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EPA Ground Water Currents

Developments in innovative ground water treatment

Low-Level Uranium Removed From Ground Water

By Annette Gatchett, Risk Reduction Engineering Laboratory

EPA's SITE (Superfund Innovative Technology Evaluation) Program evaluation of the Colloid Polishing Filter Method (CPFM) has demonstrated that CPFM is effective in removing low levels of uranium from contaminated ground water at the Department of Energy's Rocky Flats Plant in Golden, Colorado. Additionally, the developer of the technology, Filter Flow Technology, Inc. (FFT), has stated that the CPFM system has effectively removed trace concentrations of colloidal, complexed, chelated and ionic heavy metals and nontritium radionuclides from surface and ground water, wastewater, and secondary wastewater generated from soil washing. The CPFM is a transportable, trailer mounted system.

At the heart of the technology is the sorption unit which consists of four horizontal polypropylene filter plates that house three colloid filter packs that remove contaminants by sorption, chemical mechanisms, adsorption and physical filtration. Each filter pack contains a proprietary, inorganic, insoluble, oxide-based, filter bed material in particle and bead form Operationally, the filter packs are pneumatically pressure sealed between each set of plates.

The system can process contaminated waters continuously at 5 to 100-gallons per minute. At Rocky Flats approximately 10,000 gallons of ground water containing about 100 picoCuries per liter (pCi/L) of uranium was processed at 5 gallons per minute. The contaminated water may be pretreated if necessary to adjust the chemical oxidation state and acidity (pH) in mixing tanks. Total suspended solids (TSS) are removed in a small, parallel plate separator or mini-clarifier and bag filters to prolong colloid filter pack life. Sludge from the mini-clarifier is pumped through a small filter press; and, the filtered water is returned to the mini-clarifier. Effluent from the bag is routed to the colloid filter units and evenly dispersed throughout the filter packs which remove the contaminants. Water from the filter packs is collected and directed to a final pH adjustment tank. If necessary, effluent from the colloid filter units is treated with acid in this tank prior to discharge to reduce the pH to between 8.0 and 8.3.

Once treatment is complete, air blow-down is used to dewater the filter bed; then the hydraulic pressure on the support plates is released, the plates separated and the filter packs removed. Spent filter media is then mixed with solids from the mini-clarifier and bag filters and stabilized to meet EPA land disposal restrictions. The developer has stated that, alternatively, the filter media can be regenerated and reused.

The SITE evaluation focused on the ability of the CPFM system to remove uranium from ground water. For the first three test runs, removal efficiencies for uranium and gross alpha were approximately 75%. Run 4, which pretreated the effluent with sodium sulfide, achieved removal efficiencies of 95% for uranium and 96% for gross alpha.

Prior to the SITE demonstration, preliminary bench-scale studies using Rocky Flats feed water spiked with uranium, radium, plutonium and americium had shown greater than 99% removal rates. Initial influent pCi/L concentrations had

(See Uranium, Page 4)

This Month in Currents

THIS MONTH'S CURRENTS FEATURES REMOVAL TECHNOLOGIES FOR HEAVY METALS AND RADIONUCLIDES.

Sorption	1
Ion-Exchange	2
Membrane	3
New for the Bookshelf	4

Promising Ion-exchange Technology Seeks Site for Demonstration

By Naomi Barkley, Risk Reduction Engineering Laboratory

Pilot-scale studies through EPA's Superfund Innovative Technology Evaluation (SITE) Emerging Technologies Program and through a Department of Energy (DOE) effort have confirmed that the AlgaSORB® technology represents an advancement of the ion-exchange "state of the art". EPA's Emerging Technology Program tested AlgaSORB® in an onsite, pilot-scale demonstration on mercury-contaminated ground water at a hazardous waste site in Oakland, California. Additionally, ground waters contaminated with heavy metal ions were treated from three different DOE sites: Savannah River, Hanford and Oak Ridge Y-12 Plant. Based on the good results from these two evaluations, the EPA SITE program would like to evaluate AlgaSORB® in a full-scale demonstration. The technology developer, Bio-Recovery Systems, Inc., needs a sponsor and a site for the demonstration. Could it be your site?

AlgaSORB®, is a biological sorption process designed to remove heavy metal ions from aqueous solutions. The system functions as a biological ion-exchange resin to bind both metallic cations and metallic oxoanions. AlgaSORB® is composed of a non-living algal bio-mass immobilized in a silica polymer. It is a hard material where the algal cells are protected from decomposition by other microorganisms. The material can be packed into columns (similar to commercial ion exchange resins) which, when pressurized, exhibit good flow characteristics. The technology is based on the natural affinity of algae cell walls for heavy metal ions and thus functions well for removing heavy metals from ground waters that contain high levels of dissolved solids and/or organic contaminants. Dilute solutions containing heavy metals are passed through columns where metal ions are absorbed by the AlgaSORB® resins and anions such as chlorides or sulfates are only weakly bound or not bound at all. Compared to traditional ion exchange resins, an advantage of the immobilized algal biomass resins is that they are capable of producing effluent metal ion concentrations in the low parts per billion (ppb) range, even in the presence of high concentrations of salts such as calcium or magnesium.

Each contaminated ground water has unique contaminating metals, metal concentrations, ionic composition and treatability target goals. Treatability studies form the basis for choosing the optimum adsorbent and flow rates to meet effluent quality standards and to minimize operating costs. The algal biomass resins can be "tailor-made" for specific site conditions, including type of metal. Different species of algae can be immobilized on silica gel heads to produce adsorbents which vary in their metal ion binding capability. The high selectivity of the resins for a particular metal allows for high capacity and thus opportunities for recovery of removed constituents due to the very high pollutant concentrations. Once saturated by the resins, the metal ions can be stripped from the resin biomass in highly concentrated form by using acids, bases or other suitable reagents. This solution may require additional treatment to further concentrate the metals for recycling or disposal.

The EPA Emerging Technology pilot demonstration and the DOE treatability studies addressed the issues of optimum flow rates, binding capacities and the efficiency of the stripping agents. During the EPA's three-week demonstration, 588 bed volumes (235 liters), containing mercury concentrations varying from 330 to 1,000 ppb were passed through the test apparatus. The demonstration was continued until the effluent mercury exceeded the discharge limit of 10 micrograms per liter (µg/L) At least 534 bed volumes (214L) were successfully treated prior to column breakthrough. Data confirmed previous tests that AlgaSORB® 624 was capable of removing the majority of the mercury and that AlgaSORB® 640 was further capable of polishing effluent from AlgaSORB® 624 below permitted discharge limits to 7.7 ppb.

The objective of the DOE treatability studies at Hanford, Oak Ridge and Savannah River was to establish treatment protocols and to optimize an AlgaSORB®/ion exchange technology system to remove and recover toxic metal ions from these contaminated ground waters. Because the chemical nature of the ground waters from each site was unique, different metal ion adsorbents (which included different algae species as well as certain specialty ion exchange resins), different operational parameters and different stripping protocols were developed for treatment of each contaminated ground

(See Site Research, Page 3)

PERVAPORATION MEMBRANE REMOVES VOCS

By Lisa Keller, Environment Canada

The Zenon pervaporation membrane process removes volatile organic compounds (VOCs) from contaminated ground water, wastewater and leachate. Pervaporation has advantages over conventional technologies such as activated carbon or air stripping because it allows for contaminant recovery. Pervaporation can be applied when VOCs in ground water exceed 10 parts per million (ppm). Environment Canada's Development and Demonstration of Site Remediation Technology (DESRT) program sponsored a four-month pilot scale study of the system at a pumping station in southern Ontario, where ground water had become contaminated with BTEX compounds (benzene, toluene, ethylbenzene and xylenes). The pervaporation removal efficiency for the BTEX compounds was 98.2% based on average concentrations obtained with hourly sampling over an eight-hour period.

In the pervaporation system, organic-contaminated water flows into a pervaporation module containing a dense, organophilic membrane. The contaminated water is pumped across one side of the membrane, while the opposite side of the membrane is exposed to a vacuum. Organics are adsorbed to the membrane and diffuse through to the other side where they are drawn off by a vacuum (typically 29" Hg). Treated water which is depleted of organics by the pervaporation module exits the Zenon system for reuse or discharge. Organics passing through the membrane, now called permeate, are condensed and flow to a permeate collection tank where gravity separation of water and organics occurs. The concentrated organics are pumped from the collection tank to storage, while collected water is returned to the pervaporation system for further treatment. The vacuum is vented to a condenser to eliminate VOC releases to the air. The permeate contains high concentrations of organic compounds which often separate into an aqueous and organic phase, making the organic fraction potentially recoverable.

During the DESRT study, ground water from the well with the highest concentrations of BTEX compounds was routed to the pervaporation system. Initial untreated VOC concentrations and concentrations in treated water were: benzene, 480 micro-grams per liter µg/L) untreated to 9 µg/L in treated water; toluene 340 µg/L to 6 µg/L; ethylbenzene, 120 µg/L L to 2 µg/L and total xylenes, 690 µg/L to 12 µg/L. System performance was verified by the U.S. EPA during eight hours of sampling and monitoring. No detectable BTEX compounds were measured in the air vent from the vacuum pump. Higher removal efficiencies of treated water could be achieved by increasing residence time in the system.

Design and construction of a full-scale pervaporation unit by Zenon is currently underway. An EPA SITE (Superfund Innovative Technology Evaluation) demonstration of the unit has tentatively been scheduled for the summer of 1994 in San Diego, California.

For more information, call Lisa Keller of Environment Canada at 819-953-0962. A report of the study should be available by the end of 1994.

(Site Research cont. from page 2)

water. The bench scale treatability studies consisted of four segments. First, several adsorbents were screened and tested for effectiveness and selectivity in recovery of target metal ion(s). Then, protocols to strip target metal ions from the adsorbents were developed. Column studies to optimize flow rates for target metal ion binding and stripping were conducted next. The final task involved column studies to verify adsorbent recyclability. In general, these experiments were designed to investigate treatment options rather than to optimize engineering applications which would require on-site testing.

The specialty ion exchange/ AlgaSORB® resins tested in these studies show promise for selectively removing chromium, mercury and uranium from contaminated ground waters at all three DOE sites. The data show that effluents which satisfy the allowable metal ion limits are possible and most likely achievable. At Hanford, concentrations in ground water from several wells of 200 ppb uranium, 323 ppb chromium and 300 ppb chromium, dropped to 10 ppb, 50 ppb and 40 ppb, respectively, after treatment. At Oak Ridge, 2000 bed volumes of ground water containing 30 ppb mercury, dropped to 2 ppb after treatment. At Savannah River, ground water containing approximately 4 ppb mercury was spiked to

(See Site Research, Page 4)

NEW FOR THE BOOK SHELF

GROUNDWATER SAMPLING INFORMATION AVAILABLE

Get ready to order your copy of the Proceedings from EPA's Ground Water Sampling Work Shop that was held late last Fall in Dallas, Texas. The Work Shop provided a valuable forum for the presentation and discussion of recent research findings on ground water sampling. Participants included: representatives of universities and private industry; environmental consultants; and scientists and other innovative technology personnel from the U.S. EPA, U.S. Geological Survey, U.S. Department of Energy and several State environmental agencies.

The Proceedings will be in published form by early Fall 1994. To get on the mailing list, send a FAX to EPA's Robert S. Kerr Environmental Research Laboratory at 405-436-8503.

(Uranium cont. from page 1)
been approximately: 98 for total uranium; 56 for uranium-234; 35 for uranium-238; 7 for plutonium-239; and 22 for americium-241. Other removal rates and their initial approximate initial concentrations were: 86% of 166 pCi/L gross alpha; 54% of 124 pCi/L gross beta; and 46% of 13 pCi/L radium-226.

For more information, call Annette Gatchett at EPA's Risk Reduction Engineering Laboratory at 513-569-7697. Key findings from the demonstration, including complete analytical results and economic analysis, will be issued in a Capsule Report, an Innovative Technology Evaluation Report and a videotape, all of which will be available by the Fall of 1994.

(Site Research cont. from page 3)
contain 10 ppb mercury, which dropped to less than 2 ppb following treatment. At Hanford and Savannah River, recycling experiments show no diminution in performance. However, at Oak Ridge, there was some diminished activity of the adsorbent by the third cycle.

For more information, or if your site may be a candidate for a full-scale SITE demonstration, call Naomi Barkley at EPA's Risk Reduction Engineering Laboratory at 513-569-7854 or Michael Hosea at Bio-Recovery Systems, Inc. in Las Cruces, New Mexico at 800-697-3190.

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 513-891-6685. or send a mail request to NCEPI. 11029 Kenwood Road, Building 5, Cincinnati, OH 45242-0419. 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: Managing Editor, *Ground Water Currents* (5102W). U.S. Environmental Protection Agency, 401 M Street S.W.. Washington, DC 20460

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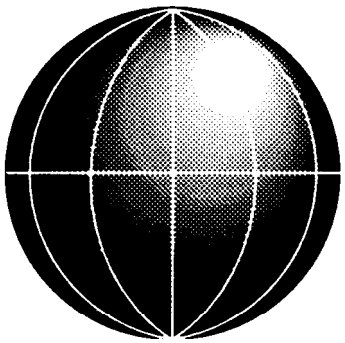
The U.S. EPA Environmental Technology Initiative (ETI) was announced by President Clinton in his State of the Union address on February 17, 1993. By promoting the development, commercialization and use of environmental technology, ETI will improve environmental quality while fostering the creation of new jobs and businesses. ETI is funded at $36 million in Fiscal Year 1994 (October, 1993-September, 1994) and a proposed $80 million in FY95. EPA's Innovative Technology Council (ITC) coordinates ETI activities Agency-wide. The Council is working closely with a broad network of interested parties including other federal agencies, the environmental technology industry, non-profit groups. universities, state and local governments, and others.



"Environmental technologies" include technologies, goods, and services whose developement is triggered primarily by environmental improvement objectives. These include: products and services to monitor and assess pollutant releases and exposure levels; innovative technologies which prevent pollution, control air and water pollution levels, safely manage waste and remediate contaminated soil and groundwater; and, manage environmenta data

The *FY94 Program Plan* describes 73 projects including: seven projects involving the metal fabrication industry aimed at reducing emissions and compliance costs for electroplaters and metal finishers; partnerships with other federal agencies to demonstrate pollution control, monitoring, and prevention technologies in Mexico, South America, Asia, Central and Eastern Europe; and, the Clean Car Technology Demonstration Program where EPA, the Department of Energy and domestic auto manufacturers will demonstrate ways to improve car and truck fuel economy and lower carbon dioxide emissions. The *EPA Technology Innovation* Strategy is a blueprint for the Agency's future efforts to create incentives for the development and use of innovative technologies in federal and state environmental regulations, to reduce trade barriers to technology innovation strategy, and improve the competitivness of the environmental technology industry in domestic and international markets.

EPA is now in the process of soliciting FY 1995 project proposals. In the first solicitation, EPA is seeking environmental technology proposals from federalagencies, stategovernments (including state colleges that are departments of state agencies), and tribal governments (including Alaska Native Villages). The second solicitation will seek proposals from non-profit groups, universities and their partners. The third solicitation will be awarded to Phase 3, Small Business Innovation Research (SBIR) projects. Candidate projects must have already completed Phases 1 and 2 of the SBIR process.

Copies of the **EPA Environmental Technology Initiative: FY 1994 Program Plan** (S/N 055-00000465-O), the **EPA Technology Innovation Strategy** (S/N 055-000-00466-8), and the **EPA Environmental Technology Initiative: Program Solicitation Package for FY 1995** (S/N 055-000-00476-5) are available through the GPO Order Desk. *Please contact the Order Desk at (202) 512-1800.*