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Spectroscopic characteristics of soil organic matter in drained and re-wetted peatlands

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Draining peatland for agriculture and other land uses have transformed many peat soils from a C sink to a C source. It has been estimated that more than 930,000 ha of peatlands in Germany have been drained that emit about 20 million tCO_2-equivalents every year. To address this problem, 29,764 ha have been rewetted in Mecklenburg-Western Pommeria/Northeast Germany between 2000 and 2008 but the effects on the C storage are unknown. The objective of this study was to investigate the impact of draining and rewetting of peatlands on soil organic matter (SOM) quality and quantity as one of a key indicators of peat restoration. We collected soil samples from 0 - 60 cm and 0 - 80 cm depths of pairs of drained and rewetted peat soil profiles under forest (alder), permanent grassland in a percolation mire and permanent grassland under the influence of occasional flooding at the Baltic Sea coast. We used classic chemical analyses, pyrolysis field ionization mass spectroscopy (Py-FIMS) and carbon and nitrogen X-ray near-edge absorption spectroscopy (XANES) and, for the SOM characterization. The results of the chemical analyses revealed that total organic carbon (Corg) concentration was significantly ($P<0.05$) different within and among the different depths and types of peatlands. The Corg ranged from 14 to 37% in the upper 0-20 cm depths of the drained peatlands, whereas from 31 to 33% Corg in the rewetted peatlands. The Corg concentrations increased significantly ($P<0.05$) with depths in rewetted forest peatlands, drained and rewetted percolation mires; however, such an increase with depths were not observed in coastal drained and rewetted peatlands and drained forest peatland. The total nitrogen (N) concentrations were strongly correlated ($R2 = 0.80$) ($P<0.000$) with the Corg concentrations. A principal component analysis with all Py-FI mass signals clearly discriminated the peat profiles according to origin/vegetation and management practices. Among the ten compound classes determined by Py-FIMS, the proportions of carbohydrates, phenols and lignin monomers significantly declined with depths in all peat profiles but were more enriched in the upper 0-20 cm depths of the rewetted peat soils. The relative abundance of lignin dimers, lipids, alkylaromatics, heterocyclic nitrogen compounds and peptides showed slight differences within and among the different depths and profiles, whereas the relative abundance of suberin was enriched with depths in all peatland types. The carbon K-edge spectra indicated the presence of quinone, protonated and aromatic C, aromatic C bound to nitrile, aldehyde, imidazole, purines, and carbonyl C bound to amine and aliphatic C bound to COOH. Similarly, the nitrogen K-edge spectra revealed the dominant features of imine, nitrile, amide, and pyrrole in all peatlands. However, the relative abundance of functional groups bound to carbon and nitrogen did not show any trend with depths and among the peatland types and management practices. Overall, the results indicate that rewetting increased the concentration of Corg and the proportions of carbohydrates and lignin monomers in the studied peatland types. Since these compounds are rather labile, our results (= their relative enrichments) indicate a success of the rewetting efforts.