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Greenhouse gas fluxes from nutrient-rich organic soils in Estonia

Muhammad Kamil Sardar Ali[1], Thomas Schindler[1,2], Ain Kull[1], Hanna Vahter[1], Ülo Mander[1], and Kaido Soosaar[1,2]
[1]Department of Geography, Institute of Ecology & Earth Sciences, University of Tartu, 46 Vanemuise, EST-51014 Tartu, Estonia
[2]Department of Ecosystem Trace Gas Exchange, Global Change Research Institute of the Czech Academy of Sciences, Belidla 4a, CZ-60300 Brno, Czech Republic *Email: kamil.sardar@ut.ee

Nutrient-rich organic soils are one of the largest key sources of greenhouse gas (GHG) emissions in cool moist climate regions in Europe, and around 15 Mha of wetlands are drained for forestry across the world's temperate and boreal areas. Drainage promotes the decomposition of the organic material stored in these naturally water-saturated organic soils, turning the wetland from a carbon sink into an emitter of CO_2. Lower soil water content in drained histosols leads to reduced CH_4 emission, while N_2O emission can increase due to increased mineralization and more favorable conditions for nitrification. However, detailed information of GHG emissions from drained organic soils under different land use and management in the hemiboreal zone is still scarce.

We conducted a full-year study at drained peatland sites with different land uses to assess the impact of drainage and land-use on GHG fluxes in Estonia. We investigated ten sites: (I) five forests with different tree species, (II) three grasslands with different water regimes, (III) cropland and (IV) natural wetland (fen). The GHG fluxes were measured twice per month using the manual static (CH_4 and N_2O) and dynamic (heterotrophic respiration (CO_2)) closed chamber method from Jan 2020 to Dec 2021. Additionally, groundwater level, soil temperature and moisture were measured hourly with automatic loggers to determine soil conditions.

Our preliminary results show that all drained forest soils were annual CH_4 sinks (−59.4 ± 2.5 μg m^{-2} h^{-1}, mean ± SE). However, CH_4 uptake from the studied fen, crop and grasslands were lower, –13.2 ± 4.4, -12.2 ± 2.0 and -8.2 ± 3.3 μg m^{-2} h^{-1}, respectively, while grassland with poor drainage soil was a less source of CH_4 emission. Most of the sites were annual emitters of N_2O; forest sites were higher emitters (15.9 ± 2.3 μg m^{-2} h^{-1}) than cropland (12.7 ± 4.1 μg m^{-2} h^{-1}) and fen soils (6.3 ± 1.1 μg m^{-2} h^{-1}). N_2O fluxes from grasslands depend on drainage intensity and the site with poor drainage emitted less. Higher N_2O emissions and temporal variability were associated with sites where the water level had high seasonal fluctuations. Soil CO_2 fluxes (heterotrophic respiration) were highest from grasslands and peaked over all the study sites during the summer. Methane flux had a statistically significant correlation with water level and soil moisture, while N_2O flux was controlled by soil temperature, having higher emissions in a warmer season. The results provide insights into GHG fluxes over temporal and spatial scales and indicate the need for mitigation

measures and further enhancement of modeling tools for climate-friendly land management practices in nutrient-rich organic soils.

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