Removal of Per- and Polyfluoroalkyl Substances with Nanofiltration Membranes in Laboratory and Site Studies

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Background/Objectives. Per- and polyfluoroalkyl substances (PFASs) have recently received considerable attention due to their ubiquitous presence, recalcitrance in the environment, and toxic properties. Aqueous film forming foams (AFFFs) contain a variety of PFASs and are a major source of PFAS contamination in water. AFFFs are often used in firefighting applications, especially for extinguishing fuel fires on Department of Defense (DoD) sites, airports, and firefighting training areas. As a result, many utilities near these installations have reported elevated PFAS concentrations above the USEPA issued human health advisory of 70 ng/L for two perfluoroalkyl acids (PFAAs): perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) individually or combined.

Approach/Activities. Reverse osmosis (RO) and nanofiltration (NF) membranes are known to remove PFASs; however, NF has a significantly lower energy cost than RO. Further, membranes in general may be an attractive treatment method as membranes produce a highly concentrated stream of PFASs. This concentrated stream of PFASs may then be more effectively destroyed through processes such as UV-persulfate, plasma, processes that produce hydrated electrons, and others.

Previous studies have shown that NF membranes can remove PFASs based on a variety of rejection mechanisms including size exclusion, charge repulsion, and different factors influencing membrane-solute affinity. However, previous studies show discrepancies in PFAS rejection as a function of chain length as well as over a range of membrane operating conditions. Furthermore, previous studies have been performed with only a few spiked PFASs in a lab based matrix utilizing a membrane “coupon” system, which contains <1% of a typical spiral wound membrane surface area. As a result, the goal of this study seeks to further and better understand the different factors influencing PFAS rejection by NF membranes in both laboratory and pilot scale studies.

Results/Lessons Learned. First, we evaluated rejection of not only the common PFASs but of a variety of PFASs by using a spiked AFFF formulation, AFFF-impacted groundwater from a DoD site, and AFFF-impacted groundwater from an affected community near the aforementioned DoD site. By diversifying the different PFAS compounds in the feed water and various feed water matrices, the impact of PFAS chain length, size, charge, and membrane affinity, as well as matrix composition and membrane system operating conditions was evaluated. Furthermore, the analytical capability at the Colorado School of Mines propels PFAS rejection understanding by not only quantifying the most common PFAS rejection, but also determining the relative rejection of more than 300 different PFASs. Preliminary results indicate >90% rejection of common PFAS compounds in spiked laboratory experiments.