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RTDF Update

A Progress Report on the Remediation Technologies Development Forum (RTDF)

Results are in for Several RTDF Field Studies

INSIDE

About the RTDF

The Remediation Techncologies Development Forum (RTDF), which was established in 1992, is a consortium of partners from industry, government, and academia who are working together to develop safer, more effective, and less costly hazardous waste characterization and treatment technologies. For information on the RTDF and Action Teams visit the RTDF Home Page at http://www.rtdf.org

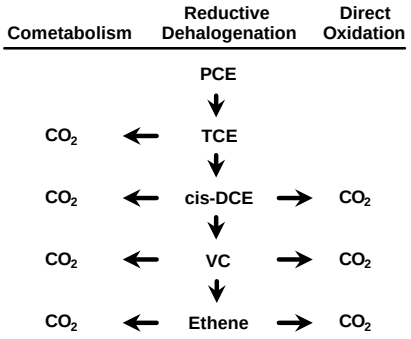
Intrinsic Bioremediation of TCE at Dover Air Force Base

In 1995, the RTDF Bioremediation Consortium initiated a Phase I field study at Dover AFB to test the effectiveness of intrinsic bioremediation of chlorinated ethylenes in groundwater. The goals of this four-year intrinsic bioremediation study are to evaluate whether trichloroethylene (TCE) is being destroyed through intrinsic bioremediation, to identify degradation mechanisms, and to develop and validate protocols for implementing the process at other sites.

The plume at Dover AFB occupies an area approximately 9,000 feet long and 3,000 feet wide and there are at least three sources of TCE in the area. Intrinsic bioremediation of perchloroethylene (PCE) and TCE is evident from the presence of daughter products such as cis-1,2-dichloroethene (DCE), vinyl chloride (VC), and ethene. Evidence for biotransformation is also supported by changes in chloride ion concentration. While total chloroethene concentrations decrease along the plume from 15 ppm to below 1 ppm, the dissolved chloride concentrations increase from 10 ppm (background level) to over 40 ppm. This increase is large enough to account for the entire observed loss of solvents. The chemical composition of the groundwater suggests that multiple biodegradation pathways are operating at the site. The central region of the plume appears to be anaerobic (dissolved oxygen is < 1 ppm), with iron reduction and methanogenesis as the dominant microbial processes. On the periphery of the plume and downgradient from the anaerobic region, dissolved oxygen concentrations increase from 1 to 5 ppm.

Microcosm studies conducted with materials collected from three areas within the plume confirm the potential for multiple degradation pathways. Soil/water samples incubated under anaerobic conditions exhibit reductive chlorination of PCE to ethene, consistent with the results of the groundwater analysis. In addition, microcosms prepared under aerobic conditions indicated that DCE and VC can also be oxidized by aerobic micro-organisms to carbon dioxide. The latter observations may explain why DCE and VC, although more mobile, have smaller lateral distributions in the groundwater as compared to TCE. The Consortium believes that there is clear evidence of reductive dehalogenation of TCE to DCE and that DCE is biodegraded

Multiple Biodegradation Pathways Operating at Dover AFB



by a combination of oxidation, co-metabolism, and reduction. The carbon source for reductive de-halogenation at the site is under investigation. In some areas the carbon source appears to be petroleum hydrocarbons; in other areas it could be natural organic matter in the soil.

The Consortium plans to conduct a second intrinsic bioremediation field study at the Strother Field Industrial Park Superfund site in Winfield, Kansas.

Based on the collaborative work accomplished to date and the expertise and knowledge of the participating companies and organizations, the Bioremediation Consortium has prepared a principles and practice manual on natural attenuation of chlorinated solvents. The document presents an overview of the current science and practice of natural attenuation of chlorinated solvents in an easy-to-use question and answer format. It is available on the World Wide Web (http://www.rtdf.org) and in print form. The Consortium plans to publish guidance handbooks for accelerated anaerobic bioremediation and co-metabolic bioventing in the future.

Accelerated Anaerobic Bioremediation Pilot Underway

The RTDF Bioremediation Consortium installed an accelerated *in situ* anaerobic pilot system at Dover AFB in June 1996. The goal of the pilot is to demonstrate microbial degradation of groundwater contaminated with PCE, TCE, and daughter products (i.e., DCE, VC, and ethene). Accelerated in situ anaerobic bioremediation is a technology that accelerates the indigenous anaerobic degradation of the chlorinated contaminants through nutrient addition and enhancement of anaerobic conditions in a controlled treatment area. The objectives of the pilot project are to: (1) demonstrate that degradation of PCE and/or TCE can be stimulated in the deep portion of the aquifer; (2) confirm that degradation will proceed through biogenic intermediates to nontoxic end products (*e.g.*, ethylene); (3) develop operation and cost data for a full-scale system; and (4) document methodologies for implementing the technology at other sites. The Consortium conducted laboratory studies to identify optimal substrate and nutrient concentrations to accelerate degradation at the site.

The pilot consists of two phases. The first phase involved laboratory testing of various redox conditions, amendments, and residence times to facilitate and accelerate microbial anaerobic reductive dehalogenation of the chlorinated solvents in the groundwater. The Consortium's efforts included laboratory microcosm as well as soil column tests.

Installing Wells at the Dover AFB Accelerated Anaerobic Bioremediation Test Site

The second phase of the pilot study involves hydrogeologic modeling and system design. This includes an active pumping system for adding amendments to the subsurface via injection wells and extracting the amended groundwater from a downgradient location for recirculation and reinjection. The system has been designed to operate at varying residence times, varying flow rates and varying amendment rates. Results from the laboratory testing indicated that bioaugmentation may be necessary to enhance complete dehalogenation in situ. This possibility has been discussed with State of Delaware and EPA Region 3 officials. If normal operation does not promote full dehalogenation, bioaugmentation (using microorganisms isolated from another site where active TCE biodegradation is occurring) may be pursued.

A numerical flow and transport model was used to simulate the flow field created by the injection/extraction system. Substrate degradation kinetics and dehalogenation degradation kinetics, as well as hydrogeological parameters were used in this model. Various modes of injection (e.g., continuous, pulsed) were modeled and investigated in the field to optimize system performance. The pilot is expected to continue through December 1997.

The Consortium is currently preparing a work plan for a second accelerated anaerobic field study to be conducted at Strother Field Industrial Park Superfund site. This study will investigate the accelerated anaerobic degradation of both TCE and trichloroethane (TCA).

Cometabolic Bioventing Study Initiated at Dover AFB

In June 1996, the RTDF Bioremediation Consortium initiated a cometabolic bioventing study at Dover AFB. This study is focused on the remediation of a TCE source area in the vadose zone through delivery of oxygen and a volatile cosubstrate such as toluene, methane, or propane. Microcosm studies were conducted with soil collected from the

Dover AFB site to determine whether the indigenous microorganisms were capable of cometabolically degrading TCE under aerobic conditions in the presence of a substrate. The laboratory studies compared TCE degradation rates using toluene, methane, propane, or butane as substrates. Toluene, methane, and propane were all shown to induce cometabolic degradation of TCE in the soil. Scale-up data, including degradation rates for TCE and consumption rates of toluene and propane were determined from the soil column studies. In these studies, the Consortium also assessed the mode of addition of substrate, comparing low flow continuous to pulsed addition.

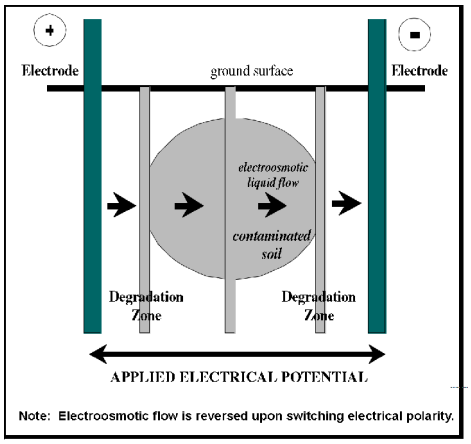
Based on laboratory study results, the Consortium designed and began installing the pilot-scale field study in March 1997. The test site is located adjacent to the jet engine maintenance building at Dover AFB, where TCE was used in the past for degreasing operations. The cometabolic bioventing system resembles a typical bioventing installation except that air is injected with the volatile cometabolite. A second cometabolic bioventing study is planned for Hill AFB, Utah. Soil was obtained from the site in February 1997, and laboratory studies using this soil are underway.

Lasagna™ Technology May be Selected for Cleanup Effort at DOE Facility

Based on the success of the Phase I test at the Department of Energy's Gaseous Diffusion Plant in Paducah (PGDP), Kentucky, the Lasagna™ Partnership initiated a Phase II-a study at PGDP to treat a TCE-contaminated area 20 ft wide x 30 ft long x 45 ft deep. (Approximately 100 yd^3 were treated in Phase I and approximately 1,000 yd^3 will be treated in Phase II-a.) If the Phase II-a study is successful, the Lasagna™ technology could be used to remediate the entire Solid Waste Management Unit (SWMU) at the PGDP facility (Phase II-b).

For the Phase II-a field test, three treatment zones, each filled with 20% iron by weight, were installed 5 feet apart. This study will investigate alternative emplacement methods, optimization of the treatment zones and electrical and hydraulic conductivity, the effectiveness of coupling electroosmosis with iron dechlorination, the mechanism and kinetics of dechlorination, and scale-up issues. The Phase II-a field study was initiated in June 1996 and the unit was stopped for a two-week sampling period in September. The unit was then restarted and will operate through the spring of 1997.

Vertical Configuration of the Lasagna™ Process



The results will be used to determine whether the technology will be used to remediate the SWMU. This decision will also be based on cost projections developed by the Lasagna™ Partnership. If DOE selects the technology, the Phase II-b effort will be initiated. It is expected that the test site will be 105 ft wide x 60 ft long x 45 ft deep (approximately 10,000 yd^3 treated). Four electrodes will be installed at 35 foot intervals with a total of 18 treatment zones between the electrodes. The Phase II-b system will operate at a rate sufficient to treat one pore volume every 6 months (required to observe a reduction in the TCE concentration). A model will be used to predict the voltage required to circulate one pore volume in 6 months. If initiated in 1997, the Phase II-b study could continue through 1999.

IINERT Action Team Plans Field Study

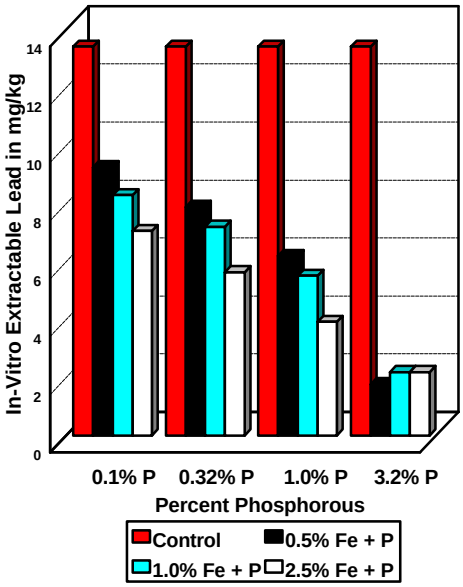
The RTDF In-Place Inactivation and Natural Ecological Restoration Technologies (IINERT) Soil-Metals Action Team (in conjunction with the U.S. Department of Agriculture, the Missouri Department of Natural Resources, and EPA Region 7) plans to initiate a field study at a site in Joplin, Missouri. IINERT refers to technologies that chemically or physically inactivate soil metals by reducing and essentially eliminating their solubility and bioavailability without the need for excavation.

The primary contaminants at the site are lead and zinc. Mining was conducted at the site until the early 1900s, followed by smelting operations until the 1940s. The one-acre test site, with lead levels of approximately 1,000 to 5,000 ppm, is located three to four blocks from the primary smelter. Lead bioavailability has been determined to vary significantly, with values as high as 30%.

Preliminary tests performed by the U.S. Department of Agriculture using lead-contaminated soil from the Joplin site (see graph on the following page) indicate that various levels of iron and phosphorous amendments may be effective in reducing the bioavailability of lead in the soil.

Bench-scale tests will be performed to identify the most promising IINERT treatments for the Action Team's study.

Effect of Different IINERT Treatments on Joplin, MO Lead-Contaminated Soil



The Action Team expects to investigate two different treatments via a microswine study, which will follow the EPA Region 7 protocol. A control, lead acetate addition, and treatments at three amendment levels will be investigated. Five microswine will be used for each test unit (a total of 25 microswine will be required per treatment investigation). The microswine study is expected to be completed 3 to 4 months after it is initiated. The amended soils fed to the microswine will be highly homogenized to establish a benchmark, against which the field results may be compared. In addition to the microswine study, the Action Team plans to investigate other surrogates, including rats and *in vitro* studies, to determine human bioavailability from soil ingestion. The Action Team also is considering an investigation of IINERT technology at a second site that is contaminated with mine tailings.

Permeable Barrier Field Study Scheduled for 1997

A design team for the RTDF Permeable Barriers Action Team has been advising the Air Force Environics Directorate on a field study to be conducted at Dover AFB to test the effectiveness of granular iron permeable zones to treat plumes contaminated with chlorinated solvents. The project is being funded by the Department of Defense Strategic Environmental Research and Development Program (SERDP). The original project proposal called for a side-by-side comparison of two funnel-and-gate systems, one containing granular iron and one containing another material. Candidates for the second gate would include iron plated with a small amount of a catalytic metal and iron mixed with a mineral such as troilite or pyrite that would serve to moderate the pH of the reactive bed, thereby decreasing the precipitates formed. The RTDF design team evaluated the existing laboratory studies of such materials and determined that none has yet been demonstrated to be worthy of *in situ* field testing. Therefore, the design team recommended that the focus of the pilot be shifted toward testing a novel means of installing a gate filled with granular iron, aimed at dramatically reducing the cost of installing permeable reactive barriers. Specifically, the design team recommended a side-by-side comparison of a gate installed by conventional excavation and one installed by jetting a slurry containing granular iron under high pressure— a modification of high-pressure jet grouting technique. The final pilot design is still being developed, with field installation expected in Fall 1997.

The RTDF Update

Copies of the RTDF Update and factsheets on the RTDF and its Action Teams can be obtained by faxing a request to FAX: (301) 670-3815 or by downloading the files from the RTDF Home Page at http://www.rtdf.org.

Sediments Remediation Action Team Investigates Potential Test Sites

The RTDF Sediments Remediation Action Team held its third meeting at the Army Corps of Engineers Waterways Experiment Station in Vicksburg, Mississippi, in late October 1996. Several Navy sites (including Port Hueneme) and some private sites are being considered for a collaborative sediments remediation field test.

Upcoming Conferences

In Situ and On-Site Bioremediation The Fourth International Symposium
April 28 - May 1, 1997
New Orleans, Louisiana
Tel: 1-800-783-6338

97th General Meeting of the American Society for Microbiology
May 4-8, 1997
Miami, Florida
Tel: 202-942-9248

U.S. EPA National Conference on Management and Treatment of Contaminated Sediments
May 13-14, 1997
Cincinnati, Ohio
Tel: 617-674-7374

The First International Conference on Remediation of Chlorinated and Recalcitrant Compounds
May 18-21, 1997
Monterey, California
Tel:1-800-783-6338 or 614-424-5461

IBC's Second Annual International Conference on Phytoremediation
June 18-19, 1997
Seattle, Washington
Tel: 503-481-6400