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How do peat type, sand addition and soil moisture influence the soil organic matter mineralization in anthropogenically disturbed organic soils?

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Drained peatlands are hotspots of carbon dioxide (CO_2) emissions from agriculture. As a consequence of both drainage induced mineralization and anthropogenic sand mixing, large areas of former peatlands under agricultural use contain soil organic carbon (SOC) at the boundary between mineral and organic soils. Studies on SOC dynamics of such “low carbon organic soils” are rare as the focus of previous studies was mainly either on mineral soils or “true” peat soil. However, the variability of CO_2 emissions increases with disturbance and therefore, we have yet to understand the reasons behind the relatively high CO_2 emissions of these soils. Peat properties, soil organic matter quality and water content are obviously influencing the rate of CO_2 emissions from strongly anthropogenically disturbed organic soil, but a systematic evaluation of the hydrological and biogeochemical drivers for mineralization of disturbed peatlands is missing. With this incubation experiment, we aim at assessing these drivers by systematically comparing strongly degraded peat with and without addition of sand under different moisture conditions and for different peat types.

We sampled undisturbed soil columns from topsoil and subsoil in triplicates of ten peatland sites all used as grassland. Peat types comprise six fens (sedge, Phragmites and wood peat) and four bogs (Sphagnum peat). All sites have an intact peat horizon that is permanently below groundwater level. Five sites have a strongly disturbed earthified topsoil horizon while the other five sites have a topsoil horizon additionally altered by sand-mixing. All 60 soil columns were installed in a microcosm system under a constant temperature of 10°C. The initially fully saturated soil columns were drained via suction plates at the bottom of the columns by stepwise increase of the suction until -300 hPa followed by irrigation until saturation was reached. Via online gas chromatography CO_2, nitrous oxide (N_2O) and methane (CH_4) concentrations were permanently measured in the flushed head space of the soil columns. Concentrations of dissolved organic carbon (DOC) were measured in the column discharge.

Our results showed clearly higher CO_2 fluxes from the disturbed topsoils compared to their subsoils which are assumed to be reference material before agricultural use. The highest CO_2 fluxes occurred under low suctions around field capacity, thereby peat substrate of the bog samples seemed to react more severe to drainage than fen samples. Overall the bog samples had surprisingly high CO_2 fluxes from both earthified and sand-mixture topsoils. As expected, the N_2O fluxes from fen samples were higher than from bog samples. CO_2 was the main contributor to the greenhouse gas balance for all samples followed by N_2O or DOC. CH_4 fluxes were negligible. Overall, sand addition on peat seems not to be a favorable option to mitigate CO_2 emissions.