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EPA Ground Water Currents

Developments in innovative ground water treatment

AIR LIFT/AIR STRIPPING COMBINE TO CLEAN AQUIFERS

By Michelle Simon, EPA National Risk Management Research Laboratory

The Weston/IEG UVB technology is an in situ ground water remediation technology that combines air-lift pumping and air stripping to clean aquifers contaminated with volatile organic compounds. The UVB technology, in a Superfund Innovative Technology Evaluation (SITE) program demonstration, has removed trichloroethene (TCE) and 1,1 -dichloroethene (DCE) from ground water at Site 31, March Air Force Base, California.

A UVB system consists of a single well and two hydraulically separated screened intervals installed within a single permeable zone. The air-lift pumping occurs in response to negative pressure introduced at the wellhead by a blower. This blower creates a vacuum that draws water into a well through the lower screened portion of the well. Simultaneously, air stripping occurs as ambient air (also flowing in response to the vacuum) is introduced through a diffuser plate located within the upper screened section of the well, causing air bubbles to form in the water pulled into the well. The rising air bubbles provide the air-lift pump effect that moves water towards the top of the well and draws water into the lower screened section of the well. This pumping effect is supplemented by a submersible pump that ensures that water flows from bottom to top in the well at a rate of approximately 20 gallons a minute. As the air bubbles rise through the water column, volatile compounds are transferred from the aqueous to the gas phase. The rising air transports volatile compounds to the top of the well casing where they are removed by the vacuum blower. The lower effluent is treated before discharge using granular activated carbon.

The transfer of volatile compounds is further enhanced by a stripping reactor located immediately above the air diffuser. The stripping reactor consists of a fluted and channelized column that facilitates the transfer of volatile compounds to the gas phase by increasing the contact time between the two phases and by minimizing the coalescence of air bubbles.

Once the upward stream of water leaves the stripping reactor, the water falls back through the well casing and returns to the aquifer through the upper well screen. This return flow to the aquifer, coupled with inflow at the well bottom, circulates ground water around the UVB well. The extent of the circulation pattern is known as the radius of influence, which determines the volume of water affected by the UVB system.

The UVB technology demonstration evaluated not only the reduction of TCE and DCE concentrations in the ground water discharged from the treatment system, but also, over the course of the study, the radius of influence of the system and the reduction (both vertically and horizontally) of TCE and DCE concentrations in the ground water within the radius of influence. Demonstration results indicate that TCE concentrations were reduced by greater than 94% in ground water discharged from the system. TCE concentrations were reduced from a mean of approximately 54 micrograms per liter (µg/L) in the system's influent to approximately 3 µg/L in the system's effluent. A meaningful estimate of the system's ability to remove DCE could not be made due to the low (less than 4 µg/L) influent concentration of DCE. Based on the results of the dye tracer study, the radius of influence was estimated to be at least 40 ft.

The developer claims that the technology can also clean up aquifers contaminated with other organic compounds, including volatile and semivolatile hydrocarbons. Additionally, the developer claims that in some cases the UVB technology is capable of simultaneous recovery of soil gas from the vadose zone.

For more information, call Michelle Simon at EPA's National Risk Management Research Laboratory at 513-569-7469. To get on the mailing list for the Capsule Report and the Innovative Technology Evaluation Report of the demonstration, send a FAX to Michelle Simon at 513-569-7676.

CURRENTS ON-LINE

GROUND WATER CURRENTS now will be available only by computer access. See page 4 under the "Mailing List/Order Info/On-Line Access" heading for specific information about on-line and other order information.

ELECTRON BEAM TECHNOLOGY FOR VOCs

By Franklin Alvarez, EPA National Risk Management Research Laboratory

EPA's Superfund Innovative Technology Evaluation (SITE) program demonstrated the High Voltage Environmental Applications, Inc. (HVEA), electron beam (E-beam) technology. The E-beam was developed to destroy semivolatile and volatile organic compounds (VOCs) in liquid wastes, including ground water, wastewater and landfill leachate. The objective of the demonstration, conducted at the U.S. Department of Energy Savannah River Site in Aiken, South Carolina, was to determine the effectiveness of the E-beam for treating ground water contaminated with VOCs.

The E-beam system treated about 70,000 gallons of ground water. The principal contaminants were trichloroethene (TCE) and tetrachloroethene (PCE), which were present at concentrations of about 27,000 and 11,000 micrograms per liter (µg/L), respectively. The ground water also contained low levels (40 µg/L) of cis-1,2-dichloroethene (1,2-DCE). Removal efficiencies were greater than 99% for TCE and PCE and 91% for 1,2-DCE.

During a portion of the demonstration, the groundwater was spiked with 1,2 dichloroethane (1,2-DCA); 1,1,1-trichloroethane (1,1,1-TCA); chloroform; carbon tetrachloride (CCl_4); and aromatic VOCs, including the BTEX compounds benzene, toluene, ethylbenzene and xylenes. The influent concentrations of these spiking compounds ranged from 100 to 500 µg/L. These compounds were chosen either because they are relatively difficult to remove using technologies that employ free radical chemistry such as the E-beam does (i.e., 1,2-DCA, 1,1,1-TCA, chloroform and CCl_4) or because they are common ground water contaminants (i.e., BTEX). Removal efficiencies ranged from 68 to >98% for the chlorinated compounds and from >96 to >98% for BTEX compounds.

The treatment system effluent met Safe Drinking Water Act (SDWA) maximum contaminant levels (MCL) for 1,2-DCE, CCl_4 and BETEX at a significance level of 0.05. However, the treatment system effluent did not meet this test for the other compounds. In addition, the effluent LC50 values (the percentage effluent in the test water at which at least 50% of the test organisms died) ranged from less than 6.2 to 8% for water fleas and from 8.6 to 54% for flathead minnows.

Here's how the E-beam works. It irradiates water with a beam of high-energy electrons, causing the formation of three primary transient reactive species: aqueous electrons, hydroxyl radicals and hydrogen radicals. Target organic compounds are either mineralized or broken down into low molecular weight compounds, primarily by these species.

The HVEA E-beam system (model M25W-48S) used for the SITE demonstration is housed in an 8 ft. by 48 ft. trailer and is rated for a maximum flow rate of 50 gallons per minute (GPM). The system has a strainer basket, an influent pump, the E-beam unit, a cooling air processor, a blower and a control console.

After particulates larger than 0.045 inch are removed from the influent by the strainer basket, the influent pump transfers contaminated water to the E-beam unit. This unit is made up of an electron accelerator, a scanner, a contact chamber and lead shielding. The electron accelerator is capable of generating an accelerating voltage of 500 kilovolts and a maximum beam current of about 42 milliamps, which results in a maximum power rating of 21 kilowatts. The scanner deflects the E-beam, causing the beam to scan the surface of the water as it flows through the contact chamber. The E-beam significantly heats the titanium window, which is cooled by air recirculated through the contact chamber. The air is conditioned by a cooling air processor.

E-beam dose is a key operating parameter for this technology. This is a function of several parameters, including the density and thickness of the water stream; E-beam power, which is a function of beam current and accelerating voltage; and the length of time that the water is exposed to the E-beam which depends on the flow rate.

The carbon adsorber was used to destroy ozone (O_3) formed in the cooling air when exposed to the E-beam. Vapor phase VOCs not destroyed by the E-beam are removed by the carbon adsorber. Since the SITE demonstration, HVEA has replaced the carbon adsorber with an O_3 destruction unit.

For more information, call Franklin Alvarez at EPA's National Risk Management Research Laboratory at 513-569-7631. Key findings will also be documented in a SITE Technology Capsule, an Innovative Technology Evaluation Report and the Technology Evaluation Report; to get on the mailing list for these reports, send a FAX to Franklin Alvarez at 513-569-7677 with your name and address.

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IN SITU REMEDIATION -- STATUS REPORTS

EPA has identified six abiotic technologies that are emerging as possible cleanup remedies. These technologies are: thermal enhancements, surfactant enhancements, treatment walls, hydraulic fracturing/pneumatic fracturing, cosolvents and electrokinetics. For each technology, EPA has produced a separate IN SITU REMEDIATION TECHNOLOGY STATUS REPORT. The purpose of each report is to identify research projects and to describe recent field demonstrations and commercial applications of the technology. The technologies contained in the reports either treat ground water and soil in place or increase the solubility and mobility of contaminants so that pump-and-treat remediation of the contaminant is improved.

These emerging technologies grew out of a need identified by researchers and regulators who recognize that the source of much ground water contamination is dense non-aqueous phase liquids and other compounds that migrate downward into aquifers, creating pools of subsurface contamination. Thus, pump-and-treat systems can only treat the symptom, not the cause. Technologies such as the ones discussed in these reports are emerging to treat the cause and improve pump-and-treat efficiency.

The reports do not cover trends in the use of bioremediation. EPA has other resources summarizing the progress of bioremediation technologies. A brief summary of the technologies and report contents follows.

Thermal enhancement technologies include: (1) the injection of hot water or steam or (2) the use of radio frequency or electrical resistance heating to increase the mobility, solubility or volatilty of organic contaminants, particularly immiscible compounds. Physical site conditions, not chemical reactions, are the major controlling factors on the use of this technology. The thermal enhancement status report discusses 16 completed, ongoing or future demonstrations. The 11 completed demonstrations provide some cost and performance information. Most of the demonstrations treated volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs) and the BTEX compounds (i.e., benzene, toluene, ethylbenzene and xylene). However, two demonstrations were designed to treat polyaromatic hydrocarbons (PAHs) from wood treating sites; and, one treated pesticides.

Surfactants increase the solubility of the contaminant in water. They also directly mobilize the contaminant by reducing interfacial tension between the contaminant and the soil matrix. The report contains nine research projects, six ongoing or future demonstrations, three completed demonstrations and one commercial application. The target contaminants were VOCs, SVOCs, BTEX and PCBs. Continued surfactant research is important. There are a variety of surfactants available to be tested; the effectiveness of each of these to treat a specific contaminant in a specific geochemical environment is usually unknown until laboratory and bench scale treatability tests are conducted. Treatment walls are vertical treatment zones installed across the flow path of a contaminant plume to treat the contaminants as the plume passes through the zone. These mechanically simple barriers may contain metal-based catalysts for degrading volatile organics, chelators for immobilizing metals or nutrients and oxygen to enhance bioremediation. There are 11 research projects, nine ongoing or future demonstrations, two completed demonstrations and one commercial application. Four of the 11 ongoing or completed demonstrations are using or have used in situ metal-enhanced dehalogenation; and, the patent for this technology is held by the University of Waterloo. The remaining demonstrations are testing the use of O^2 nutrients for bioremediation and chemical reactants to reduce Cr^{+6} The ten research projects are divided between the treatment of metals and organics.

Hydraulic fracturing/pneumatic fracturing consists of the injection of pressurized water or air to increase the size and number of fractures in a consolidated material or relatively impermeable unconsolidated material. The enlarged fractures provide more treatment area for an in situ technology or more pathways to remove solubilized or mobilized contaminants. There are two ongoing or future demonstrations and ten completed demonstrations discussed in the report.

Cosolvents are a form of in situ flushing that involves the injection of a solvent mixture (e.g., water plus a miscible organic solvent such as alcohol) that enhances the solubility of organic contaminants. The use of cosolvents is in the very early stage of development. One research project was completed in 1991; and, there are three ongoing or future demonstrations. No vendors were identified who are marketing the technology. The three planned demonstrations will be conducted by a partnership between a federal laboratory, a military base and a university.

Electrokinetics has as its basis that positively-charged organic or inorganic contaminants can be made to migrate in an electric field to a collection point for removal by pumping. There are ten research projects, five ongoing or future demonstrations

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BIOATTENUATION ON VIDEO

Data from the St. Joseph, Michigan, Superfund site were used in a peer-reviewed video entitled "Natural Bioattenuation of Trichloroethene at the St. Joseph, Michigan Superfund Site". Computer visualizations of the data set show how trichlorethene, or TCE, can degrade under natural conditions. The purpose of the tape is to present sampling results from the site to a technical audience. Although the visualizations show the general distribution of chemicals at the site, it is not possible to determine the precise concentrations from the tape. Thus the data set itself is available in a companion document.

Analysis of the data from the St. Joseph site indicates that natural bioattenuation of TCE is occuring as the contaminants flow toward Lake Michigan. Depletion of oxygen, the presence of methane and the appearance of degradation products indicate that the reduction in TCE concentrations is not solely due to volatilization or dilution. Rather, they are indicative of microbial processes helping to reduce the contaminant concentrations below EPA drinking water standards before the water is discharged into Lake Michigan.

The authors of the video, James W. Weaver, John T. Wilson and Don H. Kampbell, are with EPA's National Risk Management Research Laboratory Subsurface Protection and Remediation Division in Ada, Oklahoma 74820. The video (Document No. EPA/600/V-95/001) will be available upon request from: Subsurface Remediation Information Center, National Risk Management Research Laboratory, U.S. Environmental Protection Agency, P.O. Box 1198, Ada, Oklahoma 74820. The telephone number is 405-436-8651; the FAX number is 405-436-8503. The Project Officer is James Weaver.

There is also an amplified text version of the narration on the video available as a Project Summary (Document No. EPA/600/SV-95/001). The Project Summary can be ordered by calling CERI at 513-569-7562.

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and one completed demonstration. There are a relatively large number of universities conducting research in electrokinetics, many being supported by the U.S. Department of Energy.

The full status reports can be ordered from EPA's National Center for Environmental Information and Publications (NCEPI). You can order the reports by mail or by FAX. The FAX number is 513-489-8695. The mail address is: NCEPI, 11305 Reed Hartman Highway, Suite 219, Cincinnati, OH 45241. Please refer to the document number when ordering. The individual report document numbers are: Thermal Enhancements (EPA542-K-94-009); Surfactant Enhancements (EPA542-K-94-003); Treatment Walls (EPA542-K-94-004); Hydraulic Fracturing/Pneumatic Fracturing (EPA542-K-94-005); Cosolvents (EPA542-K-94-006); and Electrokinetics (EPA542-K-94-007).

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Ground Water Currents welcomes readers' comments and contributions. Address correspondence to:

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