In Situ Bioremediation of 1,4-Dioxane in Mixed Contaminant Plume with Metabolic Bioaugmentation and Cometabolism

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Background/Objectives: 1,4-Dioxane is widely associated with chlorinated solvent source-zones/plumes and presents a significant remediation challenge due to high mobility and persistence. Geochemical conditions that are suitable for chlorinated solvent degradation (e.g., strongly negative ORP) are generally incompatible with 1,4-dioxane degradation. Biodegradation of 1,4-dioxane can occur through two types of processes, both of which require aerobic conditions. Direct metabolism of 1,4-dioxane may be feasible, but requires a specific bacteria that are often not naturally occurring. Alternatively, cometabolism of 1,4-dioxane has also been demonstrated, but field-scale implementation has been limited to a handful of sites.

This presentation will focus on an industrial site in Puerto Rico. The source area is impacted with mixed constituents including chlorinated solvents, hydrocarbons, and 1,4-dioxane (and others). Under ambient conditions there is a robust microbial community with both aerobic and anaerobic biomarkers. While natural attenuation appears to be occurring, engineered methods are being evaluated to expedite treatment.

Approach/Activities. A side-by-side aerobic bioremediation pilot test was started in the summer of 2022 to investigate direct metabolism and cometabolism. Both sides are treated by a single biosparge system that delivers air at moderate flow rates and pressures to establish aerobic conditions. Bioaugmentation was performed to support direct metabolism. SiREM's DXO-88™ bioaugmentation culture was injected into sparge wells and pushed into the formation with the biosparge system. This bioaugmentation culture has been isolated from industrial sludges where 1,4-dioxane degradation was observed. Cometabolism is being implemented by propane sparging.

Results/Lessons Learned. Performance assessment includes groundwater sampling for VOCs, 1,4-dioxane, geochemical parameters, and microbial community evaluation (qPCR and NextGen sequencing). Implementation was completed in summer 2022 and data collection to date indicates that target conditions, which are amenable to degradation of 1,4-dioxane, are becoming established. The results suggest that simultaneous implementation of bioaugmentation and cometabolism at portions of the site are a feasible remedy for 1,4-dioxane source areas. Preliminary data available in late fall 2022 indicate 1,4-dioxane concentration reductions of 40% to 75% have been attained within 4 months of system startup.