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Biogeochemistry of thermokarst lakes in discontinuous and sporadic permafrost zone of Western Siberia

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Active processes of the permafrost thawing in Western Siberia increase the surface of water thermokarst (thaw) lakes and ponds. In continuous permafrost zone, this process promotes soil carbon mobilization to the water reservoirs and organic matter biodegradation producing a permanent flux of CO2 to the atmosphere (Shirokova et al., 2009; Pokrovsky et al., 2010). At the same time, biogeochemical evolution of aquatic ecosystems situated in the transition zone between continuous permafrost and permafrost-free terrain remains poorly understood. The Central part of Western Siberia offers a unique possibility of studying this transition zone because of highly homogeneous physico-geographic conditions (peat soil, sedimentary bedrocks and typical taiga vegetation) developed in Western Siberia. Another important factor making this zone highly attractive for multidisciplinary biogeochemical field studies is relatively easy ground access to various lakes located at the watershed divide zone between adjacent rivers. This is in contrast to most other studies in Siberia and Alaska of thermokarst lakes that are being conducted within the small and large river valleys. Towards a better understanding of biogeochemical processes occurring in the water column of thaw lakes, we studied, in August 2010, approximately 30 small shallow (< 1.5 m depth) lakes and ponds formed due to permafrost subsidence and thawing of the palsa bog located in the transition zone between tundra and forest-tundra (region of town Nojabrsk, central part of Western Siberia). All newly-formed shallow lakes are acidic (pH = 3-4.5), highly organic (10-30 mg/L DOC) and low mineralized (10-50 μS). Dialysis experiments allowed quantifying the proportion of low-molecular weight (LMW, < 1 kDa) and high molecular weight (HMW, > 1 kDa) organic ligands and associated trace metals. The average proportion of LMW DOC is equal to 30 +/- 12%. In-situ lake water incubation experiments yielded extremely low primary productivity but significant mineralization rate of dissolved organic matter by heterotrophic bacterioplankton. Therefore, regardless of the stage of the thaw lake evolution, from small forming pond to large lake subjected to draining, there is always significant degradation of dissolved organic matter accompanied by permanent CO2 flux to the atmosphere. We observed a systematic decrease of conductivity and trace element concentrations concomitant with OC concentration decrease among all studied lakes and ponds. Overall, our observations suggest that dissolved organic matter mineralization by aquatic heterotrophic bacterioplankton is the main process controlling the chemical composition of thaw lakes. Results of this study allow straightforward extrapolation of obtained results to other vast areas of thaw lake and pond development, notably of discontinuous permafrost zone, where the lake are capable of both increasing and decreasing their surface areas due to permafrost thawing.

References:

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