EMSP
Environmental Management Science Program
Project Summary Fact Sheet • October 1999

STABILIZATION OF CONTAMINANTS IN THE VADOSE ZONE

IMMOBILIZATION OF CONTAMINANTS MAY BE THE ONLY VIABLE REMEDIATION TECHNOLOGY FOR CERTAIN SITES AND MAY BE USED TO PREVENT NEAR-TERM MIGRATION AT MANY OTHERS

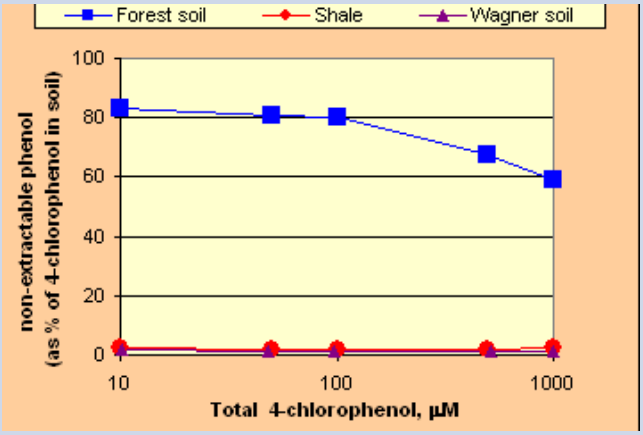
Most projects in this category are related to in-situ techniques capable of containing or immobilizing contaminants to stop continued leaching into surrounding environments or groundwater. These techniques are particularly useful at buried waste sites and at active facilities where excavation could disrupt work or pose undue worker health risks. Furthermore, in some cases contaminants are at depths where excavation is impractical, if not impossible.

One EMSP project is investigating reactions that can cause phenol and related chemicals commonly found in soils and sediments at U.S. Department of Energy (DOE) sites to bind to various soil components and thus render them immobile.

Two projects have goals related to immobilization of strontium-90:

- An investigation of microbial reduction of hydrous ferric oxide in anaerobic, carbonate-rich environments has shown that strontium can be precipitated as strontium carbonate or it can be incorporated into other carbonate precipitates. In either case, the process can result in the immobilization of strontium in the subsurface.
- In a related investigation of the factors that influence the rates of growth and activity of bacteria that reduce ferric oxides, conditions that optimize the continued activity of the bacteria have been identified.

Plutonium remediation, which is one of the most frequently mentioned problems in the Site Technology Coordination Group (STCG) needs statements, is the subject of another project. In particular, a prerequisite for both subsurface and tank remediation efforts is a thorough understanding of the redox chemistry of plutonium and the interactions of plutonium with other compounds in the environment.



Binding of Phenols in Soils
The University of Michigan team is studying natural and induced chemical reactions that can cause binding of compounds to soil components. In the example above, most of the 4-chlorophenol sorbed to the near-surface Forest soil, comprised of younger organic matter, could not be solvent extracted. However, there was almost complete reversibility of sorption on Wagner soil and shale at the same chlorophenol concentration range.

PROBLEMS/SOLUTIONS

- As described in a Hanford STCG statement, "in-situ technologies that are more cost effective than the baseline excavation/disposal costs ($105/cubic meter) are needed to treat the top 15 feet of soil and...may be required if soil contamination extends beyond 15 feet to depths where excavation costs become prohibitive." Two of the four projects in this area involve potential in-situ immobilization of strontium-90, one of the primary radionuclides of concern at Hanford.
- Contamination by semivolatile organic compounds extends to depths of a hundred feet at the Pantex Plant, for example, where remediation by excavation is impractical. One project is investigating reactions that could be used to immobilize phenols and related compounds by binding them to subsurface components.
- In-situ stabilization of plutonium and other actinides is essential for sites where near-term excavation or other removal technologies cannot be used. A thorough understanding of the various species of plutonium that can exist in a wide variety of conditions is being developed by another project.

ANTICIPATED IMPACT

- Excavation, handling, and transport of hazardous materials are expensive and may pose worker exposure risks. In-situ treatment technologies can provide a cost-effective alternative with significantly reduced risks for workers.
- Needs for more effective treatments for subsurface strontium-90 contamination have been cited at Brookhaven National Laboratory, Idaho National Engineering and Environmental Laboratory, Hanford, and Savannah River Site.
- There are 78 STCG need statements related to remediation of plutonium, and many of the problems require a thorough understanding of the oxidation and reduction chemistry of plutonium as a prerequisite to development of the appropriate technology.

Project Teams

Lead Principal Investigator (Award Number)

- University of Michigan
  PI: Walter J. Weber (54548)
- University of Toronto
  PI: F. Grant Ferris (54790)
  University of Alabama
- Florida State University
  PI: Gregory R. Choppin (54893)
  Pacific Northwest National Laboratory
- University of Alabama
  PI: Eric E. Roden (55164)

In-Situ Immobilization of Contaminants

Phenols and related compounds are priority pollutants, and these compounds are commonly found in soils, sediments, and groundwater at DOE facilities. The objective of the University of Michigan project is to study natural and induced chemical reactions that can cause binding of these compounds to soil components. They have found that soils having younger organic matter have greater potential for immobilizing phenols. Addition of certain enzymes and manganese oxide minerals greatly enhanced immobilization by catalyzing reactions that resulted in phenols binding directly to the soil organic matter or forming large polymers with decreased mobility.

The University of Toronto/University of Alabama team (54790) has studied the immobilization of aqueous strontium during carbonate mineral formation coupled to microbial reduction of hydrous ferric oxide. As bacterial reduction of Fe(III) to Fe(II) occurred, ferrous carbonate was precipitated and the strontium in solution was also captured by carbonates. The results showed that this process exceeded the capacity of strontium sorption on ferric oxide surfaces, so it may provide a mechanism for the removal of strontium from anaerobic, carbonate-rich environments. These processes are being explored in laboratory investigations to see if they show promise for application at DOE sites where strontium and other radionuclides exist in the subsurface.

In a study closely related to the previous one, the University of Alabama team (55164) has studied the factors that influence the rates of growth and activity of Fe(III)-reducing bacteria. Several different anaerobic bacteria use Fe(III) as an oxidizing agent, and this project has shown that removal of the reduced form of iron produced by this process greatly affects the continued activity of the bacteria and must be considered in models of the process. They have also studied the growth rate of two different iron-reducing bacteria, and they have developed methods that use a tritium-substituted amino acid for tracking instantaneous bacterial growth rates.

Speciation and Mobility of Plutonium

A detailed understanding of the effects of oxidizing or reducing agents on the chemistry of plutonium and other actinides is needed to design effective separation agents for nuclear wastes and to model actinide migration in contaminated soils and waters. The Florida State University/Pacific Northwest National Laboratory team is exploring the various chemical species of plutonium that occur as a function of the redox behavior, hydrolytic effects, and the presence of both synthetic and natural complexing agents. They have, for example, studied the rates of the reduction of Pu(V) by hydrogen peroxide, and they have calculated the rate of reduction for a range of environmentally relevant conditions. Knowledge of the chemical transformations that can occur in the high-level waste storage tanks is also crucial to developing reliable remediation procedures in that environment.

EMSP

Office of Science & Technology
Office of Environmental Management
U.S. Department of Energy

For additional information about the EMSP, please contact one of these representatives:

Mark A. Gilbertson
Director, Office of Science & Risk
(202) 586-7150
emsp@id.doe.gov
www.em.doe.gov/science

Tom Williams
EMSP Director, DOE-ID
(208) 526-2460
emsp@id.doe.gov
www.id.doe.gov/emsystems/emsp

Roland Hirsch
EMSP Director, Office of Science
(301) 903-9009
emsp@id.doe.gov
www.er.doe.gov