

Understanding Fate and Transport of PFAS to Develop Good Conceptual Site Models of AFFF-Impacted Facilities

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Background/Objectives. Poly- and perfluoroalkyl substances (PFAS) are used in a wide range of industrial applications and commercial products due to their unique surface tension and levelling properties.. PFAS are also major components of firefighting foams known as Aqueous Film Forming Foam (AFFF). The PFAS group of compounds consists of both perfluorinated compounds, where all carbons are saturated with F atoms, and polyfluorinated compounds, where both fluorine saturated carbons and carbons with hydrogen bonds are present. The understanding of the fate and transport of these compounds in the environment is complex and challenging and will be discussed.

Approach/Activities. Polyfluorinated compounds are often referred to as precursors to the perfluorinated sulfonic acids (PFSAs) and perfluorinated carboxylic acids (PFCAs), collectively referred to as perfluoroalkyl acids (PFAAs). PFAA precursors are so named because they transform slowly over time through abiotic and biological processes to the PFAAs. There is a natural “biological funneling” in which a whole host of PFAA precursor compounds containing a range of perfluorinated alkyl chain lengths and functional groups, aerobically biotransform to persistent PFAA products.

AFFF formulations are composed of many PFAS that are PFAA precursors. Unlike the PFAAs, these species are not strictly anionic, as some contain multiple charges (zwitterionic) and some are positively charged (cationic). These zwitterionic and cationic PFAA precursors are currently undetected by conventional analytical tools and are thus termed “Dark Matter”. A significant mass of PFAA precursors in addition to the PFAAs have been detected in both AFFF-impacted soil and groundwater. A conceptual site model describing PFAS fate and transport at a firefighter training area is hypothesized and will be presented, as described below.

Cationic PFAA precursors (and some zwitterions) will be retained in the soils at the source zone via strongly binding ion exchange processes. The source zones will be anaerobic as a result of the presence of residual hydrocarbons used in firefighter training, so these strongly sorbing cationic precursors will biotransform very slowly to simpler, anionic PFAA precursors and PFAAs under these redox conditions. Anionic PFAAs and PFAA precursors will migrate away from the source as they enter the redox recharge zone where conditions become increasingly aerobic thus promoting in situ generation of detectable PFAAs from the hidden anionic PFAA precursors. PFAAs will not break down further, and will continue to migrate as a plume with shorter chain PFAAs generally migrating further.

Results/Lessons Learned. The concepts of “biological funneling” and “dark matter” show that PFAS behave significantly differently to other contaminants and existing conceptual site models (CSM) need to be adapted to adequately understand the fate and transport of these contaminants. Examples of CSMs from AFFF impacted sites will be presented.