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Quantification and characterization of colloids and organic carbon released under oscillating redox conditions

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Wetlands account for 8-10% of the world's land surface but their soils contain 20-30% of globe terrestrial carbon. The carbon is intimately mixed with minerals in the soils. Thus, mineral-associated-organic carbon (MOC), which often exists as colloids, can directly affect global carbon cycling at multiple scales. When wetland soils become reduced, large quantities of MOC are released due to dissolution of metal oxides, and mobilized and discharged into adjacent streams during rainfall events. Despite the clear relevance of wetlands to global carbon reservoirs and cycling, MOC, as an important component of wetland carbon pool, is poorly understood. Further, understanding of the key factors controlling the fluxes and compositional characteristics of MOC thus the underlying reaction mechanisms that are responsible for the sequestration and stabilization of OC is also lacking. Here we present results from both field sampling and laboratory experiments on the amount, size distribution, and composition of MOC as influenced by oscillating redox conditions. Using both conventional and advanced analytical techniques, including x-ray photoelectron spectroscopy (XPS) and isotope ratio mass spectroscopy (IRMS), we identify 4 MOC size fractions: 450-1000 nm, 100-450 nm, 2.3-100 nm and < 2.3 nm. Normalized atomic% of different elements obtained from XPS analysis reveal clear variations in mineral and OC compositions in the different size fractions. In particular, the "nano sized" MOC (i.e. 2.3-100 nm fraction) has the highest Mg/Al ratio and OC/mineral ratio, the lowest percentages of Al and Si, is mostly depleted in C-C/C-H functional groups but enriched with C=0 and C-O/C-N groups in contract to other size groups. IRMS analysis shows depletion of the heavier isotope 13C from the 2.3-100 nm fraction indicating the presence of more lignin derivatives in this size fraction. The observed size-dependent heterogeneity on C attachment and release to/from MOC can lead to more accurate assessment of OC stability in redox dynamic environments such as wetlands. We propose that size-dependent MOC behavior and associated processes must be considered in future studies of OC in natural systems.