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NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
GROUND WATER AND ECOSYSTEMS RESTORATION RESEARCH

Performance Evaluation of an Organic Carbon/Zero-Valent Iron-Based PRB for Treatment of Arsenic and Heavy Metals

Problem Definition

The Columbia Nitrogen site in Charleston, South Carolina, is extensively contaminated with spent pyrite from phosphate fertilizer production at the site between 1905 and 1972. Sulfide oxidation processes (acid rock drainage) have resulted in the subsurface mobilization of arsenic and heavy metals, including lead, cadmium, nickel, and zinc. In addition, the ground water is characterized by a low pH and high acid-producing ferrous iron concentrations. The contaminated ground water is impacting a tidal marsh located immediately downgradient of the site. A pilot permeable reactive barrier (PRB), consisting of a combination of municipal compost and zero-valent iron, was installed at the site in September 2002. The pilot PRB, measuring approximately 30 feet in length, 12 feet in depth, and 6 feet in width, is designed to treat arsenic and heavy metals through the process of microbially mediated sulfate reduction.

Background

Sulfate reduction-based PRB systems are increasingly being recognized as an effective means of removing heavy metals and arsenic from solution. In the process of sulfate reduction, sulfides are produced and they combine with the metals and arsenic to produce relatively insoluble secondary sulfide minerals. In addition, during the microbially mediated sulfate-reduction process, carbonate alkalinity is produced; this serves to help neutralize acidity and maintain near-neutral pH conditions.

Although promising, organic carbon-based PRB systems have not yet been fully evaluated. Issues of key interest include the longevity of the organic carbon based systems, the ability of organic carbon-based PRB systems to maintain their hydraulic conductivity properties, and the types of organic carbon substrates most suitable for use in PRB systems.

Objectives

- Determine whether the compost zero-valent iron PRB system is effective in removing arsenic and heavy metals from ground water
- Determine whether the hydraulic conductivity properties of the PRB are maintained over time
- Determine how long the PRB remains sufficiently reactive to remove the targeted contaminants

Approach

Two transects of multi-level bundle wells were installed through the PRB, allowing for collection of up to 90 ground water samples upgradient, downgradient, sidegradient, and within the PRB. Ground water samples were analyzed for multiple parameters, including cations, anions, total organic carbon/dissolve organic carbon, total inorganic carbon/dissolved inorganic carbon, sulfide, alkalinity, oxygen-reduction potential, pH, conductivity, and ferrous iron. Comparison of data upgradient within, and downgradient of, the PRB were used to evaluate performance of the PRB. Hydraulic conductivity testing within and outside the PRB was used to evaluate hydraulic conductivity changes, if any, during the course of the study. Solid-phase analysis was conducted on core samples collected from the PRB to determine the types of precipitates being deposited and their potential impact on the long-term performance of the PRB.

Accomplishments to Date

Eight rounds of ground water sampling spanning a period of 3.5 years were completed at the site.

Near-Future Tasks

Performance evaluation of the pilot PRB was completed and a paper discussing the results was published.

Ludwig, R.D., D.J.A. Smyth, D.W. Blowes, L.E. Spink, R.T. Wilkin, D.G. Jewett, and C.J. Weisener. (2009). "Treatment of Arsenic, Heavy Metals, and Acidity Using a Mixed ZVI-Compost PRB." *Environ. Sci. Technol.*, 43, 6: 1979–1976.

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