Short communication

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Sedimentary processes in Lake Onego at the present time

Belkina N.A.[1]*, Strakhovenko V.D.[1,2], Subetto D.A.[1,3], Efremenko N.A.[1], Potakhin M.S.[1], Kulik N.V.[1], Gatalskaya E.V.[1], Ryabinkin A.V.[1], Kukharev V.I.[1], Rybalko A.E.[1,4], Zdorovennova G.E.[1], Zdorovennov R.E.[1], Ludikova A.V.[5]

[1] *Northern Water Problems Institute KRC RAS, 50 Aleksander Nevsky str., Petrozavodsk, 185030, Russia*
[2] *V.S. Sobolev Institute of Geology and Mineralogy SB RAS, 3 Akademik Koptyug ave., Novosibirsk, 630090, Russia*
[3] *Herzen University, 48 Moika Embankment, Saint-Petersburg, 191186, Russia*
[4] *Arctic and Antarctic Research Institute, 38 Bering str., Saint-Petersburg, 199397, Russia*
[5] *Institute of Limnology RAS, 9 Sevastianova str., Saint-Petersburg, 196105, Russia*

ABSTRACT. The data on studies of sedimentation processes in the Lake Onego were collected. The research program includes monitoring of atmospheric precipitation, the river flow, the distribution of suspended matter in the water column, the flow of suspended matter to the bottom and point source of pollution. The distribution and accumulation rates of sedimentary matter in the lake were determined. The composition of sedimentary matter has been studied.

Keywords: big lake, genesis of sediments, distribution of suspended matter, geochemical composition of sedimentary matter, accumulation rate

1. Introduction

Lake Onego is the second largest Europe Lake. The catchment area (53,100 km^2) and lake depression (9,720 km^2) are located in the Northwest of the East European Platform on the border of the crystalline shield and the sedimentary plate (61°42´ N, 35°25´ E; 33 m a.s.l.). The northern part of the basin is composed of hard-to-dissolve crystalline rocks of the Archean-Proterozoic Fennoscandian shield, overlain by Quaternary deposits of small thickness (7-10 m). The southern part composed of rocks of the Upper Devonian and Lower Carboniferous. The crystalline rocks of the catchment area of Lake Onego are covered by a cover of Quaternary sediments (interglacial, continental, and marine formations of the Early, Middle, and Late Pleistocene).

Lake Onego basin has a well-developed hydrographic network including more than 6500 rivers and 9500 lakes (the lake-surface area density of 6.5%) (Litvinenko and Karpechko, 2015). The intensive destruction of Quaternary sediments is observed under the influence of denudation processes in a humid climate (Demidov, 2010; Subetto et al., 2020; Strakhovenko et al., 2018; 2020; Kulik et al., 2020a; 2020b; 2022; Belkina et al., 2008; Belkina and Kulik, 2018).

*Corresponding author.
E-mail address: bel110863@mail.ru (N.A. Belkina)

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2. Materials and methods

Studies of sedimentation processes in Lake Onego include: (1) monitoring of atmospheric precipitation; (2) monitoring of river flow (10 large rivers, 4 seasons); (3) periodic observations of the distribution of suspended matter in the water column; (4) monitoring of the flow of suspended matter to the bottom (26 sedimentation traps (ST) are installed in different areas of the lake, the time exposition – 1 year (Fig.); (5) monitoring of the flow of solid material from point anthropogenic sources (official information). In order to perform task (4), a ST was constructed, a unique scheme for setting and lifting ST was developed, a method for sample preparation of suspensions from ST was developed, a method for selecting and separating suspended matter from natural water was modified.

3. Results and discussion

The features of the distribution of suspended matter in the water column are established. Increased turbidity values are typical for shallow coastal areas of bays and at the confluence of rivers into the lake. Increased turbidity values throughout the water column were recorded in shallow small bays (Kizhi

Skerries). In deeper bays (Gorskaya and Lizhemskaya Bays), turbidity increases with depth. Pronounced heterogeneity of turbidity distribution along the water column was revealed in the Kondopoga Bay. The reason for this is the spread of polluted waters of the Kondopoga Pulp and Paper Mill. In Petrozavodskay, Unitskaya and Povenetsky Bay, the connection of seasonal and interannual changes in turbidity to the development of phytoplankton was revealed. The deep-water central areas of the lake are characterized by maximum transparency, turbidity values increase with depth. In the southern part of Lake Onego, the interannual variability of turbidity is associated with wind effects on shallow water areas and river runoff.

Monitoring of the intake of the substance into the ST showed the uniformity of the granulometric composition and the uneven nature of the accumulation of sedimentary matter in Lake Onego. The amount of solid matter entering sedimentation traps during observations varied from 0.5 to 20 g $year^{-1}$. Very high quantitative indicators of the average annual intake of substances to the bottom were recorded in the peripheral areas of the open part of the lake (1600 $g \cdot m^{-2} \cdot year^{-1}$ in the North and 1100 $g \cdot m^{-2} \cdot year^{-1}$ in the South). In the Central part of the lake, it did not exceed 590 $g \cdot m^{-2} \cdot year^{-1}$. The maximum average annual intake of the substance in the bottom was recorded in the upper part of the Kondopoga Bay (more than 2 kg), but on average in the bay it was 1100 $g \cdot m^{-2} \cdot year^{-1}$ (the range of fluctuations in values in this bay is the widest). The minimum values of the average annual intake of substances to the bottom were recorded in the Povenetsky Bay (350 $g \cdot m^{-2} \cdot year^{-1}$, with fluctuations of 140 – 500 $g \cdot m^{-2} \cdot year^{-1}$) and at the outlet of the Gorskaya Bay (270 $g \cdot m^{-2} \cdot year^{-1}$, fluctuations of 160-370 $g \cdot m^{-2} \cdot year^{-1}$).

The rate of accumulation of suspended matter at the bottom, expressed in units of length (the thickness of the accumulated layer per year), varies by more than an order of magnitude for different stations: from 1 $mm \cdot year^{-1}$ (C4) to 3 $mm \cdot year^{-1}$ (K3) (on average 7 mm) of freshly deposited unconsolidated matter. Differences in the depths of the lake, as well as in the qualitative and quantitative composition of sedimentation material and differences in diagenetic transformations determine the different degree of compaction of the substance entering the bottom during the formation of bottom sediments. The lowest sedimentation rates were estimated for the deep-water areas of the lake: Bolshoe Onego, Povenetsky Bay and Lizhemskaya Bay. The highest rate of sedimentation is observed in the shallow upper part of the Kondopoga Bay, where bottom sediments are formed under the influence of wastewater from the Kondopoga Pulp and Paper Mill. The obtained values of the sedimentation rate for two stations (L18 and S3) were compared with the values of the sedimentation rate based on age dating by the distribution of isotopes ^{137}Cs and ^{210}Pb in the sediment column. The values were close: for L18 – 0.23 and 0.16 $mm \cdot year^{-1}$, for the southern part of the lake (S3) – 0.43 and 0.47 $mm \cdot year^{-1}$, respectively.

Chemical composition of the waters and the elemental, mineral and detrital particle composition of sedimentary matter in rivers and lake have been studied. The ratio of suspended and dissolved forms of elements varies depending on the area of the lake (the suspended form predominates mainly in Petrozavodsk and Kondopoga bay). The detrital matter in Lake Onego is represented by skeletons of diatoms, which are destroyed as they are deposited. The terrigenous component from ST and bottom sediments collected in different parts of the lake have a similar composition. It is represented by fragments of large and small grains of quartz, feldspar, muscovite, chlorite (which contain the ratio $Fe \approx Mg$) and numerous small grains of accessory minerals. The suspended material of the sedimentation traps is similar in its external characteristics and physical properties to the surface (0-1 cm) bottom sediment in the areas of their installation on the lake bottom.

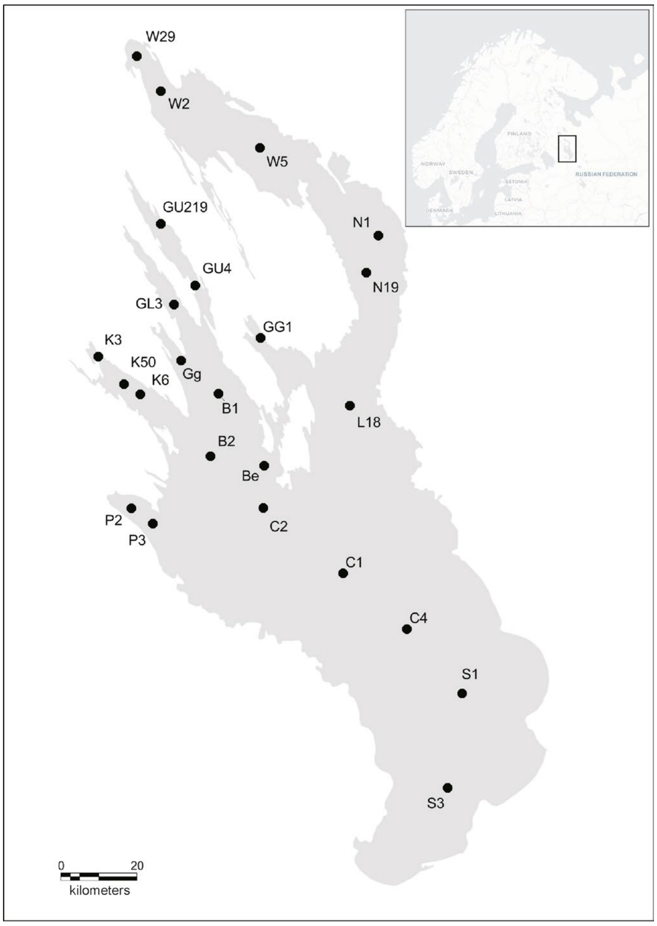

Fig. Monitoring stations for studies sedimentation processes in Lake Onego

4. Conclusions

The basin of the Lake Onego has a complex structure, which affects the thermal regime and the dynamics of the waters, increases the heterogeneity of the ecosystem of the lake. As a result, there are local sedimentation basins with their own regime in the lake.

The sedimentary process in Lake Onego, controlled by water dynamics, involves the transformation of suspended matter in a complex biogeochemical way, resulting in the formation of new mineral phases of iron, manganese and silicon.

The rate of accumulation of suspended matter at the bottom varies by more than an order of magnitude for different areas of the lake.

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Conflict of interest

The authors declare no conflict of interest.

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