Study of the Microbial Impact in Permeable Barrier Applications

Introduction to the Problem

Chlorinated aliphatics are among the most widespread contaminants in ground water due to their use for degreasing, dry cleaning, and as solvents. When present in sufficient quantity, most chlorinated solvents have the tendency to form dense nonaqueous-phase liquids (DNAPLs) that may move downward in the subsurface until they reach a low-permeability zone or aquitard. During their downward movement, they leave a trail of free-phase and residual DNAPLs, resulting in a long-term source for the release of contaminants into ground water.

One DNAPL remedial approach is to remove their source; however, they are difficult to locate and characterize. A more practical approach is the treatment of the plume. A conventional active treatment technique involves pump-and-treat to capture and treat the plume, but past experiences have shown that this remedial option is costly and inefficient. Because the systems should be in operation as long as the source zone and plume persist, the operational cost is usually a limiting factor. The development of permeable reactive barriers (PRBs) provides a viable alternative to pump-and-treat for remediation of chlorinated solvent contaminated aquifers. Furthermore, the implementation of PRBs can address other contaminants of environmental significance, such as dissolved metals (e.g., chromium), petroleum hydrocarbons, and nitrate/ammonia.

Background

The design and implementation of PRBs are usually based on the assumption that the potential for biologically mediated reactions are not significant; the beneficial or deleterious contributions of biotic processes on the long-term performance of PRBs are not considered. There is no question that respiring microbes are associated with various subsurface environments. One of the most intriguing aspects of microbial interactions with zero-valent iron is that they derive energy from the oxidation of hydrogen gas (H2). This affinity would lead to growth and biofilm development in the presence of usable sources of carbon. The production of readily metabolizable organic substrates from contaminants of concern via abiotic pathways can support microbial growth. The generation of daughter products from biotic pathways (e.g., cis-dichloroethene) downgradient from PRBs suggests that the processes of microbes are beneficial. It is evident, therefore, that this assertion requires a thorough investigation of microbial activities and that the processes involved require an in-depth investigation.

Objectives

The objective of this project is to determine overall impact of biotic processes on performance of select PRBs.

Approach

Several contaminated sites are necessarily targeted because of the inherent diversity in the types of contaminants (inorganics and organics), as well as the availability of reactive media (granular zero-valent metal, granular iron with amendments, and other innovative reactive media). Another important consideration is the characterization of microbes and microbial biogeochemistry related to newly developed PRBs in comparison with mature sites.

Shifts in population development and levels of activity are also under investigation. Aquifer materials are acquired from the following sites: Elizabeth City, North Carolina; Columbia Nitrogen, South Carolina; Delatte, Louisiana; Cimarron Pork, Inc., Facility, Oklahoma.

This project is being addressed in two parts by combining the findings of both field and laboratory studies. A special focus is to delineate microbial community structures in different redox zones in which chemical species are segregated. The microbes are being filtered from ground water. Purified 16s rDNA genes are then amplified by polymerase chain reaction (PCR) using universal Eubacterium- and Archaea-specific primers. The PCR products are analyzed by sequencing and terminal restriction fragment length polymorphism.

Accomplishments to Date

Aquifer material and ground water samples from three sites were analyzed for the microbial abundance using microbiological and biogeochemical assays. The samples were screened for the presence of sulfate-reducing bacteria. Selected samples from the Elizabeth City Site were tested for the presence of *Dehalococcoides sp*.

Near-Future Tasks

Tasks include collection of aquifer material and ground water samples from each of the five PRBs. Identification and characterization of the microbial community using phylogenetic tools will be continued for an additional two years

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