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Microbial Processes in Stratified Lake Doroninskoe (Transbaikal Region)

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In recent decades, meromictic ponds attract the attention of researchers in different directions, because here the character of the physical, chemical and biological processes differ from those of typical mixing waters (Kuznetsov, 1970; Hutchinson, 1969).

In Transbaikalia widely distributed soda and salt lakes with different salinity. Notable among them is Lake Doroninskoye, which has a pronounced stratification for a variety of physico-chemical and biological parameters with hydrosulfide present in the monimolimnion (Zamana, Borzenko, 2007; Gorlenko et al., 2010). Lake Doroninskoye characterized as continental soda pond with a maximum depth in the central part of 6-6.5 m. Major anions in the lake are sodium carbonate and sodium chloride. Salinity in the lake varies from 26 to 32 g/l. During the onset of stratification zone, chemocline observed at a depth of 3-3.5 m, coinciding with the thermocline.

The results of determination of the chlorophyll content in the water column of the lake showed the presence of chlorophyll a. This suggests that the main primary producers of organic matter are cyanobacteria and diatoms. The presence in the concentrated water samples of the bacteriochlorophyll was not detected.

Production of organic matter in the lake water is 0.8 mg/l per day. In the euphotic zone production occurs mainly due to photosynthesis. In the upper layers (up to 2 m) the main role in photosynthesis belongs to oxygenic phototrophics - cyanobacteria and diatoms. The role of anoxic photosynthesis increases with depth. On the border of aerobic and hydrogen sulfide zones the production of organic matter occurs predominantly by anoxic photosynthesis reaching up to 99 % of light carbon dioxide assimilation.

One of the integral indicators of the microbial community activity is the rate of dark carbon dioxide assimilation. Activity of the microbial community of the water column has three peaks - in the upper layer (1-2 m) in the chemocline zone and in the bottom layer of water (4.5-5 m).

Presence in the water of significant quantities of reduced compounds, including hydrogen sulfide, provides a high activity of chemolithoautotrophic microorganisms. In monimolimnion the dark fixation of CO_2 occurs predominantly during the process of chemosynthesis.

Sufficient content of sulfate ions in water causes a high activity of sulfate reducing prokaryotes. The rate of sulfate rediction in the water column reaches up to 0.7 mkg S/l per day. The process reaches greatest rate in the lower layers of water. Sulfate reduction is the main process of decomposition of organic matter at the terminal stage. During the sulphate reduction process consumes up to 70% of organic matter formed during the microbial production. The process of methanogenesis was probably very low and was not identified.

In the upper layers of sediments (up to 10 cm) dark fixation rate was lower than in the water column and was 25-54 g C/dm^3 per day. A significant part of the carbon dioxide fixed during the process of chemosynthesis. The rate of sulphate reduction in contrast, exceeded the one in the water column and ranged from 6 to 110 mg S/dm^3 per day.

The rate of methanogenesis was 0.5-13.3 l CH_4/dm^3 per day. Determination of quantitative and qualitative composition of the fraction of volatile acids (C_2 - C_5) showed the maximum amount of acetate ions in the surface layer of sediments (25.4 mg S/dm^3), in the next layers the amount of acetate dramatically decreased to 5.74 mg S/dm^3. Also in the surface layer were observed propionate - 0.54 mg S/dm^3 and 2-methyl butyrate - 6.3 mg S/dm^3. The content of other volatile fatty acids were in trace amounts or not detected.

The results of measuring of carbon isotope composition of lake bottom sediments showed that the content of $\delta^{13}C$ of organic matter and carbonates ranged from -27.51 to -29.41 and from -5.26 to -7.13 ‰, respectively. Organic carbon of the bottom sediments from the surface to 4-5 cm

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is enriched to 0.8 ‰ by heavy carbon ^{13}C, with a further reduction of its content. Distribution of carbon isotopes of organic matter and carbonates of the bottom sediments correlates with the velocity curves of sulfate reduction and methanogenesis along the profile. At a depth of 4-5 cm are marked the maximums of weighting of carbon isotope composition of organic matter and facilitate of carbon isotope composition of carbonates. Development of sulfate reducing bacteria is accompanied by enrichment of organic carbon by heavy isotope ^{13}C. This is due to the consumption by sulfate reducing bacteria of lightweight carbon of organic matter. At the same time in the zone of development of methanogens observed weighting of carbon isotope composition of carbonates, indicating the consumption of lightweight carbonates carbon in the process of methanogenesis.

Thus, studies have shown that for the functioning of the ecosystem of Lake Doroninskoe is essential sulfur cycle, carried out a variety of sulfate reducing and sulfur-oxidizing chemotrophic and phototrophic microorganisms.

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Key words: Lake Doroninskoe, microbial community, activity of microbial processes, photosynthesis, dark fixation of CO_2, sulfate reduction, cycle of sulfur.

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