Addressing PFAS ‘Forever Chemicals’ Contamination in the Environment

Position statement by the PFAS Working Group, EBNet
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Per- and polyfluoroalkyl substances (PFAS) are a class of synthetic chemicals widely used in industrial and consumer products due to their water and grease-resistant properties. Despite their relatively low market price of ~£15 per kilogram, the true cost of PFAS is far greater when societal impacts are considered (nearly 1000 times higher) (ChemSec, 2023)[1]. Their persistence, mobility, and bioaccumulative nature have triggered global alarm, leading to stringent regulatory limits in drinking water, now measured in nanograms per litre. A widely circulated report from the Europe Forever Lobbying Project warns that cleaning up PFAS contamination could surpass £1.6 trillion across the UK and Europe over the next two decades, with the UK alone facing annual costs of £9.9 billion. As the number of sites contaminated with PFAS continues to rise, urgent action is required to mitigate environmental and human health risks.

Scientific Bases to Address PFAS Challenges

Despite growing evidence of the prevalence and harmful effects of PFAS, significant knowledge gaps remain regarding their environmental fate, transport, transformation, and degradation. Moreover, the structural diversity of PFAS compounds further complicates efforts to predict their behaviour and ecological impacts. The first PFAS list hosted by the NORMAN Network in 2015 consisted of ~4700 PFAS species. In 2021, the Organisation for Economic Co-operation and Development (OECD) revised the definition of PFAS, and consequently, over 7 million PFAS were summarised in one of the largest open chemical collections, PubChem. Recent drinking water regulations have included only a small portion of these compounds, with the EU and Scotland focusing on 20 PFAS and the rest of the UK on 48 PFAS. Although the statutory PFAS list is limited, previous studies from the PFAS WG attempted to develop an AI-driven model to simulate the removal performances of PFAS in contaminated water. This effort was still significantly inhibited by the lack of revealed basic chemical characteristics of those PFAS. The following urgent research needs were summarised and recommended by the UK Research Council through a specific call named ‘Addressing Environmental Challenges’ in 2024:

- Optimising analytical methods to detect PFAS sources, precursors, and degradation products
- Understanding PFAS behaviour and toxicity in different environmental compartments
- Improving modelling approaches to predict PFAS distribution, bioavailability, and ecological risks
- Enhancing knowledge of PFAS toxicity mechanisms to establish ecologically relevant exposure thresholds

Evidence-Supported Technologies

Numerous treatment technologies have been explored to mitigate PFAS contamination, including granular activated carbon, ion exchange resins, membrane processes, and chemical oxidation. In these approaches, the final steps typically involve thermal/incineration processes for the complete breakdown of chemical structures. The development of cost-effective approaches capable of efficiently reducing PFAS or achieving complete mineralisation of PFAS remains a significant challenge. The key obstacle is the stability of the carbon-fluorine (C-F) bond, which requires substantial energy (526 kJ/mol) to break. Exploring biotechnology-based solutions, such as microbial degradation and enzymatic breakdown, offers a promising avenue for PFAS remediation.

Encouragingly, some studies have demonstrated the feasibility of PFAS biodegradation. However, further research is needed to improve efficiency and long-term viability. To achieve meaningful progress, it is essential to develop sustainable and scalable technologies for PFAS removal and destruction. These efforts should be integrated with broader strategies, such as implementing PFAS bans and reducing the flow of these contaminants into the environment at their source.

The PFAS Working Group, as part of the Environmental Biotechnology Network, is committed to advancing scientific research, developing innovative solutions, and informing policy to mitigate the impacts of PFAS pollution. By addressing the challenges outlined in this position paper and prioritising the identified research needs, we can work towards a cleaner, safer, and more sustainable future.

1. https://chemsec.org/reports/the-top-12-pfas-producers-in-the-world-and-the-staggering-societal-costs-of-pfas-pollution/

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