



Mercury: sources, pathways and environmental data

October 2019

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Executive summary

Mercury is a naturally occurring metallic element, but much of the mercury found in the environment today arises from past industrial activity.

Mercury can occur in various chemical forms which differ in their degree of toxicity and bioavailability. The change from one form to another occurs in water and sediment through biological processes. Methylmercury is the most toxic and bioavailable form.

Historically, mercury has had many industrial and domestic uses which are now banned or severely restricted in favour of safer alternatives. It has been used in electrical equipment such as thermostats and batteries, cosmetics, wood preservatives, textile treatment agents and as an antifouling agent on boat hulls. A major use of mercury has been in mercury amalgam dental fillings, although this is now declining. Liquid mercury has been used for many years in measuring devices such as thermometers, barometers and blood pressure monitors.

Mercury and its compounds are classed as Water Framework Directive priority hazardous substances under the Environmental Quality Standards Directive (EQSD; Directive [2008/105/EC](#) amended by Directive [2013/39/EU](#)) because they readily bioaccumulate, are highly toxic and persistent.

Mercury is found in measureable concentrations in fish and mussels at all locations we have sampled in our biota monitoring programme.

At approximately 80% of freshwater sites sampled we measured mercury residues in fish at concentrations above the relevant environmental quality standard (EQS; 20 µg/kg). In estuarine and coastal waters fish were only sampled from a small number of locations, but all had mercury residues above the EQS.

Where levels are above the EQS, there may be an increased risk to those animals taking and consuming local fish. However, the levels observed in fish are well below the food regulatory limit for mercury in fish and fisheries products and do not represent a risk to the human consumer providing advice from the Food Standards Agency is followed.

In recent decades there have been significant efforts to reduce emissions and losses of mercury to air and water. The UK is signatory to the Minamata convention, a global treaty ratified in 2017. The treaty seeks to protect human health and the environment from the adverse effects of mercury. It bans a range of activities and products with the aim of phasing out emissions of mercury.

Atmospheric releases of mercury are significantly greater than direct emissions to water, with thermal power plants and combustion installations being the largest industrial source emitters of mercury to the atmosphere.

Over the past 50 years emissions of mercury to air have declined by 94% as a result of improved and tighter emission controls and restrictions on mercury use and release.

Aerial deposition originating from outside the UK is now a significant source of mercury. Further reductions will rely on the success of promoting international action.

A commitment to further reduce land-based emissions of mercury to air and water by 50% by 2030 is set out in the [Government's 25 year environment plan](#) as part of its overarching commitment to reduce the levels of harmful chemicals entering the environment.

It's vital that businesses comply with existing measures to limit further releases of mercury into the environment. It may be a long time though before levels in the environment begin to decline. Mercury cannot be degraded and can be remobilised to water from soil or

sediment, so it is difficult to accurately predict environmental trends resulting from reduced emissions

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1. Introduction

Mercury is a volatile, metallic element occurring naturally in the environment as elemental mercury, inorganic mercury or methylmercury compounds. These forms differ in their degree of toxicity and natural processes can change one form to another ([UNEP, 2002](#)).

Historically, mercury has had many uses. In recent years many of these uses have been phased out, banned or restricted in favour of safer alternatives.

Mercury is released from both industrial processes and consumer products. Releases to the environment will continue for years to come as products reach their end-of-life and are disposed of.

The risk to both humans and wildlife from mercury and its compounds, is determined by the likelihood of exposure and the form of mercury present. Methylmercury is the most toxic and bioavailable mercury compound. It is formed primarily by microorganisms in soil, sediment and water converting elemental mercury into methylmercury ([RPA, 2002](#)).

Methylmercury can be released from sediments back into the water column, where it readily bioaccumulates and biomagnifies through the food chain ([WHO, 2003](#)). Low levels of mercury in surface waters can lead to high concentrations in insects, fish and birds. This results in very toxic contamination in parts of the ecosystem, especially in higher levels in the food chain ([Environment Agency, 2010](#)).

Mercury is highly toxic to humans. Exposure, even to small amounts, may have toxic effects on the nervous, digestive and immune systems, and on the lungs, kidneys, skin and eyes ([WHO, 2013](#)). Methylmercury is particularly damaging to developing embryos, which are five to ten times more sensitive than adults ([USGS, 2000](#); [WHO, 2013](#)).

Human exposure to methylmercury is almost exclusively through consumption of contaminated fish and shellfish. [Commission Regulation 1881/2006](#), on setting maximum levels for certain contaminants in foodstuffs, sets a threshold for the level of mercury in fish intended for human health consumption.

EU maximum regulatory limits in food are set through a process that takes into account actual occurrence data, supported by consumption guidance and advice from the European Food Safety Authority (EFSA). Maximum limits exist for heavy metals such as mercury in fish and shellfish.

For mercury, the maximum level is 0.5 milligrams per kilogram (mg/kg; wet weight) with a higher threshold of 1mg/kg being set for specified larger fish such as tuna, pike and eel. Current advice on safe consumption of fish and shellfish from the Food Standards Agency with regards to mercury can be found in the [Committee on toxicity of chemicals in food consumer products and the environment \(COT\) statement following release of updated guidelines in mercury in fish from the World Health Organisation](#).

The Water Framework Directive (WFD) 2008 Environmental Quality Standards Directive (EQSD) ([2008/105/EU](#)) introduced the biota standard of 20 microgram per kilogram ($\mu\text{g}/\text{kg}$) for mercury along with water column standards for the protection of wildlife. The Directive was updated in 2013 ([2013/39/EU](#)), retaining the biota standard but clarifying that it was set on the basis of levels in fish. The water column based annual average was withdrawn.

Predators like otters and large fish are more sensitive to mercury via the food chain than humans eating contaminated fish. For this reason the biota EQS for mercury is determined

by risks to wildlife rather than risks to human health, and is more stringent than standards for the human consumption of fish and shellfish.

The [Shellfish Waters Directive \(2006/113/EC\)](#) which previously included standards for mercury in water was repealed at the end of 2013 by the Water Framework Directive ([WFD; 2000/60/EC](#)). In 2016 the Water Environment (Water Framework Directive) (England and Wales) Regulations 2016 ([SI 2016/138](#)) were amended to ensure that the protections provided by the Shellfish Water Directive continued ([SI 2016/138](#)). In 2017 this legislation was repealed and replaced by the Water Environment (Water Framework Directive) England and Wales Regulations ([SI 2017/407](#)).

Mercury and its compounds are classed as WFD priority hazardous substances because they readily bioaccumulate and are highly toxic and persistent.

In October 2013, the UK became a signatory to the [Minamata Convention on mercury](#). This is a global treaty, which aims to protect human health and the environment from the adverse effects of mercury. In May 2017, the Minamata Convention was ratified and became legally binding for all its Parties ([European Commission, 2017a](#)). At the time the UK signed the Minamata Convention, most of the requirements were met by existing EU legislation. To address any gaps and enable ratification of the Minamata Convention, the Mercury Regulation ([EU/852/2017](#)) was adopted by EU Member States.

The [Government's 25 year environment plan](#) sets out a commitment to reducing land-based emissions of mercury to air and water by 50% by 2030 as part of its overarching commitment to reducing the levels of harmful chemicals entering the environment.

The focus of this narrative is on contributing effects to and assessment of the condition of surface waters in relation to mercury. However, the contribution that groundwater makes to the surface water status failures is also considered as part of the WFD and the Groundwater Directive ([2006/118/EC](#) as amended by [2014/80/EU](#)). If groundwater contributes more than 50% of the mercury load in any surface water status failure then the groundwater body will also go to poor chemical status.

2. Use pattern

The single largest industrial use of mercury in England has been its use as an electrode in the production of sodium hydroxide, chlorine and hydrogen by electrolysis, a process known as chlor-alkali production. The revised EU Mercury Regulation ([EU/852/2017](#)) prohibited the use of mercury in chlor-alkali production from December 2017.

Prior to the introduction of this ban, the single largest industrial use of mercury in England was at a chlor-alkali plant located in the north west of England. It was used for the continuous production of chlorine, sodium hydroxide and hydrogen by electrolysis of a brine solution using 'mercury cell' technology. This use was required to cease by December 2017 and was replaced by a membrane process which does not involve the use of mercury. The use of mercury for chlor-alkali production has now ceased at this plant. The mercury from this site has now been converted back to the original form it was refined from and has been sent for permanent deep, underground storage.

In addition to its industrial uses, mercury has had many product applications. A major use of metallic mercury has been in dental amalgam fillings. Demand for mercury amalgam in dental fillings has decreased in recent years because of improvements in oral health, use of alternative materials, and the adoption of minimally invasive dentistry practices ([BDIA, 2015](#)).

The Mercury Regulation ([EU/852/2017](#)) places restrictions on the use of dental amalgam including banning the use of dental amalgam for dental treatment of deciduous teeth, of children under 15 years and of pregnant or breastfeeding women. Mercury dental amalgam is now only permitted as pre-dosed capsules and there is an explicit requirement for dental facilities to fit and maintain amalgam traps if they work with or extract mercury amalgam.

Waste mercury-based amalgam is classified as hazardous waste and dental practices must comply with the [Hazardous Waste \(England and Wales\) Regulations \(2011\)](#) under which there is a duty of care to dispose of mercury contaminated waste via licensed carriers and brokers. Further details are provided in Section 5.

Liquid mercury was used for many years in measuring devices such as thermometers, barometers and blood pressure monitors, although these uses are now restricted.

Mercury has been used in electrical control and switching equipment such as thermostats and tilt switches, and electrical and electronic equipment such as fluorescent lamps, although its use is now prohibited, with a few exemptions.

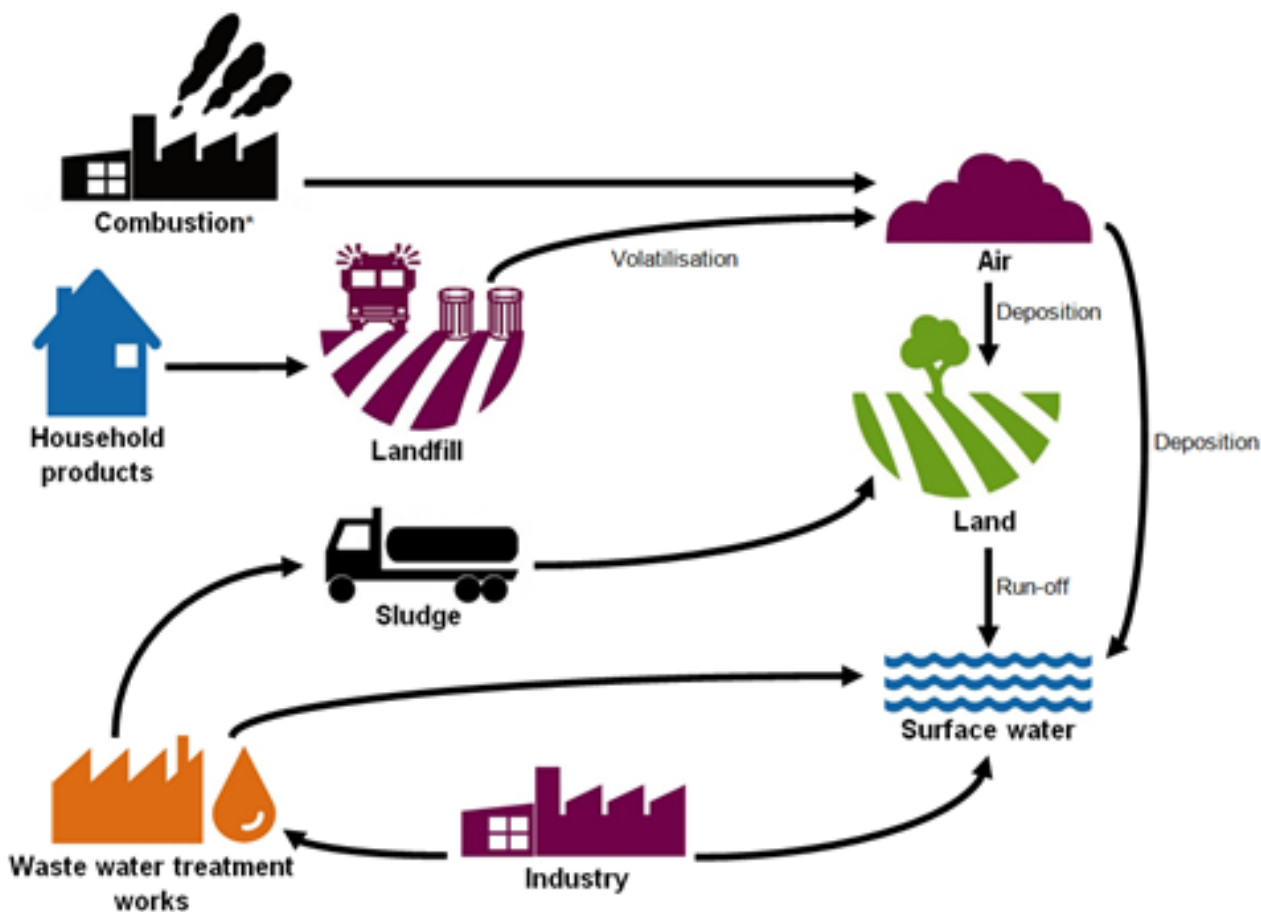
Other uses have included batteries, cosmetics, wood preservatives, textile treatment agents and anti-fouling agents for boat hulls, although the EU now prohibits or restricts these.

A range of actions are being taken to reduce mercury levels in products or to phase out mercury-containing products. These are mostly co-ordinated under the EU Mercury Strategy and the Minamata Convention on mercury, with measures implemented in the EU by the Mercury Regulation ([EU/852/2017](#)) ([European Commission, 2016](#); [European Commission, 2017a](#), [European Commission, 2018](#)).

3. Emissions, sources and pathways

Mercury is released from natural reservoirs in the earth's crust to the atmosphere through volcanic and geological activity. There is a natural biogeochemical cycle of atmospheric transport, deposition to land and water, and volatilization to the atmosphere. Emitted to the atmosphere in its elemental form, atmospheric mercury travels worldwide before deposition to land and water. Mercury continues to circulate between the atmosphere, oceans and terrestrial system for centuries to millennia before it returns to deep-ocean sediments (Selin, 2009).

Human activity has significantly increased the amount of mercury in the global cycle principally through combustion of fossil fuels for power and heating, releasing mercury to the atmosphere, and mining activities; artisanal and small scale gold mining and metal production (Lambert et al, 2012). Figure 1 shows the main anthropogenic sources and pathways of release of mercury and its compounds to surface waters. Figure 1. Anthropogenic sources and pathways of mercury into the environment (Environment Agency, 2015)



*e.g. coal fired power plants, waste incineration, cremation – dental amalgam fillings, production – metal / chloroalkali industries

3.1 Atmospheric emissions - sources

The UK reports emissions information to meet various international and EU commitments. Such data help provide a picture of important sources and trends over time. Further information on the purpose of the emissions inventories mentioned in this section, as well as the methodologies used to build them, can be found within the corresponding references.

Data reported to the [UK-Pollutant Release and Transfer register](#) (UK-PRTR) show that atmospheric releases of mercury are significantly greater than direct emissions to water.

The UK-PRTR reports that in 2016, the most recently reported year, almost twice as much mercury was released to air (2703 kg) compared with reported releases to water (1266 kg) from regulated industries. No releases of mercury to soil are reported by the UK-PRTR. This is most probably a consequence of the UK-PRTR only reporting releases from specified activities and installations which meet or exceed stated pollutant thresholds.

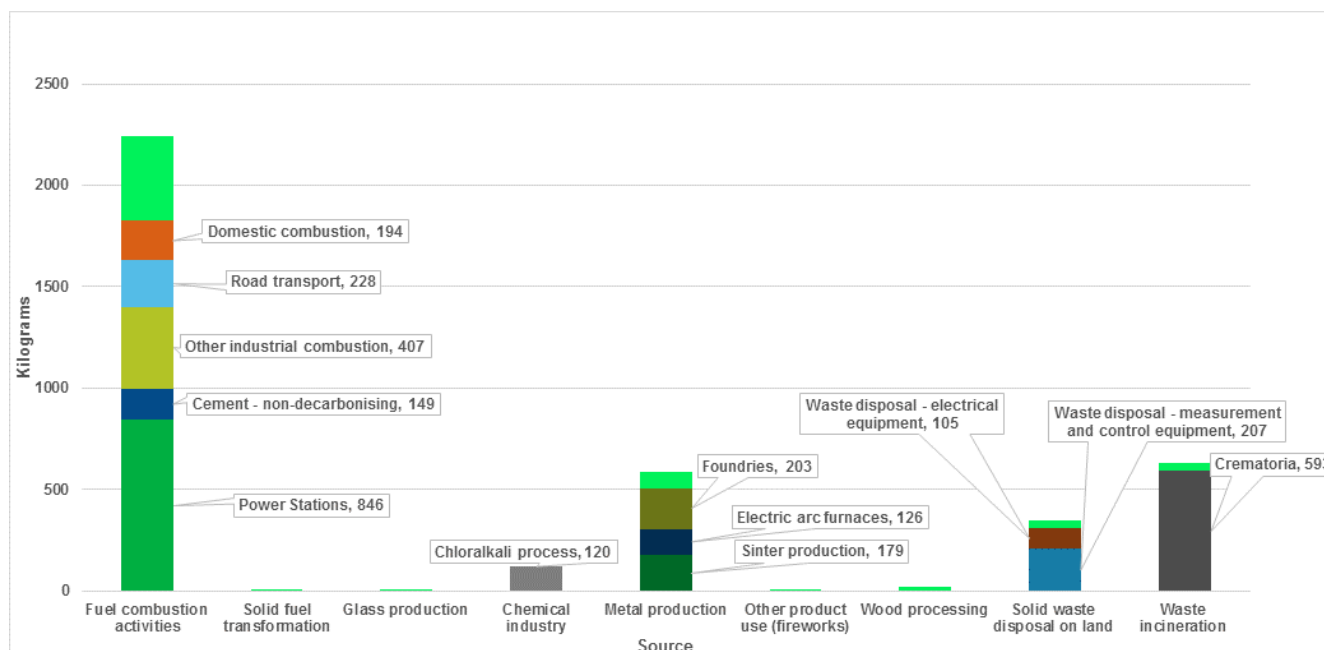
Thermal power plants and combustion installations are identified as the largest industrial source emitters of mercury to the atmosphere. Other industrial processes with significant atmospheric releases include cement production, nonferrous metal production, iron and steel production, the chemical industry, and waste disposal through the incineration of non-hazardous waste and hazardous waste.

The UK's [National Atmospheric Emissions Inventory](#) (NAEI) provides further detail on sources of mercury emissions to air and includes some emissions not captured by the UK-PRTR.

Emissions of mercury to air by sector, as reported by the NAEI are illustrated in Figure 2.

Power stations are identified as contributing approximately 45% of the reported total load (846 kg) from fuel combustion activities.

Figure 2. Emissions of mercury to air reported by sector in 2016. Numeric values in brackets are load in kg. National Atmospheric Emissions Inventory (Environment Agency, 2019)



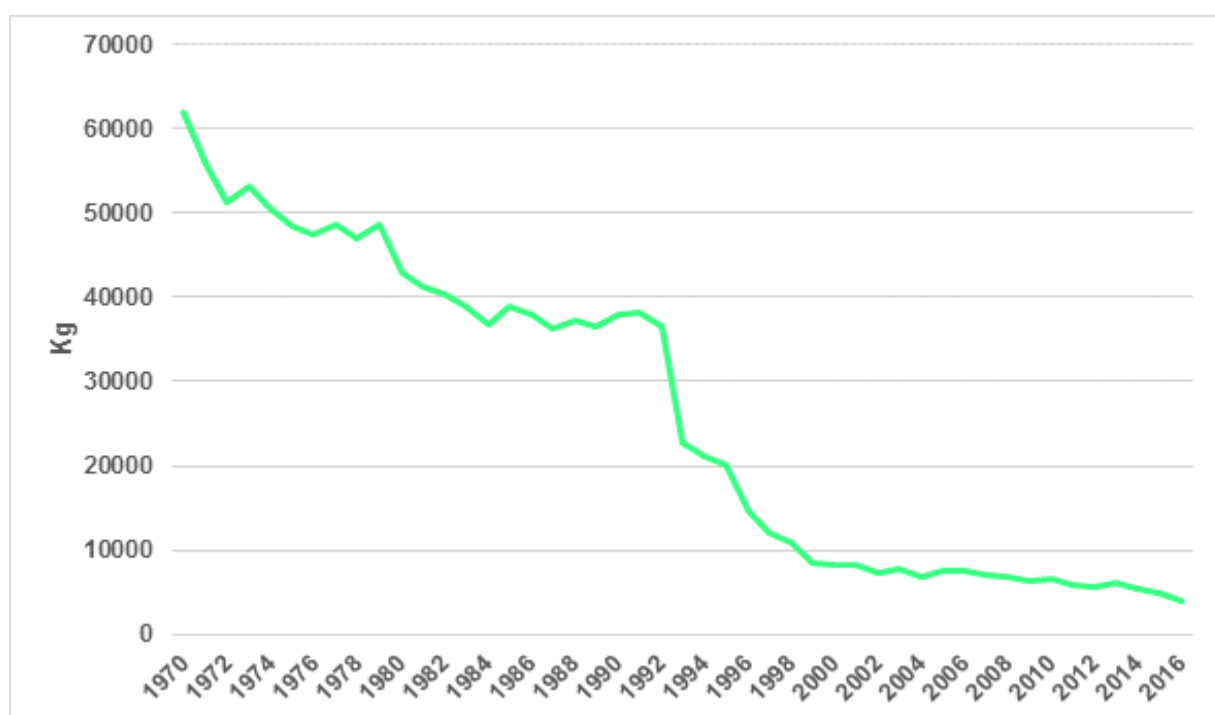
Significant releases from waste incineration are also reported, with crematoria comprising almost all the reported releases of mercury (593 kg) from this sector to air.

Metal production is the third most significant sector for atmospheric releases of mercury, with foundries contributing slightly more than sinter production and electric arc furnaces.

3.2 Atmospheric emissions - trends over time

Over the past 50 years emissions of mercury to air have declined by 94% (NAEI, 2016; Figure 3). This is a direct result of tighter regulatory controls and restrictions on mercury use and releases. For example, improved controls on mercury cells and their replacement by diaphragm or membrane cells, the decline in the use of coal, and tighter abatement controls on waste incineration.

Figure 3. Mercury emissions to air, 1970 - 2016, National Atmospheric Emissions data



3.3 Emissions of mercury to water - sources

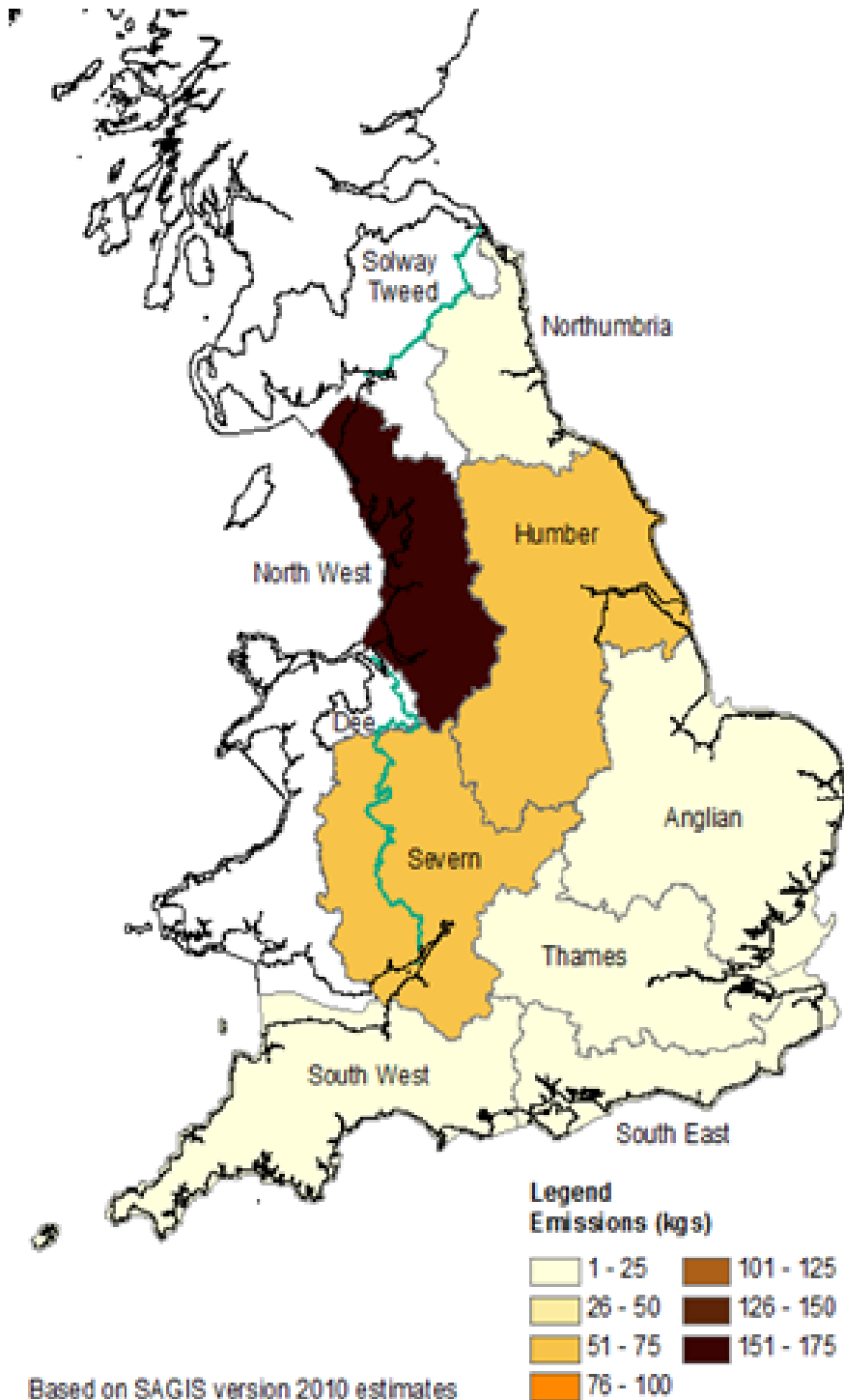
The UK-PRTR identifies thermal power plants and urban waste water treatment works as the most significant industrial source emitters (106kg) of mercury to controlled waters in England in 2016.

The [inventory of emissions, discharges and losses of priority and priority hazardous substances to surface waters](#) is a formal requirement of the WFD under the 2008 EQSD (2008/105/EC). The inventory was reported as part of the 2015 river basin management plans. It will be updated in 2020 for publication as part of the river basin management plans in December 2021.

The inventory provides an estimate of emissions of mercury from both point and diffuse sources to surface waters for the baseline reporting year (2010). Total emissions of mercury to water per river basin district as reported in the baseline are shown in Figure 4. Results for the Solway Tweed river basin district are reported by the Scottish

Environmental Protection Agency and the Dee river basin district by Natural Resources Wales.

Figure 4. Baseline year total emissions, discharges and losses to water for mercury for each river basin district. Results for Solway Tweed are reported by the Scottish Environmental Protection Agency and the Dee by Natural Resources Wales



Estimates have been determined using SAGIS (Source Apportionment Geographic Information System, v2010); a GIS based source apportionment tool and surface water model (Comber et al., 2012) combined with estimates of releases to sea from long sewer outfalls from the Pollution Inventory. The Pollution Inventory reports annual emissions of certain substances to air, controlled waters and land, and off-site transfers from regulated industries.

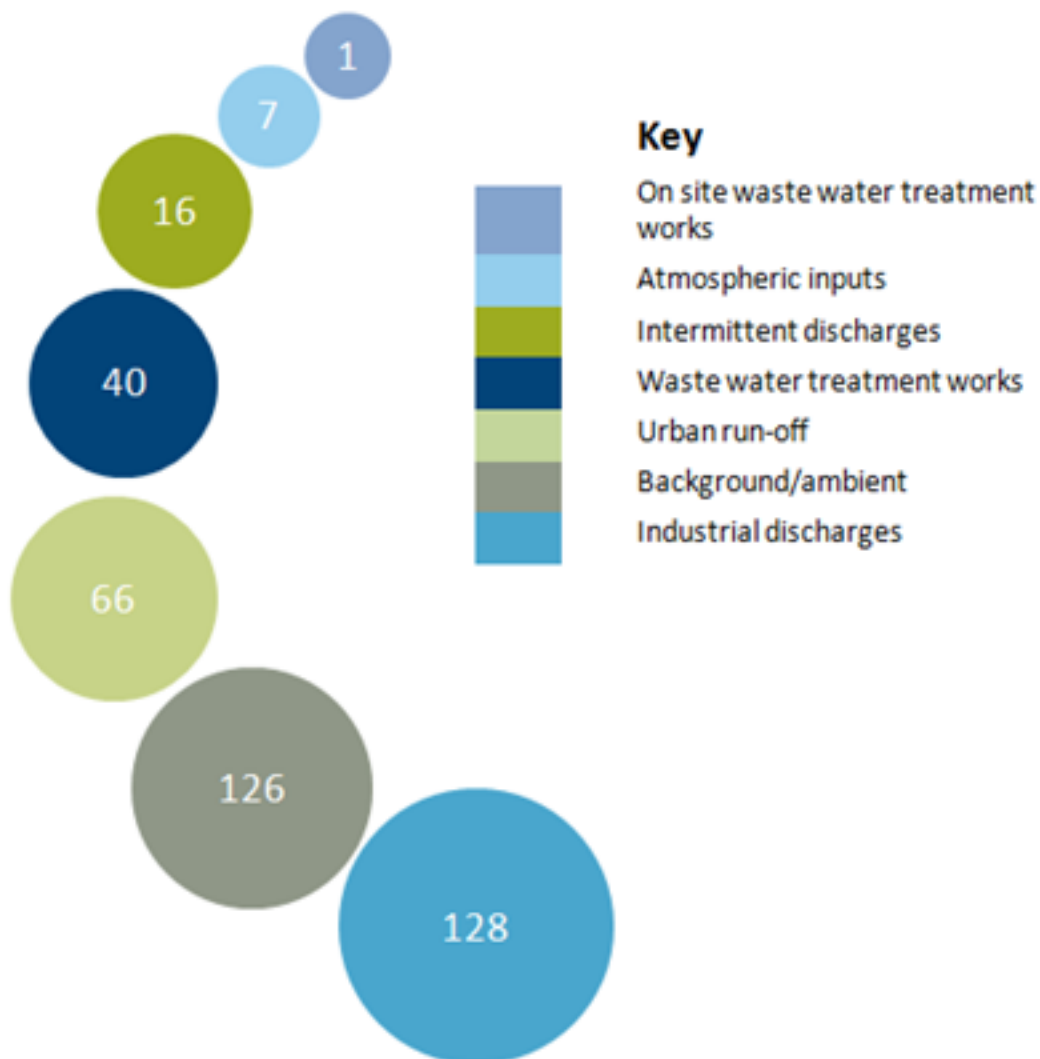
We estimate that approximately 385.4kg of mercury was released to surface waters in England in 2010; 184.3kg from point sources and 201.1kg from diffuse sources.

Estimates of these emissions of mercury to water vary across river basin districts, ranging from 11kg/yr in Northumbria to 156kg/yr in the North West.

Point source and diffuse emissions within each river basin district also vary. Point source emissions range from approximately 5kg/yr in Northumbria to 126kg/yr in the North West. Diffuse inputs range from 7kg/yr (Northumbria) to 54kg/yr (Humber).

Figure 5 shows modelled source apportionment of mercury emissions from different sectors to water using modelled outputs from SAGIS (v2010).

Figure 5. Sectoral analysis of mercury emissions (kg/yr) as modelled by SAGIS v2010 (Environment Agency, 2015).



Of the total mercury load released to water, the modelled results suggest industrial discharges contribute the largest proportion of the load (128kg/yr), closely followed by background/ambient discharges (126kg/yr), and then urban run-off (66kg/yr) and waste water treatment works (WwTWs) (40kg/yr).

WwTWs are a direct pathway, but not the primary source, of the mercury they release to the aqueous environment. We anticipate that the gradual abrasion of dental amalgam and the fraction of waste amalgam that escapes recovery at dental surgeries may also contribute to the diffuse mercury load in waste water received by WwTWs ([WRC, 2009](#)).

Monitoring of WwTW influent and final treated effluent as part of the first Chemical Investigations Programme (CIP) ([UKWIR, 2014a, 2014b](#)) suggests that mercury is not readily removed during waste water treatment processes. Removal rates of less than 50% were reported ([Gardener et al., 2013](#)).

Monitoring of WwTW final treated effluent as part of the CIP demonstrated that mercury is generally found at low levels, suggesting that inputs to sewers are generally low. At two sites, higher concentrations of mercury were detected in the WwTW effluent although in these instances the source was considered to be associated with a specific local point source ([UKWIR, 2014a, 2014b](#)).

At a local scale, the significance of different sources as contributors to the total mercury load will vary according to land use, local industry, population density and degree of historical contamination. For example, in contrast to the sectoral source apportionment described above (Figure 5), which identified background and ambient, as well as industrial inputs as the most significant sources at a national scale, [Chon et al. \(2012a\)](#) identified urban run-off as the most significant source of mercury runoff (47% of total load) in a study to assess the relative contribution of WwTWs to levels of metals in receiving waters in the Yorkshire Aire-Calder catchment.

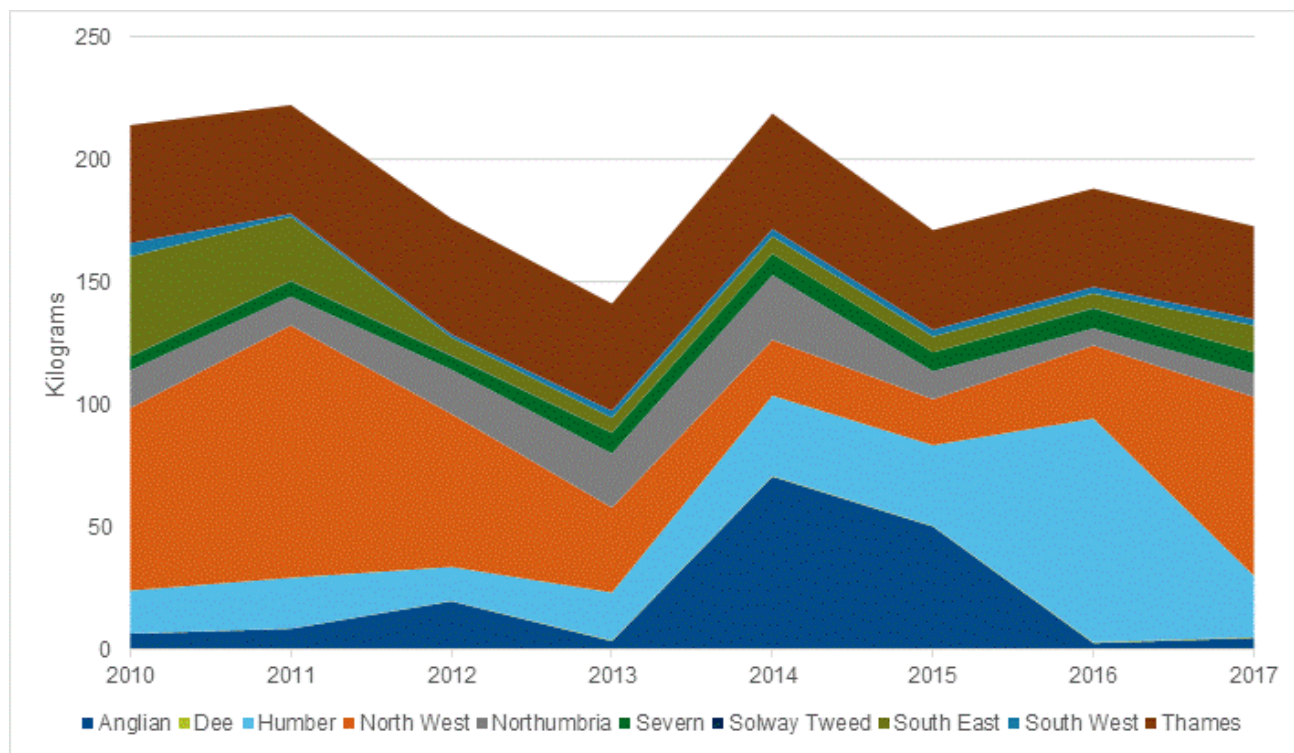
Discrepancies between the SAGIS sectoral breakdown and sectoral emissions reported by the Pollution Inventory reflect differences in estimating and reporting emissions. The Pollution Inventory provides information about releases and transfers of substances from regulated industrial activities. SAGIS is a modelled estimate capturing a wider range of emissions such as atmospheric deposition. Both sources contain estimated values.

3.4 Emissions of mercury to water – trends over time

With only one year of data in the inventory of emissions we cannot yet describe any temporal trends in emissions to water using this modelled data. The inventory of emissions will be updated and published again as part of the 2021 river basin management plans. However, mercury releases to controlled waters, as reported to the [Pollution Inventory](#) – a subset of the UK-PRTR dataset - have been compiled at a river basin district scale. We have used data from 2010 to 2017 as an interim emissions data source to supplement the emissions inventory data described above in Section 3.3.

Mercury emissions to controlled waters from regulated industries have fluctuated year on year between 2010 and 2017, but overall remained relatively constant, as illustrated below in Figure 6.

Figure 6. Total quantity of mercury released to controlled waters as reported by industry to the Pollution Inventory.



4. Environmental monitoring data

As part of a programme of work to enable us to assess risks from persistent, bioaccumulative and toxic (PBT) substances in England we have gathered data on mercury residues in freshwater and saline biota from a surveillance network around England.

Sampling for this programme began in 2014, with the saline monitoring building on an existing OSPAR monitoring programme, established in 1999.

Monitoring of biota presents a number of challenges that are not encountered when we sample water. These include animal welfare concerns, costs and problems accessing sites with sufficient animals for analysis. This constrains the extent of the biota surveillance programme compared with our water column monitoring programme.

The number of sites and their locations has varied year on year, although a subset of sites have been consistently sampled for at least four years and can be used to start to explore trends in concentrations over time (see [Section 4.3](#)).

We have compared our data against the biota Environmental Quality Standard (EQS) to get an understanding of risk. The 2008 EQSD ([2008/105/EU](#)) introduced the biota standard of 20µg/kg wet weight for mercury along with water column standards for the protection of wildlife. The Directive was updated in 2013 ([2013/39/EU](#)) retaining the biota standard but, where this could be monitored in any biota before, this has now been clarified as applicable only in fish. The annual average water column standard is omitted from the new Directive.

Sampling locations and mean measured mercury concentrations in freshwater and saline fish are shown in Figure 7.

The mean measured concentration is based on the most recent three years of data where available. Some sites have means generated from only 1 or 2 years' data.

We have compared this data against the biota based EQS for mercury (20µg/kg) as an assessment of risk.

Mercury is found in measureable concentrations in biota at all locations. Concentrations are variable between years and sites, but at several sites they are close to, either just above or below, the EQS threshold and appear to fluctuate around this threshold over the past 4 years.

4.1 Freshwater data

Between 2014 and 2018 we have sampled 70 freshwater sites for fish (roach 'Rutilus rutilus' and chubb 'Squalius cephalus').

Concentrations of mercury reported here are those measured in whole fish. Values are reported as wet weight for comparison with the EQS but have been normalised to a standard dry weight of 26%. Normalisation of measured concentrations is a useful approach in biota for allowing comparison of concentrations in samples from different locations. The [EC guidance document](#) advises normalisation of measured concentrations of mercury using a default dry weight factor of 26% for fish.

In freshwater fish, mean measured concentrations of mercury range from 13.7 to 237.5µg/kg.

Measured concentrations of mercury in fish are below the EQS at 14 out of 70 freshwater sites (20%), although the concentrations below the EQS are close to the threshold in biota

of 20 µg/kg. The biota EQS value is close to background environmental concentrations and this fluctuation probably reflects influences such as re-release of mercury from historically contaminated sediment. The results are summarised in Table 1.

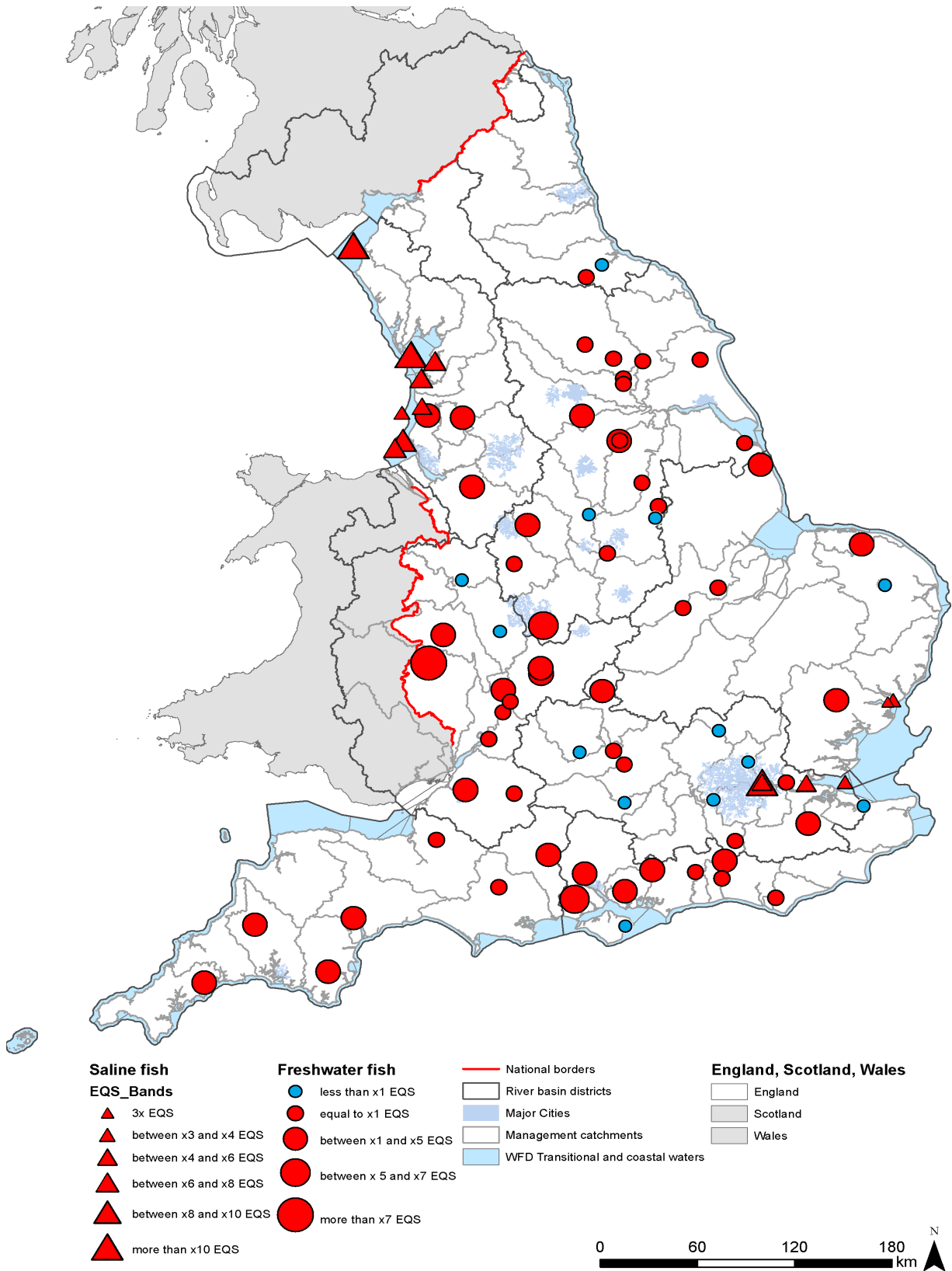
Table 1. A summary of mercury concentrations in freshwater and saline fish and mussels ('Mytilus edulis') from saline waters. Fish data are reported as wet weight, normalised values; mussel data are reported as wet weight, no normalisation

Sample type	No. of sites mercury concentration is below EQS biota	No. of sites mercury concentration is above EQS biota	Concentration range (µg/kg)
Freshwater, fish	14	56	13.7 - 237.5
Estuarine and coastal waters, fish	0	16	28.5 - 260
Estuarine and coastal waters, mussels	7	23	12.4 - 89

The fish sampled are typically smaller than those likely to be consumed by humans, but we report concentrations in those fish at “face value”. The European Commission (EC) suggest transforming this data to estimate the concentrations that would occur in larger fish representing a higher trophic level (EC, 2014). This transformation of the data allows a harmonised view across the EU about levels observed in the different types and sizes of fish but is subject to uncertainty because of uncertainties and variations in possible trophic magnification factors. By reporting concentrations at ‘face value’ and not adjusting concentrations to larger higher trophic level fish it is possible that concentrations of chemicals that biomagnify in fish at a higher trophic status may be under estimated.

Residues of mercury in fish that we are measuring are comparable with data reported by other monitoring programmes. For example, [Rose et al. \(2014\)](#) reported a similar concentration range of 27 to 402µg/kg for mercury in whole fish sampled from UK freshwaters; exceeding the EQS at all sites.

Figure 7. Concentrations of mercury measured in freshwater fish (2014–2018) and saline fish (2018) expressed as a wet weight normalised 3-year mean compared against the biota EQS



4.2 Estuarine and coastal waters

Although the biota standard is applicable in fish, Member States have the flexibility to apply an EQS for an alternative matrix or biota taxon, for example the blue mussel 'Mytilus edulis'. On this basis, and recognising the importance of the trend information that we have been collecting since 1999, we have continued to sample mussels as part of our saline waters sampling programme.

We have sampled both blue mussels ('Mytilus edulis' (30 sites)) from 2014 to 2018 and fish (dab 'Limanda limanda' and flounder 'Platichthys flesus' (16 sites in 2018 only)) in estuarine and coastal waters around England.

Concentrations measured in fish are not directly comparable with those measured in mussels. Fish and bivalves represent different trophic levels in the food chain and an adjustment factor is required to directly compare concentrations for an assessment of risk. Unfortunately, despite ongoing investigation, no reliable trophic level adjustment factor is currently available, so the data must be interpreted with this in mind. The concentrations measured in mussels will be lower than the concentrations in fish because concentrations of mercury will be greater in biota at higher trophic levels because of bioaccumulation.

All fish sampled had concentrations of mercury above the EQS threshold of 20µg/kg wet weight.

Mean concentrations of mercury in whole fish ranged from 28.5µg/kg - 260µg/kg (wet weight normalised). The highest concentrations measured in this small sampling programme were found in fish from the Mersey estuary, Morecambe Bay and the Thames estuary as shown in Figure 7.

Mean measured concentrations in the flesh of mussels ranged from 12.4µg/kg - 89µg/kg.

The highest mercury concentrations reported in mussel flesh are at a site on the north east coast (Longhoughton) and two sites in the north west - Morecambe Bay and the Wyre estuary. In the latter locations, residues of mercury in fish are also amongst the highest we have observed.

Although there are currently few whole fish analyses carried out under our sampling programme (2018 only) wider marine monitoring data collected as part of the UK [Clean Seas Environmental Monitoring Programme](#) (CSEMP) under OSPAR reports a comparable picture.

Elevated concentrations of mercury in fish flesh and mussels are reported in industrialised estuaries, in particular the Thames and the Mersey estuaries. Elevated concentrations of mercury in sediments sampled from industrialised estuaries such as the Tyne, Tees, Thames, Severn and Mersey are also reported ([HM Government, 2012](#)).

[CEFAS \(2012\)](#) reported mercury concentrations in dab ('Limanda limanda') muscle tissue ranging from 52 to 305µg/kg wet weight between 2006 and 2010 in coastal areas of England and Wales. For England, elevated concentrations were recorded in the Tyne and Humber areas and slightly less elevated values were given for the Eastern and Western Channel. Concentrations were found to be more elevated in some waters adjacent to industrialised estuaries.

There is no obvious association between the location of current industrial emissions (Figure 6) and the results from our biota monitoring programme (Figure 7). This supports the view that historical mercury contamination is likely to be an influence on environmental trends and concentrations.

There is a growing body of evidence ([OSPAR, 2017](#)) to suggest that atmospheric sources from non-OSPAR assessment countries contribute significantly to the total load of mercury entering surface waters, together with re-suspension and release of mercury from historically contaminated sediment.

Further investigation is required to understand whether processes that lead to sediment disturbance, such as an increased frequency of storm events as a consequence of climate change or human activity such as dredging operations, are likely to lead to re-mobilisation and release of mercury from historically contaminated sediments.

4.2 Trends in freshwaters
We have limited monitoring data to assess and report on trends in mercury residues in the freshwater environment.

Previously we have reported monitoring data on mercury concentrations in water (as opposed to biota) for a large number of water bodies. The method used to assess values reported below the limit of detection has changed over time as have sampling locations. Because of this we have not been able to use this water column data to assess true temporal trends.

We have analysed our historic freshwater sediment data for mercury (1991 to 2012) to identify any trends in concentrations. It was not possible to discern any statistically significant trends (Environment Agency, 2015).

As described in the previous section, we have been measuring mercury residues in biota since 2014. Although sampling locations have changed over time, there are a number of sites which we have consistently sampled. We have data on residues of mercury in fish sampled from the same site for consecutive years from 2014 to 2018. Although these data are limited, we can start to visually examine them for trends in residue levels.

We have 13 freshwater sites where we have collected four or more year's data on mercury residues in fish. We have visually examined the data for trends rather than applying any statistical analysis to the data because we do not yet have sufficient data. We will continue to collect data on trends to enable further analysis in the future. Overall there is no consistent and observable trend across sites. For the majority of sites there is no trend or a flat trend. At two sites there is a possible increasing trend and at three sites a possible decreasing trend.

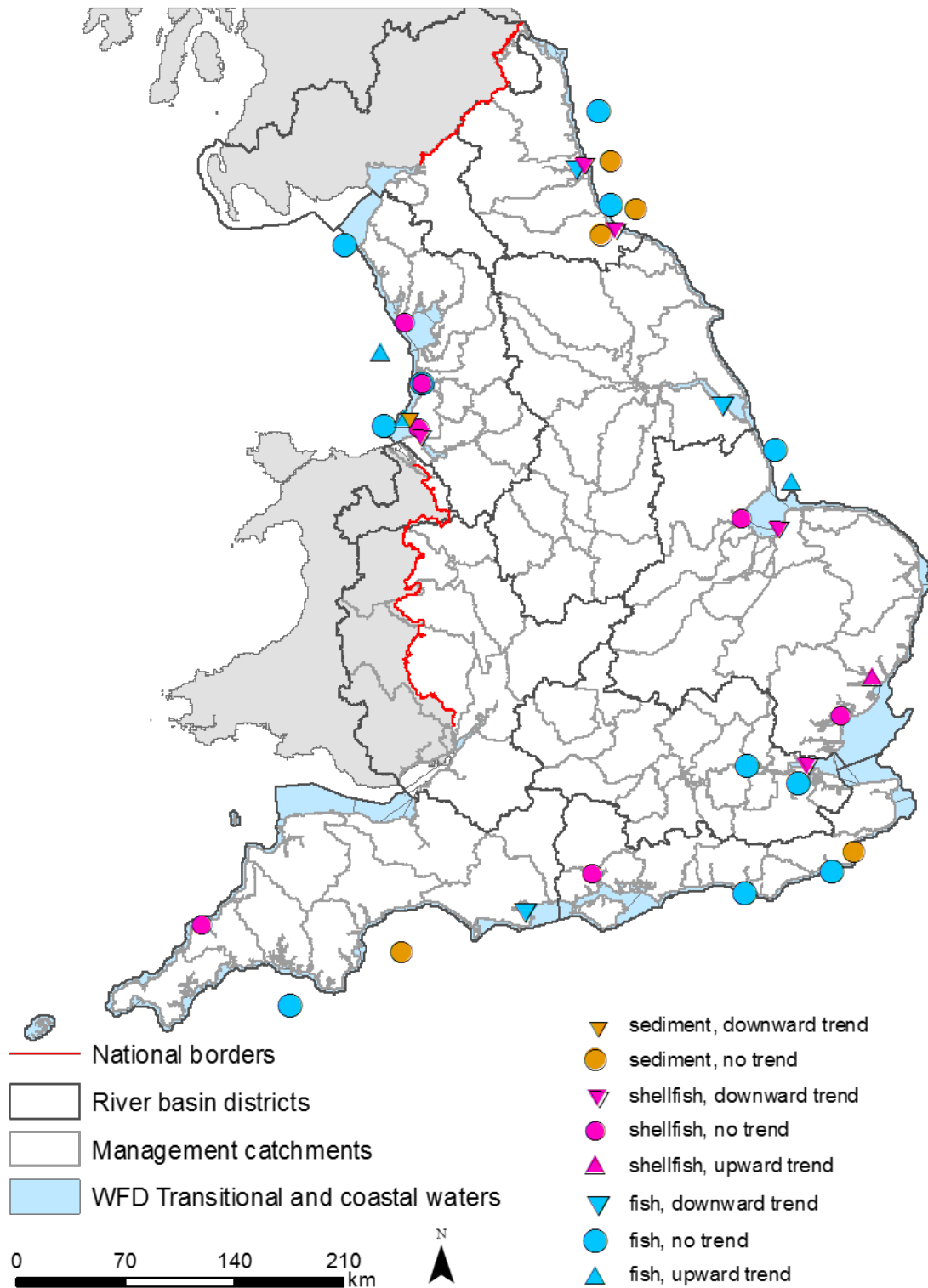
4.4 Trends in saline waters

Under OSPAR, the Clean Seas Environment Monitoring Programme ([CSEMP](#)) has collected data on concentrations of mercury in fish, sediment and mussel ('*Mytilus edulis*') in saline waters since 1999. Data collected under this programme is collated for the International Council for the Exploration of the Sea (ICES) and can be viewed using the [Database on Oceanography and Marine Ecosystems \(DOME\) web portal](#).

An overview of monitoring data for mercury assessed for trends through this programme, within English territorial waters (within 12 nautical miles) for which the EQSD applies, is given in Figure 8. The analysis as performed for the ICES show that data are very variable with only a few sites exhibiting a statistically significant trend over the period 1999 to 2017.

Under the CSEMP fish ('*Limanda limanda*' and '*Platichthys flesus*') muscle tissue has been analysed for mercury from 17 sites around England. At 3 sites concentrations of mercury in muscle tissue show a downward trend in concentrations over the reported period. These are sites where historically we have observed elevated concentrations because of legacy pressures.

Figure 8. Monitoring and trends in concentrations of mercury in biota and sediment in English coastal waters over the period from 1999 to 2017. Data accessed from [ICES Environmental database \(DOME\)](#) '2018 OSPAR rolover assessment'. Downloaded May 2019; Chemical data for the OSPAR CSEMP, Reporting laboratory(s) via British Oceanographic Data Centre (UK). ICES, Copenhagen



There is an upward trend in mercury concentrations in fish sampled from 3 sites; Morecambe Bay, Liverpool Bay and Inner Wash (Figure 8).

The strongest evidence base for a declining trend in mercury residues comes from sampled mussels. Of the 13 sites assessed for trends, 5 sites in the North West, Northumbria, Anglian and Thames river basin districts show a downward trend in mercury residues over time. For 7 sites, there are no trends observed and at one site in Thames there is a possible increasing trend in mercury residues in mussels. (Figure 8).

Interpretation of the data requires care as these site specific trends appear to be substantially influenced by local, short-term conditions. For example, winter storms and floods appear to have triggered elevated concentrations in the Tyne and Tees in 2014, possibly because of resuspension of contaminated sediment, which can mask longer term trends, although concentrations since 2014 have declined. At sites where there are limited legacy pressures such as in the south west of England, no trend is detected. Levels at these sites reflect current background concentrations seen across the North East Atlantic.

Data for mercury in sediment are also available under the same programme. Of the 6 sites assessed for trend, one has declining mercury concentrations. For the remaining sites, there are no trends observed (Figure 8).

5. Restrictions

There are numerous control measures for mercury emissions and restrictions for the use of mercury in products.

The UK is a signatory to the Minamata Convention on mercury. This is a global treaty, ratified in 2017, that aims to protect human health and the environment from the adverse effects of mercury ([United Nations, 2017](#) [European Commission, 2017a](#)). It bans a range of activities and products with the aim of phasing out emissions of mercury.

The Convention entered into force on 16 August 2017. It limits and prohibits the use mercury in industrial processes and in products from 2020. It requires phase out and phase down of the use of mercury in several products and processes, control measures on emissions to air and releases to land and water, and regulates the informal sector of artisanal and small-scale gold mining.

The Convention introduced a ban on new mercury mines, the phase out of existing mercury mines and control measures on air emissions. Amongst other obligations the Convention also requires control of mercury emissions from industrial sources such as coal fired power stations, phasing out of mercury use in products such as batteries and measuring devices, phasing out the use of mercury in manufacturing processes such as chlor-alkali manufacture, and controls over the supply and trade in mercury

The EU Mercury Regulation ([EU/852/2017](#)), implemented in the UK by the Control of Mercury (Enforcement) Regulations 2017, bans the import into the EU and the export from the EU of mercury, mercury compounds, mixtures of mercury and mercury added products. The use of mercury or mercury compounds is prohibited in a number of manufacturing processes from specified dates, including from 11 December 2017 for chlor-alkali production in which mercury was used as an electrode.

The Regulation also sets requirements for the usage and storage of mercury, mercury compounds and mixtures of mercury, as well as the management of mercury waste to ensure protection of human health and the environment.

Since 2005 waste dental amalgam containing mercury has been classified as hazardous waste under the Hazardous Waste Regulations (2008/98/EC), implemented in England by the Waste (England & Wales) Regulations 2011. It requires disposal without endangering human health and the environment. This means that waste dental amalgam cannot be flushed down the drain and must be separated using an amalgam separator.

The EU Mercury Regulation ([EU/852/2017](#)) sets out stricter measures to reduce this source. The use of dental amalgam in children under 15 years of age, and pregnant or breastfeeding women, was restricted from July 2018. High performance filters, known as amalgam separators, prevent water contamination by dental clinics became compulsory in January 2019.

Amalgam wastes need to be handled by an authorised waste management establishment, and dental practitioners must not to release mercury to the environment under any circumstances. This regulation revoked and replaced the Mercury Export Ban (Regulation [EC/1102/2008](#)) implemented in the UK by the Mercury Export and Data (Enforcement) Regulations 2010.

The Battery Directive ([2006/66/EC](#)), implemented in the UK by The Batteries and Accumulators (Placing on the Market) Regulations 2008, Waste Batteries and Accumulators Regulations 2009, prohibits batteries and accumulators (rechargeable batteries) being placed on the market if they contain more than 0.0005% of mercury by weight. Military and space applications are exempt. The Directive also seeks to improve

the environmental performance of batteries and accumulators and promotes the safe production, use and disposal of batteries and accumulators by manufacturers, distributors, end users and those involved in the treatment and recycling of waste batteries and accumulators.

Annex XVII of the REACH Regulation ([EC/1907/2006](#)), implemented in the UK by the REACH Enforcement Regulations 2008, has several entries relating to mercury restrictions:

- Entry 18 – prohibits the placing on the market or use of mercury compounds for antifouling of boats, as a wood preservative, impregnation of industrial textiles and treatment of industrial waters ([EC/552/2009](#))
- Entry 18a – since 2009 the placing on the market of measuring devices (thermometers, sphygmomanometers, barometers) containing mercury intended for sale to the general public has been prohibited, with few exceptions. After 10 April 2014 this ban was extended to cover measuring devices containing mercury intended for industrial and professional uses, with few exceptions ([EC/847/2012](#)).
- Entry 62 – prohibits the placing on the market or use of five phenylmercury compounds from 10 October 2017 ([EU 848/2012](#)).

The Restriction of the use of certain Hazardous Substances (RoHS) in Electrical and Electronic Equipment (EEE) Directive ([2011/65/EU](#)), implemented in the UK by the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012, prohibits new electrical and electronic equipment containing mercury at levels above 0.1 % from being placed on the market with the exception of some fluorescent lamps.

The Industrial Emissions Directive (IED) ([2010/75/EU](#)), implemented in England by the Environmental Permitting (England and Wales) (Amendment) Regulations 2013, aims to minimise emissions of mercury and other substances from major industrial sources and replaced a number of older directives. These sites require permits which place limits on emissions. Emissions to air are addressed by the specific inclusion of mercury in the IED as a substance requiring application of 'best available techniques' to minimise emissions.

Mercury is not approved for use in biocidal products under the Biocides Regulations ([EU/528/2012](#)), implemented in the UK by the Biocidal Products and Chemicals (Appointment of Authorities and Enforcement) Regulations 2013. Use of mercury in cosmetic products is also prohibited under the Cosmetics Regulations ([EC/1223/2009](#)), implemented in the UK by the Cosmetic Products Enforcement Regulations 2013, and for many years prior to this under the preceding legislation.

6. Discussion

Mercury is a naturally occurring metallic element but concentrations in the environment have increased because of anthropogenic activity. Mercury has the potential for global, long range transport. Emissions, atmospheric transport and deposition of mercury are therefore a global environmental issue.

In recent decades there have been significant efforts to reduce emissions and losses of mercury to air and water. The UK is signatory to the Minamata Convention - a global treaty, ratified in 2017. The Convention seeks to protect human health and the environment from the adverse effects of mercury ([United Nations, 2017](#) [European Commission, 2017a](#)). It bans a range of activities and products containing mercury with the aim of phasing out emissions of mercury.

A commitment to further reduce land-based emissions of mercury to air and water by 50% by 2030 is set out in the [Government's 25 year environment plan](#) as part of its overarching commitment to reducing the levels of harmful chemicals entering the environment.

We are already taking action to reduce emissions to land and water. The phase out of coal in the UK energy mix is an important component of this, with an intent to move away from coal fired power stations by 2027.

Atmospheric mercury inputs from background sources and from outside the OSPAR Maritime Area are now greater than the combined waterborne and atmospheric emissions of OSPAR countries around the Greater North Sea (OSPAR, 2017).

After coal fired power stations, the most significant source of mercury to air in England is crematoria where progress has already been made to reduce emissions. Further progress may be problematic because of technical and ethical considerations.

Further reductions in atmospheric emissions will primarily rely on the success of promoting international action. Significant progress has been made towards achieving the OSPAR objectives of reducing discharges, emissions and losses of hazardous substances in the OSPAR maritime area to near background concentrations (OSPAR, 2017).

The major industrial use of mercury in chlor-alkali plant has now ceased and liquid mercury has been converted to solid waste prior to export to Germany for secure disposal in deep mines.

The British Dental Association's good practice quality assurance programme requires dentists to have mercury separators to prevent releases of mercury to sewers.

The Environment Agency will continue to take enforcement action on illegal use. This will help to disrupt the international market in mercury products.

Mercury emissions also arise from re-suspended material such as from historically contaminated sediment and exposed soils. Knowledge gaps remain concerning the retention and export of mercury in estuaries, limiting the knowledge of the proportion of metals that reach the marine environment ([OSPAR, 2017](#)).

In previous river basin planning cycles, assessment of environmental concentrations against the water column based annual average EQS, demonstrated a high degree of compliance with the 2008 Environmental Quality Standards Directive ([2008/105/EC](#)) in England. This water column based annual average standard was withdrawn in the updated EQSD ([2013/39/EU](#)).

In the 2021 River Basin Management Plans we will adopt a new approach, based on robust evidence, to report compliance for substances that accumulate in animals and food chains.

Whilst the majority of these substances are not a concern, mercury is ubiquitous in the environment as a result of historic use and accumulates in sediment and biota. Our biota monitoring programme shows mercury concentrations in fish and mussels are greater than the relevant EQS threshold.

However, the levels observed in fish are well below the food regulatory limit for mercury in fish and fisheries products and do not represent a risk to the human consumer providing advice from the Food Standards Agency is followed.

Biota EQSs are set at levels intended to protect both aquatic wildlife and human health by basing the EQS on the most sensitive receptor. EU maximum regulatory limits in food are set through a separate process that takes into account actual occurrence data, supported by consumption guidance and advice from the European Food Safety Authority (EFSA). Maximum limits exist for heavy metals such as mercury in fish and shellfish.

For mercury, the most sensitive receptors used to derive the EQS are fish-eating wildlife such as otters and birds, which consume a much greater proportion of fish as part of their diet than humans. The levels observed in fish in English rivers and estuarine and coastal waters are not exceptional compared to the rest of Europe or worldwide. Where levels are above the EQS, there may be an increased risk to those animals taking and consuming local fish. Despite this risk, otter populations are recovering.

Ensuring compliance with existing measures to reduce further emissions are important elements in managing the issue of environmental mercury, but the success of this strategy is likely to become apparent only over an extended period of time. Mercury cannot be degraded over time. Local concentrations may even increase due to remobilisation from land or sediment. Therefore it is difficult to accurately predict environmental trends resulting from reductions in emissions.

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List of abbreviations and acronyms

BDE

Bromodiphenyl ether

CEFAS

Centre for Environment, Fisheries and Aquaculture Science

CIP

Chemical Investigations Programme

CSEMP

Clean Seas Environment Monitoring Programme. UK CSEMP data collected using the principles set out by the OSPAR [Coordinated Environmental Monitoring Programme](#) (CEMP)

EEE

Electrical and Electronic Equipment

EQS

Environmental Quality Standard

EQSD

Environmental Quality Standards Directive

IED

Industrial Emissions Directive

OSPAR

The OSPAR convention is the Convention for the Protection of the Marine Environment of the North-East Atlantic. See <https://www.ospar.org/convention>. It is the mechanism by which 15 Governments & the EU cooperate to protect the marine environment of the North-East Atlantic.

PBDEs

Polybrominated diphenylethers

PBT

Persistent, bioaccumulative, toxic

PS

Priority substance

PHS

Priority hazardous substance

RBMP

River basin management plan

REACH

Registration, Evaluation, Authorisation and Restriction of Chemicals

SAGIS

Source Apportionment Geographic Information Systems

TraC

Transitional and coastal

uPBT

Ubiquitous PBT

UK-PRTR

UK Pollutant Release Transfer Register

WFD

Water Framework Directive

WwTWs

Waste water treatment works

Glossary

Amalgam

In dentistry, amalgam is an alloy of mercury with various metals used for dental fillings. It commonly consists of mercury (50%), silver (~22–32%), tin (~14%), copper (~8%), and other trace metals.

Anthropogenic

(Chiefly of environmental pollution and pollutants) Originating in human activity

Bioaccumulate

The accumulation of a substance, such as a toxic chemical, in various tissues of a living organism

Biota

The animal and plant life of a particular region, habitat, or geological period

Bioavailability

The extent to which a substance can be absorbed by a living organism

Biomagnification

The sequence of processes in an ecosystem by which higher concentrations of a particular chemical are reached in organisms higher up the food chain, generally through a series of prey-predator relationships

Chlor-alkali

The chlor-alkali process (also chlor-alkali and chlor alkali) is an industrial process for the electrolysis of sodium chloride. It is the technology used to produce chlorine and sodium hydroxide (caustic soda), which are commodity chemicals required by industry

Inorganic

Not consisting of or deriving from living matter

Microorganisms

A microscopic organism, especially a bacterium, virus, or fungus

PBT

Persistent, bioaccumulative and toxic. These substances are a class of compounds that have high resistance to degradation from abiotic and biotic factors, high mobility in the environment and high toxicity.

Remobilisation

The process of returning a substance to circulation within a particular system

uPBT

Ubiquitous PBT. PBTs that are widespread and found everywhere

Volatile

(Of a substance) Easily evaporated at normal temperatures liable to change rapidly and unpredictably, especially for the worse

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