DOI: 10.17117/na.2016.05.03.456

<http://ucom.ru/doc/na.2016.05.03.456.pdf>

Поступила (Received): 24.05.2016

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Некоторые особенности гидрогеохимии
городских озер в криолитозоне

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Some characteristics of the hydrogeochemistry
of urban lakes in a permafrost Region

Рассматриваются особенности формирования химического состава городских озерных вод в области криолитозоны. Отмечаются специфические особенности химического состава озерных вод. В последние 30-35 лет наблюдается отчетливая тенденция понижения содержания макрокомпонентов и величины минерализации воды в городских озерах. Уменьшение поступления вещества в озера с метеорными водами и поверхностным стоком приводит к изменению химического состава воды в озерах за счет подтока надмерзлотных вод

Ключевые слова: озера, гидрогеохимия, криолитозона

The features of the formation of the chemical composition of urban lake water in the permafrost zone. There have been specific features of the chemical composition of the lake water. In the last 30-35 years there has been a clear downward trend content macro components and quantities of mineralization of water in urban lakes. Reducing the flow of matter in the lake with meteoric waters and surface runoff leads to changes in the chemical composition of the water in the lakes due to the inflow of water suprapermafrost

Key words: lake, hydrogeochemistry, permafrost

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The chemical composition of urban lake water is characterized by specific features. The role of man-made sources of matter is carried out mainly through precipitation, suprapermafrost groundwater and surface runoff. Direct impact rocks (through the bottom and sides of the lake) is very small. Paramount importance biogenic processes (living organisms – water), since the conditions established in the lakes, mostly favorable for the development and activity of microorganisms, plankton and other creatures. The gas composition of the lake waters is dominated by gas emissions enterprises and natural gases of the atmosphere, which lake waters are in close contact, and the gases of biochemical origin.

Receipt of substance in the lake with precipitation, suprapermafrost groundwater and surface runoff, on the one hand, and the impact on the chemistry of lake waters in rainfall and the evaporation on the other, define a wide range of salinity changes

and chemical composition of water in urban lakes. Mineralization of water in urban lakes Yakutsk ranges from 0.101 to 8.7 grams per 1 liter, the average values for all lakes in the last fifteen years, 0.598 g /l. The magnitude of mineralization within the city lake two different groups: 1) fresh, $M < 1$ g /l; 2) brackish water and salt, $M = 1 - 9$ g /l. Due to the significant mineralization oscillation amplitude varies greatly chemical composition of lake water: Lake of the first group on the predominant component mainly $\text{HCO}_3\text{-Mg}$, Na, Ca and Cl, $\text{HCO}_3\text{-Mg}$, Na, the second group – HCO_3 , Cl-Mg, Na or SO_4 , Cl-Mg, Na. Widespread magnesium ions of the cations associated with the processes of freezing lake waters. Over the past 15 years there has been a clear downward trend magnitude of mineralization of the lake waters, with the magnitude of the trend of about 17 mg /l per year (Fig. 1).

Fig. 1. Trend (dotted line) and the curve of change of salinity Yakutsk city lakes

On present trends, the value of desalination water salinity urban lakes in 2020 decreases by about $\frac{1}{4}$ and will be about 0.5 g /l, with a constant of their chemical composition. As currently in saline water comprising sodium ion concentration and ammonium exceed fishery MPC (Table).

Table 1. Weather changes of components water in urban lakes to 2020 mg / l

Components	1998 г.	2013 г.	Trend, mg / l year	2020 г.	MPC _{fishery}
Ca^{2+}	48.90	42.40	-1.44	32.32	180
Mg^{2+}	38.50	40.30	-0.85	34.35	40
Na^+	172.24	174.10	-2.41	157.23	120
K^+	20.46	18.60	-0.39	15.87	50
NH_4^+	0.89	1.13	0.018	1.26	0,51
SO_4^{2-}	51.29	81.70	-1.85	68.75	100
Cl^-	234.40	202.70	-5.22	166.20	300
F^-	0.68	0.43	-0.013	0.34	0.05
Salinity	790.40	600.90	-16.85	482.95	-

Annual rainfall in the city of Yakutsk in 1998-2013 years characterized by a pronounced interannual variability. On average background values in this period about 280 mm, some years were significantly different amount of precipitation. Thus, in 2001-2002 and 209-2010, and 2012's, annual precipitation in Yakutsk was 180-230 mm, and in 1999, 2003, 2005-2007. greater than 300 mm. During this period, the trend changes averaged values of annual precipitation in Yakutsk is an almost horizontal line (Fig. 2).

Fig. 2. Trend (dotted line) and the curve of change in annual precipitation in the city of Yakutsk

From periods to maximize the amount of precipitation (2005-2007 years), coincides lowering lake water salinity values Yakutsk. At the same time, the general trend of change of the salinity of the lake waters and rainfall antagonistic. If the underlying trend changes of annual precipitation in Yakutsk in 1998 is almost a horizontal line (see Fig. 2), the amount of mineralization of lake water has a distinct downward trend (see Fig. 1). Reducing the flow of material in the lake with meteoric water and surface runoff at a constant value of evaporation, should lead to an increase in salinity in the lakes by increasing the proportion of the substance coming from the underground runoff suprapermafrost waters. However, we observe a clear decreasing trend in salinity values of lake water and the contents of all of macrocomponents (HCO_3^- , SO_4^{2-} , Cl^- , K^+ , Na^+ , Ca^{2+} , Mg^{2+}). The maximum annual trend downward in the water of lakes – about 9 mg /l is typical for HCO_3^- , minimum – 0.4 mg /l K^+ :

The positive trend is characteristic only of ammonium intensity of about 0.02 mg /l year. The reason for such anomalies can serve lowering depth suprapermafrost waters and, consequently, reduce the amount of groundwater flow due to the increase of power seasonally thawed layer due to climate warming. The average air temperature at the meteorological station for the period 1971-2011 Yakutsk region. increased

from -9.9 to -7.8°C, two degrees. Average snow depth increased during the same period from 30 cm in 1971-1975 up to 37 cm in 2006-2010 years.

Results

In the last 30-35 years there has been a clear downward trend of macro content (HCO_3^- , SO_4^{2-} , Cl^- , K^+ , Na^+ , Ca^{2+} , Mg^{2+}) and salinity values in urban lakes Yakutsk is not associated with an increase in rainfall. Annual downward trend ion content in the water of lakes range from 0.4 mg / l (K^+) and 9 mg / l (HCO_3^-). Long-term trend of annual precipitation in Yakutsk is almost horizontal line. Reducing delivery substance in the lake with meteoric water and surface runoff at a constant value of evaporation leads to increased salinity in the lakes by increasing the proportion of the substance coming from the underground runoff suprapermafrost waters. On present trends, the value of desalination water salinity urban lakes in 2020 decreases by about $\frac{1}{4}$ at constant their chemical composition.

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