Aerobic Biodegradation of PFOA/PFOS? Promising Benchtop Studies and Preliminary Field Applications

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Aqueous film forming foams (AFFF) release per- and polyfluoroalkyl substances (PFAS) and are a growing environmental concern. These releases typically include multiple PFAS, many of which cannot be analytically quantified. Bio-oxidative transformation of long chain "precursor" to "dead-end," PFOS and/or PFOA (PFOS/A) can result in increases in these compounds in more aerobic portions of the aquifer (such as downgradient of the release area). In-situ remediation technologies to address PFOS/A are limited. Carbon has been successfully used to immobilize and retard PFAS migration in groundwater. However, without a means to destroy the sorbed PFAS contaminants, carbon alone, does not permanently reduce the risk. Unlocking a biodegradation mechanism to degrade PFOS/A is needed to create a cost effective, in situ remedy to address these contaminants.

Microbes were isolated from a suspected AFFF Site, where PFOS/A concentrations increase when conditions in Site groundwater become more aerobic (i.e., downgradient from the source). Six candidate microbes were isolated from Site soil and groundwater that were found to be viable in a PFOS/PFNA growth medium. In an initial microcosm study, the isolated microbes were found to biodegrade PFOS/A in PFOS/A spiked tap water and Site groundwater in 2- and 8-weeks with additions of various bioenhancements with the most significant reductions observed with aeration. In another microcosm study, the PFOS/A biodegradability is further assessed using a diffusive oxygen source, oxygen supplied by a shaker table, peroxide and aeration. This study included triplicate analyses, use of whole bottle extraction methods and additional controls/tests to assess microbe viability at each stage. Qualitative assessment of inorganic fluoride formation was also included. The second study was also performed with "stored" microbial stock as well as "fresh" microbial stocks to assess whether other, unquantified environmental parameters may play a potential role in gene expressions that may influence PFAS degradation.

PFAS are considered "forever chemicals" because of the strong carbon-fluorine bonds and they are not observed to readily biodegrade in the environment. However, PFOS/A biodegradability is difficult to verify in the field, particularly when precursors are transformed into PFOS/A at rates that may be faster than PFOS/A biodegradation. This study isolated a site-specific microbial culture acclimated to PFAS in groundwater. Under aerobic conditions and spiked systems, PFOS/A concentrations in the initial microcosm study were reduced by 97% and 94%, respectively. Total PFAS levels in Site groundwater treated with microbes+aeration and microbes alone were decreased by 62% and 52%, respectively, at 2-weeks; however, PFOS concentrations increased slightly (8%) due to transient bio-transformation of precursors. PFOS declined by 70% at 8 weeks. The stored stock did not demonstrate PFAS reduction in 2022-23 but also did not show significant adsorption of PFAS into the biomass and additional results from "fresh" microbes will be presented. A preliminary bioaugmentation field pilot study demonstrated PFOS/A degradation potential, but the kinetics of precursor biotransformation to PFOS/A may cloak ongoing degradation of PFOS and/or PFOA, particularly under field conditions.

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Ms. Hellman, MSc, PBiol, is an Environmental Scientist working at WSP (and its predecessors) for the last 15 years. Her primary experience consists of assessment, remediation, and management of contaminated sites within Alberta. She holds a Bachelor's of Science degree in Cellular, Molecular and Microbial Biology and a Masters of Science degree in Environmental Microbiology from the University of Calgary and is a member of the Alberta Society of Professional Biologists (ASPB).

Len Mankowski

Len Mankowski is a VP - Geology at WSP with over 18 years of site characterization and remediation experience at contaminated Sites across Michigan and the Midwest. His primary areas of expertise include: innovative remedial investigation techniques; hydrogeologic and conceptual site model development; emerging contaminants; and conceptual remedial design/technology assessments. Len earned a Bachelor of Science degree (applied geophysics, 1999) and a Master of Science in (geology, 2023) from Michigan Technological University and was an instructor at Michigan Technological University prior to entering consulting. Mr. Mankowski has published and/or presented several papers on applied, innovative characterization and remediation approaches.

Len is married with two children. He leads hands-on geology fieldtrips for elementary students in the area and previously served as a board member and chair for the non-profit SEEDs, located in Traverse City, Michigan. Len enjoys backpacking, camping, canoeing and working with kids.