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*GEOCHEMICAL FEATURES OF NATURAL WATERS OF WEST SIBERIA: MICROELEMENT COMPOSITION**

SUMMARY. The data concerning microelement composition of waters of small lakes in West Siberia not subjected to direct anthropogenic impact are summarized. For the 130 lakes of various natural zones ranged from tundra to forest-steppe, the concentrations of more than 60 trace elements (Fe, Cr, Ni, Pb, Cu, Zn, Cd, Hg, Si, P, B, Mn, Ba, Sr, Li, Rb, As, V, Co, U, etc.) are determined by atomic emission analysis (ICP-MS). For each natural zone, the medians, minimum and maximum concentrations of trace elements in lakes are calculated. All the trace elements are ranked in descending order according to their content in the waters of the lakes in certain natural zones. It is stated that the contents of macroelements (Na, K, Ca, Mg) and most of trace elements (Si, P, B, Mn, Ba, Sr, Zn, Cu, Li, Rb, As, V, Co, U) are in their highest concentration in the southern taiga and forest-steppe zones, except for iron and aluminum, their concentrations being higher in the swampy waters of tundra and northern taiga zones, characterized by high colour index and acidity. Moreover, the highest concentrations of Ti, Ni and Bi are also determined in the northern lakes. The data obtained can be used as the baseline values for evaluating the anthropogenic impact on the water ecosystems of West Siberia.

KEY WORDS: Microelements, small lakes, zonal features.

The chemical composition of waters in small lakes (if there is no direct sources of pollution) clearly demonstrates the zonal and regional features of the conditions of its forming, as well as those global anthropogenic processes that recently occur in the environment. The research papers devoted to the changes in the chemical composition of waters in regional scale are not numerous, as they require compliance with common principles and methods of research, providing comparable data and high precision of analytical measurements. Similar investigations were carried out in European Russia (ER) from the tundra zones to the arid ones; they determine the zonal features and natural-climatic variety of natural waters, assess the influence of anthropogenic factors, as well as predict the possible effect of climate warming on the hydrochemistry of these lakes [1-2]. In West Siberia (WS), which stretches from the high-tundra zone to the arid one, there are many

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lakes. This fact determines wide natural variability of chemical composition of waters. This region has significant oil and gas reserves that have been intensively developed since 1970s. We suppose that the exploitation of oil and gas fields for more than 40 years might have effected the land waters in a varying degree, even in those cases when water bodies are located far from direct sources of pollution.

The purpose of this paper was to present the zonal features and variability of microelement composition of the waters of small lakes in West Siberia (not effected by direct anthropogenic load) basing on the extensive research from the tundra to steppe zones, and to identify the major factors determining the microelement contents in the lakes of these natural zones.

The data and methods of the research. The basis of this research is to summarize the data concerning the chemical composition of 130 small lakes in the territory of West Siberia from the tundra zones (Gydan and Yamal peninsulae) to the steppe zone in the south of the Tyumen Region, obtained in 2011 by the constituent methodological scheme [3]. The research includes lakes not subject to any direct sources of pollution, with water surface area no more than 20 km^2. The water samples were taken from the lake surface or from the overflow stream in the period from August (the tundra and forest-tundra lakes) till the late October (southern zones) using helicopter and air routes. The samples were placed in special containers and transported in the shortest possible time to the laboratory.

The methods of the research. The chemical analysis was carried out according to the standard methods. In the water samples, the following parameters were determined:

- pH, electrical conductivity (χ) and basic mineralization ions (Ca^{2+}, Mg^{2+}, K^+, Na^+, alkalinity (Alk), SO_4^{2-} Cl^-);
- colour index, total organic carbon content (TOC), NO_3^- NH_4^+, total nitrogen (TNb), PO_4^{3-}, total phosphorus (TP), Si;
- microelement contents (Sr, Al, Fe, Mn, Cr, Cu, Ni, Zn, Cd, etc.);

The chemical analyses were carried out in stationary conditions. These parameters were determined by means of the following methods:

— pH: by the potentiometric method, with a glass electrode (the I-130.M ionomer);

— electrical conductivity at 20 °C: by the conductometric method (the Anion 4100 conductometer);

— colour index: by the spectrophotometric method by chromium-cobalt colour scale at the wavelength of 380 nm (the UNICO spectrophotometer);

— concentrations of microelements (Sr, Al, Fe, Mn, Cr, Cu, Ni, Zn, Cd, Co, Pb) in the filtered water samples were determined by atomic absorption spectrophotometry with electrothermal atomisation. The analysis was carried out with an atomic absorption spectrometer with a new generation continuum xenon lamp (ContrAA-700, AnalitykJena, Germany). The other microelements (> 60 elements) were determined by the emission method of inductively coupled plasma with the Element (UK) mass spectrometrometer in the Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Science.

ALPEFORM, the specialized software, was used to control the quality of measuring pH, Alk, and the contents of Cl^-, SO_4^{2-} alkali and alkaline earth elements. This software evaluated the balance of ions, basing on the monitoring of the measured and calculated electrical conductivity and electrical neutrality taking into account the content of organic matter A, estimated empirically by the TOC value. [4] The divergence from the conformance values is <10%.

General characteristics of the microelement distribution

The chemical lake composition is in direct dependence with the composition of rocks, forming the water-producing area and the floor of a certain lake. The chemical composition of water and total mineralization is formed as a result of the crystalline rock leaching in the water-producing area caused by the climatic conditions as well as the processes in the water body due to changes of acidity, the lake eutrophication degree and other factors. West Siberian Plain has a strongly marked natural zoning, and each natural zone is characterized by the specific type of soil. Table 1 presents the natural zones of West Siberia and the corresponding types of soils.

Table 1

Types of soils in the natural zones of West Siberia

Natural zones	Types of Soils	
	Drained areas	Undrained areas
Tundra	Cryosolic tundra-gley	Bog
Forest-tundra	Gley-bleached	Bog
Forest (Forest-bog)	Bleached Sod-bleached Gray forest	Gley-bleached Bog-bleached Meadow-bog Bog
Forest-steppe	Leached black soils Gray forest-bleached	Meadow-black soil Saline Bog

Latitudinal zoning determines the diversity in the combinations of the natural condition formation of chemical composition of waters, such as temperature, humidity, the composition of rocks, soils, and vegetation. Therefore, we processed all these data, taking into account latitudinal zoning. We calculated the median values, minimum and maximum concentrations of microelements in the lakes for each natural area. The data concerning the content of macro- and microelements in the waters of the lakes located in various natural zones of West Siberia are presented in Table 2 and Figures 1-3.

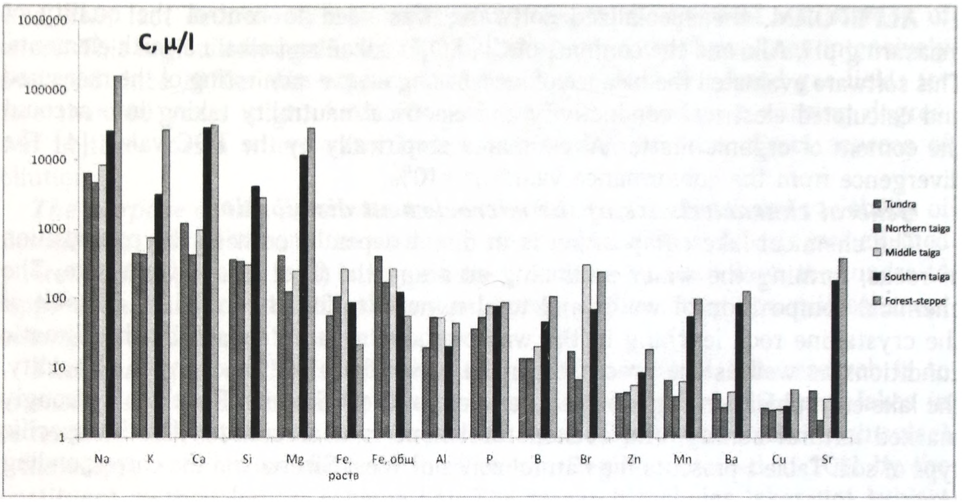

Fig. 1. The contents of macro- and microelements (median values) in the waters of the lakes of various natural zones in WS (the results were obtained by ICP-MS)

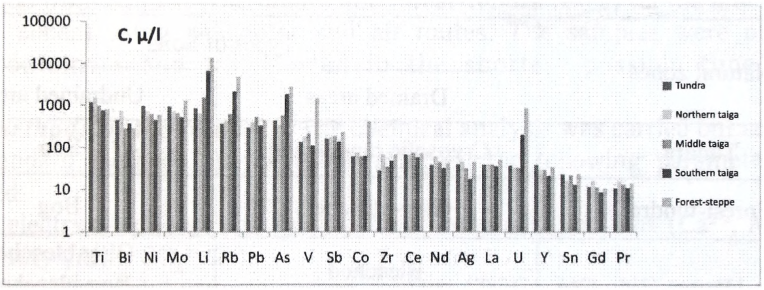

Fig. 2. The contents of microelements (median values) in the waters of lakes of various natural zones in WS (the results were obtained by ICP-MS)

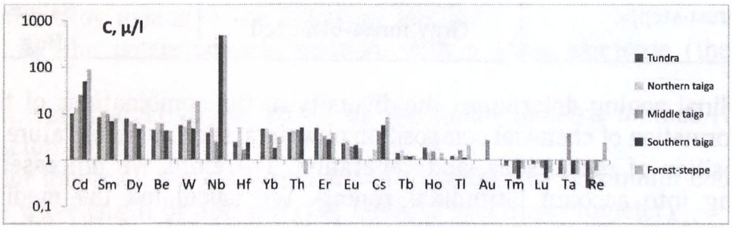

Fig. 3. The content of the microelements (median values) in the waters of the lakes in various natural zones in WS (the results were obtained by ICP-MS)

In addition to the microelement concentration, the data concerning such parameters as pH, colour, specific electrical conductivity (SEC), the contents of macro components, silicon, and nutrients are presented in Table 2. The elements with the concentration lower than the analytical detection limit were not included into the analysis (Ga, Hg, Sc, Ge, In, Pt, Ru, Pd, Te, Rh, Os, Ir).

Table 2

The elemental composition of lake waters in various natural zones in WS (median values, minimum and maximum values in brackets)

Element, unit of measurement	Natural zone				
	Tundra, Forest-tundra	Northern taiga	Middle taiga	Southern taiga	Forest-steppe
n	48	27	36	16	11
pH	6.34 (4.81-7.39)	5.41 (4.94-6.90)	5.70 (4.54-7.42)	7.39 (6.50-7.68)	7.92 (7.47-8.75)
Color, deg.	19.6 (1.28-160)	55.8 (4.9-56.0)	79.55 (7.4-146)	54.3 (14.0-166)	33.8 (28.9-89.0)
SEC, µSm/ cm	27.7 (99.1-166)	15.6 (6.7-59.8)	35.7 (8.8-255)	263 (39.5-298)	247 (98.1-1042)
TOC, mg/l	4.88 (1.25-14.6)	10.7 (2.21-24.1)	11.4 (1.52-20.3)	13.7 (7.04-271)	26.5 (19.0-39.4)
TNb, mg/l	0.61 (0.11-2.34)	0.83 (0.19-1.65)	0.81 (0.02-2.27)	1.29 (0.40-2.22)	2.60 (1.68-3.28)
TP, mg/l	0.04 (<0.01-0.19)	0.04 (0.01-0.18)	0.03 (<0.01-0.16)	0.05 (0.01-0.15)	0.02 (0.01-0.05)
S, µg/l	358 (144-2,339)	292 (177-924)	719 (386-1,753)	555 (345-1,560)	4672 (978-123,656)
Ca, mg/l	1.24 (0.219-7.05)	0.44 (0.127-1.72)	0.99 (0.189-15.5)	29.7 (1.61-65.3)	32.2 (27.1-68.2)
Mg, mg/l	0.44 (0.054-4.35)	0.13 (0.032-0.87)	0.25 (0.043-4.43)	12.0 (0.50-15.5)	29.0 (24.5-109)
Na, mg/l	6.36 (3.33-26.0)	4.78 (2.55-13.4)	8.40 (3.05-58.6)	26.2 (6.68-35.2)	160.5 (68.8-563)
K, µg/l	456 (169-1,700)	437 (117-1,215)	752 (211-2,481)	3250 (632-4,401)	27,446 (8,665-44,364)
Si, µg/l	387 (121-2,339)	349 (130-1,115)	309 (114-3,059)	4,301 (188-6,730)	2,887 (259-8,312)
Li, mg/l	0.844 (0.32-4.14)	0.64 (0.28-1.72)	1.52 (0.29-5.12)	6.60 (2.05-12.8)	17.3 (13.2-46.0)
µg/l					
Rb	0.37 (0.16-0.947)	0.41 (0.14-1.06)	0.63 (0.21-1.86)	2.19 (0.54-4.83)	4.81 (1.06-6.94)
Cu	2.74 (1.23-9.02)	2.51 (0.76-5.90)	2.56 (1.32-8.54)	2.83 (1.53-4.29)	5.00 (3.19-8.92)
Cu (AAS)*	2.41 (0.51-16.8)	2.19 (0.24-7.58)	1.58 (0.38-6.09)	2.30 (0.79-6.72)	4.52 (2.05-5.30)
Sr	4.78 (0.70-34.8)	1.77 (0.51-8.92)	3.58 (0.72-222)	184 (8.0-328)	381 (293-1064)
Sr (AAS)	15.17 (2.09-124)	8.84 (0.82-19.47)	10.9 (3.60-235)	151 (16.1-262)	367 (269-700)

Table 2 continued

Ba	4.26 (0.6-26.8)	2.72 (0.7-9.14)	4.52 (1.0-48.9)	86.6 (6.4-161)	127 (88-223)
Zn	4.33 (1.94-20.0)	4.51 (1.30-100)	5.61 (1.84-27.5)	8.58 (4.63-21.4)	18.6 (10.6-30.7)
Zn (AAS)	0.71 (<0.05-15.2)	0.46 (0.09-2.52)	0.14 (<0.05-9.10)	1.41 (<0.05-3.11)	1.29 (0.12-3.42)
Sc	<0.04 (<0.04-<0.04)	<0.04 (<0.04-<0.04)	<0.04 (<0.04-<0.04)	<0.04 (<0.04-<0.04)	<0.04 (<0.04-<0.04)
Y	0.039 (0.006-0.287)	0.029 (0.005-0.205)	0.030 (0.006-0.170)	0.021 (<0.002-0.07)	0.035 (<0.024-0.09)
La	0.039 (0.018-0.174)	0.039 (0.009-0.180)	0.040 (0.009-0.122)	0.036 (0.018-0.116)	0.052 (0.032-0.074)
Ce	0.068 (0.017-0.556)	0.067 (0.009-0.447)	0.075 (0.014-0.230)	0.058 (0.021-0.178)	0.074 (0.043-0.123)
Pr	0.011 (0.004-0.076)	0.016 (0.003-0.056)	0.014 (0.003-0.052)	0.011 (0.004-0.023)	0.014 (0.009-0.021)
Nd	0.039 (0.009-0.347)	0.060 (0.005-0.226)	0.046 (0.007-0.617)	0.032 (0.011-0.092	0.042 (0.033-0.086
Th	0.004 (0.001-0.053)	0.004 (<0.001-0.030)	0.005 (<0.001-0.009)	0.005 (<0.001-0.006)	<0.001 (<0.001-<0.001)
U	0.038 (0.019-0.064)	0.033 (0.016-0.072)	0.033 (0.019-0.125)	0.202 (0.019-0.716)	0.863 (0.490-4.21)
B	13.9 (8.4-37.4)	13.8 (7.9-34.1)	20.4 (10.7-156)	46.5 (15.7-72.5)	107 (77-277)
Al	19.9 (10.0-310)	54.7 (7.8-230)	53.4 (14.1-105)	20.8 (14.0-33.1)	44.4 (25.4-88.3)
Al (AAS)	18.3 (1.93-625)	28.7 (0.75-204)	37.3 (5.27-78.6)	13.1 (4.72-51.1)	13.2 (6.53-29.3)
Ti	1.2 (<0.6-4.8)	1.6 (<0.6-4.2)	1.0 (<0.6-1.7)	<0.6 (<0.6-0.8)	<0.6 (<0.6-0.9)
Pb	0.30 (0.11-3.39)	0.39 (0.09-1.21)	0.52 (0.12-2.36)	0.34 (0.14-0.64)	0.45 (0.31-0.92)
V	0.13 (<0.04-1.0)	0.19 (<0.04-1.0)	0.21 (<0.04-0.83)	0.11 (<0.04-0.51)	1.45 (<0.16-2.78)
As	0.43 (0.10-1.56)	0.34 (0.11-2.00)	0.58 (0.36-2.05)	1.85 (0.60-4.13)	2.82 (1.82-7.35)
Sb	0.16 (0.12-0.27)	0.17 (0.24-0.37)	0.19 (0.10-0.49)	0.14 (0.09-0.69)	0.23 (0.16-0.38)
Bi	0.45 (0.13-3.86)	0.76 (0.59-3.67)	0.29 (0.011-4.42)	0.38 (0.27-1.18)	0.30 (0.16-0.61)
Cr	<0.4	<0.4	<0.4	<0.4 (<0.4-3.8)	<0.4
Cr (AAS)	0.30 (<0.05-8.46)	0.28 (<0.05-0.89)	0.41 (<0.05-2.17)	0.46 (0.12-8.14)	1.80 (0.27-14.1)

The end of Table 2

Mo	0.93 (0.25-6.26)	0.72 (0.25-7.44)	0.65 (0.25-8.28)	0.52 (0.32-3.80)	1.28 (0.62-2.33)
Mn	6.7 (1.1-26.1)	3.9 (0.63-9.57)	6.4 (0.09-49.6)	56.1 (7.0-981)	99.7 (59.9-307)
Mn (AAS)	3.06 (0.13-8.46)	0.93 (<0.05-15.2)	5.68 (1.98-29.7)	4.70 (2.13-30.0)	4.72 (1.10-24.0)
Fe_{aq}	57 (10-1,474)	108 (9-1,134)	270 (11-987)	891 (13-3,181)	22 (18-3,128)
Fe_{aq}, (AAS)	24.5 (1.41-465)	48.4 (0.2-959)	152 (2.76-452)	25 (0.41-640)	11.3 (0.25-62)
Fe_{total}, μg/l	416 (75.6-2,328)	173 (24.9-1,416)	272 (11-730)	126 (47.2-1,393)	56.4 (11-227)
Co	0.06 (<0.04-0.19)	0.08 (<0.04-0.19)	0.06 (<0.04-0.11)	<0.04 (<0.04-0.06)	<0.04 (<0.04-0.41)
Co (AAS)	<0.05 (<0.05-0.17)	<0.05 (<0.05-0.26)	<0.05	<0.05	<0.05
Ni	0.98 (<0.2-2.78)	0.73 (<0.2-16.3)	0.63 (<0.2-4.34)	0.46 (<0.2-4.54)	0.59 (<0.2-0.84)
Ni (AAS)	1.63 (<0.1-5.52)	1.32 (<0.1-8.88)	1.19 (0.30-5.93)	1.21 (0.53-4.80)	0.95 (0.65-4.92)
ng/l					
Cd	10.1 (<4-84.1)	13.4 (<4-111)	25.3 (<4-93.5)	49.9 (10.5-400)	92 (73-126)
Cd (AAS)	<50 (<50-367)	<50 (<50-430)	<50 (<50-465)	<50 (<50-246)	<50 (<50-219)
Cs	1.04 (0.33-9.3)	1.61 (0.46-7.6)	4.25 (0.81-20.1)	5.64 (1.78-10.8)	8.42 (4.47-22.6)
Ag	41.7 (9.9-26,720)	45.4 (12-24,188)	32.2 (9.3-24,439)	18.2 (5.7-55.0)	45.8 (<4-2,055)
Be	4.73 (<1-185)	6.47 (<1-21.3)	6.12 (<1-16.8)	4.31 (<1-8.04)	4.20 (<1-9.13)
Zr	27 (<7-417)	69 (<7-292)	35 (<7-150)	<7 (<7-71.9)	70 (<7-222)
Sn	23 (<12-132)	16.2 (<12-58.7)	22.3 (<12-108)	<12 (<12-17.4)	<12 (<12-26)
Re	0.25 (<0.1-0.53)	0.28 (<0.1-0.95)	0.58 (<0.1-1.41)	0.96 (0.3-1.84)	2.38 (1.69-21.4)
W	5.6 (<4-19)	5.3 (<4-14)	7.2 (<4-5,281)	4.8 (<4-12.9)	19.0 (4.5-65.2)
Nb	<1 (<1-4.9)	<1 (<1-5.3)	<1 (<1-15.4)	<1	<1

* The analysis of the contents of all the elements was carried out by the ICP-MS method; some elements were identified by the atomic absorption spectrometry (AAS).

Despite the low contents, microelements can substantially affect the soil formation processes, being their active participants, and then migrate into the water bodies. Layered aluminosilicates, typical for these soils, are modified, i.e. they change their structure and properties, when isomorphic substitution reactions occur. Thus, in the mineral chlorites, aluminum in the octahedral layers can be replaced by Cr^{3+}, Mn^{3+}, magnesium in the brucite layer can be replaced by Mn^{2+}, Ni^{2+}; in montmorillonites, aluminum is replaced by Ni^{2+}, Zr^{2+}, Cu^{2+}, Co^{2+}, in vermiculites, it is replaced by Cr^{3+}, V^{3+}, etc. Such types of substitution reactions can alter the electrical charges in the unit cell of a mineral that can consequently affect the degree of their water content, as well as the ability to absorb cations and organic matter [6]. The contents and distribution of microelements are actively influenced by many processes of the soil profile formation. They are removed from the eluvial (bleached, solodized) horizons and accumulated in the illuvial horizons and gley (reduced) horizons.

The general scheme of microelements involved in different soil processes according to V.A. Kovda [7] is given in Table 3.

Table 3

Microelements involved in the most significant soil processes (according to V.A. Kovda)

Process	Soils or soilbornes	Accumulated microelements
Small biological cycle	Litterfall, fresh or partially decomposed	Mo, Zn, Cu, Co, B, I, Br, Se, Ni, U, Ba, Mn, Sr, V
Synthesis of humus	Humic substances	B, I, Mn, Co, Cu, Mo, Zn, Ni, Pb, Br, F
Formation of clay and synthesis of colloids	Highly dispersed part of the soil	Mn, Fe, Cu, Co, V, Cr, Ni, Mo, Li, Rb, Cs, Ba, Sr, Pb, Zn, V, I, B
Illuviation	Illuvial horizons	Cu, Ni, Co, V, Cr, Zn, Mo, B
Gleying	Gley horizons	Mn, Co, Cu, V
Hydrogenic accumulation	Northern meadow soils	Mn, Cu, Ni, V, Co, B
	Southern meadow soils	Ba, Sr, B
	Saline soils	B, I, F, Li, Rb, Cs, Zn, Ca, Co

The effect of the soil processes on the accumulation of microelements is discussed below in the comparative analysis of the data concerning their contents in waters of various natural zones.

The microelement composition of the lakes in various natural zones of West Siberia

Tundra. The waters of tundra zone are characterized by low mineralization, decreasing with the distance from the Barents Sea. The contents of trace elements in the lake waters of the tundra zone are relatively low; the typomorphic elements are Al and Fe. The samples from some tundra lakes are characterized by the increased Sr content (up to 125 mg/l), that is generally typical for the quarternary glacial-marine and marine deposits of Yamal Peninsula [8]. The contents of typomorphic elements in the waters formed in the forest-tundra zone increase sharply (as high as ten times, compared to tundra), that indicates an increase in Al and Fe mobility due to the growing bogginess degree and the intensity of gley processes in the watershed soils. The mobility of aluminum is significantly influenced by the acidity of water and the colour of the water bodies. The microelement distribution for tundra and forest-tundra is as follows:

10-100 µg/l: Fe>Al>B
1-10 µg/l: Mn>Sr>Zn>Ba>Cu
0.1-1 µg/l: Mo>Ni >Li>Bi>As>Rb>Ti>Pb>Cr>Sb>V
0.05-0.1 µg/l: Ce
Lower than 0.05 µg/l Y >Nd> La > U > Ag >Pr> Cd > Hg >Sm>Dy>Sn>Er>Yb>Zr> Be >Eu> Ho > W>Th> Tb>Cs>Lu>Tm>Re

Northern taiga. The contents of microelements in the waters of the northern taiga lakes are slightly lower than in other taiga subzones (Table 2, Figure 1-3). Such a decrease is caused by leaching of elements in the conditions of waterlogging and rinsate water regime forming in unconsolidated rocks. Moreover, in the northern taiga of West Siberia, there is a high percentage of oligotrophic bogs (70% of the total area of the subzone swamps) [9].

The microelement distribution for the northern taiga zone is as follows:

More than 100 µg/l: Fe
10-100 µg/l: Al>B
1-10 µg/l: Zn>Mn> Ba> Cu>Sr
0.1-1 µg/l: Bi>Mo>Ni>Li>Rb>Pd>As>Ti>Cr>Sb
0.1-0.05 µg/l: V>Ce>Nd
Less than 0.05 µg/l Ag> La> U> Y>Zr>Gd>Pr>Sm> Cd> Hg>Sn>Dy>Yb> Be> W>Er>Eu>Th> Cs> Ho> Tb> Lu> Tm> Re

Middle taiga. Podsolic and bog soils dominate in middle taiga, acidity and colour of the water bodies in this subzone vary in a wide range (pH 4.54-7.42, colour 7.4-146 colour degrees). The contents of the majority of microelements in this zone are approximately the same as in the northern zones. As Fe becomes water-soluble in anaerobic conditions of bogs, its high content in water indicates high waterlogging level in this territory.

The microelement distribution for the middle taiga zone is as follows:

Higher than 100 µg/l: Fe
10-100 µg/l: Al>B
1-10 µg/l: Mn>Zn>Ba>Sr>Cu>Li
0.1-1 µg/l: Mo>Rb>As>Pb>Ni>Ti>Bi>Cr>V>Sb
0.05-0.1 µg/l: Ce>Nd
Lower than 0.05 µg/l La>U>Ag>Y>Zr>Cd>Pr>Gd>Hg>Sm>Dy >Be> Sn> W>Th> Cs>Yb>Er>Eu> Ho> Tb> Re> Lu> Tm

Southern taiga. In the area where middle taiga gives the way to southern taiga, the increase in the concentration of the following microelements (Zn, Mn, Ba, Bi, Li, Rb, As, U, Cd, Nb, Cs) is registered. Such an increase can be caused by the active involvement of microelements into the small biological cycle, with the effect of anthropogenic factors.

The microelement distribution for the southern taiga zone is as follows:

More than 100 µg/l: Sr
10-100 µg/l: Fe>Ba>Mn>B>Al
1-10 µg/l: Zn>Li>Cu>Rb>As
0.1-1 µg/l: Mo>Bi>Pb>Ti>U>Cr>Sb>Ni
0.05-0.1 µg/l: V>Ce>Cd
Lower than 0.05 µg/l La>Nd>Y>Ag>Pr>Hg>Gd>Sm>Sn>Cs>Dy> Zr> Be>Er> W>Yb> Ho> Re> Tb>Eu>Th> Lu>Tm

Forest-steppe. The waters of the forest-steppe lakes differ greatly from the taiga lakes. The humidity factor isoline with the value of 1.1 runs along the forest-steppe zone of West Siberia. The precipitation-vaporization ratio tends to 1, the soil nutrition increases. Soils and quaternary rocks are richer in microelements, carbonates, and other salts than the glacial deposits of taiga. Subaerial deposits and lake loamy loesslike deposits containing carbonates are widespread in the forest-steppe zone. Among these soils, we can observe desalted soils (solod and solodized black soils) and salinized soils (sodic and solonized black soils) [8]. All these result in the increase in lake water mineralization and the appearance of saltish and saline lakes with weak-base or basic reaction. The average pH value in the lakes under study is 7.92, while pH value in one of the lakes of Isetsky District, the Tyumen Region is 8.3. It is the zone where the increased concentrations of most of macro- and microelements are typically registered.

The microelement distribution for the forest-steppe zone is as follows:

Higher than 100 µg/l: Sr>Ba>B
10-100 µg/l: Mn>Al>Fe>Zn>Li
1-10 µg/l: Cu>Rb>As>V>Mo
0.1-1 µg/l: U>Pb>Ti>Bi>Sb>Cr>Ni
0.05-0.1 µg/l: Cd>Ce>La
Lower than 0.05 µg/l Nd> Ag> Y>Pr>Gd> Hg> Cs>Sm> W>Sn> Dy> Zr>Er> Yb> Re> Ho> Tb>Th> Be> Tm> Lu>Eu

To sum up all the data concerning the microelement contents in the lakes of the basic natural zones of West Siberia, we can conclude the following:

The macroelement contents (Na, K, Ca, Mg) and most of microelement contents (Si, P, B, Mn, Ba, Sr, Zn, Cu, Li, Rb, As, V, Co, U) have their highest values in the southern taiga and forest-steppe zones. The exceptions are iron and aluminum, their concentrations being higher in the swampy water bodies of the tundra and northern taiga zones characterized by high colour index and acidity. The highest concentrations of Ti, Ni, and Bi were also registered in northern lakes, except for Fe and Al. The data obtained can be used as the baseline values for evaluating the anthropogenic impact on the water ecosystems of West Siberia.

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