Short communication

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Distribution of mercury in the system water-suspended matter-bottom sediments of Lake Onega (NW Russia)

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ABSTRACT. For the first time for Lake Onega, the lateral distribution of gross mercury in the water-suspended matter and bottom sediments system was revealed. Regularities in vertical distribution of gross mercury in two types of bottom sediments were established. The average content of mercury in water is 0.321 μg/L; in the material of sediment traps - 0.621 μg/g; in the upper and lower parts of bottom sediments - 0.067 μg/g and 0.034 μg/g, respectively.

Keywords: Lake Onego, bottom sediments, mercury, geochemistry

1. Introduction

Mercury is among the ten most hazardous chemicals due to its high mobility and bioaccumulative capacity (O'Connor et al., 2019). In aquatic ecosystems, Hg can be converted to methylmercury, a more toxic form that bioaccumulates in aquatic food chains. Lakes are one of the main objects of the freshwater ecosystem. Mercury enters freshwater systems from a variety of sources and undergoes complex transport pathways. Studying the migration routes of pollutants is the most important task of geochemistry.

This work was carried out in order to study in detail the distribution of mercury concentrations in the system water-suspended matter-bottom sediments.

2. Materials and methods

The object of the study is Lake Onega. The factual material was sampled at 2016-2021 by the R/V"Ekolog" throughout Lake Onega. Sampling was carried out for the Povenetsky, Zaonezhsky, Small Onego, Lizhemskaya, Unitskay, Kondopoga and Petrozavodsk Bays in Big Onego, Central Onego, Southern Onego (Fig. 1). During the expedition, water samples were sampled in conjunction with suspended matter, sedimentary material from sediment traps, and bottom sediments.

Mercury in water was determined by the "cold vapor" method using the amalgamation technique on a Perkin Elmer 3030 atomic absorption spectrometer with an MHS-20 mercury hydride attachment. In bottom sediments, the gross mercury content was determined on the RA-915M analyzer with the RP-91S attachment (Russia).

Analytical work was carried out at the Analytical Center for multi-elemental and isotope research SB RAS, Novosibirsk, Russia.

3. Results and discussion

3.1 Mercury in the water-suspended matter system

The total content of mercury in the water of Lake Onega is on average 0.321 μg/L. The minimum values were obtained for the Povenetsky Bay – 0.022 μg/L. The maximum values were obtained for water samples taken in Southern Onego (0.852 μg/L) and Big Onego (0.552 μg/L).

The concentration of mercury in suspended particles in the water of Lake Onega varies from 0.002 μg/L (Lizhemskaya Bay) to 0.073 μg/L (Zaonezhsky Bay), the average content is 0.021 μg/L. The content of mercury in dissolved + colloidal form varies in a wide range: from 0.01 μg/L in Kondopoga Bay and Povenets Bay to 0.85 μg/L in South Onego. Thus, the predominant form of mercury in water is solution + colloid. Only in the Kondopoga Bay and the Pavenets Bay, mercury in suspended form predominates, which is explained by the location of industrial facilities on the shores of the Kondopoga Bay and the Pavenets Bay, which can be a source of mercury-containing particles.

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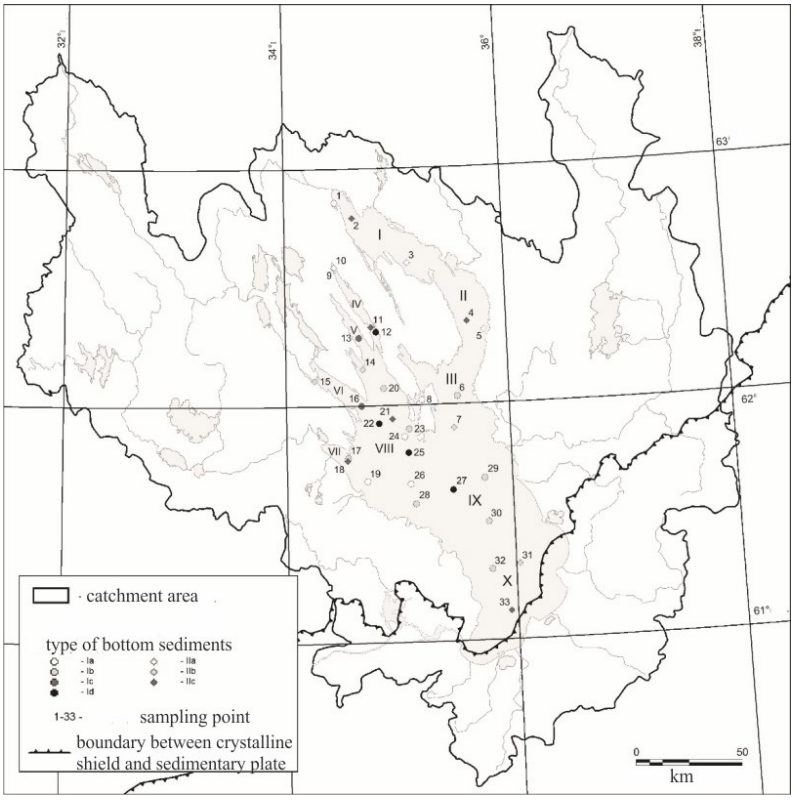

Fig.1. Scheme for sampling the components of the lake ecosystem of Lake Onega. With removed and color-coded mercury content in the upper part of bottom sediments. I Povenetsky Bay; III Small Onego; IV Unitskaya Bay; V Lizhma Bay; VI Kondopoga Bay; VII Petrozavodsk Bay; VIII Big Onego; IX Central Onego; X South Onego. The points color shows the mercury content in the ranges 0.05 -0.08-0.11-0.14 μg/g from white to black.

We found that the mercury content in the material of sediment traps varies in a wide range from 0.062 μg/g to 4.37 μg/g. It should be noted that high values are observed only in two areas of Lake Onega: in the area of the Lizhemskaya Bay (4.37 μg/g) and in the Povenetsky Bay (0.76 μg/g).

3.2 Mercury in bottom sediments

The geochemical and mineral composition of the bottom sediments of Lake Onega was described in detail in Strakhovenko et al. (2020) Based on the analysis of the composition and geochemical features of the upper particles (0-20 cm) of the bottom sediments of Lake Onega, the authors found that the Holocene sediments of Lake Onega can be divided into two types.

Both types of section are characterized by higher mercury concentrations in the upper parts of the sections (Fig. 2). Moreover, the concentrations of mercury in both types are close to each other in terms of values. And they differ only in the thickness of the zone with increased values of mercury concentration, which is just different for the two types of sections. From the analysis of mercury concentrations in the section of bottom sediments, it was found that in the upper part of the section (up to 20 cm), the concentration is higher than in the lower part of the section (on average 0.065 μg/g and 0.034 μg/g for the upper and lower parts of the section, respectively). At the same time, increased concentrations are observed precisely for layers of oxidized layers and layers enriched with Fe-Mn.

In the course of the work, the lateral distribution of mercury in bottom sediments was studied

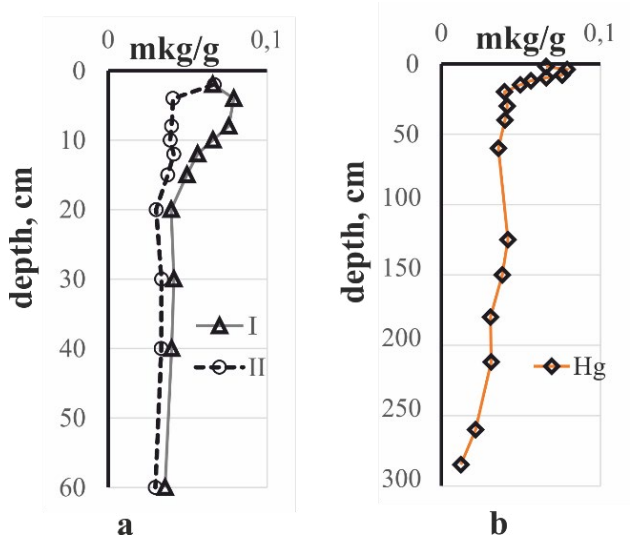

Fig.2. Distribution of mercury: a) in the I and II types of sections of bottom sediments of Lake Onega, b) in the average section of bottom sediments of Lake Onega

throughout Lake Onega. It has been established that the northeastern part of Lake Onega (the Povenetsky and Zaonezhsky Bays, Small Onego) is characterized by lower values than for the rest of Lake Onega. The maximum values of mercury content in the upper part of the bottom sediments are reached in the Kondopoga Bay (0.089 μg/g).

Throughout the entire water area, the mercury content in the lower part of the bottom sediment section is lower than the concentrations in the upper

part of the bottom sediment section and averages 0.034 μg/g. The lowest values are observed in the bottom sediments sampled in the Unitskaya Bay - 0.016 μg/g, the maximum values in the Bolshoy Onega swarm 0.058 μg/g.

As can be seen from the results obtained for Lake Onega, the concentration of mercury in the material of sediment traps is higher than the content of mercury in bottom sediments. This is most likely due to the greater amount of organic residues in the material of the sediment traps, since mercury has a high bioaccumulative capacity.

4. Conclusions

The research of mercury concentrations in various components of ecosystem of Lake Onega led to the following conclusions:

1) The total content of mercury in the water of Lake Onega is on average 0.321 μg/L. The predominant form of mercury in water is solution + colloid, with the exception of water samples from Kondopoga Bay and Pavenets Bay.

2) From the analysis of mercury concentrations in the section of bottom sediments, it was found that in the upper part of the section (up to 20 cm), the concentration is higher than in the lower part of the section (on average 0.065 μg/g and 0.034 μg/g for the upper and lower parts of the section, respectively).

3) It has been established that the northeastern part of Lake Onega (the Povenets and Zaonezhsky Bays, Small Onego) is characterized by lower values than for the rest of Lake Onega. The maximum values of mercury content in the upper part of the bottom sediments are reached in the Kondopoga Bay (0.089 μg/g).

4) We found that the mercury content in the material of sediment traps varies in a wide range from 0.062 μg/g to 4.37 μg/g and is higher than the content of mercury in the corresponding bottom sediment cores.

Acknowledgments

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Conflict of interest

Conflicts of Interest: The authors declare no conflicts of interest.

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