EMSP
Environmental Management Science Program
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CHEMICAL TREATMENT OF THE VADOSE ZONE

TECHNOLOGIES IN THIS AREA ARE CURRENTLY BEING DEPLOYED AT DOE SITES, AND EMSP PROJECTS ARE EXPLORING THE FUNDAMENTAL SCIENCE THAT MAY LEAD TO IMPROVED IN-SITU REMEDIATION

Projects in this category involve studies of chemical processes that can change the chemical form of contaminants in the subsurface without excavation and without emplacement of physical barriers.

The remediation methods for metals and radionuclides involve converting the chemical form of the metal into a form that is less toxic and/or less mobile, usually by a reaction that reduces the oxidation state of the metal. Organic contaminants, on the other hand, can be converted into products that are not environmental hazards, and possible ways to accomplish this in the subsurface are being explored by one of the projects in this category. Each of the EMSP projects discussed here is exploring the fundamental science related to practical technologies currently being investigated for in-situ remediation:

- Permeable, reactive barriers are being demonstrated for immobilization of chromium, and two projects are studying fundamental aspects of chemistry related to this technology. One project involves detailed studies of the interaction of chromates with iron oxide surfaces using some of the most sophisticated tools of modern surface science. Another project is exploring the chemistry of chromate-clay interactions with the goal of understanding methods to maximize the reduction of chromate to chromium(III) in the subsurface.
- Electroosmotic processes are being demonstrated for in-situ remediation, and one EMSP project is investigating some fundamental aspects of the nature of electroosmotic processes as well as mechanisms of an oxidation reaction that can convert certain organic contaminants to safe products.

Fundamental Studies of the Interaction of Metal Ions with Soil Components
Alabama A&M University and the University of Wisconsin are using X-ray Spectroscopy (EXAFS/XANES) at beamline X23B, National Synchrotron Light Source, at Brookhaven National Laboratory.

PROBLEMS/SOLUTIONS

- An electroosmotic process has been demonstrated to move trichloroethylene (TCE) into a treatment zone. A fundamental understanding of the factors that affect the efficiency of this process is the focus of one EMSP project.
- A combination of hydrogen peroxide and iron(II) has long been known as a good oxidizing reagent for many organic compounds. An EMSP project is also exploring a technique to combine electroosmotic flow techniques and electrochemical generation of hydrogen peroxide to first concentrate and then destroy organic contaminants.
- In-situ treatment of oxidized metals to reduce them to less mobile species is being demonstrated at several U.S. Department of Energy (DOE) sites. Understanding the fundamental chemistry of metal ion interactions with subsurface components is essential to designing reliable reactive barriers; one EMSP project is studying the fundamental details of chromate interactions with mineral surfaces, while another is investigating methods by which various clays can be used to reduce chromate.

ANTICIPATED IMPACT

- Chromate remediation is a high-priority need at Hanford and Sandia, and reactive barriers that involve reducing chromate to chromium(III) are the most promising methods for immobilization. Fundamental studies of the effects of subsurface components on the chemistry of this process may lead to improved reliability and efficiency of several practical redox methods.
- An electroosmotic process for TCE remediation in low-permeability soils has already been demonstrated to cost much less than pump-and-treat techniques. Fundamental understanding of the process may contribute to additional improvements in this technology.

Fundamental Studies of the Interaction of Metal Ions with Soil Components

The Pacific Northwest National Laboratory/Stanford University team is using an array of sophisticated techniques to study the detailed surface structure and chemistry of some iron and manganese oxide minerals. They have studied the molecular processes that occur when two iron oxides, hematite and magnetite, interact with water and with chromate solutions to form a reduced, less toxic form of chromium. They have also developed a laser-spectroscopic technique to monitor low levels of chromate in solutions containing iron oxides, and they have used this technique to study how other common anions can interfere with the chromate reduction.

Project Teams

Lead Principal Investigator (Award Number)

- Pacific Northwest National Laboratory
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- University of Delaware
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- Alabama A&M University
  PI: Robert W. Taylor (55014)
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The Alabama A&M University/University of Wisconsin team has studied clays containing structural iron(II) and is able to reduce chromate to chromium(III). The team has found that initial close contact between clay surfaces and chromate is required for the reduction, and the detailed chemistry of various types of iron(II)-containing clays interacting with chromate has been studied. Mechanisms of other heavy metals binding to soil minerals are also being studied by this team, which has investigated the species from humic substances that are responsible for binding mercury ions and thereby aiding their transport. Thus, these two studies are exploring the fundamental chemistry related to some demonstrations of in-situ chromate reduction at DOE sites, such as projects described in TMS #2155 and #46. [Technology Management System; http://ost.em.doe.gov/IFD/OSThome.htm]

Electrochemical Processes for In-Situ Treatment of Contaminated Soils

The University of Delaware team is investigating some fundamental aspects of electrochemical processes for in-situ treatment of contaminated soils. The motion of ions in an electric field also results in transfer of water toward an electrode, and many organic pollutants are carried with the water toward an electrode. It has been found that control of the pH with nontoxic sodium acetate and acetic acid improves the efficiency of this process, with up to 90-percent organic removal in 15 days. They have also found that the electrochemical generation of hydrogen peroxide can provide an effective means of mineralizing a number of chlorinated hydrocarbons using a well-known oxidation process that requires the peroxide along with an iron salt. This project is studying fundamental science related to two demonstration projects (TMS #2161 and #4).

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