Geophysical Research Abstracts
Vol. 15, EGU2013-4289, 2013
EGU General Assembly 2013

Methane metabolism in a stratified boreal lake

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Stratified lakes, typical of the boreal zone, are naturally anoxic from their bottoms. In these lakes methanogenesis can account for up to half of organic matter degradation. However, a major part of the methane (CH_4) is oxidized in the water column before reaching the atmosphere. Since methanotrophs use CH_4 as their sole carbon and energy source, much CH_4-derived carbon is incorporated into their biomass. Microbially produced CH_4 has strongly negative δ^{13}C compared to other carbon forms in ecosystems, making it possible to follow its route in food webs. However, only a few studies have estimated the amount of this microbial biomass or its carbon stable isotopic composition due to difficulties in separating it from other biomass or from other carbon forms in the water column. We estimated methanotrophic biomass from measured CH_4 oxidation, and δ^{13}C of the biomass from measured δ^{13}C values of CH_4, DIC, POM and DOC. An estimate of the fraction of methanotrophs in total microbial biomass is derived from bacterial community composition measurements.

The study was made in, Alinen Mustajärvi, a small (area 0.75 ha, maximum depth 6.5 m, mean depth 4.2 m,), oligotrophic, mesohumic headwater lake located in boreal coniferous forest in southern Finland. CH_4 and DIC concentrations and their δ^{13}C were measured over the deepest point of the lake at 1 m intervals. ^{13}C of DOM and POM were analyzed from composite samples from epi-, meta-, and hypolimnion. Evasion of CH_4 and carbon dioxide from the lake surface to the atmosphere was estimated with boundary layer diffusion equations. CH_4oxidation was estimated by comparing differences between observed concentrations and CH_4potentially transported by turbulent diffusion between different vertical layers in the lake and also by actual methanotrophy measurements and from vertical differences in δ^{13}C-CH_4. The estimate of CH_4 production was based on the sum of oxidized and released CH_4. Molecular microbiology methods were used to evaluate which bacteria might be participating in these processes.

A substantial part of the CH_4 produced was oxidized in the anoxic water column. Our results further show that production and oxidation of CH_4 was important in microbial biomass production and also affected the δ^{13}C of biota in the water column.