EXECUTIVE SUMMARY

Flame retardants are functional additives used to prevent ignition or slow the growth of fires. A chemically diverse group of substances, they play an important role in improving the fire safety of products used in industry and everyday life. Reports of the widespread occurrence of some organophosphate flame retardants (OPFRs) in environmental and biological matrices have raised concern regarding this group of contaminants. Several studies have shown that OPFRs could have harmful impacts on human health including neurotoxicity, carcinogenesis, and endocrine disruption activity.

Defra and the DWI have commissioned this project to understand whether OPFRs are likely to occur in source waters and drinking water. This is a critical first step in characterising the potential risk to drinking water sources and human health from this group of substances. Information on use, pathways to the environment, occurrence, physico-chemical properties, and removal during drinking water treatment processes have been gathered. The data have been used to examine the potential for OPFRs to be present in drinking water and to identify those most likely to be present.

Production of OPFRs

There is very limited publicly available information on amounts of OPFRs supplied and used in the EU and UK. REACH registration data accessed through the European Chemicals Agency (ECHA) database indicates that several OPFRs are high supply volume chemicals. Some OPFRs such as tris(2-chloroethyl) phosphate (TCEP) and tris(2-chloroiso-propyl) phosphate (TCIPP) have been used historically in high supply volumes but are now subject to regulatory restrictions.

Supply information is only available as a tonnage band for the EU and does not include use in imported articles, consequently the data should be treated with caution. More precise values are not readily accessible via publicly available sources. Following the UK withdrawal, comparable data for the UK are not yet publicly available.

The majority of OPFRs are additive flame retardants and are not chemically bound in the articles in which they are used. Since many articles containing these substances have a long in service life, even small gradual losses can lead to a significant release to the environment over time. Significant pathways of release for OPFRs into the environment include direct disposal of consumer products, release via WWTP effluents, landfill leachate and release to the atmosphere and subsequent deposition during from electronic waste recycling.

OPFRs are a chemically diverse group of substances. Their physico-chemical properties and environmental fate and behaviour vary considerably across the group according to their chemical structure and molecular weight. Some OPFRs such as TEP and TMP will be very mobile in the environment with the potential for long range transport via water and the potential to reach groundwater. Others, such as IPP, TDMPP and the oligomeric phosphate tri-esters RDP and BDP are very hydrophobic. These substances will tend to adsorb to soil or partition out of the water phase onto sediment or soil in the environment. During wastewater treatment these hydrophobic substances will be removed from wastewater through partitioning to sludge.

Occurrence in Water and the Environment

Monitoring data reported in the scientific literature for OPFRs in English and Welsh waters are very limited. Evidence from international monitoring studies in the scientific literature suggests widespread occurrence of TCEP, TCIPP, TDCPP, TNBP and TPhP in environmental waters. For many other OPFRs there are very limited or no data.

Analysis of data collected through the Environment Agency's semi-quantitative targeted screening monitoring programme revealed the presence of 11 OPFRs in English environmental waters. The most frequently detected substances were TCIPP, TPhP, TCEP, TDCPP and TPPO. Data collected as part the national non-target screening campaign in Welsh rivers by National Resources Wales (NRW) was also interrogated. TCEP, TDCPP, TMPP, TPhP, EHDPP were detected in the surface waters sampled. TPPO was sampled for, but not detected.

Removal by Water Treatment Processes

Data on occurrence of the OPFRs in drinking water samples are very limited. We could not find any data on occurrence in drinking waters for seven of the 23 OPFRs of interest in this project.

There are significant data on removal through water treatment for some of the OPFRs of interest whilst over 50% of substances (13 out of 23) have no reported data on removal rates. For those substances with data, removal through conventional water treatment is limited due to the uncharged, persistent nature of the OPFRs. However, many can be effectively removed through advanced treatment, particularly with GAC.

Exposure Ranking

A simple, first tier relative exposure ranking exercise has been performed to identify OPFR substances most likely to be present in raw or treated drinking water, based on relative emission score (E-score), persistence and mobility. It should not be interpreted as evidence that these substances are present in drinking water at high concentrations.

The substances TEP, TCEP and TDCPP have a high relative exposure potential based on the outcome of this exercise. These substances have a high E-score, are persistent and mobile and have low removal rates through conventional drinking water treatment. These three substances have been reported in English surface and groundwaters by the Environment Agency. TDCPP is currently being evaluated in the EU for potential ED effects.

TCEP is not currently supplied in the EU according to the ECHA database. The high score in this relative exposure ranking exercise is driven by its persistence, mobility, and low removal rates through conventional drinking water treatment. It is still likely to be present in consumer articles with a long in service life, providing a reservoir of releases to the environment for some time to come.

The substances V6 and TMP are classed as having a high/medium likelihood of exposure. No monitoring data for England and Wales are available for either. TMP has toxicological properties of concern.

A further seven substances are identified as having a medium likelihood of presence in drinking water. Of these, TPhP is currently undergoing evaluation in the EU because it has been identified as a suspected endocrine disruptor. There are no occurrence data in England and Wales for five of these substances (IPP, TiBP, BDP, DNBP and TEHP)

Removal of OPFRs through conventional drinking water treatment is poor but for some substances, good (greater than 50%) removal is observed through advanced drinking water treatment.

Further work is recommended to address the evidence gaps identified in this project. This will enable a more refined assessment of risk to drinking water from OPFRs and should include:

- Collation of accurate tonnage data on use and supply of OPFRs in the UK.
- Further monitoring data on OPFRs in source and treated waters should be collected. Quantitative monitoring data, reporting concentrations of OPFRs in raw and treated drinking waters. Specifically, for V6, TMP, IPP, TiBP, BDP, DNBP and TEHP, as a minimum, targeted screening analysis is recommended to establish whether they are present in UK waters.
- Characterisation of sources and emissions of OPFRs across the full cycle of manufacture, use and disposal (including wastewater treatment works, landfill leachate and contributions from e-waste sites) in the UK, to understand the relative significance of different UK sources.
- Using information sources above, refine existing estimates of indicative concentrations of OPFRs in drinking water.
- Further consideration of the impacts on human health for those OPFRs identified as most relevant to the UK through collation of toxicological data.
- Characterise risk to human health using information on predicted exposure levels and toxicological data.