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U.S. Environmental Protection Agency

Office of Solid Waste and Emergency Response

Office of Research and Development

BIOREMEDIATION IN THE FIELD

An information update on applying bioremediation to site cleanup.

Prepared Bed Land Treatment Effective in Remediating Wood Preserving Wastes at Libby Site

Data collected over a 2-year period indicate that prepared bed land treatment was effective in reducing concentrations of wood preserving contaminants to target remediation levels at the Champion International Superfund Site in Libby, Montana. At this site, where a former wood preserving facility had contaminated the soil with polycyclic aromatic hydrocarbons (PAHs) and pentachlorophenol (PCP), EPA's Bioremediation Field Initiative provided support for an evaluation of a prepared bed land treatment system consisting of two 1-acre, lined land treatment units (LTUs). The purpose of the evaluation was to assess LTUs' treatment effectiveness, treatment rate, and detoxification of the contaminated soil. Utah State University (USU) designed and conducted the evaluation with support and technical direction from EPA's National Risk Management Research Laboratory (NRMRL).

Prior to the study, Champion International excavated the primary sources of contamination at the Libby site and moved the contaminated soils to a waste pit. The company constructed two LTUs, lining and surrounding each with low-permeability materials to ensure containment of contaminated soils and leachate, and to control surface runoff. The company began operating the LTUs in 1991.

Six- to 12-inch layers of contaminated soils (lifts) were applied to each LTU. When target contaminant concentration levels were achieved, an additional lift was applied. Periodically, nutrients and moisture were added and the soil was tilled to

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Protocol on Natural Attenuation of Petroleum Hydrocarbons Now Available

Researchers involved in a joint effort of EPA's National Risk Management Research Laboratory (NRMRL) and the U.S. Air Force's Center for Environmental Excellence (AFCEE) Technology Transfer Division have released a two-volume report entitled, *Technical Protocol for Implementing Intrinsic Remediation With Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Ground Water*. This report was developed for Air Force personnel and their contractors, as well as for scientists and others working on ground-water remediation.

The report discusses intrinsic remediation—the use of natural attenuation to remediate contaminants in the subsurface. Natural attenuation is defined as the biodegradation, dispersion, dilution, sorption, volatilization, and/or chemical and biochemical stabilization of contaminants to effectively reduce contaminant

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Prepared Bed Land Treatment Effective in Remediating Wood Preserving Wastes at Libby Site

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increase oxygen transfer and promote aerobic degradation of the contaminants. Active treatment occurred from March to October each year.

Over the study period (1991 to 1992), soil samples from the LTUs were collected and analyzed to identify and measure the levels of target chemicals in the prepared bed system. In total, more than 300 soil samples from the surface soil and buried lifts were analyzed, generating more than 5,000 individual chemical concentrations for 16 PAHs and PCP. The collected data indicate that land treatment was effective in remediating the contaminated soils (see Table 1).

Table 1 Initial and 09/01/92[a] Concentrations of Target Contaminants in the Libby LTUs (All Lifts)

Contaminant	Target Concentration (mg/kg)	Mean Initial Concentrations (mg/kg)	Percentage of Samples Below Target Levels on 09/01/92
PAHs			
Naphthalene	8.0	1.1-4.5	~100%
Phenanthrene	8.0	<0.95-2.5	~100%
Pyrene	7.3	76-135	>80% in LTU 1; >85% in LTU 2
TCPAH	88	200-254	>90%
PCP	37	100-132	97% in LTU 1; 95% in LTU 2

[a] Date of the last sampling event.

To calculate treatment rates, a first-order degradation model was used to linearize the contaminant concentration data. Table 2 presents the pyrene, TCPAH, and PCP half lives and degradation rates calculated for individual and composited soil samples. Calculated half lives and degradation rates varied significantly from lift to lift because of variations in initial contaminant concentrations and the timing of sampling dates in relation to lift application/burial.

Contaminant concentrations in soil lifts on different sampling dates were analyzed further to determine whether treatment occurred after a lift was buried.

Table 2 Half Lives and Degradation Rates for Pyrene, TCPAH, and PCP

	Treatment Rates for LTU 2, Lift 1, Soil Samples				Range of Half Lives for LTU 1, Lifts 4 and 5, All Samples (Days)
	Composited Samples		Individual Samples		
Contaminant	Half Life (Days)	Degradation Rate, k (1/Day)	Half Life (Days)	Degradation Rate, k (1/Day)	
Pyrene	45	-0.0155	55	-0.0125	27-61
TCPAH	38	-0.0183	55	-0.0127	33-56
PCP	36	-0.0192	43	-0.0163	16-32

The fact that pyrene, TCPAH, and PCP concentrations in early lifts (e.g., LTU 1, Lift 1) continued to decline after application of subsequent lifts indicates that biodegradation continued after active treatment. Degradation occurred more slowly in buried lifts than during active treatment.

To determine whether soil toxicity declined with the contaminant levels, the toxicity of LTU soil samples was measured using the Microtox™ assay. Soil toxicity (EC_{50} values) declined significantly over time, and the reductions in EC_{50} corresponded with reductions in pyrene, TCPAH, and PCP concentrations. Soils remediated to target levels were detoxified to background levels.

Two chemical mass balance laboratory studies were conducted to obtain direct evidence of microbial degradation (mineralization) of target contaminants in site soil and to collect information about the role of other processes (e.g., volatilization) that could account for the apparent degradation of soil contaminants in the Libby site LTUs.

- A biological mineralization study designed to evaluate the extent and rate of mineralization of radiolabeled phenanthrene and PCP spiked into site soil.
- A biological mineralization and humification study designed to provide additional information about the distribution of radioactive carbon label in the soil, air, and solvent phases.

Both studies involved constructing microcosms to which LTU soil was added. Radiolabeled phenanthrene or PCP was then added, and the microcosms were maintained under simulated site conditions (i.e., with similar oxygen and nutrient levels). The microcosms were purged and aerated every 4 days, and the radioactivity of samples taken from traps in the microcosms was measured. These studies suggest that the contaminant-level reductions observed in the LTUs were attributable in part to mineralization by indigenous soil microorganisms.

Taken together, the results of the Libby site bioremediation field evaluation indicate that land treatment was effective in remediating select contaminants to target levels and in detoxifying contaminated soils to background levels.

For more information on the prepared bed land treatment system used at Libby, contact Scott Huling of NRMRL at 405-436-8610 or access the Technology Support Center, Bioremediation Field Initiative—Libby, section of EPA's Kerr Laboratory Home Page on the Internet at http://www.epa.gov/ada/kerrlab.html.

Principles and Practices for Bioventing Now Available

EPA and the U.S. Air Force have jointly released *Manual: Principles and Practices of Bioventing* (EPA/540/R-95/534). This two-year collaborative effort documents the combined knowledge and experience of EPA's National Risk Management Research Laboratory, the Air Force's Armstrong Laboratory and Center for Environmental Excellence (AFCEE), Battelle Memorial Institute (the project contractor), and other researchers and practitioners from around the world. The manual, which was carefully reviewed by experts from government, academia, and industry, is a product of EPA's Bioremediation Field Initiative.

Bioventing is the process of forcing air through unsaturated soil at low flow rates to stimulate aerobic biodegradation of organic contamination. Because bioventing has predominantly been used to remediate petroleum contamination, such as jet fuel, gasoline, and fuel oil, the manual focuses on soil contaminated with petroleum. The basic framework described in the manual, however, should be useful for applying bioventing to other aerobically biodegradable contaminants.

The manual comprises two volumes: "Volume I—Bioventing Principles" and "Volume II—Bioventing Design." Volume I explains how bioventing works, including the physical processes that influence bioventing (e.g., soil gas permeability and contaminant distribution) and the microbial processes important to bioventing, such as the influence of environmental parameters on microbial kinetics.

The volume includes case histories of key field studies from the development of bioventing. Two of these case histories, the field studies at Eielson and Hill Air Force Bases, describe projects sponsored jointly by the Bioremediation Field Initiative and the Air Force.

Volume I concludes with an overview of the data collected in AFCEE's Bioventing Initiative, a program that tested bioventing at 135 sites. The data are compiled into a statistical model to examine the influence of environmental parameters such as nutrient concentrations, pH, soil moisture levels, and petroleum concentration on the rate of bioventing-induced biodegradation.

Volume II, the "how-to" portion of the manual, is based on the cumulative experience of the Bioventing Initiative, EPA's bioventing research projects, Battelle's experience at government and industrial sites, and other experiences from the literature. The volume details a well-tested approach to site characterization, system design, process monitoring, and site closure.

The first section, on site characterization, offers approaches to soil gas surveys, soil characterization, in situ respirometry, and soil gas permeability treatability tests. Gathering this information is essential when determining the feasibility of bioventing and takes a first step toward system design.

The next section, system design, explains how to determine the required air flow rates, well spacing, blower sizes, vent well, and soil gas monitoring point construction. The section discusses the advantages of operating with air injection, and identifies when air extraction might be a useful system configuration.

The essential elements of performance monitoring, the topic of the next section, are described in detail, including soil gas measurements and in situ respirometry. The section also covers monitoring techniques, such as surface emissions monitoring and the use of stable-carbon isotope ratio measurements to validate that biodegradation is occurring.

Volume II closes by describing how to determine when to shut down the bioventing system. Indispensable

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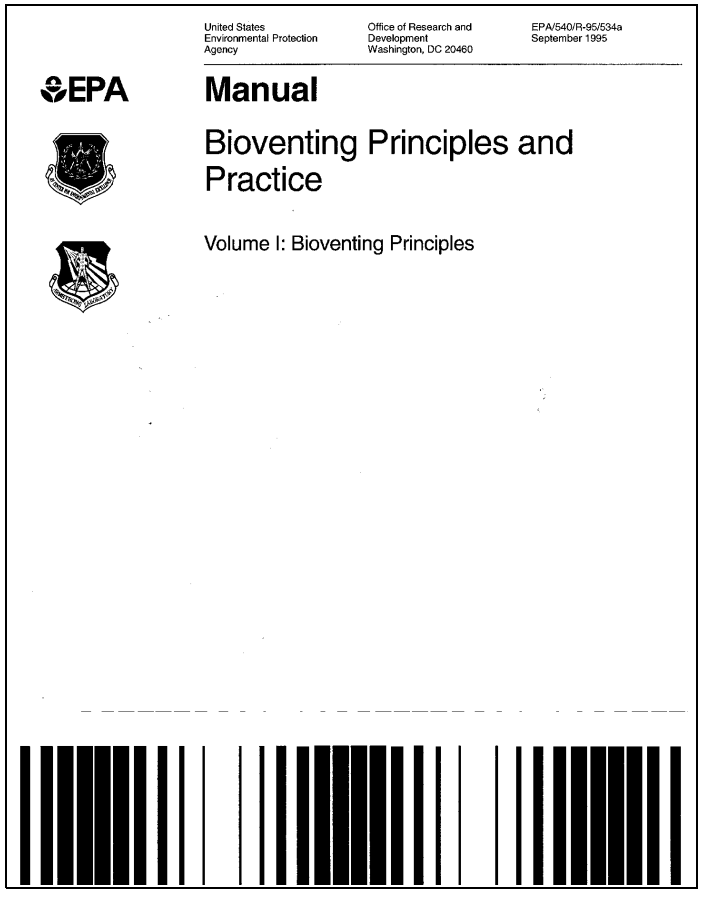

Protocol on Natural Attenuation of Petroleum Hydrocarbons Now Available

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toxicity, mobility, or volume to levels that are protective of human health and the ecosystem.

The report also presents a data collection and analysis protocol for evaluating the fate in ground water of fuel hydrocarbons that have regulatory standards. The use of this protocol, the report states, should in many cases demonstrate that natural attenuation can reduce the concentration of such contaminants below any applicable regulatory standards before significant exposure occurs. Based on experience at over 40 Air Force sites, the cost to fully implement this protocol ranges from $100,000 to $175,000, depending on site conditions.

The EPA/AFCEE report highlights several advantages that natural attenuation has over conventional engineered remediation technologies: 1) lower remediation costs for sites with low contaminant concentrations; 2) the transformation of contaminants to innocuous byproducts; 3) the technique's nonintrusive nature, which enables the continued use of infrastructure during remediation; 4) the absence of equipment limitations found with other, mechanized remediation techniques; and 5) the absence of risks that engineered remedial technologies present when transferring contaminants to the atmosphere. In addition, those fuel compounds that are the most mobile and toxic tend to be the most susceptible to biodegradation.

Because of these and other advantages, the AFCEE Remediation Matrix—Hierarchy of Preferred Alternatives identifies natural attenuation as the first option to be evaluated. The report does note the technique's limitations, however, including the potential for a relatively long timeframe for completion.

After discussing intrinsic remediation, Volume I of the report describes the protocol used to obtain scientific data to support the intrinsic remediation option, then offers a complete list of references. Volume II presents case studies describing the use of intrinsic remediation at two Air Force sites: Hill Air Force Base in Utah and Patrick Air Force Base in Florida. Appendixes to the report describe the collection of site characterization data and sampling and analysis procedures, provide an in-depth discussion of the destructive and nondestructive mechanisms of intrinsic remediation, cover data interpretation and pre-modeling calculations, and describe solute fate and transport modeling in support of intrinsic remediation.

This report will be available on the Internet at http://www.epa.gov/docs/ORD. For more information about the report, contact:

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Principles and Practices for Bioventing Now Available

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appendixes cover equipment specification and manufacturers that have been used successfully in the past, example procedures for conducting bioventing treatability studies, and off-gas treatment options for air-extraction systems.

The manual is useful for a wide audience. It will help state and federal underground storage tank regulators determine the applicability of bioventing at their sites and evaluate work plans for bioventing. Engineering firms with limited experience in bioventing will find the manual invaluable in gaining an understanding of the technology. Educators can use the manual to teach in situ bioremediation process design and operation to students. The manual will also be helpful for professionals whose work is associated with nonpetroleum contamination, such as that found at Superfund sites, as they consider the use of bioventing.

Manual: Principles and Practices of Bioventing is currently available on the Internet at http://www.epa.gov/docs/ORD. For further information, contact:

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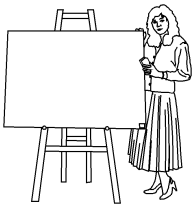
Symposium on Natural Attenuation of Chlorinated Organics in Ground Water, September 11-13, 1996 Hyatt Regency Dallas, Dallas, TX

A 3-day symposium on natural attenuation is being organized by the U.S. Environmental Protection Agency, the U.S. Air Force Armstrong Laboratory's Environics Directorate, Tyndall Air Force Base, Florida, and the U.S. Air Force Center for Environmental Excellence at Brooks Air Force Base, Texas.

Natural attenuation, the biodegradation and/or chemical destruction or stabilization of contaminants, can reduce contaminants to levels protective of human health and the ecosystem. The symposium is intended to increase participant's understanding of the natural attenuation process, to review methods for screening sites, and to help participants determine the feasibility of natural attenuation at sites contaminated with chlorinated solvents. The symposium will also obtain feedback from the regulatory and industrial communities on the appropriate application of natural attenuation and the developing protocol for natural attenuation of chlorinated organics.

Invited speakers will discuss the natural attenuation process, methods for assessing the process's potential for use at contaminated sites, and techniques for measuring results. Platform presentations will cover both laboratory studies and field demonstrations conducted in support of natural attenuation at government and industry sites.

To register for the symposium, please call Eastern Research Group, Inc. (ERG), at 617-674-7374.



Seminar Series on Bioremediation of Hazardous Waste Sites: Practical Approaches to Implementation

This technology transfer seminar series is sponsored by the U.S. Environmental Protection Agency's (EPA's) Biosystems Program, which coordinates EPA's research, development, and evaluation of full-scale bioremediation activities. The Biosystems Program strives to balance research on degradation processes with engineering activities that contribute to environmental cleanups. The seminars will take place in the following cities:

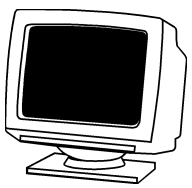
Chicago, IL	May 29-30, 1996
Kansas City, MO	June 4-5, 1996
Atlanta, GA	June 6-7, 1996
San Francisco, CA	June 18-19, 1996

This seminar series will provide participants with state-of-the-art information on the practical aspects of implementing bioremediation. The series will be divided into the following sections:

- In Situ Treatment of Soils, Sediments, and Shorelines
- Ex Situ Treatment With and Without a Reactor
- Natural Attenuation of Ground Water and Soils
- Treatment of the Subsurface

Each section will include discussion of advantages and limitations, materials handling, types of wastes amenable to the treatment process, and capital and O&M costs. The overall focus will be on applications in use in the field today, although the series will touch on processes that are nearing readiness for field use. The presentations will contain useful information for field personnel in bioremediation from federal, state, and local agencies, as well as for industry representatives, vendors, contractors, and academics. Although some background information will be provided, participants should have some experience with the technology.

To register for the seminar series, please call Eastern Research Group, Inc. (ERG), at 617-674-7374.



EPA Bioremediation Information Available On Line

Researchers and other individuals interested in gathering information about bioremediation research can now access EPA publications and other bioremediation-related information on the Internet.

Office of Research and Development (ORD) publications on bioremediation that are currently available at http://www.epa.gov/docs/ord/nrmrl/tdb.html include:

- Bioremediation Field Evaluation: Eielson Air Force Base, Alaska (EPA/540/R-95/533).
- Six Bioremediation Field Initiative Site Profiles: Bioremediation Field Initiative Site Profile: *Libby Groundwater Superfund Site* (EPA/540/F-95/506A), *Bioremediation Field Initiative Site Profile: Eielson Air Force Base Superfund Site* (EPA/540/F-95/506B), *Bioremediation Field Initiative Site Profile: Hill Air Force Base Superfund Site* (EPA/540/F-95/506C), *Bioremediation Field Initiative Site Profile: Public Service Company of Colorado* (EPA/540/F-95/506D), *Bioremediation Field Initiative Site Profile: Escambia Wood Preserving Site* (EPA/540/F-95/506G), and *Bioremediation Field Initiative Site Profile: Reilly Tar and Chemical Corporate Superfund Site* (EPA/540/F-95/506H).
- Bioremediation in the Field Electronic Questionnaire (EPA/540/F-95/508).
- Bioremediation of Hazardous Wastes: Research, Development, and Field Evaluations (EPA/600/F-95/076).
- Principles and Practices of Bioventing (EPA/540/R-95/534).
- Bioremediation in the Field Bulletin, No. 12 (EPA/540/N-95/500).

These documents are available in Portable Document Format (PDF) and require special viewing software called Adobe Acrobat Reader to access them. The Robert S. Kerr Environmental Research Laboratory (RSKERL) home page links to a site where users can download this viewing software free of charge.

RSKERL, which conducts extensive work on subsurface bioremediation, also maintains a home page at http://www.epa.gov/ada/kerrlab.html. The site, which is linked to the TDB home page, contains a number of useful information resources relevant to bioremediation:

- A weekly synopsis of RSKERL's activities and recent discoveries.
- The complete text of the Ground Water Issue Papers based on RSKERL research. Many of these papers are relevant to bioremediation techniques.
- An extensive bibliography of research articles on subsurface remediation.

ORD's Treatment and Destruction Branch (TDB) is also developing a WWW home page at http://www.epa.gov/docs/ord/nrmrl/tdb.html. TDB's home page, which will be on line by early June, will be a resource for a significant amount of bioremediation information.

After an introduction to the mission and goals of TDB, visitors to the home page will be able to view descriptions of the latest research that TDB's labs are conducting. Leading researchers from the labs will post outlines of their work, including studies of bioventing, in situ ground-water and soil bioremediation, and confined treatment for sediments. Users will be invited to contact these labs if they have questions or would like further information. TDB will update this information periodically as research in the labs progresses.

The TDB and RSKERL home pages add to the information available via the ORD electronic bulletin board system (BBS), which the Technology Transfer and Support Division has maintained for several years. On this BBS, users can join different conferences or forums dedicated to specific topics. The conferences also allow users to communicate via electronic messages with other BBS users. In addition, the BBS contains the ORD Bibliographic Database, which can be used to search all ORD publications dating back to 1976 by topic, author, or other category. The call-in number is 513-569-7610.

Back issues of *Bioremediation in the Field* can be ordered from EPA by calling 513-569-7562 and from NTIS by calling 800-553-6847. When ordering, please specify the issue and publication number.

Issue #	*Publication #*	*Issue #*	*Publication #*	*Issue #*	*Publication #*
1	NTIS PB91-228023	**5**	NTIS PB93-126175	**9**	EPA/540/N-93/002
2	EPA/540/2-91/007	**6**	EPA/540/N-92/002	**10**	EPA/540/N-94/500
3	NTIS PB92-224807	**7**	EPA/540/N-92/004	**11**	EPA/540/N-94/501
4	NTIS PB92-224708	**8**	EPA/540/N-93/001	**12**	EPA/540/N-95/500

To be added to the mailing list to receive *Bioremediation in the Field*, call 513-569-7562.

New Bioremediation Publications Released

Due to EPA's continuing resolutions and the lack of an operating budget, the Office of Research and Development (ORD) has limited ability to publish EPA documents. Below are a number of recently published papers that describe bioremediation research being conducted in ORD laboratories. Reprints of articles can be obtained by writing to the author whose name appears below in boldface type at: [Name of Author], U.S. Environmental Protection Agency, 26 West Martin Luther King Drive, Mail Stop 420, Cincinnati, OH 45268.

Bishop, D., and R. Govind. 1995. Development of novel biofilters for treatment of volatile organic compounds. In: Hinchee et al., eds. Biological unit processes for hazardous waste treatment. Columbus, OH: Battelle Press. pp. 219-226.

Fu, C., S. Pfanstiel, C. Gao, X. Yan, R. Govind, and **H.H. Tabak.** 1996. Studies on contaminant biodegradation in slurry, wafer, and compacted soil tube reactors. Environ. Sci. Tech. 30(3):743-750.

Fu, C., S. Pfanstiel, C. Gao, X. Yan, R. Govind, and **H.H. Tabak.** 1995. Studies on contaminant biodegradation in slurry, wafer, and compacted soil tube reactors. Environ. Sci. Tech. (December).

Gao, C., R. Govind, and **H.H. Tabak.** 1995. Predicting soil sorption coefficients of organic chemicals using neutral network model. Environ. Toxicol. Chem.

Glaser, J.A. 1996. Development of a versatile compost reactor system for treatment evaluation of hazardous waste. Presented at The Engineering Foundation's First International Conference on Bioremediation of Surface and Subsurface Contamination, Palm Coast, FL (January 21-26).

Glaser, J., and R.T. Lamar. 1995. Lignin-degrading fungi as degraders of pentachlorophenol and creosote in soil. In: Skipper, H.D., and R.F. Turco, eds. Bioremediation: Science and applications. SSA Special Pub. No. 43. Madison, WI: Soil Science of America, American Society of Agronomy, and Crop Science Society.

Govind, R., C. Gao, and **H.H. Tabak.** An automated system for simultaneous and continuous monitoring of oxygen uptake and carbon dioxide evolution in respirometric bioreactors. Special ACS Series Issue on Bioremediation. In preparation.

Gupta, M., M.T. Suidan, and **G.D. Sayles.** Modeling kinetics of chloroform cometabolism in methanogenic and sulfate-reducing environments. Water Sci. Tech. In press.

Haines, J.R., E.L. Holder, K.I. Strohmeier, R.T. Herrington, and **A.D. Venosa.** Hydrocarbon-degrading microbial populations by a 96-well most-probable-number procedure. J. Indus. Microbiol. In press.

Hutchins, S.R., D.E. Miller, F.P. Beck, A. Thomas, S.E. Williams, G.D. Willis. 1995. Nitrate-based bioremediation of JP-4 fuel at Elgin AFB, FL: Pilot scale demonstration. In: In Situ and On-Site Bioreclamation: The Third International Symposium, San Diego, CA. Applied Bioremediation of Petroleum Hydrocarbons. 3(6): 123-132. Columbus, OH: Battelle Press.

Hutchins, S.R., J.T. Wilson, and D.H. Kampbell. 1995. In situ bioremediation of a pipeline spill using nitrate as the electron acceptor. In: In Situ and On-Site Bioreclamation: The Third International Symposium, San Diego, CA. Columbus, OH: Battelle Press. pp. 143-154.

Kuman, U., R. Puligadda, J. Antia, R. Govind, and **H.H. Tabak.** Biorecovery of metals from acid mine drainage. Presented at the 1995 ACS, I&EC Special Symposium. In: ACS Book Series. In preparation.

Kupferle et al. 1995. Anaerobic pretreatment of hazardous waste leachates in publicly owned treatment works. Water Environ. Res. 67:910-919.

Liang, R., J.G. Uber, and **P.T. McCauley.** 1995. Visualization of air-water flow in two-dimensional porous media using visible light transmission. Presented at a meeting of the American Geophysical Union, San Francisco, CA (November 27-December 1).

Lyon, W.G., C.A. West, M.L. Osborn, and G.W. Sewell. 1995. Characterization of microbially available organic carbon native to the vadose zone on an aquifer. J. Environ. Chem. Quality A30(7):1,627-1,639.

Miller, D.E., and S.R. Hutchins. 1995. Petroleum hydrocarbon biodegradation under mixed denitrifying/microaeropholic conditions. In: In Situ and

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New Bioremediation Publications Released

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On-Site Bioreclamation: The Third International Symposium, San Diego, CA. Microbial Processes for Bioremediation 3(8):129-136. Columbus, OH: Battelle Press.

Semprini, L., P.K. Kitanidis, D.H. Kampbell, and J.T. Wilson. 1995. Anaerobic transformation of chlorinated aliphatic hydrocarbons in a sand aquifer based on spatial chemical distributions. Water Resour. Res. 31(4):1051-1062.

Smith, R.S., J.G. Uber, and **P.T. McCauley.** 1995. Delivery of liquids to the vadose zone for enhancement of in situ bioremediation. Presented at a meeting of the American Geophysical Union, San Francisco, CA (November 27-December 1).

Sorial, G.A., F.L. Smith, M.T. Suidan, P. Biswas, and **R.C. Brenner.** 1995. Evaluation of trickle bed biofilter media for toluene removal. J. Air and Waste Mgmt. Assoc. 45:801-810.

Tabak, H.H., et al. 1995. Methodology for testing biodegradability and for determining bioavailability and biodegradation kinetics of toxic organics in soil. In: Akin, C., R. Markruszewski, and J. Smith, eds. Gas, oil, and environmental biotechnology V. Chicago, IL. pp. 1-54.

Tabak, H.H., C. Gao, X. Yan, L. Lai, S. Pfanstiel, and R. Govind. 1995. Determination of bioavailability and biodegradation kinetics of polycyclic aromatic hydrocarbons in soil. In: ACS Symposium Series 607. 21:264-283.

Tabak, H.H., C. Gao, X. Yan, L. Lai, S. Pfanstiel, C. Fu, and R. Govind. 1993. Kinetics of biodegradation, adsorption, and desorption of alkyl phenols and polycyclic aromatic hydrocarbons in soil slurry systems. In: Akin, C., R. Markruszewski, and J. Smith, eds. Gas, oil, and environmental biotechnology VI. Chicago, IL. pp. 27-95.

Tabak, H.H., R. Govind, C. Fu, and C. Gao. 1996. Bioavailability and biodegradation kinetics protocol for organic pollutant compounds to achieve environmentally acceptable endpoints during bioremediation. Presented at the Engineering Foundation Conference on Bioremediation of Surface and Subsurface Contamination, Palm Coast, FL (January 21-26). New York Annals of Academy of Science.

Tabak, H.H., R. Govind, C. Fu, and C. Gao. 1995. Bioavailability and biodegradation kinetics protocol for organic pollutant compounds to achieve environmentally acceptable endpoints in soil treatment. Presented at the Eighth International Institute of Gas Technology Symposium on Gas, Oil, and Environmental Biotechnology, Colorado Springs, CO (December 11-13). In: Gas, oil, and environmental biotechnology, VIII.

Tabak, H.H., R. Govind, C. Fu, and C. Gao. Bioavailability and biodegradation kinetics protocol for organic pollutant compounds to achieve environmentally acceptable endpoints in soil treatment. In: Proceedings of the 1995 IGT Symposium. Submitted.

Tabak, H.H., R. Govind, C. Fu, and C. Gao. Bioavailability and biokinetics protocol for organic soil pollutants for application to the enhancement of in situ and ex situ bioremediation. In: Norris, R., ed. Bioremediation. Submitted.

Tabak, H.H., R. Govind, C. Fu, and C. Gao. Biokinetics and bioavailability protocol or organic pollutants in soil to enhance bioremediation. To be presented at the AWMA Annual Meeting and Exhibition, Nashville, TN (June 23-28). In: 1996 Proceedings of AWMA. Submitted.

Tabak, H.H., R. Govind, C. Fu, and C. Gao. Protocol for determining bioavailability and biodegradation kinetics of organic soil pollutants in soil systems to enhance bioremediation of polluted soil sites. In: Protocols in bioremediation. Humana Press. Submitted.

Tabak, H.H., R. Govind, C. Fu, and C. Gao. Protocol for determining bioavailability and biokinetics of organic pollutants in dispersed, compacted and intact soil systems to enhance in situ bioremediation. J. Indus. Microbiol. Special Ed. (June). Submitted.

Tabak, H.H., R. Govind, C. Fu, X. Yan, and C. Gao. 1996. Development of bioavailability and biokinetics determination methods for organic pollutants in soil to enhance in situ and on-site bioremediation. Presented at the National Meeting of AIChE, New Orleans, LA (February 25-29). Environ. Prog.

Tabak, H.H., R. Govind, C. Fu, X. Yan, and C. Gao. 1995. Studies on development of soil bioavailability models for enhancement of in situ bioremediation. Presented at the International Chemical Congress of Pacific Basin Societies, Honolulu, HI (December 17-22).

Tabak, H.H., R. Govind, C. Fu, X. Yan, C. Gao, and S. Pfanstiel. 1996. Development of bioavailability and biokinetics determination methods for organic pollutants in soil to enhance in situ and on-site bioremediation. Presented at the National

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New Bioremediation Publications Released

(Continued from page 8)

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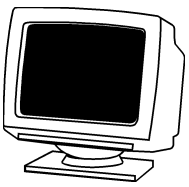


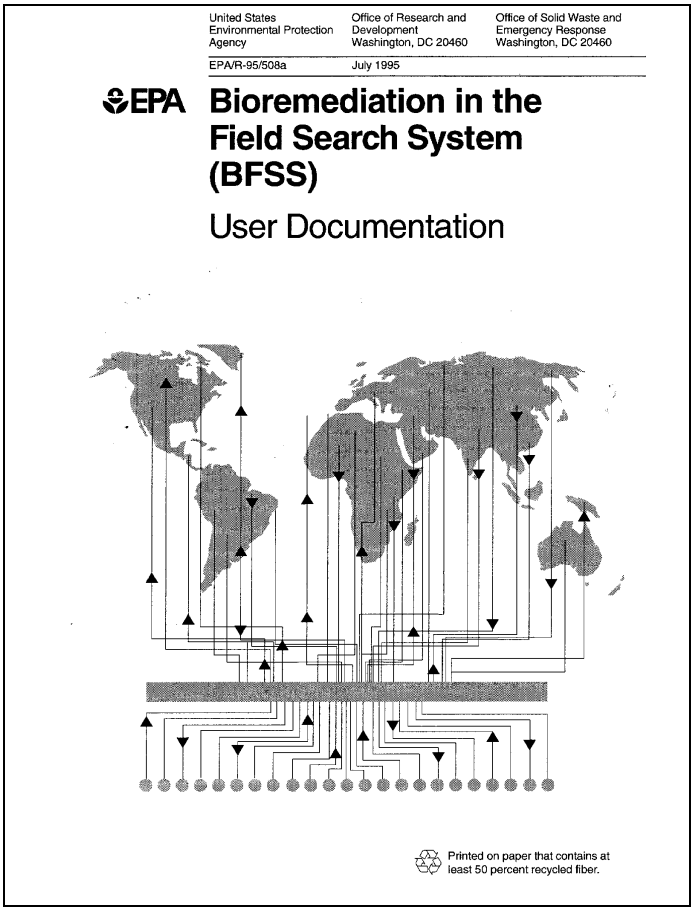
EPA Updating Bioremediation in the Field Search System (BFSS)

EPA's Bioremediation Field Initiative is currently updating the Bioremediation in the Field Search System (BFSS), a PC-based database of information on waste sites in the United States and Canada where bioremediation is being tested or implemented, or has been completed. The database provides information about the site location, media, contaminants, treatment technologies, costs, and performance. BFSS users can search the database electronically, view data on specific types of bioremediation sites, and print reports containing selected information.

In addition to updating the existing sites in the database, EPA plans to add about 50 new sites, bringing the total number to over 500. To facilitate this process, EPA has designed the Bioremediation in the Field Electronic Questionnaire (BFEQ), which site contacts can use to submit or revise information about their sites electronically. The anticipated release date of BFSS Version 2.5 is August 1996.

BFSS is currently available on EPA's Alternative Treatment Technology Information Clearinghouse (ATTIC, 703-908-2138), Cleanup Information (CLU-IN, 301-589-8366), and Office of Research and Development (ORD, 513-569-7610) electronic bulletin board systems. BFSS is also available on diskette from EPA's National Risk Management Research Laboratory (NRMRL); to request a copy, call 513-569-7562. As a registered user, you will receive EPA's quarterly *Bioremediation in the Field* bulletin, as well as notices of system updates.

If you would like to receive updates of BFSS and other information related to bioremediation, please call 513-569-7562 and request to be placed on the bioremediation mailing list.



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The Bioremediation Field Initiative is a cooperative effort among the Technology Innovation Office (TIO), Office of Solid Waste and Emergency Response (OSWER), and the Office of Science, Planning, and Regulatory Evaluation (OSPRE) and Office of Environmental Engineering and Technology Demonstration (OEETD), Office of Research and Development (ORD). Major contributors to the Initiative include the waste programs in the EPA Regional Offices and the following laboratories in ORD: Ada, OK; Athens, GA; Cincinnati, OH; Gulf Breeze, FL; and Research Triangle Park, NC.

Phytoremediation Field Work

Phytoremediation is the technology of using plants to clean contaminated sites. Plants naturally remediate contaminants through several mechanisms, depending on the contaminant and the plant. Some plants degrade organic pollutants directly or indirectly by supporting microbial communities. Other plants take up inorganic contaminants from soil or water and concentrate them in the plant tissue, where the contaminant can be removed and disposed of separately, leaving the soil clean.

Proven at both greenhouse and pilot scale, phytoremediation is too new to have widespread acceptance among site managers, regulators, owners, and responsible parties. The Superfund Innovative Technology Evaluation (SITE) program, sponsored by EPA's National Risk Management Research Laboratory, is attempting to demonstrate and evaluate the technology's efficacy and cost in the field at sites in Oregon, Utah, Texas, and Ohio.

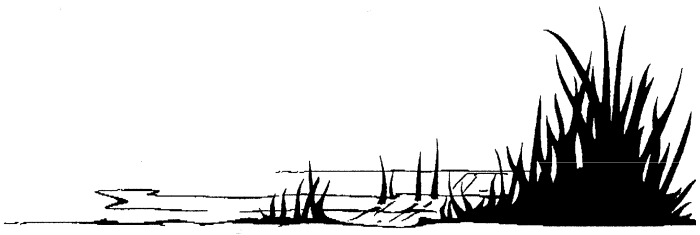
At a wood treatment site in Portland, Oregon, shallow soil is contaminated with pentachlorophenol and polycyclic aromatic hydrocarbons. Perennial ryegrass, which grows well in the Northwest, has passed a greenhouse treatability test on the site soil. The site has been seeded and the irrigation system installed. Greenhouse studies indicate that significant contaminant degradation should occur in two growing seasons.

In Ogden, Utah, a combination of poplar trees, juniper trees, alfalfa, and fescue has been planted to remediate a petroleum spill which has polluted both the soil and the ground water. Two-year-old hybrid poplars were planted in three rows to form a subsurface interceptor barrier in the saturated zone. Poplar poles (7 to 9 feet) will be planted in the spring of 1996 to intercept another part of the plume. This project involves Chevron Research, Phytokinetics, Inc., and EPA's SITE program.

On a U.S. Air Force facility near Forth Worth, Texas, eastern cottonwood trees are being used to intercept a part of a large trichloroethylene (TCE) ground-water plume. The Air Force, the U.S. Geological Survey, and EPA are starting a multiyear project not only to clean up the ground-water pollution but also to evaluate the difference between planting seedlings (whips) and older trees (1 to 1½-inch caliper). The older trees cost substantially more, but may send their roots to the water table much more quickly. Because some of the TCE could be transpired by the trees, researchers will also investigate the mechanism of that transport.

In Ohio, a former metal plating site is a candidate for a demonstration of phytoextraction of lead, cadmium, and hexavalent chrome. Phytotech Inc., Ohio EPA, and U.S. EPA will evaluate the effectiveness of Indian mustard plants in uptaking the metals. Phytotech will use standard agronomic practices and some proprietary techniques to induce metals to accumulate in the plant shoots in the percent levels. The plants will be harvested, then either disposed of or recycled for their metals content. Two or three plantings per year are expected.

For more information on these projects or to share information about other field work in phytoremediation, contact Steve Rock (513-569-7149).



Regulatory Update

HWIR-Media

On April 29, 1996, EPA proposed a rule entitled "Requirements for Management of Contaminated Media (HWIR-Media)" (61 FR 18780), which addresses contaminated media currently subject to regulation as hazardous waste under the Resource Conservation and Recovery Act (RCRA). The rule's purpose is to develop more flexible management standards for media and wastes generated in the course of site cleanups (see *Bioremediation in the Field* No. 12, August 1995). The public comment period for this proposed rule ends on July 29, 1996.

RCRA Subpart S Corrective Action

On May 1, 1996, EPA issued an Advanced Notice of Proposed Rulemaking on "Corrective Action for Releases From Solid Waste Management Units at Hazardous Waste Management Facilities" (61 FR 19432). The notice introduces EPA's strategy for promulgating corrective action regulations and requests public input on a variety of issues and concepts associated with corrective action. The public comment period for this notice ends on July 30, 1996.

Notice of Availability:

Initiatives To Promote Innovative Technology in Waste Management Programs

EPA's Office of Solid Waste and Emergency Response (OSWER) has issued a directive containing initiatives to support environmental technology development and commercialization.

Environmental technology development and commercialization are a top national priority. Both public and the private sectors have made considerable progress in developing and using new technologies in Superfund, RCRA, and Underground Storage Tank remediation programs. Nevertheless, significant challenges remain. Some problems have no effective solution; others require more cost-effective alternatives.

The initiatives in this directive place a high priority on developing innovative treatment and characterization technologies, reducing impediments (regulatory and informational) to their development and use; and sharing the risks of using innovative technologies. Specific initiatives are designed to increase use of field measurement and monitoring methods; focus attention on new approaches to ground-water remediation; streamline regulatory approval processes and consider alternatives to conventional permits; recognize the promise of in situ approaches and the value of federal facilities as "test beds" for technology development; highlight the importance of accurate information on technology performance and cost; and encourage responsible-party consideration of promising alternatives through agreements to share the costs if those alternatives fail.

The success of these initiatives depends on strong partnerships between federal agencies, states, and the private sector. While directed primarily to EPA programs, states pursuing innovation may find these initiatives useful. A number of initiatives, such as sharing risks and encouraging greater use of field monitoring methods, are already under way.

To obtain copies of OSWER Policy Directive 9380.0-25 (EPA 540/F96/012), contact:

National Center for Environmental Publications and Information (NCEPI)
P.O. Box 42419
Cincinnati, OH 45242

Or fax orders to: 513-489-8695

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