SOIL ORGANIC MATTER AND CONTENTS OF OXYGEN IN ATMOSPHERE

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Introduction. The study of turnover of biophil elements and, in particular, cycles of carbon and oxygen, is an important line of investigation. This line takes on special significance in conditions of global warming of climate especially. The warming of climate is connected with surplus contents of carbon dioxide in atmosphere usually. Modern understanding the enrichment of atmosphere by the oxygen is founded on activities of photosynthesis only. An increased attention to photosynthetic activity of plants is explained this reason somewhat. Somewhat this is explained increased attention to photosynthetic activity of plants. Successes in this line are significant. With the development of functional approach to all ecological systems, the existing models of cycles of carbon and oxygen are subjected deeper and more critical conceptualisation. Seems that a great deal is known about cycles of carbon and oxygen. However as it turned out, the cycles of carbon and oxygen has being rated individually, but a functioning of plant-soil system is seldom taken into consideration.

The aim of this article is a statement the conceptual model of interrelationship of cycles of carbon and oxygen. The soil organic matter plays main role in this model. The suggested model allows considering a gas composition of atmosphere as a result of a plant-soil system functioning.

The ecological function of soil organic matter. The soil organic matter (SOM) is highly dynamic complex and heterogeneous system. In natural orderly functioning habitat the components (individual compounds and humic substances) of SOM are interconnected between they self and are presented in certain stable proportion. The soil organic matter occupies one of the central places in trophic chain of plant-soil system. The trophic function of SOM is very concerned with trophic function of soil – its fertility, since the turnover of ash elements just as the cycles of carbon and oxygen is concerned with SOM (Popov and Chertov, 1996). Thus, for comparison the contents of carbon in terrestrial organisms is 560.5, in atmosphere – 728, in fossil fuel – 7660, in SOM – from 2000 to 13950 trillions of kilograms (Post et al., 1982; Kobak, 1988).

Green vascular plants may be considered as a facultative heterotrophic organisms with symbiotic both digestion and nutrition. From position of trophology the plant consumption of organic compounds broadens greatly a notion about the plant nutrition and ways of its regulation.

In particular, beside the main known cycle of carbon: plant → litter (soil) → humic substances (HS) → carbon dioxide → plant, there is a second cycle of carbon (turnover of organic compounds, which are structural fragments of biological macromolecules): plant → litter (soil) → HS → fragments of macromolecules (organic nutrients) → plant; this turnover is an additional cycle of nitrogen too (Fig. 1).

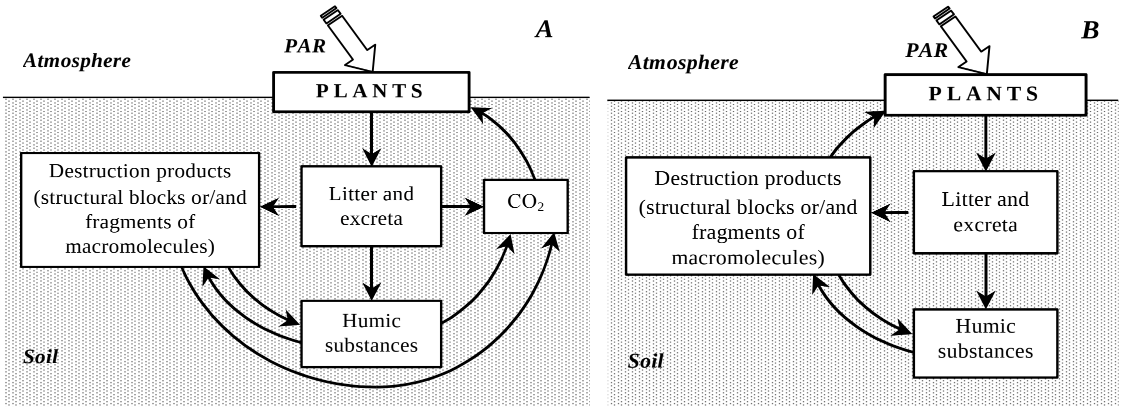

Figure 1 – Biological carbon cycles:
A – known biological cycle of carbon, B – turnover of organic compounds, which are structural fragments of biological macromolecules; PAR – physiologically active radiation.

The biological sense of plant consumption of organic compounds, which are structural fragments of biological macromolecules, is concluded in "economy" of energy by plants. Since plants can use allochthonous organic compounds as building or functioning blocks (assimilation of organic compounds by plants). On our opinion, the structural fragments of lignin circle in the plant-soil system. Thus, first the structural fragments of lignin, which are included in the plant litter composition, come in soil. The most part of lignin fragments are oxidized, and the remainder of these compounds is built to HS in result of organic material transformation. Then lignin fragments, incoming in HS structural units, come in plant, and ones are built in cell wall after hydrolytic decomposition (Popov, Chertov, 1993; 1996).

The modelling of interrelation of carbon and oxygen cycles. An enrichment of atmosphere by the oxygen is one more ecological effect of heterotrophic nutrition of photosynthesising organisms. As far as in the second biological carbon cycle (photosynthesising organisms → litter → destruction products → photosynthesising organisms) the organic molecules, being structural and functional blocks of biological macromolecules, are built to bodies of photosynthesising organisms; and at the same time a content of the oxygen in atmosphere increases on the same amount of oxygen, which should be used up on the oxidizing of organic molecules c assimilated by photosynthesising organisms (Fig. 2).

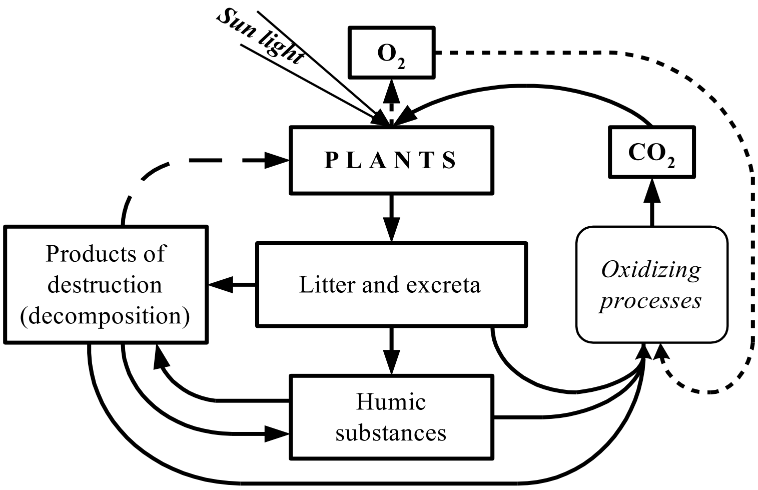

Figure 2 — interrelation of carbon and oxygen cycles:
——— carbon cycle, – – – oxygen cycle,
— — assimilation of organic compounds by plants.

Explain. If consider that enrichment of atmosphere by the oxygen is "a merit" of photosynthesis only, and at the same time the one known carbon cycle is taken into account only, the atmosphere will hardly be enriched by the oxygen. So far as a quantity of the oxygen, which needed for biogenic and/or abiogenous oxidation of photosynthetically bound carbon (organic compounds), is equal to one, which will be formed by photosynthetic assimilations of carbon dioxide:

$$\left.\begin{array}{l} CO_2 \rightarrow [C] + O_2 \text{ (photosynthesis)} \\ [C] + O_2 \rightarrow CO_2 \text{ (oxidizing)} \end{array}\right\} \Rightarrow \Delta O_2 = 0.$$

Indicated above (see Fig. 2) the graphic model of carbon and oxygen cycles is described by following combined equations:

$$
\begin{cases}
\dot{P} = +\alpha_1 D(P) + \alpha_2 C(P) - \alpha_3 P(L) \\
\dot{L} = +\alpha_3 P(L) - \alpha_4 L(D) - \alpha_5 L(H) - \alpha_6 L(O) \\
\dot{D} = +\alpha_1 D(P) + \alpha_4 L(D) + \alpha_7 H(D) - \alpha_8 D(H) - \alpha_9 D(O) \\
\dot{H} = +\alpha_5 L(H) - \alpha_7 H(D) + \alpha_8 D(H) - \alpha_{10} H(O) \\
\dot{C} = -\alpha_2 C(P) + \alpha_6 L(O) + \alpha_9 D(O) + \alpha_{10} H(O) \\
\dot{O} = 8/3(\alpha_2 C(P) - \alpha_6 L(O) - \alpha_9 D(O) - \alpha_{10} H(O))
\end{cases},
$$

where P – carbon, being included in plants, L – carbon, being included in plant litter, D – carbon, being included in products of destruction (water-soluble organic matter – SOM), H – carbon, being included in HS, C – carbon, being included in CO_2 of atmosphere, O – oxygen, being included in atmosphere; $\alpha_1 D(P)$ – quantity of SOM carbon, assimilated by plants, $\alpha_2 C(P)$ – quantity of carbon CO_2 atmosphere, which is photosynthetically bound by plants, $\alpha_3 P(L)$ – quantity of carbon, being included in plant litter, $\alpha_4 L(D)$ – quantity of SOM carbon, which was formed from plant litter, $\alpha_5 L(H)$ – quantity of carbon of plant litter, which was used for humification, $\alpha_6 L(O)$ – quantity of carbon of plant litter, which was oxidized by the oxygen of air, $\alpha_7 H(D)$ – quantity of carbon of newly formed HS, which was used on formation of SOM, $\alpha_8 D(H)$ – quantity of SOM carbon, which was used for humification, $\alpha_9 D(O)$ – quantity of carbon SOM, which was oxidized by the oxygen of air, $\alpha_{10} H(O)$ – quantity of carbon of HS which was oxidized by the oxygen of air, 8/3 – stochiometric coefficient of converting of carbon atomic mass to the oxygen molecule mass.

For solution of combined equations, which is indicated above, we accepted that: plant-soil system is climax (i.e. in such system the arrival of matter is equal to expense of one); all quantity of photosynthetically assimilated carbon, which is a part of plant litter, came into soil completely and yearly (i.e. the phytocenosis was presented by one-year plants); coefficients of humification of both plant litter and products of destruction were 0,1 (10 %); coefficient of destruction of plant litter and HS was 0,1 (10 %); coefficient of oxidation of plant litter was 0,8 (80 %); coefficient of oxidation of destruction products was 0,9 (90 %), if consider that plants do not assimilate these compounds, it was 0,8 (80 %), if suppose that plants can assimilate these organic compounds (i.e. when certain part of destruction products are not assimilated by plants, they are oxidized); coefficient of oxidation of HS was 0,9 (90 %), when does not take place the increasing a contents of humificired material in soil, it was 0,8 (80 %), in case if contents of HS in soil was increased yearly; coefficient of yearly oxidation of all HS was 0,01 (1 %); coefficient of possible yearly accumulation of HS in soil was 0,1 (10 %); coefficient of possible assimilation of destruction products by plants was 0,1 (10 %); initial contents of carbon in phytomass was accepted as 1.

From results of modeling was got the following. If both a consumption of organic compounds by green plants and an accumulation of HS in soil is absent, the changes to the contents of O_2, CO_2, phytomass and HS in the plant-soil system does not take place, in spite of the photosynthesis. If accumulation of HS in soil no, but consumption of organic compounds by plants is 10 % from the contents of destruction products for instance, it is observed increase of contents O_2 and (to a lesser degree) phytomass, as well as a decrease of contents CO_2. As is well known, the increase of O_2 in atmosphere can also occur to the account of gradual increasing a quantity of HS in soil. In the development ecosystem, in which both accumulation of HS, and consumption of organic compounds by plants are possible, there is an evident increase of O_2, a decrease of CO_2, and a supplement of phytomass, which corresponds to consumption value of carbon of organic compounds (Fig. 3).

Thus, if noospheric change of top-soil will bring to decrease of contents of organic material, this will increase contents of carbon dioxide and decrease ones of oxygen in atmosphere. It is necessary to create such conditions that plants could consume and assimilate organic compounds. In this case a gas composition in atmosphere will be changed aside increasing a concentration of oxygen. Such conditions, which in particular can be reached as a result of forming mull-humus in soil, but mull-humus can be formed only at presence earth warms in the composition soil biota.

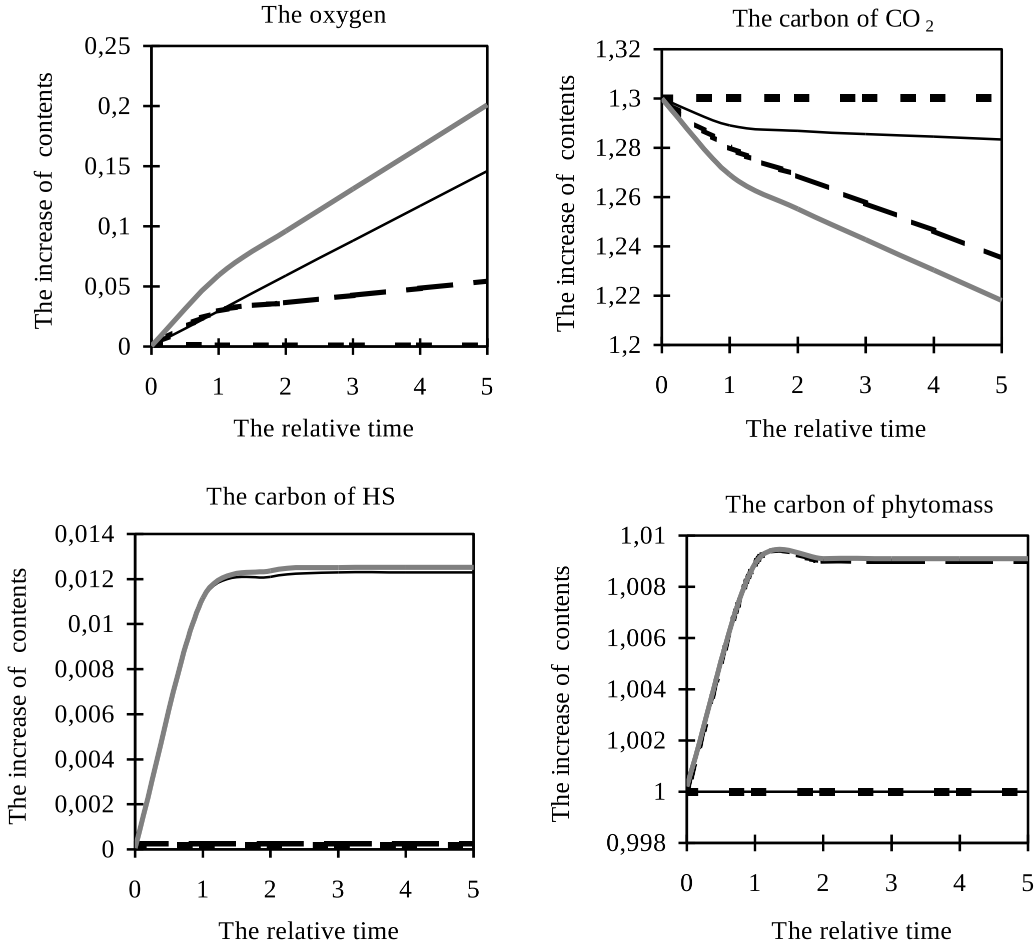

Figure 3 — Increase of contents of oxygen, carbon of carbon dioxide, carbon of humic substances and carbon of phytomass:

- - - consumption of organic compounds by plants and accumulation of HS in soil is absent;
— — there is consumption of organic compounds by plants, but accumulation of HS in soil no;
—— there is accumulation of HS in soil, but consumption of organic compounds by plants no;
—— there is both consumption of organic compounds by plants and accumulation of HS in soil.

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