Sustained Microbial Oxidation of Vinyl Chloride under Low Oxygen Flux Conditions

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Background/Objectives. Natural attenuation is a widely accepted method for the treatment of several groundwater contaminants, including the chlorinated solvents PCE and TCE. However, lower chlorinated ethenes, such as vinyl chloride (VC), are often considered to have low potential for natural attenuation. Natural attenuation potential is highly dependent on local geochemistry and the composition of the indigenous microbiota. Using natural attenuation as a remedial alternative requires demonstration of contaminant removal as well as evidence of the removal mechanism.

Biodegradation is considered the dominant mechanism in natural attenuation of chloroethenes. Both anaerobic and aerobic microbial processes are known to degrade VC into non-toxic end products. These processes are optimal at opposite ends of the redox potential spectrum, which is often considered to coincide with large physical separation. Anaerobic processes are most favorable under very reducing (i.e., sulfate reducing) conditions, while existing guidance for aerobic processes indicate that highly oxidizing (>5 mg/L dissolved oxygen) conditions are optimal. Most contaminated sites feature regions with redox conditions intermediate to these values. VC biodegradation under intermediate redox conditions is poorly understood. Recent studies indicate that active aerobic and anaerobic VC degrading bacteria co-exist in groundwater samples and even coexist in sediment samples on a millimeter scale. An improved understanding of VC biodegradation under intermediate redox conditions would facilitate broader use of natural attenuation as a remedial alternative, particularly sites where enhanced reductive dechlorination is used to treat PCE/TCE source zones.

The objective of this study is to evaluate VC natural attenuation potential under very low dissolved oxygen concentrations and determine the roles that aerobic VC-degrading bacteria play. Molecular biological tools will be used in conjunction with chemical data to evaluate VC degradation.

Approach/Activities. Aerobic VC degrading bacteria were grown under very low oxygen conditions, while being provided a continuous oxygen flux from a permeation tube. Vinyl chloride and oxygen concentrations were monitored over the period of a month. Microbial activity was also measured through quantitative polymerase chain reaction (qPCR).

Results/Lessons Learned. Aerobic enrichment cultures have been shown to be capable of continued VC degradation even when oxygen concentration were below detection (<0.03 mg/L). VC oxidation was rapid with initial dissolved oxygen concentrations of 0.9 mg/L, and significantly slower when the same mass of oxygen was provided via permeation tube over a period of >20 days.