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Motivation

Per- and polyfluoroalkyl substances (PFAS) are a large group of human-made chemicals that, due to their strong surface activity, have been widely used in consumer products. Because of their high persistence and stability, PFAS have accumulated in the environment for decades and are now detected in water bodies worldwide. PFAS have also been found in drinking water sources, highlighting the need for advanced treatment technologies during drinking water production.

Foam fractionation is a simple and low-cost separation process for surface-active compounds that can be adapted to different water matrices. These characteristics make it a promising sustainable method for PFAS remediation. Previous studies have shown that foam fractionation is effective in concentrating PFAS from wastewater. However, few studies have examined its performance under conditions directly relevant to drinking water, such as concentrate streams from (membrane) filtration processes. This study aims to investigate the application of foam fractionation for drinking water treatment, as well as to deepen our understanding of the mechanisms involved in the process.

Technological challenge

Foam fractionation is a separation process based on the tendency of surface-active components (such as PFAS) to adsorb at the water–gas interface. Gas is injected into the solution, forming bubbles. As the bubbles rise, the surface-active compounds migrate toward them and attach at the water–gas interface. When the concentration is sufficiently high, the bubbles become stabilized and accumulate at the top of the column as foam. After

gathering and breaking the foam, PFAS are concentrated in the foamate stream. ^[1] (Fig. 1)

Having high concentrations of PFAS in lower volumes makes destructive methods more technically and economically viable.^[2] Foam fractionation is promising for long-chain and high PFAS concentrations ^[3]; however, for environmentally relevant concentrations and short-chain PFAS it hasn't been effective, which requires further optimization.

In addition, while previous research has shown the potential of foam fractionation for PFAS removal in multiple water sources^[3], the influence of water matrix effects, as well as the presence of co-surfactants and additives on process efficiency, is not fully understood.

Addressing these factors is essential for improving the robustness and scalability of foam fractionation for drinking water treatment.

Research goals



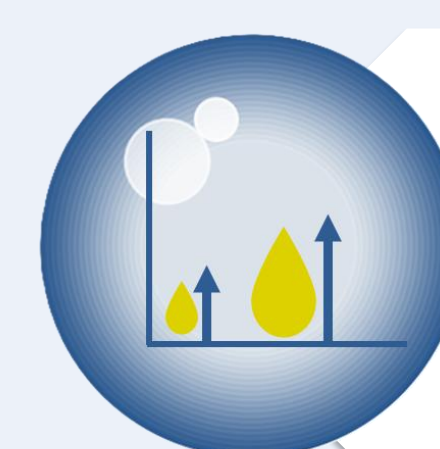
Understand mechanisms behind the influence of water matrices on the efficiency of foam fractionation for PFAS removal.



Optimize foam fractionation process parameters to maximize PFAS removal and increase the concentrating factor.



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.

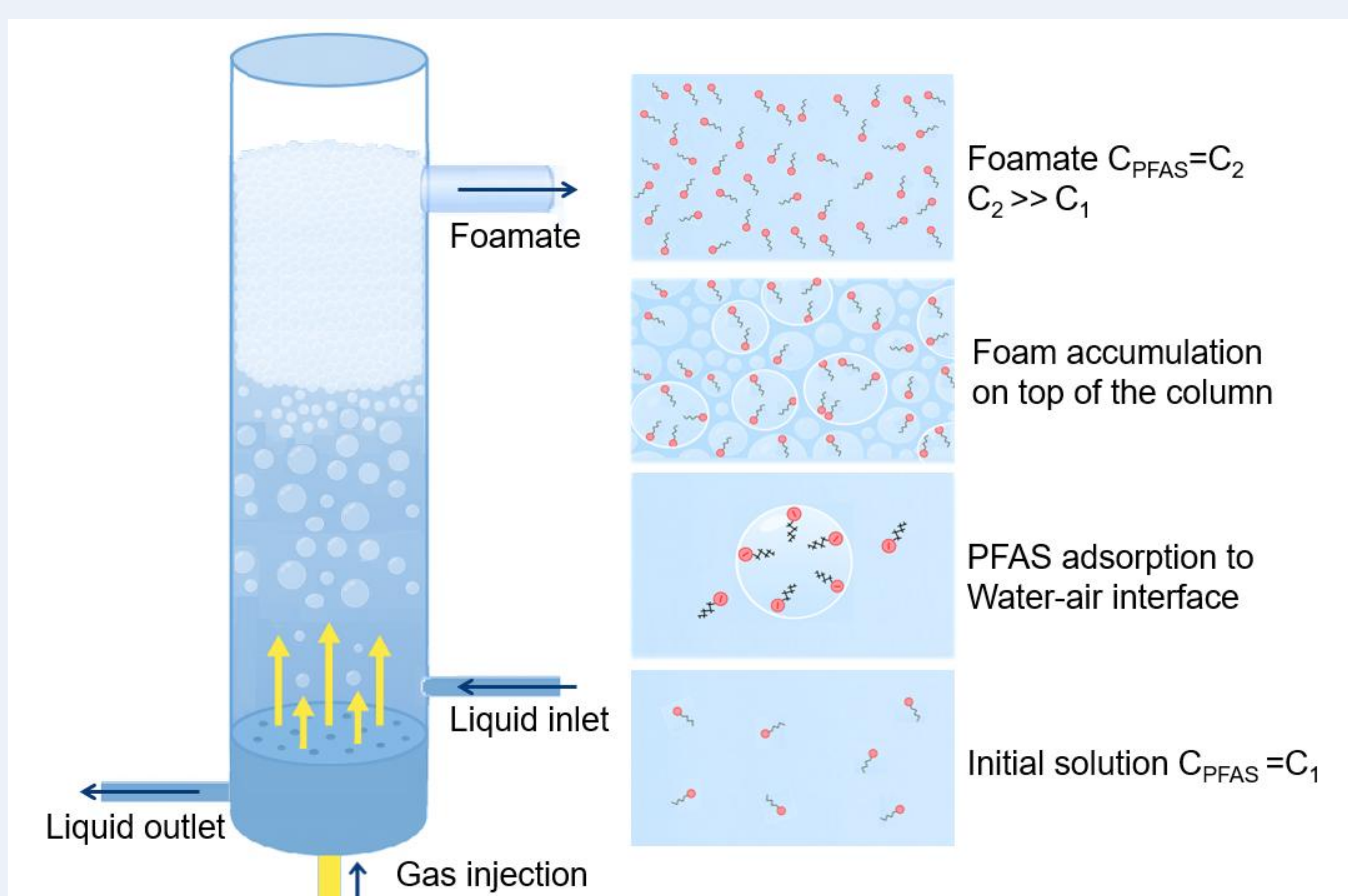


Fig. 1. Schematic of the foam fractionation process

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