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Only low methane production and emission in degraded peat extraction sites after rewetting

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In Central Europe rewetting of bogs after peat extraction is a wide spread technique to halt secondary aerobic decomposition and to reestablish plant species such as *Sphagnum* spp. and *Eriophorum* spp. that initialize accumulation of organic carbon in peat. Before extraction, such sites are often used for agriculture causing the aerobic degradation of peat and mobilization of phosphorus, ammonia, and dissolved organic matter (DOM). In nutrient poor ecosystems such as bogs, additional supply of P and N does not only trigger the establishment of uncharacteristic vegetation but also the formation of more labile plant litter and DOM that is readily degradable. Therefore, after rewetting and the development of anoxic conditions especially in initial stages high methane (CH_4) emissions are reported for these systems compared to pristine bogs.

Regarding the potential of methane production and emissions we investigated three common practices to prepare extraction fields for restoration (years since rewetting): i) Filling of drainage ditches, passive rewetting (1 site, Altendorfer Moor, Stade, NW-Germany, ca. 20 yr.), ii) Removal of upper 30 cm peat layer, removed peat used for construction of polder dikes (2 sites, Königsmoor, Leer, NW-Germany, 2 and 3 yr.), iii) Removal upper peat layer down to 50 cm grown peat, not extracted peat used as polder walls (2 sites, Benthullener Moor, Wardenburg, NW-Germany, 3 and 7 yr.). In each site two vegetated replicate mesocosms (diam. 30 cm, depth 40 cm) were sampled and placed in a greenhouse from May-October 2014 to maintain the water table at surface level. Pore water concentrations of ions, fermentation products and DOM, DOM electron acceptor capacity (EAC), soil gas concentrations of CO_2, CH_4 and H_2, gas fluxes as well as element composition and organic matter quality of DOM and SOM were analyzed.

We found out that practice i) with least efforts of nutrient removal in the peat produced the highest CH_4 emissions (3.5 mmol m^{-2} d^{-1}) although still within the range of northern pristine bogs. Also practice ii) showed still inputs of external nutrients and labile DOM, but CH_4 production was not yet developed (0.23 and 0.07 mmol m^{-2} d^{-1}). Practice iii) was most effective in nutrient removal, but only in the 7 yr. site little methane (in the 3 yr. site 0.025 vs. 0.41 mmol m^{-2} d^{-1}in the 7 yr. site) was emitted. The emissions were well in accord with soil gas concentrations, maximum values for CH_4 in practice i) were 115 μmol L^{-1}, 2-5 μmol L^{-1} in practice ii) and 0.5 vs. 16 μmol L^{-1} in practice iii). Only small concentrations of inorganic electron acceptors such as sulfate imply the importance of organic matter as electron acceptor.

The results show that restored bogs on former strongly degraded extraction fields do not necessarily act as exceptionally high CH_4 sources. Contrary to other findings in early stages of rewetting CH_4 emissions can also be very low until other electron acceptors are exhausted and methanogens become effective competitors for substrates which happens in the order of years.