

PFAS in air: extending brownfield air quality practice into a new phase



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As environmental professionals, our role is to assess and mitigate the impact of known contaminants on the environment and public health and anticipate emerging threats.

We know that brownfield land can host a variety of environmental hazards, from heavy metals to asbestos to volatile organic compounds (VOCs). There is now a growing body of research on per- and polyfluoroalkyl substances (PFAS), which demand our attention and action.

The term PFAS refers to a group of over 10,000 synthetic chemicals that have been widely used in industrial processes and consumer products since the 1940s.^{1,2} They comprise a diverse class of highly persistent synthetic chemicals extensively used for their oil- and water-repellent properties, in everyday items such as cosmetics, food packaging, clothing, fabrics and cookware and also in aqueous firefighting foams (AFFFs). Wastewater treatment facilities are not equipped with the technology to effectively remove PFAS, which has enabled them to be discharged to rivers and farmland. These factors have resulted in its widespread environmental distribution.^{3,4}

PFAS are highly resistant to degradation and are found in groundwater, surface water and soils, but there is a growing body of evidence of their presence in the atmosphere.^{5,6} They also have an alarming persistence in the human body, leading to a growing concern about their toxicity as they bioaccumulate due to long elimination half-lives. Ingestion via food and drinking water is the dominant exposure pathway, and while air is generally not the main environmental reservoir, we are also likely to be exposed via inhalation during a variety of activities, both outdoors and in our homes.⁷

We were part of the [IAQM](#) and [IES Land Condition Community](#) working group which produced guidance on [air quality monitoring for brownfield sites during remediation](#). This focused on volatile organic compounds (VOCs) but we have been considering: what can we take from that work to inform our approaches to management and monitoring of PFAS, or will these chemicals disrupt our established approaches?

The harm and persistence associated with PFAS has only been recognised relatively recently and as a result, emissions of PFAS to land, water and air have occurred for decades without monitoring or abatement. Even modern regulatory instruments for controlling pollution such as the Environmental Permitting Regulations 2016 (England & Wales) or Environmental Authorisations (Scotland) Regulations 2021, do not fully recognise PFAS as a contaminant. The persistence of PFAS in the environment means that historical emissions from permitted and unpermitted industrial facilities can continue to impact receptors today. In particular, PFAS in air emissions from such facilities is poorly monitored and poorly understood.

PFAS can enter the atmosphere from a range of industrial, manufacturing and combustion sources, as well as via domestic wastes given the ubiquity of PFAS-containing products in the home.

Atmospheric relevance is greatest for neutral and volatile PFAS and PFAS precursors, which can be directly emitted to air and subsequently transformed and deposited to land and water.^{8,9} The atmosphere also acts as an important secondary medium for PFAS transport, due to the mobility and long-range transport of PFAS within fine particulate matter, which can subsequently deposit to soils and surface waters. Erosion of coastal landfills containing PFAS with evaporation from sea spray,^{10,11} as well as biosolids processing and sludge incineration, are emerging areas of concern for PFAS pathways to air.

The development of IAQM brownfield guidance for air quality provides several useful learning points. The absence of established air quality criteria or regulatory requirements for VOC monitoring was not a justification for inaction. Early steps in emissions monitoring and mitigation were taken by consultants and developers in advance of the IAQM guidance. Proportionate, transparent decision-making grounded in first principles: identifying sources, characterising pathways, and applying precautionary assumptions for professional judgement where uncertainty exists, were applied to develop emission controls. A similar approach would be suitable for PFAS emissions to air.

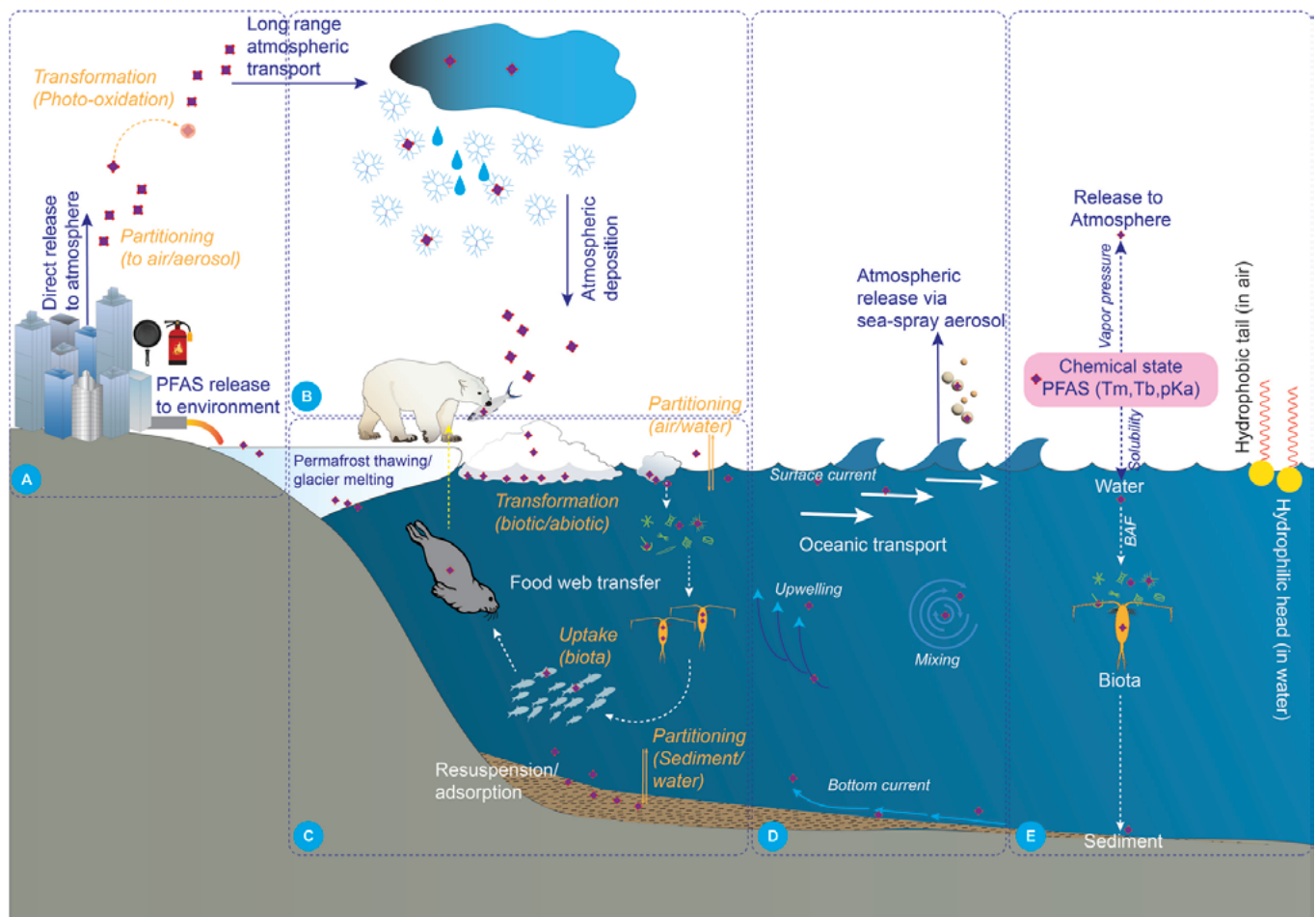
The focus of air quality assessments for brownfield sites in the UK to date has been on potential nuisance contaminants, most notably dust and odours. Odours can be generated by mixtures of tens or hundreds of VOCs and it is these compounds that the IAQM guidance focuses on. Rather than a single class of chemicals, PFAS represent many thousands of compounds with physio-chemical properties spanning several orders of magnitude. At one end are more volatile species such as perfluorocarboxylic acids (PFCAs) and fluorotelomer alcohols (FTOHs) capable of existing in the gas phase and undergoing atmospheric transport and transformation; these may be expected to behave like VOCs. At the other end of the spectrum are low-volatility, ionic compounds such as perfluoroalkyl acids (PFAAs), including PFOA and PFOS, which have negligible vapour pressures and so may associate more with particulates or remain bound to soil and water.

Routine monitoring of PFAS in ambient air is not undertaken in the UK, and so the evidence base

is derived predominantly from targeted research studies and biomonitoring rather than established regulatory air quality networks.¹² Available data indicate that atmospheric emissions are primarily associated with industrial activities and product use, though the significance of these pathways for human exposure remains largely unexplored.

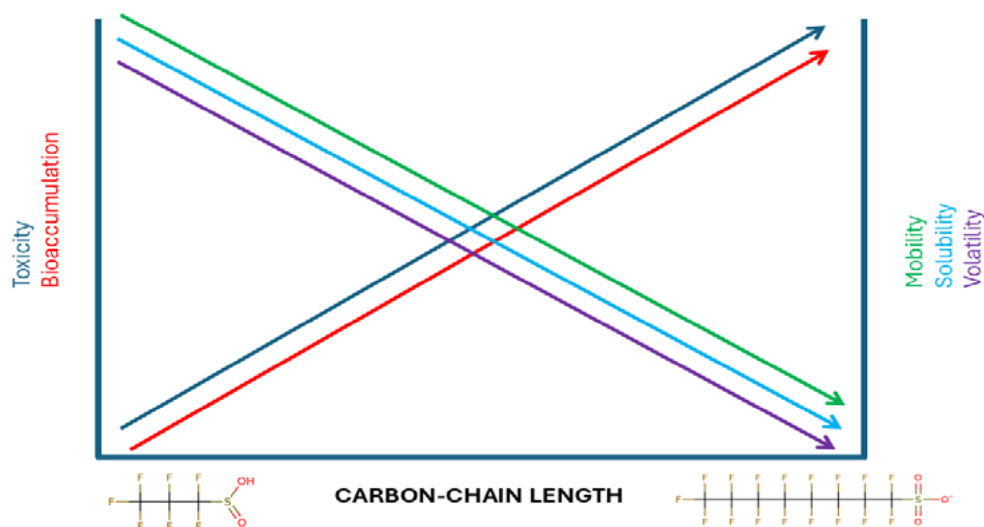
Direct measurement of PFAS in air remains technically challenging and is an emerging field, with monitoring typically focused on a small selection of specific compounds or emission scenarios rather than being part of routine ambient air concentrations. Moreover, monitoring equipment needs to have very low detection limits given the toxicity of the compounds. Currently, the Environment Agency is not funded to routinely monitor either soils or air for PFAS.¹³ UK Water Industry Research (UKWIR) highlights that PFAS are most assessed through water pathways, including runoff and deposition, and notes the difficulty of apportioning pollution loads from atmospheric deposition compared with aquatic sources.¹⁴ Techniques may be replicated

Figure 1. Occurrence, accumulation and ecotoxicological impact sites of PFAS



Taken from Arulananthan A, Vilhelmsson OP, Karsten U, Grossart H-P, Sigurbjörnsdóttir A, Rolfsson Ó, Joerss H and Scholz B (2025) Per- and polyfluoroalkyl substances (PFAS) in the cryosphere – occurrence, organismic accumulation, ecotoxicological impact sites. (CC BY-4.0)

Figure 2. Impact of PFAS chain length on toxicity, bioaccumulation, mobility, solubility and volatility



Recreated from <https://www.3fff.co.uk/news/from-afff-to-fluorine-free-f3-foams-part-4/>

from the USA or Australia where PFAS monitoring is more established,¹⁵ but capacity and expertise in UK laboratories may not be sufficient to obtain accredited analysis on samples. Rather than operating reactively, waiting for contaminants to become embedded in statutory guidance and regulatory standards, there is an urgent need for a more anticipatory approach: one that recognises patterns from past experience and applies them to emerging risks earlier.

Undertaking targeted, exploratory monitoring where risks are plausible will be essential while methodologies and criteria are evolving. Selection of monitoring techniques for PFAS can be aligned to phase behaviour, including both sorbent-based sampling for semi-volatile compounds and high-volume sampling for particulate-bound phases. Volatile PFAS can be captured by similar monitoring techniques to those used on brownfield sites, such as pumped sampling onto thermal desorption tubes followed by analysis by gas chromatography-mass spectrometry (GC-MS) to identify trace compounds.

As is the case for VOC emissions, careful characterisation of the individual components in the PFAS mixture will be necessary to distinguish between ambient exposure, historic sources and the activity in question. The challenge sits with needing to know which PFAS within the thousands out there that you want to target the analysis for. Once we have some results, we can draw on other international screening values, or surrogate compounds where UK-specific criteria are yet to be established for PFAS – this has parallels with the approach to VOCs in air at brownfield sites for which there are only a limited number of air quality

standards and a few more assessment criteria used in permitting and indoor air assessments. The IAQM guidance provides an approach to selecting other criteria to help practitioners interpret results. The clear documentation of assumptions and uncertainties will support findings based on application of professional judgement, and enables decisions that are subsequently based upon them to be revisited as the science develops.

Crucially, approaches to PFAS management will require consideration of the mitigation hierarchy, which promotes avoidance of the source or where that is not feasible, source reduction. For brownfield remediation or redevelopment where PFAS is present and may be disturbed, many of the techniques within the IAQM guidance will be relevant. Land condition professionals will need to ensure that not only are soils and groundwater effectively characterised but that remediation techniques do not create inadvertent pollutant linkages, through the mobilisation or distribution of PFAS into other environmental media including the atmosphere. Air quality professionals need to be part of the conversation when different remediation options are weighted up to ensure the objective of removing contamination from soil and water does not inadvertently create new exposure pathways.

In summary, PFAS in air currently occupies a position analogous to VOCs in the early stages of brownfield site management: monitoring methods are developing, evidence is emerging, and consensus is still forming. This has implications for how monitoring and mitigation strategies are designed, requiring closer integration between air, land and water quality professionals. In this context, PFAS is part

of a continuing trend that challenges the profession to respond proportionately and collaborate more closely across environmental disciplines and media, to address gaps in our evidence base without delaying action.

The UK Government's PFAS Plan⁷ sets out a science-led, proportionate regulatory approach to minimising risks to human health and the environment, while allowing continued use where PFAS are considered essential and no viable alternatives exist. The effective management and evaluation of comprehensive PFAS exposure pathways will require a robust conceptual understanding of sources, pathways, and receptors; applying precautionary thinking where uncertainty exists; and communicating assumptions transparently. In doing so, practitioners can ensure that monitoring and assessment evolve pragmatically and proportionally with the risks they are intended to manage.

The regulatory framework around PFAS in the UK is changing rapidly and, as it does, practitioners in air quality, land condition, ecological and water resources disciplines will need to work ever more closely together to ensure that potential polluters are complying with permits and that regulations keep pace with the emerging science.

These Insights Articles are designed to provide a view on topical issues affecting those working in air quality. This personal opinion piece has been authored by Sarah Horrocks and Dan Maher.

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¹⁵ United States Environmental Protection Agency (USEPA) Other Test Methods (OTM-45 and OTM-50) for measuring PFAS in air emissions from industrial stacks.

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The IAQM aims to be the authoritative voice for air quality by maintaining, enhancing and promoting the highest standards of working practices in the field and for the professional development of those who undertake this work. Membership of the IAQM is mainly drawn from practising air quality professionals working within the fields of air quality science, air quality assessment and air quality management.

About the Land Condition Community

The Land Condition Community connects members to share expertise, shape resources, and drive standards across the sector. The Community leads the annual Land Condition Symposium, runs webinars and discussions, develops professional guidance, and contributes to policy and consultation responses. Through collaboration with partners like SiLC, the National Brownfield Forum, and BSI, the Community champions best practice and strong professional standards in the sector.

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