TECHNICAL SUPPORT TIMES

SPRING
2005

ISSUE #2

RESEARCH AND DEVELOPMENT – OFFICE OF SCIENCE POLICY

The Technical Support Times is an online newsletter highlighting EPA's field activities, research, and new documents on current topics. This issue is the second in a series of periodic publications from the Hazardous Substances Technical Liaisons (HSTL), which are available on the intranet at http://intranet.epa.gov/ospintra/scienceportal/.

Felicia Barnett, the Office of Research and Development (ORD) HSTL for Region 4, compiled this article from various EPA resources.

FOCUS ON: PHYTOREMEDIATION

Phytoremediation is the use of plants and botanical processes to effectively control or remediate hazardous wastes in the environment. Although typically associated with the removal and treatment of contaminated groundwater, through the evapotranspiration of trees, phytoremediation includes any use of vascular plants, algae, and fungi either to remove and control wastes or to spur a waste breakdown by microorganisms.

Different types of phytoremediation include vegetated-covers, wetlands for water treatment and flooded soils, trees for groundwater treatment and leachate reduction, organic degradation in soil, mine site and spoil reclamation, and potentially some metals extraction. Research into arsenic, selenium, and mercury extraction by specific plants is promising.

Growing and, in some cases, harvesting plants on a contaminated site as a remediation method is an aesthetically pleasing, passive technique that can be used to clean up sites with shallow, low to moderate levels of contamination and can be used in conjunction with other remediation methods. The wide range of uses and the fact that phytoremediation is generally less intrusive and potentially less costly than other remediation options have increased interest in the use of this technology; however, applicability varies greatly based on site characteristics, the amount and type of contamination, and the cleanup or containment goals. ■

INSIDE

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SCIENCE AT WORK

Plume Interception: Aberdeen Proving Ground, MD
Aberdeen Proving Ground is a military installation along the western shore of the Chesapeake Bay in Maryland. The J-Field testing area was used for weapons testing and disposal activities for a number of decades, which has caused extensive releases of chemicals to the soil and groundwater. The toxic burning pits at the J-Field consisted of several trenches where disposal activities occurred, and significant levels of volatile organic compounds (VOCs) contamination, most significantly trichloroethylene (TCE) and perchloroethylene (PCE), as well as vinyl chloride, were detected in groundwater samples.

The majority of the groundwater contamination from the burning pits is confined to the surficial aquifer, which has a depth of 6 to 7 feet below a ground surface with a thickness of about 30 feet, and discharges to nearby fresh water marshes. Because of the favorable site conditions (remoteness of site, low groundwater velocity, stable VOC plumes), an extensive full-scale pilot treatability study was initiated in the late 1990s using hybrid poplar trees and later two native species (i.e., tulip trees and silver maple) to capture the groundwater plume, and possibly enhance the *in-situ* biodegradation of vinyl chloride that was already occurring at the site. Performance of the plume interception was evaluated using groundwater modeling and monitoring of numerous site conditions including, but not limited to, water table elevations, tree transpiration rates using sap flow and tree growth rates, transpiration vapor data, seasonal hydraulic gradients, natural attenuation parameters in groundwater, and contaminant levels.

After 5 years of monitored performance at the site, the data demonstrated that natural processes at the site including phytoremediation and *in-situ* bioremediation are a major component contributing to the remediation of the dissolved-phase VOC plume. Phytoremediation was chosen as a component of the site remedial action for groundwater in the Record of Decision. Additional remediation action will be required to address the dense nonaqueous phase liquid (DNAPL) source of the contamination. (Site Contact: Frank Vavra, Reactive Plume Model, Remedial Project Manager, Region 3)

(Additional examples of sites using phytoremediation to address plume contamination are Aberdeen Pesticides in Aberdeen, NC; Argonne National Laboratory in Argonne, IL; Orlando Naval Station in Orlando, FL; and Beale Air Force Base in Northern CA.)

Phyto-Irrigation: Savannah River Plant, Aiken, SC
As a result of data generated by the National Institute of Environmental Health Sciences (NIEHS) Superfund Basic Research Program, the Department of Energy (DOE) Savannah River Plant has implemented a feasibility study and current program to determine the efficiency of phytoremediation, through deep well irrigation, as a solution to one of the large groundwater contamination problems. The design was installed in A-area, where a large TCE plume is located. Several other technologies are being applied to this plume, but due to the physical size (more than 700 hectares) and amount of TCE released to the environment (approximately 1.5 million pounds of TCE), no one technology will likely be able to treat the complete plume.

The plume is approximately 70 feet below a ground surface and the intervening soil has a clean aquifer running between the plume and the soil surface. Wells were installed to pump the contaminated water to the surface, and the design employs a spray irrigation system to water two acres of trees with the contaminated water. One acre is freshly planted hybrid poplar (see Figure 1), and the second acre is mature pine

FIGURE 1. Freshly Planted Hybrid Poplar Acre

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forest (see Figure 2). The spray strips the majority of the TCE to the atmosphere, and the trees act as a final polishing step as well as a water management system.

FIGURE 2.
Mature Pine Forest Acre

Initially, monthly analyses were done to determine the amount of TCE treated, the amount of TCE and metabolites in the plant tissue, the amount of TCE remaining in the soil column, and the moisture and oxygen levels in the soil. Over the course of 18 months, approximately 3 million gallons of water were treated by the trees, without accumulation of TCE in the trees or soil, or adversely affecting the health of the trees. (Site Contact: Dawn Taylor, Reactive Plume Model, Remedial Project Manager, Region 4)

Leachate Control: LCP Chemical Company, Brunswick, GA

LCP Chemicals is a 550-acre former oil refinery, paint manufacturing company, power plant, and chlor-alkali facility that operated between 1919 and 1994. Soil and sediments at the site are contaminated with lead, mercury, and polychlorinated biphenyls (PCBs). Mercury and lead have been detected in groundwater in concentrations as high as 180 parts per billion and there is a caustic brine pool below some of the buildings. The site currently is in the remedial investigation/feasibility study phase, but significant Potentially Responsible Party (PRP)-led removal actions occurred in 1999.

The removal actions at the site included the excavation of contaminated portions of the shoreline that separates the upland soils from the tidal marsh. It was discovered during wet seasons that seepage of groundwater occurs along these portions of the shoreline with the potential to recontaminate the area. Some of the seeps are a noticeable dark brown color, and mercury is present at elevated levels.

To control potential recontamination of the area, it was determined that locally suppressing the groundwater table (0.9 ft) would prevent the seeps from occurring. Phytoremediation was proposed as the remedy of choice because of its relatively low cost, the early shoreline remediation, and environmental aesthetics. A conceptual depiction of the phytoremediation action implemented on the site is shown in Figure 3.

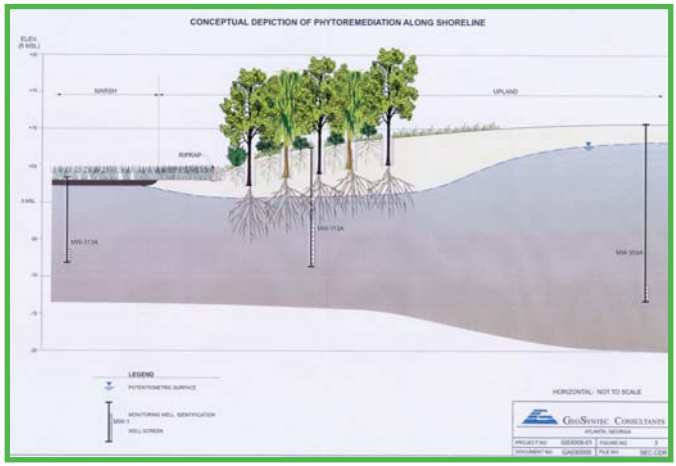

FIGURE 3.
Conceptual Depiction of Phytoremediation Along Shoreline

A list of potentially applicable plants was examined and narrowed down based on tolerance to site conditions (i.e., high pH and salinity) and desirable quantities such as high water and deep roots. The plants chosen were salt tolerant Japanese black pine, hybrid poplar trees (fast-growing with a high water demand), desert false indigo (a deciduous shrub), and Bermuda and Spartina grasses.

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Shrubs and trees were mixed together to maximize evapotranspiration and to achieve different rooting depths. A grass cover will be established to help minimize erosion and maximize water uptake in different soil layers. A rip-rap border also was installed between the upland areas and the newly dredged zone using concrete pieces from onsite stockpiles. Plants have been in place 6 months and monitoring is in progress including frequent visual inspection of the marsh area for seepage of the discolored water. (Site Contact: Shea Jones, Reactive Plume Model, Remedial Project Manager, Region 4) ■

IN THE LABORATORY

EPA's Office of Research and Development (ORD) has performed research on a number of phytoremediation technologies, as well as funded research through grants and cooperative agreements such as the Science To Achieve Results (STAR) Program, Hazardous Substance Research Centers (HSRCs), and Interstate Technology & Regulatory Council (ITRC). Below are some highlights of ORD research on phytoremediation.

Research on the Remediation of Explosives in Water and Soil

The EPA National Exposure Research Laboratory in Athens, Georgia, performed studies on the phytoremediation of explosives using created wetlands. Phytotoxicity and transformation of explosives were investigated. Macrophytic algae's stonewort, parrot feather, and Eurasian water milfoil were some of the wetland plants studied. Other studies established operating design parameters for the wetlands (trinitrotoluene [TNT] concentration, plant species, plant density, temperature, detention times, plant nutritional needs, and other parameters).

Based on these studies, the U.S. Army is conducting two full-scale pilot tests for treating royal demolition explosive (RDX) and TNT contaminated groundwater at the Iowa Army Ammunition Plant in Middletown, Iowa, using constructed wetlands. After 3 years of operation, no explosives have been discharged from the wetlands, and no explosives or transformation products have been detected in vegetation. (Contact: Steve McCutcheon, ORD Athens Laboratory)

Extramural Environmental Research Grants

EPA's National Center for Environmental Research (NCER) administers the STAR Program, including funding on phytoremediation research under different competitive solicitations. (Reference: http://epa.gov/ncer/index.html)

Phytoremediation Research under the "RARE"

A phytoremediation study involving arsenic uptake using the Chinese brake fern is being conducted for Region 4 at the Columbia Nitrogen Site in Charleston, South Carolina, under the Regional Applied Research Effort (RARE). (Reference: http://www.epa.gov/osp/regions/rare.htm) The Region 4 contact is Judy Sophianopoulos, Science and Ecosystems Support Division, and the work is being conducted in conjunction with ORD's Laboratory in Ada, Oklahoma.

SITE Program

One example is the SITE demonstration and evaluation of enhanced bioremediation at Savannah River, Aiken, South Carolina. (Reference: http://www.epa.gov/ORD/SITE/ and http://www.epa.gov/ORD/NRMRL/pubs/540r00504/540r00504.pdf)

Some other SITE phytoremediation evaluations include:

- TCE in groundwater with cottonwood trees at the former Carswell Air Force Base, Ft. Worth, Texas. (Publication: EPA/540/R-03/506)
- Hydrocarbons in groundwater with poplar trees at a Chevron Transfer Station in Odgen, Utah.
- Lead in soil with Indian mustard and sunflower at the Magic Marker Site in Trenton, New Jersey.
- Pentachlorphenol and polynuclear aromatic hydrocarbons in soil with perennial ryegrass at the McCormick Baxter Wood Treating Facility in Portland, Oregon. ■

AVAILABLE RESOURCES

Technical support for work with respect to phytoremediation or any other waste-related sites (Superfund, Brownfields, Resource Conservation and Recovery Act [RCRA]) is available through ORD. You can contact the HSTL in your region for more information. Information on the HSTLs can be found at http://intranet.epa.gov/ospintra/cp/stl.html. Some helpful references for phytoremediation are listed below.

Publications

Introduction to Phytoremediation, February 2000 (EPA/600/R-99/107).

Phytoremediation: Transformation and Control of Contaminants, McCutcheon, Steven C. and Schnoor, Jerald L., eds., Wiley-Interscience, Inc., 2003. (Reference: http://www.wiley.com/WileyCDA/WileyTitle/productCd-0471394351.html)

Use of Field-Scale Phytotechnology for Chlorinated Solvents, Metals, Explosives/Propellants, and Pesticides (EPA/542/R-05/002).

Evaluation of Phytoremediation for Management of Chlorinated Solvents in Soil and Groundwater (EPA/542/R-05/001).

Online Links

General EPA Web Page on Phytoremediation (Reference: http://cluin.org/techfocus/default.focus/sec/phytoremediation/cat/overview/). This page will guide you to other related phytoremediation information on the EPA Web Site.

Remediation Technologies Development Forum (RTDF) Phytoremediation of Organics Action Team (Reference: http://www.rtdf.org/public/phyto/default.htm)

Alternative Cover Assessment Program (Reference: http://www.acap.dri.edu/)

Citizens Guide to Phytoremediation (Reference: http://www.epa.gov/tio/download/citizens/citphyto.pdf)

USEPA Bioremediation Documents on the Web (Reference: http://www.epa.gov/ord/webpubs/biorem/index.html)

Ground Water Issue Paper: Phytoremediation of Contaminated Soil and Ground Water at Hazardous Waste Sites (Reference: http://www.epa.gov/ada/download/issue/epa_540_s01_500.pdf)

Phytoremediation Field Studies Database for Chlorinated Solvents, Pesticides, Explosives, and Metals (Reference: http://www.clu-in.org/download/studentpapers/hoffnagle-phytoremediation.pdf)

Introduction to Phytoremediation in The Standard Handbook of Hazardous Waste Treatment and Disposal (Reference: http://www.epa.gov/ORD/NRMRL/lrpcd/rcb/introphy.htm)

Phytoremediation of Petroleum in Soil & Groundwater (Reference: http://www.epa.gov/ORD/NRMRL/lrpcd/rcb/phytopet.htm)

Phytoremediation of TCE - Contaminated Shallow Groundwater (Reference: http://www.epa.gov/ORD/NRMRL/lrpcd/rcb/phytotce.htm)

Phytoremediation of Wood Treatment Facility Soils (Reference: http://www.epa.gov/ORD/NRMRL/lrpcd/rcb/phytwood.htm)

Evapotranspiration Landfill Cover Systems Fact Sheet (Reference: http://www.epa.gov/tio/download/remed/epa542f03015.pdf)

Reference material on constructed wetlands (Reference: http://www.epa.gov/ORD/SITE/reports/540_R-93_523.pdf)

Conferences

Phytoremediation State of the Science Conferences

The Third International Phytotechnologies Conference will be held April 20-22, 2005, at the Hyatt Regency in Atlanta, Georgia. More information on the conference can be found at http://www.clu-in.org/phytoconf.

The first meeting was held in Boston, Massachusetts, in May 2000, to allow all ORD researchers and

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the international community to review the state of the science of phytoremediation research. Presentation material and a summary of the meeting can be found at the following EPA intranet site http://www.epa.gov/ORD/NRMRL/Pubs/625R01011b/625R01011b.pdf

A follow-up conference was held March 3-5, 2003, in Chicago, Illinois, and information on that conference can be found at http://www.clu-in.org/studio/2003phyto/agenda.cfm.

ITRC Phytoremediation Training

The ITRC has worked in conjunction with EPA to provide state agencies and other interested parties basic training on remediation including innovative technologies like phytoremediation. Check CLU-IN and the ITRC Web Site for future training times and dates. (Reference: http://www.clu-in.org and http://www.itrcweb.org) ■

HAZARDOUS SUBSTANCES TECHNICAL LIAISON (HSTL) PROGRAM

The HSTL Program was created in 1990 in a joint effort by ORD, the Office of Solid Waste and Emergency Response (OSWER), and the Regional Offices to expand the technical support available to regional staff. It is managed within ORD's Office of Science Policy (OSP) at EPA Headquarters.

The HSTL Program was created to:

- Station a HSTL in each EPA region to facilitate access to scientific and technical support from ORD's laboratories and centers.
- Provide and facilitate technical support programs in regional hazardous waste and emergency response programs.
- Promote the use of sound science and engineering in regional decision making in the hazardous waste and emergency response programs.

The name of the program was changed in 2001 (from Superfund Technical Liaison Program or STLP) to reflect an expansion in the mission of the program to all work that focuses on hazardous substances and/or hazardous wastes, as well as Superfund.

Technical liaisons are senior scientists and engineers located in the regional Superfund offices. They interact on a daily basis with Superfund Remedial Project Managers (RPMs), On-Scene Coordinators (OSCs), RCRA Project Managers, Federal Facility Project Managers, regional management, and other regional scientists and engineers. The liaisons foster communications—especially the transfer of scientific and engineering products—between ORD laboratories and the regions. They also provide direct assistance by applying their expertise in a variety of areas. ■

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