of family *Asteraceae* (*Artemisia vulgaris, Calamagrostis epigeios, Tanacetum vulgare, Achillea millefolium*) that were proposed for phytomelioration of ^{137}Cs polluted soils (Rakhimova 2014). In this regard, the fact of the increased accumulation of ^{137}Cs in leaves and thin branches of the oak, established by us, is naturally-determined. Oak is an aridanite species that prefers soil with a neutral or slightly alkaline reaction, and even endures a moderate alkalinity.

It should be noted that active nitrate nutrition is typical not only for aridanite plants. Enhanced uptake of nitrate nitrogen, accompanied by high rate of its assimilation in leaves, is also typical for humidokite (originated from humid areas and actively absorbed cations) pioneer (ruderal) species. In this regard, the fact of the increased accumulation of ^{137}Cs in aspen leaves and thin branches is naturally-determined.

Conclusion. Thus, such plant physiology aspects as NO_3^- and K^+ root absorption, NO_3^- reduction in the aboveground phytomass, formation of excess organic acids in shoot and ^{137}Cs hyperaccumulation are elements of a single process that is the intensive nitrate nutrition of aridanite and humidokite pioneer plant species. Proposed explanation of ^{137}Cs hyperaccumulation mechanism can help to select plant species that can be used for phytoremediation of ^{137}Cs polluted soils. According to our results such plant species can be the representatives of the order *Caryophyllales* (*Amaranthaceae* and *Chenopodioideae*), plants of family *Asteraceae* and also woody plants such as *Quercus robur* and *Populus tremula*.

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Input and behavior of polycyclic Aromatic Hydrocarbons in Sub-urban and Urban soils under Pollution from a Local Industrial Source

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The increased interest in polycyclic aromatic hydrocarbons (PAHs) is related to the carcinogenic and mutagenic activity of some of them, which poses a human health risk. One of the main ways of PAHs contamination of soils is their accumulation from the atmosphere, where, in turn, they are released by industrial enterprises. Meanwhile, in the literature, these processes are not illuminated sufficiently; features of PAHs accumulation on soil surface in urban and suburban areas from the atmosphere and transformation in soil cover have been studied in rare works. For a better understanding of their behavior in the environment it is necessary the further research characterizing features of income, accumulation and transformation of these compounds in the soil.

The aim of this study was to compare the PAHs content in snow and soil cover in urban and suburban areas under pollution from a local industrial source, identification and testing of the indicator significance of the individual polyarenes ratios to establish the characteristics of their accumulation from the atmosphere and transformation in soils at different combinations of natural and anthropogenic factors. In the literature there is no information on the comparison of different PAHs ratios according to the degree of their stability in soil and snow samples, this approach is applied for the first time.

The studied key-site was subjected to the technogenic impact, mainly related to the technical carbon-producing plant for a long time. The studies were conducted along a transect directed from the source of industrial emissions (industrial zone of the technical carbon-producing plant) to the east. The transect included six soil-testing plots with a total length of 11 km. There were no other industrial enterprises along the transect, except the initial plot occurring in the industrial zone.

Earlier in the specified paper the authors described the content of different hydrocarbon compounds in soils of studied key-site: the bitumoids, free and held hydrocarbon gases and polyarenes (Gennadiev et. al., 2016). However, that work have been devoted exclusively to the content of these substances in soils. In this paper, the focus was on a comparison of polyarenes contents in soil and snow, as well as a calculation of various ratios of individual PAHs as an indicator of their stability and degradation.

Soil samples were taken from genetic horizons in soil profiles. Snow samples were taken at the same points where the soil profiles were previously studied. Sampling the snow was conducted in sealed plastic containers by special trumpet samplers with fixed diameter. Snow was melted in a container at room temperature. Melted snow water was filtered through a membrane filter (pore diameter of 0.45 microns) on a vacuum filtration unit. At each sampling point was determined snow water reserve by the volume of snow and snow moisture.

Polycyclic aromatic hydrocarbons in soil and snow samples were analyzed by spectrofluorimetry at low temperatures (Shpol'skii spectrometry). The analysis of PAHs was performed on a Lumex Fluorat-Panorama spectrofluorometer equipped with an LM-3 monochromator and a Cryo-1 accessory. The identification and quantification of individual hydrocarbons were performed from characteristic lines in the fluorescence spectra of bitumoid solutions at –196°C using the certified international standard NIST 2260a. The analysis of highly diluted solutions was performed using spectral fractionation, which involved the selection of characteristic excitation and fluorescence wavelengths for each compound.

The following conclusions are made on the basis of the results obtained. On the major part of the studied territory, especially in the suburban zone, PAHs get into soils mainly because of atmospheric transfer. Only within the most industrial area and in the close vicinity of it there are inclusions of solid material with some hydrocarbon containing products in soils.

As a result differences in the radial distribution of PAHs and their penetration depth among the soils of urban and suburban area are established. In suburban soils under forest, the radial distribution of PAHs is of accumulative character. Four-, five-, and six-ring PAHs are detected only in the upper 5-cm-thick layer of soils under natural vegetation. In forest soils with morphological indices of old plowing, the penetration depth of heavy four-, five-, and six-ring PAHs corresponds to the lower boundary of the old plow horizon. In the cultivated soils, the penetration depth of PAHs is slightly greater than in the soils of forested areas. The contents of four-, five-, and six-ring PAHs in all plow horizons are maximum in the profile, and their contents in the subsurface horizons decrease abruptly to the trace level. The maximum penetration depth of heavy PAHs in tilled soils coincides with the lower boundary of the plow horizons.

In urban area high contents of PAHs throughout the profile are noted in the toxiindustrates and chemozems. On some plots in the industrial zone, the maximum contents of total PAHs are observed at a depth of 50–75 cm.

Volume of PAHs income, defined by their reserves in the snow cover, within the study area is high. They range from 1.5 to 85 mg/m^2 in different sampling points, which corresponds to the following average annual PAHs entering to the territory: about 1 g/ha per year – on average in a suburban area (forest, arable and fallow land) and about 45 g/ha per year on average near the source of pollutants. These rates correspond to PAHs receipt data in the literature, according to which in urban areas and close to major industrial centers the rate of receipt of PAHs ranged from 4 to 40 g/ha per year (Wilcke, 2000). It should be noted that such high rates of PAHs income on the territory take place, despite of the fact that in the last decades of soot production was dropped sharply and the plant was almost completely redeveloped for production, much less conducive to PAHs enter to the environment. Probably, high PAHs content revealed in snow samples, due to the scattering of the previously manufactured product that was accumulated over a century of operation of the plant on the surface of buildings and other elements of enterprise infrastructure and adjacent to the plant site.

It was also identified a clear trend of a sharp increase in PAHs reserves as well as coefficient of variation of PAHs reserves both in the soil and in the snowpack when approaching to the industrial zone.

Monodominant phenanthrene association of PAHs prevailed in the snow and the soils, which is found in almost all sampling points, regardless of the distance from the source of pollutants and land use types. In addition to the dominance of phenanthrene characteristic of PAHs identified associations for all sampling points is the lack of fluorene and biphenyl in all snow samples. The absence of these polyarenes in snowy samples is probably caused by the fact that diphenyl and fluorene are light 2-3-ringed hydrocarbons, which may be in the atmosphere in gaseous phase (Baek et al., 1991, Shimmo et al., 2004). In the soil samples the fluorene and biphenyl are present, but in small quantities (in the majority of samples less than 1% of the amount of PAHs).

Analysis of the data indicates that in suburban area the intensity of PAHs transformation is more intense and depends on land use. Under the forest about half polyarenes have a similar share of the amount of PAHs in soil and snow; on the croplands almost all polyarenes have different proportion of the amount of PAHs in soil and snow. Conversely in urban soils near the source the transformation of PAHs in soil is weak and polyarenes association in snow and soil are similar in composition.

In urban area the proportion of reserves of individual polyarenes in the snow to the reserves in soils are minimal and have a small range of variation for different compounds; in suburban area range of variation for different compounds is much higher an order.

Also there was analyzed the relationships within the selected pairs of polyarenes, which are isomers, but with different resistance to transformation, in snow and soil. In particular, there were considered proportions of benzo(a)pyrene to pyrene (BP/P) and anthracene to phenanthrene (A/F). It was revealed that the ratios of BP/P have a higher indicator potential compared with ratios A/F in terms of assessment of the intensity of the transformation of PAHs in soil for various land use regimes. Nevertheless both indicators (BP/P and A/F) confirmed that the most intense transformation of PAHs is typical for soil plowed land, less intensive - for soils under forest and the lowest - to the urban soil, on the territory near the source of pollutants.

Amplification of the transformation of PAHs in the soils of suburban agricultural land may be due to their better aeration and more intensive photo-destruction of PAHs under conditions of turbation of arable horizon during the plowing. Slowing the transformation of PAHs in the urban soil near the source, probably due to inhibition of microbial activity due to the toxic effect of extremely high concentrations of polyarenes.

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