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"Environmental Remediation Science at Beamline X26A at the National Synchrotron Light Source"

Report # 110713

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Executive Summary- The goal of this project was to provide support for an advanced X-ray microspectroscopy facility at the National Synchrotron Light Source, Brookhaven National Laboratory. This facility is operated by the University of Chicago and the University of Kentucky. The facility is available to researchers at both institutions as well as researchers around the globe through the general user program. This facility was successfully supported during the project period. It provided access to advanced X-ray microanalysis techniques which lead to fundamental advances in understanding the behavior of contaminants and geochemistry that is applicable to environmental remediation of DOE legacy sites as well as contaminated sites around the United States and beyond.

1. Project Goals and Objectives

The extent to which heavy metals and engineered nanomaterials pose an environmental hazard depends on their potential for release to and transport in the environment, i.e., environmental availability, and their potential for introduction into biological systems, i.e., bioavailability. Although there exists a substantial body of literature pertaining to the fate, distribution, and bioavailability of contaminant metals in model laboratory systems, few studies have examined the biogeochemical cycling of heavy metals and nanomaterials in complex aged-contaminated soils and sediments at a fundamental level. Even fewer have coupled detailed information on chemical speciation from state-of-the-art microscopic analytical and spectroscopic techniques with macroscopic observations obtained using indirect chemical extractions, metal desorption and leaching experiments, and biological uptake and toxicity assays.

Consequently, a major knowledge gap exists in translating basic geochemical science performed in simple model systems, short duration sorption/desorption laboratory experiments, and decoupled aqueous and solid phase speciation studies to real world systems that reflect the complexity arising from interaction of mixed waste contaminant source terms, long term aging reactions, multiple mineral surfaces, and naturally occurring organic matter. Moreover, the fundamental reactions governing contaminant aging, environmental availability, and bioavailability of metals, engineered nanomaterials and radionuclides, which dramatically influence the efficacy of environmental remediation and management strategies, remain poorly defined and understood.

The overall **goal of this project** was to provide technical support for the hard X-ray microprobe beamline, X26A, at the National Synchrotron Light Source (NSLS). Beamline X26A has been developed by a consortium led by the University of Chicago since the 1980s. It is a critical resource for investigators conducting fundamental research in environmental remediation science. This beamline has capabilities that include X-ray fluoresce microscopy, micro-X-ray absorption spectroscopy, micro-X-ray computed tomography, and micro-X-ray diffraction. These capabilities enable the elucidation of the fundamental mechanisms underlying contaminant behavior at the molecular level.

2. Research Progress to date:

The beamline supported numerous research activities either performed by researchers at the University of Kentucky, our collaborators at the University of Chicago, or by general users from a variety of institutions. Some of the scientific accomplishments from our group include the first evidence for bioavailability of engineered nanomaterials in soil invertebrates (Unrine et al., 2008, 2010a, 2010b). Insights into the bioavailability of molybdenum in soils (Wichard et al., 2009), metal homeostasis in plants (Punshon et al., 2009) and arsenic mineralogy at a contaminated site (Wallker et al., 2009) are among the many topics which were investigated at X26A during the grant period. These research activities are likely to lead to fundamental advances in environmental remediation science that will benefit the DOE environmental remediation missions. A list of publications produced as a result of work performed at the beamline during the period of support, or resulting from research conducted during this time is listed in section 4.

3. Ongoing and Planned Research Activities:

Support for the beamline has been maintained through a combination of DOE grants and support from the University of Kentucky office of the vice president of research and will continue until the decommissioning of the NSLS in November 2014. The PI and collaborators are working to establish support for a transitional hard X-ray microprobe beamline at the NSLS-II in order to continue to support these fundamental advances.

4. Information Access:

Publications

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Leskovjan, A., Lanzirotti, A., and Miller, L. (2009) Amyloid plaques in PSAPP mice bind less metal than plaques in human Alzheimer's disease, *NeuroImage*, v.47, p. 1215-1220.

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Unrine, J., Bertsch, P., and Hunyadi, S. (2008) Bioavailability, Trophic Transfer and Toxicity of Manufactured Metal and Metal Oxide Nanoparticles *in* **Terrestrial Environments, Nanoscience and Nanotechnology: Environmental and Health Impacts**, p. 345-360, John Wiley & Sons, Hoboken.

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