Short communication

ISSN 2658-3518
LIMNOLOGY FRESHWATER BIOLOGY
www.limnolfwbiol.com

Comparison of mineralogy and geochemistry of the suspended matter of waters from river runoff and snow cover of Lake Onega

Strakhovenko V.[1]*, Belkina N.[2], Subetto D.[3], Kulik N.[2], Efremenko N.[2], Malov V.[1], Ovdina E.[1]

[1] *V.S. Sobolev Institute of Geology and Mineralogy of the Siberian Branch of the Russian Academy of Sciences (RAS), 3 Akad. Koptyug Ave., Novosibirsk, 630090 Russia*
[2] *Northern Water Problems Institute of the Karelian Research Centre of the Russian Academy of Sciences, 50 Alexander Nevsky Pr., Petrozavodsk, 185030, Russia*
[3] *Herzen State Pedagogical University of Russia, 48 Moika Emb., Saint-Petersburg, 191186, Russia*

ABSTRACT. The data of mineralogy and geochemistry of suspended matter in water (filtered 0.45 microns), suspended solids (from filters of snow-fallen, river, lake waters) are compared from different parts of Lake Onego. We revealed the mineral composition of the suspended matter differs in the absolute contents of the suspended matter in the water, the ratio of the amount of organic matter in it, the presence or absence of aggregates of technogenic genesis and their quantity. The geochemistry of suspended matter from river's waters is highly similar to the geochemistry of suspended matter from water in various areas of Lake Onego, but significantly differs from the suspended matter of snow-covered waters.

Keywords: Lake Onego, suspended matter, water, snow cover, geochemistry, mineralogy

1. Introduction

To gain new knowledge about the suspended matter entering the bottom sediment of Lake Onego, the mineralogo-geochemical composition of the suspended matter from river waters and snow cover has been studied. The purpose of the work is a comparative analysis of the mineralogo-geochemical composition of modern suspension coming from the river and snow runoff and suspension of the water in various areas of Lake Onego.

2. Materials and methods

The samples of water's rivers and lake, snow accumulated over the entire period of snow cover were selected in 2020-2021 in different parts of Lake Onega (Central and South Onega, Unitskaya, Kondopoga, Petrozavodsk Bays) and in 9 estuaries of tributaries (among them Vodla, Shuya, Suna which give 68% of the water flow into the lake) and at the source of the Svir river. The suspension from the water was separated by vacuum filtration with specially prepared pre-weighted membrane filters (0.45 μm). The thin colloidal phase remains in the filtrate. It is known that this phase contains a part of the metals that form organic complexes with humic matter. Analytical studies were carried out at the Analytical Centre for Multi-Elemental and Isotope Research of the SB RAS (IGM, Novosibirsk), the Laboratories of Hydrochemistry, Hydrogeology and Paleolimnology of NWPI KRC RAS (Petrozavodsk). The major and trace element compositions were studied using the atomic absorption and the ICP-MS methods. A detailed study of the structural features, the morphology at the level of individual mineral grains of the *suspended matter* was carried out using scanning electron microscope (SEM). The specific modification of the equipment used an Si(Li) energetic detector, and enabled to carry out a quantitative chemical analysis on micro volumes.

3. Results and discussion

The studied suspended matter samples of rivers and snow are grouped according to the geographical location of river catchments taking into account the geological and geomorphological structure of the lake basin and the areas of Lake Onega into which they flow.

*Corresponding author.
E-mail address: strahova@igm.nsc.ru (V. Strakhovenko)

Received: May 27, 2022; ***Accepted:*** August 10, 2022;
Available online: September 02, 2022

A previously published article presents the results of a detailed study of the chemical composition of waters and suspended matter of Lake Onega (Strakhovenko et al., 2021; Kulik et al., 2022). SEM of the studied suspended matter samples of rivers showed similar spectra of minerals, but their ratios differed. The uneven distribution of particles by size, degree of their rolling as well as different ratios of the mineral and organic parts of the suspended matter were revealed. It is established that the mineral part of the detrital material is represented by an aggregated substance of lithogenic particles of different dimensions in association with shells and biodetrite of diatoms. The suspended material is represented by mineral particles (1-5 μm in size) grouped into aggregates (with a diameter of 15-40 μm) which consist of quartz grains, irregular grain clots of hydroxides and carbonates of Fe, Mn, plagioclase (albite, oligoclase, andesine), potassium feldspar, muscovite, illite, chlorite. It is important to note that illite and chlorite with Mg and Fe content in approximately equal amounts prevail sharply in the suspension of rivers, and their large leafy aggregates begin to be replaced by their ferruginous varieties. The mineral composition of the suspension in one river depends slightly on the season of the year and between rivers differs in the absolute content of the suspension on the filter and the ratio of the amount of basic minerals in it, the dimension, the presence or absence of grains of unusual composition, and the morphology of the excretions of aggregates of iron minerals. The jelly-like aggregates of Fe and Mn oxides/ hydroxides are present in significant quantities in the mineral matter of all rivers, their amount increases significantly relative to other of the Lososinka, Vytegra, Sheltozerka rivers. Anthropogenic particles in samples of the suspended matter of river waters are sparsely represented, mainly they are individual small (from 2 to 25 μm) irregularly shaped grains with a chemical composition that does not occur in nature and/or have an unusual morphology. The largest number of these particles was found in the suspension of the Suna, Andoma rivers: large and small grains of irregular shape (Zn-Ni-Cu and Ni-Sn). SEM of the studied suspended matter samples of snowmelt waters showed an uneven distribution of lithogenic particles of different dimensions and degree of pelletizing (mainly sharp-angled irregularly shaped particles ranging in size from 1 to 8 μm) and their ratios with organic matter, the amount of which varies from 5-10% and is mainly represented by fragments of shells of diatoms and plant residues (size from 5 to 20 μm). Among the mineral particles grouped into aggregates (up to 80 μm in size), grains of quartz, plagioclase (albite, oligoclase), potassium feldspar, muscovite, biotite, actinolite, illite and chlorite (Mg ≥ Fe). Grains of diopside, enstatite, epidote, titanite, magnetite, ilmenite, garnet and some other accessory minerals are present in significant quantities in the mineral matter. All samples shows the aggregates of siderite with a columorphic structure and small crystals of rhombohedral habit. Technogenic aluminosilicate microspheres, spheres of combustion of ferrous composition and large individual grains of various shapes of native iron with chromium, native lead with nickel, chromium, and copper with aluminum or zinc (particle size from 2-5 to 50 μm) were detected in quantities up to 10% of the total volume of suspension samples. A comparison of the geochemical composition of the suspended matter of the waters of the tributary rivers, snow and lake in each individual area revealed that the composition of the suspended matter of the rivers and the lake's water is not significantly distinct in trace elements with a completely different spectrum for snows (Fig.). Comparison of the average content of elements in suspended matters from different parts of lake Onega, rivers and snow normalized by concentrations of the

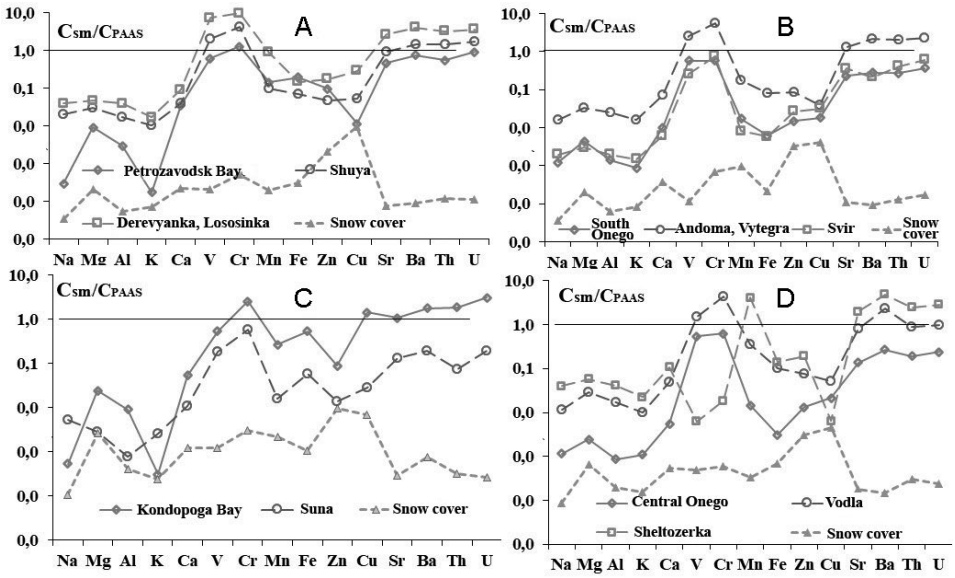

Fig. The spectrum of element contents in the suspension of the waters of the rivers, snows and Lake Onego, normalized to PAAS: A - Petrozavodsk Bay, r. Shuya, Derevyanka, Lososinka; B – South Onego, r. Andoma, Vytegra, Svir; C – Kondopoga Bay, r. Suna; D – Central Onego, r. Vodla, Sheltozerka.

Post-Archaean Australian Shale PAAS (Taylor and McLennan, 1988) allowed us to establish that snowmelt waters are characterized by high concentrations of Mg, Zn, Cu, Cr (both in filtered water and in suspended). The content of trace elements of the suspended matter of the of the rivers in terms of dry matter relative to the level of their concentrations in the suspensions of the rivers of the World (Savenko, 2007; Shevchenko, 2006) are characterized by an increased content of Cu, Zn, Mn, Fe, Mo, Cd, Sb and Pb, the remaining metals are at a comparable level. Basically, the predominant form of finding elements in the water of rivers, snows and Lake is dissolved + colloidal (Kulik et al., 2022). Only in Kondopoga Bay, the suspended form for the studied metals sometimes prevails over the dissolved + colloidal form with maximum amounts of suspension in water.

4. Conclusions

For the first time, a study of the mineral composition of the suspended matter of the waters of the rivers, snow cover in comparison with the suspended matter of the waters of the areas of Lake Onego into which they flow was carried out. It was revealed that the mineral composition of the suspended matter entering the lake is weakly dependent on the season of the year and differs in the absolute contents of the suspended matter, the ratio of the amount of organic matter in it, the presence or absence of aggregates of technogenic genesis and their quantity. The suspended material in all areas of Lake Onego is enriched with quartz, feldspar, mica, hydroxides and iron carbonates, illite and chlorite (Mg ≥ Fe). Among the technogenic grains, microspherules of ferruginous or aluminosilicate composition predominate sharply.

It has been established that the geochemistry of suspended matter from river's waters is largely similar to the geochemistry of suspended matter from water in various areas of Lake Onego with a significant difference from the suspended matter of snow-covered waters. The high concentrations of Mg, Zn, Cu, Cr and Hg detected in the suspended matter correspond to the presence of anthropogenic particles entering the waters due to the atmospheric transport. The proximity of metallurgical plants of the Kola Peninsula may cause the increased intake of particles of technogenic genesis.

Acknowledgements

The study was supported by the Russian Foundation for Basic Research (grant №19-05-50014, geochemistry and mineralogical composition of suspended matter from rivers, snow) and the Russian Science Foundation (grant №18-17-00176, geochemistry and mineralogical composition of lake's water).

Conflict of interest

The authors declare no conflict of interest.

References

Kulik N., Efremenko N., Belkina N. et al. 2022. Fe, Mn, Al, Cu, Zn, and Cr in the sedimentary matter of Lake Onego. Quaternary International. DOI: 10.1016/j.quaint.2022.04.005 (in press)

Savenko V.S. 2007. Chemical composition of sediment load carried by rivers. Geokhimiya [Geochemistry International] 45(8): 816-824. (in Russian)

Shevchenko V.P. 2006. Vliyaniye aerozoley na sredu i morskoye osadkonakopleniye v Arktike [Influence of aerosols on the environment and marine sedimentation in the Arctic]. Moscow: Nauka. (in Russian)

Strakhovenko V., Belkina N., Subetto D. et al. 2021. Distribution of rare earth elements and yttrium in water, suspended matter and bottom sediments in Lake Onego: evidence of the watershed transformation in the Late Pleistocene. Quaternary International. DOI: 10.1016/j.quaint.2021.07.011 (in press)

Taylor S., McLennan S. 1988. The Continental Crust: its Composition and Evolution. An Examination of the Geochemical Record Preserved in Sedimentary Rocks. Mir: Moscow, USSR. (In Russian)