Air Sparging and In-Situ Bioremediation Research and Demonstration

Cleanup
CU-744

LEAD AGENCY: U.S. Army

LAB: Picatinny Arsenal, New Jersey

PRINCIPAL INVESTIGATOR: Mr. Jeffery M. Fisher (609) 771-3953

PROBLEM STATEMENT:
Goal: Bioremediation enhancement to air sparging technology may provide a cost effective strategy for removing trichlorethylene (TCE) and related chlorinated solvents from ground water. However, unresolved technical issues focus on quantifying the incremental benefit and designing efforts to stimulate microbial degradation. The overall goal of Phase I of this project is to develop laboratory and field methods for determining the effect of sparge gas-composition on the partition of mass removal due to volatilization and microbial processes. The methods will be demonstrated at Picatinny Arsenal, New Jersey, a site with a well-characterized plume of TCE contamination. Phase II of the project will involve the design and operation of a full-scale sparging/bioremediation demonstration at Picatinny Arsenal based on the findings of Phase I. The overall project will resolve technical and institutional issues that inhibit operational use of the technology.

BACKGROUND: Air-sparging and coupled in-situ bioremediation has been implemented at the Savannah River site. The Savannah River Project was designed as a scientific demonstration. In addition, the site is characterized by specific geochemical conditions, most notably, the plume was aerobic. An anaerobic contaminant plume, like the one at Picatinny Arsenal, is perhaps more typical of TCE plumes, and introduces questions related to the rate of adaption of the microbial consortium and engineering considerations related to induced precipitates.

TCE is the dominant contaminant in a plume within an unconfined glacial aquifer at Picatinny Arsenal. The unconfined aquifer is about 50 feet thick in the vicinity of the contaminant plume. In 1991, the highest measured concentration of TCE was 21,000 micrograms per liter. In 1986, the site was selected by the USGS Toxic Substances Hydrology Program as its research site chlorinated solvents. Research includes characterization of TCE, related contaminants, and contaminant geochemistry in the aquifer and the unsaturated zone, and fate and transport evaluation. The Army has initiated an interim action under CERCLA to contain and treat the plume by pumping before it enters a continuing source of contamination may necessitate that the pump and treat operation continue indefinitely. The enhanced sparging technology could mitigate this condition.

PROJECT DESCRIPTION: Technical Objective: The objective is to develop methods to quantify the total rate of removal of TCE contaminant for an air sparging remediation system adapted to enhance contaminant removal with aerobic cometabolism. The total rate of removal is the sum of a component due to physical stripping (volatilization) and a component due to aerobic cometabolism. Both components will be quantified to allow for an evaluation of the cost effectiveness of the microbial enhancement. The methods are to be demonstrated at an existing site of TCE contamination and in the laboratory with porous media collected from the site.

TECHNICAL APPROACH: The workplan has three major components: (1) development of methods to conduct sparging/cometabolism laboratory experiments with contaminated sediment, (2) application of overall method to pilot scale experiments at Picatinny Arsenal, and (3) development of a mathematical model to analyze the transport of sparged vapor phase constituents from the water table to extraction wells for the purpose of determining the distribution of mass flux across the water table.

Site geochemistry will be monitored to assess initial conditions with respect to a wide range of inorganic and organic solutes. Initial site assessment will also include analysis of sediment cores to define lithology, total contaminant mass, physical characteristics, and selected microbial guild characterizations.

Laboratory experiments will be conducted with sediment collected during the site assessment described above. Two types of experiments will be conducted: closed systems microcosm experiments and open system column experiments. The microcosm experiments will determine the feasibility of aerobic cometabolism over the range of anticipated geochemical conditions and methane concentration. The open column experiments will allow for emulation of the field experiments under controlled conditions. Cores of sediment taken from the Picatinny site will be instrumented for the columns. Control experiments conducted with pure nitrogen as the sparge gas will provide physical removal rate information to be compared with experiments conducted with sparge gases with various methane and oxygen concentration. These experiments will allow for quantification of the effect of varying design parameters on system performance. The information obtained for the Picatinny sediment will allow for the rational design of pilot-scale experiments.

Pilot scale sparging experiments will be conducted at Picatinny Arsenal within the well- characterized site. The purpose of these experiments is to apply the overall method in-situ and to demonstrate the scaling up of laboratory information and application of the mathematical model (discussed below). The experiments will be conducted with a single sparge well. Mass removal rates will be calculated by collecting vapors with a vapor extraction well and analyzing the exhaust stream for a wide suite of vapors, including TCE and related contaminants, methane as well as signature gasses like carbon dioxide, oxygen, and hydrogen sulfide. The monitoring will allow for separation of removal into a physical volatilization component and into a microbial component inferred by stoichiometric relationship to signature gases. It is anticipated that the experiment can be repeated at the same location to study variable injection rates and methane loading after a time interval passes which allows for the recontamination of the sparged column from surrounding ground water. It is anticipated that pilot scale experiments can be by-passed in subsequent operational applications of the technology.

A mathematical model of the vapor extraction process will be constructed to determine the spatial effect of the sparge well by allowing for the calculation of constituent-specific mass flux across the water table to the extraction well. Reactions that occur in the unsaturated zone while TCE, methane and oxygen are in transit to the extraction well(s) will also be simulated. This model is currently under development at USGS. It will be completed, applied, and published as a public domain code during this project.

EXPECTED PAYOFFS: (1) Development of methods for performance evaluation and development of design criteria for air sparging with bioremediation enhancement. (2) Demonstration of methods at a site with geochemical conditions different than previously investigated at Savannah River.

TRANSITION PLAN: The subject technology, which was develop under a DOE program, will be implemented at a DoD site under regulatory auspices of the U.S. Environmental Protection Agency and the New Jersey Department of Environmental Protection and Energy. Appropriate aspects of the project will be published in peer review journals.