



Tender Energy X-Ray Spectroscopy for Determining Phosphorus Speciation in Soils

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Phosphorus (P) is an essential nutrient for all living organisms, but can act as a pollutant when excessive quantities enter aquatic systems. Elevated P levels can cause excessive phytoplankton growth and decreased levels of dissolved oxygen, threatening drinking, recreational, and industrial water supplies. A fundamental understanding of soil phosphorus (P) speciation is vital for understanding P retention and transport in soils. Although the chemistry of P has been extensively studied, specific mechanisms for P adsorption to soils remain largely unclear. Current methods for soil P speciation rely heavily on sequential chemical extractions which are *ex situ* and can introduce artifacts during the analysis procedure. To overcome limitations of current methods for examining the P speciation, non-invasive spectroscopic techniques can be used to analyze soils *in situ*. This study will use tender energy X-ray absorption spectroscopy (XAS) to elucidate bonding mechanisms for inorganic P species at the P K-edge (1.5-4.5 eV). In addition, experiments at the L_{2,3}-edge (100-1000 eV) will be used to characterize bonding mechanisms of organic P species. Phosphorus extended X-ray absorption fine structure spectroscopy (EXAFS) data may be used to determine nearest-neighbor identity, bond distances, and coordination number for P. Soils with high (>1000 ppm) P loadings and a variety of chemical and physical properties have been selected from field sites throughout the Chesapeake Bay watershed (USA) to evaluate P speciation. To assess the mobility and bioavailability of P, three soils will be selected for laboratory desorption studies in stirred-flow reactors. Samples from desorption studies will be analyzed with XANES to determine P species present before and after desorption. Initial spectra have been collected at beamline X15B, a tender X-ray (i.e., 1-5 keV) microprobe at the National Synchrotron Light Source, to perform micro-scale XAS and X-ray fluorescence (XRF) imaging at the P K-edge. These studies have indicated the presence of Al-bound and Ca-bound P in soils from the Chesapeake Bay watershed. Additional bulk XANES spectra will be collected at beamlines SXS and TGM at the Brazilian Synchrotron Light Laboratory. Additions to the current knowledge of P speciation from this study will improve understanding of soil P chemistry at a fundamental level and will have implications for P management strategies in eutrophic water bodies around the globe.

