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Pond emissions of CO2 and CH4 in a rewetted peatland

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Natural peatlands are crucial for global terrestrial carbon storage but have historically been extensively drained. Mitigating enhanced greenhouse gas (GHG) emissions linked to peatland drainage often involves rewetting, leading to pond formation. While rewetting is perceived to contribute to net GHG reduction, observational data of carbon dioxide (CO2) and methane (CH4) emissions from these restored ecosystems remains highly variable and overall insufficient. Ponds created after rewetting may be hot spots for CH4 emissions and this study focused on assessing net CO2 and CH4 emissions from a pond in a rewetted peatland over a one-month period in 2023.

The field study took place on a former fen at Mårumhus Pond in Gribskov, Denmark, rewetted in 2008 by clear-cutting a Norway spruce plantation and blocking ditches. This intervention resulted in a permanent pond covering the entire former fen area, with water depths ranging from approximately 0.5 to 1 meter. CO2 and CH4 fluxes were measured using automated chambers (AC) and manual bubble traps (BT). The study, conducted from September 19th to October 18th, 2023, involved eight AC and BT devices deployed along a 50-meter transect perpendicular to the pond's shore.

Throughout the measurement period, the daily average CO2 efflux from all eight AC chambers ranged between 3663 – 9074 mg CO2 m-2 d-1. Concurrently, daily average net CH4 emission from these AC chambers ranged from 224 – 1231 mg CH4 m-2 d-1, contrasting significantly with the average BT-derived CH4 flux range of 30 – 91 mg CH4 m-2 d-1. AC measurements indicated ebullition as the primary emission pathway, with one main hotspot across the transect, a pattern also observed by the BT. Interestingly, CO2 and CH4 emission patterns showed no correlation with water depth but demonstrated a clear response to the disruption of thermal stratification during the measurement period, attributed to wind-driven mixing of the water column. CH4 emissions measured with the AC increased during sudden air pressure drops.

AC and BT displayed substantial differences in measured fluxes, with AC showing CH4 fluxes nearly ten times higher than BT, which also failed to capture valid CO2 emissions. These difference can be attributed to method specific limitations, which will be discussed. The observed variations in CO2 fluxes using the AC method align with literature values, while CH4 emissions are notably higher. This study underscores the need to include spatiotemporal variations in both fluxes and environmental drivers and emphasizes the need for further research and method development of GHG emissions from ponds in rewetted peatlands, as these environments may serve as significant hotspots for CH4 emissions.