United States
Environmental Protection
Agency

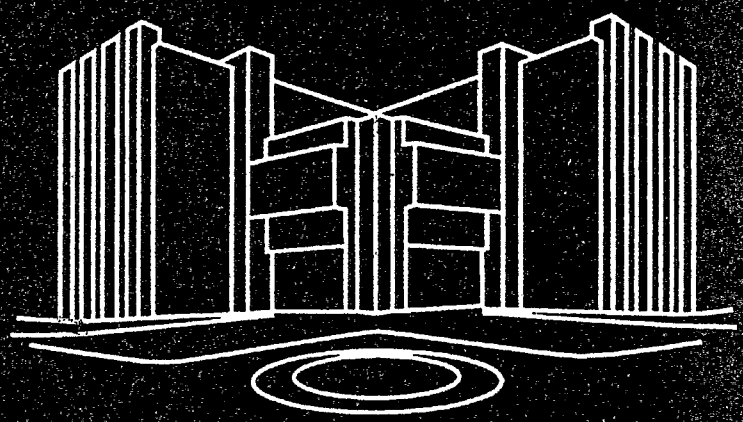
Office of Research and
Development
Washington, DC 20460

EPA/540/F-98/501
August 1998

EPA

Land Remediation and Pollution Control Division

Science and Technology to Treat Contaminated Soils, Sludges, and Sediments



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NRMRL

National Risk Management Research Laboratory

Mission

Advance the scientific understanding and the development and application of technological solutions to prevent, control, or remediate important environmental problems that threaten human health and the environment.

Vision

To be world leaders in developing sound technological solutions for reducing environmental risks.

Description

One of five national laboratories/centers within the U.S. Environmental Protection Agency's Office of Research and Development, the National Risk Management Research Laboratory (NRMRL) is headquartered in Cincinnati, OH. Other NRMRL research facilities are located in Research Triangle Park, NC; Ada, OK; and Edison, NJ. A Technology Coordination Office for NRMRL is in Washington, DC.

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Land Remediation and Pollution Control Division

Mission

Advance the scientific understanding, development, and application of technologies and methods for treating and remediating contaminated land sites.

Description

The Land Remediation and Pollution Control Division (LRPCD) is one of six divisions within NRMRL. Through its three branches LRPCD identifies, develops, evaluates and demonstrates methods, systems and technologies to control or remediate contaminated land sites and related land areas. Legislation supported by the division includes SARA, RCRA, CWA, TSCA, and FIFRA. The Division collaborates closely with other NRMRL divisions and maintains a close working relationship with trade and professional organizations and academia.

Research is conducted at the basic level, including bench- and pilot-scale, to provide new technologies and treatment methodologies for innovative solutions to current and future land pollution problems. Field evaluation of innovative technologies, covering applied research, demonstration, and verification

programs are performed to ensure that the environmental industry is developing reliable and cost-effective alternatives for the domestic, federal, and international markets.

A strong technical assistance capability for both Superfund and non-Superfund contamination round out the division's capability to provide relevant support to EPA's Regional and Program Offices, state regulatory authorities, and other federal agencies. The division conducts program activities through a variety of mechanisms including in-house research; extramural research through cooperative agreements with academia and nonprofit organizations; interagency agreements with other federal entities (e.g., USDA, DOE, US Air Force); and contracts with environmental consultants and for-profit companies.

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Treatment and Destruction Branch (TDB)

MISSION

Develop, evaluate, and demonstate cost-effective treatment strategies for bioremediating hazardous waste contamination encountered in soil, sediments, industrial effluents, and the atmosphere and oil contamination from marine, estuarial, and freshwater spills.

Manufactured Gas Plant Site Remediation

Since 1995, the Treatment and Destruction Branch has been involved in evaluating the effectiveness of different biotreatment strategies for treating PAH contamination in soil. The most recent studies have involved bench-, pilot-, and field-scale research on PAH-contaminated soil from two former manufactured gas plants. Large samples of soil obtained from each site are transported to EPA's fully permitted Test and Evaluation Facility in Cincinnati and homogenized. The blended material is then available for use in the separate processes.The pilot-scale processes studied thus far include land treatment, composting, biopile treatment, and bioslurry. Treatment trains consisting of one or more of these processes will also be studied. In addition, tertiary treatment of previously biotreated soils including

phytoremediation and abiotic processes such as addition of Fenton's Reagent will be investigated. At the field scale, bioventing and natural attenuation have been evaluated. Additional field work to evaluate land treatment, composting, and phytoremediation will be carried out at a former manufactured gas plant near Cincinnati. This study is expected to provide information on both cost and performance.

Contaminated Sediments Treatment

Since 1996, the Treatment and Destruction Branch has been investigating cost-effective ways to treat contaminated sediments. Working with the Corps of Engineers, studies are under way to investigate ways to treat contaminated sediments that are currently retained in Confined Disposal Facilities (CDFs). Cost-effective treatment is needed to reclaim existing CDF capacity which is dwindling. A pilot-scale evaluation of biotreatment strategies for contaminated sediments from the East River in New York is currently under way. Also, working with the Corps of Engineers, plans are under way to initiate field work at a CDF on the shore of Lake Michigan. In other studies, bench-scale tests are evaluating innovative techniques for encouraging the anaerobic degradation of contaminated sediments using either hydrogen or

zero valent iron. In addition, work is under way to develop new ways to measure contaminant biodegradation using isotope ratio mass spectrometry. Natural attenuation is being given increasing consideration as a remediation option at sites in which sediments do not need to be dredged for navigation purposes. Field studies are being initiated to investigate the efficacy of natural attenuation at a sediment site in Michigan, and possibly two other sites. The results of this field work will provide valuable decision support information for site owners/managers faced with determining when natural attenuation can be used.

Treatment Technology Development

The Treatment and Destruction Branch is actively involved in developing cost-effective *in-situ* treatment strategies for remediating contaminated sites. Most research involves biotreatment processes, although studies are also investigating the use of Fenton's Reagent as a polishing step. One of the more successful technologies TDB has been involved in developing is bioventing.

Bioventing

Bioventing is an *in-situ* bioremediation process that promotes aerobic degradation of organic contaminants in vadose zone soils. Air is pumped

into the vadose zone where it spreads throughout the subterranean treatment area. Air flow must be at such a rate that the oxygen supply meets the demand of microorganisms and minimizes volatilization of volatile contaminants. NRMRL has been a key developer of the bioventing process. EPA has completed and is conducting intensive field research projects including a full- scale study to treat jet fuel at Hill Air Force Base near Salt Lake City, Utah, and a cold climate study at Eielson Air Force Base near Fairbanks, Alaska. Based on EPA's, and other's field experience with bioventing, a design and operating manual, *Bioventing Principles and Practices,* has been jointly prepared by EPA and the U.S. Air Force.

Evaluation of Composting Techniques for Effective Treatment of Hazardous Waste

Bioremediation of contaminated soil in static piles and windrow systems has been shown to be an effective technology for destroying certain toxic chemicals. To ensure the proper use of this technology an improved process control is required to ascertain pollutant degradation rates and identify optimum operating conditions for biodegradation of various contaminants in differing soil types. Studies using fully enclosed reactors are collecting data on the fate

of toxic chemicals during soil composting. Research parameters of interest include aeration, moisture dynamics, heat production, and physical and chemical properties of the compost mixture. Optimum temperature conditions may vary depending on a number of conditions. Aeration studies will investigate roles of anaerobic and aerobic metabolism in chemical degradation. The research program will attempt to identify optimal aeration rates and pile mixing frequency for the most effective conditions for biodegradation of recalcitrant substrates. Emphasis will be placed on diagnosing population changes throughout the treatment cycle and identifying microbial species responsible for biodegradation of contaminants.

Oil Spills Research

Since the 1989 grounding of the Exxon Valdez tanker in Alaska, oil spill remediation research has been conducted by the Treatment and Destruction Branch. A protocol was developed for objectively testing the biodegradation effectiveness of oil spill bioremediation agents. A new Most Probable Number method of quantifying alkane and aromatic degraders was also developed and published. A respirometric microcosm was constructed and used in experiments defining minimum nitrogen requirements for marine shoreline bioremediation under tidal

flow conditions. The first permit to release crude oil onto a Delaware beach was obtained for the purpose of studying oil spill bioremediation under controlled field conditions. Results were definitive, and bioremediation effectiveness was proven. A real bonus from the project was the establishment of a link between laboratory research and the field with respect to oil analyte biodegradation rates.

More recently, investigations have begun on freshwater and wetland spill remediation. During the summer of 1999, another controlled spill will be conducted to study bioremediation along a river shoreline. A current study jointly with the Tennessee Valley Authority will investigate the remediation of oil-contaminated wetlands. Also planned is a study to investigate the recovery of oil-contaminated salt marshes.

Future plans call for studies involving the biodegradation of non-petroleum oil. One aspect will be to determine the nature of any by-products formed as these substances degrade in the environment.

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For more information about the TDB Program, check out the Internet Web Site at:
http://www.epa.gov/ORD/NRMRL/irpcd/tdb

Remediation and Containment Branch (RCB)

MISSION

Develop a rigorous understanding of the basic processes, capabilities, and limitations of physical, chemical, and biological approaches to destruction, separation, or containment of contaminants in soil and sediment systems. Major technical areas encompassed within this Mission are:

Lasagna™ Technology

The Lasagna™ process, so named because of its treatment layers, combines electroosmosis with treatment zones that are installed directly in the contaminated soil to form an integrated *in situ* remedial process. In the horizontal configuration, electrodes and treatment zones are placed in the soil through a hydraulic fracturing technique. Conceptually, the Lasagna™ process would be used to treat organic and inorganic contaminants, as well as mixed waste, completely *in situ*. A pilot test was begun in FY97 to apply the process at a TCE-contaminated site. Test cells were established to study bioremediation and dechlorination using zero valent iron. A natural attenuation control cell is also being observed. Additional TCE degradation field tests are being conducted on a larger scale during 1998.

Soil-Contaminant Interactions

In order to understand and predict the success of various restoration or land use scenarios, it is necessary to study the mechanisms by which contaminants move through or bind to soils and sediments. Research in the laboratory and at field sites is attempting to address the behavior of organic and inorganic soil contaminants in the environment. Studies include separation kinetics for a number of compounds preliminary to application and refinement of models, application of electroosmosis and reductive dechlorination for degradation of TCE, and use of phosphate compounds and other soil amendments (including sewage sludge) for reduction of mobility and bioavailability of metals such as lead and cadmium.

Containment Systems

For years landfills and waste disposal sites have relied on the use of hydraulic control, liner materials, caps, and covers for contaminant isolation or containment. Work currently in progress is evaluating the efficacy of these engineered systems and the applicability of newly developed geosynthetic membranes, landfill designs, and cover options. Water balance covers, for example, allow some surficial penetration of water but rely on mechanisms such as evapotranspiration to eliminate deeper penetration which could potentially mobilize contaminants contained at

deeper levels in the subsurface. Further work is required to address the subject of submerged containment systems that may be necessary for control of sediments in coastal regions.

Phytoremediation

Phytoremediation uses locally grown plants and trees to enhance the microbial degradation of contaminants and/or hydraulically control contaminant movement in soil and aquifers. With plants, bioremediation appears to occur primarily in the rhizosphere (soil that surrounds the roots of a plant) through a combination of bacterial and fungal activity whereby plants can degrade organic pollutants indirectly by supporting microbial communities. With trees, contaminant removal appears to proceed through a combination of root zone degradation and uptake whereby contaminants are concentrated in the plant tissue. The contaminants can then be removed and disposed separately, leaving the soil clean. Adequate quantities of soil gas oxygen are required to ensure that aerobic conditions enhance rhizosphere degradation. Additional research, complementing EPA's efforts, continues to develop plant species that tolerate contaminants and which show potential for

contaminant destruction, removal, or immobilization. Field studies are under way in Oregon, Utah, Texas, and Ohio to demonstrate and evaluate efficacy and cost.

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SITE Management Support Branch

Mission

To provide engineering and scientific assistance to EPA Regional Offices, Program Offices, and others associated with Superfund and RCRA Corrective Action Sites. The Branch addresses all areas of technology involving remedial treatment.

Engineering Technical Support Center

The Engineering Technical Support Center (ETSC) is part of the Technical Support Project, a joint effort by OSWER, ORD, and the regions to provide technical assistance to Regional Project Managers implementing the Superfund program. The ETSC responds to site-specific requests from the regions to assist with selection, evaluation, design, and implementation of cleanup actions. The range of assistance projects covers technical reviews of work plans and reports, screening of technologies, conduct and oversight of sampling and characterization, treatability tests, technical input for unilateral and consent orders, and oversight of remedial action. Two to three hundred assistance actions are completed annually. ETSC also provides technical support to the

Program Office on program and policy development related to cleanup technologies and site remediation; assistance is also provided for RCRA, Brownfields, and voluntary cleanup sites.

For more information about the Technical Support Project, check out the Internet Web Site at:

http://www.clu-in.com/tsp/tsp.htm

Superfund Technical Assistance Response Team (START)

START provides in-depth, ongoing technical support to remedial Project Managers for Superfund sites. A START project is a partnership between Regional and ORD staff to work cooperatively to accomplish specific phases of work at the site, such as technology screening through remedy selection or Record of Decision through post-remedy monitoring.

START support is provided for highly complex or high profile sites, potential applications of innovative remedies, and sites where remedial action is expected to be costly or controversial. Recent sites include a 400-square-mile hardrock mining complex and several wood treater sites with multiple inorganic and organic contaminants. START actions have

assisted Regions in restarting stalled remedial actions, selecting innovative technologies, meeting strict timetables, and achieving documented cost savings.

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Cross Branch Programs

Part 1: SITE Program

Introduction to the SITE Program

The U.S. Environmental Protection Agency's (EPA) Superfund Innovative Technology Evaluation (SITE) Program was established by the Agency's Office of Research and Development (ORD) and Office of Solid Waste and Emergency Response in response to the 1986 Superfund Amendments and Reauthorization Act, which recognized a need for an "Alternative or Innovative Treatment Technology Research and Demonstration Program." The SITE Program is administered by ORD's National Risk Management Research Laboratory, headquartered in Cincinnati, Ohio. The SITE Demonstration Program encourages the evaluation and implementation of (1) innovative treatment technologies for hazardous waste site remediation and (2) monitoring and measurement of environmental parameters related to technology evaluations. In the SITE Demonstration Program, the technology is field tested on hazardous waste materials. Engineering and cost data are gathered on the innovative technology

so that potential users can assess the technology's applicability to a particular site. Data collected during the field demonstration are used to assess the performance of the technology, the potential need for pre- and post-processing of the waste, applicable types of wastes and waste matrices, potential operating problems, and approximate capital and operating costs. At the conclusion of a SITE demonstration, EPA prepares an Innovative Technology Evaluation Report, Technology Capsule, and Demonstration Bulletin. These reports evaluate all available information on the technology and analyze its overall applicability to other site characteristics, waste types, and waste matrices. Testing procedures, performance and cost data, and quality assurance and quality standards are also presented.

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For more information about the SITE Program, check out the Internet Web Site at:
www.epa.gov/ORD/SITE

Part 2: Contaminated Sediments Program

EPA's recent National Sediment Quality Survey reported that about three-quarters of the watershed sampling stations showed an intermediate or higher probability of adverse effects on aquatic life or human health. Aquatic sediments represent the ultimate repository for many contaminants in surface waters from point and nonpoint sources. Removal and/or treatment of the sediments may be necessary in order to guarantee the future health of the ecosystem. Characteristics unique to sediments (e.g., high moisture content, small particle size, and significant organic fraction) present numerous difficulties for existing remediation technologies. These characteristics, coupled with the relatively low contaminant concentrations and large volumes requiring treatment, make the majority of existing technologies impractical from either an operational or economic point of view. Research is needed to evaluate the performance of existing sediment management options, including dredging, disposal, and treatment. Research is also needed to develop new sediment management options for those situations where current options are either ineffective in adequately

reducing risk or are not cost-effective. LRPCD has selected four focus areas for research on managing risks from contaminated sediments. The first area is improving our basic understanding of the fate and transport of contaminants in sediments, specifically how intrinsic processes influence risk. This area includes investigation of how natural attenuation processes reduce the health or environmental effects of the contamination over time (dilution, dispersion, microbial transformation, deposition of clean sediments etc.). The other three research areas involve development and/or evaluation of management approaches based on the location of the sediments and treatment/containment operations: *in situ*, in confined disposal facilities, and *ex situ*. Research is targeted specifically at persistent contaminants, including PAHs, PCBs, and metals.

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