Influence of Redox Processes on Phosphorus Storage, Transformation, and Mobilization

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Coastal wetlands are dynamic sites that act as biogeochemical hotspots for nutrient and mineral transformations. Globally, and particularly in the southeastern U.S., coastal areas are experiencing saltwater intrusion and shifts in redox conditions associated with sea level rise and human activities, which affect carbon and nutrient storage, transformation, and export. Prolonged flooding shifts soils from transiently oxidizing to persistently reducing conditions, while salinity varies according to relative contributions of fresh- and saltwater during inundation, with implications for phosphorus (P) fate and transport. Phosphorus is often a limiting nutrient in fresh- and saltwater environments but can also affect water quality and cause eutrophication at high concentrations. However, P speciation and solubility are understudied compared to C and N in coastal soils, representing a key knowledge gap. The aim of this research is to develop a new understanding of P biogeochemistry in coastal systems by evaluating controls on P mobility across redox and salinity gradients. We hypothesize that highly abundant redox interfaces in freshwater wetlands will favor P sorption to metal oxides, and that changes in redox conditions driven by soil flooding will regulate P mobility via formation and dissolution of Fe oxides. Soils were collected along an inundation gradient on the emerging Wax Lake Delta in the Atchafalaya basin in Louisiana to investigate how soil organic matter and metals influence phosphorus cycling in freshwater deltas. Soils were collected in bulk (surface soils; 0-5 cm) and cores (0-30 cm) from five plots along the transect. We used a suite of analytical tools to investigate P speciation, incorporating analyses targeted towards both the organic and mineral phases in the system. Chemical separations and other complimentary techniques were used to quantify total soil P and determine P associations (e.g., iron-bound, aluminum-bound, etc.). Soil extractions revealed differences in total phosphorus and the proportion of phosphorus associated with soil minerals associated with inundation pattern. Sites that were more frequently inundated stored less phosphorus in iron mineral associations, accompanied by an increase in reduced iron-sulfur associations at the same sites. The results of this research will improve our understanding of how nutrients are stored and processed across flooding and salinity gradients that represent current and future coastal ecosystems.