Bioremediation of Per- and Polyfluoroalkyl Substances (PFAS): Is It Feasible?

Jeff Roberts (JRoberts@siremlab.com), Sandra Dworatzek, Jen Webb, and Philip Dennis (SiREM, Guelph, ON, Canada)
Yujie Men (University of California, Riverside, CA, USA)

Background/Objectives. Per- and poly-fluoroalkyl substances (PFAS) are a large group of man-made chemicals used in a variety of sectors and in consumer and industrial products including: non-stick coatings, packaging, photographic imaging, aviation industries, electronics, and aqueous film-forming foams (AFFFs). These compounds have many manufacturing and product applications because they impart oil resistance, repel water, resist temperature extremes, and reduce friction. Over the years, manufacturing and use of PFAS at fire training/fire response sites, industrial sites, landfills, and wastewater treatment plants/biosolids has resulted in subsurface contamination which is a challenge to remediate cost-effectively with current approaches. PFAS are mobile, persistent, bioaccumulate and are not widely reported to degrade in the environment with severe adverse health effects reported from these compounds at very low concentrations.

Remediation strategies such as conventional oxidation and reduction, electrolysis, and hydrolysis have to date been proven ineffective in treatment of PFAS. Unique surface-active properties and strong carbon-fluorine bonds make remediation challenging. Nonetheless, a number of studies did report the feasibility of biotic carbon-fluorine C-F bond cleavage in non-PFAS compounds as early as the 1960s. However, to date there is little evidence of biotic C-F bond cleavage in PFAS.

Approach/Activities. Laboratory biotreatability studies were conducted to evaluate the potential for commercially available bioaugmentation cultures to remediate selected PFAS compounds in simulated and site groundwater and soils. Selected compounds included: perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), Hexafluoropropylene oxide dimer acid (HFPO-DA, GenX), perfluoro-3,7-dimethyloctanoic acid (PFdiMeOA), perfluoro(4-methylpent-2-enoic acid (PFMeUPA), 4,5,5,5-tetrafluoro-4-(trifluoromethyl)-2-pentenoic acid (FTMeUPA), and 4,5,5,5tetrafluoro-4-(trifluoromethyl) pentanoic acid (FTMePA).

Results/Lessons Learned. Bioaugmentation treatment was effective in defluorinating PFMeUPA and FTMeUPA. These compounds are branched unsaturated compounds with intermediate chain length (C6). Treatment failed to defluorinate the other tested PFAS. This indicates that defluorination treatment in this study was effective only with specific C-F bonds in unsaturated compounds. Other preliminary microcosm testing including bioaugmentation showed promise in removal of PFOS with added chlorinated VOCs. *Dehalococcoides* were not involved in the reductive defluorination of the two branched and unsaturated structures. Instead, it might be the minor members in the community that carried out the reductive defluorination. Further investigation is currently underway, as there is still much to discover on the bioremediation of PFAS compounds. Encouragingly, this study demonstrates that reductive defluorination with hydrogen acting as the primary electron donor is feasible, which gives hope for future use of this technology for site remediation. This presentation will highlight the exciting findings to date and discuss next steps for furthering our understanding of the extent of PFAS biodegradation.