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# Seasonal changes of methane concentration in boreal lakes of NW Russia

Svetlana Zabelina (1), Chandrashekhar Desmukh (2), Oleg Pokrovsky (2), Alexander Savvichev (3), Liudmila Shirokova (1,2), Frederic Guerin (2), and Elena Zakharova (3)

(1) Institute of Ecological Problems of the North, 163061, Nab. Severnoi Dviny, 23, Arkhangelsk, Russia (svetzabelina@rambler.ru), (2) LMTG, CNRS, IRD, Universite Paul Sabatier, Observatoire Midi-Pyrénées, 14 Avenue Edouard Belin 31400, Toulouse, France (oleg@lmtg.obs-mip.fr) , (3) Institute of Microbiology of the Russian Academy of Sciences, Moscow, 7/2, Prospekt 60-letiya Oktyabrya 117312, Russia

Methane (CH4), produced by methanogenic Archaea under strictly anoxic conditions in sediments, is an important atmospheric greenhouse gas, contributing to global warming. Besides, the importance of boreal lakes in global methane evaluation stem from the high coverage of arctic and subarctic land surface by lakes of glacial or thermokarst origin. The first step in the evaluation of methane biogeochemical cycle in high latitudes is the measurement of its concentration in the water column and bottom porewater sediments.
In this work, we investigated several typical seasonally stratified lakes in Arkhnagelsk region of the NW Russia. Methane concentrations profiles were measured in the water column and sediment porewaters of two lakes of the Kenozersky National Park (KNP) (Lake Maselgskoe and Lake Vilno) located in the middle of taiga zone southwest from Arkhangelsk, and the lake Svjatoe located in the Geobiopsheric station "Rotkovetz" during the summer (2007, 2009) and winter (2008) stratification period. In addition, the lake Maselgskoe was studied during spring and autumn water overturn. During summer period, methane profiles in the lake Maselgskoe showed three zones with differed CH4 concentration: constant concentration around 0.22 $\mu$mol/L in the surface layer (0 to 6-7 m), then gradual decrease to 0.05 μmol/L (8 to 15 m) and significant increase to 80 μmol/L in near-bottom water. During autumn lake water overturn, mean 4 concentration (0.31 $\mu$mol/L) in the water column of the lake Maselgskoe gradually but decreased insignificant from the surface to depth horizons. Stratified lake Svyatoe in 2007 and shallow lake Vilno in 2009 demonstrated similar features of CH4 concentration profile, however near-bottom concentration in lakes was an order of magnitude less than in Maselgskoe.
The sediment porewaters of stratified lakes exhibit the concentration of methane ranging from 0.43 to 2.0 mmol/L in summer and from 1 to 2.4 mmol/L in winter in lake Maselgskoe and from 0.3 to 1.3 in summer and winter in lake Svyatoe. Such a high concentration indicates that the methane production carried out by anaerobic Archaea and process significant amount of organic matter competing with the bacterial sulphate reduction.
Observed profiles result from a combination of several factors such as 1) the flux from the sediments to the water column, 2) spatially variable vertical mixing, and 3) aerobic and anaerobic microbial oxidation of methane in the water column. Note that at the oxic–anoxic interface in the water column or in the sediments, CH4-oxidizing bacteria transform CH4 carbon to bacterial biomass, microbial metabolite compounds and carbon dioxide. Therefore, CH4 has a potential of significant carbon source for the food web. Elevated methane concentrations in the subsurface water are not related solely to the methane fluxes from the sediments but probably result from microbial production of methane in the gut of zooplankton and higher aquatic organisms, as well as within the fecal pellets and detrital material at the anoxic microzone.
Obtained results demonstrate the high importance of boreal aquatic ecosystems in methane biogeochemistry. There are more than 220 thousand of lakes in the Arkhangelsk region and these lakes are ice covered for about six months (November–April). In winter, the stratification period produces oxygen depletion and it can increase CH4 emissions from the lake to the atmosphere which will be essentially pronounced during spring ice thawing period. Today, there is no rigorous evaluation of methane fluxes associated with this seasonal process in NW of Russia. Because the allochtonous input of organic matter from adjacent wetlands is likely to increase both CH4 and CO2 production in lakes, this will have a direct impact on the greenhouse gas emissions from lakes.