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Methane cycling in alpine wetlands - an interplay of microbial communities and vascular plants

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Wetland environments play an important role for the global climate, as they represent a major terrestrial carbon store. These environments are potential sinks for atmospheric carbon due to reduced decomposition rates of plant material in the waterlogged, anoxic subsurface. In contrast, wetlands are also a major source of the highly potent greenhouse gas methane (CH_4), which is produced in the anoxic zones through methanogenic archaea (methanogens) degrading organic matter. The CH_4 emitted into the pore water diffuses upwards towards the surface, and is partially oxidized in the oxic zones by aerobic methanotrophic bacteria (methanotrophs) before reaching the atmosphere. Nonetheless, global emissions of atmospheric CH_4 from natural wetlands are estimated to range from 100 to 230 Tg a^{-1}.

Natural wetlands can be found around the globe, and are also common in temperate-cold climates in the Northern hemisphere. Methane release from these environments is influenced by many factors ($e.g.$, vegetation, water table, temperature, pH) and shows high seasonal and spatial variability. To comprehend these variations and further predict potential responses to climate change, the biotic and abiotic processes involved in CH_4 turnover need to be understood in detail. Many research projects focus on (sub-)arctic wetland areas, while studies on CH_4 emissions from alpine wetlands are scarce, despite similar processes occurring in these different regions. Recently, we conducted a survey of 14 wetlands ($i.e.$, fens vegetated with vascular plants) located in the Swiss Alps, showing CH_4 emissions between 74 ± 43 and 711 ± 212 mg CH_4 m^{-2} d^{-1} (Franchini *et al.*, in press). A detailed study of one fen also revealed that CH_4 emission was highest immediately after snowmelt, followed by a decrease in CH_4 emission throughout the snow-free period (Liebner *et al.*, 2012).

Even though the CH_4 cycle is largely driven by microbially mediated processes, vascular plants also play a crucial role in CH_4 emissions from wetlands, as CH_4 generated in the deeper layers can bypass the oxic, methanotrophic zones through the plant aerenchyma. In addition, O_2 transported to the root system facilitates CH_4 oxidation in the rhizosphere. To further comprehend these complex processes, the present study focused on selected fens dominated by different plants ($i.e.$, *Carex* spp. or *Eriophorum* spp.). We combined field-measurements of overall CH_4 emissions, CH_4 and O_2 pore water concentrations and plant-mediated bypass with molecular biological analyses of methanogenic and methanotrophic subpopulations at different soil depths. Methane emissions and pore water concentrations varied with location and dominating plant species. Nevertheless, in all fens we observed the presence of active methanogens and methanotrophs throughout the depth profile, independently of O_2 and CH_4 concentrations, with active methanogens being highly abundant even in the oxic layers indicating the presence of microniches. The often described spatial separation of methanogenic activity in anoxic zones and methanotrophic activity in oxic zones and oxic-anoxic interfaces could not be observed. The composition of the methanogenic and methanotrophic subpopulations that are active at different depths is currently analyzed in detail, providing new insights into the complex processes involved in CH_4 turnover in alpine regions.