

GEOCHEMISTRY. ANALYTICAL CHEMISTRY

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ON THE ESTIMATION OF THE CORRECTNESS OF THE MAXIMUM PERMISSIBLE CONCENTRATIONS OF HEAVY METALS IN NATURAL WATERS OF WESTERN SIBERIA

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Abstract

Humus substances are one of the main accumulators for carbon in the biosphere. They control the global biogeochemical cycle of organic carbon. They also play a crucial role in reduction-oxidation, sorption, complexation, transfer of contaminants and microelements, plant growth. Humus substances are found in the soil and take part in its formation. Humus compounds are important for many natural processes.

In the materials on biogeochemistry and geochemistry of soils, V.I. Vernadsky noted the significance of living organisms in changing the chemical composition of soils: "This role is so great that, in one way or another, all processes in the soil are associated with the participation of living matter or the products of its change. In the broadest sense of the word, all phenomena can be considered biochemical". The basis of soils are humic substances (HS), which relate to organic objects stochastic nature along with such classes of compounds as oil and lignin. Humic substances are randomized polymers of aromatic oxy-poly-carboxylic acids [1-3].

Due to the specific structure (Fig. 1): the hydrophobic aromatic skeleton and the richness of the functional groups, the humus substances are characterized by macro-ligands properties. They form complexes with metal

ions [2], which determines, as noted in [2-3] their protective properties in the biosphere.

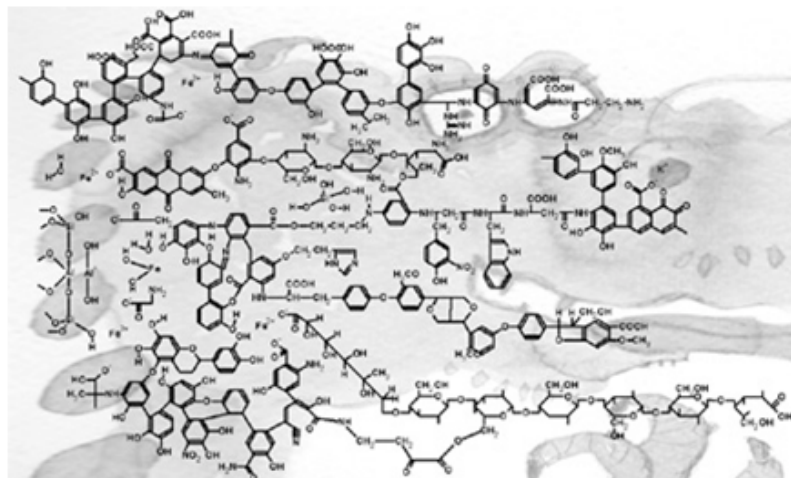


Fig. 1 Structure of humus acid (theoretical view, Orlov, 1999)

Metals in natural waters for domestic and cultural facilities are in various forms. Forms of finding metals are characterized by varying degrees of toxicity. For most of them, the ionic form and some inorganic forms are characterized by the maximum degree of toxicity. Under the conditions of interaction of metal ions with organic components of water, complexes of different strength are formed and the degree of toxicity of the metals is sharply reduced.

Water quality standards (maximum permissible concentration or MPC) and a system of penalties for their exceeding, existing in Russia do not take into account the metals forms. This leads to an overestimation of the total toxicity of the water body and its impact on human health. In turn, decisions on cleaning a water body taken on the basis of inaccurate information can lead to contamination of the object with the using components.

Table 1 presents the existing MPCs for some elements. The greatest concentration (the least dangerous from the point of view of health) is copper (1 mg/l). The most dangerous toxicant from the presented is cadmium (0.001 mg/l). But the values indicated in the table do not take into account the degree of inactivation of metals by the humus substance of waters.

The purpose of the work was to evaluate the ionic form (the most toxic) of certain metals in a competitive system of natural waters and compare the obtained data with the existing MPC.

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For this purpose, the data on the chemical composition of the natural waters of the small lakes of Western Siberia (more than 100 objects) of some natural zones were analyzed. The main limits of variation in the concentrations of metals were identified and their forms of finding in natural waters were calculated taking into account multifactorial competition.

Table 1. Maximum permissible concentration of some elements in natural waters (RF legislation)

<i>MPC for natural waters, µg/l</i>			
Cd	Pb	Cu	Mn
1	6	1	10

In turn, geochemical zoning aspects of the spread elements in the climatic cut are also very important for the characterization of the adequacy of the MPC. Most modern Russian publications about the zonal geochemical enrichment of water elements in higher concentrations than MPC are Chebotarev et. al. [1].

An article of Chebotarev et. al. is shown the MPC system, which is based on experimental data, does not allow us to normalize pollutants from the point of view of the science. Geochemical contents (background concentrations) of metals in natural waters of various zones of Western Siberia were shown in article. As can be seen from Table 2, the geochemical levels of the metal content are significantly higher than the MPC for some elements.

Table 2. Normalization soderazhniya some metals according Chebotarev et al. On geochemistry of natural waters of Western Siberia

Zons	Normalization of Chebotarev et al.				
	CaCO₃	Cd	Pb	Cu	Mn
	mg/l	µg/l	µg/l	µg/l	µg/l
Tundra and forest tundra	60	0.2	1	2	10
Northern and middle taiga	60	0.2	2	2	20
Southern taiga and forest-steppe	60-120	0.8	4	3	20

We used the maximum metal contents in natural waters of Western Siberia for various natural zones (Table 3). As can be seen from the table, the content of manganese, copper exceeds the maximum permissible concentration. We used patented methods for calculating the forms of finding metals in natural waters (Dinu, 2012; 2015) to assess the inactivation of metals by humic substances.

Table 3. Maximum concentrations in Water Lakes (more 100 lakes)

Zones	Maximum concentrations in Water Lakes of Western Siberia, µg/l ±5%			
	Cd	Pb	Cu	Mn
Tundra and forest tundra	0.01	3.39	16.8	30.46
Northern and middle taiga	0.10	2.40	8.58	49.7
Southern taiga and forest-steppe	0.40	1.00	8.78	981.10

The calculation showed a decrease in the concentration of labile manganese by 20-40% in all natural waters of Western Siberia. In the Southern taiga and forest-steppe zone, the concentration of labile manganese is reduced by 50% (due to the prevalence of wetlands), but still exceeds the MPC. Also, the content of labile manganese is higher than the normalized concentrations.

The content of labile copper is reduced by 80-90%, depending on the contribution of organic matter to the humus nature. This leads to a copper concentration above the MPC only in the Tundra and forest tundra zone at a pH below 6. In the waters of lakes of other natural zones of the region, the content of labile copper (after taking into account the Cu formation) decreases significantly and does not exceed the MPC.

The carried out researches have shown influence of competitive reactions in natural waters on a degree of toxicity of water objects on the maintenance of metals.

In addition, the literature data used have shown that the background level (geochemical normalization) is often higher than the declared MPC. In this connection it is required to take into account the share of labile and non-labile forms of metal for an adequate assessment of the toxicity of the object.

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Reference:

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