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CONTENTS

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ABOUT THIS ISSUE

This issue highlights innovative bioremediation technologies used to treat contaminated soils.

Cometabolic Bioventing Field Test Conducted at Dover Air Force Base

by Gregory Sayles, Ph.D., EPA/ National Risk Management Research Laboratory

Under stewardship of EPA's government/ industry collaboration, the Remediation Technologies Development Forum (RTDF) Bioremediation Consortium, a cometabolic bioventing demonstration was conducted during 1998-1999 at Dover Air Force Base in Dover, DE. Results of the demonstration have shown that 99% of the chlorinated organic contamination was removed through cometabolic bioventing. RTDF researchers are continuing to compile and disseminate information on the lessons learned during this demonstration, and to conduct similar testing at Hill Air Force Base in northern Utah.

Cometabolic bioventing is the injection of air and a cosubstrate into the vadose zone to promote *in situ* biodegradation of chlorinated solvents. Although the use of cometabolism for ground water treatment has been studied in the field for several years, the RTDF study is the first known field test of cometabolic bioventing.

The demonstration occurred adjacent to a jet engine maintenance area (Building 719) contaminated with trichloroethylene (TCE), 1,1,1-trichloroethane (TCA), and 1,2-*cis* dichloroethylene (DCE). Early laboratory tests using soil from this location showed that propane and toluene each performed well as cosubstrates, and propane was chosen for the demonstration. Testing indicated that 30 moles of propane were required to promote biodegradation of one mole of TCE.

The field system consisted of three injection wells screened to 10 feet below ground surface, which was the lowest expected elevation of the water table. Thirteen soil gas monitoring points, each of which were equipped with two gas probes, also were installed to monitor soil gas conditions throughout the demonstration. An additional 11 temporary soil gas monitoring points were installed for use during initial air permeability testing and for soil gas monitoring during operation of the system. Operation began with pulsed injection of propane in air over a three-month period in order to acclimate the microbial environment of the 600 square-foot test plot. Over the following 14 months, continuous injection of 0.03% (v/v) propane in air was applied at a rate of 1.0 feet^3/minute.

Statistical analysis showed that TCE, TCA and DCE were removed significantly during the test, with most final concentrations reaching below the detection limit of 6 µg/kg. As a product of chlorinated solvent biodegradation, deposition of chloride was used to demonstrate overall contaminant biodegradation. Chloride ion was found to accumulate at a median rate of 58 mg/kg of soil, for a total chloride accumulation rate of 10 times the initial amount present at the test plot. Based on these rates, it is estimated that a total of 13 kg of chlorinated solvents (in TCA equivalents) biodegraded as a result of the cometabolic bioventing process. Figure 1 provides histograms of the initial and final TCE and chloride concentrations during the demonstration.

Researchers found that an initial cosubstrate acclimation period prior to full operation of the system is required for effective use of propane as a cosubstrate

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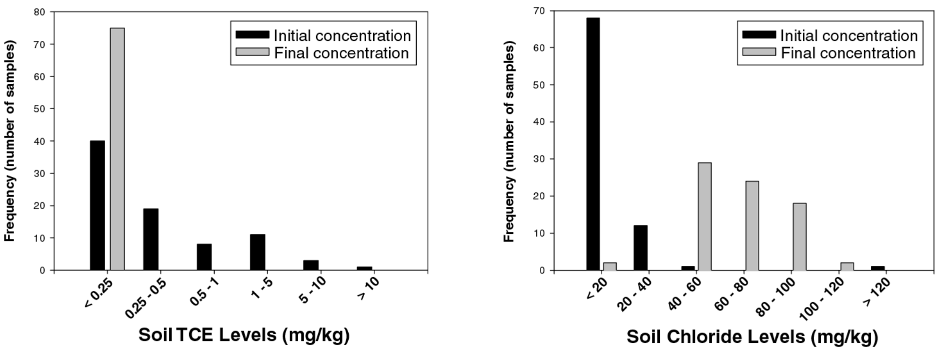
Figure 1. Histograms of Initial and Final TCE and Chloride Concentrations



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during the bioventing process. It was also recognized that reliance on the use of indirect measures of biodegradation (such as chloride accumulation) rather than direct measures highlights the need for innovative approaches to proving that biodegradation occurs in the field.

Although detailed costing of this technology is not yet available, aerobic bioventing of fuel contamination typically costs $5-25/yard[3]. Cometabolic bioventing incurs additional costs for elements such as the cosubstrate and additional monitoring, but these expenses are expected to be less than $10/yard[3].

Dover Air Force Base is considering full-scale application of this technology to complete vadose-zone remediation at Building 719. Visit the RTDF Web site at www.rtdf.org for more information, or contact Dr. Gregory Sayles (EPA/National Risk Management Research Laboratory) at 513-569-7607 or e-mail sayles.gregory@epa.gov.

Anaerobic/Aerobic Composting for Removal of Pesticide Contaminants

by Brad Jackson, EPA/Region 4, and Frank Peter, Stauffer Management Company

Field demonstration of a unique composting process was completed recently at the Stauffer Management Company (SMC) Superfund site in Tampa, FL. This process, known as Xenorem™, uses anaerobic and aerobic cycles to bioremediate pesticide-contaminated soil via indigenous bacteria and the addition of amendments. The demonstration resulted in an overall destruction rate of 90% for all contaminants of concern (chlordane, DDD, DDE, DDT, dieldrin, toxaphene, and molinate). Based on these results, this technology now is being used to remediate approximately 16,000 cubic yards of soil at the SMC Tampa site and in other full-scale commercial applications.

The field demonstration was conducted in an enclosed warehouse at the SMC Tampa manufacturing facility using soil taken from two areas with high concentrations of pesticides. Preparation for the tests included the installation of an odor abatement system and an ambient air monitoring system. Tests began in June 1997 with the construction of a uniformly-mixed, 905 cubic-yard pile of the excavated soil, which had been run through a two-inch screen. Locally-available cow manure and straw were added as amendments to the soil to create an environment with high levels of nutrients and to maintain desired conditions of temperature, oxygen, pH, and nutrient availability.

The pile was covered with a 40 mil 30-by-60-foot woven tarp to begin the anaerobic cycle. The testing period was extended until September 1998 in order to provide sufficient time for experiencing hot and cold weather operations, assessing the quality of the amendments, and using various mixing equipment such as a loader, roto-tiller, and Fecon and SCAT turners. Amendments were added at weeks 0, 14, 22, 33, and 48 to create a total volume of 1,193 cubic yards after week 48. Aerobic conditions in the pile were created by either mechanically mixing and turning the windrow or by injecting compressed air through injectors spaced 15 feet apart along the length of the pile. Aerobic and anaerobic operating cycles were varied to maximize contaminant destruction rates. Key operating parameters of the process included a pH of 5-9, residence time of less than six months, temperatures of 35-60^{0}C, and a moisture content of 30-90%.

Soil samples were collected weekly from four locations of the pile, and analyzed for pesticide content, inorganic composition, microbial enumeration, moisture and dry matter, organic matter, pH, surface tension, thiocarbamates, and water-holding capacity. Laboratory analysis indicated that targeted cleanup levels, as specified in the site's record of decision, were achieved for the primary contaminants of concern. In particular, concentrations had dropped significantly for chlordane (47.5 mg/kg to 5.2 mg/kg), DDD (242 mg/kg to 23.1 mg/kg), DDT (88.4 mg/kg to 1.2 mg/kg), and toxaphene (469 mg/kg to 29 mg/kg). Figure 2 illustrates the typical DDT destruction rate observed during this demonstration.

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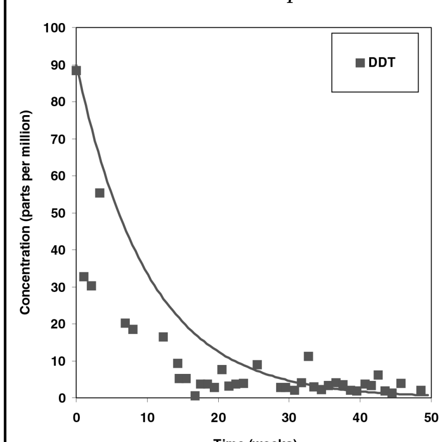
Figure 2. Typical DDT Destruction Rate at the SMC Tampa Site



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Of the five amendment periods employed, two were identified as operating under optimal environmental/process conditions. Researchers found that the mixing equipment and duration of mixing steps is critical to the efficiency of this technology. (The SCAT turner proved to serve as the more efficient turner of the composted material.) Although costs are very site-specific, SMC estimates that the cost for cleanup using Xenorem composting at a project such as this is $192/yard^3.

Based on its successful use in pesticide destruction, application of Xenorem technology has been extended to include nitro-aromatics (TNT, RDX, and MX), polyaromatic hydrocarbons, polychlorinated biphenyls (in development) and other persistent compounds. For more information, contact Brad Jackson (EPA/Region 4) at 404-562-8925 or e-mail jackson.brad@epa.gov, or Frank Peter (SMC) at 302-239-9222 or e-mail jfpeter@aol.com.

Anaerobic Bioremediation of Soil on Tribal Lands

by Jeff Inglis, EPA/Region 9, and George Padilla, Navajo Nation Superfund Program

The Navajo Nation, through its Superfund Program , has teamed with the U.S. EPA's Region 9 Office and the Environmental Response Team (ERT) to remediate soils on tribal lands contaminated with toxaphene, the active constituent of livestock dipping solutions used in the past. At these sites, anaerobic bioremediation through the addition of a multi-part amendment to excavated soils is resulting in a minimum of 80% reduction of toxaphene. Remediation using this process is complete at 22 dip vat sites located on the Navajo Nation lands.

In the 1930s, the Department of the Interior established laws and programs for livestock grazing, and the Bureau of Indian Affairs (BIA) began administering and managing these programs on many tribal lands. Toxaphene was used by the BIA and the Navajo Nation as a pesticide at 250-300 dip vat sites on Navajo lands from 1948 to 1982, when it was banned by the EPA. During this time, sheep and cattle were driven routinely through concrete-lined vats that were positioned partially below grade level and filled with pesticide solutions for the control of ectopic parasites. Approximately 20,000 gallons of the pesticide solution was used each year, and then discharged on-site into ground-level pits. These management practices ceased in the 1980s, but toxic residues had accumulated over the years as a result of pesticide discharge. This pattern was repeated at several other reservations in the Southwest.

In 1992, the Navajo Superfund Program expressed its concerns regarding these sites to EPA's Region 9 Office. As a result, the ERT began researching the potential for an *in-situ* or on-site bioremediation method to treat the sites. A comparison study was conducted to evaluate the effectiveness of anaerobic processes versus combined anaerobic/aerobic processes. Study results indicated that an anaerobic process would achieve the targeted toxaphene cleanup level (25 parts per million for buried soil) in the most cost-effective manner.

In 1994, the EPA Region 9 Emergency Response Office began implementing this anaerobic process for treatment of soils at a dip site located at Nazlini Chapter, near Window Rock, AZ. With toxaphene levels as high as 33,000 parts per million, this site ranked highest on the BIA's list of 22 priority sites. In the area of each dip vat, remediation efforts began with soil screening to determine the horizontal and vertical extent of contamination, followed by excavation of up to four feet of soil and its transfer to a polyvinyl chloride (PVC)-lined treatment cell. A slurry consisting of 10% manure, 5% lime, 5% blood meal, 0.75% disodium phosphate, 0.25% monosodium phosphate, and 79% contaminated soil was mixed with water and poured into the treatment pit. The pit then was sealed with a PVC cover, and vents were installed to allow for gas emissions.

Over the following 12-month resting period, indigenous bacteria were allowed to multiply while feeding on the toxaphene. Quarterly samples were taken to ensure the progression of contaminant biodegradation. Once target levels were achieved, the pits were opened, drained, left to dry, backfilled, and revegetated. Follow-up sampling has confirmed that toxaphene cleanup levels have been maintained.

Based on the successful results at Nazlini, this anaerobic bioremediation process was applied at the remaining 21 high-priority dip vat sites in treatment cells as long as 300 feet. The Navajo Superfund Program has evaluated an additional 48 dip vat sites on Navajo lands, and currently is working with the BIA to develop a long-term cleanup plan for the remaining sites. It is anticipated that this approach to anaerobic bioremediation may be applied successfully to the remediation of other chlorinated solvents and pesticides, such as DDT. An environmental videotape on this work (*Navajo Vats II*) is available through the ERT products line offered at www.ert.org. For more information, contact Jeff Inglis (EPA/Region 9) at 415-744-2348 or e-mail inglis.jeff@epa.gov, or George Padilla (Navajo Nation Superfund Program) at 520-871-6861 or e-mail ggpad@cia-g.com.

[This technology, using a more refined slurry recipe, also has been piloted at two aerial pesticide spraying facilities and used to treat dip vat sites on the Zuni and Pueblo Reservations. Information on using this technique for treatment of pesticide-contaminated soil on the Zuni Reservation is available from Michael Torres (EPA/Region 6) at 214-665-2108 or e-mail torres.michael@epa.gov.]

Upcoming Monitoring Technology Conference

On September 19 and 20, 2000, EPA will sponsor the National Environmental Monitoring Technology Conference at the Hynes Convention Center in Boston, MA. More than twenty panel sessions will be held on topics such as surface water, ground water, and watersheds; ozone and air monitoring; innovative technology verification; hazardous substance

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monitoring in soils; and technology commercialization.

EPA program offices will be represented by plenary speakers from the National Exposure Research Laboratory, Technology Innovation Office, Environmental Monitoring Public Access and Community Tracking Program, Environmental Technology Verification Program, Small Business Innovative Research Program, and Center for Environmental Industry and Technology.

During the conference, over 100 exhibitors will display information on environmental monitoring and related technologies. To register for exhibit space at the trade show, call 1-888-EPA-7341. Conference registration information is available on the Internet at www.epa.gov/region1.

New Resources Available on EPA's CLU-IN Web Site

The Hazardous Waste Clean-up Information (CLU-IN) Web site, which is managed by EPA's Technology Innovation Office, provides information on innovative treatment technologies to the hazardous waste remediation community. Visit CLU-IN at www.clu-in.org to obtain more information on resources such as these:

An Analysis of Barriers to Innovative Treatment Technologies: Summary of Existing Studies and Current Initiatives. This report (publication number EPA 542-B-00-003), which was published in March 2000, presents a summary of existing studies on barriers that have historically impeded the successful commercialization of innovative treatment technologies. Users may download the document at http://clu-in.org/pub1.htm.

Innovative Remediation Technologies: Field-Scale Demonstration Projects in North America, 2nd Edition. This updated system provides a searchable database of information about innovative remediation technology field demonstration projects conducted in North America. Users may search or browse the system at http://clu-in.org/pub1.htm.

Upcoming Courses and Conferences. This feature of CLU-IN provides users with the capability to search for courses and conferences by date, name, location, or description from among 172 currently-posted events. Users also may suggest the addition of an event not yet listed in the system. This feature is available at http://clu-in.org.

Errata

The correct Web site for the Sediment Management Work Group, as referenced in the February 2000 issue of *Tech Trends*, is: www.smwg.org.

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