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A mesocosm study on the impacts of eutrophication on methane and carbon dioxide concentrations in two small boreal lakes

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Freshwater lakes are increasingly recognized as significant sources of greenhouse gases to the atmosphere and hence their role in the global carbon budget has previously been significantly underestimated. In particular, many small and shallow lakes in the boreal region are important hot spots for methane and carbon dioxide release due to their morphology and catchment characteristics, and subsequently high allochthonous DOC-content and elevated nutrient concentrations. Moreover, the boreal lakes are under severe pressure by climate change and anthropogenic activities which can enhance the transport of DOC and nutrients into these small and shallow lakes, potentially accelerating their greenhouse gas fluxes.

Here we present results from an ongoing study where we employ floating mesocosms in two small lakes (brown and clear water) in eastern Finland. These mesocosms contain six chambers (dia. 1 m, depth 4 m) isolating water from the surface to the sediment, with regular additions of nutrients (either PO_4^{-} or PO_4^{-}, NO_3^{-} and NH_4^{+}) and monitoring of dissolved CH_4 and CO_2 concentrations for two years. As expected, the phytoplankton abundance increased rapidly with nutrient additions and especially in the tanks where both phosphorus and nitrogen were added. Chlorophyll a ranged from 0.2 μg/L to as high as 127.6 μg/L, while CH_4 concentrations ranged from 13.3 nmol/L to 1026.8 nmol/L and CO_2 concentrations from 0.1 μmol/L to 298.2 μmol/L. Both CH_4 and CO_2 concentrations showed notable seasonal variation but correlated also with chlorophyll a concentrations (phytoplankton abundance) with highest CH_4 and lowest CO_2 concentrations recorded with highest chlorophyll a concentration. Unexpectedly the highest CH_4 concentrations were observed in the clear water lake with low DOC concentrations but highest chlorophyll a after nutrient enrichments.

These results illustrate that climate change, with predicted increases in precipitation and nutrient transport, as well as cultural eutrophication may increase the methane fluxes from boreal lakes, further increasing their role in the global carbon budget and as contributors of greenhouse gases.