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The linkage between methanotrophy and diazotrophy in boreal environments

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Many methanotrophic bacterial groups fix nitrogen in laboratory conditions. Furthermore, nitrogen (N) is a limiting nutrient in many environments where methane concentrations are highest. Despite these facts, methane-induced N fixation has previously been overlooked, possibly due to methodological problems. To study the possible link between methanotrophy and diazotrophy in terrestrial and aquatic habitats, we measured the co-occurrence of these two processes in boreal forest, peatland and stream mosses using a stable isotope labeling approach ($^{15}N_2$ and $^{13}CH_4$ double labeling) and sequencing of the *nifH* gene marker.

N fixation associated with forest mosses was dependent on the annual N deposition, whereas methane stimulate N fixation neither in high ($>$3 kg N ha^{-1} yr^{-1}) nor low deposition areas, which was in accordance with the *nifH* gene sequencing showing that forest mosses (*Pleurozium schreberi* and *Hylocomium splendens*) carried mainly cyanobacterial N fixers. On the other extreme, in stream mosses (*Fontinalis* sp.) methane was actively oxidized throughout the year, whereas N fixation showed seasonal fluctuation. The co-occurrence of the two processes in single cell level was proven by co-localizing both N and methane-carbonfixation with the secondary ion mass spectrometry (SIMS) approach.

Methanotrophy and diazotrophy was also studied in peatlands of different primary successional stages in the land-uplift coast of Bothnian Bay, in the Siikajoki chronosequence, where N accumulation rates in peat profiles indicate significant N fixation. Based on experimental evidence it was counted that methane-induced N fixation explained over one-third of the new N input in the younger peatland successional stages, where the highest N fixation rates and highest methane oxidation activities co-occurred in the water-submerged *Sphagnum* moss vegetation. The linkage between methanotrophic carbon cycling and N fixation may therefore constitute an important mechanism in the rapid accumulation of N during the primary succession of peatlands. It is still an open issue whether methanotrophy induces N fixation directly or by enhancing phototrophic or heterotrophic N fixation.