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The level of ecological and geochemical features of water from specially protected natural lakes of Russia

Andrey Vladimirovich Kozlov[1]*, Nataliya Nikolaevna Koposova[1], Irina Pavlovna Uromova[1], Elena Aleksandrovna Krotova[1], Anna Vladimirovna Matveeva[1] and Anna Yuryevna Veselova[2]

[1]Minin Nizhny Novgorod State Pedagogical University, Nizhny Novgorod, Russia
[2]Nizhny Novgorod State University of Engineering and Economics, Knyaginino, Nizhny Novgorod region, Russia

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ABSTRACT

The study presents a primary ecological and geochemical analysis of water from lakes in the left-bank part of Nizhny Novgorod Oblast (Russia), which are the objects of specially protected natural areas of the region. In general, waters of the studied water bodies revealed approximately the same trend in the content of basic substances, including neutral acidity in the range of 6.04-7.78 pH, soft and medium hardness in the range of 0.19-5.95 mg-eq./l, ultra-fresh and fresh mineralization in the range of 20-232 mg/l. The identified levels of indicators are typical for natural water bodies located in the area of natural podzolic pedogenesis of the southern taiga zone.

***Key words**: Natural water bodies, Natural area, Natural geochemical background of the region.*

Introduction

The main purpose of specially protected natural areas (hereinafter referred to as SPNAs) is to preserve the genetic diversity of living biota, reserve certain natural resources, maintain the ecological balance of the area, and represent the maximum biogeocenotic diversity of local biomes. They also serve as objects of the scientific study of the evolution of individual flora and fauna species, ecotope objects (soil cover, surface, and groundwater), and the ecosystem in general (Stishov and Dudley, 2018).

In Nizhny Novgorod Oblast, over 400 different SPNAs are covering almost 480.000 hectares, among which are sites of local, regional, and federal significance. Among the protected areas, more than 350.000 hectares are located on lands of the forest fund. Another distinctive feature of the region is the protected status of more than 90 marshes, lakes, and water bodies (Bakka and Kiseleva, 2008; Gagarina, 2012), which determines the interest in studying them as sites of intact nature and the preserved state of the hydrosphere (Kozlov *et al*., 2017, 2019a).

A natural lake as a conditionally permanent natural water body is usually characterized by very low temporal hydrological dynamics and little ecological and hydrochemical renewal of substance in the water column, and its internal currents are often not the predominant factors in determining the hydrological regime (Dmitriev *et al*., 2019). In this regard, the chemical state of water bodies under the conditions of natural protected biogeocenoses characterizes the basic geoecological features of the territory, and the level of concentrations of its typical components can serve as a regional ecological background. In the conditions of the current state of environmental objects and, in particular, water bodies staying in anthropogenically modified areas

(Kozlov *et al*., 2020; Kozyreva, 2021), identification of this ecological background is an acute task, as chronic pollution of water bodies by industrial and municipal wastes often does not allow determining the level of concentrations of natural components, and anthropogenic introduction of pollutants into waters can disrupt their natural biogeochemical cycles (Trifonova *et al*., 2007). Carrying out these studies will allow one to determine the level of natural concentrations of substances in waters, including those determined by the geochemical features of the area.

The objective of the study is the primary characterization of ecological and geochemical features of water of lakes having the category of SPNA located in Zavolzhye, Nizhny Novgorod Oblast.

Materials and Methods

The objects of the study were waters of protected lakes of regional and federal protection status located in the southern taiga territory of Zavolzhye in Nizhny Novgorod Oblast, namely lakes Titkovskoye and Kocheshkovskoye, located in the Urensky district (57.474915, 46.011889), Lake Zharenskoe, located in the Krasnobakovsky district (57.211665, 45.468623), lakes Svetloyar (56.818784, 45.093056) and Nestiar (56.558794, 45.329160) located in the Voskresensky district, Lake Spasskoe (56.404339, 43.970781) in the Gorodetsky district, and Lake Yurasovskoe (56.373111, 44.026225) in the Borsky district of Nizhny Novgorod Oblast.

Water samples were collected in September 2020 and delivered to the Environmental Analytical Laboratory for Environmental Monitoring and Protection at the Kozma Minin Nizhny Novgorod State Pedagogical University, where they were subsequently analysed within 3 days of collection. Using a hydrological water meter BG-1.0, four samples were taken from each lake, each with a volume of 2 litres. Two 2-litre samples were taken from the Titkovskoye and Kocheshkovskoye lakes. Further, the number of indicators of the ecological state and hydrochemical regime were determined in the samples, including acidity (hydrogen index) by potentiometric method, total mineralization by conductometry, hydrocarbonate, sulphate, and chloride content by classical titrimetric methods, and total iron content by spectrophotometric method (Kozlov, 2016; Kozyreva, 2020).

Results and Discussion

The data in Table 1 reflect the level of indicators of the ecological and geochemical state of the lakes studied in Zavolzhye, Nizhny Novgorod Oblast.

The absence of statistically significant shifts of water pH to strongly acidic or alkaline side and very low variability of acidity level in water bodies indicate the presence of low concentrations of hydrolytic acid or alkaline substances, as well as the steady state of acid-base processes occurring in the water column of all lakes. In the taiga area, the total hardness index may be due, among other things, to the content of hydrocarbonates and is consistent with the level of total water mineralisation.

Among the main ions determining the geochemical background of watercourses flowing through the southern taiga, sulphate and chloride anion were identified consistently. Their concentrations and variability were at a low level. The relatively high total iron content (0.44-0.60 mg/l) is caused by the active migration of Fe^{2+} and Fe^{3+} Among the main ions determining the geochemical background of watercourses flowing through the southern taiga, sulphate and chloride anion were identified consistently. Their concentrations and variability were at a low level. The relatively high total iron content (0.44-0.60 mg/l) is caused by the active migration of Fe2+ and Fe3+ ions into ground and surface waters from the soil cover and lithological base. The revealed levels of indicators are typical for natural water bodies located in the territory of natural podzolic pedogenesis of the southern taiga zone across Nizhny Novgorod Oblast (Kozlov, 2016; Kozlov *et al*., 2019b; Letopis prirody, n.d.). This pattern is consistent with ultra-fresh and fresh mineralisation, low levels of total bicarbonate hardness, and the presence of low concentrations of geochemical background ions and relatively elevated total iron content in the waters, which are characteristic of the hydrochemical characteristics of small rivers flowing through the Kerzhenets State Nature Biosphere Reserve (Letopis prirody, n.d.). This SPNA is also located in Zavolzhye, Nizhny Novgorod Oblast (Semyonovsky and Borsky municipal districts).

Conclusion

The study presented the results of primary ecological and geochemical studies of water from natural lakes in Nizhny Novgorod Oblast (Titkovskoye,

Table 1. Variability of basic indicators of ecological and geochemical status in waters of protected lakes in Zavolzhye, Nizhny Novgorod Oblast (2020)

Indicator	M	V, %	TLV
Lake Titkovskoe / Lake Kocheshkovskoe			
Acidity (pH), u. pH	7.24	2	6.5-8.5
Total hardness, mg eq/l	2.69	32	7.0
Mineralisation, mg/l	232	28	1,000
Hydrogen carbonates (HCO_3^-), mg/l	134.2	23	500
Sulphates (SO_4^{2-}), mg/l	83	25	500
Chlorides (Cl^-), mg/l	2.0	20	350
Total iron (Fe), mg/l	0.60	11	0.3
Lake Zharenskoe			
Acidity (pH), u. pH	6.04	2	6.5-8.5
Total hardness, mg eq/l	0.19	26	7.0
Mineralisation, mg/l	20	7	1,000
Hydrogen carbonates (HCO_3^-), mg/l	15.4	16	500
Sulphates (SO_4^{2-}), mg/l	34	21	500
Chlorides (Cl^-), mg/l	2.5	38	350
Total iron (Fe), mg/l	0.50	9	0.3
Lake Svetloyar			
Acidity (pH), u. pH	7.17	1	6.5-8.5
Total hardness, mg eq/l	1.30	3	7.0
Mineralisation, mg/l	138	16	1,000
Hydrogen carbonates (HCO_3^-), mg/l	70.4	5	500
Sulphates (SO_4^{2-}), mg/l	47	75	500
Chlorides (Cl^-), mg/l	3.0	14	350
Total iron (Fe), mg/l	0.51	4	0.3
Lake Nestiar			
Acidity (pH), u. pH	6.86	1	6.5-8.5
Total hardness, mg eq/l	1.16	5	7.0
Mineralisation, mg/l	132	2	1,000
Hydrogen carbonates (HCO_3^-), mg/l	61.6	10	500
Sulphates (SO_4^{2-}), mg/l	63	21	500
Chlorides (Cl^-), mg/L	5.4	5	350
Total iron (Fe), mg/l	0.47	2	0.3
Lake Spasskoe			
Acidity (pH), u. pH	7.51	3	6.5-8.5
Total hardness, mg eq/l	5.83	1	7.0
Mineralisation, mg/l	512	2	1,000
Hydrogen carbonates (HCO_3^-), mg/l	124.3	2	500
Sulphates (SO_4^{2-}), mg/l	105	31	500
Chlorides (Cl^-), mg/l	31.4	7	350
Total iron (Fe), mg/l	0.47	15	0.3
Lake Yurasovskoe			
Acidity (pH), u. pH	7.78	2	6.5-8.5
Total hardness, mg eq/L	5.95	2	7.0
Mineralisation, mg/l	599	2	1,000
Hydrogen carbonates (HCO_3^-), mg/l	134.2	4	500
Sulphates (SO_4^{2-}), mg/l	215	6	500
Chlorides (Cl^-), mg/l	36.8	2	350
Total iron (Fe), mg/l	0.44	4	0.3

Kocheshkovskoye, Svetloyar, Nestiar, Spasskoye, and Yurasovskoye), which have the status of a specially protected natural area. In general, waters of the water bodies showed approximately the same trend in the content of substances of basic composition, including neutral acidity in the range of 6.04-

7.78 pH u., soft and medium hardness in the range of 0.19-5.95 mg-eq./l, ultra-fresh and fresh mineralisation in the range 20-232 mg/l (excluding highly mineralised water from lakes Spasskoe and Yurasovskoe), caused mainly by hydrocarbonate anions (15.4-134.2 mg/l) but also by sulphates (34-215 mg/l) and chlorides (2.0-36.8 mg/l). A relatively elevated background of total iron is caused by natural geochemical processes of excessive washing out of its salts from podzolic soils and underlying rocks, typical for the territory of the taiga zone. In general, to understand the feasibility of using the obtained data in the regional ecological monitoring of water bodies as water reservoirs with a natural geochemical background, it is necessary to conduct these studies in seasonal dynamics.

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