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Effects of nitrate fertilization on CO_2 and CH_4 concentrations in small boreal lakes

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Ecosystem functioning in boreal lakes is largely affected by atmospheric nitrogen loading enhanced by anthropogenic activities. Additional deposition of nitrate entering these systems affects pelagic metabolic processes and thus the production and consumption of aquatic greenhouse gases. This study assesses the effect of nitrate fertilization on concentrations of dissolved carbon dioxide (CO_2) and methane (CH_4) in six small lakes in northern Sweden (area: 1.0-4.8 ha, max. depth: 4.5-8.5 m) with three different levels of dissolved organic carbon (DOC) concentrations (clear lakes: 7 mg l^{-1}, medium brown lakes: 13 mg l^{-1}, dark brown lakes: 18 mg l^{-1}). A whole lake fertilization experiment was carried out utilizing a Before-After-Control-Impact (BACI) design with one reference year (2011) and one impact year (2012); including one control lake and one impact lake for each DOC level. During 2012, the impact lakes were fertilized with potassium nitrate once in March and biweekly from June to September. Fertilization caused epilimnion total nitrogen concentration to increase by around 10% in the impact lakes relative to the reference year while it decreased by around 20% in the control lakes. From June to September, epilimnion water was sampled biweekly by grab sampling and analyzed in the field by an infrared gas analyzer or in the laboratory using a gas chromatographer. Three additional samples were taken along a depth profile on three occasions. In the reference year, concentrations of CO_2 and CH_4 did not differ significantly between control and impact lakes ($p>0.05$). In the impact year, epilimnion CO_2 concentrations were significantly higher compared to the reference year in all medium and dark brown lakes. Fertilization mostly caused a slight reduction in CO_2 and CH_4 concentrations in the impact lakes relative to the control lakes. This effect was not significant but most pronounced and coherent across the whole water column in clear lakes. In clear lakes, CO_2 and CH_4 concentrations may have been more sensitive to internal primary production affected by fertilization rather than by external inputs of CO_2 and CH_4. In turn, external gas inputs not affected by fertilization may have been relatively more important for pelagic gas concentrations in brown lakes. The results suggest that increased nitrogen loading may have only a minor effect on CO_2 and CH_4 concentrations in boreal lakes relative to natural interannual variation. Our experiment also shows that the effect of nitrogen addition may depend on the trophic state of small boreal lakes.