Development of an on-site electrochemical regeneration method of activated carbon filters for PFAS removal

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Motivation

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are persistent and mobile pollutants that present significant challenges in water treatment. Long-chain PFAS have received considerable attention in academic research and health regulation [1]. The increasing implementation of regulatory limits on the use of long-chain PFAS results in a worldwide shift to short-chain production [2]. Current solutions, such as granular activated carbon (GAC) filters, demonstrate effective removal for long-chain PFAS but exhibit limited removal efficiency for (ultra) short-chain PFAS, such as trifluoroacetic acid (TFA) [3]. Furthermore, frequent off-site regeneration of GAC filters at elevated temperatures (>1000 °C) requires high energy and labour input [4]. Therefore, developing alternative, sustainable, and, preferably, on-site regeneration technologies is required.

Technological challenge

This research explores a novel on-site regeneration technique for GAC filters, referred to as electro-regeneration (Figure 1). By applying an electrical charge to GAC filters, PFAS are desorbed through electrostatic repulsion. This approach aims to eliminate the need for thermal reactivation and significantly reduces the associated environmental impact. First, we use a dual-column system in which the carbon granules are sequentially subjected to adsorption and regeneration steps (Figure 2). Upon saturation of the GAC filters, an electrical current is applied, facilitating the desorption of PFAS. Afterwards, the carbon filters are considered regenerated and prepared for subsequent adsorption cycles. Improved cell configurations and process schemes will be developed. This iterative process offers a sustainable and efficient solution for PFAS removal.

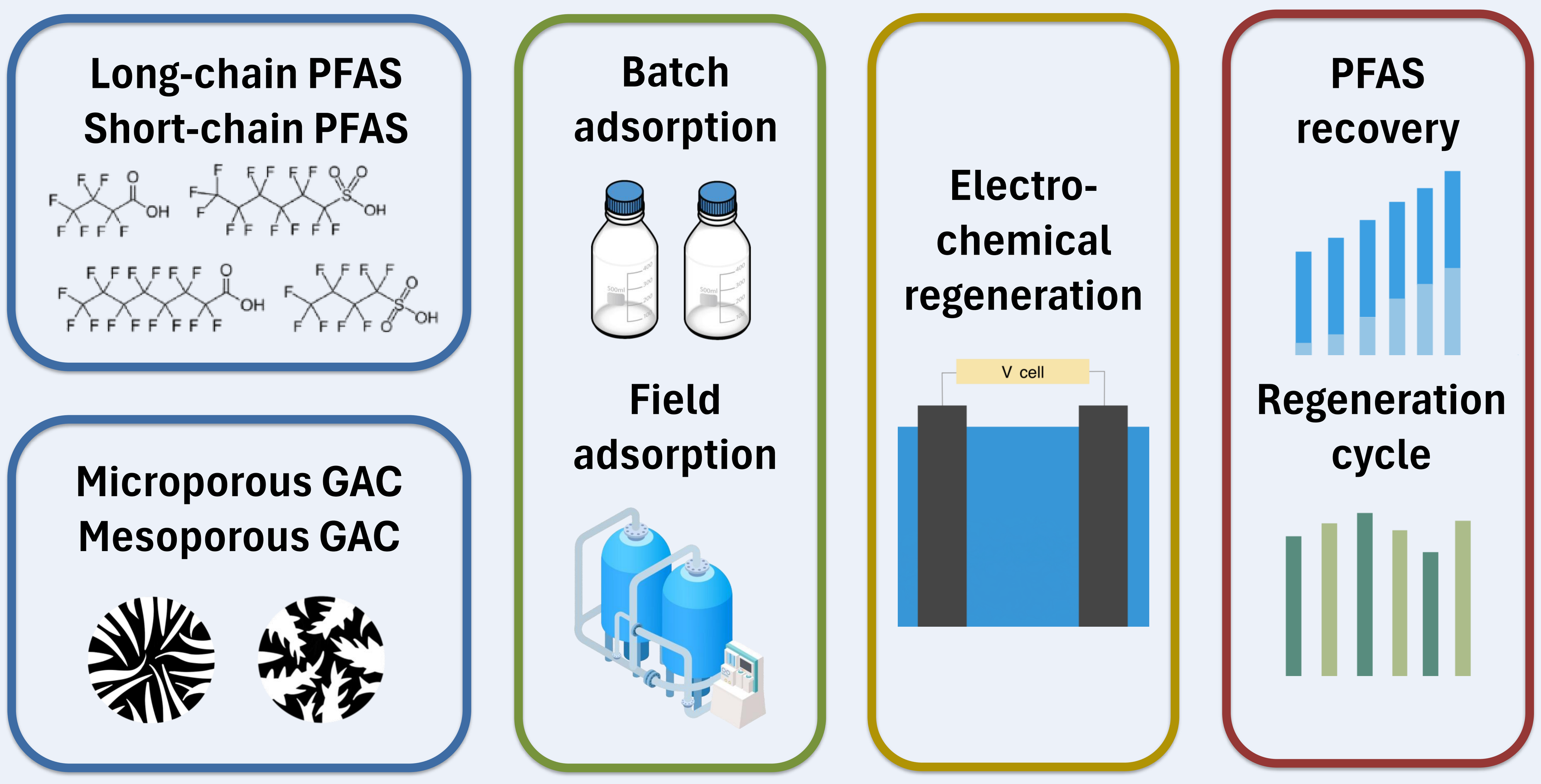

Figure 1. Project overview.

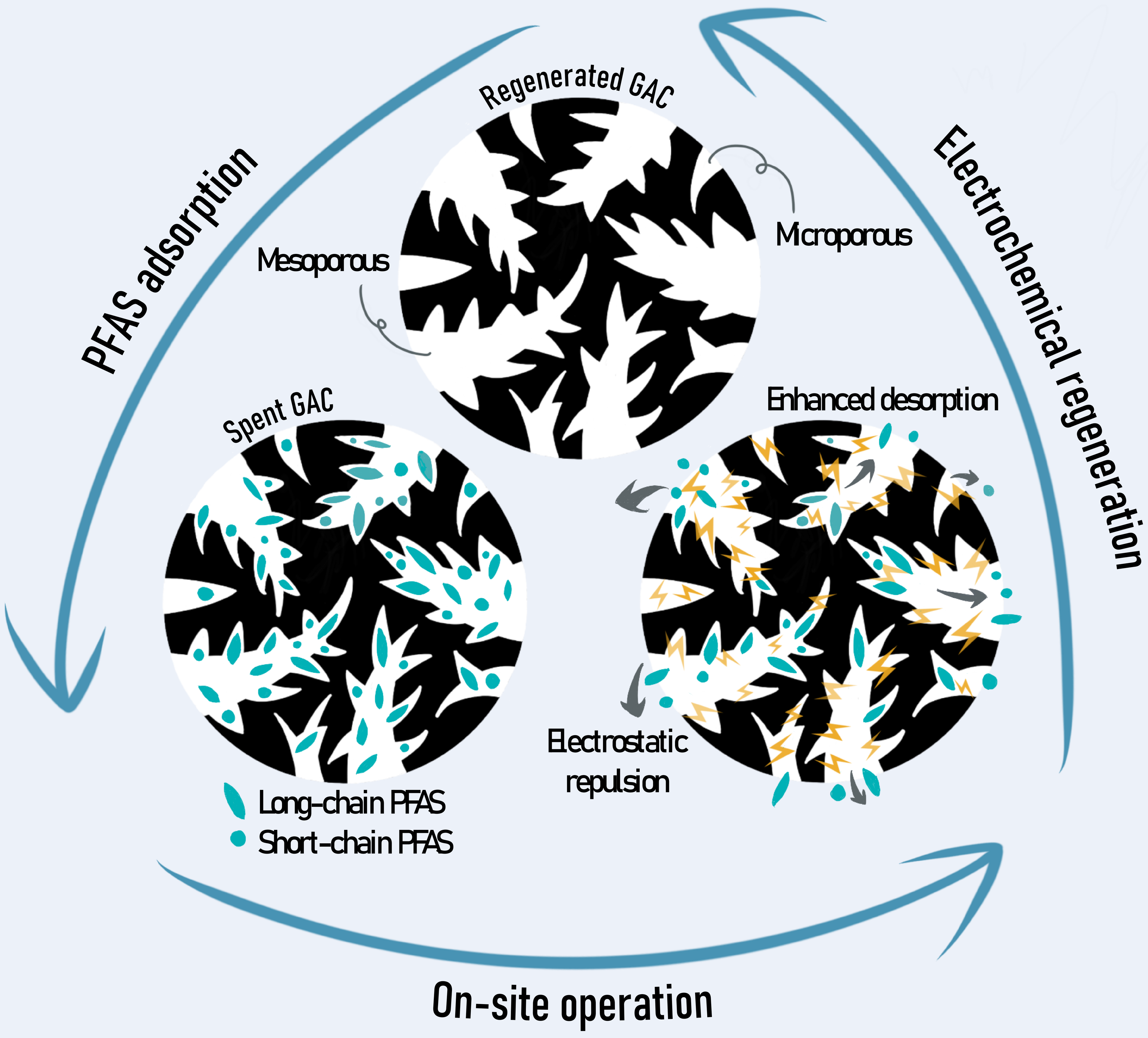

Figure 2. Proposed on-site operation of adsorption and regeneration cycles.

Research goals

The primary focus of this research is to optimize the desorption of a broad spectrum of PFAS, covering various chain lengths and functional head groups. Key areas of investigation include the interactions between PFAS molecules and electrically charged carbon surfaces, and the possibility to remove (ultra) short-chain PFAS. This research will also evaluate diverse operational conditions, water matrices, and reactor configurations. The development of an on-site regeneration technology provides a sustainable approach for PFAS removal.

References

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[2] Li et al., Chemical Engineering Journal (2020), 380, 122506.
[3] Crone et al., Critical reviews in environmental science and technology (2019), 49(24), 2359-2396.
[4] Baghirzade et al., Environmental Science & Technology (2021), 55(9), 5608-5619.

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