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Foam fractionation of concentrates for PFAS removal

Monir Taherkhani
monir.taherkhani@wetsus.nl

Motivation

Per- and polyfluoroalkyl substances (PFAS) are human-made chemicals used in many products. Due to their persistence, PFAS have accumulated in the environment and are now found in water bodies worldwide, including drinking water sources. Their removal requires advanced treatment technologies. Foam fractionation is a simple, low-cost process that uses the surface activity of PFAS to concentrate them. Previous studies have demonstrated its effectiveness for wastewater, but few have examined its potential for drinking water applications, such as concentrate streams from membrane filtration processes that are often discharged directly into the environment. (Fig. 1) Concentrating PFAS into smaller volumes makes destructive methods more technically and economically feasible[2].

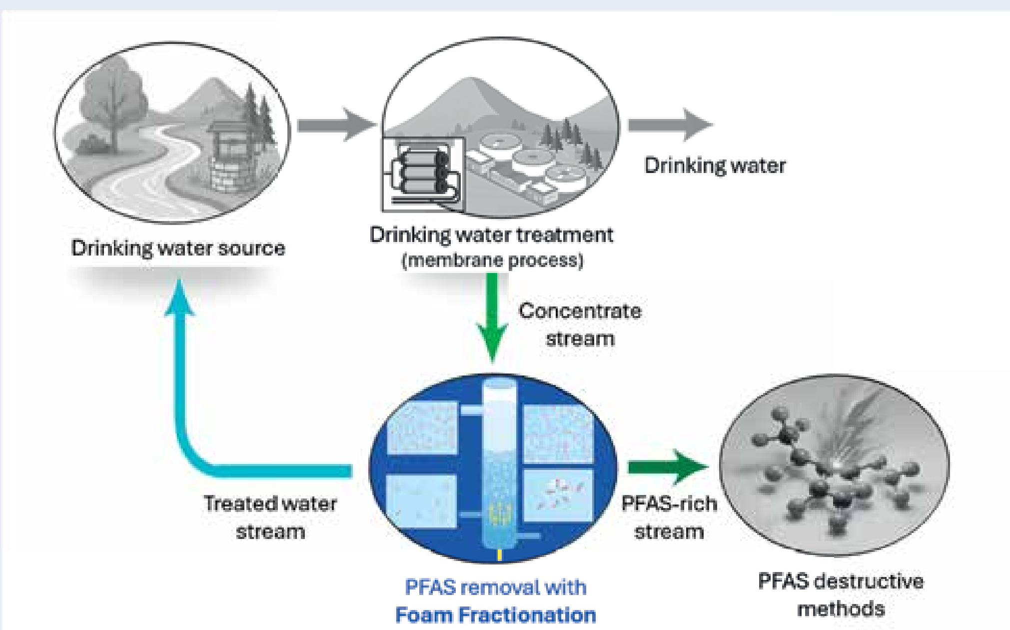

Fig. 1. PFAS removal and destruction cycle with foam fractionation

Technological challenge

Foam fractionation relies on the tendency of surface-active compounds to adsorb at the water–gas interface. Gas is injected into the solution, forming bubbles. As the bubbles rise, PFAS molecules attach to the bubble surfaces and accumulate in the foam layer. After collecting and breaking the foam, PFAS are concentrated in the foamate stream[1]. (Fig. 2)

Foam fractionation is effective for long-chain PFAS and high concentrations[3]; however, its efficiency for short-chain and low-level PFAS remains limited and requires further optimization.

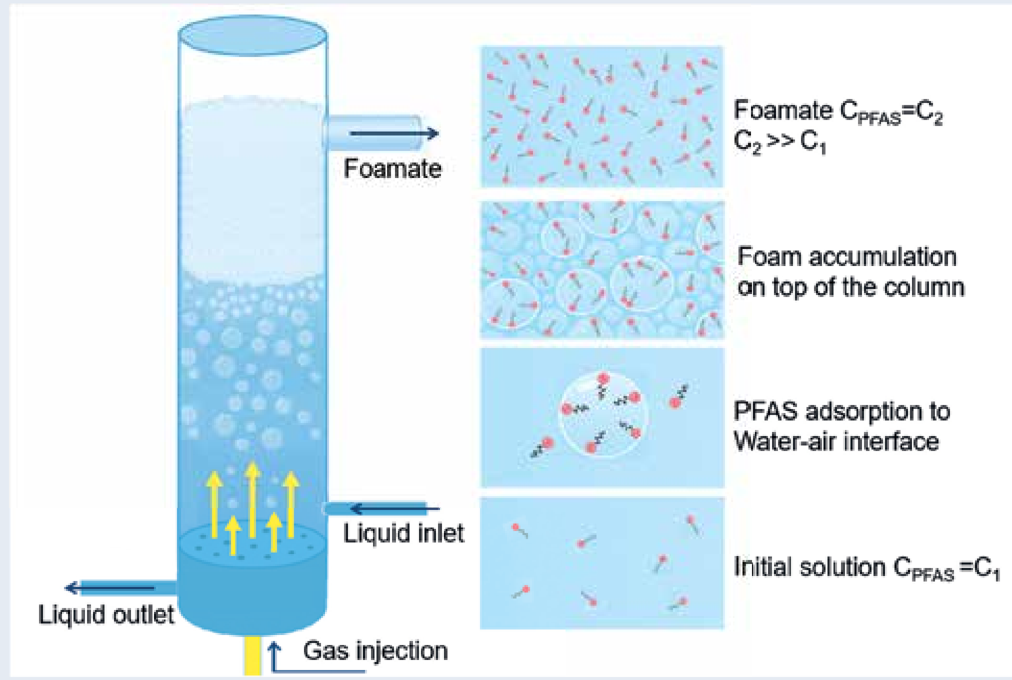

Fig. 2. Schematic of the foam fractionation process

Although previous research has shown the potential of foam fractionation for PFAS removal from various water sources [3], the effects of water matrix composition and the presence of co-surfactants or additives on process efficiency remain unclear. Addressing these factors is key to improving the robustness and scalability of foam fractionation for drinking water treatment.

Research goals

- Understand mechanisms behind the influence of water matrices on the efficiency of foam fractionation for PFAS removal.
- Optimize foam fractionation process parameters to maximize PFAS removal and increase the concentrating factor.
- ΔG Elucidate transport phenomena governing PFAS adsorption at the air–water interface and assess how these can be controlled for process optimization.
- Evaluate the robustness and scalability of foam fractionation under environmentally relevant conditions and diverse water matrices.
- Expand the applicability of foam fractionation by investigating its potential for removing co-surfactants and other emerging contaminants.

References

[1] Buckley et al., Separation Science and Technology (2022), 57(6), 929-958
[2] McCleaf et al., Water Research (2023), 232, 119688.
[3] We et al., Journal of Hazardous Materials (2024), 465, 133182

UPPWATER Dutch water tech
SBO-instituut Dutch Institute for Strategically Important Research

ir. M. Taherkhani, dr.ir. S. B. Rutten, dr.ir. M. Biesheuvel, dr. S. Porada

Wrocław University of Science and Technology