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FLASK TO FIELD RESEARCH CENTERS

In this issue of *Tech Trends* we feature our Hazardous Substance Research Centers (HSRCs). The HSRCs provide a national program of basic and applied research, technology transfer and training. Five multi-university centers, each located in a pair of Federal regions, focus on different aspects of hazardous substance management. They bring together researchers from a variety of disciplines to collaborate on integrated research projects. They draw financial support from EPA and the Departments of Energy and Defense, with additional funding from academia, industry and other state and Federal government agencies. The HSRC research agendas are shaped with the assistance of advisory committees made up of representatives from industry, regulatory organizations, academic institutions and government. Under the leadership of center directors, these panels help to focus the HSRCs' work on practical problems of hazardous substance management as well as long-term, exploratory research. The five HSRCs and their main focus are described below.

The Great Lakes & Mid-Atlantic HSRC serves EPA Regions 3 and 5, with the University of Michigan as lead institution, with Howard University and Michigan State University as the other two participating institutions. The center's Director is Dr. Walter J. Weber, Jr. (313-763-1464). Core funding comes from EPA and is matched by the Michigan Department of Natural Resources. The center's projects focus on remediation of the hazardous organic compounds found in soil and ground water. Ongoing research focuses on improving understanding of fundamental processes of in-situ bioremediation. The projects are organized into three cluster areas: in-situ bioremediation technologies; surfactant introduction technologies and bioventing technologies. Additionally, the National Center for Integrated Bioremediation Research and Development (NCIBRD) has been established to provide an accessible site and supporting infrastructure for field projects and is available for all HSRCs to use. We profile NCIBRD elsewhere in this issue of *Tech Trends*.

The Great Plains/Rocky Mountain HSRC covers EPA Regions 7 and 8 under the leadership of its Director, Dr. Larry E. Erickson (913-532-6519) at Kansas State University. Other participating universities are Haskell Indian Nations University, Lincoln University and Montana State University, South Dakota State University, Utah State University and the Universities of Iowa, Missouri, Montana, Nebraska, Utah and Wyoming. Because the geographic area it represents has diverse interests in mineral processing, mining and agriculture, this HSRC's activities focus on contaminated soils and mining wastes. Specific research interests include: soil and water contaminated with heavy metals; soil and ground water contaminated by organic chemicals; wood preservatives that contaminate ground water; pesticides identified as hazardous substances; improved technologies and methods to characterize and analyze contaminated soil; and waste minimization and pollution prevention methods and technologies.

The Northeast HSRC covers EPA Regions 1 and 2, with the New Jersey Institute of Technology serving as the lead institution under Director, Dr. Richard Magee (201-596-3233). Other participating universities are: Massachusetts Institute of Technology, Princeton University, Rutgers University, Stevens Institute of Technology, Tufts University and the University of Medicine & Dentistry of New Jersey. This HSRC's research programs are developing and demonstrating treatment and remediation technologies in four broad areas: incineration/thermal treatment; characterization and monitoring; in-situ remediation; and ex-situ treatment processes. This research agenda reflects the unique attributes of Regions 1 and 2: the age of much of their industrial base, as well as the population density, dominant types of economic activity, concentration of chemical and pharmaceutical industries and rapidly developing base of high-tech industry. Another factor shaping the center's research focus is the large number of sites in its regions that are on the National Priorities List. See the article in this issue of *Tech Trends* by Peter Jaffé, one of the researchers connected with the center, on a novel slurry washing technology.

The South and Southwest HSRC in EPA Regions 4 and 6 is under the leadership of Dr. Danny D. Reible of Louisiana State University. Other participating universities are Georgia Institute of Technology and Rice University. This center focuses on the management of hazardous substances in contaminated sediments and dredged materials, with more than half of the centers research and technology transfer efforts relating to these problems. The contaminated sediments and dredge materials of concern contain organics, metals and conventional pollutants that are either suspended in water or are deposited on the bottoms of rivers, bayous, lakes, harbors, estuaries, fresh water wetlands and adjoining regions of the continental shelf. Specific topics of research projects within the contaminated sediments/dredge materials focus area include: in-situ chemical mobilization processes in beds and confined disposal facilities; in-situ remediation; and in-situ detection.

The Western HSRC is led by Stanford University with Dr. Perry L. McCarty (415-723-4131) as Director and with Oregon State University participating. Its primary

(continued on page 3)

NEWS FROM THE CENTERS

This issue of *Tech Trends* features news about our Hazardous Substances Research Centers. We have featured some of the research being conducted at three of the Centers. Future issues of *Tech Trends* will feature additional Centers.

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NOVEL SLURRY WASHING FOR HYDROPHOBIC ORGANICS

By Dr. Peter R. Jaffé, Princeton University

Nonionic organics
Slurry washing
Soils

Researchers Dr. Jae-Woo Park from the University of Hawaii and Dr. Peter R. Jaffé from Princeton University are looking for a site to test their soil-slurry washing technique that has decontaminated soils in standard bench treatability studies. The technique is particularly intriguing because it removes low-solubility nonionic organic pollutants such as polychlorinated biphenyls (PCBs) which are not readily amenable to bioremediation or conventional pump-and-treat methods. One of the factors contributing to obstinate removal is that nonionic organic contaminants in the subsurface are effectively sorbed onto the naturally occurring organic materials in the soil. The technique is based on first transferring the sorbed pollutant from the soil to anionic surfactant-coated oxide particles and then separating these anionic surfactant-coated oxide particles with the sorbed pollutant from the soil slurry via a magnetic separation technique.

For the study, two different soils were examined. Soil 1 was a sandy soil with a relatively low organic carbon content. Soil 2 was a topsoil with a higher organic carbon content than Soil 1. The anionic surfactant Emcol CNP-60 was used. The oxide used in the research was Pferrico 3570 (cobalt treated gamma ferric oxide). The nonionic organic contaminant was phenanthrene.

The objective of the research was to: (1) describe the distribution of an anionic surfactant and a nonionic organic contaminant in a system consisting of oxide, soil and water; (2) study the effectiveness of the transfer of the nonionic organic contaminant from soil to the treated oxide in a soil slurry, followed by the separation of the treated oxide from the soil slurry; and (3) investigate the use of this soil-slurry washing technique for practical applications.

To prepare the soil for the bench treatability study, 10 grams of soil and 54 milliliters (mL) of deionized water were put into a disposable glass centrifuge tube, to which was added from 46.4 to 55.6 micrograms of [^{14}C]phenanthrene. The tube was tumbled in a tumbler for 24 hours to facilitate mixing and to allow for a complete sorption of the phenanthrene onto the soil.

The first step of the removal technique consists of adding surfactant-treated magnetite, which was shown to sorb a significant fraction of the pollutant, to the tube, thus transforming the tube into a reactor. For this phase, 1 gram of oxide and 2 mL of Emcol CNP-60 solution (10.68 grams per liter) were added to the tube.

After an equilibration period, the treated magnetite and pollutant sorbed to it are removed using a magnetic separation technique. The researchers assumed linear relationship for the sorption of the anionic surfactant to soils and magnetite over the relevant concentration range; they obtained a simple expression for the surfactant distribution between magnetite, soil and water as a function of the solution pH. Distribution of the nonionic organic contaminant between soil as a function of the sorbed surfactant concentration, magnetite as a function of the sorbed surfactant concentration and water could be described in terms of partition coefficients normalized with respect to the sorbed surfactant mass. The results from actual experiments and theoretical estimates were in good agreement. The mass of anionic surfactant sorbed onto the oxide particles was about 30% of total surfactant uptake capacity of the oxide. The amount of phenanthrene transferred divided by total phenanthrene in the system was approximately 36.1% for Soil 2 and 85% for Soil 1. That is, phenanthrene in Soil 2 went from 5.1 milligrams (mg) per kilogram (kg) of soil to 3.25 mg.; and, phenanthrene in Soil 1 went from 5.1 mg. per kg. of soil to 0.76 mg. These figures are for a single extraction. Additional extractions could improve extraction rates.

Numerical simulations were conducted using a simple model that was verified against the batch experimental results. Various scenarios were investigated, illustrating the differences in pollutant removal rates for different oxide- and surfactant-application rates in multistage soil slurry reactors. It was shown that the most significant improvement in the pollutant removal rate could be achieved by using surfactants that have a low degree of loss from the oxide to the soil.

A mathematical model was developed to simulate the operation of a multi-step soil-slurry washing process. The batch-type multi-step soil-slurry washing process can also be implemented as a multi-step continuous flow process. In a continuous flow system, the soil, slurry, oxide and surfactant are applied to the first reactor continuously. As the slurry is pumped to the next reactor, the oxide is removed continuously via magnetic separation; and, a new oxide and surfactant dose is applied to that slurry stream.

The technique is ready to be scaled up to a pilot demonstration using contaminated soils from a site. The researchers are looking for a site that has relatively low organic carbon content, on the order of 1% or less, and has a high octanol water partitioning coefficient on the order of 10,000. The existing patent on the process is held by Princeton University; and, they are looking for financial collaboration to put together the pilot scale demonstration.

If you are interested, contact Peter R. Jaffé at Princeton University by telephone (609-258-4655), FAX (609-258-2799) or the Internet (jaffe@soil.princeton.edu). For more detailed information about the research, see "Phenanthrene Removal from Soil Slurries with Surfactant-Treated Oxides," Jae-Woo Park and Peter R. Jaffé, Journal of Environmental Engineering, June 1995, pp. 430-437.

ELECTROCOAGULATION REMOVES METALS FROM WASTEWATER

By Dr. Ronald C. Sims, Utah State University

PAHs, PCP
Bioremediation
Soils

Research funded through the Great Plains/Rocky Mountain Hazardous Substance Research Center will help engineers in designing prepared bed treatment units for soil contaminated with polycyclic aromatic hydrocarbons (PAHs) and pentachlorophenol (PCP). The research found that using prepared bed bioremediation technology and maintaining a minimal supply of oxygen in contaminated soil (lifts) applied to the bed will make it possible to apply a new lift of contaminated soil more quickly. This will significantly reduce the time required to complete remediation in prepared bed treatment systems. The research used soils from the Champion International Site, a former wood preserving facility in Libby, Montana, which used creosote and PCP.

A treatment bed is prepared by lining it with clay or plastic to retard the transport of contaminants from the site or by adding uncontaminated soil to provide additional treatment medium. Treatment is generally enhanced with physical and chemical methods that stimulate the activity of indigenous microorganisms, including fertilizing, tilling, controlling moisture and adjusting pH. A prepared bed system functions as a treatment unit for unsaturated soil as well as an ultimate disposal site for the remediated soil.

A two-year microcosm evaluation of Libby soils was conducted by Dr. Ronald Sims of Utah State University to determine effects of oxygen concentration in the soil gas on biodegradation rates. This was followed by a field study at Libby where, after a lift of contaminated soil [an amount of soil generally 9 to 12 inches deep and applied across the land treatment unit (LTU)] was treated to target remediation levels, another lift of contaminated soil was added and treated until target remediation levels were reached. To manage the soil, nutrients and moisture were added periodically and the soil was tilled to increase oxygen transfer into the prepared bed. Chemical analyses indicated that the target remediation levels were achieved at each level of soil. In the evaluation, a new lift of contaminated soil was placed on top of another one in a LTU only after the first lift reached target remediation levels for individual chemicals. However, information about the decrease in oxygen, obtained during the evaluation, indicated that it might be possible to place a new lift on top of a lift before the latter has reached target remediation levels, but has been treated to some significant level. This led them back to the laboratory microcosm where it would be possible to measure only biodegradation in relation to a decrease in oxygen by measuring mineralization (which cannot be measured in the field) as an indicator of biodegradation. The microcosm study demonstrated that significant mineralization occurred once oxygen concentration was available at a concentration of 2 to 5%. Additional enrichments of the soil with oxygen did not produce significant increases in mineralization rates. The researchers confirmed that there is a relationship between the concentration of oxygen in the soil in buried lifts and the rate of PCP and PAH disappearance. They are now in the process of going back to the field to enhance buried lifts to 2 to 5% oxygen to increase the rate at which the PCPs and PAHs degrade. These results will be used to further define the potential for decreasing the time required to treat soil in LTUs.

In the full-scale prepared bed system, initial concentrations of contaminants and % reduction were: 101.4 milligrams per kilogram (mg/kg) PCP reduced by 58% by day 54; 84.9 mg/kg pyrene reduced by 49%; 204.0 total carcinogenic PAH reduced by 50%. Oxygen concentrations were 1-17% at 1 foot, 3-20% at 2 ft., 0-21% at 3 ft. In the second laboratory microcosm study average concentrations before application of another lift and after application of another lift were: 150 mg/kg PCP to 20 mg/kg 420 days after application (and 120 days after covering); 175 mg/kg pyrene to 3 mg/kg; 32 mg/kg PAH compound (benzo(b)fluoranthrene) to 5 mg/kg.

As part of the research effort, a guidance manual on the use of prepared beds for the bioremediation of contaminated soils will be developed. Additionally, an interactive computerized decision support system incorporating the information contained in the guidance manual will be developed.

For more information on the research results, call Dr. Ronald Sims at Utah State University at 801-797-2926 or send e-mail to: rcsims@cc.usu.edu. To get on a mailing list for information about availability of the manual and computer decision support system projected for May 1997, send a FAX to Dr. Sims at 801-797-3663 or an e-mail at address above.

(continued from page 1)

interests are the hazardous substance problems most dominant in EPA Regions 9 and 10. Researchers in this HSRC are focusing on problems of ground water cleanup and site remediation, with a strong emphasis on biological approaches. This center's research, technology transfer and training are addressing chlorinated and non-chlorinated solvents, petroleum products and toxic inorganic compounds including heavy metals. Environmental problems from these substances result largely from the production of electronic equipment, chemicals, forestry products, food and mining and military activities — all important industries in Regions 9 and 10. In addition to chlorinated solvents, research projects are focusing on halogenated aromatic compounds such as pentachlorophenol and PCBs; nonhalogenated aromatics including petroleum derivatives; ordnance wastes such as TNT; heavy metals; evaluation of factors affecting the transport and fate of the above chemicals in the environment; and design and management issues for site remediation.

Information about the HSRCs is now available on the Internet's World Wide Web (WWW). The WWW site contains "pages" about the national HSRC program and the regional centers, electronic versions of HSRC publications, project abstracts and links to other pertinent Web sites. To visit this Web site, the uniform resource locator (URL) address of the HSRC site is: http://www.gtri.gatech.edu/hsrc/. For more information, call EPA's Director of the HSRC Program, Dr. Dale Manty, at 202-260-7454.

Great Lakes/Mid-Atlantic Center

NATIONAL INTEGRATED BIOREMEDIATION R&D TEST SITE

Petrochemicals
Bioremediation
Soils, sediments, ground water

The National Center for Integrated Bioremediation Research and Development (NCIBRD) has developed a unique resource for research and development efforts at Wurtsmith Air Force Base in Oscoda, Michigan. It provides a test site for rigorously controlled field studies and demonstrations where promising characterization and remediation technologies can be tested, evaluated and demonstrated. The focus of NCIBRD is to find integrated bioremediation solutions to the problems caused by contamination of surface and subsurface environments by petroleum, oils, lubricants and solvents. It was initiated by and is headquartered at the Great Lakes and Mid-Atlantic HSRC; and, it is supported by the Strategic Environmental Research and Development Program of the Department of Defense (DoD) and EPA. The Wurtsmith site is part of the Department of Defense National Environmental Technology Demonstration Program (DNETDP) network of test locations. All the existing test locations, including Wurtsmith and those to be established within the DNETDP network in the future represent a range of subsurface hydrogeologic and contaminant mixtures that are common to thousands of hazardous waste sites.

The site offers outstanding prospects for study of the remediation of contaminated surface soils, sediments, vadose (unsaturated) zones and ground water. Moreover, the aq[illegible] with three different typ[illegible] systems: Lake Huron, s[illegible]ands and the Au Sable River. These surface water bodies, bottom sediments and their respective interfaces with the aquifer present outstanding and varied field conditions for remediation research. A number of sites to be remediated are contaminated with a variety of adsorbed, dissolved and non-aqueous phase petroleum hydrocarbon mixtures, chlorinated solvents, heavy metals and PAHs.

A site-wide hydrogeochemical database is being developed for Wurtsmith. The database includes more than 600 borings and wells. It provides information on the hydrologic, geologic, meteorologic and chemical conditions prevailing at more than 43 sites contaminated by spills of fuels and solvents and by landfill leachates and at several ongoing pump-and-treat hydraulic containment situations.

Researchers outside the Great Lakes and Mid-Atlantic HSRC are encouraged to contact the NCIBRD offices in Ann Arbor, Michigan, to explore potential use of the site for their own research and demonstrations of remediation technologies. *Please direct inquires to either Walter J. Weber, Jr., Executive Director or Michael J. Barcelona, Director of Field Operations and Research, by phone (313-763-2274), by FAX (313-763-2275) or by mail addressed to: The National Center for Integrated Bioremediation Research and Development, Suite 181, Environmental and Water Resources Engineering Building, The University of Michigan, Ann Arbor, MI 48109-2125.*

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Tech Trends welcomes readers' comments and contributions. Address correspondence to: Tech Trends, NCEPI, P.O. Box 42419, Cincinnati, OH, 45242-2419

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