

**Environmental Engineering**

**and Earth Sciences**

‟Improved Approaches for Assessing Natural Attenuation of 1,4-Dioxane”

**Presented By**

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**Abstract**: Millions of pounds of 1,4-dioxane have been produced in the United States since its first industrial use dating back to 1929. Since the late 1950s, the main use for this compound was as a stabilizer for chlorinated solvents, including 1,1,1-trichloroethane and trichloroethene. Large amounts of 1,4-dioxane have been released into the environment along with chlorinated solvents, with significant amounts contaminating aquifers at thousands of sites in the United States. 1,4-Dioxane is resistant to chemical, physical, and biological degradation and tends to persist in the environment. The cost for active remediation is substantial and is driven by increasingly stringent concerns over human health effects. On-going monitoring of aquifers contaminated with 1,4-dioxane suggest that many plumes are undergoing natural attenuation. However, documenting this process has been challenging. This presentation will review the application of several approaches to documenting natural attenuation, following the EPA lines of evidence approach. This includes estimation of plume attenuation based on groundwater monitoring data, compound specific isotope analysis based on enrichment in 2H and 13C, the presence of biomarkers that are specific for biodegradation of 1,4-dioxane, analysis of geochemical conditions that are favorable to biotic degradation, and use of a novel assay to measure biodegradation rates in the laboratory using 14C-labeled 1,4-dioxane. The multiple lines of evidence approach was assessed with groundwater samples from multiple wells at 10 sites around the county.

Site-wide rate constants were established using a calibrated fate and transport model at 8 sites (median = 0.07 yr‑1). The 14C-1,4-dioxane assay confirmed 1,4-dioxane degradation capacity at 9 of 10 sites, with a median rate constant of constant of 0.0137 yr-1. The constants from the 14C assay are likely more conservative and variability in rates suggested that biodegradation capacity at sites may be localized. Stable isotope fractionation was observed at 7 of 10 sites and served as another direct line of evidence of in situ biodegradation of 1,4-dioxane. This includes sites where indirect lines of evidence, including geochemical conditions or genetic biomarkers for degradation, would not necessarily have been supportive. These outcomes highlight the importance of collecting multiple lines of evidence to document 1,4-dioxane natural attenuation, and the widespread prevalence of biodegradation suggests that this process should be part of long-term management decisions.

**Bio:** Dr. Freedman is a professor and Chair of the Department of Environmental Engineering and Earth Sciences at Clemson University. He received a B.S. degree in Environmental Sciences from the University of Wisconsin-Green Bay, an M.S. in Environmental Engineering from the University of Cincinnati, and a Ph.D. in Environmental Engineering from Cornell University. Dr. Freedman served as a post-doctoral fellow at Cornell University on a project funded by the American College of Toxicology. His first academic position was at the University of Illinois at Urbana-Champaign. He moved to Clemson University in 1996. Throughout his academic career, Dr. Freedman has performed research on anaerobic reductive dechlorination and anaerobic and aerobic oxidation processes for chlorinated aliphatic compounds and other emerging contaminants, including 1,4-dioxane. Dr. Freedman has received research support from SERDP, ESTCP, EPA, US DOE, US Army Construction Engineering Research Laboratory, US Air Force Office of Scientific Research, Westinghouse Savannah River Corporation, Battelle, and numerous consulting firms. He is currently leading a project on wastewater surveillance for SARS-CoV-2 in three sewersheds in the Clemson, SC area.

***Friday, September 3, 2021 at 2:30 pm***

**Rich Lab Auditorium and Online via Zoom**

***Attendance is mandatory for graduate students enrolled in EES 8610, EES 9610, and GEOL 8510***