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Energy content of soil organic matter pools under cropland and grassland sites

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The storage of organic carbon in soils is regulated by different physicochemical mechanisms. The physical fractionation of soil organic matter (OM) into particulate and mineral-associated pools has advanced our knowledge based on these operationally-defined different storage forms of organic carbon in soils. Attempts to integrate a thermodynamic perspective to decipher mechanisms of soil organic carbon storage require the integration of our understanding of different physicochemical mechanisms. Here we analyzed the energy contents related to different pools of OM using differential scanning calorimetry. Various pools of OM were isolated by combined density and size fractionation differentiating free particulate OM (fPOM), occluded particulate OM larger than 20 µm ($oPOM_{>20\ \mu m}$), occluded particulate OM smaller than 20 µm ($oPOM_{<20\ \mu m}$) and mineral-associated OM smaller than 20 µm ($MOM_{<20\ \mu m}$). We compared cropland and grassland sites from long-term monitoring sites across Bavaria (Germany). Our aim was to relate the novel energy analyses with characterizations of the carbon storage and OM composition. In the cropland sites we found an energy gradient with increasing energy content (J/mg C) across fPOM, $oPOM_{>20\ \mu m}$, $oPOM_{<20\ \mu m}$, $MOM_{<20\ \mu m}$. The increasing energy gradient was independent of different carbon contents and correlated with decreasing C:N ratios. These results indicate an important role of energy accumulation through association of OM with minerals along the gradual decomposition of different OM pools. A relationship of the energy content with the alkyl/O-alkyl ratio serving as a proxy of decomposition based on ^{13}C NMR spectroscopy was also related with the energy content but to a lower extent. In the grassland sites, the energy content gradient of different OM pools was in a similar range and the C/N ratios of the POM fractions were also lower compared to the cropland sites. By comparing energy stored in OM pools from cropland and grassland sites, we will discuss potential implications of energy analyses for our understanding of soil organic carbon storage.