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ABOUT THIS ISSUE

This issue highlights ongoing field and laboratory demonstrations concerning the remediation of contaminated sediments.

Field-Scale Testing of a Composite Particle Sediment Capping Technology

by John Hull, P.E., Hull & Associates, Inc., and Casey Stephens, City of Toledo/Division of Environmental Services

In September 1999, the City of Toledo began conducting a long-term sediment capping demonstration project on the Ottawa River, which is a Lake Erie tributary located in northwestern Ohio. The project involves field-scale testing of AquaBlok™, a composite aggregate material consisting of clay minerals and aggregate. AquaBlok was applied through the water column to physically stabilize and isolate sediments contaminated with polychlorinated biphenyls (PCBs) and other contaminants in a particular portion of the river. The material hydrates and forms a cohesive, low-permeability, and erosion-resistant barrier between sediments and the overlying aquatic ecosystem (Figure 1). Early field monitoring results indicate that the composite material was applied successfully and is isolating PCB-contaminated sediments effectively.

Three sediment caps of different design were installed along a 2.5-acre section of the river: a composite aggregate, exclusively; a basal geogrid component overlain by composite aggregate; and a geogrid plus composite aggregate and surficial stone layer. Target hydrated cap thicknesses range from approximately 5-6 inches for the first two cap designs and approximately 5-8 inches for the design incorporating a surficial stone layer.

Various installation techniques also were demonstrated as part of the project. Following geogrid installation from workboats, approximately 364, 82, and 15 tons of composite aggregate were installed using telescoping conveyor, helicopter, and dragline delivery systems, respectively. An additional 206 tons of approximately one-inch stone then were installed by the conveyor and helicopter to finish construction of the stone-covered cap. Spatial uniformity of capping material applications was observed closely during cap installation to ensure that an adequate degree of coverage was achieved through each of the application techniques.

The adequacy of capping-material applications was determined by collecting bathymetric survey data at 297 points along 13 cross-river transects. Post-capping survey data were compared to pre-capping data to determine net elevational increases (estimated cap thickness) across the project area. Survey results indicated that good spatial coverage was achieved and that constructed cap thicknesses generally fall within respective targeted ranges for the three different cap designs. River-bottom core samples are being collected and evaluated to more directly document constructed cap thicknesses across selected portions of the demonstration area.

A baseline study of benthic invertebrate organisms in the demonstration area was conducted during the summer of 1999. A follow-up study will be conducted during the summer of 2000 to determine if organisms have colonized the encapsulated areas. Since benthic organisms typically colonize only the upper few inches of sediment, they should remain isolated from contaminated sediments.

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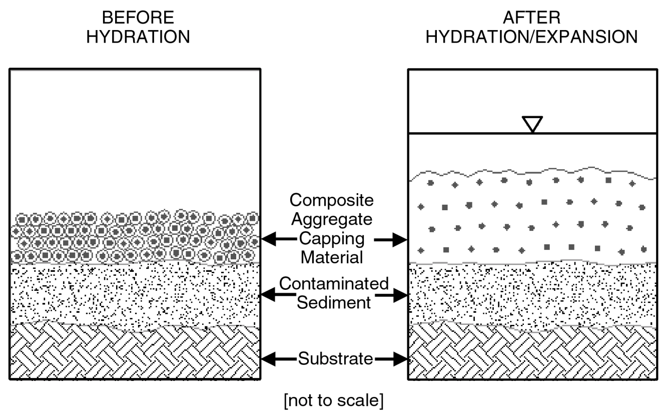
The composite particle system was originally developed in 1994 at the Fort Richardson Superfund site in Alaska to address waterfowl mortality from contact with white phosphorus-contaminated wetland sediments. After a multi-year testing and observation period, the use of AquaBlok was incorporated into the Fort Richardson Record of Decision to cap contaminated sediments in difficult-to-reach marsh areas that cannot be addressed by other technologies.

Figure 1. Composite Aggregate Capping Material



Technical assistance and input at the inception of the Ottawa River project was provided by the Ohio EPA, U.S. EPA, and U.S. Fish & Wildlife Service. The project was funded in large part through a grant from the Ohio Lake Erie Protection Fund. Darin Lockert (Ohio Lake Erie Commission) may be contacted at 419-245-2778 for additional information on the Fund. For further information, contact Casey Stephens (City of Toledo/Environmental Department) at 419-936-3757 or casey.stephens@ci.toledo.oh.us, or John Hull (Hull & Associates, Inc.) at 419-385-2018 or jhull@hullinc.com.

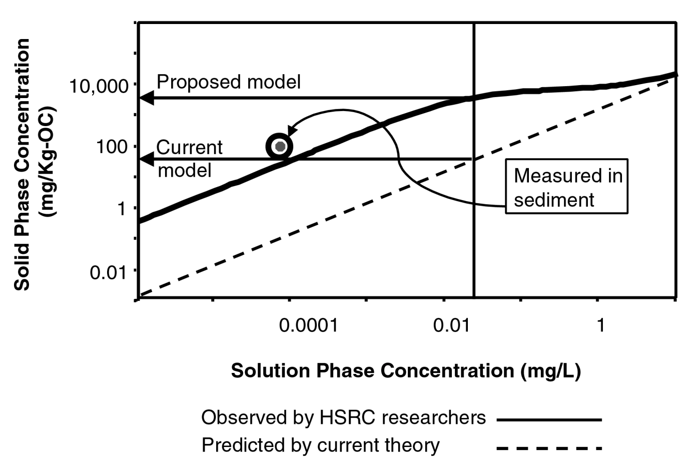
Studies Conducted to Determine Biological Uptake from Contaminated Sediments

by Joseph Hughes, Ph.D., and Mason Tomson, Ph.D., Rice University/Department of Environmental Science & Engineering

Researchers at Rice University, Louisiana State University, and Southern University at Baton Rouge are studying the physical, chemical, and biological mechanisms governing contaminant release and biological uptake from contaminated sediments. Laboratory studies on sediments from Dickinson Bayou in Galveston County, TX, confirmed that desorption-resistant contaminant is available to degrading microorganisms. Similar studies have been conducted by these researchers on sediments from Bayou Manchac, LA, Utica Harbor, NY, and Lake Charles, LA. Most significantly, results indicate that the presence of an inducing substrate may enhance rates of mineralization of sorbed contaminants, whereby endpoints of degradation are similar regardless of initial contaminant concentration.

Researchers anticipate that these findings may help to set soil or sediment quality limits for regulatory purposes or to establish endpoints (no-action levels) for remediation purposes. Findings suggest that sediments and soils presently requiring treatment could be left untreated without increasing the risk to human health or local ecosystems (Figure 2). In addition, modified clean-up levels (such as allowing 10 percent of the contamination at a site to be left in place) could reduce remediation costs by 50-75 percent and save several years in remediation time.

Figure 2. Potential Clean-Up Scenarios



This multi-university applied research project, which is sponsored by the Southern Hazardous Substance Research Center (HSRC), involves studies in three distinct areas of biological uptake in: (1) bacterial microbes; (2) bioturbating worms, and (3) wetland plants. In the bacterial microbe studies, a naphthalene solution was applied on the Dickinson Bayou sediments to prepare two types of contaminated soil: sediment with desorption-available naphthalene and sediment with desorption-resistant naphthalene. The rates of naphthalene mineralization demonstrated that despite the low aqueous concentration of naphthalene used in this study, biodgradation could be initiated and sustained. Both high and low levels of contamination were degraded rapidly to similar levels by the introduced micro-organisms. In addition, it was found that the rate and extent of mineralization of desorption-resistant naphthalene could be increased by the addition of naphthalene vapor.

Studies on bioturbating worms focus on determining the degree to which the worms redistribute organic carbon matter, thus releasing polycyclic aromatic hydrocarbons (PAHs) into overlying water and helping aerobic bacteria to biodegrade PAHs through soil aeration. These types of

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worms are "conveyer-belt" feeders, mixing soils by feeding at a depth and defecating on the surface. Bioturbating worms were introduced into beds containing known quantities of contaminanted sediments and constant water flow. The worm *Limnodrilus hoffmeisteri* was found to rapidly accumulate contaminant at high concentrations, but its metabolic processes of ingestion and defecation reduced the overall level of accumulation.

The third part of the study examines plant enzyme systems, focusing on the rhizosphere (the area near plant roots where bacteria are active) and the litter layer (where recently discarded carbon matter accumulates). Herbaceous grasses and woody plants common in wetlands were introduced to samples containing radionuclide-contaminated organic sediment from a U.S. Department of Defense site. Measurements of contaminants in the soil and plant roots, shoots, and leaves were taken to determine how much desorption-resistant material has been taken up and whether contaminants are available and biodegraded in the rhizosphere.

Researchers will continue to monitor biological uptake studies such as this in both laboratory and field environments over the coming year. For additional information, contact Dr. Joseph Hughes (Rice University) at 713-348-5903 or hughes@owlnet.rice.edu, or Dr. Mason Tomson (Rice University) at 713-348-6048 or mtomson@rice.edu.

HSRC Conference to Be Held in May

The Great Plains/Rocky Mountain Hazardous Substance Research Center (HSRC) will sponsor *2000 Conference on Hazardous Waste Research* in Denver, CO, on May 23-25, 2000. Additional information is available on the Internet at http://www.engg.ksu.edu/HSRC/Conferences.html.

Phytoremediation Used for Mining Sediments

by Brad Littlepage, U.S. Bureau of Reclamation, and Duane Johnson, Ph.D., Colorado State University

Plot testing of phytoremediation in the Leadville Mine Drainage Tunnel (LMDT) at the Leadville Mining District receiving mine drainage from the California Gulch Superfund site in Colorado is leading to potential full-scale implementation of the system in 2001. The pilot project, which was conducted from June-December 1999, resulted in removal of 70 percent of the metal contaminants in ground water (with a pH of 7.2) that presently drains from the tunnel. The U.S. Bureau of Reclamation (BOR), Colorado State University (CSU), Leadville Institute of Science and Technology (LIST), and U.S. EPA are cooperating in this effort.

To initiate the project, BOR, CSU, and LIST researchers collected and analyzed an array of plant species native to the Leadville area and placed them in the pilot hydroponics system. Plant analysis indicated that several species contained significant levels of metals, and in fact, recoverable quantities of zinc were found in the tissue of *Achillea* sp. *In situ* pilot testing began with the installation of a six-foot trough in which several species (ranging from mosses to mint and marigolds) were placed. One month of treatment by plants exposed to incandescent lights reduced the total metals content of ground water flowing through the tunnel pilot system from 6,000 *u*g/L to 840 *u*g/L at the point of discharge.

EPA is working with BOR to begin conducting a treatability study involving phytoremediation and metal hydroxide precipitation (the current system) to remediate surface water at the California Gulch Superfund site. It is estimated that 300,000 gallons of surface water will require treatment annually. The phytoremediation system could reduce the volumes of mine drainage water (at pH 5.5 or higher) passing through the metal hydroxide precipitation system, thus allowing for increased volumes of the pH 1.8 surface water into the current system. Researchers estimate that phytoremediation in the tunnel could reduce the current flow of water to the treatment plant (1,700-2,000 gallons per minute [gpm]) by 600-1,000 gpm. Flow reduction achieved through phytoremediation would allow the metal hydroxide system to treat surface waters with total metals loadings as high as 1,000,000 *u*g/L. As a result, full-scale operation of the systems should enable the facility to meet EPA's national pollutant discharge elimination system requirements.

The study's large-scale phytoremediation system uses three plant species selected for their capability in manganese, zinc, and cadmium uptake. Plants placed in troughs throughout the tunnel will be evaluated for their potential to treat 600-1,000 gpm of water; the volume of water the troughs are capable of processing within fifty feet will serve as a study model. Upon entering the tunnel, ground water will flow through a 55-gallon heating barrel that will raise the water temperature from 44^{o}F to 50^{o}F. Water then will enter three drainage runs, each containing four 50-foot troughs that will treat the water consecutively. Each treatment trough will contain distinct sections of silica sand, a foam bridge, and a vegetable-based gel. Mustard (*Brassica juncea*), quinoa (*Chenopodium quina*), and yarrow (*Achillea lanulosa*) will be planted separately in each of three troughs per run, while the fourth trough will be used for new experimental species.

Monitoring will include the sampling of each species, within each medium, at three-week intervals over 10 collection dates to determine maximum metal uptake levels. In addition, discharge water will be composite-sampled on a daily basis to determine the impact of each species on ground-water contaminant concentrations. Within the 11,300 foot-long tunnel, an additional 450 feet of accessible space is available for testing, if needed. Electrical power for the phytoremediation system currently is obtained from the water treatment plant, but a solar system will be installed for full-scale operations to provide heat, light, and electricity inside the tunnel.

This technology may be applied in other remote mining areas requiring remediation. Project partners anticipate that the LMDT ultimately will be used for development of

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additional mining technologies, *in situ* studies on metals recovery, and genetic engineering of plants. The Leadville Institute of Science and Technology (a local non-profit organization focusing on technology and economic needs of the Leadville area) also is working with the World Bank to develop practical approaches and cost-effective technologies such as this in third-world countries. For additional information, contact Brad Littlepage (U.S. Bureau of Reclamation) at 719-486-2035 or e-mail blittlepage@gp.usbr.gov, or Frank Burcik (Water Treatment and Decontamination International) at 303-202-9324 or e-mail wtdifb@juno.com.

Sediment Management Work Group Addresses Strategies

In 1998, private industry, trade associations, and government agencies formed the Sediment Management Work Group (SMWG) in an effort to advance risk-based, scientifically sound approaches for evaluation of sediment management decisions. SMWG's primary objectives are to collect, develop, analyze, and share information on the effectiveness of sediment management, technologies, and approaches. Information products developed by the SMWG (and available at www.smwg.org) include a decision tree for sediment management alternatives, a series of sediments-related technical papers, and a database on contaminated sediments sites. For more information, contact the Group's Coordinator, Steven C. Nadeau (Honigman Miller Schwartz and Cohn) at 313-465-7492 or e-mail scn@honigman.com.

Newsletter on Contaminated Sediments Available

Contaminated Sediments News is produced by the U.S. EPA's Office of Water/Office of Science and Technology (OST) to exchange information on contaminated sediments. *"CS News"* provides extensive information on EPA headquarters, regional, and laboratory activities addressing contaminated sediments, and updates readers with announcements concerning related resources such as training courses, Web sites, and upcoming events. The newsletter is available on the Internet at http://www.epa.gov/OST/pc/csnews/ or by contacting OST at 202-260-9830.

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