USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Project ID: 2002WA6B

Title: Reactive Transport of Reducible Metal Ions: Reaction Kinetics, Column Experiments and Transport Modeling

Project Type: Research

Focus Categories: Hydrogeochemistry, Models, Toxic Substances

Keywords: Chromium, Groundwater, Reactive transport model

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Abstract

The use of ionic metal species in industries such as wood preservation, leather tanning, electroplating, paint pigment and dye manufacturing, automobile manufacturing, steel production, and as a corrosion inhibitor in power plants and nuclear facilities, as well as the use of metal ions for governmental purposes, such as weapons production, has led to discharge of such ions into the environment at many locations. Many of these metals have several environmentally significant valence states. Typically, metals in one of these valance states form ions that can be transported through the environment much more easily than can the ions formed when the metal is in other valence states. Unfortunately, most often, the state that is most transportable is also the most hazardous.

Fortunately, however, previous research has shown that some oxidized metals (the transportable, hazardous state) can be reduced to a much less mobile, much less hazardous form through the action of indigenous subsurface microbes. Examples of metals that can be microbially reduced include chromium, uranium, and technetium. When reduced, these metals form insoluble metal oxides that will become immobilized, thus preventing further spread of heavy metal contamination. Of these metals, chromium is the second most common hazardous inorganic contaminant in the US and will be the focus of this proposed research project. In particular, Cr(VI) is hazardous and forms oxyanions that are easily transported through the environment.

Cr(VI) can be microbially reduced to Cr(III), which is much less hazardous and which, under typical groundwater conditions, will form stable insoluble species that are not easily transported. Our ongoing work has shown that indigenous microbes can reduce Cr(VI) to Cr(III). While previous experiments have focused on understanding the enzyme systems that catalyze the microbial reduction of Cr(VI) to Cr(III), and on the kinetics of the microbial reduction processes, little work has focused on the study of these processes in soil column reactors or on the development of predictive mathematical models that allow determination of expected plume concentrations and development of effective remediation strategies. Here, we propose to conduct a series of soil column experiments designed to elicit information on the complex interactions between soil, indigenous microbes, nutrients and contaminants. Moreover, we will develop modifications to an established groundwater modeling system, accounting for these interactions, which will allow the prediction of chromium plume concentrations as functions of space and time. By linking these two activities, we will provide a tool that can be begin to predict plume concentration profiles and to develop remediation strategies for chromate contaminated sites. Further, this tool can then be extended to allow such understanding for sites contaminated with other reducible metal ions (e.g. uranium).