Current Knowledge of Bioaugmentation Cultures for 1,4-Dioxane Biodegradation

Dora Chiang, Ph.D., P.E. (CDM Smith, Atlanta, Georgia, USA)
Claudia Walecka-Hutchison, Ph.D. (The Dow Chemical Company, Midland, Michigan, USA)

Background/Objectives. 1,4-Dioxane (dioxane) is listed by the US EPA as a probable human carcinogen and is an emerging contaminant in groundwater at many military and industrial contaminated sites. Numerous studies provide evidence that dioxane can be biodegraded aerobically and several cases have documented both metabolic and cometabolic dioxane biodegradation since the early 1990s. Over years, cultures that metabolically and cometabolically degrade dioxane have been discovered and characterized for their functionalities and mechanisms of degrading dioxane and co-contaminants (i.e., chlorinated solvents). Microbial manipulated Fenton's reaction for dioxane degradation was also documented. However, applications of enhanced biodegradation have been limited by inconsistent microbial performance in the field, generally unfavorable geochemical conditions present at dioxane impacted sites, and lack of understanding of the benefits of bioaugmentation for dioxane treatment. *Pseudonocardia dioxanivorans* CB1190 (CB1190) is a monooxygenase-expressing microorganism that has been shown to metabolically degrade dioxane as a source of carbon and energy in the laboratory. Preliminary field studies suggest challenges of distributing the CB1190 culture in the subsurface and sustaining its growth as most sites do not have the high enough dioxane concentration required. As research continues to discover new microbial cultures capable of dioxane degradation, there is a need to assess the current status of development, potential, and roadblocks of future field applications as well as the regulatory acceptance of this evolving technology.

Approach/Activities. In October 2017, a dioxane biodegradation workshop was held to discuss new findings on dioxane degrading cultures, the interferences of co-contaminants on dioxane biodegradation, biomarker development and applications, natural attenuation, perspectives of dioxane regulatory trends and future research needed. The workshop is a primer to this study of re-assessing knowledge gaps and identifying field application potentials from a practical perspective. The re-assessment of dioxane biodegradation for field applications evaluates three major types of microbial cultures that (1) metabolically degrade dioxane (2) co-metabolically degrade dioxane and (3) manipulate microbial processes for dioxane oxidation. Each group of microbial cultures is evaluated and compared based on five criteria (a) dioxane removal efficiency (b) impact by chlorinated solvents (c) growth sensitivity to intrinsic geochemical conditions (d) field implementation status (e) commercialization (f) regulatory acceptance.

Results/Lessons Learned. Laboratory research of dioxane biodegradation has been ongoing for over 10 years, However, field applications of this technology are still limited. Re-assessment of practicing dioxane biodegradation for site remediation is urgently needed. This reassessment effort identifies the root cause of lacking field applications and makes recommendations on how academic researchers and remediation practitioners can achieve the overarching goal of successfully demonstrating dioxane biodegradation as a sustainable treatment alternative.