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Solid Waste and Emergency Response (5102G)

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The Applied Technologies Newsletter for Superfund Removals & Remedial Actions & RCRA Corrective Action

ABOUT THIS ISSUE

This issue highlights joint international efforts to demonstrate and evaluate the performance of innovative technologies for remediating sites with contaminated soil.

NATO/CCMS Pilot Project for Innovative Cleanup Technologies

by Stephen C. James, U.S. EPA/ Office of Research & Development/National Risk Management Research Laboratory

In 1985, North Atlantic Treaty Organization (NATO) partners initiated a pilot study to identify, discuss, and review innovative, emerging, and alternative technologies, and to transfer technical performance and economic information to potential users in the civilian and military sectors. This pilot study, known as the *Evaluation of Demonstrated and Emerging Remedial Action Technologies for the Treatment of Contaminated Land and Groundwater*, is now in its third phase of evaluation under NATO's Committee on the Challenges of Modern Society (CCMS).

The pilot study has established two international focus areas for risk management and contaminated land. Information exchange is facilitated by the CCMS pilot study and NATO through specific networks such as the:

- European Commission, DG XI (waste) and DG XII (environmental) Programs
- Common Forum on Contaminated Land in the European Union
- NICOLE (Network for Industrially Contaminated Land in Europe)
- CARACAS (Concerted Action on Risk Assessment in Contaminated Sites in the European Union)
- CLARINET (Contaminated Land Rehabilitation Network)
- Ad Hoc Work Group on Contaminated Land, and
- European Environment Agency (topic center for soil).

The United States serves as the lead organizing nation for the pilot study, with assistance from Germany and the Netherlands and participation from 22 additional countries and the European Union. Through annual meetings, over 70 delegates present yearly updates on legislative and regulatory issues, as well as technology research, development, and demonstrations associated with contaminated land cleanup in each country. The pilot study addresses six general types of cleanup technologies: biological, physical-chemical, chemical, thermal, stabilization/solidification, and other cleanup activities such as site characterization.

This year's CCMS pilot study meeting, which will focus on validation of in situ remediation performance, will be held September 10-15 in Liège, Belgium. The U.S. will provide updates on three models:

- *Interagency DNAPL Consortium Side-by-Side*

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Washington, DC 20460
Phone: 703-603-7198
Fax: 703-603-7195

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several broad-based initiatives (including the Great Lakes Contaminated Sediments Program) to provide field, financial, and technical support in the Great Lakes Basin. Efforts are made under the Contaminated Sediments Program to apply lessons learned previously through the Assessment and Remediation of Contaminated Sediments (ARCS) Program (1987-1993), which was Congressionally mandated to study and demonstrate methods for addressing contaminated bottom sediments in the Great Lakes. Subsequent ARCS reports, such as the *ARCS Assessment Guidance Document* (EPA-905-B94-002), *ARCS Remediation Guidance Document* (EPA-905-B94-003), and *Risk Assessment and Modeling Overview Document* (EPA-905-R93-007), have been developed to provide technical assistance to those involved in contaminated sediment cleanup projects.

Currently, the GLNPO is working with the U.S. interagency Remediation Technologies Development Forum's Sediment Remediation Action Team to coordinate the technical aspects of a potential remedial technology demonstration project in Duluth Harbor, MN. This project would involve an in situ electrochemical technology that requires minimal equipment and processing, compared with alternative technologies. In addition, the GLNPO will award a total of $3.15 million during this fiscal year for innovative projects that advance the protection and cleanup of the Great Lakes ecosystem, including priority topics such as contaminated sediments, environmental indicators, and strategic or emerging issues.

SedPAC reports, ARCS guidance, and other Great Lakes regional updates and technical documents are available on the Web from the GLNPO (www.epa.gov/glnpo) or the IJC's Great Lakes Water Quality Board (www.ijc.org/boards/wqb). Additional information on the GLNPO Contaminated Sediments Program is available from Dr. Marc Tuchman (U.S. EPA/Region 5) at 312-353-1369 or e-mail tuchman.marc@epa.gov.

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Technology Demonstrations at Cape Canaveral, FL: ground-water cleanup demonstrations of chemical oxidation with potassium permanganate, in situ thermal remediation with six phase heating, and in situ thermal remediation with steam and co-air [see July 2001 *Ground Water Currents* (www.clu-in.org)]

- *Bioremediation of Pesticides*: full-scale demonstration of composting techniques for soil at the Stauffer Management Company site in Tampa, FL [see August 2000 *Tech Trends* (www.clu-in.org)], and
- *Surfactant-Enhanced Aquifer Remediation (SEAR)*: field validation of SEAR technology for remediating dense non-aqueous phase liquids at Camp Lejeune, NC, and evaluation of the potential for surfactant recycling [see upcoming issue of *Ground Water Currents*]

The United States also will present four additional new projects to the pilot study:

- *Phytoremediation Evaluation for Petroleum Hydrocarbons in Surface Soils*
- *Field-Scale Performance Data for Alternative Final Landfill Covers*
- *Slurry Injection for Zero-Valent Iron into Chlorinated Solvents Groundwater Plume*, and
- *Combined Chemical Oxidation – Natural Attenuation Approach for Chlorinated Solvents Contaminated Groundwater.*

For each meeting, the U.S. EPA and NATO publish an annual report and a special session report. These reports are available on the Internet from EPA (www.clu-in.org/partner1.cfm) and from NATO (www.nato.int/ccms), and on a CD-ROM (EPA 542-C-01-002, in limited supply) from the National Service Center for Environmental Publications (800-490-9198, 513-489-8190, or http://www.epa.gov/ncepihom/).

The following meeting will be held in Rome, Italy, during 2002. For more information, contact the U.S. pilot study directors Stephen C. James (U.S. EPA/National Risk Management Research Laboratory) at 513-569-7877 or e-mail james.steve@epa.gov, or Dr. Walter W. Kovalick, Jr., (U.S. EPA/Technology Innovation Office) at 703-603-9910 or e-mail kovalick.walter@epa.gov.

Steam Injection Used in Unsaturated Zone at German Landfill

by H.-P. Koschitzky, Ph.D., and T. Theurer, University of Stuttgart

A thermally enhanced remediation scheme currently operates at a former hazardous waste disposal site near the City of Muehlacker, Germany, to remove chlorinated solvents. Conventional soil vapor extraction (SVE) was used initially to remove contaminants from the unsaturated zone, and a hydraulic pump and treat (P&T) system was used to remediate ground water. Finding SVE to be ineffective in the unsaturated soil zone, a pilot-scale project was initiated in 1999 to employ steam injection in the highly contaminated area 7-15 meters below ground surface (bgs). With projected completion of the project at the end of this year, approximately 2.5 tons of chlorinated hydrocarbons already have been removed from the 3,000 cubic-meter target area.

This project serves as a NATO/CCMS pilot project for Germany. It also serves as a pilot site in the State of Baden-Wüerttember EPA (Landesanstalt fuer Umweltschutz, LfU) site cleanup program, "Modellvorhaben," which is funded through the State's "Kommunaler Altlastenfonds." Technical oversight is provided by the Research Facility for Subsurface Remediation, *VEGAS*, at the University of Stuttgart in Germany.

In the late 1960s, the disposal site opened in a forest near Mühlacker to receive local industrial waste. Although waste was deposited within a layer of silty loam considered to be impermeable enough to protect the subsurface from leachate contamination, by the late 1970s contaminants had migrated through the highly heterogeneous, weathered sandy marl in the unsaturated zone. Contaminants were identified in the underlying Keuper gypsum aquifer located 30 meters bgs, suggesting that separate-phase contaminants (primarily trichloroethylene [TCE]) have not been retained by a capillary barrier intersecting the unsaturated zone at a depth of 15 meters bgs.

Remedial design for the entire site was completed in 1996. Implementation of the remediation plans began with encapsulating the contaminated area in sheet piles and constructing an asphalt cover to reduce leachate flux to the atmosphere. SVE and P&T applications then were employed to address the unsaturated-zone soil and ground-water contamination. Detailed evaluation of SVE technology had indicated that the low soil permeability in this region served as a limiting factor for "cold" SVE. As

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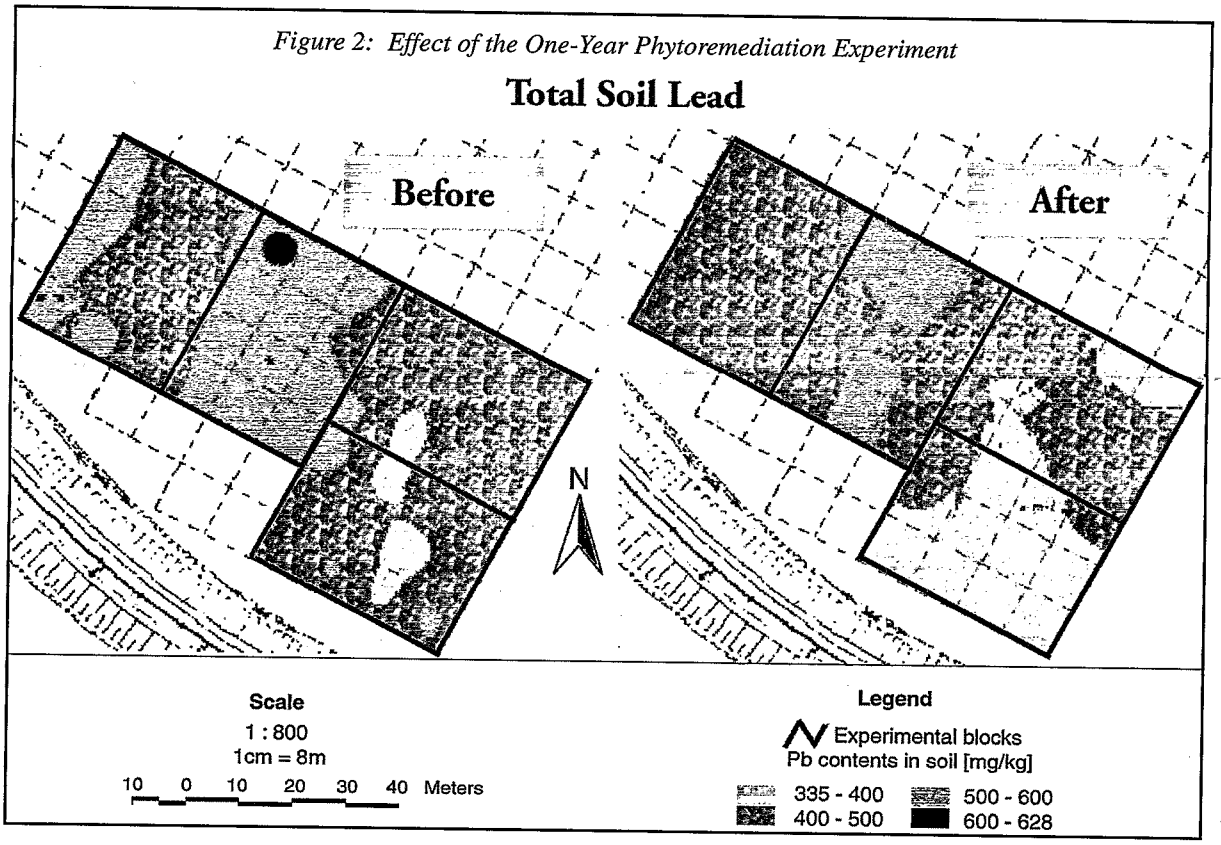

Figure 2: Effect of the One-Year Phytoremediation Experiment

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over the deployment area during these times are illustrated in Figure 2.

Full-scale use of phytoextraction for lead in soil is now in use at this site as well as several other industrial sites in Poland. Currently, the consortium is conducting a series of investigations concerning the potential for phyto-remediation to address mercury contamination throughout the country. Preliminary results show the potential of a combined stabilization technique using plants and chemical amendments (especially sulfur and zeolites) to stabilize mercury in contaminated soils. For additional information, contact Mike Kuperberg (Florida State University/Institute for International Cooperative Environmental Research) at 850-644-5516 or e-mail mkupe@mailer.fsu.edu.

International Efforts to Clean Up the Great Lakes

by David Cowgill, U.S. EPA/ Great Lakes National Program Office

As part of the International Joint Commission (IJC) of the U.S. and Canada, the Great Lakes Water Quality Board sponsors several activities to facilitate government progress in controlling and managing persistent toxic substances in water, soil, and sediments of the Great Lakes Basin. The characterization and remediation of contaminated sediment, which is found in all 42 areas of concern recognized by the IJC, continues to present particular challenges. Agencies in both nations have been working together with the IJC to identify innovative techniques for determining the volumes of sediment that require cleanup, understanding the extent of short- and long-term ecological harm posed by contaminated sediment, and predicting potential changes in contaminant bioavailability.

From 1995 through 1999, the IJC's Sediment Priority Action Committee (SedPAC) examined the reasons for the slow progress in addressing the contaminated sediment problem in the Great Lakes. A major component of this examination was the review of benefits from remedial actions previously taken in the Collingwood Harbor (Ontario), Waukegan Harbor, (Illinois), and Black River (Ohio) areas. Although significant volumes of contaminated sediment were removed from these and other areas through the use of innovative and conventional dredging methods, in general, it was found that insufficient information on the ecological effectiveness of sediment cleanup had been collected. SedPAC consequently studied and advised the IJC on filling these information gaps and overcoming obstacles to sediment remediation.

The EPA's Great Lakes National Program Office (GLNPO) coordinates U.S. activities in the Great Lakes with the IJC and Environment Canada. In this capacity, the GLNPO manages

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Phytoextraction Demonstration in Poland for Lead Removal

by Mike Kuperberg, Florida State University, Rafal Kucharski, Institute for Ecology of Industrial Areas in Poland, and Skip Chamberlain, U.S. Department of Energy

The Institute for International Cooperative Environmental Research at Florida State University, U.S. Department of Energy, and Institute for Ecology of Industrial Areas from Poland have collaborated in a field demonstration of phytoremediation for lead-contaminated soil. The primary goals of this consortium, which was initiated in 1995, are to identify technologies for large-scale removal of contaminants in soil and ground water at industrial sites throughout Poland, and to evaluate the cost and performance of appropriate technologies.

Analysis of costs incurred during a one-year phytoextraction demonstration indicated that as much as 70 percent of the total costs for this technology are associated with soil amendment. It is estimated that improved techniques for applying soil amendments may result in an overall cost savings of up to 35 percent. Improved techniques involve a more precise application of the chemicals to the soil, and a computerized application of amendments in correlation with lead concentrations identified in the soil.

Located in the Upper Silesian Region of Poland, the demonstration site contains large areas of soil contaminated with high concentrations of lead (600 mg/kg), cadmium (30 mg/kg) and zinc (2,400 mg/kg) as a result of nearby smelting operations. The phytoextraction experiment took place on a one-hectare target area, beginning in the Spring of 1998. Primary steps of the technology deployment included site characterization, plant species selection, planting and growing of plants for several months, amendment distribution, harvesting, and finally crop disposal and volume reduction through composting techniques. Two crops of Indian mustard (*Brassica junea*) were cultivated and harvested over a period of one year. Soil was amended with ethylene diamine tetracetic acid (EDTA), as needed.

Analysis of lead concentrations before and after the first growing season indicates a significant reduction for total lead in soil. Lead contamination patterns

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ITRC Updates

Upcoming Conference

The Interstate Technology and Regulatory Cooperation (ITRC) is a state-led organization working to overcome regulatory barriers to the deployment of innovative environmental technologies. The 2001 ITRC Fall Conference will be held November 5-6 in Long Beach, CA, at the Westin Long Beach. This conference will provide opportunities for environmental technology networking, technology exhibits, and training on topics such as permeable reactive barriers, chemical oxidation, and phytotechnologies. On the following two days, ITRC Work Team members will meet to discuss specific technology topics. Public and private sector professionals are encouraged to register for the conference before October 10 at the ITRC Web site, www.itrcweb.org.

New Guidance Documents

Three guidance documents were released recently by ITRC work groups to assist regulators, environmental consultants, and other stakeholders in addressing issues surrounding specific remediation technologies:

Phytotechnology Technical and Regulatory Guidance Document (PHYTO-2) describes various aspects of phytotechnology applications, including regulatory considerations, current research, case studies, and work plan components.

Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater (ISCO-1) addresses the technical and regulatory issues impacting the use of chemical oxidants to destroy and/or convert contaminants into innocuous compounds.

User's Guide for Polyethylene-Based Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells (DSP-1) was prepared by the U.S. Geological Survey in cooperation with the ITRC, U.S. Air Force, Naval Facilities Engineering Command, U.S. EPA, and other agencies to provide methods for employing passive diffusion bag (PDB) samplers, approaches for determining PDB sampler applicability, and factors influencing data interpretation.

With the addition of these documents, more than 30 guidance documents on innovative environmental technologies now are available on-line at www.itrcweb.org.

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a result, alternative technologies were considered and thermally enhanced SVE by steam injection was selected in 1998 to address the unsaturated zone contaminants.

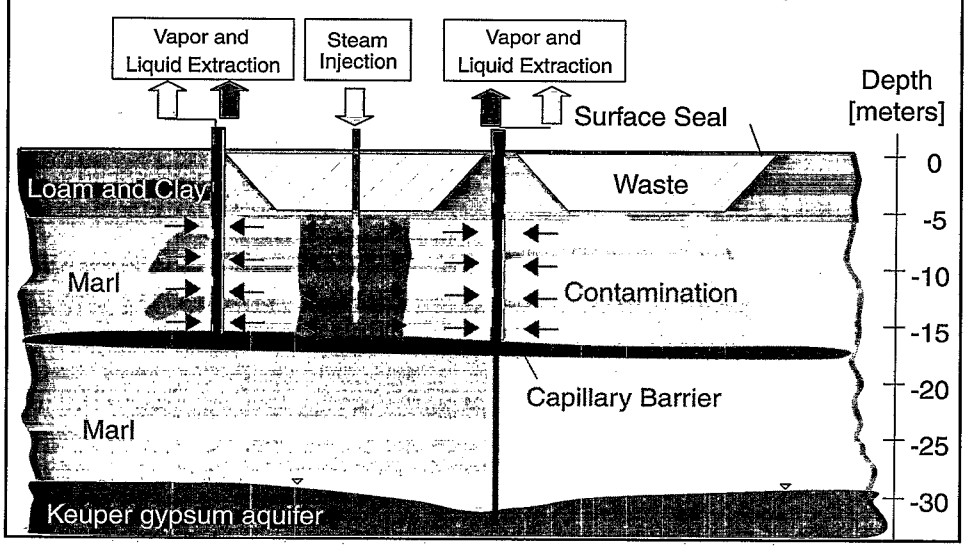
A 20-meter diameter, egg-shaped testing area was constructed at the site for pilot-scale demonstration of the steam injection process. The testing area comprises one central injection well surrounded by six extraction wells that can be used simultaneously for vapor and liquid extraction. All wells reach a depth of 15 meters bgs and are screened from 7 to 15 meters bgs in the unsaturated zone. Ten monitoring lances with a total of 100 temperature sensors positioned at 0.7-meter increments measure subsurface temperatures through the soil horizon. Using a gas-fired 100 kW generator, steam is injected at a rate of up to 100 kg/hour and a pressure of up to 2.5 bars.

The high-pressure steam front advances from the central injection well through the ground (Figure 1). Evaporated water and contaminant accumulate ahead of the steam front and are driven to the extraction wells to be recovered in the gas or separate-fluid phase. Gases are extracted from the system and passed through a condenser, from which condensate flows into liquid separators where the non-aqueous phase contaminant is separated from the water. Gases that are not condensable flow through a catalytic combustion unit before venting to the atmosphere. Liquids are removed from the extraction system using surge pumps and then passed through a cooler to a separator where the non-aqueous phase material is separated from the water.

After ten months of steam injection, nearly complete heating of the target zone has been achieved. Of the 2,500 kilograms of TCE removed, approximately 95 percent was extracted in the gaseous phase and the remaining part as solute in water from the capillary barrier. Researchers found that the common problem of heat front buoyancy resulting from subsurface capillary water could be overcome. The use of steam with low water content was important to avoid displacement of the heat front. It also was found that conductive heat transport during breaks in the steam injection significantly warmed soil regions with low temperature, while convective heat transport brought energy to the steam front. Weak temperature gradients resulting from a slow heating process did appear to avoid excessive saturation of the soil, thereby avoiding mobilization of the TCE.

Despite the low permeability of the subsurface, steam injection was found to be successful at this site. The final cooling process that was begun in March 2001 is expected to conclude in October, at which time the final project performance and costs will be documented. Extrapolated estimates indicate a cost of approximately $175/kg of removed chlorinated hydrocarbon through use of steam injection, compared to an estimated cost of $250/kg for cold SVE (assuming SVE would be able to remove the same amount of contaminant). Additionally, employment of steam injection has been estimated to achieve an 8.5-year time savings over the use of SVE.

Figure 1: Steam Injection Process at the Mühlacker Landfill



Research will continue at the University of Stuttgart to test the use of thermal treatment involving higher temperatures to remove contaminants with higher boiling points. Researchers also will examine the potential of a combined parallel treatment involving steam injection and alcohol flooding for the unsaturated/saturated zones and ground water. For more information, contact Dr. Hans-Peter Koschitzky (University of Stuttgart) at 49/711-685-4716 or e-mail hans-peter.koschitzky@iws.uni-stuttgart.de.

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