

Investigating the Fate of Rhizodeposited Phosphorus Interactions with Iron Oxides and Its Implications for Soil Organic P Cycling

CALEB E.B. SHACKELFORD¹, INDIA REDDELL¹,
KATHRYN DARIA SZERLAG¹, PAUL NORTHRUP², RYAN
V TAPPERO³, HARRISON R. COKER¹, DONALD L
SPARKS⁴, YOUJUN DENG¹, PEYTON SMITH¹ AND JULIE
A. HOWE¹

¹Texas A&M University

²Stony Brook University

³Brookhaven National Laboratory

⁴University of Delaware

In the rhizosphere, plant roots play a pivotal role in nutrient cycling through rhizodeposition, which involves the release of both organic and inorganic compounds from living roots. This process includes the release of root border cells, sloughed root cells, root hairs, and non-specific substances such as exudates, mucilage, enzymes, and ions. Rhizodeposited products can release essential nutrients, including phosphorus (P), nitrogen (N), and sulfur (S) in various forms. Release of these compounds can influence P cycling by contributing to the release of organic phosphorus (Po), which may be available for microbial degradation and subsequent plant uptake. Understanding the mobility of these Po compounds, particularly in relation to minerals like iron oxides with high P affinities, is crucial for elucidating P availability and its role in Po cycling.

This study investigates the fate, speciation, and sorption behavior of rhizodeposited Po compounds, including glucose phosphate, phospholipids, and adenosine triphosphate (ATP), on ferrihydrite and hematite using synchrotron-based X-ray absorption spectroscopy (XAS). Recent advancements at the X-ray Fluorescence Microprobe (XFM) beamline 4-BM at the National Synchrotron Light Source II (NSLS II) enable precise microprobe analyses of both tender and hard energy elements, making it possible to investigate P and iron (Fe) at the same beamline. This study leverages these innovations to examine the spatial distribution and speciation of simulated rhizodeposition of Po compounds on ferrihydrite and hematite. To determine the co-location of Po with the Fe oxides, first, large survey micro X-ray fluorescence (μ XRF) mapping was completed at 2700 eV with a 10 μ m beam size. P hotspots were then probed with micro-focused X-ray absorption near-edge structure (μ XANES) spectroscopy. The results indicate that the P in glucose phosphate and ATP form direct inner-sphere adsorption complexes with Fe in both iron oxide minerals, whereas the P in phospholipids do not have direct associations with Fe. Results also show that ferrihydrite exhibits a higher sorption capacity than hematite, likely due to its amorphous structure and larger surface area. These findings contribute to a more comprehensive understanding of the stabilization and availability of