

Abstract No. toku405

In-situ Remediation of Cr(VI) in Contaminated Soils Through Organic Carbon Amendment

T. Tokunaga, J. Wan, T. Hazen, K. Olson (LBNL), M. Firestone (U. California, Berkeley), A. Lanzirotti, S. Sutton (CARS, U. Chicago)

Beamline(s): X26A

Introduction: Chromium is used in a variety of processes and products such as wood preservation, metal plating, pigmentation, leather tanning, and corrosion inhibition, and is now a common soil contaminant in industrial areas. In soils and sediments, Cr occurs primarily in two oxidation states, having very different behavior and toxicity. Cr(VI) is generally more soluble, mobile, and toxic. Cr(III) is typically much less soluble, and much less toxic. Because of the very high p_e of Cr(VI)/Cr(III) transformations, soil environments are typically reducing enough to favor stabilization of Cr as Cr(III). Thus in-situ transformation of Cr(VI) contamination through reduction to Cr(III) is an attractive remediation strategy. This study examines the effectiveness of organic carbon added to contaminated soils for purposes of accelerating Cr(VI) reduction to Cr(III).

Methods and Materials: A clayey, calcareous subsoil from Altamont Pass (California) was packed into small, 30 mm long, soil columns. These soil columns were rapidly contaminated with Cr(VI) solutions (1,000 and 10,000 ppm Cr), then placed in contact with solutions containing from 0 up to 4,000 ppm organic carbon (as tryptic soy broth or lactate). Profiles of total Cr, Cr(VI), and Cr(III) in the soils were obtained by micro-XRF and micro-XANES line scans, through Kapton windows along one side of each column. Redox potential profiles were obtained through Pt electrodes embedded along the length of each column. Columns were later sectioned for microbial community analyses.

Results: In these aerobic soils that are rapidly exposed to high Cr(VI) concentrations, reduction rates are slow, and not diffusion-limited. Under such conditions Cr is fairly uniformly distributed. This is in contrast to cases previously tested, where microbial activity was high, and Cr(VI) contamination was diffusion-limited [Tokunaga et al., 2001a,b]. The high redox potentials maintained in these soils suggest that neither ferrous iron or sulfide are responsible for the observed Cr(VI) reduction. Cr(VI) reduction resulting from in-situ addition of OC is proportional to the amount of OC supplied, and inversely proportional to the level of Cr(VI) contamination. The influence of OC addition can occur directly through redox reactions with Cr(VI), and indirectly through microbially mediated Cr(VI) reduction. Analyses of the collective data showed that the native soil contained 290 ppm of organic carbon having an availability for Cr(VI) reduction equivalent to that of the tryptic soy broth amendment. This readily reactive native soil organic carbon amounts to about 3% of the total native soil organic carbon content.

Conclusions: These results show that Cr(VI) reduction in response to organic carbon addition occurs at rates slow enough such that diffusion does not exert a strong limitation at the scale of soil aggregates (up to several cm). Low populations of microorganisms remaining after exposure to very high levels of Cr(VI) prevent generation of strongly reducing conditions necessary for efficient reduction by ferrous iron and sulfide.

Acknowledgments: Funding was provided through the U. S. Department of Energy, Natural and Accelerated Bioremediation Research Program (NABIR), and Basic Energy Sciences, Geosciences Program.

References:

T. K. Tokunaga, J. Wan, M. K. Firestone, T. C. Hazen, E. Schwartz, S. R. Sutton, and M. Newville, "Chromium Diffusion and Reduction in Soil Aggregates", Environmental Science and Technology, 35, 3169, 2001.

T. K. Tokunaga, J. Wan, E. Schwartz, T. C. Hazen, M. K. Firestone, S. R. Sutton, M. Newville, K. Olson, A. Lanzirotti, and W. Rao "Diffusion-limited Reduction of Chromium in Soil Aggregates", Environmental Science and Technology, submitted, 2001.