Synchrotron X-ray Microbeam Techniques in Assessing Metal Bioavailability in the Environment

A. LANZIROTTI[1] AND S.R. SUTTON[2]

[1] Consortium for Advanced Radiation Sources, Univ. of Chicago; lanzirotti@bnl.gov

[2] Consortium for Advanced Radiation Sources, Univ. of Chicago; sutton@cars.uchicago.edu

In evaluating the biotoxicity of metals in the environment it is important not only to measure contaminant abundance, but also constrain their form and the geochemistry and mineralogy of the matrix in which they reside. Synchrotron x-ray microprobes offer distinct advantages in evaluating metal bioavailability by allowing multiple spectroscopic techniques such as microbeam x-ray fluorescence (XRF) and absortion spectroscopy (XAS), diffraction (XRD), and fluorescence microtomography to be employed *in-situ* with little or no sample pretreatment.

For example, microbeam XAS and XRD were used to determine the host mineralogy and oxidation state of As in roaster-derived iron oxides from the Giant gold mine in Yellowknife, Canada [1]. This demonstrated that the oxides are mixtures of maghemite and hematite containing up to 7 wt.% As and mixed As5+ and As3+. A similar approach was used in investigating As retention mechanisms from lead arsenate contaminated soils in the northeastern United States, showing that aging effects can alter the original As-bearing chemical constituent [2]. Micro-XAS and XRF were also used in studying As solid-state chemical speciation, desorbability, and total levels of As in As-containing biosolids such as poultry litter [3].

These approaches can also be used in evaluating an organism's response to metals in soils. For example, a combined micro XRF, XAS, XRD approach to evaluate soil nematode response to, and uptake of, Pb contaminants to assess bioavailability [4], demonstrating that these soil organisms detoxify Pb through biogenic pyromorphite precipitation. Fluorescence microtomography can also be useful for the 3D imaging the metal distribution in organisms, often *in-vivo*. For example in assigning functions (uptake, storage and transport) to the genes involved in metal homeostasis in plants [5].

References

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