

# **Enhancement of Microbial Sulfate Reduction for the Remediation of Hydrocarbon Contaminated Aquifers - A Laboratory and Field Scale Demonstration – Annual Report**

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**Title:** Enhancement of Microbial Sulfate Reduction for the Remediation of Hydrocarbon Contaminated Aquifers - A Laboratory and Field Scale Demonstration – Annual Report

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**Project Period:** October 1, 2000 to September 30, 2001 (N/C Ext. to May 31, 2002)

**Project Amount:** \$150,323

**Research Category:** Groundwater remediation

## **Description:**

### **Objective(s) of the Research Project:**

The primary goal of this project is to design, implement, and monitor a simple but effective enhanced anaerobic bioremediation technology for treating hydrocarbon contamination in aquifers. The specific goals of this project are to:

1. Use laboratory experiments coupled with geochemical, hydrological, and contaminant characterizations to design the sulfate injection process and to evaluate the feasibility of this approach.
2. Establish baseline contaminant, geochemical, and microbiological conditions prior to sulfate injection.
3. Monitor the performance of the enhanced anaerobic biodegradation process primarily for BTEX remediation.
4. Identify the applicability and limitations of enhancing sulfate reduction for stimulating BTEX biodegradation.

## **Progress Summary/Accomplishments:**

### **Laboratory**

Laboratory biodegradation experiments were conducted to identify the effect of sulfate addition on sulfate reduction and benzene biodegradation activities. The potential for dissolved sulfide formation was also evaluated. Sulfate addition stimulated benzene biodegradation in samples obtained from many of the sampling locations but not all of them. As anticipated, the sulfate reduction rates in groundwater samples correlated positively with the in-situ concentration of sulfate. In consistent fashion, the addition of sulfate to groundwater samples containing negligible sulfate stimulated sulfate reduction. Environmental factors other than sulfate availability have also been evaluated for their

impact on benzene biodegradation. For instance, toxicity experiments indicate that benzene concentrations over 100 mg/L did not inhibit sulfate reduction in sediment slurries. Thus, benzene toxicity may not be an important variable that will govern benzene biodegradation linked to sulfate reduction at this site. The sediments were found to have a high capacity to precipitate produced sulfide thereby minimizing the chances for dissolved sulfide accumulation. Further, sulfate reduction did not have a substantial impact on the hydraulic conductivity in sediment cores. Experiments are being conducted to evaluate why sulfate did not stimulate benzene biodegradation in some of the samples. Overall, the laboratory findings are consistent with preliminary field observations as discussed below.

### **Field**

Groundwater samples were collected from approximately fifty wells for a variety of geochemical and hydrocarbon analyses over the course of approximately one year prior to sulfate injection. A survey of these groundwater samples and sediments for geochemistry, hydrocarbon biodegradation metabolites, and BTEX concentrations, indicated that the conditions were suitable for stimulating benzene biodegradation by sulfate addition. These analyses established the baseline trends in geochemistry (dissolved oxygen, iron, methane, iron, sulfide) and BTEX throughout the anticipated treatment zone. Sulfate injection has initiated decreases in benzene concentrations in the southeastern portion of the treatment area that cannot be accounted for by dilution. Additional injection and monitoring will be required to identify whether sulfate injection will result in decreasing benzene concentrations in other areas.

### **Future Activities:**

Additional experiments are being conducted to identify the sulfate requirements due to the biodegradation of hydrocarbons other than BTEX. Monitoring of field parameters including BTEX, sulfate, conservative tracers, geochemical conditions, and hydraulic head differentials continues.

**Supplemental Keywords:** biodegradation, bioremediation, groundwater, BTEX, benzene, anaerobic