

Metal ion complex formation in small lakes of the Western Siberian Arctic zone

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The paper is based on joint investigation of the Tyumen State University (Russia, Tyumen) and the Geochemistry and Analytical Chemistry Vernadsky Institute of Russian Academy of Sciences (Moscow, Russia) during 2012-2014 period. It presents the results of research of chemical composition of about 70 small lakes located in the area of tundra and northern taiga of West Siberia (Russia, Yamal-Nenets and Khanty-Mansi Autonomous Districts of the Tyumen region).

The investigation includes determination of different parameters of natural water samples:

- content of trace elements (Al, Fe, Mn, Cr, Cu, Ni, Zn, Cd, Co, Pb, etc., total more than 60 elements) by emission method with an inductively coupled plasma (ICP-MS) using mass spectrometrometre Element 2 equipment;
- content of inorganic and total carbon (TIC and T) by elemental analysis and the difference between the total and inorganic carbon gives the organic carbon content (TOC);
- pH value by potentiometric method;
- content of basic ions (Na⁺, Ca²⁺, K⁺, Mg²⁺, NH₄⁺, Cl⁻, SO₄²⁻, NO₃⁻, PO₄³⁻) by ion chromatography.

Determination of the chemical composition of samples was conducted in the accredited laboratory according to standard procedures with regular quality control of results.

Heavy metals in natural waters can exist in various forms: free (hydrated) ions bound in complexes with organic or inorganic ligands, as well as in the form of suspensions. The form of metal existence has a significant influence on their availability to transport in aquatic organisms. Metal ions associated in stable complexes with organic substances are considered less toxic. From the previous investigations state that the most stable complexes are ligands with organic ions Fe³⁺, Al³⁺.

The main conclusion of the present research states that if the total content of aluminum, iron and manganese ions (meq/dm³) is equal to or greater than the concentration of dissolved organic carbon (TOC, mg/dm³) in lakes water other heavy metals will be predominantly in free, ionic or bound form with inorganic ligands. This state means paradox consequence that the increase of dissolved Fe content will lead to toxicity rise of other elements having less affinity to organic material. For surface waters of Western Siberian Arctic zone this situation is quite common. The total concentration of iron and aluminum ions in most lakes of tundra and northern taiga zones is approximately equal to water complexing ability. From the other side humic substances participation in inactivation of other more toxic metals (Cu, Pb, Cd, Cr, Ni et al.) will be poor.

Arctic part of Western Siberia undergoes significant anthropogenic load due to extensive oil and gas recovery in this zone. Surface waters of Western Siberia are characterized by high natural content of iron, aluminum and copper ions and anthropogenic load of heavy metals makes the situation more serious.