Short communication

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Geochemical features of river runoff and its influence on sedimentation processes in Lake Onego

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ABSTRACT. Suspended matter entering Lake Onego with river runoff was studied from 2019 to 2021. Observations on rivers in different seasons on the basis of an interdisciplinary systematic approach combining modern landscape-geographical, biogeochemical, mineralogical, geochemical, hydrochemical, ecological methods allowed us to gain new knowledge about the weighted average flow of substances into Lake Onego for seasonal variability.

Keywords: big lake, Lake Onego, suspended matter, geochemical composition of sedimentary matter, geochemistry, metals

1. Introduction

Lake Onego (61°42' N, 35°25' E) is the second largest freshwater lake in Europe (the area of the lake is 9,720 km^2) and one of the largest reservoirs of the Russian Federation, belongs to the Baltic Sea basin. The geological structure, orography, climatic conditions, vegetation and hydrography are different over the entire significant area of the lake's catchment area (53,100 km2). In 2021, work continued with the study of the lake's suspended matter and suspended matter entering Lake Onego with river runoff (Kulik et al., 2022). To assess the flow of substances into Lake Onego with river waters, work continued on the survey of 9 of its tributaries and the Svir River, among them are three large rivers - Vodla, Shuya and Suna, which give 68% inflow into the lake.

2. Materials and methods

According to the geographical location of the catchments, the objects of study were grouped based on the geological and geomorphological structures of the lake basin. Thus, the investigated rivers - Lososinka, Shuya, Suna (Northwest coast) and Kumsa (North coast) and Vodla (East coast) drain the territory of the Archean-Proterozoic Fennoscandian Crystalline Shield (FCS), the Vytegra River (South coast) drains the territory of the East European Platform, and the Andoma River (Southeast the coast), Sheltozerka and Derevyanka (Southwest coast) are located at the junction of two geological structures (Atlas of the Republic of Karelia, 2021). The Svir' River is the outlet from Lake Onego (Fig.).

The surface water was sampled into ten-liter polyethylene cans. In laboratory conditions, the aqueous suspended matter was divided into dimensional fractions by sequential filtration through membrane filters with different pore diameters. The analysis of the chemical composition of water samples (pH, NH_4^+, NO^3,

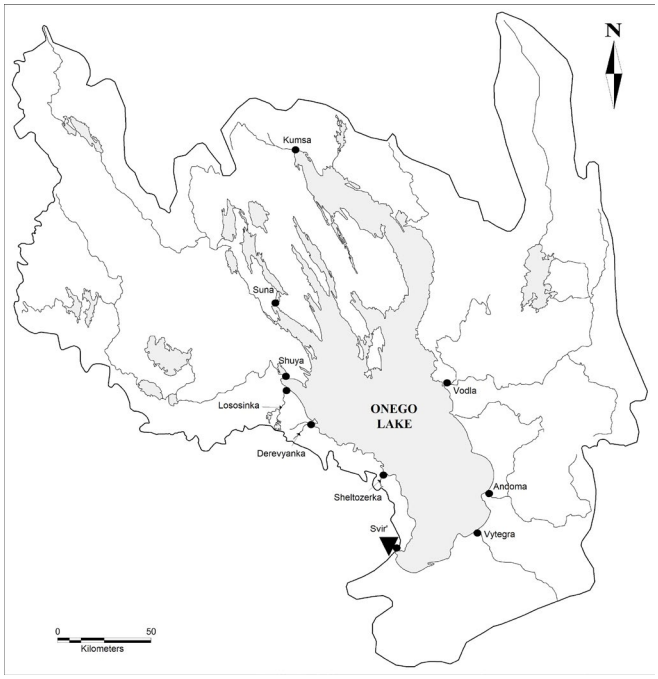

Fig. Schematic map of Lake Onego with sampling points.

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N_{total}, $P_{mineral}$, P_{total}, BOD5, permanganate index, COD, Si, color of water) was carried out in the NWPI KarRC RAS according to the methods generally accepted in the hydrochemical research (Zobkov et al., 2022). The micro-component composition in water and aqueous suspended matter was analyzed in the NWPI KarRC RAS by atomic absorption (AA6800, Shimazu) and mass spectrometric ICP-MS (Agilent 7500a) methods on the scientific equipment of the Core Facility of the Karelian Research Centre of the Russian Academy of Sciences and the analytical Centre of the IGM SB RAS (Novosibirsk).

3. Results and discussion

3.1 Water samples

Mineralization of rivers located in the catchment of the Archean-Proterozoic Fennoscandian Crystalline Shield varied from 11 to 60 mg/l for the observation period. Mineralization the Vytegra River draining over limestone carboniferous is much higher from 110 to 193 mg/l. The waters of the studied tributaries are related to the bicarbonate-calcium type. The ratio of calcium and magnesium ions are determined by the geochemical conditions of the lake's catchment basin. Concentrations of alkali metals are insignificant. In the anionic composition, attention should be paid to the content of anions of organic acids - their increased content was observed in rivers with a heavy swampy catchment (Sheltozerka, Derevyanka, Andoma). Like most rivers of the Taiga zone, the studied tributaries are enriched with humus substances, which causes a high content of $C_{organic}$. During the year, the maximum content of P_{total} in all the studied rivers was occurred for summer and winter. Of the forms of N in the tributaries, the organic form prevailed.

The lowest concentrations of dissolved silicon were obtained for the summer. The exception was the Sheltozerka and Derevyanka Rivers, when the silicon content increased 1.5 times in summer compared to spring. Silicon enters river waters mainly as a result of leaching of acidic igneous rocks on Lake Onego catchment. Such an increase may be due to the acceleration of denudation processes in red-colored and gray-colored quartzite sandstones with an increase in temperature and the active removal of Aeolian material from open pits in the summer.

The Svir' River is an outlet from Lake Onego, the chemical composition at its source is determined by the lake regime. The waters of the river, as well as all tributaries belong to the bicarbonate clash of the calcium group. In the anionic composition, sulfate ions predominate over chloride ions. The content of organic matter and biogenic elements in the waters of the river is lower than in the studied tributaries and is mainly determined by the flow of intra-reservoir processes in Lake Onego. There were no significant seasonal fluctuations in the chemical composition of river water for the year.

The average concentrations of most elements obtained as a result of research do not significantly differ from those in the global river flow (Gaillardet et al., 2003; Savenko, 2006). Some discrepancies in comparison with the values of the world runoff were obtained for Fe, Zn and Pb. High concentrations of iron are associated with regional peculiarities. The excess of Zn and Pb for some rivers is probably due to anthropogenic influence, this issue requires further study.

3.2 Suspended matter

During the sequential separation of the suspended matter in the studied water samples into coarse and fine suspended components, the predominance of suspended particles > 0.8 microns was observed.

Electron microscopic examination (SEM) of suspended matter showed that the content of the mineral component was closely to ones from the many rivers of the Arctic territories. We have identified similar spectra of suspended matter minerals in rivers. However, more uneven distributions were in particle sizes, degree of rolling and relationship with organic matter. According to the SEM results, the suspended mineral part is represented by an aggregated substance of lithogenic particles of different dimensions in association with frustules and biodetrite of diatoms. Among the mineral particles (1-5 μm) grouped into aggregates (with a diameter of 15-40 μm), quartz grains, irregular grain clots of hydroxides and carbonates Fe, Mn, plagioclase (albite, oligoclase, andesine), potassium feldspar, muscovite, illite (Mg, Fe), chlorite (Mg, Fe) predominate. It is important to note that illite and chlorite with Mg and Fe content in approximately equal amounts sharply prevail in the suspended matter of the rivers, and their large leafy aggregates begin to be replaced by ferruginous varieties of illite and chlorite.

Contents of trace elements are characterized by an increased content of Mn, Fe, Cu, Mo, Cd, Sb and Pb, contents of other metals are a comparable with the contents in the rivers of the World (Viers et al., 2009; Shevchenko et al., 2010; Chudaeva and Chudaev, 2011). The increased content of the metals is probably related to the geological features and diversity of the soil cover of river catchments.

Thus, the geochemical features of Karelian landscapes are a high degree of swampiness of the territory and an increased Fe content in the soils. This element enters water bodies from the catchment area in combination with humus substance and is a sign of Fe-Mn of the province (Belkina et al., 2018.). According to published data (Fedorets et al., 2015), a significant amount of Mn accumulates in the forest litter of the region, and in some territories significantly exceeding the maximum permissible concentrations (from 1.5 to 5 times). According to the literature data, the proportion of the suspended form of Cu increases due to the receipt of terrigenous and biological material from the catchment area of rivers and depends on the season (Belkina et al., 2012). The data obtained in our study on the content of Cd are 9 times higher than the global values. According to the literature data, the Cd content in soils increases significantly in the areas of

sulfide deposits characteristic of the Karelo-Kola region (Dauvalter and Kashulin, 2015). Using the example of Fe, Mn and P_{total}, the seasonal course of the distribution of migration forms of these elements in the tributaries and the source of Lake Onego was considered.

4. Conclusions

Observations on rivers in different seasons on the basis of an interdisciplinary systematic approach combining modern landscape-geographical, biogeochemical, mineralogical, hydrochemical, ecological methods allowed us to gain new knowledge about the weighted average flow of substances from river waters into Lake Onego, their mineralogical composition and seasonal variability of the geochemical composition of river waters. Quantitative estimates of sedimentary matter intake from various sources have been performed. The nature of the spatial seasonal heterogeneity of the distribution of microparticles in the river suspended matter entering the lake and its rather monotonous mineral composition is shown. Despite the similarity of the main chemical characteristics due to the common climatic conditions of the entire catchment basin, due to the heterogeneity of its geological and geomorphological structure and hydrographic features, the chemical composition and regime of river waters within the region differs.

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Conflict of interest

The authors declare no conflict of interest.

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