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Seasonal methane dynamics in three temperate grasslands on peat

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Natural peatlands are important sources of atmospheric methane (CH_4) due to their waterlogged, highly organic soils. Approximately 14 % of the European peatland area has been drained for agriculture, mainly for grasslands. Drainage leads to a strong decrease in CH_4 emissions or may even turn peatlands into CH_4 sinks because the anaerobically produced CH_4 can be effectively oxidized in unsaturated soil layers. Maybe as a result of the small net fluxes observed, below-ground dynamics of CH_4 in grasslands on peat have largely been neglected.

The objective of this study was to investigate seasonal CH_4 dynamics of temperate grasslands under different soil moisture regimes. A former bog with partly well preserved *Sphagnum* peat and two fens with highly decomposed peat – one with a high pyrite (FeS_2) content – were chosen as study sites. Groundwater fluctuations were less than 40 cm at the pyrite-poor fen and $\sim$ 90 cm at the other sites during the course of a year. Fluxes of CH_4 were monitored with closed chambers for one year as part of a project for the determination of emission factors for managed organic soils in Denmark. In addition, 1-m deep soil CH_4 concentration profiles were measured in each of the four meteorological seasons and the associated archaeal communities assessed via molecular fingerprint (T-RFLP) analysis. Methanogens were identified by sequencing and phylogenetic analysis of 16S rRNA genes. For the former bog site, CH_4 production potentials were determined in short-term laboratory incubation experiments at 20 ˚C in parallel to the soil concentration profiles.

Averaged over all sites, the grasslands were sinks for CH_4 with a flux of -4$\pm$8 μg CH_4 m^{-2} h^{-1} (mean $\pm$ SE, n = 254), with no apparent seasonality at either site. At the pyrite-rich fen, CH_4 dynamics were suppressed with soil CH_4 concentrations never exceeding 15 ppm and no detection of methanogens. At the other sites, methanogens were detected in all samples. There were marked differences in archaeal community composition between sites and peat depths, but not between seasons. Soil CH_4 concentrations reached up to 150 and 1000 μmol CH_4 dm^{-3} soil at the pyrite-poor fen and the former bog, respectively. At the fen, groundwater table seemed to control the concentration profile shapes as expected. In contrast, at the former bog site the *Sphagnum* peat's water holding capacity and physical structure seemed to reduce the effect of drainage, leading apparently to CH_4 production and accumulation well above the groundwater table. CH_4 production potentials were measurable in $\sim$ 40 % of the bog's peat samples (n = 98) mainly below 30 cm peat depth, ranging from 0.001 to 0.40 μmol CH_4 g dry $peat^{-1}$ day^{-1}. Surface peat showed CH_4production after a lag phase of 2 – 7 days.

At the pyrite-poor fen and the former bog, the CH_4 oxidation zone was large enough to suppress substantial CH_4 emissions. However, aerenchymous plants may create emission hotspots within these grasslands. This was shown in additional measurements at both sites on single spots with occurrence of Soft Rush (*Juncus effusus*). These spots showed a yearly average CH_4emission of 1.07$\pm$0.11 (n = 38) and 1.79$\pm$0.49 (n = 38) mg CH_4 m^{-2} h^{-1} for the bog and the fen, respectively, which is comparable to annual average emissions from natural European peatlands. The distribution of aerenchymous plants, the peat's physical structure and potential capillary fringe effects should be considered more intensively in the evaluation of grasslands on peat as potential CH_4 emission sites. Also, data on the distribution of methanogens should be further pursued in these ecosystems to allow interpretations regarding their influence on soil CH_4 concentrations in comparison to environmental factors.