



# Ground Water Currents

Developments in innovative ground water treatment

## SPONGE TECHNOLOGY FOR GROUND WATER TREATMENT OF METALS

By Carolyn Esposito, EPA Risk Reduction Engineering Laboratory

The Dynaphore, Inc. Forager™ Sponge is an open-celled cellulose sponge incorporating an amine-containing chelating polymer that has selective affinity for dissolved heavy metals in both cationic and anionic states. Through the EPA's SITE (Superfund Innovative Technology Evaluation) Program, the ability of this technology to remove heavy-metals from contaminated ground water was evaluated at the NL Industries, Inc. site in Pedricktown, New Jersey. The technology effectively achieved a 97% removal of copper and lead from average influent concentrations of 917 micrograms per liter ( $\mu\text{g/l}$ ) and 578  $\mu\text{g/l}$ , respectively. There was 90% removal of cadmium from influent concentrations of 537  $\mu\text{g/l}$ . The Forager™ Sponge can also be utilized to remove and concentrate heavy metals from a wide variety of other contaminated aqueous media such as surface water, landfill leachate and industrial effluents. According to the developer, the Sponge can scavenge metals in concentration levels of parts per million and parts per billion from industrial discharges, municipal sewage,

process streams and acid mine drainage.

Here's how the Sponge works. The Sponge is highly porous, thereby promoting high rates of absorption of ions. The polymer in the Sponge provides ligand sites that surround the metals to form complexes, especially with ions of transition-group heavy metals. The ability of the Sponge to preferentially bind toxic heavy metals is particularly beneficial for the treatment of contaminated natural waters and has advantages over conventional ion exchange or precipitation technologies where valuable ion exchange sites or chemicals are wasted because they also remove cations such as calcium, magnesium, aluminum, sodium and potassium. The Forager™ Sponge's low affinity for these cations allows these ions, for the most part, to pass through the system, enabling greater absorption of toxic heavy metals. The extent of the affinity of the polymer for metals is influenced by solution parameters such as pH, temperature and total ionic content. Absorbed ions can be removed from the Sponge by techniques typically employed for regeneration of ion exchange

resins, after which the Sponge can be reused. Alternatively, the Sponge can be compacted for disposal or can be incinerated.

The Sponge can be used in columns, fishnet-type enclosures or rotating drums. For the NL demonstration, Sponge cubes were confined in a fishnet bag in a series of four columns. Ground water was pumped through a series of four columns at a treatment flow-rate of one gallon per minute or 0.08 bed volumes per minute. The columns were situated on a trailer-mounted unit which included a water heater to raise the influent temperature by approximately 25 degrees Fahrenheit to increase reaction rates. Four columns were reportedly needed to provide sufficient path length to meet the demonstration treatment goals. Although the developer

had anticipated that replacement or regeneration of the columns would not be necessary, some of the columns became saturated with cadmium and lead and had to be regenerated during the demonstration. The capacity of the Sponge for copper was much greater as none of the columns became saturated with copper. Although the developer's treatment claims for copper, cadmium and lead were achieved, the treatment claims for chromium were not met, with only 32% removal of chromium as trivalent chrome (initial concentrations of 426  $\mu\text{g/l}$ ).

*For more information and/or to get on the mailing list for the Innovative Technology Evaluation Report describing the complete demonstration, call Carolyn Esposito at EPA's Risk Reduction Engineering Laboratory in Edison New Jersey at 908-906-6895.*

### This Month in Currents

THIS MONTH'S CURRENTS CONTAINS NOTES ON ONGOING RESEARCH AT EPA'S ROBERT S. KERR ENVIRONMENTAL RESEARCH LABORATORY.

SPONGE TECHNOLOGY	1
PCE DECHLORINATION	2
SURFACTANTS	3
RESEARCH	3



## NATURAL ORGANIC MATTER SUPPORTS REDUCTIVE DECHLORINATION OF PCE

By Candida C. West, Robert S. Kerr Environmental Research Laboratory

Recent research has shown that organic matter extracted from a soil horizon was able to support reductive dechlorination of tetrachloroethylene (PCE). Ongoing research at the site where the soil was collected (Sleeping Bear, Michigan) had been concerned with determining the rates of natural in situ biodegradation of contaminants; and, there was speculation that the presence of high concentrations of indigenous dissolved or colloidal organic matter might be contributing to the biodegradative process. Interaction of contaminants with indigenous organic matter in soil, sediment and aquifer solids are important in controlling their fate and transport. Organic matter plays a major role in sorption and potentially serves as a biologically available source of carbon supporting biodegradative processes. Organic carbon concentrations in the vadose zone are generally assumed to decrease exponentially from the soil surface becoming negligibly low to non-existent in the saturated zone. However, carbon distribution at the Sleeping Bear site is highly complex, having buried horizons of high organic matter and organic films on aquifer solids.

The primary objective of the study highlighted here was to determine if leachable

organic matter in the vadose zone might provide primary organic carbon for reductive biodegradation of PCE. The secondary objective was to examine if TCE saturated water, i.e., simulating rainwater percolating through TCE residual, enhanced either the extraction or bioavailability of the organic matter.

Organic carbon from the Sleeping Bear site was extracted from a high organic carbon spodic horizon in the vadose zone by using two extractants: (1) distilled water alone, and (2) distilled water saturated with approximately 1000 parts per million (ppm) TCE. The soil to solution ratio was 1:2.6 grams per gram (g/g); and, the solution pH for the distilled water/soil and the distilled water with TCE/soil was 7.6 and 7.47, respectively. After overnight extraction, remaining TCE was removed from the TCE/water soil extracts by purging with N<sub>2</sub> gas prior to dissolved organic carbon (DOC) analysis and microcosm construction. The concentrations of dissolved organic carbon in the water extract and the TCE-saturated water extract were 16 and 20 milligrams per liter (mg/l), respectively. The higher efficiency of carbon extraction using TCE saturated distilled water was reproduced in a second

extraction experiment; however, the mechanism for this additional extraction is not clear. It has been observed that the TCE saturated solution extracts more colloidal material. Different volumes (0, 10, 50, 100 milliliters) of the TCE/water and water only soil extracts were added to replicate microcosms containing subsurface core material. All microcosms were spiked with 5 ppm PCE. Chloroethene concentrations were monitored by purge and trap GC analysis of subsamples at various time points.

The microcosms were monitored over time to determine the utilization (dechlorination) of PCE. Results of the microcosm experiments showed the loss of PCE and the production of daughter products over time for both extracts when present in sufficient concentrations indicating that the extracts provide a metabolizable electron donor capable of supporting microbial consortia responsible for reductive dechlorination of PCE. However, we do not yet know either the specific identity of these compounds or the mechanism of extraction.

Potentially any organic substance capable of being catabolized under anaerobic conditions should be able to

support or "drive" reductive dechlorination. First, the complete degradation of large or complex compounds usually requires the activity of different types of microorganisms. Second, under anaerobic conditions the oxidation of organic compounds is linked to the reduction of electron acceptors other than oxygen. Previous research suggests that, in the subsurface, reductive dechlorination may be only a minor factor (less than 0.1%) for the reduction generated during the anaerobic oxidation reactions.

Further research activities are needed to identify the specific components of the soil organic matter being mobilized by water and solvent/water mixtures, including simple aromatic compounds and organic acids. Attempts will be made to enrich dechlorination activity by enhancements such as ferulic acid, vanillic acid and guaiacylglycerol.

*For more information, call Candida West of EPA's Robert S. Kerr Environmental Research Laboratory at 405-436-8551. Also, for a fuller discussion of this research, see: Lyon, William G., Candida C. West, Michelle L. Osborn and Guy Sewell, "Microbial Utilization of Vadose Zone Organic Carbon for Reductive*

*(continued on page 4)*

## NEW FOR THE BOOK SHELF

### SURFACTANT CONSORTIUM AND PUBLICATIONS

The Robert S. Kerr Environmental Research Laboratory has organized a Consortium for Surfactant-Based In Situ Aquifer Remediation Technologies (Consortium) and will publish proceedings of the meetings. The Consortium is described below, together with information on ordering not only Consortium Proceedings but also information on a recent evaluation of cationic surfactants.

#### Consortium for Surfactants

A meeting of representatives from 11 universities, the Department of Energy, the Department of Defense and the U.S. Geological Survey and several private industries, including surfactant technology users and surfactant manufacturers was held in Norman, Oklahoma at the

University of Oklahoma on November 30, 1994. The Consortium was organized by Robert S. Kerr Environmental Research Laboratory (RSKERL) personnel for the purpose of providing a central organization for the evaluation and implementation of surfactant-based innovative technologies for in situ aquifer remediation. A total of 45 participants were present for the Consortium which included a breakout into five discussion groups related to surfactant use: surfactant chemistry/compatibility, hydrogeology, microbiology, regulatory issues and implementation. The consensus of the group was that this organization would be useful for sharing information on developments in research on demonstra-

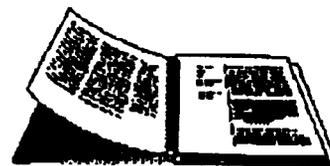
tions of surfactants, to provide peer review of work plans and manuscripts on in situ surfactant use, to provide education on the use and implications of surfactants in the subsurface and to develop protocols for implementation of surfactant-based subsurface remediation. The Consortium is planning to hold regular annual meetings and to publish the Proceedings of the meetings.

*To get on the mailing list for a copy of the November 1994 "Proceedings of the Consortium for Surfactant-Based In Situ Aquifer Remediation Technologies," send a fax to Dr. Candida West at RSKERL at 405-436-8703 who will send you your copy of the Proceedings after they are printed.*

#### Cationic Surfactants

The RSKERL has published an Environmental Research Brief on "The Use of Cationic Surfactants to Modify Aquifer Materials to Reduce the Mobility of Hydrophobic Organic Compounds," by John C. Westall, Julia Wagner and Hua Chen of Oregon State University and Bruce J. Brownawell of the Waste Management Institute, Marine Sciences Research Center at SUNY.

*A copy of the Environmental Research Brief (Document No. EPA/600/S-94/002) can be ordered from CERL at 513-569-7562.*



## RESEARCH NEWS

### RESEARCH IN PROGRESS

The EPA's Robert S. Kerr Environmental Research Laboratory (RSKERL) has some important research in progress relating to ground water remediation. What follows is a brief description of some of these efforts.

#### Surfactants.

Working under two cooperative agreements with the University of Oklahoma, Dr. Candida West of RSKERL is involved with research directed at the surfactant

enhanced remediation of subsurface material contaminated with dense non-aqueous phase liquid? (DNAPLs). The primary emphasis of the research is to show the efficiency of recovery of the surfactant solution. The first effort, conducted by Dr. David Sabatini, is designed to develop an environmentally acceptable system for enhancing pump and-treat systems. The approach involves measuring the efficiency and effectiveness of specific classes of surfactant

systems for solubilizing and mobilizing residual and free-phase DNAPLs. Studies are being carried out to test chosen systems for ionic matrix sensitivities, biodegradability, solid phase interactions and transport properties. Dr. Robert Knox will utilize the findings of the first phase of the investigation to design and conduct a small-scale field study of surfactant-enhanced contaminant removal and surfactant recovery using a recirculating well system at the

U. S. Coast Guard Station in Traverse City, Michigan.

#### Site Characterization.

An essential part of any aquifer remediation project is a site characterization that provides information necessary to select, design, operate and evaluate an appropriate remedial technology. Carl Enfield at RSKERL is working with Captain Jeffrey Stinson under an Interagency Agreement to thoroughly characterize a site at Tyndall Air Force Base using ground

*(continued on page 4)*

*Research continued from page 3* penetrating radar and other seismic techniques, cone penetrometer investigations and fiber optic spectroscopy. The goal of the project is to determine the feasibility of using selected technologies to enhance the performance of a pump and-treat system. A second site, selected from nine Department of Defense test facilities, will also be included in this investigation.

### **Cosolvent-Enhanced Remediation.**

Lynn Wood of RSKERL is conducting a research project under a Cooperative Agreement with the University of Florida to evaluate the feasibility of using miscible organic cosolvents such as alcohols to remediate subsurface environment contaminated by nonaqueous phase liquid (NAPL) hydrophobicorganic chemicals. The project, entitled "Field-

Evaluation of Cosolvent Enhanced In-Situ Remediation," is being carried out as a pilot-scale field study at Hill Air Force Base in Utah using sheet piling cells to provide hydraulic containment.

### **Chromate and TCE Treatment**

A RSKERL research team has evaluated the use of elemental iron as a surface treatment alternative for chromate and trichloroethylene (TCE) extracted from contaminated ground water at the U.S. Coast Guard Support Center at Elizabeth City, North Carolina. The field test involved the use of two 55-gallon drums packed with two different types of elemental iron mixed with aquifer material from the site. Influent concentrations of 8 milligrams per liter (mg/l) chromate, 717 micrograms per liter ( $\mu\text{g/l}$ ) TCE, 194  $\mu\text{g/l}$  c-DCE

and 51  $\mu\text{g/l}$  vinyl chloride were used. Effluent chromate concentrations were below detection (0.005 mg/l) using flow rates ranging from 0.5 to 4.0 liters per minute. Reductions in the concentrations of organic compounds ranged from 14 to 99 percent depending upon the flow rate. An array of these large "columns" is proposed as a means of intercepting the leading edges of overlapping plumes of

*PCE continued from page 2* Dechlorination of PCE," submitted to *JOURNAL OF ENVIRONMENTAL SCIENCE & HEALTH; Wilson, J. T., D. H. Kampbell and J. Armstrong, "Natural Bioreclamation of Alkylbenzenes (BTEX) From a Gasoline Spill in Groundwater,"* in R. E. Hinchee and B. C. Alleman, eds., *PROCEEDINGS OF THE*

chromate and TCE at the site. Potential long-term plans are to install a permeable reactive wall at the site composed of elemental iron to passively remediate both the chromate and TCE ground water contamination.

*GROUND WATER CURRENTS is monitoring the progress of these research efforts. We will provide additional findings of this research as they become available.*

*SECOND INTERNATIONAL SYMPOSIUM ON IN SITU BIORECLAMATION, April 5-8, 1993, San Diego, CA; West, C. C., W. G. Lyon, D. L. Ross and L. K. Pennington, "Investigation of the Vertical Distribution and Morphology of Indigenous Organic Matter at the Sleeping Bear Site, Michigan,"* *ENVIRONMENTAL GEOLOGY* (in press).

### **MAILING LIST/ORDER INFO**

To order additional copies of *Ground Water Currents*, or to be included on the permanent mailing list, send a fax request to the National Center for Environmental Publications and Information (NCEPI) at 513-489-8695, or send a mail request to NCEPI, P.O. Box 42419, Cincinnati, OH 45242-2419. Please refer to the document number on the cover of the issue if available.

*Ground Water Currents* welcomes readers' comments and contributions. Address correspondence to: *Ground Water Currents*, NCEPI, P.O. Box 42419, Cincinnati, OH 45242-2419.

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