Understanding Fate and Transport of PFAS to Develop Effective Conceptual Site Models

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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 such as aqueous film forming foam (AFFF) and fluoroprotein foams (including FP and FFFP). The PFAS group of compounds consists of both perfluorinated compounds or perfluoroalkyl acids (PFAAs), where all carbons are saturated with F atoms, and polyfluorinated compounds, where both fluorine saturated carbons and carbons with hydrogen bonds are present. Polyfluorinated “precursor” compounds biotransform to produce PFAAs as dead end extremely persistent daughter products. The understanding of the fate and transport of these compounds in the environment is complex and challenging and will be discussed. The concepts of in situ generation of perfluroalkyl acids (PFAAs) via precursor biotransformation will be used to explain how significant PFAS mass remains hidden in source areas in an analogous manner to NAPL residuals for hydrocarbon or chlorinated solvents.

Approach/Activities. 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. Fire-fighting foam formulations and many fluorochemicals used across multiple industries 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 but can be quantified using more advanced approaches such as the total oxidizeable precursor (TOP) assay. A significant mass of PFAA precursors in addition to the PFAAs have been detected in both fire-fighting foam-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.

Results/Lessons Learned. The concepts of “biological funnelling” 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. The common breakdown products from PFAS in other sources, such as landfills and wastewater treatment plants will be described.