EPA
www.epa.gov/nrmrl
NRMRL
NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
GROUND WATER AND ECOSYSTEMS RESTORATION RESEARCH

Treatment of Source Zone Chlorinated Solvents Using Emulsfied Zero-Valent Iron Nanoparticles

Background

Source zone dense nonaqueous-phase liquid (DNAPL) serves as a persistent source of dissolved contamination and is a major impediment to cost-effective remediation and attainment of site closure. Effective treatment technologies are needed to remediate the source zones. One such technology is the use of emulsified zero-valent iron (EZVI), a surfactant-stabilized, biodegradable emulsion that forms emulsion droplets consisting of an oil-liquid membrane surrounding zero-valent iron particles in water. Increased destruction of chlorinated solvents may be achieved using EZVI through increased contact between the DNAPL and the nanosized iron, and by providing vegetable oil to augment biological degradation.

This project is a pilot field study that focuses on treatment of source zone chlorinated solvents (perchloroethylene and its degradation products) using EZVI nanoparticles at the Parris Island Marine Corps Recruit Depot, South Carolina. The joint project is an Environmental Security Technology Certification Program demonstration. The project is also a pilot program project under EPA's Office of Solid Waste and Emergency Response, and a project under Remediation Technologies Development Forum Permeable Reactive Barrier.

Objectives

- Evaluate the ability of two injection technologies (pneumatic and direct push) to evenly distribute the EZVI in the subsurface
- Evaluate dechlorination pathways (biotic versus abiotic)
- Identify and evaluate the mechanisms of formation of corrosion products of injected EZVI
- Evaluate the long-term performance of EZVI to decrease the DNAPL mass

Approaches

There are both field and laboratory components in this research. Field sampling and analysis are coupled with laboratory instrumentation and detailed analysis using a variety of techniques for wet-chemical and solid-phase characterization. Compound-specific stable carbon (^{13}C) and overall volatile organic chlorine (^{37}Cl) isotopes analysis will be performed on field-collected samples. The results will be compared before and after EZVI injection at the Parris Island site. Although both abiotic and biotic dechlorination reactions will result in enrichment of the heavier carbon isotope (^{13}C over ^{12}C) and heavier chlorine isotope (^{37}Cl over ^{35}Cl) in the residual fraction of

chlorinated solvents, there may be significant differences in the degree of the enrichment. These differences may be sufficiently large to be used to separate the biotic and abiotc degradation pathways. Identification of iron corrosion products will be performed and several analytical tools (XRD, SEM, FTIR, AFM, ICP-OES) will be used for this purpose. Well waters at the Parris Island site will be monitored for at least two years after EZVI injection.

Accomplishments to Date (June 2007)

Injection of EZVI was conducted in October 2006. Soil cores were taken immediately to evaluate the distribution of EZVI. Baseline characterization of ground water and sediments was undertaken before injection. Post-injection monitoring of ground water was performed in November and December 2006; January, March, and July 2007; January and July 2008; and March 2009. Data summary and interpretation are being conducted with respect to the changes in geochemistry of ground water and characterization of solid phases. A potential long-term outcome from this research would be development of novel approaches for site remediation and characterization of the extent and conditions under which nanoparticles may be transported in ground water. The results would enhance EPA's capability to meet new challenges of environmental significance.

Investigators

Robert W. Puls
U.S. EPA
Ground Water and Ecosystem Restoration Division
Ada, Oklahoma 74820
580-436-8543

Chunming Su
U.S. EPA
Ground Water and Ecosystem Restoration Division
Ada, Oklahoma 74820
580-436-8638

Collaborators

GeoSyntec Consultants

NASA

U.S. Navy