Degradation of Cyclic Ethers by Microorganisms Isolated from Contaminated Groundwater

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Background/Objectives. The Solvents Recovery Service of New England, Inc. (SRSNE) Superfund site in Southington, Connecticut processed over 100 million gallons of solvents between 1955 and 1991. Storage of still bottoms and other wastes in unlined lagoons along with other releases produced a complex non-aqueous phase liquid (NAPL) source zone in the overburden and fractured bedrock. Groundwater sampling data are available from the Remedial Investigation (RI) in 1998 to today. These data show decreases in concentration over time of many contaminants, both from actions and from natural attenuation. However, in a specific area of the groundwater plume two notable cyclic ethers- 1,4-dioxane and tetrahydrofuran (THF) - have shown significant decreases. These two chemicals are considered by the Environmental Protection Agency to be "likely" or "probably" carcinogenic to humans. 1,4-dioxane is considered an "emerging contaminant" as only in the last decade have there been cost effective ways to analyze groundwater for it in low concentrations. Remedial actions for both chemicals are difficult, as they mix readily with water and are rarely shown to biodegrade in the environment.

The decreases seen in the groundwater over time and over distance are significant and not consistent with any standard attenuation or sorbing to the soil. Phylogenetic and functional gene testing were conducted and while the usual enzymes and organisms expected with biodegradation of these ethers were not seen, possible co-metabolic enzymes were found. The objective of this research was to isolate, culture and identify the microorganisms causing the decreases in 1,4-dioxane and THF in the groundwater at SRSNE.

Approach/Activities. Groundwater samples were taken from three wells contaminated with chlorinated solvents and other volatile organic compounds. Sample locations were chosen based on historical trends over time of reductions of the cyclic ethers as well as an environment suitable for aerobic degradation. Groundwater samples were enriched with either a single cyclic ether or an equal combination of the two. High concentrations of both cyclic ethers were used to induce the growth of organisms capable of obtaining metabolic energy from these carbon sources. Isolation and growth was done exclusively in liquid media using Bushnell Haas broth to preserve any possible consortia and to prevent the potential loss or reduction of degradation capacity. Isolates that did not grow via visible floc formation were removed from the experiment. The remaining isolates were tested for growth impacts based on the environmental conditions, their degradation capacity via CO_2 evolution, as well as their reaction to the presence of chlorinated solvents. Taxonomic analysis via 16sRNA was completed for determination of organism(s) present in isolates.

Results/Lessons Learned. Isolates were capable of degrading high concentrations of 1,4-dioxane and THF (586 micro moles and 616 micro moles respectively). Isolates were also capable of maintaining degradation of 1,4-dioxane and THF in the presence of a chlorinated solvent, tetrachloroethylene. Isolates were further tested and found capable of using 0.2 micro moles PERC as the sole carbon source comparable to the degradation of their preferred substrate. A total of six organisms were found in the four samples, with two samples having the same organisms present. All organisms identified have not previously been seen in degradation of these chemicals. It is unknown what role each of the organisms played in the degradation capacity or if the ethers were completely or only partially degraded.