United States
Environmental Protection
Agency

Solid Waste and
Emergency Response
(5102G)

EPA 542-N-97-006
December 1997
www.epa.gov
Issue No. 26

EPA

Ground Water Currents

Developments in innovative ground water treatment

Reactive Barriers for Uranium Removal

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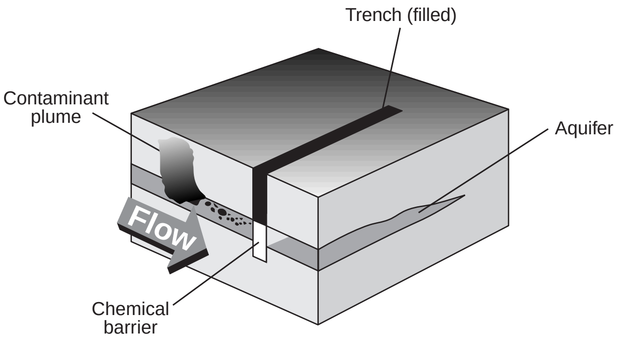

Figure 1. Schematic diagram of a reactive barrier
(Modified from Morrison and Spangler, 1992)

The U.S. EPA, U.S. Geological Survey (USGS), U.S. Bureau of Land Management, U.S. Department of Energy, and Utah Department of Environmental Quality are conducting a joint demonstration of permeable reactive chemical barriers at an abandoned uranium upgrader site in Fry Canyon, UT. Many small active and abandoned mine and mill sites throughout the Western U.S. may be suitable for using the methods demonstrated at Fry Canyon. Based on successful laboratory demonstration results showing highly effective removal of uranium in ground water, full-scale barriers were installed late this summer. Initial results collected three weeks after barrier installation indicate that the barriers are removing the majority of uranium from the contaminated ground water. These results are preliminary and may change significantly as the reactive barriers age and the hydrologic system re-equilibrates.

Figure 1 illustrates the schematics of a typical reactive barrier. Three reactive chemical barriers were emplaced at Fry Canyon using simple, inexpensive, and well-established construction methods. Installation of the barriers involved initial excavation of a barrier trench, using a metal trench box that protected workers during barrier installation. Reactive materials were dumped into the gate structure of each barrier, and monitoring ports were constructed prior to backfilling with native material. Each of the three reactive barriers contains 16 0.25-inch diameter monitoring points and 4 2.0-inch monitoring points. No-flow barriers located on both ends of the reactive gate are constructed of bentonite.

Each of the three barriers consists of different reactive materials: Cercona Bone Char Phosphate (PO4), Cercona Foamed Zero Valent Iron (ZVI) pellets, and amorphous ferric oxide (AFO). Four transducers, one water quality minimonitor (measuring temperature, pH, specific conductance, oxidation reduction potential, and dissolved oxygen), and a flow sensor are deployed in each barrier. Data from the transducers and minimonitor are recorded hourly, and flow direction and velocity are measured monthly. Four

About this Issue

This issue features demonstration and research results on the use of reactive barriers, enhanced bioremediation for site cleanup, and diffusion sampling techniques for site investigations.

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monitoring points are located downgradient of the barriers in the colluvial aquifer.

Uranium concentrations are monitored in all three barriers. Prior to entering the PO4 barrier, the contaminated ground water contains 3,050-3,920 ug/l dissolved uranium. After traveling 2.0 feet along flowpath 1 into the reactive barrier, the uranium concentration is reduced to 10 ug/l. Prior to entering the ZVI barrier, contaminated ground water contains 1,510-8,550 ug/l dissolved uranium. After traveling 0.5 feet into the reactive barrier, the uranium concentration is reduced to below the analytical reporting limit of 0.06 ug/l. Prior to entering the AFO barrier, contaminated ground water contains 14,900-17,600 ug/l dissolved uranium. After traveling 2.0 feet into the reactive barrier, the uranium concentration is reduced to less than 500 ug/l.

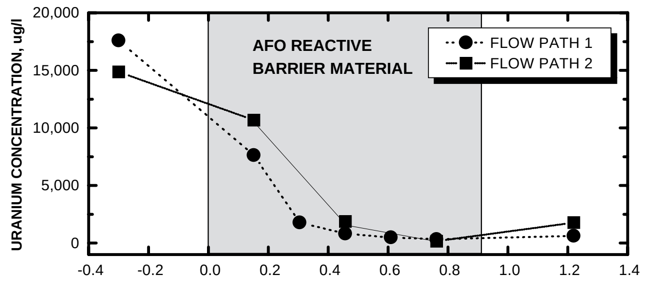

Figure 2. Cross section distance, in meters

Uranium concentration reductions in flowpaths 1 and 2 of the AFO barrier, which are of the same design but on opposite sides of the barrier, are illustrated in Figure 2.

During the next 10 months, study team members will monitor the permeable reactive chemical barriers for numerous water-quality constituents, including pH, specific conductance, dissolved oxygen, oxidation reduction potential, uranium, iron, phosphate, and major ions. For more information, contact Ed Feltcorn (U.S. EPA, Office of Radiation and Indoor Air) at 202-564-9422. Other EPA staff members contributing to this project include Ron Wilhelm (Office of Radiation and Indoor Air) and Paula Estornell (Office of Emergency and Remedial Response).

Reference: Morrison, S.J., and Spangler, R.R., 1992, Chemical Barriers for Controlling Groundwater Contamination: Environmental Progress, Volume 12, pages 175-181.

Diffusion Samplers for Investigating VOC's in Ground Water

by Don A. Vroblesky,
U. S. Geological Survey

U.S. Geological Survey (USGS) studies at a gas-turbine manufacturing facility in Greenville, SC, have shown the effectiveness of a simple, inexpensive diffusion sampler for delineating areas where contaminated ground water is discharging to surface water, and for obtaining water samples from wells. This technology provides an advantage over traditional methods for obtaining well samples because purging, which increases project costs and potentially confounds analytical results, sometimes is not required for collection of representative water samples.

The diffusion sampler consists of water or air inside a polyethylene membrane. A sealable sandwich bag obtained at a local grocery store can serve as a simple sampler. Earlier studies performed at the Aberdeen Proving Ground, MD, showed that the sampler is based on the ability of polyethylene to readily allow diffusion of volatile organic compounds (VOC's), such as aromatic petroleum hydrocarbons and chlorinated solvents, while preventing the movement of water across the membrane. Accordingly, after sufficient equilibration time, VOC concentrations of air or water in the sampler achieve equilibrium with VOC concentrations in the ambient water outside of the sampler. Recovery of the samplers and analysis of the contained air or water are used to determine VOC concentrations. Vapor-based sampler analysis, which can be performed rapidly and inexpensively on field or laboratory gas chromatographs, yields relative VOC concentrations. Water-based sampler analysis provides the advantage of quantifying specific VOC concentrations through standard laboratory methods.

One project study at the Greenville site showed that samplers were capable of determining the locations of bedrock fractures that were discharging contaminated ground water to surface water. The project involved installation of diffusion samplers in the bottom sediment of a stream to intercept discharging ground water prior to entry into the stream. Diffusion samplers consisted of air-filled, 40-ml glass vials enclosed in sealable polyethylene bags. Concentrations of total VOC's in the samplers ranged from less than 5 ppm (as vapor) in reaches of the stream outside of the contamination plume to greater than 900 ppm (as vapor) in a suspected fracture zone.

Periodic analysis of diffusion samplers was useful in analyzing increases in contaminant discharge resulting from air-rotary drilling of a nearby well in a fractured-rock aquifer. VOC vapor concentrations increased from approximately 1,000 ppm prior to well installation to greater than 10,000 ppm following well installation. As the well began pumping and

Calendar

Remediation by Natural Attenuation; January 26-28, 1998; J.F. Friedrick Center, University of Wisconsin, Madison, WI; 800-462-0876.

Subsurface Barrier Technologies; January 26-27, 1998; Weston La Palma, Tucson, AZ; 508-481-6400 ext. 451, e-mail reg@ibcusa.com, or the World Wide Web site http://www.ibcusa.com/conf/barrier.

Eighth Annual West Coast Conference, Contaminated Soils and Ground Water; March 8-12, 1998; Embassy Suites Hotel, Oxnard, CA; 413-549-5170, e-mail bknowles@aehs.com, or the World Wide Web site http://www.aehs.com.

Listing of conferences, seminars, or events in this section does not necessarily constitute endorsement by the U.S. EPA.

removing contaminated ground water, diffusion samplers indicated that VOC vapor concentrations beneath the stream decreased from greater than 10,000 ppm to less than 1 ppm. This reduction in VOC concentrations indicated that well pumpage had captured the discharging contamination.

A second Greenville site study indicated that diffusion samplers also can provide representative water samples for chlorinated VOC's from observation wells. Samplers consisted of polyethylene bags containing deionized water placed adjacent to the water-bearing fracture or screened interval in a well. In saprolite and fractured-rock wells, VOC concentrations in water samples obtained using the samplers without prior purging were similar to concentrations in water samples obtained from the respective wells using traditional purging and sampling approaches (such as a submersible electric pump, a bladder pump, and a bailer). For example, the trichloroethene (TCE) concentration obtained after purging with a submersible electric pump was 146 ug/l. TCE concentrations in down-hole diffusion samplers prior to purging ranged from 145 to 163 ug/l, indicating that the two sampling methods produced comparable results. Similar findings were obtained from other wells over a range of concentrations from undetectable to greater than 2,000 ug/l. The low cost associated with this approach (typically less than $10 per sampler) makes it a viable option for monitoring large networks of observation wells. For more information, contact Don Vroblesky (U.S. Geological Survey) at 803-750-6100.

Enhanced In Situ Anaerobic Bioremediation of Fuel-Contaminated Ground Water

by Martin Reinhard, Ph.D., Stanford University

A team of investigators from Stanford University and the Naval Facilities Engineering Service Center is demonstrating the feasibility and cost effectiveness of enhancing natural bioremediation of fuel-contaminated sites. The test site is located at the Naval Weapons Station, Seal Beach, CA, under sponsorship by the U.S. Department of Defense (DOD) Environmental Security Technology Certification Program.

Enhancing natural (or intrinsic) bioremediation utilizes naturally-occurring anaerobic microorganisms that transform hydrocarbon contaminants under nitrate- and sulfate-reducing and methanogenic conditions. The target compounds are benzene, toluene, ethylbenzene, o-, m-, and p-xylene (the BTEX compounds). These compounds are regulated and have low maximum contaminant limits in drinking water. Enhancing natural bioremediation involves amending the ground water with nitrate and/or sulfate as electron acceptors and removal of inhibitory compounds. "Push-pull" tests conducted at the Seal Beach test site have indicated that BTEX transformation under the naturally existing conditions is extremely slow. (Push-pull tests are *in situ* reactivity tests whereby slugs of groundwater (approximately 1,000 liters) containing a tracer, nutrient, and BTEX compounds are released into a test zone. Water from the test zone subsequently is analyzed, and contaminant transformation rates are inferred from the concentration versus time and tracer response. Modifications to the composition of the injection water allow for different geochemical conditions to be evaluated). By amending electron acceptors to the contaminated zone, BTEX transformation rates were significantly enhanced.

Enhancement of natural bioremediation provides several benefits. *In situ* processes are preferred over pump-and-treat technologies that produce secondary waste streams and are limited by slow mass transfer. Cleanup is accelerated and process costs for long-term monitoring and site maintenance may be lowered significantly. Complications associated with the addition of poorly water-soluble oxygen or oxygen-releasing compounds can be avoided by using anaerobic bioremediation processes instead of aerobic ones. Nitrate and sulfate are much more water soluble than oxygen and, therefore, can be added in high concentrations. Anaerobic processes are less likely to produce pore-clogging biomass and, therefore, are easier to control.

Resources

Innovations in Ground Water and Soil Cleanup: From Concept to Commercialization
This report published by the National Research Council provides an up-to-date review of the capabilities and limitations of existing ground water and soil cleanup technologies. The report also recommends solutions to institutional problems and other factors that have stifled innovation in the ground water and soil cleanup industry [June 1997, 265 pages]. Prepublication hard copies are available from National Academy Press for $45 plus $4 shipping/handling. Contact 800-624-6242 or 202-334-3313. When the report is published in October, it will be downloadable from http://www.nap.edu.

News on Technologies

Bi-weekly updates of the *Technology Innovation News Survey* contain market/commercialization information; reports on demonstrations, feasibility studies, and research; and other news of interest to the hazardous waste community. Each update summarizes articles of potential interest to technology development stakeholders who may not have enough time to read the numerous news publications that are available. Bi-weekly reports are available on the U.S. EPA Technology Innovation Office's CLU-IN World Wide Web site.

http://clu-in.com

In the ongoing demonstration, three test zones that allow for the parallel evaluation of three different treatment regimes have been established. Each test zone is equipped with five multi-level observation points (seven levels) that provide samples for a three-dimensional evaluation of the contaminant plume. Contaminant behavior is monitored using an on-site automated sampling and analysis platform that draws samples from 105 different observation points. Ground water is extracted from a common extraction well, treated and amended according to specifications, and then re-injected into the ground. Injected ground water is amended with BTEX compounds for verifying contaminant removal. Treated ground water

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containing nitrate and sulfate combined, and sulfate alone, is injected into two separate test zones. The third test zone is amended with treated ground water that contains bicarbonate as the only electron acceptor.

Preliminary data indicate the establishment of nitrate- and sulfate-reducing and methanogenic conditions in the three different plumes and BTEX removal. Study data are used to evaluate mass balances, removal rates, rate-limiting factors, and transformation intermediates. This information will be useful for developing protocols to optimize *in situ* bioremediation approaches and monitor the progress of site cleanup.

U.S. EPA estimates that approximately 300,000 fuel-contaminated sites exist across the nation. DOD alone has over 2,700 sites with contaminated ground water from underground storage tanks. Compared to conventional pump-and-treat technology with activated carbon treatment, enhanced intrinsic bioremediation is estimated to cost one-third as much, resulting in a $100 million savings for cleanup of these DOD sites.

For more information, contact Martin Reinhard, Ph.D. (Stanford University) at 650-723-0308 or e-mail Reinhard@CE.Stanford.edu, or Carmen Lebron (Naval Facilities Engineering Service Center) at 805-982-1616 or e-mail clebron@nfesc.navy.mil.

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