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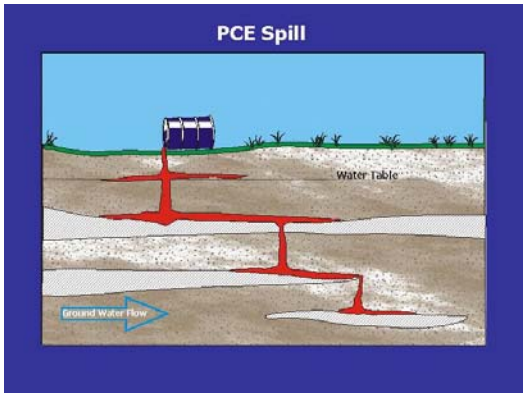
NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
GROUND WATER AND ECOSYSTEMS RESTORATION RESEARCH

Field Demonstration of the Solvent Extraction Residual Biotreatment (SERB) Technology

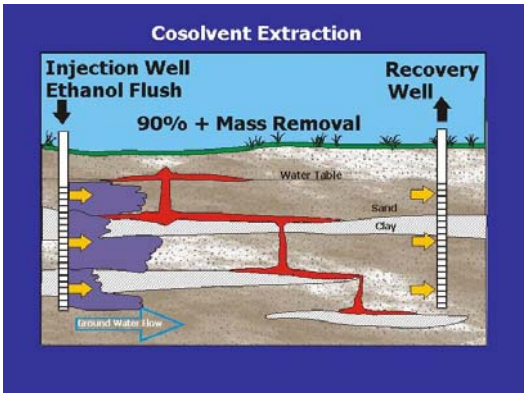
Introduction to the Problem

Tetrachloroethylene (PCE) is a dense nonaqueous-phase liquid (DNAPL) that was widely used as a degreasing agent and in dry cleaning processes. Because DNAPLs may be trapped in the pore space as a separate phase contaminant, they can serve as a long-term source of contamination to the aquifer. The physical/chemical properties of PCE and its daughter products have resulted in the chloroethenes being the most commonly detected class of organic contaminants in ground water. Parent chloroethenes can become human health hazards after being processed in the human liver or via reductive dehalogenation in the environment.



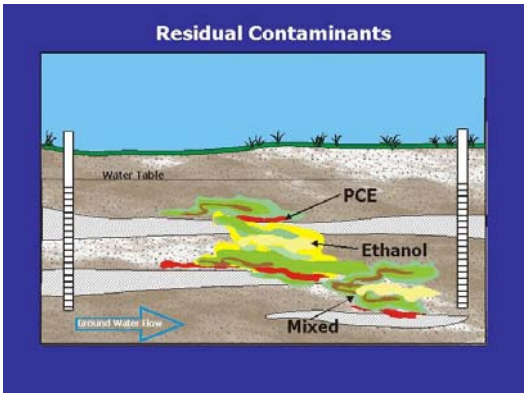
Background

The former Sages Dry Cleaner site in Jacksonville, Florida, was selected for remediation of a PCE source zone by co-solvent extraction with ethanol. Ethanol was selected as the co-solvent because it has been shown to be an acceptable electron donor for indigenous microorganisms from other locations to support reductive dechlorination processes. This project was designed to investigate the potential for merging two synergistic technologies—enhanced source remediation by in situ flushing and bioremediation by reductive dechlorination—into a treatment train to develop a comprehensive approach for site restoration.



Objectives

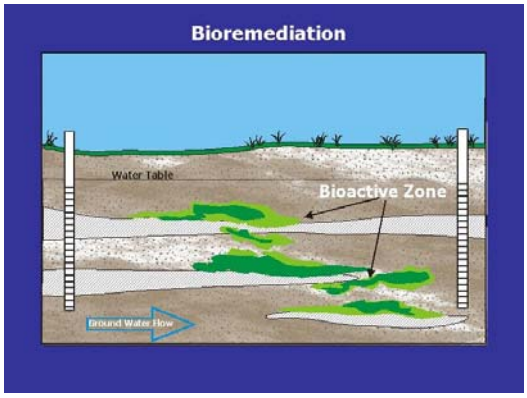
- Evaluate enhancement of subsurface microbial processes following co-solvent extraction with ethanol
- Assess extent and rates of reductive dechlorination transformations



Approach

Application of the solvent extraction residual biotreatment (SERB) technology was conducted by characterization of the source area and design of the co-solvent flushing pilot test to remove a significant portion of the PCE DNAPL. Following the co-solvent flushing test, areas of residual DNAPL were exposed to ethanol that was left in the subsurface. Indigenous microorganisms can use the ethanol as an

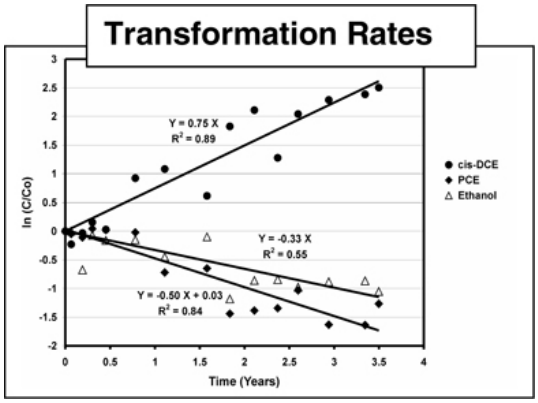
electron donor and produce hydrogen, which may then be used as a direct electron donor by organisms capable of partial and complete reductive dechlorination. Bioactive zones in the subsurface were created and monitored to determine the capacity for transformation of PCE to non-toxic products, such as ethene



Accomplishments to Date (Summer 2003)

The co-solvent flushing pilot test was conducted during August 1998 and quarterly sampling and analysis of ground water was conducted until April 2003. Ground water samples were analyzed for PCE and daughter products, dissolved gases, ethanol, and additional parameters to monitor changes in contaminant concentrations and geochemistry. Evaluation of ground water results indicates that reductive dechlorination was enhanced in areas exposed to ethanol both in the source and downgradient areas. Ground water samples collected four years after the co-solvent flushing pilot test from the source zone tested positive for three out of three primers for Dehalococcoides (the only known microorganism to dechlorinate PCE completely to ethane). Transformation rates calculated from site data, based on changes in mass estimated from contour plots, were:

- 0.75 year^{-1} for cis-dichloroethene
- -0.50 year^{-1} for PCE
- -0.33 year^{-1} for ethanol



Future Tasks

Biannual sampling and analysis of ground water will continue for evaluation of long-term performance of the SERB technology. Ground water flow and transport modeling of the site data will be conducted to better evaluate transformation rates and the impact of the drainage canal on ground water flow. Laboratory studies are planned to evaluate the impact of ethanol on microbial communities.

Publications

Mravik, S.C., G.W. Sewell, R.K. Sillan, and A.L. Wood. (2003). "Field Evaluation of the Solvent Extraction Residual Biotreatment (SERB) Technology." *Environ. Sci. Tech*., 37, 21: 5040–5049.

Sewell, G.W., S.C. Mravik, A.L. Wood, M. Annable, R. Sillan, and K. Warner. (2002). "Chlorinated Solvent Contaminated Soils and Ground Waters: Field Application of the Solvent Extraction Residual Biotreatment (SERB) Technology." In *Federal Integrated Biotreatment Research Consortium (FIBRC): Flask to Field Initiative*. Edited by R. Bajpai, et al. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi. ERDC/EL Tr-02-37.

Sewell, G.W., S.C. Mravik, and A.L. Wood. (2000). "Field Evaluation of Solvent Extraction Residual Biotreatment (SERB)." In: Proceedings 7th International FZK/TNO Conference on Contaminated Soil, September 18–22. *Contaminated Soil 2000*, Vol. 2. Thomas Telford Publishing. p. 982-988.

Mravik, S.C., G.W. Sewell, and A.L. Wood. (2000). "Co-Solvent-Based Source Remediation Approaches." In: Proceedings 2nd International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, California, May 22–25. *Physical and Thermal Technologies*, C2-5. Battelle Press. p. 269-276.

Presentations

Mravik, S.C., G.W. Sewell, R.K. Sillan, K. Warner, and A.L. Wood. (2001). "Performance Data From the Solvent Extraction Residual Biotreatment (SERB) Technology Demonstration." Presentation, DNAPL Source Remediation Workshop, sponsored by U.S. EPA's Technology Innovation Office and the National Risk Management Research Laboratory, Dallas, Texas, October 29–30.

Sewell, G.W., S.C. Mravik, R.K. Sillan, K. Warner, and A.L. Wood. (2001). "Performance Data From the Solvent Extraction Residual Biotreatment (SERB) Technology Demonstration." Presentation, Sixth International In Situ and On-Site Bioremediation Symposium, San Diego, California, June 4–7.

Mravik, S.C., G.W. Sewell, and A.L. Wood. (1999). "Field Evaluation of the Solvent Extraction Residual Biotreatment Technology." Presentation, International Symposium on Subsurface Microbiology, Vail, Colorado, August 22–27.

Posters

Mravik, S.C., A.L. Wood, M. Annable, and G.W. Sewell. (2002). "Solvent Extraction Residual Biotreatment (SERB) Demonstration at a Dry Cleaner Site." Poster, In Situ Treatment of Ground Water Contaminated With Nonaqueous-Phase Liquids: Fundamentals and Case Studies, Chicago, Illinois, December 10–12.

Mravik, S.C., G.W. Sewell, and A.L. Wood. (2000). Co-Solvent-Based Source Remediation Approaches." Poster, Remediation of Chlorinated and Recalcitrant Compounds, 2nd International Conference, Monterey, California. May 22–25.

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