

Annual Report for 2025 on the UK Toxic Organic Micro-pollutants (TOMPs) Air Monitoring and Analysis Network

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Report to the Environment Agency

Department for Environment, Food and Rural Affairs,

Northern Ireland Department of Agriculture Environment, and Rural Affairs

Scottish Government

Welsh Government

1 Executive Summary

This report contains the 2025 quarter 1 (Q1), quarter 2 (Q2) quarter 3 (Q3) and quarter 4 (Q4) ambient air concentration data for polychlorinated biphenyls (PCBs,) polychlorinated-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), polybrominated diphenyl ethers (PBDEs), decabromodiphenyl ether (decaBDE) and hexabromocyclododecane (HBCDD) from the Toxic Organic Micro-Pollutants Monitoring Network (TOMPs) which is funded by the Environment Agency on behalf of the Department for Environment, Food and Rural Affairs (Defra) and the devolved governments.

In 2025, 7 PCBs congeners, 9 PBDE congeners, 3 HBCDD isomers and BDE209 were measured in each sample. 17 PCDD/F TEF rated congeners along with 4 TEF rated PCB congeners have also measured at the 2 longest running urban sites London and Manchester. The TOMPs network includes sites in London, Manchester, Hazelrigg (Lancashire), High Muffles (North Yorkshire), Auchencorth Moss (Midlothian) and Weybourne (Norfolk). In 2022 two further sites were established, Kilmakee Leisure Centre, Dunmurry (UKA00570) and Cardiff Lakeside (UKA00452). The aim of the TOMPs network, which has operated since 1991, is to provide information on the ambient levels of organic pollutants in the UK through monitoring of air concentrations at 6 sites. The results and other related scientific work are used to inform policy development on exposure to persistent organic pollutants (POPs).

The specific aims of the TOMPs programme are:

- To identify sources of a range of POPs in the UK atmosphere.
- To quantify sources that are regarded as potentially significant.
- To measure concentrations of a range of POPs in ambient air in UK cities and rural locations, in order to assess both human exposure and the relationship between source emissions and levels in the ambient atmosphere.

The ability of certain POPs to undergo long range atmospheric transport (LRAT) has resulted in the negotiation of protocols for their reduction or elimination, and to reduce the risks to regional and global environments. These include the 1998 United Nations Economic Commission for Europe (UN/ECE) Protocol on Persistent Organic Pollutants made under the Convention on Long-

Range Transboundary Air Pollution, and the Stockholm Convention (SC) on POPs. The UK is a signatory to both these instruments and therefore has an on-going requirement to assess the extent of the presence of the listed POPs in the UK environment. Further to this, the European Commission ratified the Stockholm Convention in 2004 and adopted the POPs regulation 850/2004 in order to ensure compliance with both the Stockholm Convention as well as the UN/ECE POPs protocol. The provision of long-term environmental monitoring data, such as that provided by TOMPs, is an important component of the UK's obligations under these agreements.

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2 Introduction

Lancaster University (LU) has been involved in the TOMPs programme since its inception in 1990. LU currently manages the programme on behalf of the Environment Agency, Defra and the devolved governments and operates 8 air monitoring sites, 4 urban background and 4 rural background. The current contract commenced in October 2021 and runs until September 2026. Atmospheric sampling is carried out at each site, collecting a biweekly sample which is bulked to provide quarterly data. These data are reported to Defra and published on the [UK Air](#) website. They are also available on the [Stockholm Convention Global Monitoring Plan](#) website. 2 sites are currently maintained via sub-contracts; Auchencorth Moss by the UK Centre for Ecology and Hydrology (CEH) and the Weybourne Observatory by the University of East Anglia. Quantification of the analytes has been carried out at [Research Centre for Toxic Compounds in the Environment \(Recetox\)](#) in the Czech Republic.

This annual report includes:

- Information on PCDDs, PCDFs, PCBs, PBDEs (inc. decaBDE) and HBCDD.
- A summary of network operations including details of monitoring sites, equipment employed, details of site installations/removals, site calibration visits and equipment servicing and breakdowns.
- A summary of the analytical procedure used to detect PCBs, PCDDs/PCDFs, PBDEs and HBCDD.
- Review of annual mean and quarterly concentrations.
- Trends in estimated sources of PCBs, PCDDs/PCDFs and PBDEs in the UK.

3 Background to PCBs, PCDDs and PCDFs, PBDEs and HBCDD.

PCBs were first synthesized in 1881 by Schmidt and Schulz but their commercial production only began in 1929 in USA (*Danse et al.*, 1997). They were marketed as mixed products under various trade names depending on the country where they were produced such as Aroclor (Monosanto, USA), Phenochlor and Clophen (Bayer, EU). Because of high chemical and thermal stability, electrical resistance, low or no flammability, PCBs had extensive applications. They have been used as dielectric fluids in capacitors and transformers, in plasticizers, adhesives, inks, sealants and surface coatings (*Eduljee*, 1988; *de Voogt and Brinkman*, 1989; *Harrad et al.*, 1994). Their basic structure is a biphenyl backbone with 1 to 10 chlorine substituents and a general structure of $C_{12}H_{10-n}Cl_n$ ($n=1-10$).

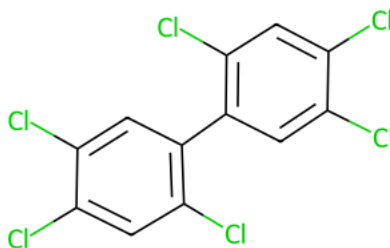


Figure 1 – PCB basic structure (example PCB-153)

There are 209 possible congeners with 1 to 10 chlorines atoms attached to the biphenyl structure. International Council for the Exploration of the Seas (ICES) identified 7 key PCB congeners which are commonly reported in environmental samples. These are PCB 28 (2,4,4'-triPCB), PCB 52 (2,2',5,5'-tetraCB), PCB 101 (2,2',4,5,5'-pentaCB), PCB 118 (2,3',4,4',5-heptaCB), PCB 138 (2,2',3,4,4',5-heptaCB), PCB 153 (2,2',4,4',5,5'-heptaCB), PCB 180 (2,2',3,4,4',5,5'-heptaCB), although several dozen different congeners can be found in the environment.

Production of PCBs peaked in the 1960s in Europe and USA and terminated in the mid 1970s, when they were ultimately banned in the late 1970s to early 1980s (*de Voogt and Brinkman*, 1989). The last inventory of PCB production estimates the cumulative global production of PCBs at 1.3 million tonnes (*Breivik et al.*, 2002). Approximately 97% of this has been used in the Northern

Hemisphere, mostly between 30 °N and 60 °N (Breivik *et al.*, 2002). Before the ban, PCBs had entered the environment through point and diffusive sources such as landfill sites, accidental releases/spillages via leaking during commercial use of electrical equipment and transformer and capacitor fires, incineration of PCB waste etc. (de Voogt and Brinkman, 1989; Danse *et al.*, 1997). Current atmospheric levels of PCBs in the environment can be accounted by on-going primary anthropogenic emissions (for example the accidental release of products or materials containing PCBs), volatilization from environmental reservoirs which have previously received PCBs (e.g. oceans and soil) or incidental formation of some congeners during combustion processes (Breivik *et al.*, 2002). The National Atmospheric Emission inventory estimates that the emission of PCBs to the UK atmosphere in 2023 was 319 kg, the majority emitted from electrical equipment such as capacitors and transformers. PCBs were added to Annex A and C of the Stockholm Convention when it entered into force in 2004.

PCDD/Fs. Polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) enter the environment from various combustion processes and as impurities from the manufacture and use of various chlorinated compounds. Considerable effort has been expended in the UK and elsewhere to try and quantify and rank these sources and their emissions into the environment, principally the atmosphere, so that cost-effective source reduction measures can be taken. Dioxin levels in the environment have been declining since the early seventies and have been the subject of a number of regulations and clean-up actions; however, current exposures levels still remain a concern. PCDDs and PCDFs were added to Annex C of the Stockholm Convention when it entered into force in 2004. The NAEI inventory estimates that the emission of PCDD/Fs to the UK atmosphere in 2023 was 101 g-TEQ (most recent data), the majority emitted from combustion processes.

In all, there are 75 possible PCDDs and 135 possible PCDFs. However, importantly, the compounds containing 0, 1, 2, or 3 chlorine atoms are thought to be of no toxicological significance and of those containing 4 to 8 chlorine atoms, those that are toxic have chlorine atoms at each of the positions 2, 3, 7 and 8. Once all four of these positions are occupied by chlorine atoms the presence of additional chlorine atoms generally progressively reduces the toxicity of the congeners. The relative toxicity of the 17 toxicologically important PCDD and PCDF congeners

is defined in a number of toxicity equivalency schemes which can be used to provide an assessment of the relative toxicities of each congener and an estimate of the overall toxicity of a mixture.

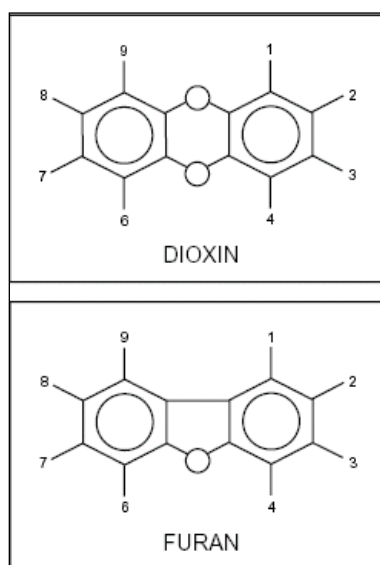


Figure 2 – PCDD and PCDF Basic Structure

The Toxicity Equivalency Factor (TEF) values have been subject to revision and amendment since their inception but the most widely accepted set of TEF values for the 2,3,7,8-substituted PCDD/Fs is the ‘WHO’ (WHO-TEF) system, originally developed in 1990s and last updated in 2005. Another commonly used scheme is the International Toxicity Equivalency Scheme (I-TEQ) which has assigned slightly different TEFs to the WHO schemes. The 3 TEF schemes data are contained in the table below. For consistency the 1998 scheme has been used by the TOMPs network throughout for the assessment of long-term trends, but also converted to I-TEF for comparison with the source inventories. There is evidence to suggest that several of the PCBs elicit similar toxic responses to the dioxins, based on their binding to an intercellular protein, the Ah-receptor. These selected PCBs have therefore also been ascribed TEF values which have been endorsed by the UK Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT). These are also listed in Table 1.

Table 1 - Toxic Equivalency schemes for PCDDs, PCDFs and co-planar PCBs

PCDD/F compound	WHO-1998	WHO-2005	I-TEF
2,3,7,8-TCDD	1	1	1
1,2,3,7,8-PeCDD	1	1	0.5
1,2,3,4,7,8-HxCDD	0.1	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01	0.01
OCDD	0.0001	0.0003	0.001
2,3,7,8-TCDF	0.1	0.1	0.1
1,2,3,7,8-PeCDF	0.05	0.03	0.05
2,3,4,7,8-PeCDF	0.5	0.3	0.5
1,2,3,4,7,8-HxCDF	0.1	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01	0.001
OCDF	0.0001	0.0003	0.0001
PCBs	WHO-1998	WHO-2005	I-TEF
PCB-77	0.0001	0.0001	0.5
PCB-81	0.0001	0.0003	0.1
PCB-126	0.1	0.1	0.1
PCB-169	0.01	0.03	0.1

PBDEs. Polybrominated diphenyl ethers were widely used as additive flame retardants in products such as furniture, cars, textiles, paints, electronic equipment and plastics to reduce fire risk. They are referred to as additive flame retardants because they were simply blended with the product. This makes them more prone to volatilize into the atmosphere during the product lifetime and waste processing/recycling. They reduced fire hazards by interfering with the combustion of the polymeric materials (BSEF, 2000; Commission of the European Communities, 2000). Their general structure is $C_{12}H_{10-n}Br_nO$ ($n=1-10$). Therefore, there are 209 possible PBDE congeners, depending on the position of the bromine atoms on the phenyls rings. 3 different types of commercial PBDE formulation have been produced with different degrees of bromination namely penta-, octa- and deca-BDE products. The penta-BDE product contains a range from tetra to hexa-BDE congeners, the octa-BDE contains a mixture of hexa- to deca-BDE and the deca contains

predominantly the BDE-209 congener and is currently the most widely used PBDE flame retardant product.

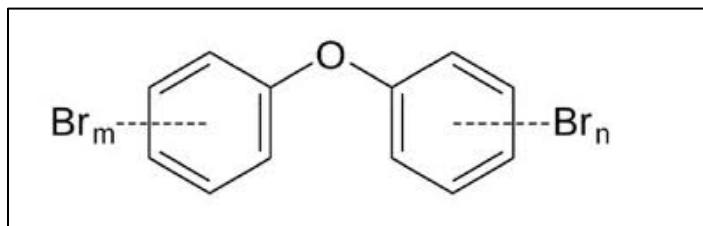


Figure 3 – PBDE Basic Structure

The global demand for PBDEs has previously been very substantial with a peak estimation of 70,000 tonnes for the year 2003 (Hites *et al.*, 2004). Of these technical mixtures, the commercial pentabromodiphenyl ether (PeBDE) and commercial octabromodiphenyl ether (OctaBDE) mixtures have been banned in the EU and Japan and were added in 2009 to Annex A of the Stockholm Convention during the 4th Conference of Parties (COP).

In the UK there has been previously high use of PBDE as a result of particularly stringent fire retardancy regulations for furniture. Lower brominated PBDEs can also be formed from the degradation of higher brominated BDEs although the environmental importance of this process is still unclear. PBDE congeners have been included in the TOMPs methodology since Q4 2010. The main congeners that have been analysed are: PBDEs 28 (tri), 47 (tetra), 66 (tetra), 99 (penta), 85 (penta), 100 (penta), 153 (hexa), 154 (hexa), 183 (hepta). Congeners BDE-47 and BDE-99 are considered key congeners as they account for approximately 72% of the composition of the penta commercial mixture (pentaBDE). The NAEI provides emissions data from the use of the penta- and octa- product mixtures suggesting a rapid decrease in emission from 1990 with zero emissions from 2013.

BDE209 (decabromodiphenyl ether) was added to the analyte suite in 2017. In the UK decaBDE was used primarily in hard plastics (e.g. electrical equipment housings) and flame retardant-backed textiles (most commonly used as curtain fabrics). BDE209 (decaBDE) was added to Annex A of the Stockholm Convention in 2017. On-going sources to the environment include emissions from products still in use, e.g. pre-treated textiles, high impact polystyrene (HIPS) and thermoplastics.

UK emission estimates for 2012 provided by Earnshaw *et al.* (2013) suggest that atmospheric emissions of decaBDE were approximately 180kg per annum, whilst emissions to soil and water are approximately 370kg and 12kg per annum, respectively. The NAEI suggests that emissions of BDE209 have decreased from 3424 kg in 1990 to 771 kg in 2024.

HBCDD is a brominated flame retardant which has to date been extensively used across the EU within expandable polystyrene (EPS) and extruded polystyrene (XPS) insulation boarding used within roof and cavity wall insulation. HBCDD also has a more limited application (around 1% of total HBCDD use) as a flame retardant for use in high impact polystyrene (HIPS) used for mouldings and housings of electrical goods such as computer monitors, and CRT based televisions. It was first used in the UK in 1975 with a steady increase in use from that time. Although UK production of HBCDD ceased in 2003, imports from the sole producer in Europe continued to supply the increasing demand. Based on VECAP data peak consumption of HBCDD was reached in Europe (including the UK) in 2008 at around 12,000 tonnes of which around 1,670 tonnes were used in the UK (based on extrapolation using GDP). Concerns of human health and environmental effects meant that HBCDD was added to Annex A of the Stockholm Convention in 2013 at the fifth Conference of the Parties with specific exemptions included to make allowances for ongoing processes under the EU REACH regulation. In 2016 a time-limited authorisation was given to 13 companies for 2 specific applications for use as a flame retardant in expanded polystyrene boarding and use as a flame retardant in the manufacture of expanded polystyrene beads. This Authorisation expired in August 2017 after which no further legal use of HBCDD was permitted in the EU. Data from Broomfield *et al.* (2010) and the REACH Annex XV dossier for HBCDD highlight that principal use (90%) was within insulation boarding with a split of 52% in extruded polystyrene insulation boards (XPS) and 48% in expanded polystyrene insulation boards (EPS). Concentrations of HBCDD were generally low at 0.5-1.0% w/w for XPS and 0.8-2.5% for EPS, although this suggests that there is a potentially large bank of articles containing HBCDD

4 TOMPs sites operating in 2025

In 2025 the TOMPs programme operated 8 sites:

Table 2 – Site List

UK – AIR SITE NAME	UK-AIR CODE	Site type and history
London (LON – Nobel House)	UKA00532	urban background site established in 1991. Sampling stopped 5 February 2025
London (LON – Seacole Building House)	UKA01057	urban background site established in 2025. Sampling commenced. 5 February 2025
Manchester (MAN)	UKA00185	urban background site established in 1991
Hazelrigg (HR)	UKA00507	rural background established in 1992
High Muffles (North Yorkshire) (HM)	UKA00169	rural background established in 1999
Auchencorth Moss (AUCH)	UKA00451	rural background established in 2008
Weybourne (WEY)	UKA00433	rural background established at the end of 2008
Kilmakee Leisure Centre, Dunmurry (KLCCC)	UKA00570	urban background site established in 2022
Cardiff, Lakeside (CAR)	UKA00452	urban background site established in 2022

The sites consist of 4 urban locations in London (LON), Manchester (MAN), Kilmakee Leisure Centre, Dunmurry (KLCCC), Lakeside primary school, Cardiff (CAR), 3 rural sites at High Muffles (HM, North Yorkshire), Auchencorth Moss (AUCH, Mid Lothian) and Weybourne (WEY, Norfolk), 1 semirural site at Hazelrigg (HR, Lancashire). At the rural and semirural sites, samplers are located away from major roads, whereas at the urban sites samplers are located in the city centre on the roof of a building. The locations of the current samplers in the network are shown in Figure 4.

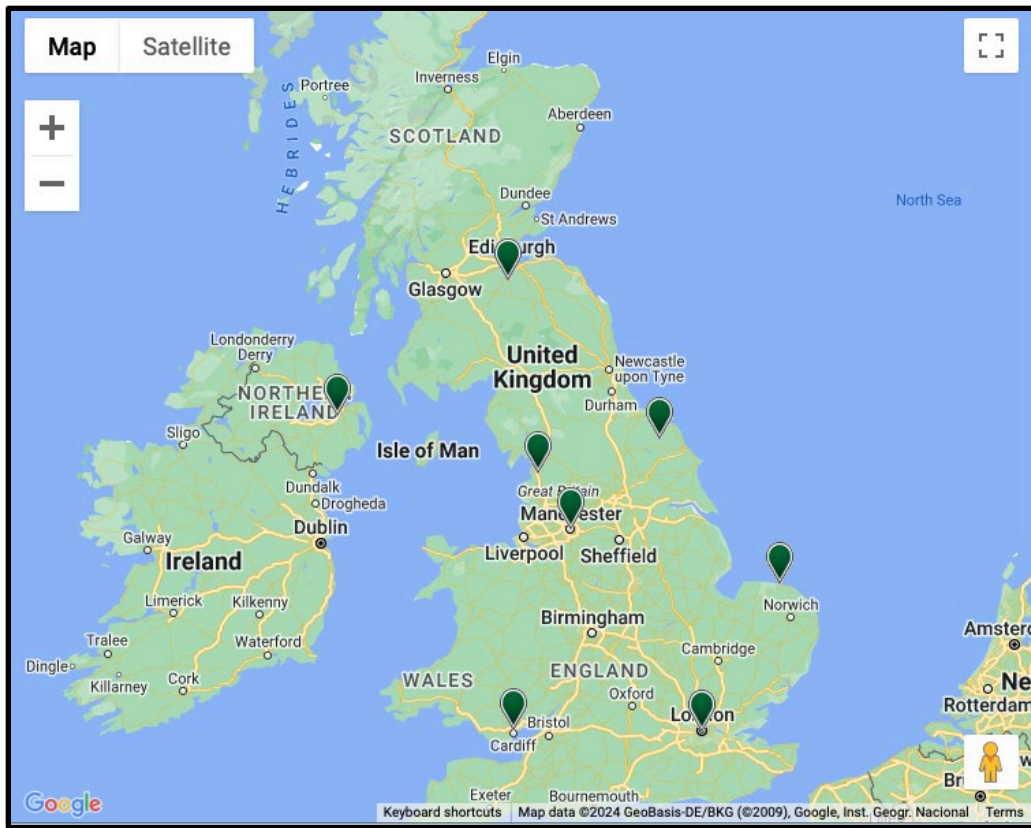


Figure 4 - Location map of the current TOMP sites

5 Network sampling operations

The majority of sampling modules for the Analytica Airflow samplers are prepared at Lancaster University just prior to deployment which involves disassembling, inspecting and cleaning the modules. Modules are stored frozen in sealed bags prior to deployment. All parts of the modules that come into contact with the glass fibre filter (GF/A Whatman) and polyurethane plugs (PUFs, Klaus Ziemer GmbH Langerwehe, Germany) are routinely solvent cleaned between each sample. In addition, the modules are fully disassembled, and all parts thoroughly cleaned in solvent. The GF/As are pre-cleaned by baking out in a muffle furnace at 450 °C for 24 hours. They are then transferred to aluminium foil packages (the aluminium foil has also been baked out) and stored sealed until they are used. Pre-cleaned PUFs and GF/As filters are regularly sent to UKCEH in Edinburgh who manage the Auchencorth Moss site and University of East Anglia who manage the Weybourne site. The PUFs are prepared for all the sites from the same batches, by a rigorous pre-extraction procedure. This involved rinsing in water, drying and Soxhlet extraction in acetone/hexane (1:1), with subsequent solvent removal in a solvent cleaned desiccator, maintained under vacuum. PUFs are also prepared to serve as field and laboratory blanks. The GF/As and PUFs are placed in the sampling modules using solvent cleaned stainless steel tongs and are exposed to the laboratory environment for the minimum amount of time possible.

The modules are changed every 14 days at all sites. Each sampler is programmed to collect 1000 m³ at a flow rate of 120 L/min over that period. This usually takes 7 days and is programmed to occur during the 14 day window. The airflow is electronically controlled, and sample information and temperature data are continuously recorded. The data is stored locally and offloaded onto a USB periodically for long term storage. Preventative maintenance checks are also carried out when necessary. Sample information after each visit is also recorded on a GoogleSheet, along with any observations that need to be communicated to the network manager. During each visit, the sampler, sampler platform and auxiliary pieces of equipment are checked for corrosion or breakages. A number of spare parts are routinely taken to each site and preventative or remedial maintenance carried out when necessary. Long life brushless motors are used to minimise samples lost through motor failures. A sampler calibration is performed once a year at each site using a BGI HiVolCal air flow calibrator (Mesa Labs, USA) and field blanks are routinely collected.

6 Extraction and clean-up procedures

The 2025 samples were analysed by the Trace Analytical Laboratory, Recetox, which is part of Masaryk University in the Czech Republic. The method is accredited to ČSN EN ISO/IEC 17025.

All samples are spiked with surrogate internal standards before extraction: ^{13}C -labelled BDEs (28, 47, 99, 100, 153, 154, 183 and 209), ^{13}C - γ -HBCDD, ^{13}C -dl-PCBs (77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, and 189), ^{13}C -PCDD/F homologues, all obtained from Wellington Laboratories Inc., Canada, and ^{13}C -ind-PCBs (28, 52, 101, 138, 153 and 180) and ^{13}C -OCPs (PeCB, HCB, p,p'-DDT, p,p'-DDD, p,p'-DDE, β -HCH and γ -HCH), obtained from Cambridge Isotope Laboratories, MA, USA.

Each sample (combined PUFs and filters) is Soxhlet-extracted (Büchi B-811, Switzerland) in dichloromethane (DCM) and toluene, respectively. Samples across quarters are then combined before clean-up to obtain quarterly data (Jan-March (Q1), April-June (Q2), July-Sept (Q3), and Oct-Dec (Q4)). Quarters contain between 6 or 7 samples (depending on the length of each quarter). DCM extracts were used whole for analysis of indicator polychlorinated biphenyls (ind-PCBs PCB 28, 52, 101, 138, 153, 180, 209), organochlorine pesticides (OCPs) and polybrominated diphenyl ethers (PBDEs BDE 28, 47, 66, 99, 85, 100, 153, 154, 183 and 209). Toluene extracts were split into three aliquots: 60% for the analysis of dioxins (PCDD/Fs) and dioxin-like polychlorinated biphenyls (dl-PCBs), 20% for the analysis of HBCDs and 20% was archived.

Clean-up of DCM extracts (ind-PCBs, OCPs and PBDEs)

Each DCM extract for ind-PCBs, OCPs and PBDEs analysis was cleaned on sulfuric acid modified silica column with anhydrous Na_2SO_4 , eluted with 40 mL of a 1:1 mixture of *n*-hexane:DCM. The eluate volume was reduced to 1 mL by a stream of nitrogen gas in a TurboVap II (Caliper LifeSciences, USA) concentrator unit and transferred into a GC vial. All eluates were further reduced to 50 μL in a LabEva concentrator (HPST, Czech Republic). ^{13}C -PCB 95, ^{13}C -BDE 77 and ^{13}C -BDE 138 were then added as a syringe (recovery) standards prior to instrumental analysis of ind-PCBs and PBDEs, respectively.

Clean-up and fractionation of toluene extracts (PCDD/Fs, dl-PCBs and HBCDs)

Each toluene extract aliquot (60%) for PCDD/F and dl-PCB analysis was cleaned using multi-layer silica column (H₂SO₄ silica, KOH silica, Na₂SO₄, AgNO₃) and fractionated using a column containing AX-21 active carbon mixed with Celite 545 (1:19, w/w) to obtain three fractions: F1 – cyclohexane:dichloromethane:methanol (2:2:1 v/v) – containing multi-ortho PBDEs, indicator PCBs (F1 was discarded as these analytes are reported for the DCM extract), F2 – toluene – containing all dl-PCBs, mono/non-ortho PBDEs and F3 – reverse-flow toluene – containing PCDD/Fs. F2 and F3 were solvent reduced and quantitatively transferred to 1.2 mL conical vials, solvent exchanged to nonane and analysed for dl-PCBs and PCDDs/Fs. ¹³C PCB 162 was used as syringe standard for dl-PCBs, ¹³C 1, 2, 3, 4-TCDD was used as syringe standard for PCDDs/Fs.

Each toluene extract aliquot (20%) for HBCDs analysis was cleaned using a sulfuric acid modified silica column with anhydrous Na₂SO₄, eluted with 40 mL of a 1:1 mixture of *n*-hexane:DCM. The eluate volume was reduced to 1 mL by a stream of nitrogen gas in a SuperVap (FMS, USA) concentrator unit and transferred into a GC vial. All eluates were evaporated to dryness in a LabEva concentrator (HPST, Czech Republic). Samples were then reconstituted with 50 µL of 5% acetone in acetonitrile.

Instrumental Analysis

Indicator PCBs and OCPs (DDT, DDE, DDD, HCHs, PeCB, HCB)

Each sample was analyzed for ind-PCBs and OCPs by gas chromatography tandem mass spectrometry (GC-MS/MS) using an Agilent 8890A GC (Agilent, USA) equipped with a 60 m x 0.25 mm x 0.25 µm Rxi-5Sil-MS column (Restek, FR), coupled to an Agilent 7000D triple quadrupole MS operating in positive electron ionization (EI+) multiple reaction monitoring (MRM) mode. Samples were splitless injected at 280°C, with He as the carrier gas at a constant flow of 1.5 mL/min. The GC temperature program was 80 °C (1 min hold), ramp 40 °C/min to 200°C (18 min hold), and final ramp 5 °C/min to 305°C (no hold). The carrier gas was helium with a constant flow rate of 1.5 mL/min. The temperature of the GC-MS transfer line was 310 °C. Ion source was heated to 280 °C. Compound quantification was done with MassHunter Workstation 10.1 software.

PBDEs

Extracts were then analyzed for PBDEs by gas chromatography high-resolution mass spectrometry (GC-HRMS) using an Agilent 7890A GC equipped with a 15 m x 0.25 mm x 0.10 μ m RTX-1614 column (Restek, USA), coupled to a Waters AutoSpec Premier MS (Waters, UK) operating in EI+ selected ion monitoring (SIM) mode at a resolution of >10,000 and 35 eV electron energy; for BDE 209, the resolution was set to >5,000. Samples were splitless injected at 280 °C, with He as the carrier gas at a constant flow of 1 mL/min. The GC temperature program was 80 °C (1 min hold), ramp 20 °C/min to 250 °C, ramp 1.5 °C/min to 260 °C (2 min hold), and final ramp 25 °C/min to 320°C (4.5 min hold). Waters TargetLynx was used for data processing.

Gas chromatography atmospheric chemical ionization tandem mass spectrometry (GC-APCI-MS/MS) is used for PBDEs analysis. The GC (Agilent 7890A, Agilent, USA) is fitted with a 15m x 0.25 mm x 0.10 μ m RTX-1614 column (Restek, USA). Injection was splitless 1 μ L at 280°C, with He as carrier gas at 1.5 mL/min. The GC temperature programme was 80°C (1 min hold), then 20°C/min to 250°C, followed by 1.5°C/min to 260°C (2 min hold) and 25°C/min to 325°C (5 min hold). The MS (Xevo TQ-S, TQ-XS or TQ-Absolute; Waters, UK) is operated in MRM mode under dry source conditions.

HBCDD

Extracts are analyzed for HBCDD by high performance liquid chromatography mass spectrometry (HPLC-MS) using an Agilent 1290 Infinity HPLC equipped with a Phenomenex LUNA C18 end-capped column (100 $\times$ 2 mm, 3 μ m particle size) maintained at 30 °C and a Phenomenex SecureGuard C18 pre-column, coupled to a tandem AB Sciex QTRAP 5500+ MS (AB Sciex, Canada) operating in ESI- MRM mode at 450°C, with N₂ as a nebulizer gas and an entrance potential of -4kV. The mobile phases for the gradient separation were a 1 mM solution of ammonium acetate in water at pH 4 (solution A) and a 1 mM solution of ammonium acetate in acetonitrile (solution B). The flow rate is 0.25 mL/min, and the injection volume was 10 μ L. The linear gradient began at an initial A/B composition of 50:50 (v/v) and ran to 10:90 over 3 min, where it was held for 4 min. Sciex OS is used for data processing.

PCDD/Fs and dioxin-like PCBs (dl-PCBs)

Each toluene extract for PCDD/Fs and dl-PCBs is analyzed by 2xGC-HRMS using dual Thermo Scientific TRACE 1310 GCs (Thermo Fisher Scientific, USA) equipped with a 60 m × 0.25 mm × 0.25 μm Restek Rtx-Dioxin2 column (for PCDD/Fs) and a 60 m × 0.25 mm × 0.25 μm SGE HT8 column (for dl-PCBs), coupled to a Thermo Scientific DFS HRMS operating at a resolution of 10,000 (10% valley) and 45 eV electron energy. PCDD/F samples were splitless injected at 280 °C and dl-PCB samples were splitless injected at 260 °C, with He used as the carrier gas for both at a constant flow of 1.5 mL/min. The GC temperature program for PCDD/Fs was 120 °C (1.5 min hold), ramp 30 °C/min to 200 °C, ramp 3 °C/min to 300 °C (2.5 min hold), and final ramp 30 °C/min to 320 °C (20 min hold). The GC temperature program for dl-PCBs was 120 °C (1.5 min hold), ramp 30 °C/min to 200 °C, and final ramp 3 °C/min to 310 °C (10 min hold). Thermo Scientific TargetQuan 3 was used for data processing.

Samples are analyzed using (GC-APCI-MS/MS) using an Agilent 8890 GC equipped with a 60 m x 0.25 mm x 0.20 μm ZB-Dioxin column (Phenomenex, USA), coupled to a Waters Xevo TQ-Absolute or TQ-XS MS operating under dry source conditions in MRM mode. For PCDDs/Fs analysis samples were splitless injected at 290 °C, with He as the carrier gas at a constant flow of 1.4 mL/min. The GC temperature program was 120 °C (1.5 min hold), ramp 40 °C/min to 220 °C, ramp 1.5 °C/min to 235 °C (1 min hold), ramp 2.5 °C/min to 290 °C and final ramp 20 °C/min to 325 °C (10 min hold). For dl-PCBs analysis samples were splitless injected at 290 °C, with He as the carrier gas at a constant flow of 1.4 mL/min. The GC temperature program was 120 °C (1.5 min hold), ramp 50 °C/min to 210 °C, ramp 7 °C/min to 240 °C, ramp 2 °C/min to 290 °C and final ramp 30 °C/min to 325 °C (10 min hold).

7 Data storage

The data are reported to Defra and published on the [UK Air](#) quality data website and made also available on the [Stockholm Convention Global Monitoring Plan](#) website. As this was the first year that Recetox provided HBCDD data, in addition to all of the other analytes, an archive sample was not retained.

8 Results for year 2025

Network Operations

Table 3 contains information on the samples collected, including, bulked air volume (in m³) and the number of samples bulked for each site for each quarter in 2025. The bulked air volume is obtained by summing the volume (in m³) obtained from each sample taken during the quarter (usually 6-7 samples depending on the sampling schedule). Total volume per quarter (bulk volume) under normal operating conditions ranges from 6000 to 7000 m³. Sampling activity at High Muffles has been reduced to 1000 m³ per quarter.

London (LON), Manchester (MAN), Hazelrigg (HR), High Muffles (HM), Auchencorth (AC), Weybourne (WEY), Kilmakee (KLCCC) and Cardiff (CAR) operated normally with sampling rates at 100% (26 samples, 1000 m³ each) over the year.

Quarterly samples for LON and MAN were analysed for PCDD/Fs, PCBs, PBDEs, decaBDE. Quarterly samples for HR, AUCH, WEY, KLCCC, CAR were analysed for PCBs, PBDEs, decaBDE and HBCDD.

Table 3 - Summary of the start and finish dates, data capture rates and bulked air volumes in each quarter in 2025.

Site	Quarter	Start	Finish	% Data capture	Volume m ³
LONDON	Q1	07/01/2025	31/03/2025	100	6000
LONDON	Q2	03/04/2025	16/06/2025	100	6000
LONDON	Q3	24/06/2025	27/09/2025	100	7000
LONDON	Q4	29/09/2025	30/12/2025	100	7000
MANCHESTER	Q1	30/12/2024	25/03/2025	100	6000
MANCHESTER	Q2	27/03/2025	22/06/2025	100	6000
MANCHESTER	Q3	25/06/2025	01/10/2025	100	7000
MANCHESTER	Q4	01/10/2025	20/12/2025	100	6000
HAZELRIGG	Q1	08/01/2025	31/03/2025	100	6000
HAZELRIGG	Q2	02/04/2025	23/06/2025	100	6000
HAZELRIGG	Q3	25/06/2025	29/09/2025	100	7000
HAZELRIGG	Q4	03/10/2025	05/01/2026	100	7000
HIGH MUFFLES	Q1	27/03/2025	03/04/2025	100	1000
HIGH MUFFLES	Q2	26/06/2025	03/07/2025	100	1000
HIGH MUFFLES	Q3	24/10/2025	31/10/2025	100	1000
HIGH MUFFLES	Q4	19/12/2025	27/12/2025	100	1000
AUCHENCORTH MOSS	Q1	26/12/2024	02/04/2025	100	7000
AUCHENCORTH MOSS	Q2	02/04/2025	25/06/2025	100	6000
AUCHENCORTH MOSS	Q3	25/06/2025	01/10/2025	100	7000
AUCHENCORTH MOSS	Q4	08/10/2025	24/12/2025	100	6000
WEYBOURNE	Q1	02/01/2025	04/04/2025	100	6000
WEYBOURNE	Q2	02/04/2025	25/06/2025	100	6000
WEYBOURNE	Q3	01/07/2025	06/10/2025	100	7000
WEYBOURNE	Q4	29/10/2025	01/01/2026	100	6000
KILMAKEE	Q1	02/01/2025	02/04/2025	100	7000
KILMAKEE	Q2	02/04/2025	25/06/2025	100	6000
KILMAKEE	Q3	25/06/2025	01/10/2025	100	7000
KILMAKEE	Q4	01/10/2025	07/01/2026	100	7000
CARDIFF	Q1	23/12/2025	02/04/2025	100	7000
CARDIFF	Q2	05/04/2025	28/06/2025	100	6000
CARDIFF	Q3	25/06/2025	01/10/2025	100	7000
CARDIFF	Q4	01/10/2025	07/01/2026	100	7000

PCDD/Fs: Results and discussion

Quarterly PCDD/F data are reported for London and Manchester only and are contained in Appendix 1 and a summary presented in Figure 5. The annual mean PCDD/Fs concentrations measured in 2025 ranged from 7.8 to 15.7 fg TEQ/m³ and are similar to those we have reported for last 10 years, with the highest concentration observed at Manchester 24.4 fg TEQ/m³. The seasonal pattern, as shown by the quarterly data, shows that the highest concentrations were generally measured in quarters Q1 and Q4 with lower values reported for quarters 2 and 3.

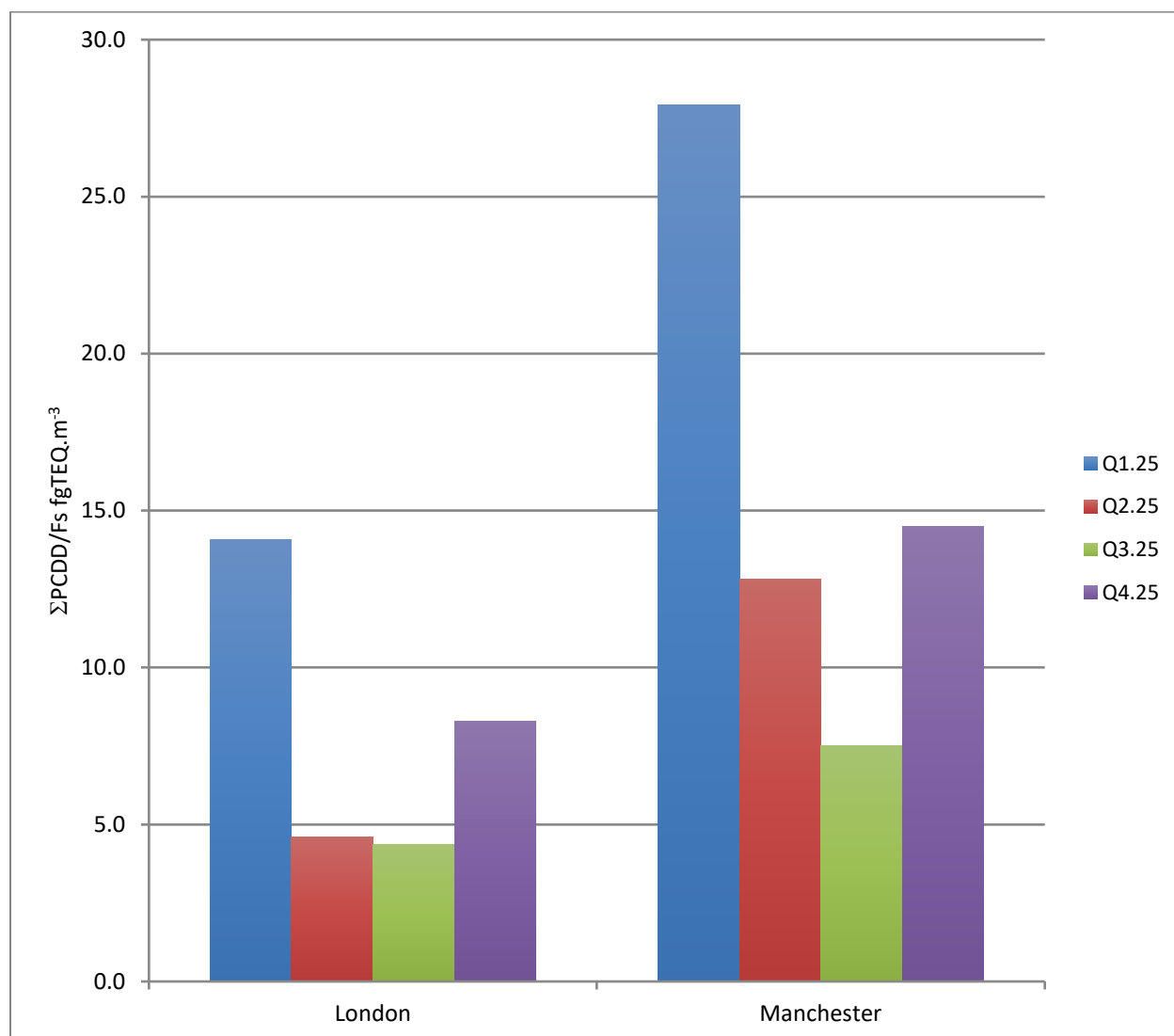


Figure 5 - Quarterly PCDD/F data for London and Manchester TOMPs site in 2025.

PCDD/Fs constitute 2 classes of chemicals that are formed unintentionally during combustion (e.g. waste incineration, burning of coal, wood etc.), iron and steel production (also combustion), several metal treatment processes and transport. The contribution from waste incineration has reduced in importance over time. The observed seasonality of PCDD/Fs in air, where winter values exceed summer values, has been seen in the TOMPs dataset and is widely reported in the literature, for example, Coutinho *et al.* (2007) reported average summer/winter ratios of 1:3 for sites in Portugal. Increased combustion (i.e., domestic space heating) and seasonal variations in the atmospheric boundary layer height are the likely causes. The sources of PCDD/Fs to the UK

atmosphere are presented in detail by Katsogiannis *et al.*, 2010 which discusses the TOMPs programme over a period of 17 years.

The temporal trends for the 2 urban sites are presented in Figure 6 (note unit change to I-TEQ), and the estimated atmospheric clearance rates (time taken for a 50% decline in concentration) for London and Manchester are 10.2 and 8.9 years, respectively. Data for UK PCDD/F emissions are provided by the [National Atmospheric Emission Inventory \(NAEI\)](#) over the period 1990 – 2021. During this period PCDD/F emissions reduced from around 1304 g I-TEQ per year in 1990 to 92 g I-TEQ per year in 2024.

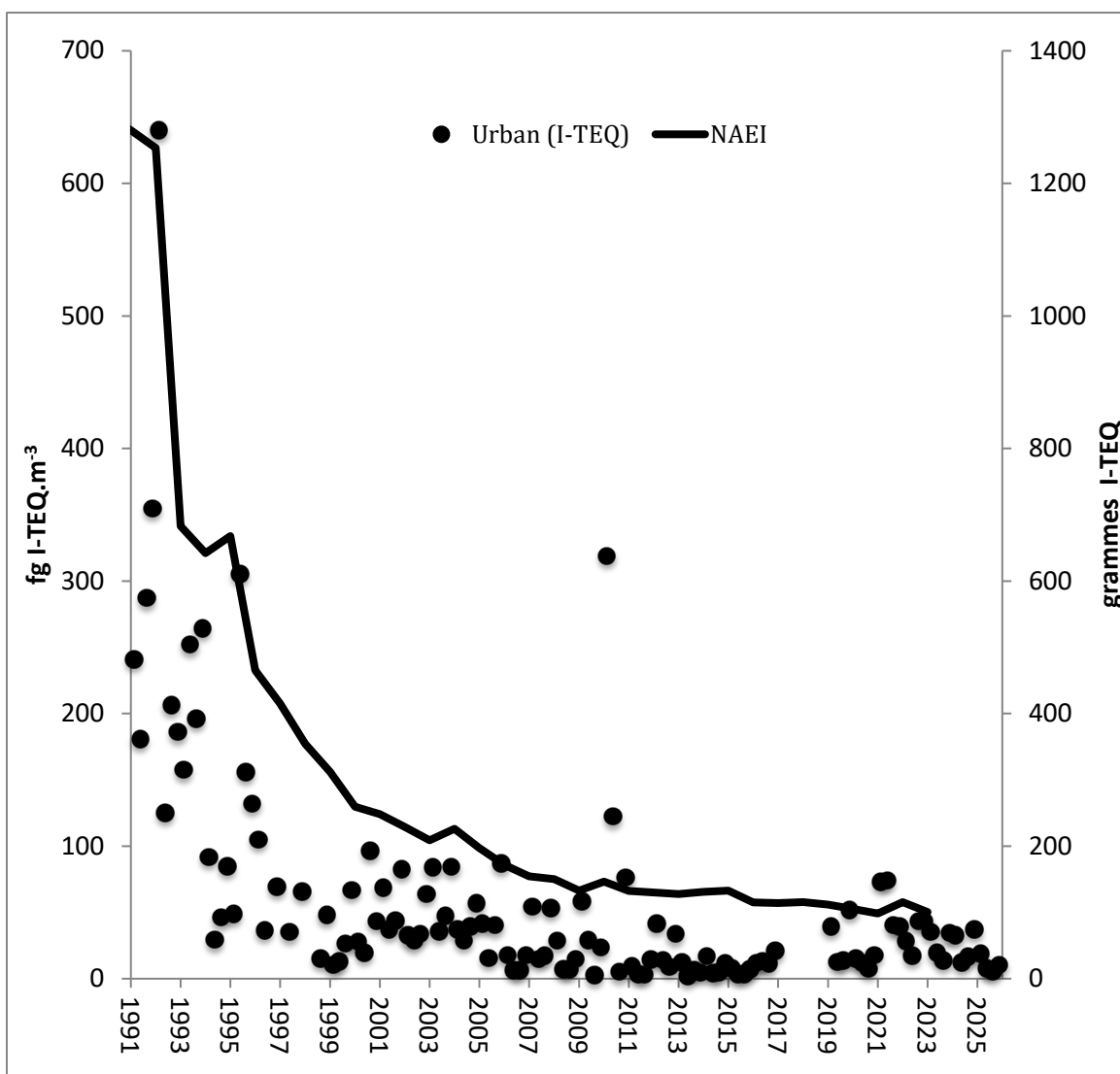


Figure 6 - Long-term PCDD/F trend data in fg I-TEQ.m-3 from the TOMPs network for the 2 urban sites (London and Manchester). Quarterly data are compared to the current NAEI estimates in g I-TEQ per annum.

PCBs: Results and discussions

Quarterly congener PCB data for the 8 TOMPs sites are contained in Appendix 2 and a summary presented in Figure 7. The annually averaged PCB concentrations measured at each of the TOMPs sites ranged from 37 pg/m³ (Manchester) to 2 pg/m³ (Auchencorth) for the sum of seven indicator PCB congeners (PCBs 28,52,101,118,138,153,180). The concentration for Σ_7 PCBs was 3.6 pg/m³ for High Muffles and has been calculated as an annual average, comprising 4 single quarterly samples. The 2 recently added urban background sites at Kilmakee and Cardiff were lower than London and Manchester, but higher than the rural background sites. The data shows, as with

previous years, that concentrations are generally proportional to the population density surrounding the site. The quarterly data showed a distinct seasonal pattern with higher levels in Q2 and Q3 which are characteristic of temperature driven diffusive sources where higher temperatures drive emissions.

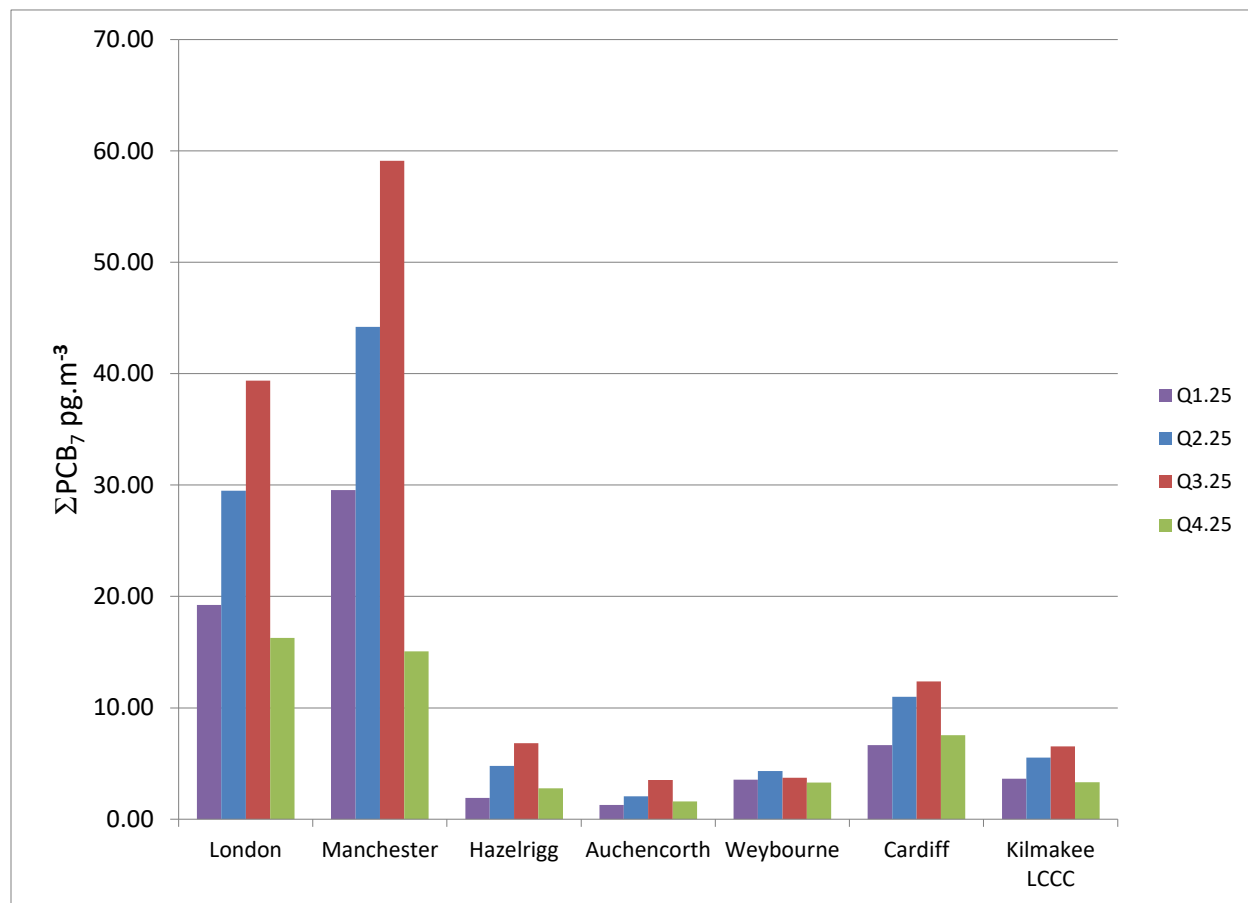


Figure 7 - Quarterly Σ PCB7 (congeners 28, 52, 101, 118, 153, 138 and 180) data at the TOMPs sites for 2025

Ambient PCB concentrations are controlled by a range of factors but primarily by proximity of sampling sites to on-going sources. These sources are generally differentiated into primary and secondary sources. Primary sources of PCBs, which are mostly diffuse, include articles or preparations to which they were added, for example, as plasticizers in plastics, sealants, paints and oils. As a result of the application pattern for PCBs in indoor environments, primary sources are mostly found in areas with high population density and hence generally remain higher in urban environments. Emissions from secondary sources describes the process of re-emission or volatilization of PCBs from environmental compartments like soil and sediments which serve as

reservoirs for persistent organic chemicals. Generally, the urban sites such as London and Manchester are still influenced by on-going diffuse primary releases of PCBs, whilst more rural sites are influenced by secondary sources and atmospheric transport. A detailed discussion of PCB sources to the UK atmosphere are discussed in detail by Graf *et al.*, 2016 which discusses the TOMPs programme since its inception in 1991. The temporal trends for the urban sites (London, Manchester) and rural sites (Hazelrigg, High Muffles, Auchencorth and Weybourne) are presented in Figure 8. These data have been plotted against the estimated UK emission data from the [NAEI](#). With the addition of the 2025 data, the clearance rates (time taken for a 50% decline in concentration) provided by the TOMPs network for urban sites averaged 7.7 years and the rural (and semi-rural) sites was 6.5 years. The data on a natural logarithmic scale used in the calculations are shown in Figure 8.

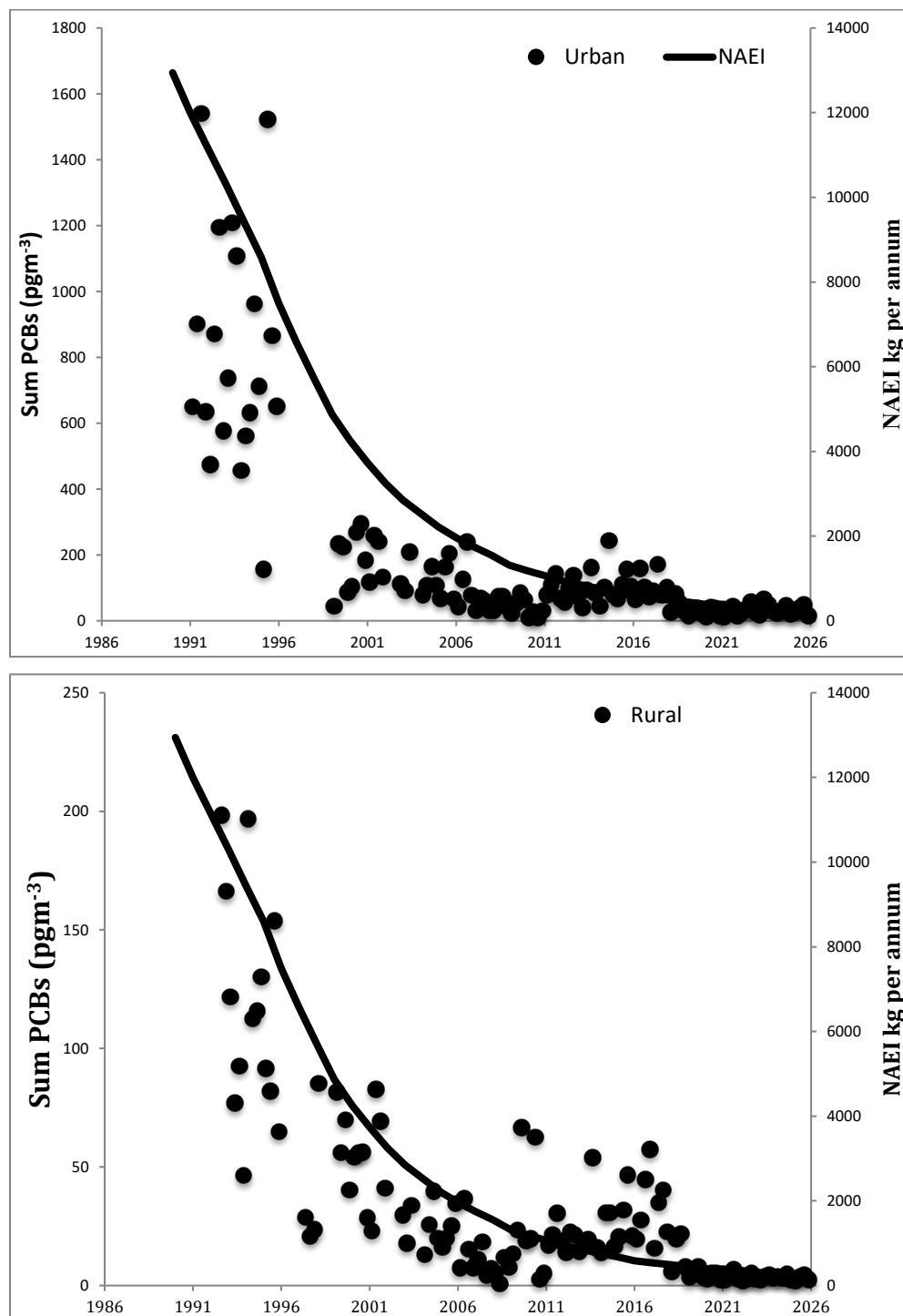


Figure 8 - Σ 7PCB Long-term PCB trend data from the TOMPs network for the urban (London and Manchester) and the rural (Hazelrigg, High Muffles, Auchencorth and Weybourne) sites. Data are presented as averages in pg m⁻³ and compared to the current NAEI estimates in kg

The NAEI suggests that emissions of PCBs to the UK atmosphere have reduced from 12943 kg in 1992 to 281 kg in 2024 (latest data). Contemporary sources include continued presence of PCBs

in dielectric fluids, power generation, small scale waste burning and sewage sludge application to land. The data in Figure 9 shows a sharp decrease in the late 1990's which is attributed to assumed significant reductions in the presence of PCBs in electrical equipment such as capacitors and transformers.

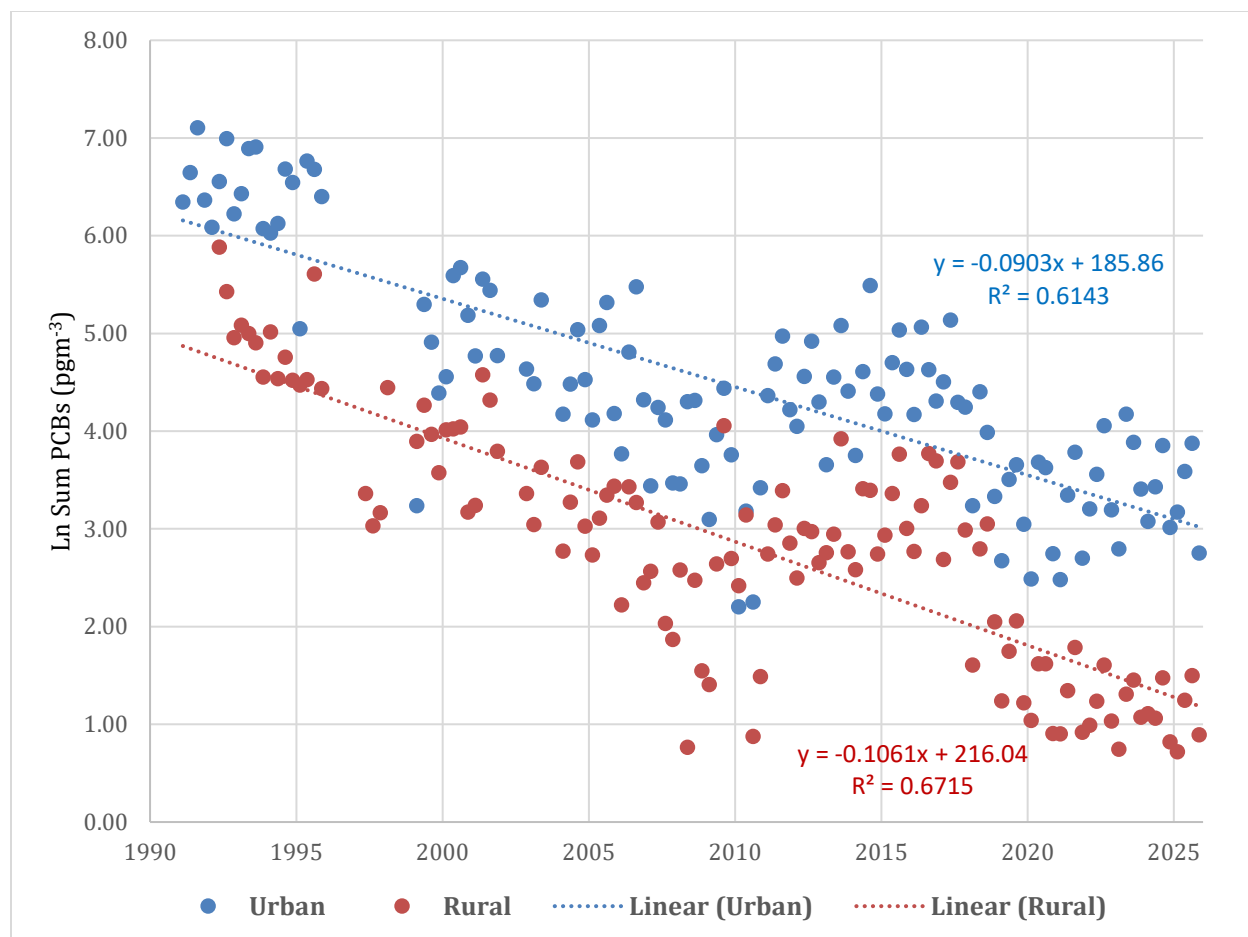


Figure 9 - Long-term PCB trend data from the TOMPs network for the urban (London and Manchester) and the rural (Hazelrigg, High Muffles, Auchencorth and Weybourne) sites. Data are presented as $\text{Ln } \sum 7\text{PCB pg m}^{-3}$ to provide decay rates.

There are few long-term POPs monitoring networks that can be compared to the TOMPs network. PCBs have been measured as part of the Integrated Atmospheric Deposition Network (IADN) since the early 1990's. IADN is joint project between the [U.S. Environmental Protection Agency and Environment Canada](#) which covers 5 ambient air monitoring sites around the Great Lakes. Using similar sampling equipment as TOMPs, the IADN network reports concentration data for 24hr samples collected every 12 days for a range of PCB congeners, organochlorine pesticides and polycyclic aromatic hydrocarbons (PAHs). PCB concentrations generally showed the slowest rate

of decline among all of the chemicals measured by IADN. The clearance rate of PCBs in the vapour phase was 14.9 ($\pm$ 1.1 years) which is longer than the clearance rates observed for the TOMPs network sites.

PBDEs: Results and discussions

Nine individual PBDE congeners have been measured and the data reported in Appendix 3. A summary of the quarterly data is shown in Figure 10. The prominent congeners in the commercial pentaBDE mix, accounting for 72% of the total were BDE47 and BDE99. These congeners have dominated the profile in past samples from the TOMPs network and in 2025 accounted for approximately 36% of the total across the sampling sites. Manchester, Cardiff and London showed the highest annual average concentrations for Σ_9 PBDEs at 2.51pg/m³, 1.96pg/m³ and 1.33 pg/m³, respectively. The other urban site at Kilmakee had an average concentration of 1.1 pg/m³. The sites at Weybourne and Auchencorth were 1.22 pg/m³ and 0.31 pg/m³, respectively. The concentration for Σ_9 PBDEs was 0.12 pg/m³ for High Muffles and has been calculated as an annual average, comprising 4 single quarterly samples. The annual average for Hazelrigg was higher than the other sites at 13.3 pg/m³ but this was dominated by a very high value of 50 pg/m³ in quarter 1. The congener pattern for this sample was similar to other sites which suggests that this is an accurate reflection of elevated ambient concentrations at that time.

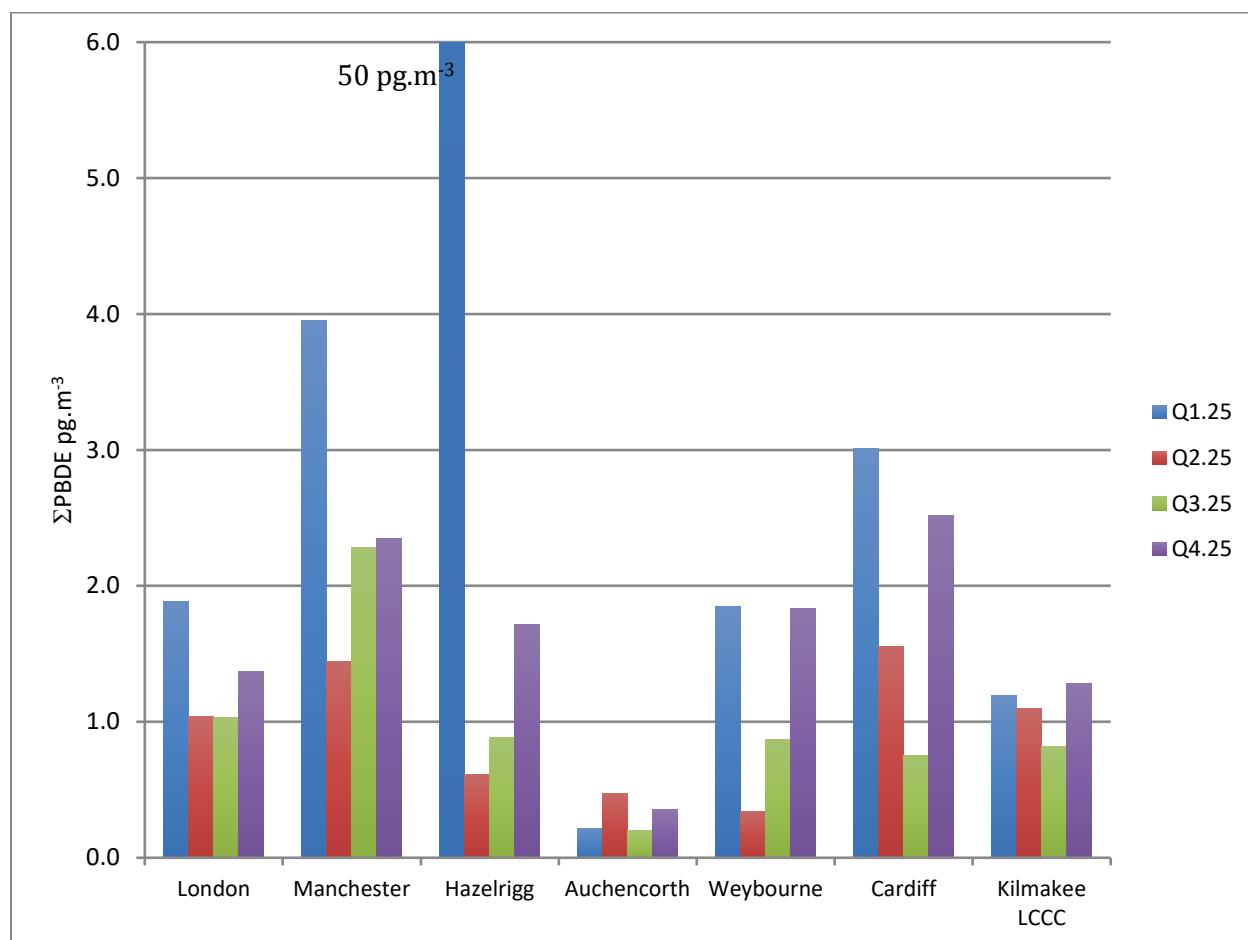


Figure 10 - Quarterly Σ PBDE data at the TOMPs sites for 2025.

The TOMPs air sample archive has been used to provide information the time-trend of PBDEs in the UK atmosphere. The re-analysis of the sample archive focused on 4 of the 6 sites over a period ranging from 1999 to 2010 (Birgul *et al.* 2012). These time-trend data demonstrated a consistent decrease in concentration over recent years with the observed decline starting during the period 2001-2003. The average Σ PBDE clearance rate (time taken for a 50% decline in concentration) for the urban sites since 2011 was 5.6 years, and for the rural sites since 2011 (including Hazelrigg) was 4.0 years. Figure 11 compares the ambient air data from the TOMPs archive and the recent TOMPs data from 2011-25, along with an estimate of emissions to the UK atmosphere from the NAEI. These data show good agreement suggesting that the sources are largely captured in the emission inventory and that ambient air concentrations are declining at a predictable rate.

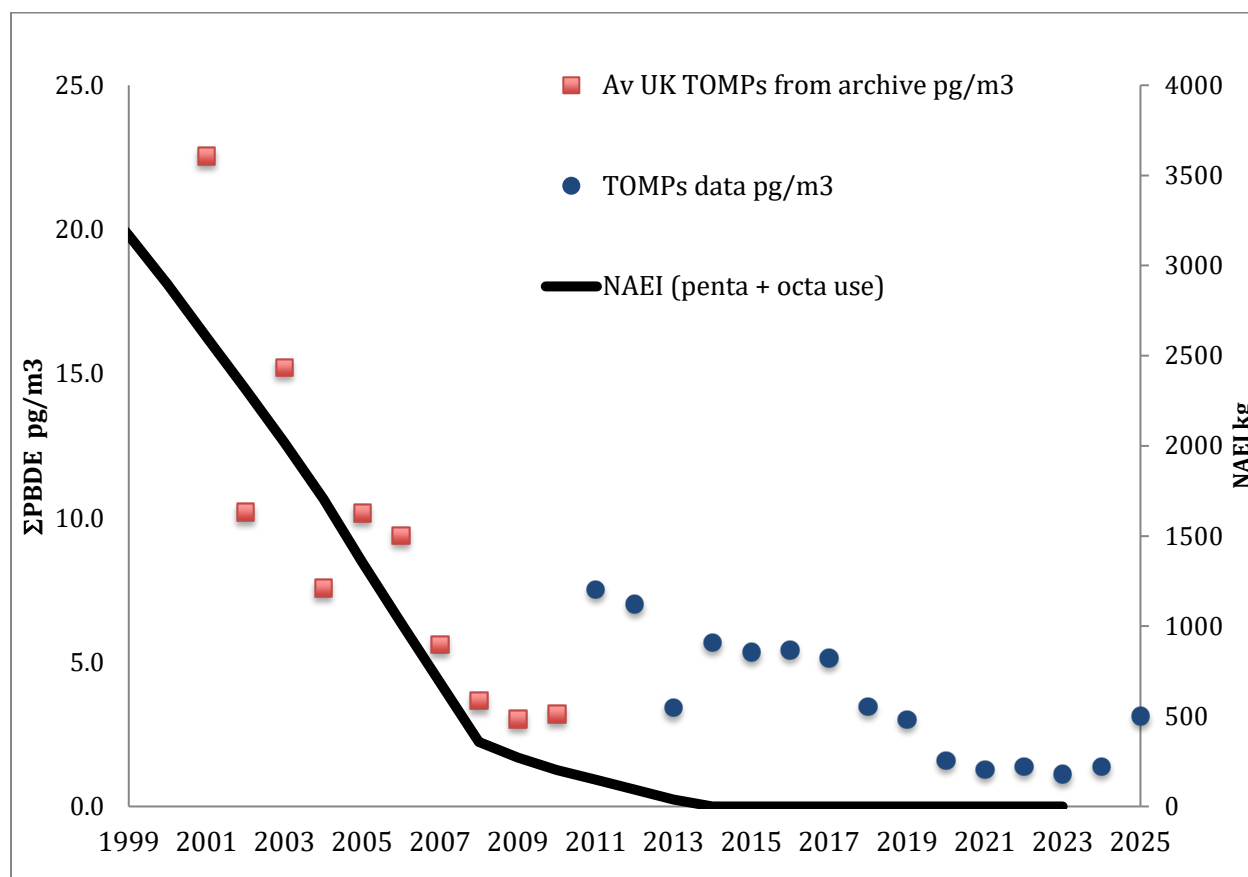


Figure 11 - Σ PBDE data at the TOMPs sites over the period 2011 to 2025 (PBDEs have been included in the TOMPs network since 2010/11, data from 2000 produced from archived samples - Birgul *et al.* 2012).

Decabromodiphenyl ether (BDE-209)

Although decaBDE was added to the Stockholm Convention in 2017 there have been few attempts to calculate emission data or to provide ambient air monitoring data. Earnshaw *et al.* (2013) carried out a substance flow analysis approach to calculate a European consumption and emission inventory which split major products containing decaBDE into 2 major categories, polymers and textiles (respective market shares were 75% and 25%). Both categories were assumed to emit BDE-209 to the atmosphere by volatilisation and particle bound emissions. The treatment of textiles with decaBDE was also assumed to emit to the wastewater system. It is clear that changes in regulation over time have affected the distribution of decaBDE use in products between the major use categories i.e. electrical and electronics, textiles, transport vehicles and building products. For example, in a recent assessment the majority (85%) of deca-BDE used in polymer production was found to be used for flame retarding polystyrene. However, with the restriction of the use in electronics and electrical, its use in other applications such as textiles and building

materials have become relatively more important. According to the Industry Voluntary Emission Control Action Plan (VECAP) report in 2012 (which covers 84% of the market), and based on 2011 data, the total volume of decaBDE sold was expected to be between 2,500 and 5,000 metric tonnes. This accounts for approximately 10% of the brominated flame-retardant market (EC 2011). VECAP market data also suggested that the importance of use in textile applications has increased from 37% to 52% (2011 data). Earnshaw *et al.* (2013) incorporated these data into an estimate of historical and future European decaBDE consumption covering the period 1970 to 2020, which is summarised in Figure 12. These data can be used to estimate the size of the current market for decaBDE (and hence estimate the challenge for identifying substitutes) and provide estimates of emission of BDE-209 to the environment. Owing to the scarcity of data 3 consumption scenarios were constructed using a combination of Industry data and assumptions concerning import rates and product types. The most uncertain period was prior to 1990 when fewer data were available describing the production and consumption patterns. Both the ‘best’ and ‘high’ estimates assumed a linear increase in consumption from the start of large-scale production (1969) to 1990 when the first Industry data became available. The ‘low’ estimate tracked bromine production over the same period and related that to brominated flame retardant production. Figure 12 also includes VECAP survey data of annual volumes sold by European Flame Retardants Association (EFRA) member companies.

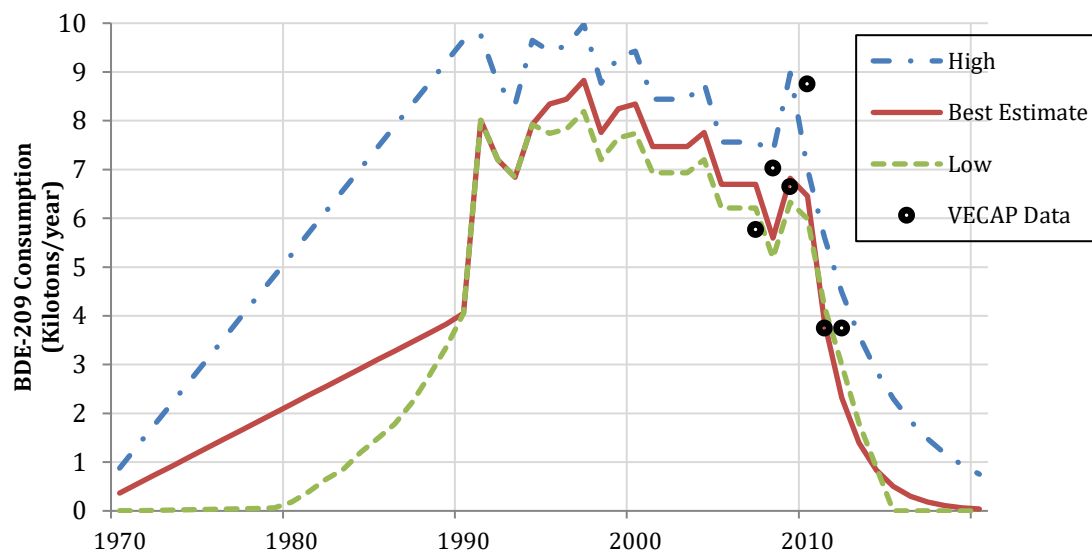


Figure 12 3 different consumption scenarios for Europe based on a range of assumptions including; inclusion/exclusion of imports, and inclusion/exclusion OctaBDE products – taken from Earnshaw et al. (2013).

A study by Wilford et al. (2008) determined a range of BDEs including BDE-209 in the UK and reported a range of between $<0.5 \text{ pg/m}^3$ to 100 pg/m^3 with a median value of 13 pg/m^3 . BDE209 accounted for 60% of the total BDE fraction associated with the particulate phase. More recent UK data using passive samplers deployed in the West Midlands suggested that mean concentrations across 8 sites ranged from 92 to 370 pg/m^3 Drage et al. (2016). Data from a global passive sampling survey of flame-retardant concentrations across 20 megacities/major cities reported decaBDE ranging from 1.7 to 84.8 pg/m^3 with London reporting the highest concentration (Saini et al. 2020). Data from the TOMPs sites across the 4 quarters is shown in Figure 13 and Appendix 3.

An important observation is that ambient concentrations of decaBDE are higher than the sum of the lower BDEs. As with the lower brominated PBDEs, Manchester and London have the highest concentrations with mean values of 8.3 and 8.8 pg/m^3 , respectively. The concentrations at Cardiff and Hazelrigg were only marginally lower at 7.5 and 7.1 pg/m^3 , respectively. These values are lower than those reported by Saini et al. (2020) for London but are based on active sampling. Direct comparisons between active and passive sampling data for particle bound contaminants should be treated with caution as passive data incorporates uncertainties with sampling rates are difficult to quantify. The annual average concentration of decaBDE at Weybourne was 5.5 pg/m^3

and the urban background site at Kilmakee was 2.9 pg/m³. High Muffles had the lowest concentration at 0.5 pg/m³, based on an average of 4 single quarterly samples collected across the year.

If the emission data provided by Earnshaw et al. (2013) are reliable then decaBDE emissions related to consumption should have decreased significantly from 2010 to 2020. An important question, however, is the role of the waste management to provide on-going emissions. Data provided by TOMPs should be able to provide important information on long-term emissions.

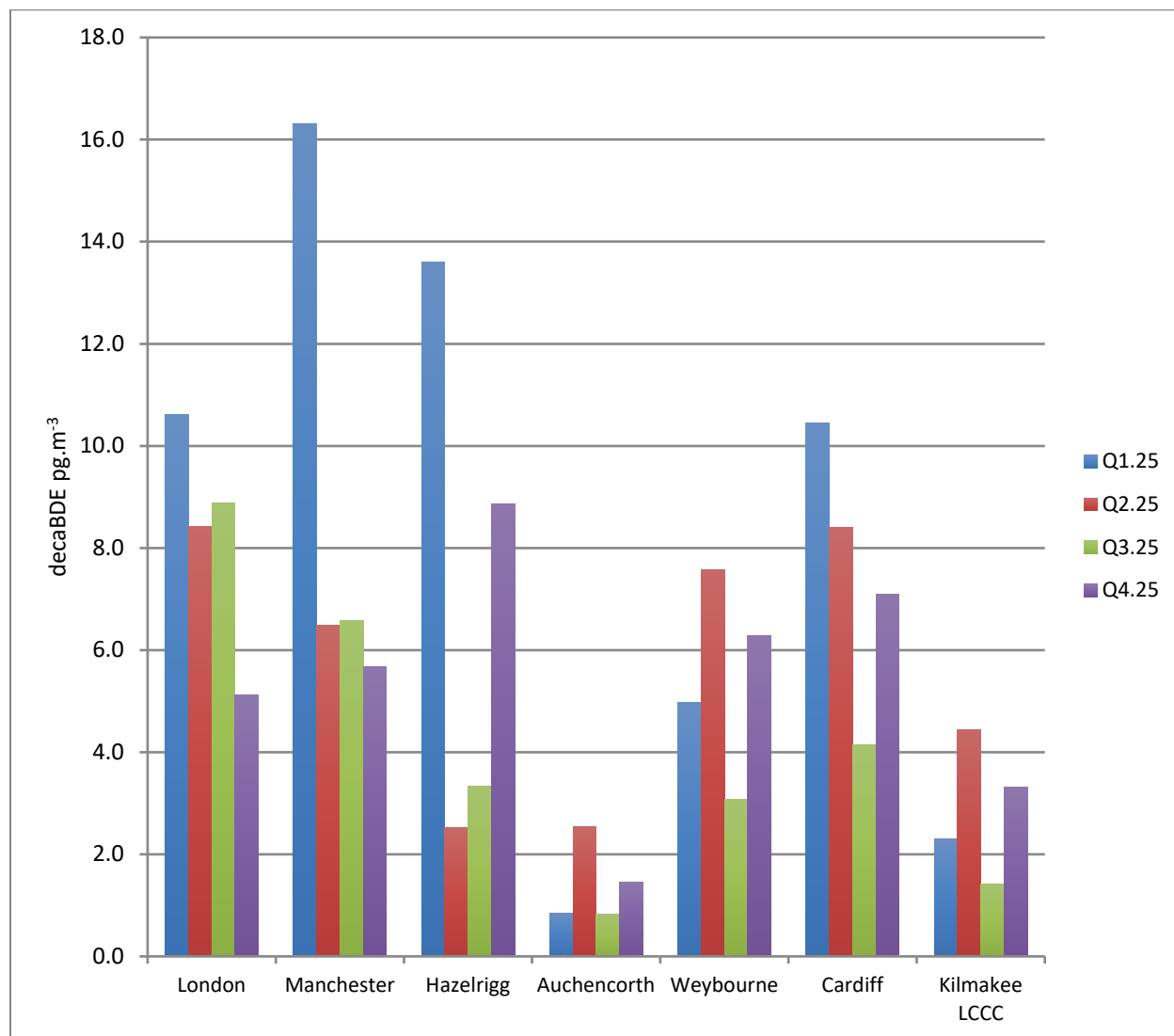


Figure 13 - Quarterly decaBDE data at the TOMPs sites for 2025

Hexabromocyclododecane (HBCDD)

HBCDD data for London, Manchester, Hazelrigg, High Muffles (single annual result), Auchencorth, Weybourne, Cardiff and Kilmakee have been reported (see Appendix 4). The

average Σ HBCDD concentration at the Manchester, London and Cardiff sites were 2.89 pg/m^3 and 1.79 pg/m^3 and 1.32 pg/m^3 , respectively. Hazelrigg and Weybourne were lower at 1.03 pg/m^3 and 0.71 pg/m^3 , respectively. Concentrations at Kilmakee, Auchencorth and High Muffles were lower still at 0.4 pg/m^3 , 0.31 pg/m^3 and 0.18 pg/m^3 , respectively. The sample at High Muffles represents an average from 4 quarterly samples collected across the year. The summary data in Figure 14 suggests that no consistent seasonal pattern was associated with any site which suggests that sources are not strongly seasonal or temperature dependent. The HBCDD technical mixture tended to be dominated by the γ -isomer ($\sim 70\%$) although this dominance was not reflected in the samples, accounting for 29% on average. However, at temperatures $>160^\circ\text{C}$, these isomers undergo thermal rearrangement resulting in a reduction of the dominance of γ -HBCDD to 9% and an increase in the proportion of α -HBCDD to 79% (Barontini et al., 2001). Data from the TOMPs sites suggests there may be a mixture of sources contributing to the signal. There are few data reported for the UK for comparison. Drage et al. (2016) using passive air samplers deployed across the West Midlands reported mean concentrations across 8 sites ranged from 64 to 136 pg/m^3 . More recently Ma et al. (2024) reported mean Σ HCBDD concentrations of 5.6 pg/m^3 ($n=16$), also using passive sampling in Birmingham, suggesting an important reduction in source strength. Data from a global passive sampling survey of flame-retardant concentrations across 6 megacities/major cities across the United Nations Western European and Others Group (WEOG) region reported median Σ HCBDD concentration of 10.8 pg/m^3 with London (Nobel House) reporting a concentration of 3.8 pg/m^3 (Saini et al. 2020).

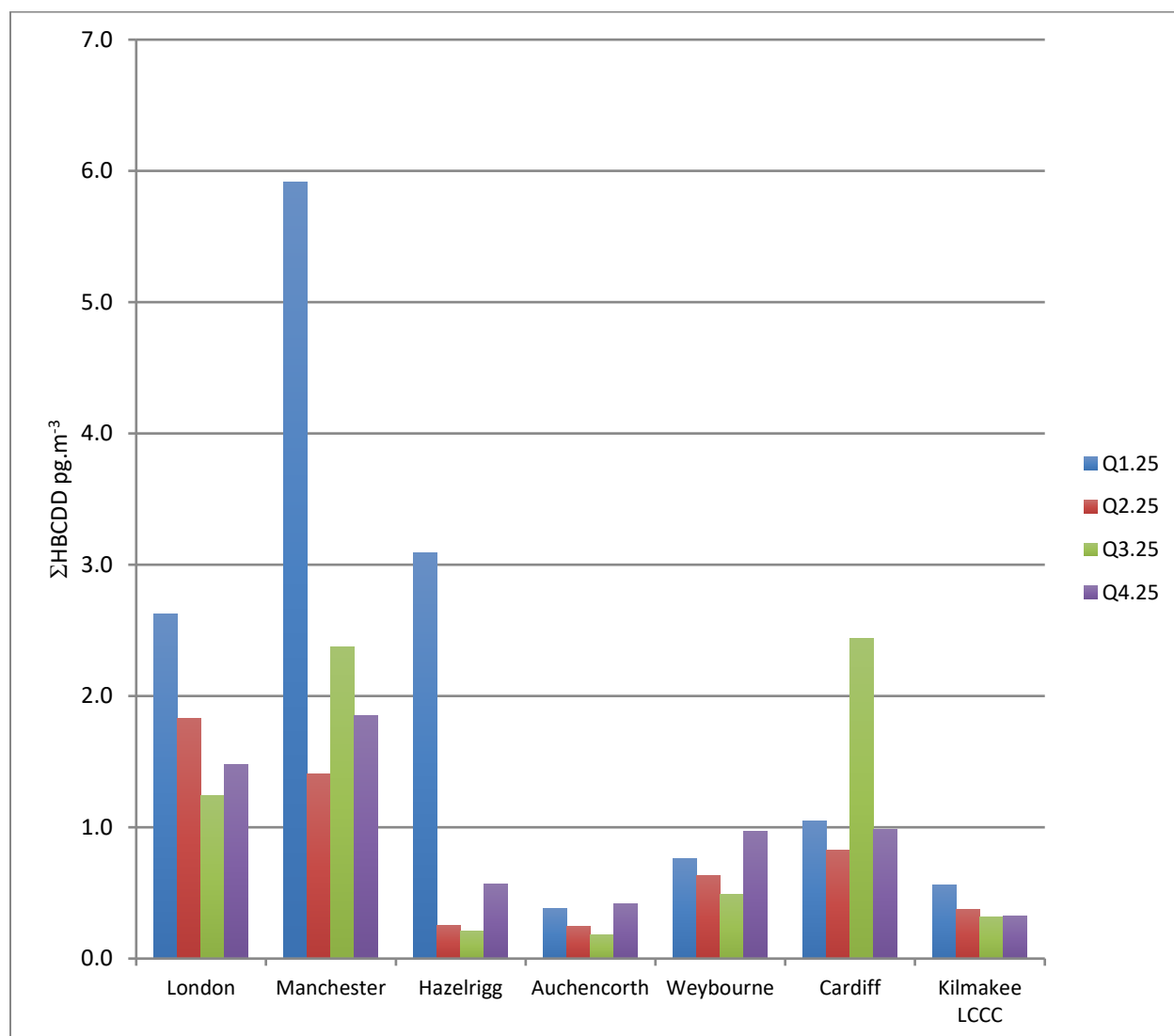


Figure 14 - Quarterly Σ HBCDD data at the TOMPs sites for 2025.

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10 Appendices

Appendix 1. PCDD/Fs data. (All data in fgTEQ.m⁻³)

Table 4: PCDD/Fs data for Manchester UKA00185 2025

<u>Manchester UKA00185 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
2,3,7,8-TCDF	0.90	0.50	0.39	0.60	0.60
1,2,3,7,8-PeCDF	0.56	0.26	0.16	0.27	0.31
2,3,4,7,8-PeCDF	8.50	4.74	2.62	4.62	5.12
1,2,3,4,7,8-HxCDF	1.44	0.88	0.59	1.04	0.99
1,2,3,6,7,8-HxCDF	1.75	0.84	0.54	0.87	1.00
2,3,4,6,7,8-HxCDF	2.52	1.25	0.75	1.39	1.48
1,2,3,7,8,9-HxCDF	0.58	0.43	0.34	0.41	0.44
1,2,3,4,6,7,8-HpCDF	0.56	0.28	0.20	0.34	0.35
1,2,3,4,7,8,9-HpCDF	0.07	0.03	0.03	0.04	0.04
OCDF	0.002	0.001	0.001	0.002	0.002
2,3,7,8-TCDD	1.19	0.50	0.33	0.73	0.69
1,2,3,7,8-PeCDD	6.72	1.80	0.87	2.17	2.89
1,2,3,4,7,8-HxCDD	0.44	0.20	0.11	0.27	0.26
1,2,3,6,7,8-HxCDD	1.18	0.48	0.23	0.69	0.65
1,2,3,4,7,8-HxCDD	0.79	0.36	0.16	0.55	0.47
1,2,3,4,6,7,8-HpCDD	0.73	0.27	0.18	0.49	0.42
OCDD	0.01	0.00	0.00	0.01	0.01
ΣTEQ dioxins and furans	27.93	12.83	7.50	14.48	15.69
3,4,4',5-TetraCB (PCB_77)	0.01	0.01	0.02	0.01	0.01
3,3',4,4'-TetraCB (PCB_81)	0.001	0.001	0.001	0.001	0.001
3,3',4,4',5-PentaCB (PCB_126)	1.15	1.12	1.11	0.59	0.99
3,3',4,4',5,5'-HexaCB (PCB_169)	0.04	0.02	0.01	0.02	0.02

Table 5: PCDD/Fs data for London UKA01057 2025

London UKA01057 2025	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
2,3,7,8-TCDF	0.47	0.20	0.20	0.27	0.29
1,2,3,7,8-PeCDF	0.25	0.10	0.08	0.11	0.14
2,3,4,7,8-PeCDF	4.82	1.78	1.49	2.36	2.61
1,2,3,4,7,8-HxCDF	0.82	0.29	0.29	0.51	0.48
1,2,3,6,7,8-HxCDF	0.66	0.29	0.27	0.44	0.42
2,3,4,6,7,8-HxCDF	1.01	0.40	0.39	0.75	0.64
1,2,3,7,8,9-HxCDF	0.29	0.16	0.11	0.21	0.19
1,2,3,4,6,7,8-HpCDF	0.29	0.11	0.11	0.20	0.18
1,2,3,4,7,8,9-HpCDF	0.04	0.01	0.01	0.03	0.02
OCDF	0.002	0.001	0.001	0.001	0.001
2,3,7,8-TCDD	0.63	0.16	0.16	0.37	0.33
1,2,3,7,8-PeCDD	2.62	0.63	0.67	1.47	1.35
1,2,3,4,7,8-HxCDD	0.26	0.06	0.08	0.20	0.15
1,2,3,6,7,8-HxCDD	0.63	0.16	0.20	0.46	0.36
1,2,3,4,7,8-HxCDD	0.57	0.11	0.14	0.41	0.31
1,2,3,4,6,7,8-HpCDD	0.71	0.15	0.17	0.48	0.38
OCDD	0.02	0.00	0.00	0.01	0.01
ΣTEQ dioxins and furans	14.08	4.62	4.36	8.30	7.84
3,4,4',5-TetraCB (PCB_77)	0.005	0.01	0.01	0.005	0.01
3,3',4,4'-TetraCB (PCB_81)	0.001	0.001	0.001	0.0005	0.001
3,3',4,4',5-PentaCB (PCB_126)	0.62	0.51	0.78	0.42	0.58
3,3',4,4',5,5'-HexaCB (PCB_169)	0.01	0.01	0.01	0.01	0.01

Table 6: TOMPs 2025 PCB data for London UKA01057 2025

<u>London UKA01057 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
PCB_28	8.40	10.70	15.00	7.00	10.28
PCB_52	3.87	6.04	7.79	3.27	5.24
PCB_101	3.67	6.93	8.14	2.80	5.38
PCB_118	0.89	1.49	2.24	0.85	1.37
PCB_138	0.87	1.46	2.26	0.87	1.36
PCB_153	1.23	2.33	3.27	1.20	2.01
PCB_180	0.27	0.55	0.67	0.27	0.44
Σ7PCB	19.20	29.49	39.37	16.27	26.08

Table 7: TOMPs 2025 PCB data for Manchester UKA00185 2025

<u>Manchester UKA00185 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
PCB_28	11.73	14.71	23.00	7.18	14.16
PCB_52	5.75	8.34	9.19	2.85	6.53
PCB_101	6.53	10.01	15.14	2.43	8.53
PCB_118	1.72	3.64	3.56	0.74	2.41
PCB_138	1.57	3.31	3.59	0.73	2.30
PCB_153	1.95	3.67	4.16	0.95	2.68
PCB_180	0.35	0.48	0.49	0.20	0.38
Σ7PCB	29.60	44.18	59.12	15.08	36.99

Table 8: TOMPs 2025 PCB data for Hazelrigg UKA00507 2025

<u>Hazelrigg UKA00507 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
PCB_28	0.71	1.57	2.11	1.05	1.36
PCB_52	0.49	1.36	2.00	0.76	1.15
PCB_101	0.30	0.93	1.41	0.44	0.77
PCB_118	0.09	0.29	0.42	0.15	0.24
PCB_138	0.09	0.22	0.32	0.12	0.19
PCB_153	0.16	0.33	0.49	0.21	0.30
PCB_180	0.04	0.07	0.08	0.05	0.06
Σ7PCB	1.90	4.76	6.83	2.77	4.06

Table 9: TOMPs 2025 PCB data for High Muffles UKA00169 2025

<u>High Muffles UKA00169 2025</u>	<u>Average 2025</u>
PCB_28	2.16
PCB_52	0.55
PCB_101	0.44
PCB_118	0.04
PCB_138	0.07
PCB_153	0.28
PCB_180	0.05
Σ7PCB	3.61

Table 10: TOMPs 2025 PCB data for Auchencorth UKA00451 2025

<u>Auchencorth UKA00451 2025</u>	<u>Q1.25</u>	<u>Q2.25</u>	<u>Q3.25</u>	<u>Q4.25</u>	<u>Average 2025</u>
PCB_28	0.55	0.97	1.89	0.70	1.03
PCB_52	0.37	0.57	0.80	0.43	0.54
PCB_101	0.17	0.23	0.40	0.22	0.25
PCB_118	0.04	0.06	0.10	0.06	0.07
PCB_138	0.04	0.07	0.11	0.05	0.07
PCB_153	0.10	0.11	0.20	0.10	0.13
PCB_180	0.01	0.02	0.04	0.03	0.03
Σ7PCB	1.29	2.04	3.53	1.59	2.11

Table 11: TOMPs 2025 PCB data for Weybourne UKA00433 2025

<u>Weybourne UKA00433 2025</u>	<u>Q1.25</u>	<u>Q2.21</u>	<u>Q3.25</u>	<u>Q4.25</u>	<u>Average 2025</u>
PCB_28	1.04	1.36	1.01	0.83	1.06
PCB_52	1.05	1.24	1.07	0.96	1.08
PCB_101	0.62	0.76	0.73	0.57	0.67
PCB_118	0.19	0.20	0.19	0.21	0.20
PCB_138	0.20	0.23	0.22	0.23	0.22
PCB_153	0.38	0.44	0.42	0.42	0.42
PCB_180	0.08	0.08	0.07	0.09	0.08
Σ7PCB	3.56	4.31	3.71	3.30	3.72

Table 12: TOMPs 2025 PCB data for Kilmakee UKA00570 2025

<u>Kilmakee UKA00570 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
PCB_28	2.10	2.61	3.61	1.87	2.55
PCB_52	0.72	1.44	1.44	0.71	1.08
PCB_101	0.32	0.65	0.73	0.30	0.50
PCB_118	0.11	0.21	0.21	0.10	0.16
PCB_138	0.11	0.18	0.17	0.10	0.14
PCB_153	0.20	0.34	0.30	0.18	0.25
PCB_180	0.06	0.11	0.07	0.05	0.07
Σ7PCB	3.63	5.55	6.53	3.32	4.76

Table 13: TOMPs 2025 PCB data for Cardiff UKA00452 2025

<u>Cardiff UKA00452 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
PCB_28	2.94	4.60	5.23	2.84	3.90
PCB_52	1.77	2.97	3.00	2.04	2.45
PCB_101	0.84	1.63	1.87	1.15	1.37
PCB_118	0.24	0.38	0.60	0.41	0.41
PCB_138	0.28	0.42	0.50	0.32	0.38
PCB_153	0.45	0.71	0.95	0.62	0.68
PCB_180	0.11	0.29	0.22	0.16	0.19
Σ7PCB	6.64	11.00	12.37	7.54	9.39

Table 14: PBDE data for 2025 for London UKA01057 2025

<u>London UKA01057 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
BDE 28	0.04	0.05	0.07	0.05	0.05
BDE 47	0.30	0.34	0.41	0.30	0.34
BDE 66	0.04	0.04	0.04	0.03	0.04
BDE 99	0.33	0.19	0.16	0.21	0.22
BDE 85	0.01	0.01	0.01	0.02	0.01
BDE 100	0.20	0.07	0.06	0.12	0.11
BDE 153	0.21	0.08	0.07	0.13	0.12
BDE 154	0.27	0.09	0.07	0.16	0.15
BDE 183	0.49	0.18	0.14	0.36	0.29
Σ₉PBDE	1.89	1.05	1.03	1.37	1.34
BDE 209	10.62	8.43	8.89	5.13	8.26

Table 15: PBDE data for 2025 for Manchester UKA00185 2025

<u>Manchester UKA00185 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
BDE 28	0.08	0.06	0.08	0.05	0.07
BDE 47	0.65	0.50	0.75	0.64	0.64
BDE 66	0.10	0.04	0.06	0.05	0.06
BDE 99	0.58	0.23	0.33	0.40	0.39
BDE 85	0.06	0.02	0.03	0.05	0.04
BDE 100	0.26	0.09	0.14	0.19	0.17
BDE 153	0.37	0.15	0.16	0.25	0.23
BDE 154	0.59	0.12	0.27	0.25	0.31
BDE 183	1.27	0.22	0.48	0.46	0.61
Σ₉PBDE	3.95	1.44	2.29	2.35	2.51
BDE 209	16.32	6.49	6.59	5.68	8.77

Table 16: PBDE data for 2025 for Hazelrigg UKA00507 2025

<u>Hazelrigg UKA00507 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
BDE 28	0.10	0.02	0.02	0.03	0.04
BDE 47	0.58	0.08	0.10	0.14	0.22
BDE 66	0.17	0.02	0.02	0.05	0.06
BDE 99	24.33	0.15	0.33	0.21	6.26
BDE 85	5.02	0.02	0.03	0.03	1.28
BDE 100	3.47	0.03	0.10	0.16	0.94
BDE 153	8.37	0.06	0.08	0.17	2.17
BDE 154	5.80	0.08	0.09	0.30	1.57
BDE 183	2.08	0.16	0.11	0.62	0.74
Σ₉PBDE	50.00	0.61	0.88	1.71	13.30
BDE 209	13.60	2.53	3.34	8.87	7.09

Table 17: PBDE data for 2025 for High Muffles UKA00169 2025

<u>High Muffles UKA00169 2025</u>	Average 2025
BDE 28	0.01
BDE 47	0.03
BDE 66	0.004
BDE 99	0.02
BDE 85	0.01
BDE 100	0.01
BDE 153	0.01
BDE 154	0.01
BDE 183	0.04
Σ₉PBDE	0.12
BDE 209	0.48

Table 18: PBDE data for 2025 for Auchencorth UKA00451 2025

<u>Auchencorth UKA00451 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
BDE 28	0.01	0.03	0.01	0.01	0.01
BDE 47	0.03	0.06	0.05	0.03	0.04
BDE 66	0.01	0.03	0.01	0.01	0.01
BDE 99	0.03	0.04	0.03	0.03	0.03
BDE 85	0.00	0.02	0.00	0.01	0.01
BDE 100	0.01	0.03	0.02	0.02	0.02
BDE 153	0.03	0.06	0.02	0.04	0.04
BDE 154	0.04	0.07	0.02	0.05	0.05
BDE 183	0.08	0.15	0.05	0.17	0.11
Σ₉PBDE	0.22	0.47	0.20	0.36	0.31
BDE 209	0.85	2.54	0.83	1.45	1.42

Table 19: PBDE data for 2025 for Weybourne UKA00433 2025

<u>Weybourne UKA00433 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
BDE 28	0.06	0.03	0.03	0.04	0.04
BDE 47	0.22	0.09	0.24	0.16	0.18
BDE 66	0.08	0.02	0.03	0.06	0.05
BDE 99	0.32	0.06	0.24	0.24	0.22
BDE 85	0.03	0.00	0.02	0.03	0.02
BDE 100	0.16	0.02	0.06	0.16	0.10
BDE 153	0.20	0.02	0.05	0.22	0.12
BDE 154	0.25	0.04	0.08	0.31	0.17
BDE 183	0.52	0.06	0.12	0.65	0.34
Σ₉PBDE	1.85	0.34	0.87	1.83	1.22
BDE 209	4.97	7.57	3.07	6.28	4.97

Table 20: PBDE data for 2025 for Kilmakee UKA00570 2025

<u>Kilmakee UKA00570 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
BDE 28	0.03	0.03	0.03	0.03	0.03
BDE 47	0.16	0.19	0.17	0.15	0.17
BDE 66	0.05	0.04	0.03	0.06	0.04
BDE 99	0.15	0.24	0.14	0.22	0.19
BDE 85	0.02	0.02	0.01	0.03	0.02
BDE 100	0.08	0.09	0.09	0.10	0.09
BDE 153	0.15	0.12	0.09	0.16	0.13
BDE 154	0.18	0.14	0.09	0.20	0.15
BDE 183	0.37	0.24	0.17	0.33	0.28
Σ₉PBDE	1.20	1.10	0.82	1.28	1.10
BDE 209	2.30	4.44	1.41	3.31	2.87

Table 21: PBDE data for 2025 for Cardiff UKA00452 2025

<u>Cardiff UKA00452 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
BDE 28	0.04	0.04	0.03	0.04	0.04
BDE 47	0.23	0.22	0.16	0.26	0.22
BDE 66	0.09	0.05	0.03	0.07	0.06
BDE 99	0.35	0.24	0.10	0.41	0.28
BDE 85	0.07	0.03	0.01	0.06	0.04
BDE 100	0.16	0.12	0.08	0.16	0.13
BDE 153	0.44	0.17	0.08	0.28	0.24
BDE 154	0.52	0.23	0.09	0.41	0.31
BDE 183	1.12	0.45	0.19	0.82	0.65
Σ₉PBDE	3.01	1.56	0.76	2.51	1.96
BDE 209	10.44	8.40	4.14	7.09	7.52

Appendix 4. HBCDD data for 2025. (All data in pg.m⁻³)

Table 22: HBCDD data for 2025 for London UKA01057 2025

<u>London UKA01057 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
α-HBCDD	1.28	0.82	0.66	0.68	0.86
β-HBCDD	0.92	0.49	0.26	0.60	0.57
γ-HBCDD	0.42	0.52	0.32	0.20	0.36
ΣHBCDD	2.63	1.83	1.24	1.48	1.79

Table 23: HBCDD data for 2025 for Manchester UKA00185 2025

<u>Manchester UKA00185 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
α-HBCDD	2.60	0.65	1.03	0.79	1.27
β-HBCDD	2.32	0.42	0.89	0.73	1.09
γ-HBCDD	1.00	0.34	0.45	0.33	0.53
ΣHBCDD	5.91	1.41	2.37	1.85	2.89

Table 24: HBCDD data for 2025 for Hazelrigg UKA00507 2025

<u>Hazelrigg UKA00507 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
α-HBCDD	0.92	0.05	0.09	0.21	0.32
β-HBCDD	1.85	0.12	0.07	0.28	0.58
γ-HBCDD	0.33	0.08	0.04	0.07	0.13
ΣHBCDD	3.09	0.25	0.21	0.57	1.03

Table 25: HBCDD data for 2025 for High Muffles UKA00169 2025

<u>High Muffles UKA00169 2025</u>	Annual average (1 sample per quarter – total 4000m ³)				
α-HBCDD	0.05				
β-HBCDD	0.06				
γ-HBCDD	0.07				
ΣHBCDD	0.18				

Table 26: HBCDD data for 2025 for Auchencorth UKA00451 2025

<u>Auchencorth UKA00451 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
α-HBCDD	0.06	0.07	0.04	0.07	0.06
β-HBCDD	0.03	0.10	0.03	0.12	0.07
γ-HBCDD	0.28	0.08	0.10	0.23	0.17
ΣHBCDD	0.38	0.24	0.18	0.42	0.31

Table 27: HBCDD data for 2025 for

<u>Weybourne UKA00433 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
α -HBCDD	0.36	0.35	0.26	0.32	0.32
β -HBCDD	0.30	0.13	0.16	0.53	0.28
γ -HBCDD	0.11	0.16	0.08	0.13	0.12
Σ HBCDD	0.76	0.63	0.49	0.97	0.71

Table 28: HBCDD data for 2025 for

<u>Kilmakee UKA00570 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
α -HBCDD	0.24	0.11	0.07	0.15	0.14
β -HBCDD	0.22	0.15	0.06	0.13	0.14
γ -HBCDD	0.10	0.11	0.19	0.05	0.11
Σ HBCDD	0.56	0.38	0.32	0.33	0.40

Table 29: HBCDD data for 2025 for

<u>Cardiff UKA00452 2025</u>	Q1.25	Q2.25	Q3.25	Q4.25	Average 2025
α -HBCDD	0.35	0.25	0.12	0.20	0.23
β -HBCDD	0.59	0.33	0.26	0.70	0.47
γ -HBCDD	0.12	0.25	2.06	0.08	0.63
Σ HBCDD	1.05	0.83	2.44	0.98	1.32