Increasing global concern about PFASs

Dr Ian Ross and Dr Jonathan Miles from Arcadis, discuss the potential impact of PFASs on the UK construction industry and how to avoid future liabilities and reputation damage

An emerging contaminant is a chemical or material characterised by a perceived, potential, or real threat to human health or the environment and where data is evolving to determine their risk.

In the context of redeveloping a brownfield site there is a concern with potential future liability management (or 'latent' liability), as there is a risk that without considering contaminants for which concerns (and regulations) are emerging some source-pathway-receptor linkages are not being identified. This has the potential to lead to future liabilities and/or negative publicity as science and understanding of possible health impacts develops. It is important that emerging contaminants are considered as a potential risk on brownfield sites.

Two perfluorinated compounds (PFCs) or pefluoroalkyl acids (PFAAs) perfluorooctane sulphonic acid (PFOS) and perfluorooctanoic acid (PFOA) emerged as contaminants of concern in the 1990s and have generally been the focus of regulatory attention, but the term for this expanding new group of contaminants was recently revised to poly- and perfluoroalkyl substances (PFASs) and comprises approximately 3000 man-made chemicals.

PFASs are extremely persistent in the environment, highly mobile, can bioaccumulate (or concentrate) in higher organisms and plants, and are subject of increasing health concerns. During 2016, PFASs were detected above regulatory guideline limits in the public water supplies of six million Americans (Hu *et al*, 2016), and in Australia and Scandinavia supplies were also found to be impacted.

One of the concerns with PFASs is the diversity of uses of the polyfluorinated 'precursor compounds and their capacity to transform in the environment to create perfluorinated compounds, which persist indefinitely, as shown in **Figure 1**. Meaning analysis and also risk assessment of PFAS has previously potentially been inappropriate.

This briefing provides a summary of the potential impact of PFASs on the UK construction industry, and discusses new management practices being adopted in differing jurisdictions across the globe. It will also highlight why PFASs should be considered during redevelopment of higher risk sites (including airports, airbases and some industrial sites) to prevent potential future liabilities and reputation damage.

What are PFASs?

Developed in the 1940s, PFASs are xenobiotics, dissimilar to anything found in nature, with a range of unique properties including the ability to repel both water and oils, high thermal stability and powerful surface tension (surfactant) effects.

These properties have led to widespread use across many industrial and consumer product applications. These include stain repellents for textiles and carpeting, non-stick cookware, uses in electronics and photographic industries, water and oil resistant coatings for food packaging, paper, and flooring and as metal plating mist suppressants.

An important use linked to their environmental release is as components of fire-fighting foams, which have been used in training exercises and fire incidents, most notably at airports, and petrochemical, civil and military facilities (Hu *et al*, 2016).

Introduction

In the UK, the regulatory focus has historically been on the PFOS and PFOA due to the listing of PFOS under the Stockholm Convention on persistent organic pollutants (2009) and the voluntary phase-out of PFOA across much of the western world. Recently, PFOA has been added to the European Union (EU) Commission Regulation 2017/1000 (the REACH Regulations) where its precursors are also restricted (Martin *et al*, 2010). However, PFOS and PFOA represent a small portion of the PFASs in products.

The majority of PFASs produced are known as polyfluorinated 'precursors'. These transform in the environment to produce persistent 'dead end' perfluorinated compounds, including both PFOS and PFOA (Barzen-Hanson *et al*, 2017), which do not degrade further. It is these extremely persistent 'dead end' perfluorinated compounds that are driving global regulatory concern.

So, while chemicals in use for various purposes include PFASs, they may not contain a restricted chemical such as PFOS at the point of use. However, in the environment they will transform to produce these restricted and persistent chemicals, such as PFOS (D'Agostino and Mabury, 2017, and Zhang *et al*, 2016). This behaviour will not be apparent from a simple understanding of materials ingredients.

Why are there environmental concerns about PFASs?

Due to releases of PFASs over time, it is now recognised that they are almost ubiquitous in the environment at very low concentrations – having been detected in food, surface and groundwater, soils, and in the blood of many human and wildlife populations. It has also become apparent that there are many sites impacted by PFASs where harm to human health and the environment may result.

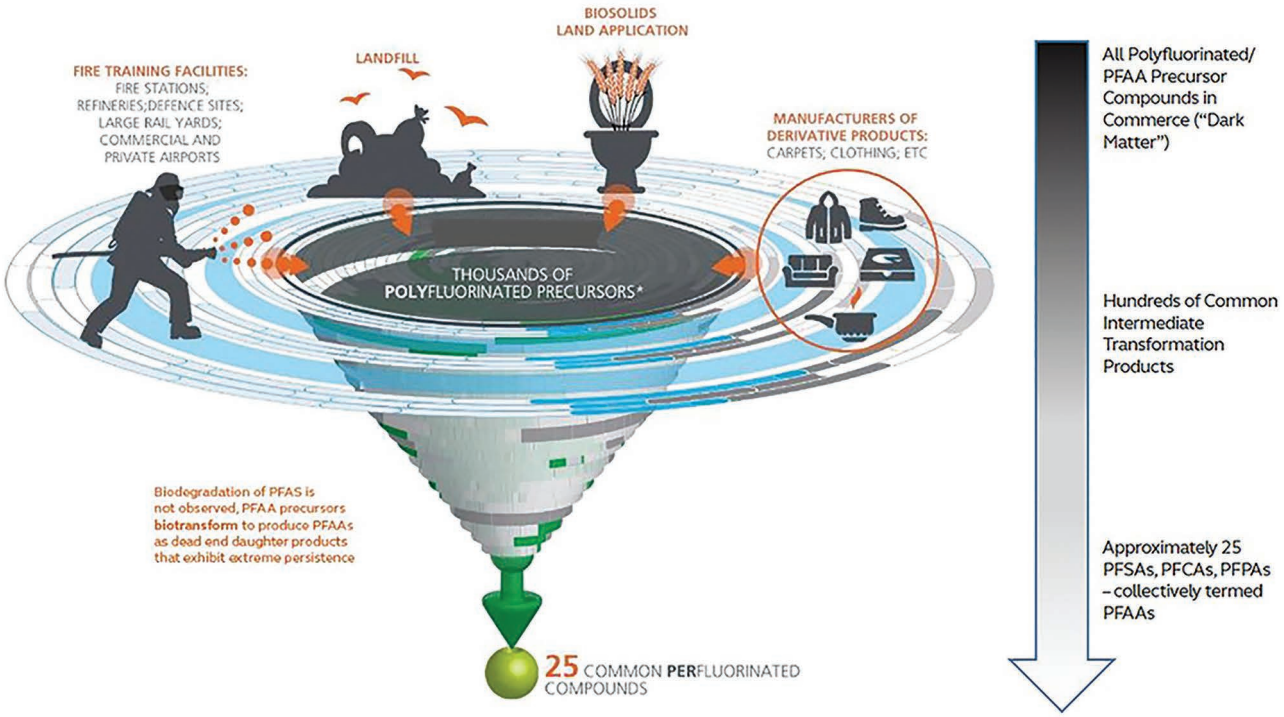

Figure 1 Thousands of precursors biotransform to PFAAs that persist indefinitely (courtesy Arcadis)

The source of PFASs release are diverse, such as in primary and secondary manufacturing and in particular fire training areas. But it may also include industrial and domestic waste water treatment plants (Ahrens *et al*, 2009) and landfills (Clarke *et al*, 2015) as many water and leachate treatment technologies used do not adequately remove PFASs that have entered the waste stream.

Many man-made chemicals biodegrade under natural conditions, but perfluorinated compounds persist indefinitely within the environment and are highly mobile in aquifers. Polyfluorinated precursors can remain undetected and transform to create perfluorinated compounds in the environment. So as PFASs are persistent and highly mobile they have the potential to impact drinking water supply wells at some distance from the point of original release.

PFOS, PFOA and PFHxS (perflurohexane sulphonate) have been shown to bioaccumulate in humans and, once ingested, remain in the human body for many years (Eriksson *et al*, 2017). These chemicals have also been shown to be passed from mother to child in the womb and later via breast feeding (Mogensen *et al*, 2015).

In addition, the C8 science panel (2008) have found probable links from exposure to PFOA, with thyroid disease, pregnancy-induced hypertension, testicular cancer and kidney cancer, while similar epidemiological studies are ongoing in Sweden considering PFOS.

In Guernsey, remedial measures have been carried out after its reservoir was impacted by PFOS from historical fire-fighting foam use at the airport. In addition, monitoring, assessment and remediation of PFOS was undertaken following the Buncefield Oil Depot fire in 2005 in order to protect drinking water abstracted from the underlying Chalk aquifer.

The concern in the UK is over continued use of some PFASs and the legacy of 60 years of use and the resulting sources of contamination to UK aquifers and surface waters.

Global impact and responses

Brownfield assessment

The assessment of PFASs on brownfield redevelopment projects is becoming increasing recognised as essential, given the widespread use of these chemicals on many industrial sites. For example, airports and airfields can have numerous areas of PFASs contamination from the use of fire-fighting foams during training, equipment maintenance, and emergency response.

These areas are likely to include topsoil, which could easily be incorporated into residential gardens during a redevelopment scenario, which raises health concerns as the uptake by fruit and vegetables of PFASs from soils has been demonstrated (Blaine *et al*, 2014 and Bräunig *et al*, 2017), but is not currently well understood.

Waste management

The increasing profile of PFASs has had an impact on waste management practices. In Australia, PFASs levels in waste soils have become an important consideration for acceptance into landfills, but as there are no currently agreed acceptance criteria on the levels of PFASs allowed, many landfill operators are increasingly nervous of accepting any PFASs-affected material. This is linked to the concern that many leachate systems fail to remove PFASs and re-release these contaminants to the environment (Lang *et al*, 2017). Landfills in many other nations including the UK do not currently screen for PFASs or have agreed acceptance criteria.

Drinking water

Advancing science and a recognition that a major route of public exposure to PFASs has been via impacted drinking water has led to regulators globally reviewing national standards. Underlying the regulatory changes are diminishing acceptable daily exposure levels for the general population known as tolerable daily intakes (TDIs), which diminished significantly because of revised U.S. Environmental Protection Agency (USEPA) assessments.

In May 2016, based on new TDIs, USEPA issued an updated long-term exposure health advisory limit for drinking water of 70 ng/L (parts per trillion) for PFOS and PFOA combined. Other states have proposed enforceable standards as low as 14 ng/l for PFOA (New Jersey). Australia matched the USEPA drinking water target for PFOS in April 2017 and also included a C6 PFC, PFHxS.

More comprehensive regulations are developing to cover other PFASs introduced as replacements for PFOS and PFOA led by certain US states and European countries, for example in Denmark and Sweden a sum of both long- and short-chain PFCs are regulated. As short-chain replacements for PFOS and PFOA have been introduced, it is notable that regulations to include these are also evolving because of concern over the extreme persistence, mobility and toxicity of these compounds.

In the UK, standards predate recent global changes, guidance by the Drinking Water Inspectorate (DWI, 2009) sets a multi-tiered approach restricting concentrations of PFOS and PFOA to 1,000 ng/L and 5,000 ng/L, respectively, with a trigger to consult and monitor at 300 ng/L. At this point it is unknown if the UK intends to review its standards in light of the changes seen globally, however the global trend downwards is clear.

UK waters

Limited publicly-available information suggest PFASs are distributed widely in UK groundwaters (Environment Agency, 2007) and surface waters (Earnshaw, 2014) and also in some drinking water (Atkinson *et al*, 2008), and there may be human exposure to PFASs that are above internationally-accepted drinking water standards.

The European environmental quality standard for PFOS is 0.65 ng/L for surface waters based on modelling, which assumes human exposure from repeated ingestion of fish. So, it is of concern that the River Severn was reported to contain 238 ng/L PFOS (Loos *et al*, 2009).

Product stewardship

Many industries are looking to reduce their exposure to potential risks associated with the use of PFASs. This trend is particularly evident in the aviation industry where there has been a transition away from PFASs containing fire-fighting foams, to fluorine-free foams. Another example comes from the furniture industry, IKEA are understood to have transitioned away from PFASs stain resistant coating for leather and textiles.

Liability assessments

Public and private organisations have begun assessing their assets and operational footprints for potential exposure to contamination from PFASs, which includes the military as a particularly large user of fire-fighting foam. Approaches typically start with assessments of PFASs use history and site sensitivity with investigation and site-specific risk assessments also employed to proactively manage liability. Liability assessments consider the risk that PFASs may be present, coupled with the site sensitivity in terms of nearby and on-site receptors.

Analytical advances

Traditional analysis techniques are not suitable to comprehensively assess PFASs on brownfield sites. Firstly, it is not practical to test for the huge range of PFASs that may be present and even if testing was done, there is limited toxicological data on precursors to then make informed decisions. Secondly, only testing for regulated chemicals (such as PFOS) is unrepresentative as it has the potential to significantly underestimate the environmental risks, as many PFASs are not accounted for and it will potentially fail to find source areas where precursors predominate. The precursors will eventually transform to these 'dead end' PFCs, but can go undetected using conventional analytical methods. The failure to detect this hidden mass leads to underestimating the risk to receptors, future liability, with further associated cost implications.

New advanced analytical tools have become commercially available to assess total PFASs mass within an environmental sample. One such technique is the Total Oxidiseable Precursor (TOP) assay (Houtz and Sedlak, 2012), which has shown that hidden PFASs mass can be significant, with increases of over 175 fold compared to traditional analysis observed in some water samples tested. This method provides a pragmatic and cost-effective solution for testing impacts from PFASs and has recently been adopted by regulators in Queensland, Australia for all PFASs analyses.

Treatment technologies

The treatment of PFASs-impacted soil and water remains a challenge and, although technologies are available, many have significant limitations (Vecitis *et al*, 2009). Established soil treatment methods include landfill, although as previously discussed, acceptance criteria are tightening and there remain questions about secondary sources. Destroying PFASs in soils is currently limited to high temperature incineration at >1,000°C, which can be prohibitively expensive and not sustainable. Soil stabilisation, using specialised binding reagents, or capping to reduce PFASs leaching has been used, as has soil washing, which also requires a water treatment solution for the recirculated wash water.

Water treatment responses generally use activated carbon to remove PFOS and PFOA, however sorption capacities are low and shorter chain PFASs and precursors may not be treated (Xiao *et al*, 2017). Other technologies including alternative sorbents, nanofiltration and reverse osmosis have been used to varying extents globally.

Conclusions

Emerging contaminants clearly pose a financial and reputational risk to brownfield redevelopment. This can be mitigated by applying the same rigour of assessment) to emerging contaminants such as PFASs as for conventional contaminants (ie following the approach by Environment Agency, 2004) in order to be protective of human health and the wider environment.

Unfortunately, compared to the global picture, the UK looks increasingly behind the curve in understanding and managing its likely significant exposure to PFASs. Given the considerable falls in acceptable international public exposure levels for PFASs seen in multiple countries in 2016 and 2017, prudent stakeholders with potential exposure to PFASs should anticipate the UK is likely to follow global trends and plan accordingly.

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