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Peat soil degradation and its impact on nitrogen and organic matter fluxes: a soil-physical perspective

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Peatlands are well-known for their global significance as long-term carbon sinks. They are denoted as important land-water interfaces and play an essential role in regulating the water budget and biogeochemical cycles of the landscape. However, worldwide, the ecological services that they provide are compromised by drainage activities for land reclamation, involving lowered water tables and soil aeration that accelerate decomposition and create non-reversible changes in peat quality. We assembled a comprehensive dataset of soil properties in a broad range of peat soils, from low to highly decomposed soils in natural to heavily drained peatland settings. The main objective was to highlight alterations of hydro-biogeochemical characteristics as a consequence of increasing bulk densities, a proxy for peat decomposition and degradation. We found that C/N ratio was negatively correlated with bulk density ($p < 0.01$). The change in peat quality was evidenced by the fact that annual nitrous oxide (N_2O) emissions and concentrations of dissolved organic carbon (DOC) were elevated in highly degraded peat soils. Pristine and less decomposed peat (bulk density < 0.1 g cm^{-3}) had a higher macropore fraction, which typically leads to a high saturated hydraulic conductivity. The pore structure of peat further suggests that the (primary) macropores of the pristine peat are part of an equilibrated continuous network, while the (secondary) macropores in more decomposed peat cause a separation of the soil water into fractions of different mobility, including preferential pathways. We propose that in addition to chemical soil changes, elucidation of altered hydrological properties is crucial for understanding the contributions of differently degraded peatland to global carbon and nitrogen fluxes of terrestrial ecosystems.