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Using carbon isotope fractionation for an improved quantification of CH4 oxidation efficiency in Arctic peatlands

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Much research effort is focused on identifying global CH_4 sources and sinks to estimate their current and potential strength in response to land-use change and global warming. Aerobic CH_4 oxidation is regarded as the key process reducing the strength of CH_4 emissions in wetlands, but is hitherto difficult to quantify.

Recent studies quantify the efficiency of CH_4 oxidation based on CH_4 stable isotope signatures. The approach utilizes the fact that a significant isotope fractionation occurs when CH_4 is oxidized. Moreover, it also considers isotope fractionation by diffusion. For field applications the 'open-system equation' is applied to determine the CH_4 oxidation efficiency:

$f_{ox} = (\delta_E - \delta_P) / (\alpha_{ox} - \alpha_{trans})$

where f_{ox} is the fraction of CH_4 oxidized; δ_E is $\delta^{13}C$ of emitted CH_4; δ_P is $\delta^{13}C$ of produced CH_4; α_{ox} is the isotopic fractionation factor of oxidation; α_{trans} is the isotopic fractionation factor of transport.

We quantified CH_4 oxidation in polygonal tundra soils of Russia's Lena River Delta analyzing depth profiles of CH_4 concentrations and stable isotope signatures. Therefore, both fractionation factors α_{ox} and α_{trans} were determined for three polygon centers with differing water table positions and a polygon rim.

While most previous studies on landfill cover soils have assumed a gas transport dominated by advection (α_{trans} = 1), other CH_4 transport mechanisms as diffusion have to be considered in peatlands and α_{trans} exceeds a value of 1. At our study we determined α_{trans} = 1.013 $\pm$ 0.003 for CH_4 when diffusion is the predominant transport mechanism. Furthermore, results showed that α_{ox} differs widely between sites and horizons (α_{ox} = 1.013 $\pm$ 0.012) and has to be determined for each case.

The impact of both fractionation factors on the quantification of CH_4 oxidation was estimated by considering both the potential diffusion rate at different water contents and potential oxidation rates. Calculations for a water saturated tundra soil indicated a CH_4 oxidation efficiency of 88% in the upper horizon.

Using carbon isotope fractionation improves the *in situ* quantification of CH_4 oxidation in wetlands and thus the assessment of current and potential CH_4 sources and sinks in these ecosystems.