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Linking Phosphorus Sequestration to Carbon Stabilization in Wetland Soils by 31P and 13C NMR Spectroscopy

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Wetlands have long been recognized as effective sinks for retention of phosphorus because of their capacity to transform dissolved inorganic phosphate into sediment and soil organic phosphorus.1 However, the long term stability of phosphorus in wetland soils remains unknown. For phosphorus sequestration to be effective, it must not be re-released when changes in environmental conditions occur (e.g. pH, temperature and water level). Incorporation of inorganic and organic phosphorus into humic structures may be responsible for a significant amount of phosphorus stabilization in wetland soils. However, soil carbon compounds arising from plant tissues degrade at markedly different rates. For example, most plant-derived carbohydrates are readily degraded in soils,2 whereas more recalcitrant compounds become stabilized and may persist in the soil for many thousands of years.3 Therefore, linking carbon characteristics and phosphorus structures is considered a key aspect of any effort to understand soil phosphorus stabilization.

Chemical information on soil organic matter that might sequester phosphorus in wetland soils is relatively limited. We are addressing this problem by combining the results of solution 31P and solid state 13C nuclear magnetic resonance (NMR) spectroscopy before and after hydrofluoric acid (HF) treatment of soils. Our hypothesis is that phosphorus strongly chelated to metals and in organic forms sorbed to cationic sorption sites will be removed during this treatment, whereas any phosphorus that remains must be a part of a stable fraction of sequestered organic phosphorus resistant to remobilization.

Solution 31P NMR spectra of alkaline-extractable phosphorus and solid-state 13C spectra of soil organic matter were collected for soil samples representing a broad range of wetlands (Florida and Alaska in the US; Panama). Enrichment in the amount of organic phosphorus after HF treatment was noted for samples where alkyl and aromatic groups dominated the soil organic matter. In contrast, soils with high amounts of O-alkyl groups showed a decrease in the organic phosphorus after HF treatment. Particularly surprising was the persistence of a considerable fraction of inorganic ortho-phosphate after the treatment, suggesting that ortho-phosphate is somehow incorporated into the stable organic matrix. Strong correlations between phosphorus and different carbon fractions support the hypothesis that HF treatment can be used to differentiate the phosphorus fraction that can be affected by environmental changes and fraction that is stabilized by incorporation into humic complexes.

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