METABOLIC BIODEGRADATION OF LOW-LEVEL 1,4 DIOXANE: AEROBIC CULTURE AUGMENTATION, SITE IMPLICATIONS, AND MONITORING CONSIDERATIONS

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Background/Objectives:

1,4-Dioxane is a highly water-soluble and persistent organic compound that is receiving regulatory attention due to its environmental persistence and potential health risks. Many sites across the United States (U.S.), including a Superfund site in the western U.S., exhibit low concentration (5 μg/L to 50 μg/L) of 1,4-dioxane-impacted groundwater in jurisdictions where regulatory limits are less than 1 μg/L . As a result, effective remedial approaches are needed to address impacts at these concentrations. Metabolic degradation offers the advantage of being environmentally friendly and a generally passive treatment approach after it is established in the subsurface. It also avoids the need for the addition or occurrence of a primary substrate required for co-metabolism. However, the effectiveness of 1,4-dioxane biodegradation has, until recently, only been widely demonstrated for higher concentration impacts (commonly ≥250 μg/L). An internal study was conducted to evaluate the feasibility of aerobic bioaugmentation in groundwater using a commercially available 1,4-dioxane-degrading microbial culture for low-level 1,4-dioxane impacts.

Approach/Activities:

A laboratory study was conducted using site groundwater and soil spiked with 1,4-dioxane. A commercially available (SiREM) 1,4-dioxane-grading aerobic culture was introduced to evaluate its ability to metabolize the compound at concentrations of approximately 10 μg/L and 50 μg/L under conditions previously demonstrated to support aerobic biodegradation. The study was conducted for a total of 90 days, with active and culture-free control treatments. 1,4-Dioxane concentration and water quality parameters were monitored to assess experimental performance.

Results/Lessons Learned:

The laboratory study demonstrated that the 1,4-dioxane-degrading microbial culture can reduce the compound at lower concentrations than previously realized. Results suggest that metabolic degradation is applicable for addressing low-level impacts and shows preliminary viability with the site's groundwater and soil, with 1,4-dioxane reduction being statistically significant compared to controls. This finding has significant implications for sites with low 1,4-dioxane impacts that could benefit from in situ bioaugmentation, such as where current land use is not compatible with the installation of typical surface infrastructure or earthworks associated with remedial efforts. Furthermore, the reduction of ongoing monitoring and maintenance offers cost and logistical benefits.

Parsons has developed monitoring programs for sites in the U.S. to evaluate the potential for aerobic monitored natural attenuation of 1,4-dioxane, to assess the potential for bioaugmentation, and to evaluate the performance of implemented remedies. Bioremediation offers a sustainable, minimally invasive, and cost-effective solution for managing 1,4-dioxane contamination in situ. This presentation will review the laboratory study and discuss how site-specific data can inform the feasibility of engineered or bioaugmentation-based remedies. Future work is proposed to further evaluate the Superfund site's compatibility with the aerobic culture over a longer study duration, with consideration of commingled contaminants. Experiment design and preliminary results to support the research objective will be shared.

About The Author

Lauren is an Environmental Engineer with Parsons, leveraging her interdisciplinary knowledge in subjects such as geology, contaminant hydrogeology, and chemistry to support site investigations, remedial objectives, and internal research and development for contaminants such as 1,4-Dioxane, PFAS, and chlorinated solvents. She holds an undergraduate degree in Geological Engineering and a doctoral degree in Civil-Environmental Engineering, both from Queen's University (Kingston, ON) where her research focused on the destructive treatment of PFAS.