NPL

NPL REPORT AS 61

Report to the Department of Environment, Food and Rural Affairs, the Welsh Government, the Department of the Environment in Northern Ireland, and the Scottish Government, by the National Physical Laboratory:

Annual Report for 2010 on the UK Heavy Metals Monitoring Network

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NOT RESTRICTED

JUNE 2011

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Analytical Science Division

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ISSN 1754-2928

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Approved on behalf of NPLML by
Mr Alan Brewin, Head of Analytical Science Division

Annual Report for 2010 on the UK Heavy Metals Monitoring Network

EXECUTIVE SUMMARY

This Report was prepared by the National Physical Laboratory (NPL) as part of the 2004-2011 UK Heavy Metals Monitoring Network contract with the Department of Environment, Food and Rural Affairs, the Welsh Government, the Department of the Environment Northern Ireland, and the Scottish Government.

This is the Annual Report for 2010 and contains, in particular:

- Measured monthly concentrations of all metals at all monitoring sites and performance against relevant data quality objectives and the requirements of the EC Air Quality Directives.
- Highlighting of exceedences, interpretation of data and discussion of trends across the Network.
- Summary of Network operation, analytical and QA/QC procedures and a description of notable events and changes to the Network during 2010.
- A summary of scientific research, publications, international representation and other activities related to the Network.

In summary, during 2010:

- None of the relevant limit or target values in European Union legislation were exceeded at any monitoring site on the Network.

- **Lead**: No annual average site concentrations above the New Air Quality Directive's Lower Assessment Threshold were recorded.

- **Nickel**: Two annual average site concentrations above the Fourth Daughter Directive's upper assessment threshold and one annual average site concentration above the Fourth Daughter Directive's lower assessment were recorded.

- **Cadmium**: No annual average site concentrations above the Fourth Daughter Directive's Lower Assessment Threshold were recorded.

- **Arsenic**: No annual average site concentrations above the Fourth Daughter Directive's Lower Assessment Threshold were recorded.

- **Total gaseous mercury**: Measured concentrations across the Network remain at background concentration levels (with the exception of the site at Runcorn Weston Point).

- The general slight downward trend in annual average concentrations has continued.

- All data quality objectives specified in the New Air Quality Directive and Fourth Daughter Directive were met, including time coverage, data capture and measurement uncertainty requirements.

- Data capture across the Network was **96%** for the year.

TABLE OF CONTENTS

EXECUTIVE SUMMARY 5
TABLE OF CONTENTS 6
1 INTRODUCTION 7
1.1 BACKGROUND 7
2 NETWORK OPERATION 10
2.1 OVERVIEW 10
2.2 SITE AUDITS 10
2.3 EQUIPMENT SERVICING AND BREAKDOWNS 12
2.4 SITE INFRASTRUCTURE AND NETWORK RE-ORGANISATION 12
3 SAMPLING AND ANALYTICAL METHODOLOGY 13
3.1 SAMPLING METHODOLOGY: PARTICULATE-PHASE METALS 13
3.2 SAMPLING METHODOLOGY: TOTAL GASEOUS MERCURY 13
3.3 ANALYTICAL METHODOLOGY: PARTICULATE-PHASE METALS 14
3.4 ANALYTICAL METHODOLOGY: TOTAL GASEOUS MERCURY 14
3.5 MEASUREMENT UNITS 15
3.6 MEASUREMENT UNCERTAINTY 15
4 METHOD PERFORMANCE CHARACTERISTICS AND QUALITY CONTROL 16
4.1 LIMITS OF DETECTION: PARTICULATE-PHASE METALS 16
4.2 LIMITS OF DETECTION: TOTAL GASEOUS MERCURY 17
4.3 QA/QC PROCEDURES 17
4.4 MEASUREMENT UNCERTAINTY 18
5 DATA QUALITY 19
5.1 DATA CAPTURE 19
5.2 DATA PROCESSING AND RATIFICATION 21
5.3 MEASUREMENT UNCERTAINTY OF ANNUAL AVERAGE 22
6 NETWORK DATA 23
6.1 MEASURED CONCENTRATIONS 23
6.2 MEASURED CONCENTRATIONS WITH RESPECT TO THE REQUIREMENTS OF THE EU AIR QUALITY DIRECTIVES 26
6.3 MEASURED CONCENTRATIONS OF NON-DIRECTIVE METALS 29
6.5 RATIO OF TOTAL GASEOUS MERCURY TO PARTICULATE PHASE MERCURY 31
7 TRENDS IN MEASURED CONCENTRATIONS 33
7.1 UK TRENDS 33
7.2 TRENDS IN NICKEL IN THE SWANSEA VALLEY 40
8 SCIENTIFIC RESEARCH, PUBLICATIONS AND RELATED ACTIVITIES 42
8.1 PUBLICATIONS 42
8.2 INTERNATIONAL AND STANDARDISATION ACTIVITY 43
ANNEX 1 LOCATION AND DETAILS OF SITES COMPRISING THE UK HEAVY METALS NETWORK 44
ANNEX 2 AVERAGE MONTHLY CONCENTRATIONS MEASURED FOR EACH ELEMENT 47
ANNEX 3 AVERAGE MONTHLY CONCENTRATIONS MEASURED AT EACH NETWORK SITE 54

1 INTRODUCTION

This Report was prepared by the National Physical Laboratory (NPL) as part of the 2004-2011 UK Heavy Metals Monitoring Network contract with the Department of Environment, Food and Rural Affairs and the Devolved Administrations[1] (the Welsh Government, the Department of the Environment in Northern Ireland, and the Scottish Government).

This is the Annual Summary Report for the UK Heavy Metals Monitoring Network (the 'Network') for 2010 and contains:

- Measured monthly concentrations of all metals at all monitoring sites and performance against relevant data quality objectives and the requirements of the relevant EC Air Quality Directives – the New Air Quality Directive (2008/50/EC[2]) for lead, and the Fourth Air Quality Daughter Directive (DD) (2004/107/EC[3]) for nickel, arsenic, cadmium, and total gaseous mercury, and the Air Quality Strategy for England, Scotland, Wales and Northern Ireland[4] for lead.

- Highlighting of exceedences, interpretation of data and discussion of trends across the Network.

- Summary of Network operation, analytical and QA/QC procedures and a description of notable events and changes to the Network during 2010.

- A summary of scientific research, publications, international representation and other activities related to the Network.

1.1 BACKGROUND

Several requirements drive the need for air quality measurements, including: measuring the exposure of the general population to a variety of toxic compounds; assessing compliance with legislative limits or similar target values; informing policy development and assessing the effectiveness of abatement strategies. In addition there is a need to provide air quality information for the general public and to inform other scientific endeavours (for example, climate change research), and to provide an infrastructure that can readily respond to new and rapidly changing requirements, such as the specification of new pollutants requiring measurement, or assessment of episodes, such as local, regional or trans-boundary pollution events.

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1 The Devolved Administrations are in detail: the Welsh Government, the Northern Ireland Executive, represented by the Department of the Environment in Northern Ireland (DoENI), and the Scottish Government, represented by the Scottish Government Enterprise and Environment Directorate.

2 Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe, *Official Journal* **L 152**, 11/06/2008 P. 0001-0044.

3 Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air, *Official Journal* **L 023**, 26/01/2005 P. 0003-0016.

4 Air Quality Strategy for England, Scotland, Wales and Northern Ireland, 2007, Cmd paper No 7169 NIA 61/06-07.

The determination of the total concentrations[5] of metals in ambient air is of great importance within this framework. The general public and the environment can be exposed to several classes of hazardous compounds containing metallic elements, which occur naturally or are released by domestic or industrial processes. The total concentration levels of Pb, Ni, As, Cd and Hg, allowable in the PM_{10} fraction of ambient air (particles with an equivalent aerodynamic diameter of 10 µm or less), are now limited by European legislation.

Human exposure to toxic air pollutants at sufficient concentrations and over long enough time periods may engender increased chances of serious health effects including cancer. Such health effects can include damage to the immune, reproductive and respiratory systems and developmental and neurological impairment. In addition to exposure from breathing in these pollutants, some pollutants such as mercury may also deposit from the air onto the earth or water, where they may enter the terrestrial and aquatic food chains, eventually resulting in human exposure through ingestion of contaminated food.

Emissions of metals in the UK arise from a variety of sources including in particular:

- Industrial combustion;
- Domestic combustion;
- Public power combustion;
- Metals processing industry;
- Road transport;
- Waste incineration;
- Chemical industry processes;
- Iron and steel industry.

The National Atmospheric Emissions Inventory has more details of anthropogenic sources and emissions of metallic pollutants in the UK [6]. These emissions have declined consistently over many years and this has generally been mirrored by the decrease in measured ambient levels. The correlation between these two data sets is quite strong, and indeed measured ambient concentrations across the Network have recently been compared against emissions [7]. This has shown that an additional benefit of the Network is to contribute supplementary evidence to show that trends in emissions inventory data for metals are correct. The UK emissions since 1980 of metals relevant to those measured on the Network are displayed in Figure 1.

In order to demonstrate compliance with legislation that provides limit and target values relating to ambient air and to measure human and environmental exposure, the total concentration levels of ambient metals, at multiple sites on nationwide air quality monitoring networks, need to be measured. The UK Heavy Metals Monitoring Network is a regulatory air quality monitoring network that discharges the majority of the UK's obligation under the EC Air Quality Directives relating to the monitoring of the mass concentrations of Pb, Ni, As and Cd, in the PM_{10} phase of ambient air, and total gaseous mercury [referred to as: Hg(v)].

5 The term 'concentration' is used in this report to refer to mass concentration.
6 www.naei.org.uk
7 Comparison of estimated annual emissions and measured annual ambient concentrations of metals in the UK 1980–2007, R J C, Brown, *J. Environ. Monit.*, 2010, **12**, 665-671.

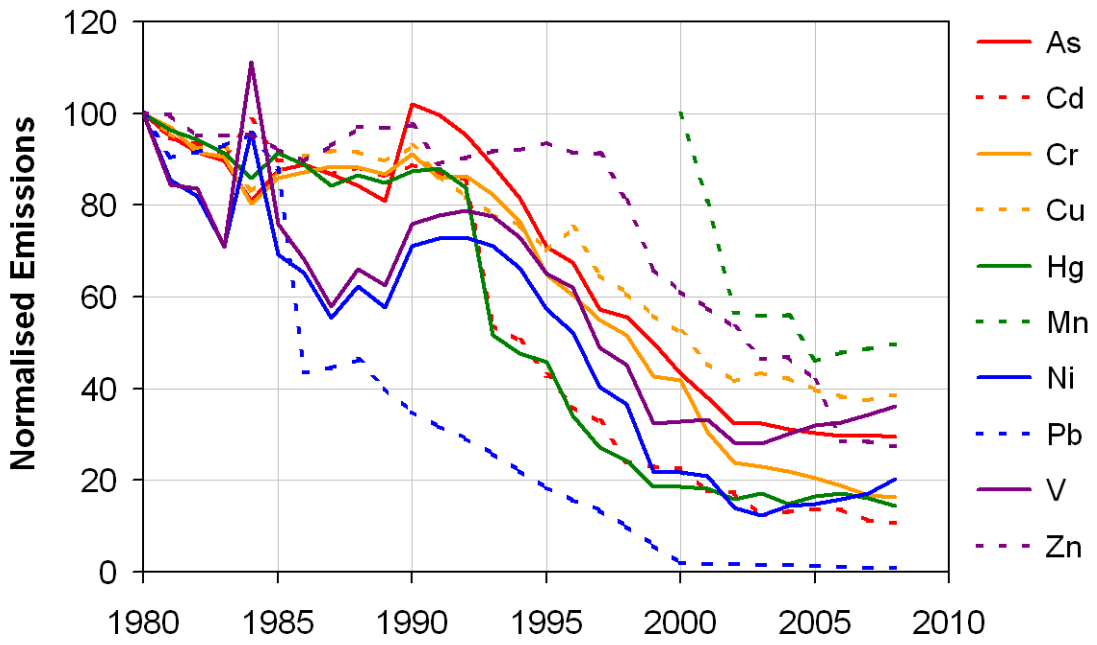

Figure 1. Estimated UK annual emissions of the metals from 1980 to 2008, normalised to their values in 1980 such that 1980 = 100 (except for Mn where values are only available since 2000 and therefore have been normalised to this year). The absolute levels of emissions in 1980, in tonnes, were: Cd, 26; Cr, 175; Cu, 154; Ni, 485; Pb, 8300; V, 1410; and Zn, 1014. The absolute level of Mn emissions in 2000 was 70 tonnes. Emissions data are not produced for Fe and Pt, although these are measured by the Network.

The Network has a number of objectives:

- To achieve compliance with monitoring requirements set out in European legislation;
- To provide data to the UK Government and European Commission on the UK's performance against the limit values, target values, and data quality objectives described in the relevant legislation;
- To assess impacts around 'hot spots' of metallic pollution to air, particularly in industrial areas;
- To produce accurate and reliable data for dissemination to the general public and for use by scientific and medical researchers and the air quality community.

Further information on the history of the UK Heavy Metals Monitoring Network can be found in an NPL publication that recently marked a quarter of a century of the nationwide monitoring of metals in ambient air[8].

8 Twenty-five years of nationwide ambient metals measurement in the United Kingdom: concentration levels and trends, Brown, R J C, *et al*, *Environmental Monitoring and Assessment*, 2008, **142**, 127-140.

2 NETWORK OPERATION

The UK Heavy Metals Monitoring Network in 2010 comprised 24 monitoring sites around the country (16 in England, 5 in Wales, 2 in Scotland, and 1 in Northern Ireland) sampling in the PM_{10} phase of ambient air onto filters (see Annex 1). These filters are then returned to NPL where they are analysed to determine the content of various metals in the particulate matter, in order to produce concentration values for these metals in ambient air. Total gaseous mercury is additionally sampled onto adsorption tubes at 13 of these Network sites (8 in England, 2 in Wales, 2 in Scotland, and 1 in Northern Ireland). These absorption tubes are then analysed at NPL to produce concentration values for total gaseous mercury in ambient air. Relevant activity related to Network operation during 2010 is detailed below.

2.1 OVERVIEW

NPL's management of the UK Heavy Metals Monitoring Network in 2010 has included the following key activities:

- NPL staff visited and fully audited all sites on the Network. This included the calibration and basic maintenance of the Partisol and total gaseous mercury samplers and re-assessment of local site operators' (LSOs') procedures.

- The Equipment Support Unit (ESU) made service visits to all Network sites twice during the year, and this has included the flow calibration of instruments.

- Data capture has remained at a very high level across the Network and is at its highest level since NPL began operating the Network.

- The UK Heavy Metals Monitoring Network and the data it produces has received extensive exposure in learned journals, trade publications and presentation during 2010 – details are given in Section 8.

2.2 SITE AUDITS

During 2010 NPL visited all the Network sites to perform annual site audits (see Image 1). At these visits the site infrastructure, performance and integrity were assessed. The LSOs were also audited and received extra training where required.

A list of sites comprising the Network as of the end of 2010, with locations, site codes, site names, site designations, identified point sources in the vicinity where applicable, is given in Annex 1.

During each Network site audit visit NPL:

- Audited the procedures of the LSO on-site, giving introductory training where necessary, and encouraged LSOs to feed-back into the running of the Network;
- Assessed the current condition of all on-site equipment, including the condition of the PM_{10} sampling head and impactor plate;
- Calibrated the flows of both the particulate (for volumetric and standard flow), and gaseous phase (volumetric flow), monitoring equipment;
- Leak tested both the particulate, and gaseous phase, monitoring equipment;

- Calibrated the site rotameter (used by the LSOs for determining the flow rate through the total gaseous mercury sampling line).

This flow calibration data is used to correct the volumes recorded by the Partisol instruments and mercury vapour sampling equipment prior to the calculation of ambient concentrations. A detailed report on the findings of the audits is available[9], but in summary:

- All of the sites have been audited fully and were found to be performing well.
- Site infrastructure was assessed and no major or minor problems were found.
- Audits of the flow-rate of the Partisol samplers and the mercury vapour sampling equipment were satisfactory and no remedial action was required.
- The LSOs were performing their duties to a high standard. Some small issues were indentified and rectified during the audits in order to improve performance even further.

The auditing of the sampler flow rates also allowed a comparison of the ESU and NPL flow calibrators. (The ESU recorded the sampler flow rate during their service visits.) The flow measurements were in good agreement with an average difference of only 2.7 %, which is well within the uncertainty of the flow measurement itself. As expected, the best agreements were found when the periods between the NPL and ESU visits were very short. As the periods between visits became longer, the difference increased as a function of the flow rate of the samplers and the calibration of the flow measuring equipment drifting slowly over time.

Image 1. The Partisol 2000 sampler at the Port Talbot Margam Network site prior to its 2010 annual audit.

9 NPL Report AS (RES) 061, "UK Heavy Metals Monitoring Network Audit Report For 2009", Beccaceci, S, Butterfield, D M, Sweeney, B, M, Williams NPL, January 2011.

2.3 EQUIPMENT SERVICING AND BREAKDOWNS

During 2010 the ESU twice fully serviced, carried out preventative maintenance and calibrated the flow of the Partisol samplers at all Network sites.

During 2010, NPL called-out the ESU to deal with Partisol sampler faults at: Motherwell South (a faulty residual current device was replaced), Sheffield (low valid hours reported), Eskdalemuir (display screen failure), Redcar AURN (temperature probe replaced), Scunthorpe Town AURN (low flow reported: flow controller and pump replaced), Walsall Centre (low flow reported: flow controller replaced) and Cardiff Rumney (low flow reported: kinked pipe causing flow restriction was replaced).

In addition, a slightly leaking O-ring seal around the filter housing was rectified by the LSO at Sheffield Centre AURN, with instruction from the ESU over the phone.

During 2010, failed or failing mercury vapour sampling pumps were replaced at: London Cromwell Road, Belfast Centre AURN, Bristol Avonmouth and Manchester Wythenshawe.

2.4 SITE INFRASTRUCTURE AND NETWORK RE-ORGANISATION

There were no significant issues to report with regard to site infrastructure during 2010. Changes to the operation of the Network during the year are detailed below.

Some site name changes occurred during 2010, and this are listed below:

- To avoid confusion with the Walsall Willenhall AURN site, Site 69: Walsall Willenhall (which is not co-located with the AURN) has become, Site 69: Walsall Bilston Lane.
- To ensure consistency with national naming strategies for the forthcoming new European Commission data reporting structure:
  - Site 61: London Cromwell Road, has become Site 61: London Cromwell Road 2.
  - Site 62: London Horseferry Road, has become Site 62: London Westminster.
  - Network sites collocated with AURN sites have dropped the AURN suffix from their names, since these do not appear in the names of the AURN sites themselves.

These changes formally occurred on 1st January 2011, but the new names will be used for reporting 2010 data.

As a result of ongoing reorganisation of the Network to meet future monitoring requirements in the Tawe Valley, the Pontardawe Tawe Terrace site, formerly operated by Neath Port Talbot Council was affiliated onto the Network to become Site 113: Pontardawe Tawe Terrace, as of 12th January 2011. A further downwind site is due to be installed in the Pontardawe area later in 2011.

As a result of the additional sites added onto the Network in the Pontardawe area, the two Network sites at Bristol Hallen and Bristol Avonmouth closed on 5th January 2011. Both of these sites have consistently recorded concentrations of less that half the Lower Assessment Threshold for the metals relevant to the EC Air Quality Directives for over five years, with a consistent downwards trend in concentrations over this period.

3 SAMPLING AND ANALYTICAL METHODOLOGY

An overview of the sampling and analytical procedures used to analyse samples from the Network is given below.

3.1 SAMPLING METHODOLOGY: PARTICULATE-PHASE METALS

Particulate samples were taken at all sites in the Network using Partisol 2000 instruments (fitted with PM_{10} heads) operating at a calibrated flow rate, nominally of 1 m^3 h^{-1}, in accordance with EN 12341 (see Image 2). Samples were taken for a period of one week onto 47 mm diameter GN Metricel membrane filters.

Image 2. The Partisol 2000 sampler at the Network monitoring site at Eskdalemuir. The grey box attached to the side of the sampler contains the mercury vapour sampling equipment.

3.2 SAMPLING METHODOLOGY: TOTAL GASEOUS MERCURY

Sampling for total gaseous mercury took place at 13 of the 24 Network sites using a low-volume pump (calibrated annually by NPL). Air was pumped through Amasil (gold-coated silica) tubes at a rate of 100 ml min^{-1} for either one week or four weeks, depending on the specific site and the expected ambient concentrations. The mercury vapour sampling equipment is housed in a specially designed box on the side of the Partisol 2000 samplers (see Image 2). A schematic diagram of the mercury vapour sampling equipment is given in Figure 2.

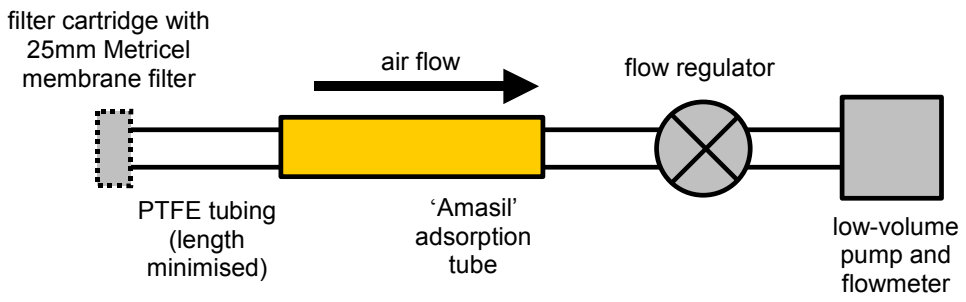

Figure 2. Schematic diagram of the total gaseous mercury sampling apparatus. The 25 mm diameter filter was used to remove any particulate material.

3.3 ANALYTICAL METHODOLOGY: PARTICULATE-PHASE METALS

Analysis for particulate-phase metals took place at NPL using PerkinElmer Elan DRC II and Elan 9000 ICP-MSs, following NPL's procedure, accredited by UKAS to ISO 17025, which is fully compliant with the requirements of EN 14902 (see Image 3).

Upon arrival at NPL, the filters were cut accurately in half, and each portion digested at temperatures up to 220°C using an Anton Parr Multiwave 3000 microwave. The digestion mixtures used were:

- Hg & Pt: 5 ml of nitric acid and 5 ml hydrochloric acid.
- All other metals: 8 ml of nitric acid and 2 ml hydrogen peroxide.

ICP-MS analysis of the digested solutions took place using at least four gravimetrically-prepared calibration solutions. A quality assurance (QA) standard was repeatedly analysed (after every two solutions), and the change in response of the QA standard was mathematically modelled to correct for the long-term drift of the instrument. The short-term drift of the ICP-MS was corrected for by use of an internal standards mixture (containing Y, In, Bi, Sc, Ga & Rh) continuously added to all the samples via a mixing block. Each sample was analysed in triplicate, each analysis consisting of five replicates.

The amount of each metal in solution (and its uncertainty) was then determined by a method of generalised least squares using XLGenline (an NPL-developed program) to construct a calibration curve.

3.4 ANALYTICAL METHODOLOGY: TOTAL GASEOUS MERCURY

Analysis of total gaseous mercury samples took place at NPL using a PS Analytical Sir Galahad II analyser with a fluorescence detector, using NPL's procedure, accredited by UKAS to ISO 17025, which is in accordance with the published standard method EN 15852 (see Image 4). The instrument was calibrated by use of a gas-tight syringe, making multiple injections of known amounts of mercury vapour onto the permanent trap of the analyser.

Sampled adsorption tubes were placed in the remote port of the instrument and heated to 900°C, desorbing the mercury onto a permanent trap. Subsequent heating of this trap then desorbed the mercury onto the detector.

3.5 MEASUREMENT UNITS

Results produced by the Network are expressed as required by the relevant air quality Directives as mass concentrations, in nanograms (of the relevant metal) per cubic metre of 'as sampled' ambient air for the particulate phase metals, and per cubic meter of air under reference conditions (at a temperature of 293.16 K and pressure of 101.325 kPa) for total gaseous mercury. The units used in both cases are: ng m^{-3}.

3.6 MEASUREMENT UNCERTAINTY

For each result produced by the Network an estimate of the uncertainty in this value is also made according to an ISO GUM (Guide to the Expression of Uncertainty in Measurement) approach. These uncertainties are used to calculate the uncertainties in the annual average values for each element and ensure that the final results meet the data quality objectives for uncertainty specified in the relevant legislation.

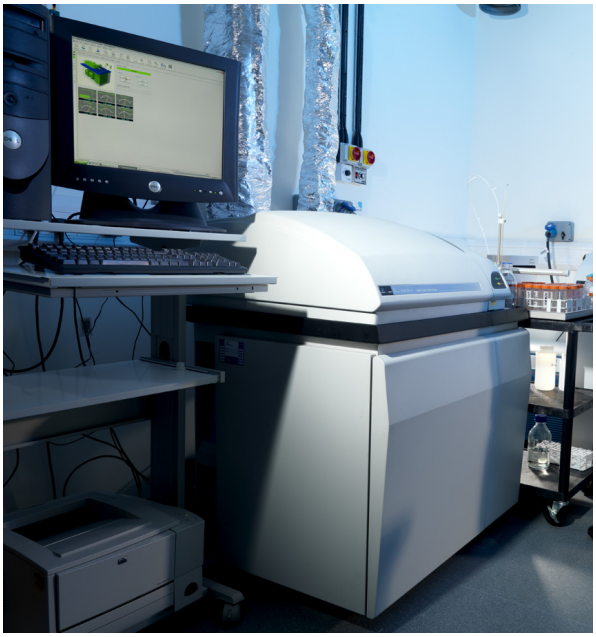

Image 3: One of two dedicated ICP-MS instruments comprising the UK ambient metals analysis facility at NPL.

Image 4: One of two thermal desorption-atomic fluorescence analysers comprising the UK total gaseous mercury analysis facility at NPL

4 METHOD PERFORMANCE CHARACTERISTICS AND QUALITY CONTROL

The application of the technical procedures used to analyse samples from the Network (metals in the particulate phase by ICP-MS, and mercury vapour by atomic fluorescence spectroscopy) was audited by UKAS, and both retained accreditation to ISO 17025 from UKAS with no mandatory corrective actions, in 2010.

4.1 LIMITS OF DETECTION: PARTICULATE-PHASE METALS

Indicative detection limits achievable by NPL using a UKAS accredited ICP-MS method, fully compatible with EN 14902, are shown in Table 1. The solution limits of detection were calculated using the method outlined in EN 14902, repeatedly analysing a typical acid blank solution and taking into account the variability between individual instrumental readings. Values for the limits of detection have been calculated assuming a solution mass of 53 g and a volume of sampled air of 168 m^3 (equivalent to seven days sampling at 1.0 $m^3 h^{-1}$).

Analyte	Limit of Detection		
	Solution ($ng\ g^{-1}$)	Filter (ng)	Air ($ng\ m^{-3}$)
As	0.08	4.2	0.03
Cd	0.003	0.16	0.001
Cr	0.08	4.1	0.02
Cu	0.07	3.6	0.02
Fe	0.5	25	0.15
Mn	0.009	0.5	0.003
Ni	0.03	1.7	0.01
Pb	0.04	2.0	0.01
Pt	0.003	0.2	0.001
V	0.007	0.4	0.002
Zn	0.2	11	0.06
Hg(p)	0.003	0.2	0.001

Table 1. Indicative limits of detection for particulate-phase metals.

The detection limits for Pt and Hg(p) have recently been significantly improved owing to technical improvements in the analysis procedure – this now means that mass concentration values for these very low concentration pollutants may now be quoted at the $pg\ g^{-1}$ level.

4.2 LIMITS OF DETECTION: TOTAL GASEOUS MERCURY

The limit of detection routinely achievable for analysis of total gaseous mercury at NPL using its UKAS accredited procedure, which is consistent with the standard method EN 15852, is 0.02 ng per tube, equivalent to an air concentration of approximately 0.02 ng m^{-3} (assuming a volume of sampled air of 1.01 m^3, equivalent to one week's sampling at 100 ml min^{-1}). This value was calculated using a minimum detectable peak height of three times the baseline noise (with the instrument detector being operated at its usual sensitivity setting).

4.3 QA/QC PROCEDURES

A sub-set of the quality assurance and quality control procedures employed during Network operation to ensure the quality of the data produced are listed below:

Sampling:

- Despatch and analysis of one field-blank filter and one field-blank adsorption tube per site per quarter.
- Thorough checks of the returned filters and adsorption tubes to check for damage during transport. Rejection of damaged filters or tubes.
- Logging of all samples on NPL's Network database. Rejection of any unidentifiable samples and full investigation of any discrepancies.
- Continued training of, and regular communication with, the LSOs. This includes assessment of performance during site audits.

Particulate phase metals (ICP-MS analysis):

- Optimisation of the ICP-MS prior to each set of analysis. Comparison of the optimised parameters with pre-defined criteria.
- Regular extraction of an appropriate certified reference material (e.g. NIST SRM 1648a or NIES No.8) to check the recovery of the digestion method. Recoveries must be within the limits specified by EN 14902.
- Regular measurement of filter blanks to ensure appropriate blank subtractions are made from measured values.
- Maximum levels for the standard deviation of the five internal standard-corrected measured intensities of each analysis of each sample.
- The XLGenline maximum absolute weighted residual for all calibration curves must be less than 1.
- Ratification of all data by an NPL Quality Circle of recognised senior NPL scientific experts independent of the analytical team.

Total gaseous mercury (atomic fluorescence analysis):

- Regular recovery tests carried out by analysing tubes spiked with a known quantity of mercury. Recoveries of between 95% and 105% must be achieved.
- Control limits on changes in instrument sensitivity between analyses.
- Analysis of clean tubes to ensure that blank levels are sufficiently low.
- Novel bracketing calibration procedure for each tube analysed in order to minimise the effect of instrumental drift.
- Ratification of all data by an NPL Quality Circle of recognised senior NPL scientific experts independent of the analytical team.

4.4 MEASUREMENT UNCERTAINTY

The average uncertainty from the analyses of single filters and tubes at NPL during 2010 are shown in Table 2. All figures are a combination of the analytical and sampling uncertainties and have been derived using full, ISO GUM compliant, uncertainty budgets. All values are stated to a coverage factor of k = 2, providing a level of confidence of approximately 95%.

Analyte	**Expanded relative uncertainty**	
	Single measurement average	EC Directive maximum
As	20 %	40 %
Cd	15 %	40 %
Cr	18 %	-
Cu	12 %	-
Fe	12 %	-
Mn	12 %	-
Ni	13 %	40 %
Pb	12 %	25 %
Pt	40 % ‡	-
V	13 %	-
Zn	12 %	-
Hg(p)	34 %	-
Hg(v)	17 %	50 %

Table 2. Average measurement uncertainties achieved at NPL during 2010. The 'EC Directive maximum' column shows the maximum permissible uncertainty at the target value allowed by the relevant EU Air Quality Directive. Hg(p) and Hg(v) are particulate phase mercury, and total gaseous mercury, respectively. ‡ Many Pt measurements are below the limit of detection, the uncertainty quoted refers to those measurements that are above the detection limit.

The measurement uncertainties displayed in Table 2 are representative of individual measurements averaged over a typical sampling period (here, one week), as required by the EU Air Quality Directives. The vast majority of the measurements used to compile the data in Table 2 were of ambient concentrations well below the appropriate target values. It is calculated that in the region of the appropriate target value – where the EU Air Quality Directive's uncertainty data quality objectives apply (except for Hg(v) where there is no target value) – these relative uncertainties will be significantly lower.

5 DATA QUALITY

5.1 DATA CAPTURE

All data capture figures are based on a target time coverage of 100 %. (The Fourth DD requires a time coverage of only 50 % for fixed measurements of As, Ni and Cd.) Therefore any lost time coverage has a direct and equal effect on the data capture achieved. This is the most stringent way by which to calculate data capture percentages and represents the absolute percentage of all available time during the year for which valid data has been produced.

Data capture across the entire Network during 2010 was **96%**. Of the data lost approximately:

- Approximately 50 % was excluded because the minimum number of valid sampling hours was not achieved during the sampling period;
- Approximately 50 % was lost owing to equipment failure or site operation problems, and;
- Less than 1 % was excluded at the analytical stage (owing to contamination of samples, instrument failure, exclusion during data ratification, etc).

The breakdown of the overall data capture between the particulate and gaseous phase, and at each site, is displayed in Table 3. The quarterly data capture, and the rolling annual average data capture, achieved by the Network over the last six years are displayed in Figure 3. The yearly average data capture is currently at its highest level since NPL began operating the Network.

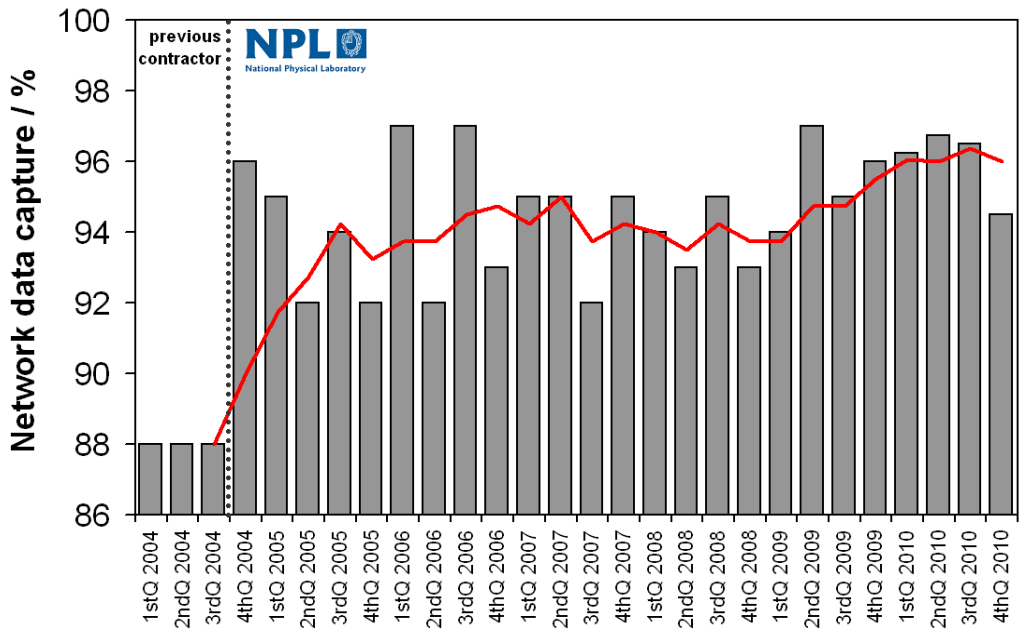

Figure 3. Network data capture from 2004-2010 (inclusive). Quarterly data capture is indicated by the grey bars, whilst the rolling annual average data capture is given by the red line. Data to the right of the dotted vertical line is associated with NPL's current operation of the Network; data to the left of the dotted line is associated with the previous contractor's operation of the Network.

Location	Data Capture / %	
	Particulate phase	**Gaseous phase**
Whole Network	**96 %**	**98 %**
46: Walsall Centre	92 %	98 %
47: Bristol Avonmouth	100 %	100 %
56: Bristol Hallen	100 %	*N/A*
58: Sheffield Brinsworth	98 %	*N/A*
59: Runcorn Weston	93 %	94 %
61: London Cromwell Road 2	96 %	100 %
62: London Westminster	98 %	100 %
65: Eskdalemuir	97 %	100 %
66: Motherwell South	90 %	90 %
67: Manchester Wythenshawe	96 %	100 %
68: Cardiff Llandaff	96 %	100 %
69: Walsall Bilston Lane	94 %	98 %
100: Swansea Coedgwilym	98 %	*N/A*
101: Swansea Morriston	98 %	98 %
103: Belfast Centre	100 %	96 %
104: Port Talbot Margam	100 %	*N/A*
105: Sheffield Centre	98 %	100 %
106: Scunthorpe Town	98 %	*N/A*
107: Scunthorpe Low Santon	100 %	*N/A*
108: Redcar	96 %	*N/A*
109: Cardiff Rumney	98 %	*N/A*
110: Chadwell St Mary	100 %	*N/A*
111: Redcar Normanby	100 %	*N/A*
112: Dartford Bean	93 %	*N/A*

Table 3. Data capture across the UK Heavy Metals Monitoring Network during 2010.

5.2 DATA PROCESSING AND RATIFICATION

Analysis of the Network samples produces individual concentration values for weekly, or for some mercury adsorption tubes, monthly periods. These individual measurement results each have a stated measurement uncertainty, quoted at the 95% confidence level, associated with them. Monthly concentrations at each site are then calculated as the means of weekly measurement data, using appropriate time weighting when exposure periods cover the change of month. Annual means at each site are produced by calculating the means of the monthly values, weighted according to the data capture each month. Network-wide annual means are then produced by averaging annual means from the individual sites, again using appropriate weighing if a site has been monitoring for less than the full year.

An NPL QA/QC circle (the 'quality circle') ratifies ambient concentration data produced by the UK Heavy Metals Monitoring Network. NPL personnel performing the ratification procedure are independent of the Network analysis and management process. It is the aim of the ratification procedure to distinguish between changing ambient concentrations (including long terms trends, seasonal variation and single pollution events), and analytical discrepancies within the large amount of Network data. Ratification takes place in accordance with several guidelines, outlined below:

1) Only data where the valid sampling hours are greater or equal to 75% of the total sampling hours will be eligible to produce valid concentration data, and count towards the total data capture percentage.

2) Data not meeting the data quality objectives for uncertainty or time coverage for the relevant air quality directive are not eligible to produce concentration data and is counted as lost data capture.

3) Data excluded following the ratification procedure will also not be eligible to produce valid concentration data, or count towards the total data capture percentage.

4) Upon production, weekly data for each element at each site is plotted in a time series, or displayed as a continuous list of values which may be easily compared.

5) In the first instance these data are assessed visually for any obvious discrepancies with due regard to long terms trends, short term variability and seasonal variation. Then outlier tests are performed to detect any potentially discrepant data, including the use of powerful chemometric techniques[10].

6) If valid reasons for obviously discrepant values are found (e.g. incorrect calculation, low exposure time, non-valid exposure volume, analytical error) these values may be either excluded or corrected (depending on the nature of the error).

7) As part of the internal quality and technical auditing procedures, a selection of ambient air concentrations calculated each month are thoroughly audited by a party independent of the analysis procedure. For these samples, the sample number, target analyte, auditor, audit date and status of the data is recorded in the designated Excel spreadsheet after auditing. These audits concentrate most heavily on Ni, As, Cd, Pb and Hg vapour analyses, as these are directly relevant to EC Air Quality Directives.

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10 Using principal component analysis to detect outliers in ambient air monitoring studies, Brown, R J C, Goddard, S L, Brown, A S, *International Journal of Environmental Analytical Chemistry*, 2010, **90,** 761–772.

5.3 MEASUREMENT UNCERTAINTY OF ANNUAL AVERAGE

ISO 11222 “Air quality - Determination of the uncertainty of the time average of air quality measurements” is used to determine the uncertainty in the annual mean for each element at each sampling location. This is easily done since NPL produce a statement of uncertainty with each measurement result.

Data capture across the Network remains high (and any gaps in coverage have generally occurred evenly throughout the year) the uncertainty in the annual mean values will be dominated by the analytical and sampling uncertainty, with only small uncertainty contributions due to less than 100% time coverage. (The effect of these contributions are calculated using the method described in ISO 11222 “Air quality - Determination of the uncertainty of the time average of air quality measurements”.)

In all cases annual mean uncertainties are compliant with the data quality objectives for uncertainty in the EC Air Quality Directives. Expanded uncertainties, quoted at the 95% confidence interval, for the annual mean concentration values of the relevant EC Air Quality Directives metals are given in the table below:

Analyte	Relative Expanded Uncertainty	
	Annual Mean	DD maximum
As	22 %	40 %
Cd	17 %	40 %
Ni	15 %	40 %
Pb	15 %	25 %
Hg(v)	21 %	50 %

Table 4. Relative expanded uncertainties, quoted at the 95% confidence interval, for the annual mean concentration values of the relevant Daughter Directive metals, averaged across the Network. Hg(v) refers to total gaseous mercury. For Hg(v) there is no limit or target value stated in the Fourth DD at which this maximum allowable uncertainty applies.

6 NETWORK DATA

6.1 MEASURED CONCENTRATIONS

The annual mean measured metals concentrations, averaged over all sites (Table 5), and at individual sites (Table 6), are given below. Table 5 also displays the maximum annual mean concentration measured at any monitoring site across the Network and the median annual concentration across all sites. In addition all data is available from Defra's UK-AIR website: http://uk-air.defra.gov.uk/data/

Analyte	2010 UK Mean Annual Concentration / ng m^{-3}	2010 UK Median Annual Concentration / ng m^{-3}	2010 Maximum Annual Mean Concentration / ng m^{-3}	EC limit or target value (UK objective) / ng m^{-3}
As	0.75	0.77	1.16	6
Cd	0.27	0.19	1.87	5
Cr	3.53	2.03	30.1	-
Cu	14.0	7.82	46.5	-
Fe	505	317	2495	-
Mn	12.5	7.52	74.1	-
Ni	2.68	1.24	14.5	20
Pb	12.5	10.6	47.2	500 (250)
Pt	0.002	<0.001	0.008	-
V	1.46	1.20	3.51	-
Zn	39.8	23.1	340	-
Hg(p)	0.043	0.015	0.57	-
Hg(v)	3.18	2.13	17.9	-

Table 5. The 2010 annual mean concentrations averaged over all sites on the UK Heavy Metals Monitoring Network, the annual median concentrations across all sites, and the maximum annual mean concentration measured at any monitoring site. Hg(p) and Hg(v) are particulate phase mercury, and total gaseous mercury, respectively. The EC limit or target value (and/or UK objective, in brackets) is also listed, where applicable.

The improvements in the detection limits for Pt and Hg(p) have meant that the concentrations for these metals are able to be stated with pg g^{-1} level sensitivity for the first time. This has enabled more accurate time-averaged values to be produced for these metals in ambient air – previously too many values below the detection limit, especially for Pt, had made assessment of such summary statistics very difficult.

The UK monthly mean concentrations of each element during 2010 are shown in Figure 4. Monthly data for each element at each monitoring site are given in Annexes 2 and 3.

2010 Annual Mean Concentration / ng m^{-3}													
Site	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg (p)**	**Hg (v)**
46: Walsall Centre	0.92	0.38	2.46	12.9	320	9.8	1.10	14.6	0.001	1.16	53.0	0.025	2.28
47: Bristol Avonmouth	0.69	0.35	1.47	5.5	283	6.2	1.10	11.0	<0.001	1.92	30.6	0.032	2.13
56: Bristol Hallen	0.67	0.26	0.93	5.5	185	3.8	0.58	8.0	<0.001	1.14	18.9	0.024	N/A
58: Sheffield Brinsworth	1.16	0.39	31.1	21.0	509	28.9	14.7	20.4	0.002	1.60	97.7	0.047	N/A
59: Runcorn Weston Point	0.84	0.17	1.39	6.7	205	4.2	1.03	10.4	0.001	1.50	17.9	0.561	17.9
61: London Cromwell Road 2	0.77	0.15	4.72	42.1	818	8.5	1.63	10.3	0.004	1.97	23.8	0.017	1.94
62: London Westminster	0.69	0.15	1.84	16.6	430	5.7	1.45	10.5	0.003	1.91	18.8	0.021	2.21
65: Eskdalemuir	0.14	0.02	0.78	0.4	31	0.9	0.15	1.3	<0.001	0.35	2.5	0.004	1.69
66: Motherwell South	0.76	0.24	0.99	6.1	173	3.6	0.32	16.8	<0.001	0.47	27.2	0.009	2.94
67: Manchester Wythenshawe	0.99	0.18	5.43	46.5	1092	11.5	1.63	10.2	0.008	1.16	35.2	0.020	2.13
68: Cardiff Llandaff	0.80	0.18	3.07	23.8	708	9.7	1.01	8.5	0.005	1.19	27.4	0.013	1.35
69: Walsall Bilston Lane	1.16	1.87	4.29	43.1	411	12.6	1.68	47.2	0.001	1.22	340	0.077	2.46
100: Swansea Coedgwilym	0.76	0.19	3.25	4.0	168	3.9	10.5	8.4	<0.001	0.85	13.8	0.018	N/A
101: Swansea Morriston	0.88	0.30	2.85	37.3	582	8.9	15.3	18.1	0.001	1.03	35.4	0.011	1.49
103: Belfast Centre	0.51	0.13	1.55	8.2	261	4.0	0.71	4.7	0.005	1.41	14.2	0.007	1.91
104: Port Talbot Margam	0.72	0.33	2.21	7.3	2486	37.6	1.51	11.3	<0.001	1.85	54.0	0.013	N/A
105: Sheffield Centre	0.69	0.18	5.25	10.7	318	12.1	2.49	11.2	0.001	0.92	25.8	0.038	1.72
106: Scunthorpe Town	0.78	0.14	2.68	5.1	610	21.9	0.81	14.3	<0.001	1.37	21.3	0.018	N/A
107: Scunthorpe Low Santon	0.80	0.15	3.03	4.2	1346	74.1	1.01	25.7	<0.001	3.55	24.1	0.016	N/A
108: Redcar	0.62	0.15	1.40	3.4	313	9.8	2.22	6.8	<0.001	1.13	17.1	0.011	N/A
109: Cardiff Rumney	0.78	0.19	1.50	6.5	239	6.5	0.83	8.3	<0.001	1.14	21.5	0.013	N/A
110: Chadwell St Mary	0.78	0.25	1.31	9.4	252	4.7	1.80	10.9	0.001	3.26	22.3	0.014	N/A
111: Redcar Normanby	0.44	0.08	0.47	2.2	103	3.5	0.39	4.3	<0.001	0.67	8.9	0.010	N/A
112: Dartford Bean	0.81	0.18	1.32	8.6	199	3.9	1.37	8.8	0.001	2.46	15.8	0.013	N/A

Table 6. The 2010 annual mean concentrations measured at individual sites on the UK Heavy Metals Monitoring Network. The monthly measured metals concentrations from all Network sites are summarised in the tables in Annex 3. Hg(p) and Hg(v) are particulate phase mercury, and total gaseous mercury, respectively. Colour coding for concentrations: **above target value**, **above upper assessment threshold**, **above lower assessment threshold**, **below lower assessment threshold.**

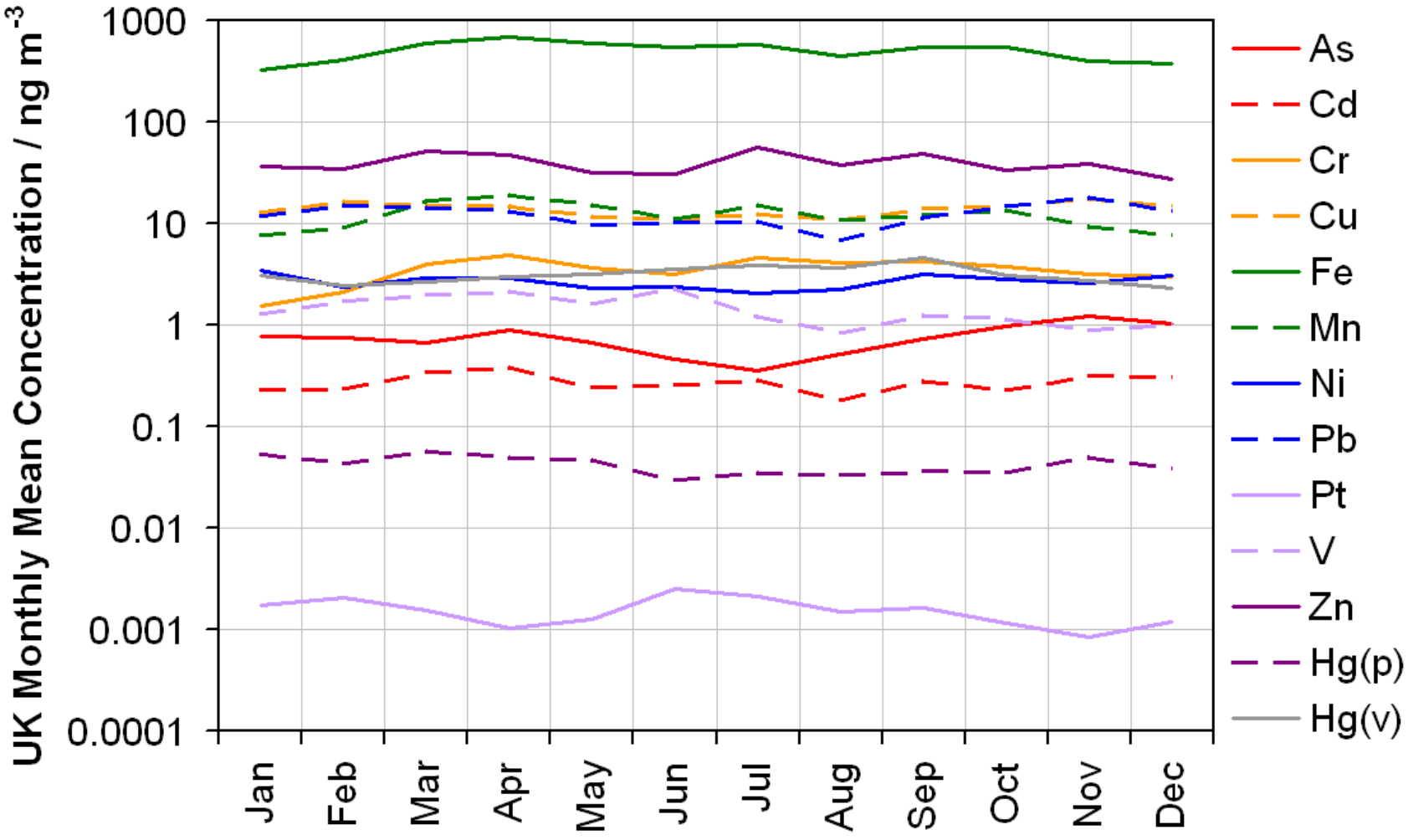

Figure 4. The measured UK monthly mean concentrations of each metal during 2010. Hg(p) and Hg(v) are particulate phase mercury, and total gaseous mercury, respectively.

6.2 MEASURED CONCENTRATIONS WITH RESPECT TO THE REQUIREMENTS OF THE EU AIR QUALITY DIRECTIVES

The annual mean concentrations are compared against the relevant limit and target values, contained within the EU Air Quality Directives, in the figure below:

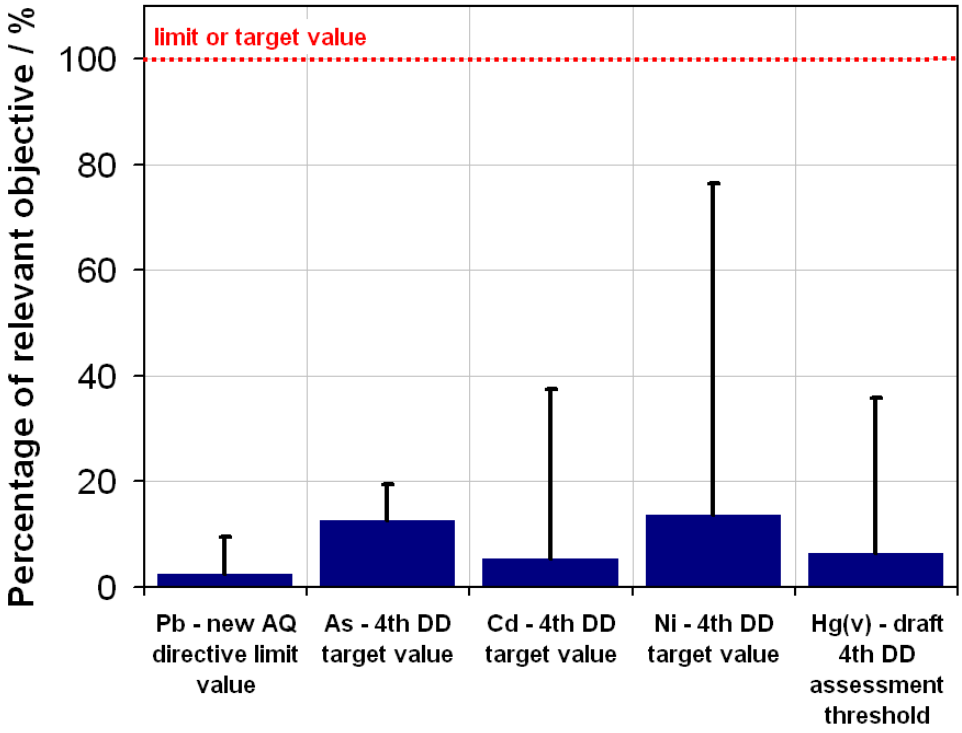

Figure 5. A summary of the annual mean measured concentrations of the heavy metals relevant to the New Air Quality Directive and Fourth Daughter Directives on the UK Heavy Metals Monitoring Network in 2010 as a percentage of the relevant air quality objectives. The bars indicate the annual mean of all sites; the lines indicate the annual means at the site with the highest concentrations. Hg(v) refers to the total gaseous mercury concentrations. The mercury objective is taken from a threshold value quoted in a draft of the Fourth DD.

In all cases the annual mean values are well below the limit and target values. Additionally the highest annual average at an individual site does not exceed any target or limit values.

Annual mean concentration values for the relevant EC Air Quality Directives metals at all Network sites are displayed in Figure 6.

The highest annual mean value for nickel has been found at Site 101: Swansea Morriston. The highest annual mean values for cadmium, arsenic and lead are found at Site 69: Walsall Bilston Lane. The highest annual mean value for total gaseous mercury has been found at Site 59: Runcorn Weston Point.

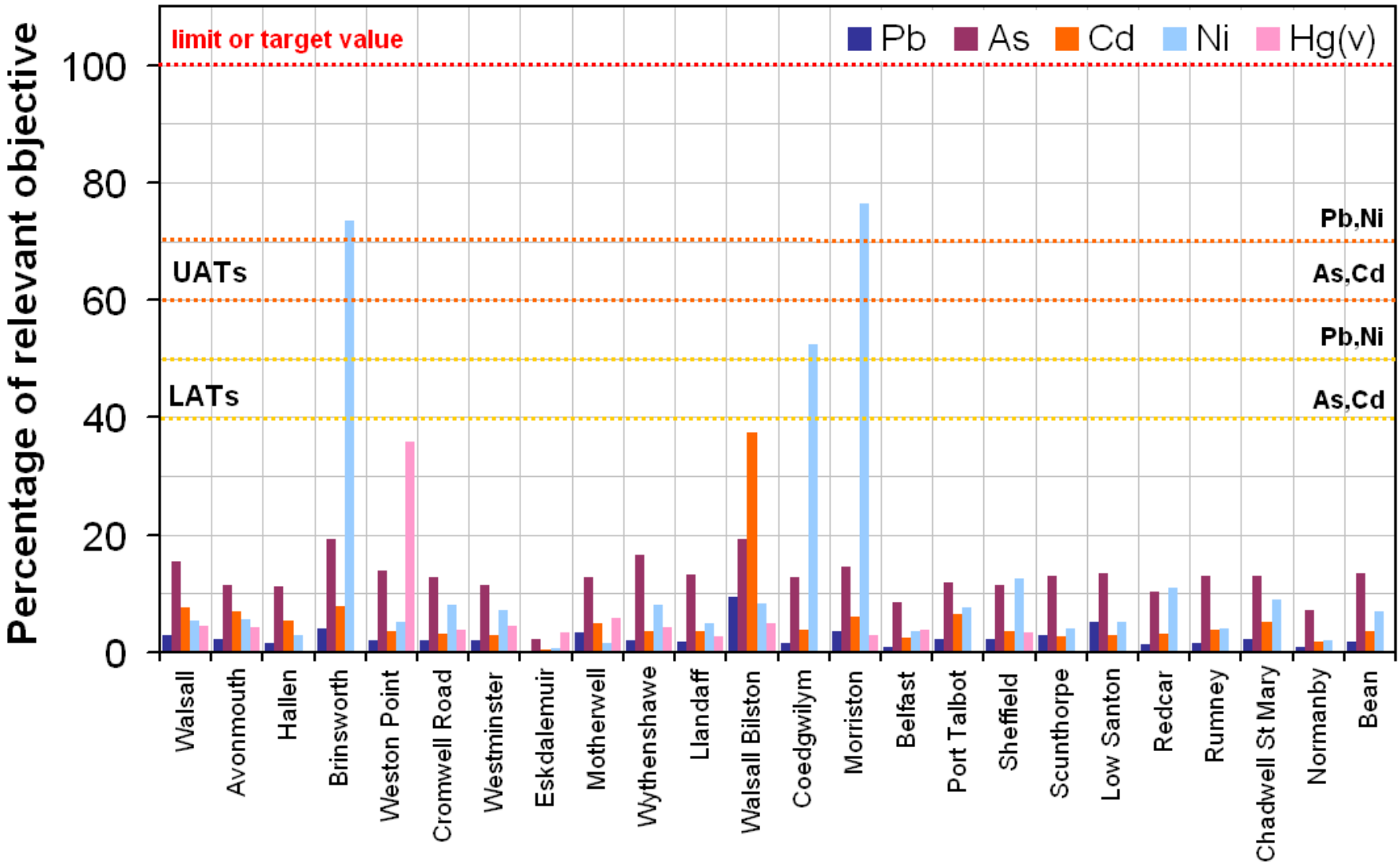

Figure 6. A summary of the annual mean measured concentrations of the heavy metals relevant to the New Air Quality Directive and Fourth DD at all sites on the UK Heavy Metals Monitoring Network in 2010 as a percentage of the relevant target values, lower assessment thresholds (LATs) and upper assessment thresholds (UATs). The mercury objective originates from a threshold value quoted in a draft of the Fourth DD. Hg(v) represents total gaseous mercury.

In only three instances do the measured annual mean values exceed the relevant lower assessment thresholds:

Annual Mean Concentrations above Target or Limit Values:

- None

Annual Mean Concentrations above the Upper Assessment Threshold:

- Nickel at Site 101: Swansea Morriston: 76 % of the target value.
- Nickel at Site 58: Sheffield Brinsworth: 73 % of the target value.

Annual Mean Concentrations above the Lower Assessment Thresholds:

- Nickel at Site 100: Swansea Coedgwilym: 52 % of the target value.

All other annual mean values at all sites for Ni, As, Cd and Pb are below the relevant Lower Assessment Thresholds.

Notable Concentrations:

- Cadmium at Site 69: Walsall Bilston Lane: 37 % of the target value, and close to the lower assessment threshold.
- Total gaseous mercury at Site 59: Runcorn Weston Point. The measured concentration represents 36 % of the target value of 50 ng m^{-3} quoted in a draft version of the Fourth DD.

The site at Swansea Coedgwilym is situated near to the Vale nickel refinery in Clydach, producing speciality nickel products and nickel-coated materials. The site at Swansea Morriston is the upwind pair of the Swansea Coedgwilym site but may also be exposed to relatively high concentrations when the wind is not in the prevailing direction. Indeed, in 2010 there was an unusually high frequency of north easterly winds. In 2010 the Swansea Morriston site recorded a higher value that the Swansea Coedgwilym site, partly as a result of a very high monthly average in January, and possibly also as a result of the unusually frequent north-easterly winds during the year.

The site at Sheffield Brinsworth is located next to the Outokumpu steel rolling mill and processing plant producing specialist steel strip, and coil, products.

The site at Walsall Bilston Lane, is close to Brookside Metal Company the UK's largest producer of gunmetal, brass, bronze and other copper alloy ingots.

The site at Runcorn Weston Point is in the vicinity of a chlor-alkali facility using some mercury-based technology.

6.3 MEASURED CONCENTRATIONS OF NON-DIRECTIVE METALS

Figure 7 shows the concentrations of the other non-directive metals normalised to the annual average for each metal.

As expected, downwind sites all exhibit higher measured concentrations than their respective upwind site pairs (except for the two Swansea sites – see Section 6.2). This continues to provides extra confidence that the direction of the prevailing weather conditions has been correctly assessed at each location and that the monitoring site pairs have been properly located. However, the concentrations recorded to date at these new sites are well below those predicted in the report[11] that recommended the locations of these sites based on modelled exceedences of lower assessment thresholds in the vicinity of point sources. This may be because the model over-estimated fugitive emissions around these point sources.

High concentration values for non-Directive metals are usually owing to specific process close to the monitoring sites concerned. For instance:

- Copper at roadside sites such as London Cromwell Road, Swansea Morriston and Manchester Wythenshawe;
- Iron and Manganese at Port Talbot AURN and Scunthorpe Low Santon, near to steel works;
- Chromium at Sheffield Brinsworth near to a steel rolling mill;
- Particulate phase mercury at Runcorn Weston Point close to a chlor-alkali plant;
- Copper and zinc at Walsall Bilston Lane close to a metal refining works.

11 AEAT Report AEAT/ENV/2243 “Preliminary Assessment of PAH and heavy metal levels in the UK”, Bush, T, AEAT, February 2007.

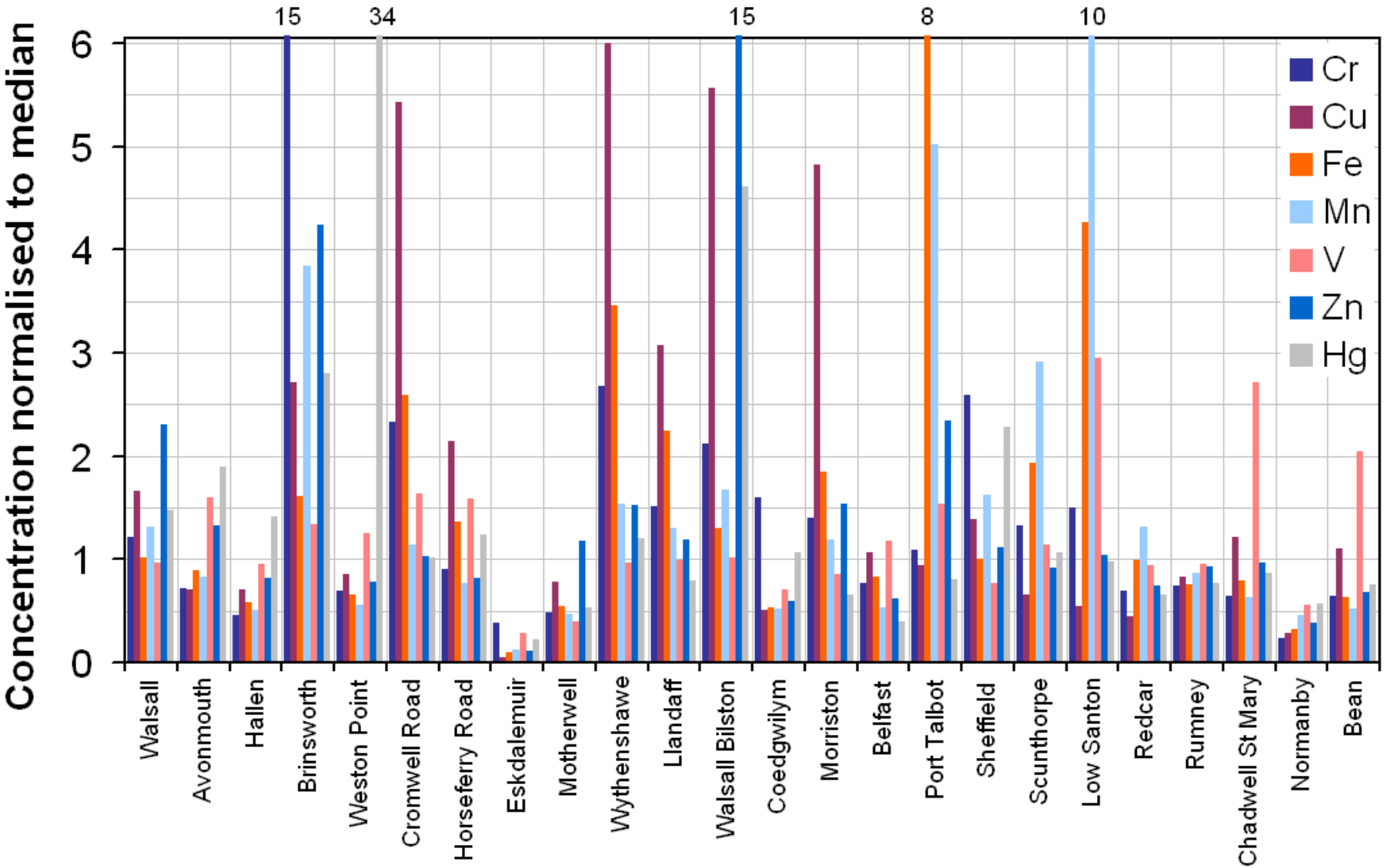

Figure 7. A summary of the annual mean measured concentrations of the non-directive metals at all sites on the UK Heavy Metals Monitoring Network in 2010, normalised to the UK annual median concentration for the relevant element. Bars that are off-scale have their values indicated at the top of the chart. Hg refers to particulate phase mercury.

6.5 RATIO OF TOTAL GASEOUS MERCURY TO PARTICULATE PHASE MERCURY

Figure 8 shows the relationship between particulate and vapour phase mercury measurements during 2010 where these are measured together on the Network.

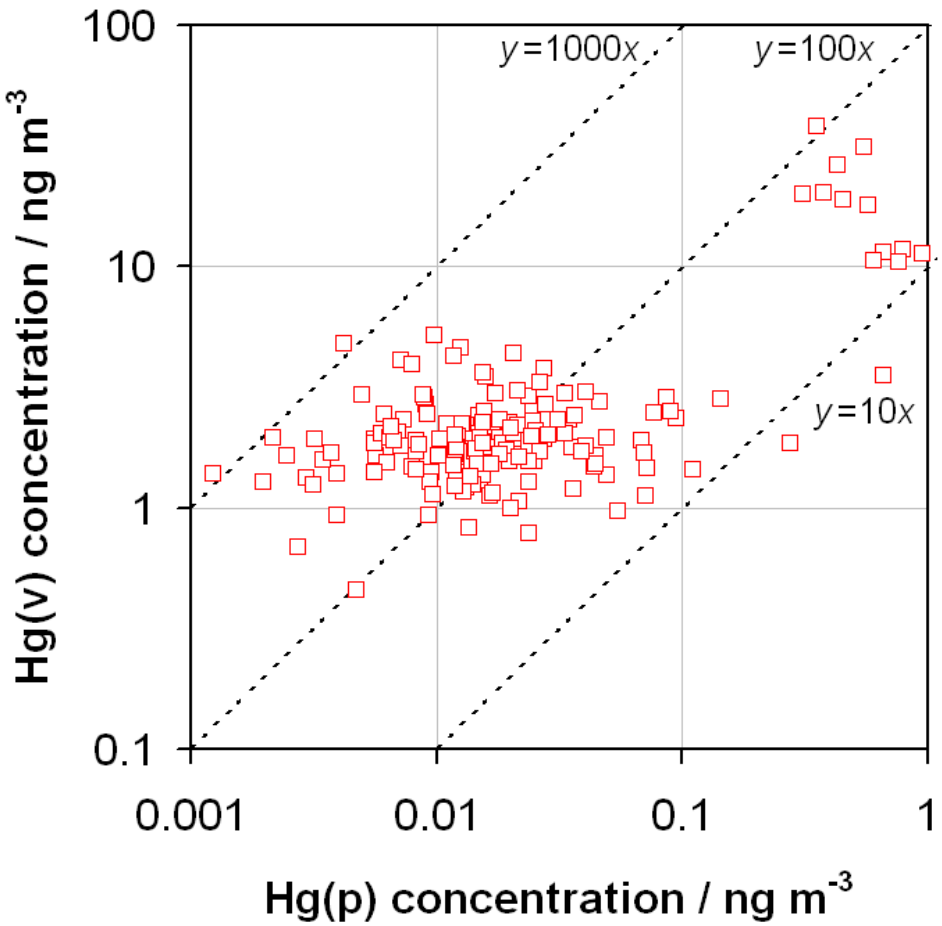

Figure 8. The relationship between monthly particulate [Hg(p)] and total gaseous [Hg(v)] mercury measurements during 2010 where these are made together. The dotted diagonal lines represent the locus of points for which the total gaseous mercury concentration (*y*) are 10, 100 and 1000 times greater than the measured particulate phase mercury concentrations (*x*), as indicated.

Figure 8 shows that in almost all cases the total gaseous to particulate mercury concentration ratio during 2010 was greater than 10 (99 % of all data points), with the majority of measurements displaying a ratio of between 10 and 100 (48 % of all data points) or between 100 and 1000 (49 % of all data points). Some ratios (about 2 % of all values) are in excess of 1000. This demonstrates that the overwhelming majority of mercury in ambient air is present in the gaseous phase, at sites where these are measured together. The overall average total gaseous to particulate mercury concentration ratio during 2010 was 150.

The table below shows the annual average total gaseous mercury to particulate phase mercury ratio at each site on the Network measuring both species.

Site	Annual average Hg(v) to Hg(p) ratio
46: Walsall Centre	**93**
47: Bristol Avonmouth	**68**
59: Runcorn Weston Point	**31**
61: London Cromwell Road	**114**
62: London Horseferry Road	**107**
65: Eskdalemuir	**457**
66: Motherwell South	**331**
67: Manchester Wythenshawe	**106**
68: Cardiff Llandaff	**102**
69: Walsall Bilston Lane	**32**
101: Swansea Morriston	**136**
103: Belfast Centre AURN	**286**
105: Sheffield Centre AURN	**45**

Figure 7. The 2010 annual average total gaseous mercury to particulate phase mercury ratio at each site on the Network measuring both species.

It is clear that there is some correlation between site type and the ratio observed. In general total gaseous mercury levels are similar across the country because of the long-range transport and relatively long atmospheric lifetime of this species compared to particulate bound metal species. In contrast, particulate bound mercury concentrations will be strongly related to distance from significant emissions sources. Hence industrially impacted sites such as Runcorn Weston Point (where both Hg(v) and Hg(p) are very high), Sheffield Centre, Walsall Centre, and Walsall Bilston Lane, show low ratios because of their relatively high Hg(p) levels. Sites impacted mostly by traffic emissions, such as London Cromwell Road, London Horseferry Road, Manchester Wythenshawe, Bristol Avonmouth, Cardiff Llandaff and Swansea Morriston, with intermediate Hg(p) levels show intermediate ratios. Sites in rural locations, such as Eskdalemuir, or in urban areas not close to significant traffic emissions, such as Belfast Centre and Motherwell South, show the highest ratios.

The mean monthly total gaseous mercury to particulate phase mercury ratios at each site are shown in Annex 2.

7 TRENDS IN MEASURED CONCENTRATIONS

7.1 UK TRENDS

Changes in the annual median metals concentrations measured, across the Network, over the past 30 years are shown in the table below. The median has been chosen since it is less sensitive to the effect of significant changes in sites measuring high concentrations from year to year.

Analyte	Changes in measured concentrations over the:			
	Last 30 Years	Last 10 Years	Last 5 Years	Last Year
As	not measured	not measured	-32%	+9%
Cd	-92%	-48%	-52%	-10%
Cr	-79%	-75%	-38%	-15%
Cu	-70%	-35%	-41%	-13%
Fe	-57%	-29%	+7%	+1%
Hg(p)	not measured	not measured	N/A*	-3%
Hg(v)	not measured	not measured	+28%	+11%
Mn	-64%	-7%	+17%	+7%
Ni	-89%	-69%	-64%	-2%
Pt	not measured	not measured	N/A*	-53%
V	-94%	-47%	-66%	-26%
Zn	-81%	-26%	-13%	-15%
Pb	-98%	-61%	-31%	-8%

Table 8. Trends in the measured annual average concentrations of metals measured by the UK Heavy Metals Monitoring Network. Hg(p) and Hg(v) are particulate phase mercury, and total gaseous mercury, respectively. (*Since monitoring began, average annual concentrations levels for Pt and Hg at some sites have been below the detection limit, although the improvement in detection limits recently means that producing trends is now possible – although the uncertainty in these trends are large.)

Measurements of annual mean concentrations for all elements have generally fallen year upon year over the period for which data is available – this generally mirrors the decrease in emissions over this period. Further details and interpretation of these data and trends is available[12]. This trend has, in the most part, continued over the last year. The trends for individual elements are discussed in more detail below:

Arsenic: Levels are uniformly low across the Network but showed a small increase in 2009 and in 2010. However, concentrations have fallen by over 30 % in the last 5 years.

Cadmium: Concentrations are low across the Network, with the exception of Walsall Bilston Lane, and have decreased further in 2010.

Chromium: Levels have decreased during 2010. Measured concentrations have decreased by almost 80% since 1980. The annual mean is dominated by the levels measured at Sheffield Brinsworth where concentrations are over 10 times those measured elsewhere in the UK.

Copper: Concentrations of this metal decreased in 2010. The highest values are recorded at roadside sites.

Iron: Following the increase in levels in 2008, primarily because the recent Network re-organisation encompassed a large number of point sources located around steel plants, levels decreased slightly in 2009 and have stayed very similar in 2010. However, concentrations are still in excess of those recorded 5 years ago. Iron remains the most abundant metal measured by the Network by almost an order of magnitude, over zinc.

Particulate phase mercury: Levels are extremely low across the whole Network and have shown a slight fall in 2010. Hg(p) mean concentrations are dominated by concentrations measured at Runcorn Weston Point, and in turn concentrations of total ambient mercury are dominated by total gaseous mercury.

Total gaseous mercury: Concentrations have shown a slight increase over the last year. Median concentrations have varied relatively little since widespread monitoring began in 2004. Hg(v) undergoes long-range transport and is thus observed concentrations are much less related to local sources than the particulate bound metals measured by the Network. The average concentration of Hg(v) in 2010 was over 160 times that of Hg(p). Mean recorded concentrations, for total gaseous mercury are strongly influenced by the very high levels at Runcorn Weston Point.

Manganese: Median concentrations increased slightly in 2010, but mean concentrations decreased slightly over the year. The mean concentration is dominated a large number of point sources located around steel plants, where the concentrations measured have decreased in 2009 and in 2010.

Nickel: Concentrations showed a slight decrease in 2010: however in general concentrations are very low across the Network. The relatively high values recorded at Swansea Coedgwilym, Swansea Morriston and Sheffield Brinsworth have a large influence on mean recorded concentrations, for this element across the Network.

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12 Twenty-five years of nationwide ambient metals measurement in the United Kingdom: concentration levels and trends. Brown, R J C, *et al*, *Environ. Monit. Assess*., 2008, **142**, 127-140

Platinum: Average annual values remain extremely low across all Network sites, but noticeably higher at roadside sites. Concentrations measured for platinum remain the lowest, by an order of magnitude, of any of the metals monitored across the Network.

Vanadium: Concentrations showed a sharp decrease in 2010, mainly as a result of decreases at sites measuring relatively high levels in 2009. The levels of this element remain generally low across the Network.

Zinc: Concentrations decreased slightly in 2010, continuing a general downward trend over the last decade. Trends and mean recorded concentrations for this element, the second most abundant measured by the Network, are influenced substantially by the high measured concentrations at Walsall Bilston Lane.

Lead: Lead levels showed a small decrease in 2010 and remain low across the Network. In the late 1980s lead competed with iron as the most abundant metal measured by the Network, but since the ban on leaded petrol its concentrations have now reduced to less than 2 % of their values 30 years ago – prompting the graph displaying the trend data (Figure 9) to use a logarithmic concentration scale for the first time this year!

Concentration trends over the last 30 years for the metals relevant to the EU Air Quality Directives are summarised in Figures 9 and 10, where both the UK mean and UK median concentrations are displayed.

The trends in both the UK annual mean and median observed for the other metals measured by the Network are shown in Figures 11 and 12. Pt has been omitted from these graphs as there is not currently enough data above the detection limit to produce a meaningful graph.

Where mean values are significantly higher than median values, this indicates that that there are a small number of sites with very high concentrations levels whose measured values and variability have a disproportionate effect on the overall mean. Under these circumstances the median value may give a more representative reflection of the long-term concentration trends.

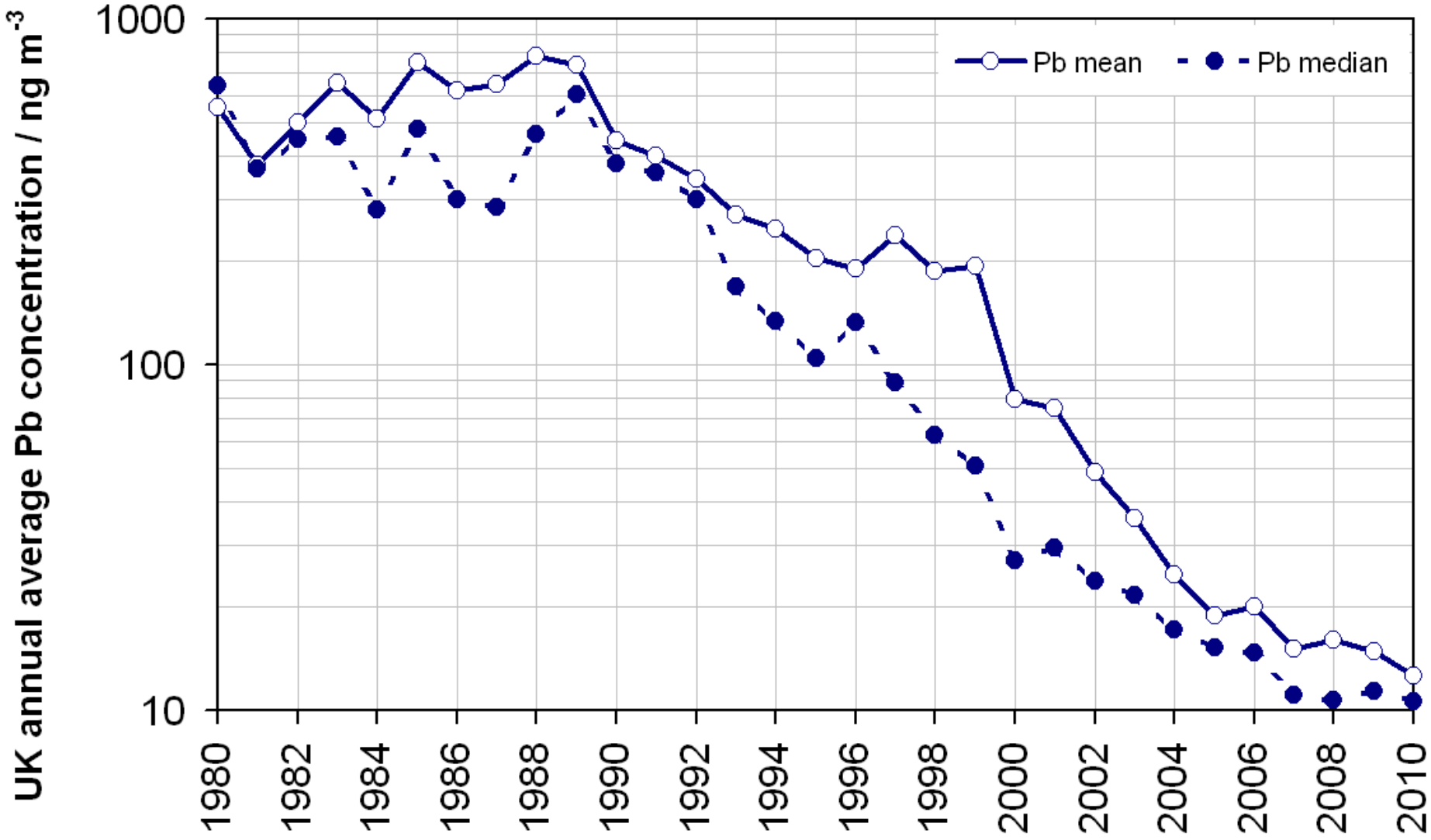


Figure 9. The UK annual average (mean and median) concentrations of Pb measured on the UK Heavy Metals Monitoring Network over the last 30 years. The EC limit value for lead is 500 ng m^{-3} and the UK Air Quality Objective for lead is 250 ng m^{-3}.

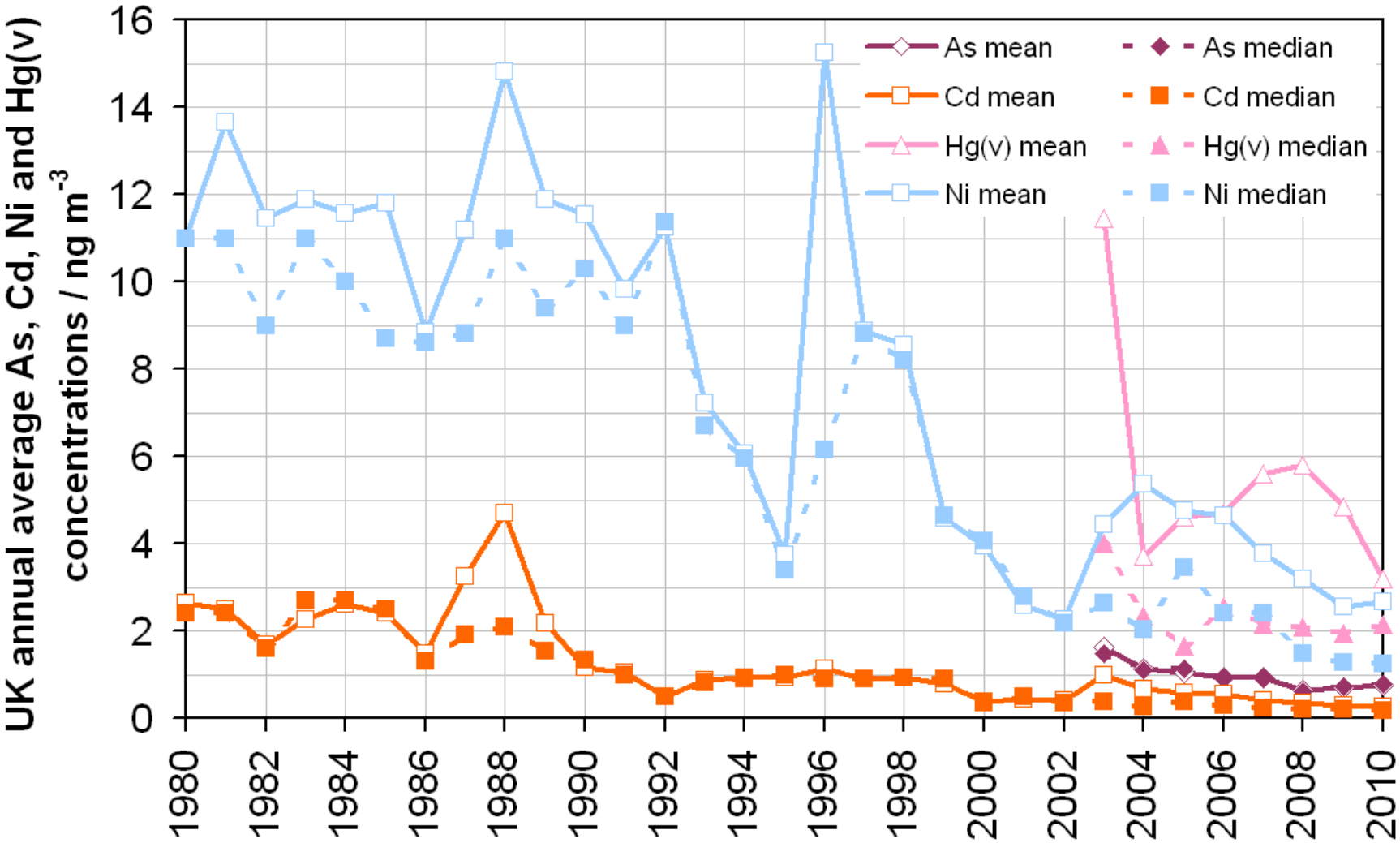


Figure 10. The UK annual average (mean and median) concentrations of Ni, As, Cd and total gaseous mercury [Hg(v)] measured on the UK Heavy Metals Monitoring Network over the last 30 years. The EC targets values for Ni, As and Cd are 20 ng m^{-3}, 6 ng m^{-3} and 5 ng m^{-3} respectively.

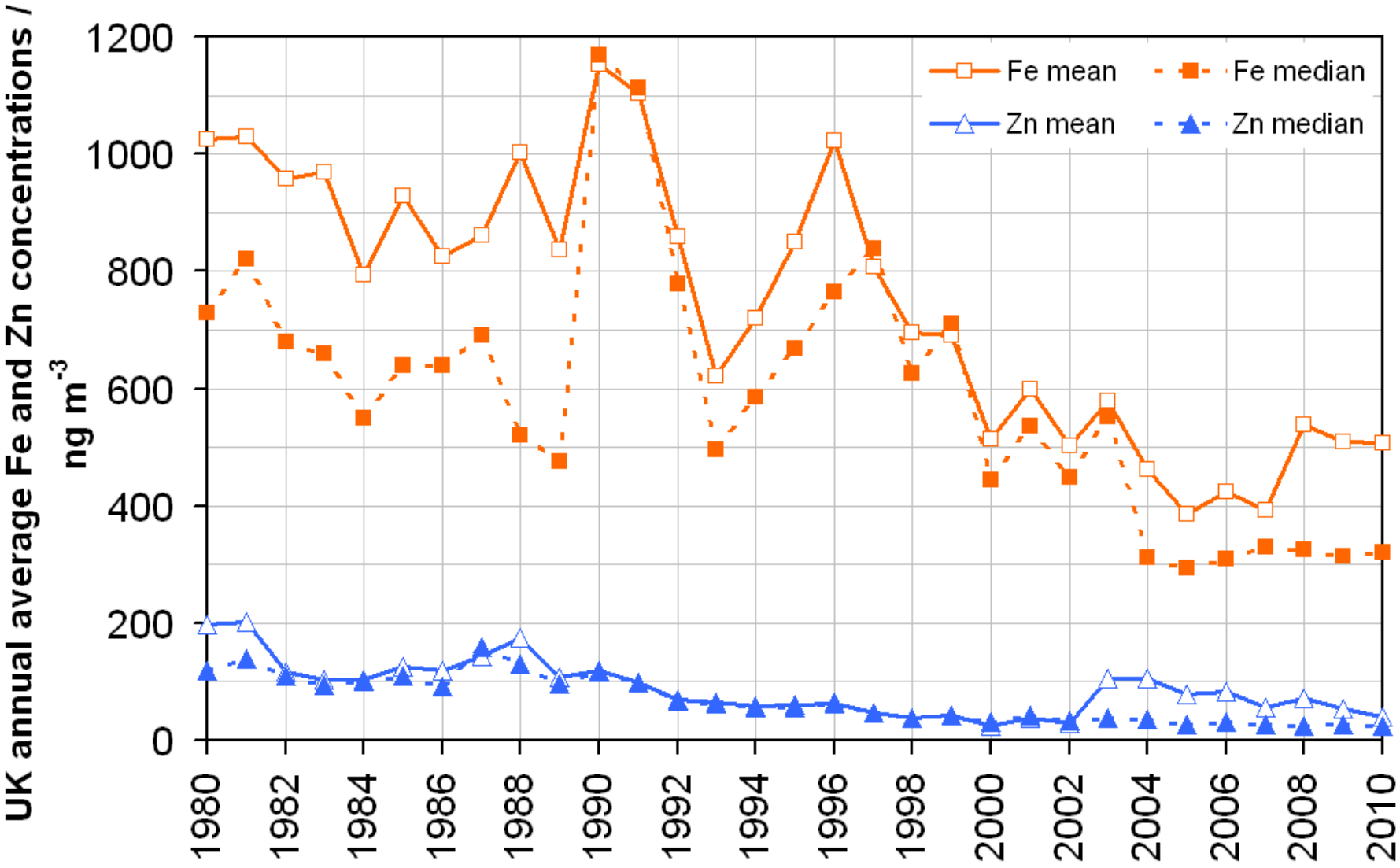


Figure 11. The UK annual average (mean and median) concentrations of Fe and Zn measured on the UK Heavy Metals Monitoring Network over the last 30 years.

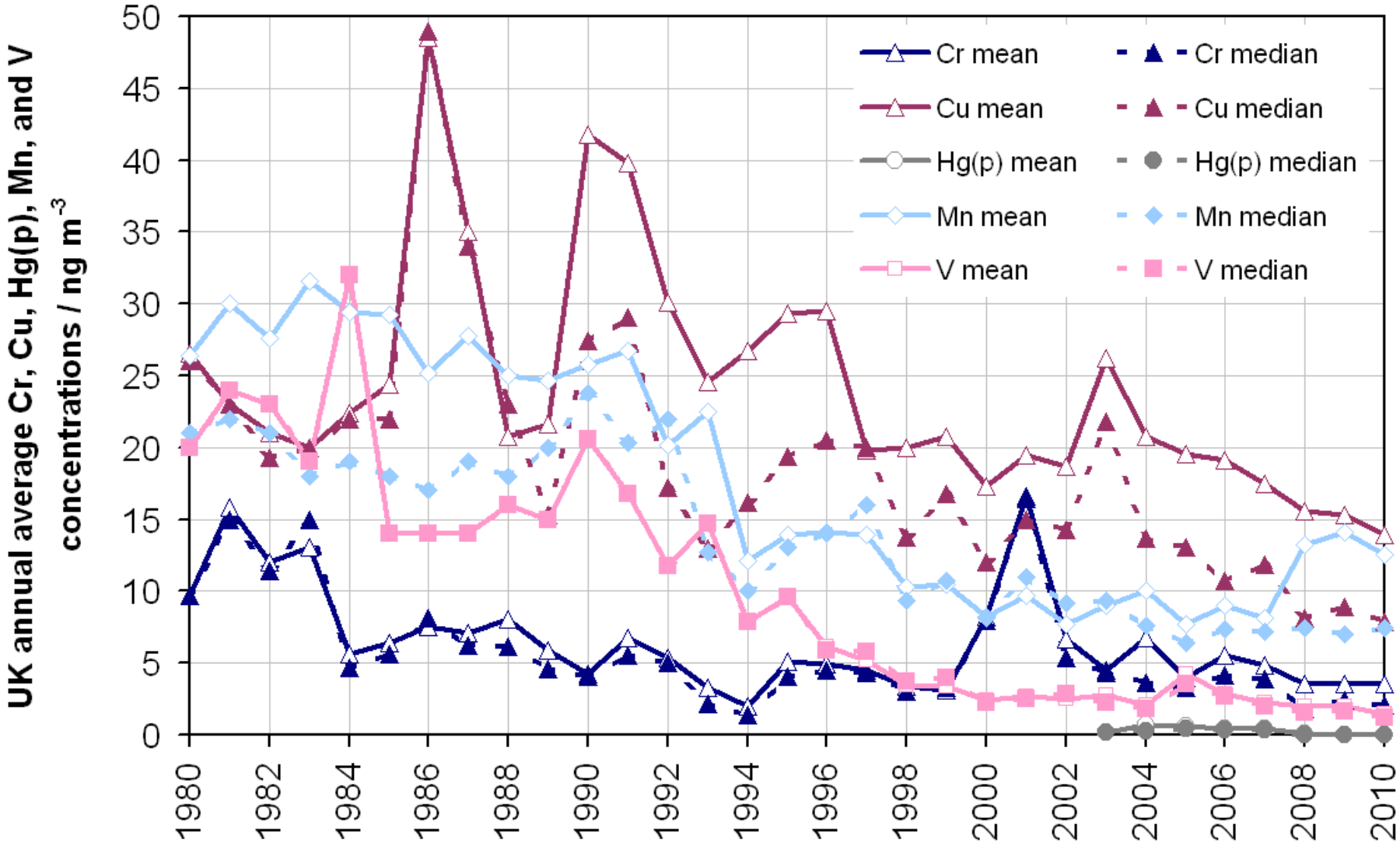


Figure 12. The UK annual average (mean and median) concentrations of Cr, Cu, Hg(p), Mn and V measured on the UK Heavy Metals Monitoring Network over the last 30 years.

7.2 TRENDS IN NICKEL IN THE SWANSEA VALLEY

The annual average concentration of Nickel at Swansea measured over the last 8 years is shown in Figure 13.

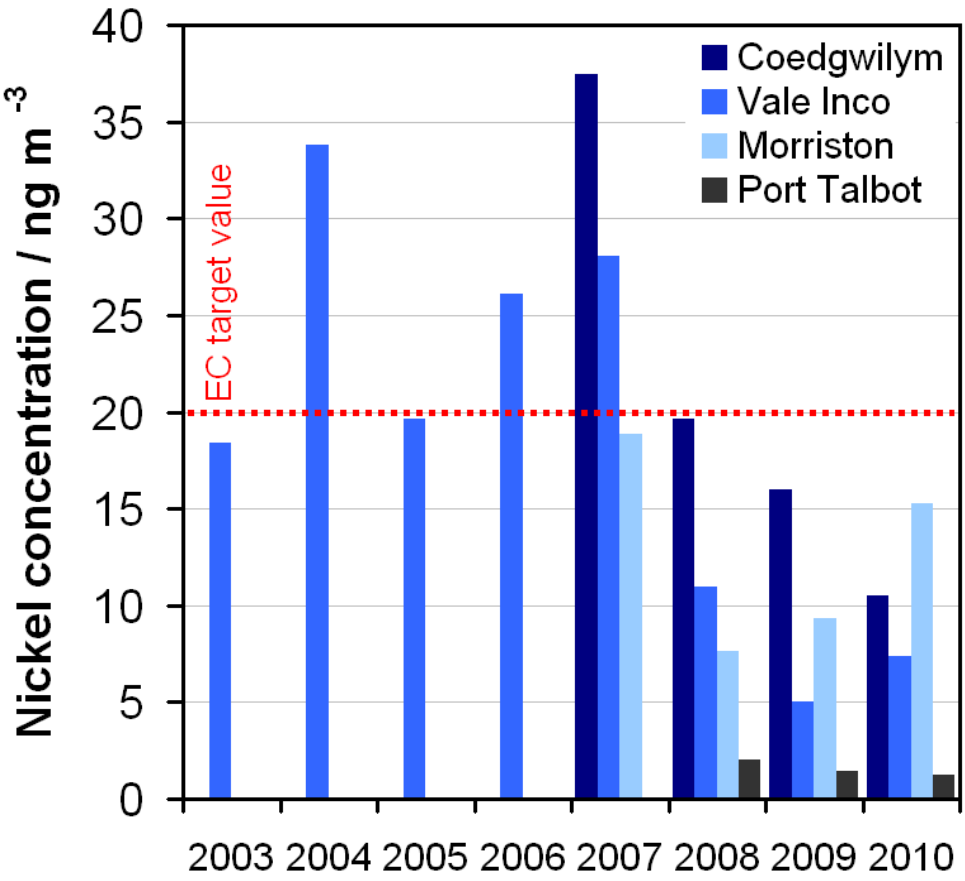


Figure 13. The annual average nickel concentrations measured at monitoring sites in the Swansea area (indicated by the key) over the last 8 years. Nickel concentrations at Port Talbot (since monitoring began in 2008) have also been included to indicate the regional background level. The red dotted line indicates the Fourth DD target value for nickel. (The data for Vale Inco in 2008, 2009 and 2010, and Coedgwilym and Morriston in 2007 are courtesy of Tom Price and the City and County of Swansea. However the sampled filters have been analysed at NPL using the methods described In Section 3, under a separate contract). Data capture at the Vale Inco site in 2010 was only about 50 % owing to repeated sampler failure in the middle of the year.

Swansea Vale Inco (located at: Glais Primary School, School Road, Glais, Swansea, SA7 9EY) was the UK Heavy Metals Monitoring site in the Swansea area from 2003 to 2007 inclusive: it is now operated as a City and County of Swansea local authority site with site auditing and analysis services provided by NPL. At the end of 2007 the local authority sites at Swansea Coedgwilym and Swansea Morriston were assimilated onto the Network.

All sites have shown a significant decrease in measured concentrations from 2007 onwards. This correlates with abatement technologies being installed in late 2007 in order to reduce particle emissions from the point source in question. Another City and County of Swansea local authority site for which NPL provide the auditing and analytical service, YGG Gellionnen (location: YGG Gellionnen School, Gellionnen Road, Clydach, Pontardawe, SA6 5LB), has shown similar concentration trends over this period. Moreover, the relative concentrations between these sites are broadly as predicted by NPL's recent modelling study of the area[13].

In 2011 the two new Network sites installed in the Pontardawe area will help to establish current concentration levels with respect to Directive compliance further up the Tawe Valley in the vicinity of other potential sources of nickel emission to air.

13 NPL Report AS 30, "Atmospheric Dispersion Modelling of Nickel in the Swansea Area", Hayman, G, February 2009

8 SCIENTIFIC RESEARCH, PUBLICATIONS AND RELATED ACTIVITIES

8.1 PUBLICATIONS

NPL has produced a number of articles in learned journals during 2010 that feature the data, analytical procedures and operation of the Network and research relevant to Network objectives. These articles are listed below.

Data treatment

a) Comparison of estimated annual emissions and measured annual ambient concentrations of metals in the United Kingdom 1980-2007
Brown, R J C
Journal of Environmental Monitoring, 2010, **12**, 665-671

b) Using principal component analysis to detect outliers in ambient air monitoring studies
Brown, R J C, Goddard, S L, Brown, A S
International Journal of Environmental Analytical Chemistry, 2010, **90**, 761-772

c) Novel method for producing uncertainty-weighted averages from a time series of ambient air measurements
Brown, R J C
International Journal of Environment and Pollution, 2010, **41**, 355-368

Particulate phase metals

d) Comparison of ED-XRF and LA-ICP-MS with the European reference method for the measurement of metals in ambient particulate matter
Brown, R J C, Jarvis, K E, Disch, B A, Goddard, S L, Adriaenssens, Claeys, N
Accreditation and Quality Assurance, 2010, **15**, 493-502

Total gaseous mercury

e) The origins of the 'Dumarey equation' describing the saturated mass concentration of elemental mercury vapour in air
Dumarey, R, Brown, R J C, Corns, W T, Brown, A S, Stockwell, P B
Accreditation and Quality Assurance, 2010, **15**, 409-414

f) A novel automatic method for the measurement of mercury vapour in ambient air, and comparison of uncertainty with established semi-automatic and manual methods
Brown, A S, Brown, R J C, Dexter, M A, Corns, W T, Stockwell, P B
Analytical Methods, 2010, **2**, 954-966

g) Standardisation of a European measurement method for the determination of total gaseous mercury: results of the field trial campaign and determination of a measurement uncertainty and working range
Brown, R J C, Pirrone, N, van Hoek, C, Sprovieri, F, Fernandez, R, Toté, K,
Journal of Environmental Monitoring, 2010, **12**, 689-695

h) Standardisation of a European measurement method for the determination of mercury in deposition: results of the field trial campaign and determination of a measurement uncertainty and working range
Brown, R J C, Pirrone, N, van Hoek, C, Horvat, M, Kotnik, J, Wangberg, I, Corns, W T, Bieber, E
Accreditation and Quality Assurance, 2010, **15**, 359-366

i) Temperature propagation through a mercury vapour calibration source and assessment of possible analytical biases caused by measurement of temperature variations
Brown, R J C, Wang, J, Brown, A S
Measurement, 2010, **43**, 1291-1298.

8.2 INTERNATIONAL AND STANDARDISATION ACTIVITY

8.2.1 Standardisation Activities

In 2010, NPL continued to represent the interests of the Network and the UK on relevant CEN standardisation committees, in particular: CEN TC264 WG25 "Mercury measurement methods in ambient air and deposition". The two WG25 standards have now been published[14,15] and the group has been disbanded.

In addition, NPL has continued to host and provide the secretariat for BSI committee EH/002/03 "Ambient Atmospheres" which is the UK mirror group shadowing the development of ambient and indoor air standards within CEN and ISO, in particular, CEN TC264 'Air Quality' and ISO TC146 'Air Quality'. BSI EH/2/3 voted in 2010 not to revise the current EN 14902 standard for particulate phase metals analysis, a decision supported by a large majority of the CEN Member Bodies in Europe. Hence there will be no changes to the fundamental analysis procedures used by the Network in the foreseeable future.

8.2.2 International Activities

NPL continued to be involved in the EC-JRC-IRMM led development of a European certified reference material for PAHs and metals in PM_{10} and, during 2010. NPL was a key partner in the analytical work to characterise the long term stability of the candidate material, and was one of seven laboratories providing data that was used for the final value assignment for the relevant legislative metals in order to certify the material, which is now available for purchase as ERM-CZ120 [16].

14 EN 15852:2010 Ambient air quality - Standard method for the determination of total gaseous mercury, 2010, CEN, Brussels.
15 EN 15853:2010 Ambient air quality - Standard method for the determination of mercury deposition, 2010, CEN, Brussels.
16 http://www.erm-crm.org/ermcrmCatalogue/details.do?id.erm_code=CZ120

ANNEX 1 LOCATION AND DETAILS OF SITES COMPRISING THE UK HEAVY METALS NETWORK

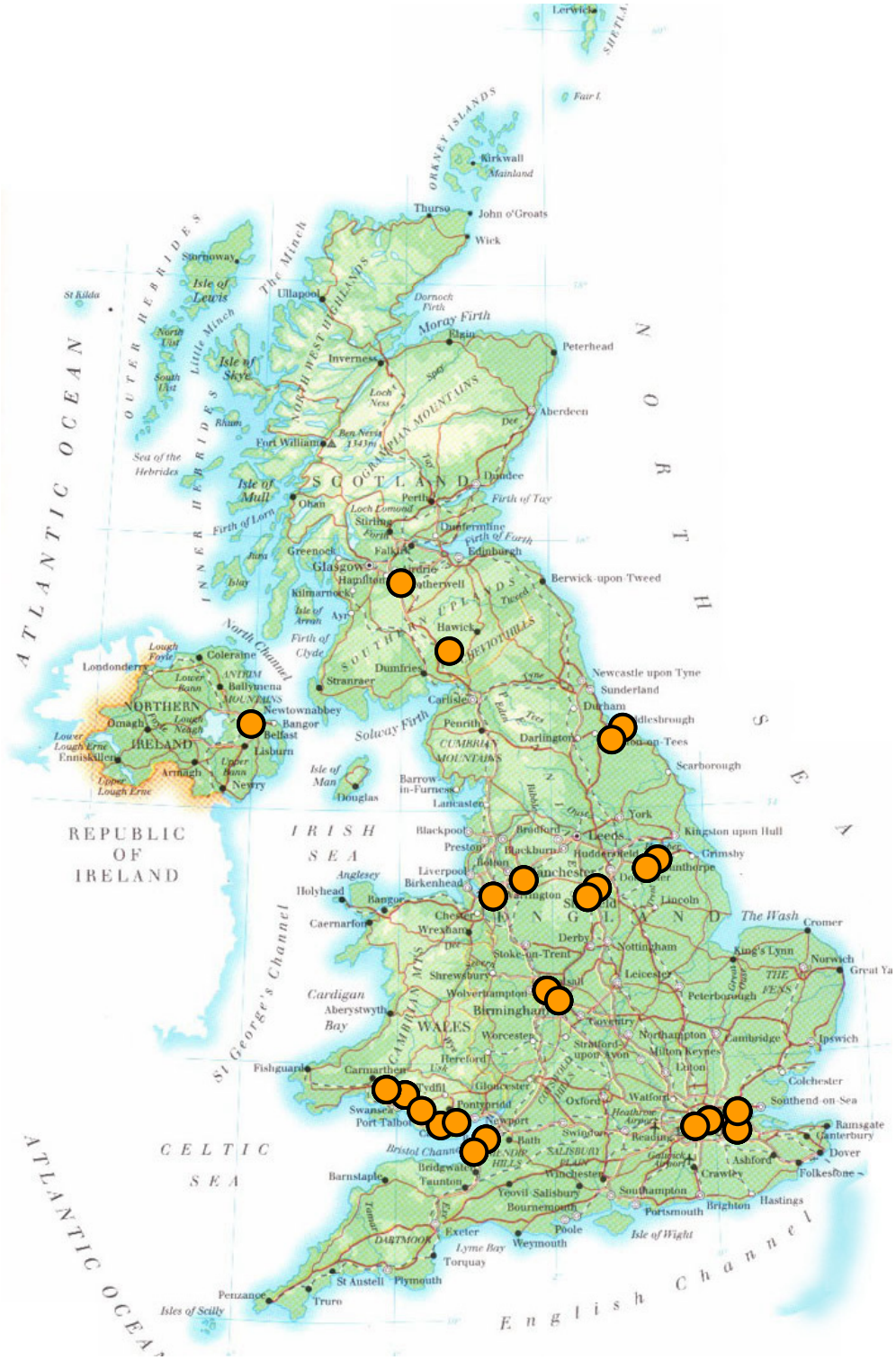


Figure A1. Location of monitoring sites comprising the UK Heavy Metals Monitoring Network during 2010 (indicated by the orange circles) – details of which are given in Table A1 below.

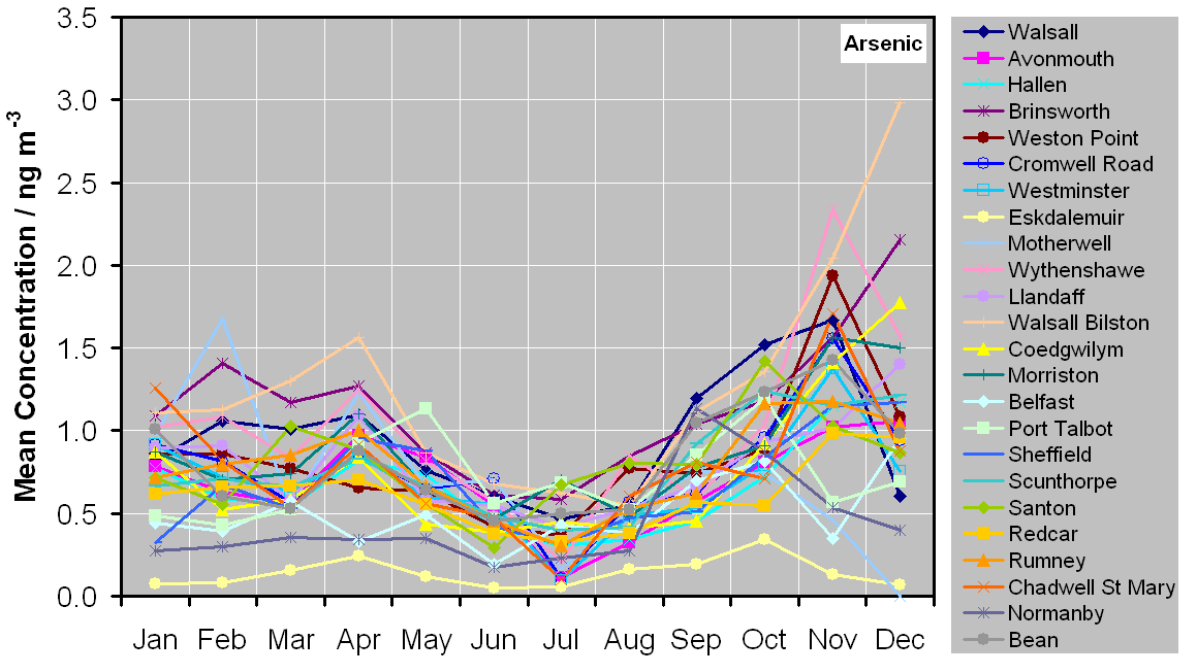
NEW Site Code: Site Name (Abbreviated Site Name)	Site Address	Site Area and Classification (with identified point source, where applicable)	Pollutants measured
46: Walsall Centre (Walsall)	74 Primley Avenue, Walsall, WS2 9UW	Industrial Urban (IMI Refiners Ltd, Walsall)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
47: Bristol Avonmouth (Avonmouth)	Avonmouth Medical Centre, Collins Street, Bristol, BS11 9JJ	Urban Industrial	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
56: Bristol Hallen (Hallen)	West Country Caravans Ltd., Moorhouse Lane, Hallen, Bristol, BS10 7RU	Suburban Industrial	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
58: Sheffield Brinsworth (Brinsworth)	BOC Gases, Bawtry Road, Brinsworth, Sheffield, S60 5NT	Urban Industrial (Outokumpu Stainless Ltd, Sheffield)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
59: Runcorn Weston Point (Weston Point)	Weston Point County Primary School, Caster Avenue, Weston Point, Runcorn, WA7 4EQ	Urban Industrial (INEOS Enterprises Ltd, Weston Point)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
61: London Cromwell Road 2 (Cromwell Road)	Natural History Museum, Cromwell Road, London, SW7 5BD	Urban Traffic	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
62: London Westminster (Westminster)	Mortuary Car Park, Horseferry Road, London, SW1P 2EB	Urban Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
65: Eskdalemuir (Eskdalemuir)	Met Office, Eskdalemuir, Langholm, Dumfrieshire, DG13 0QW	Rural Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
66: Motherwell South (Motherwell)	Our Lady's High School, Dalzell Drive, Motherwell, North Lanarkshire, ML1 2DG	Urban Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
67: Manchester Wythenshawe (Wythenshawe)	Junction 4, M56, Newhall Green, Wythenshawe, Manchester, M22 8	Urban Traffic	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
68: Cardiff Llandaff (Llandaff)	Cleansing Depot, Waungron, Fairwater, Cardiff, CF5 2JJ	Urban traffic (Celsa UK Ltd, Tremorfa)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
69: Walsall Bilston Lane (Walsall Bilston)	Adult Training Centre, Bilston Lane, Shepwell Green, Willenhall, Walsall, WV13 2QJ	Urban Industrial (Brookside Metals Ltd, Willenhall)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
100: Swansea Coedgwilym (Coedgwilym)	Coedgwilym Cemetery, Pontardawe Road, Clydach, Swansea, SA6 5PB	Urban Industrial (Vale Ltd, Swansea)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
101: Swansea Morriston (Morriston)	Morriston Groundhog, Wychtree Street, Morriston, Swansea, SA6 8EX	Urban Traffic (Vale Ltd, Swansea)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
103: Belfast Centre (Belfast)	Lombard Street, Belfast, BT1 1RB	Urban Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
104: Port Talbot Margam (Port Talbot)	Port Talbot Fire Station, Commercial Road, Port Talbot, West Glamorgan, SA13 1LG	Urban Industrial (Corus Group Ltd, Port Talbot)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn

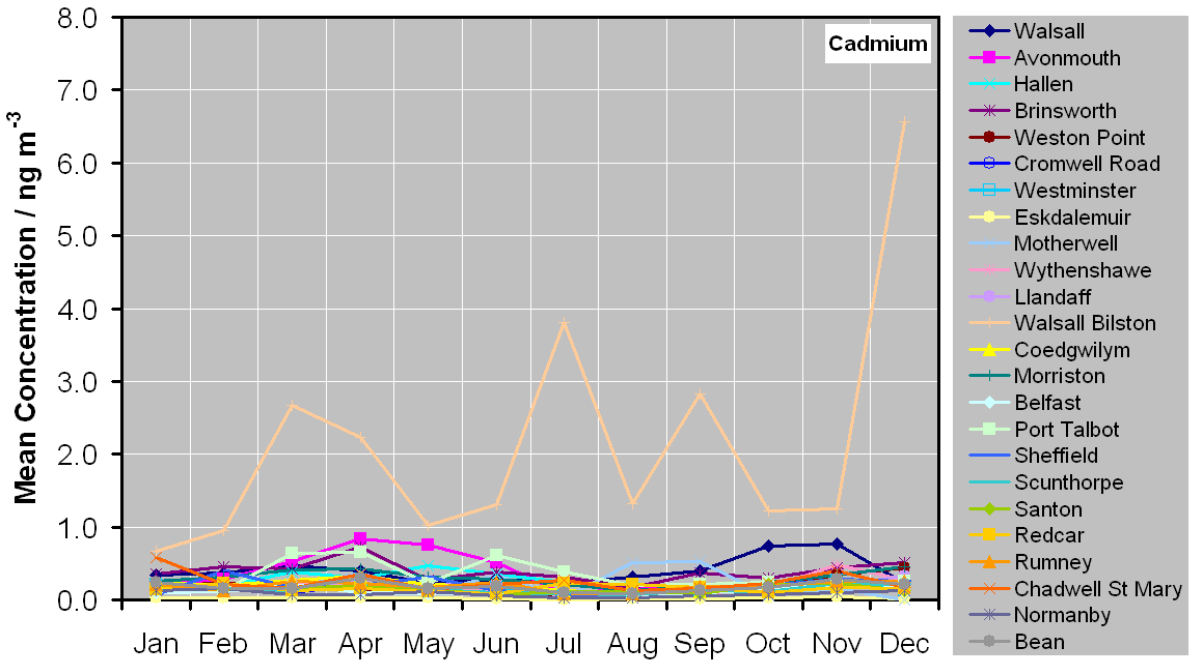
NEW Site Code: Site Name (Abbreviated Site Name)	Site Address	Site Classification (with identified point source, where applicable)	Pollutants measured
105: Sheffield Centre (Sheffield)	Charter Square, Sheffield, S1 4JD	Urban Background (Outokumpu Stainless Ltd, Sheffiled)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
106: Scunthorpe Town (Scunthorpe)	Rowlands Road, Scunthorpe, North Lincolnshire, DN16 1TJ	Urban Industrial (Corus Group Ltd, Scunthorpe)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
107: Scunthorpe Low Santon (Low Santon)	Dawes Lane, Santon, Scunthorpe, North Lincolnshire, DN16 1XH	Suburban Industrial (Corus Group Ltd, Scunthorpe)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
108: Redcar (Redcar)	Further Education Centre, Corporation Road, Redcar, TS10 1HA	Urban Industrial (Corus Group Ltd, Redcar)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
109: Cardiff Rumney (Rumney)	Greenway Primary School, Llanstephen Road, Rumney, Cardiff, CF3 3JG	Urban Industrial (Celsa UK Ltd, Tremorfa)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
110: Chadwell St Mary (Chadwell St Mary)	Council Area Housing Office, Linford Road, Chadwell St Mary, Essex, RM16 4JY	Urban Industrial (Britannia Refined Metals, Gravesend)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
111: Redcar Normanby (Normanby)	Tees, Esk and Wear Valleys NHS Trust, Flatts Lane, Normanby, Middlesbrough, TS6 0SZ	Rural Background (Corus Group Ltd, Redcar)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
112: Dartford Bean (Bean)	Bean Primary School, Bean, Dartford, Kent, DA2 8AW	Suburban Background (Britannia Refined Metals, Gravesend)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn

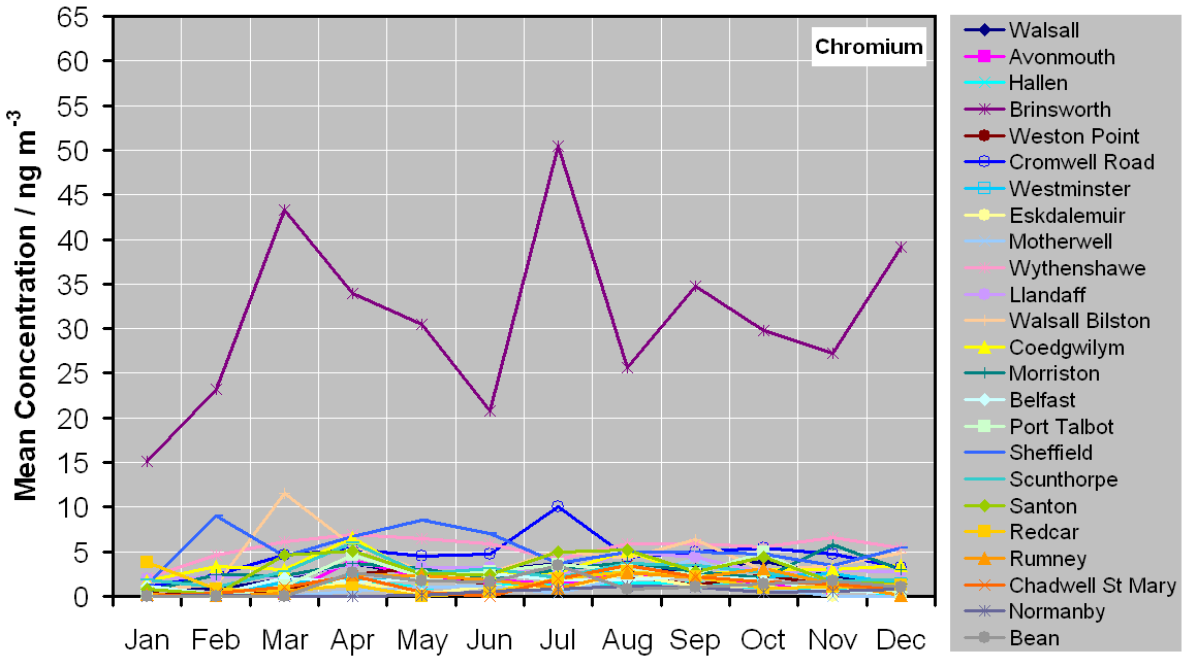
Table A1. Details of the sites comprising the UK Heavy Metals Monitoring Network, including: site names, abbreviated site names, site locations, site are and classification, point source monitored (where applicable) and pollutants measured.

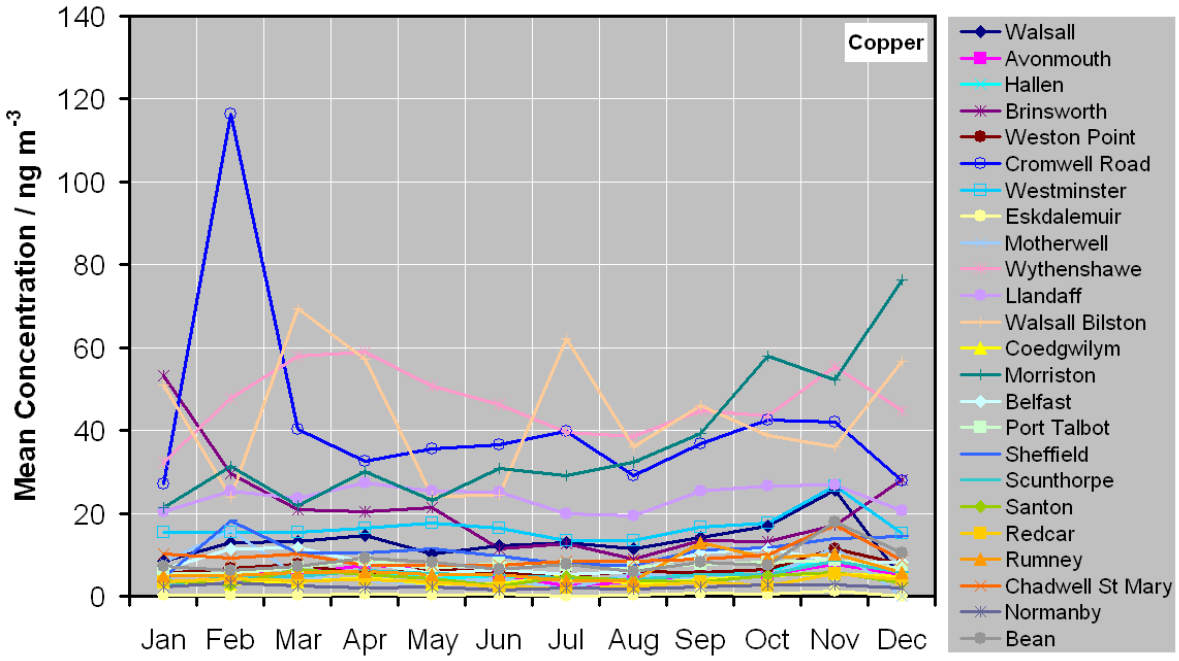
ANNEX 2 AVERAGE MONTHLY CONCENTRATIONS MEASURED FOR EACH ELEMENT

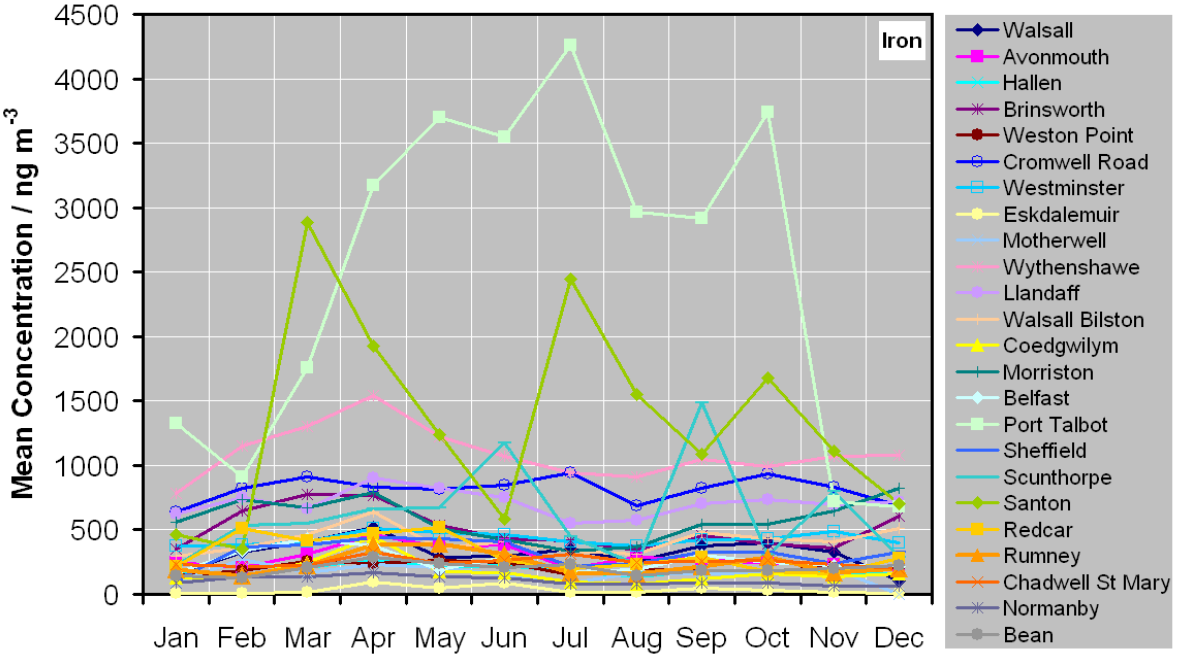
The following figures display the average monthly concentrations of each metal (as indicated in the top right-hand corner of each plot) measured at each site during 2010. The final plot shows the vapour phase mercury to particulate phase mercury concentration ratio at each site that measures both species.

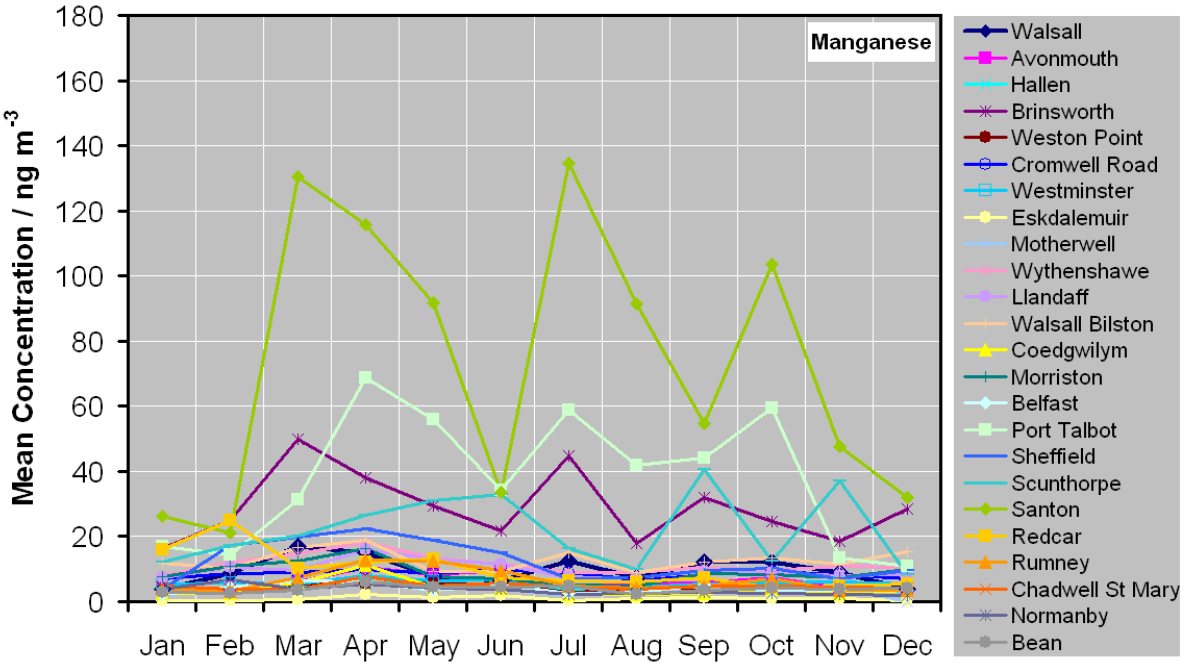


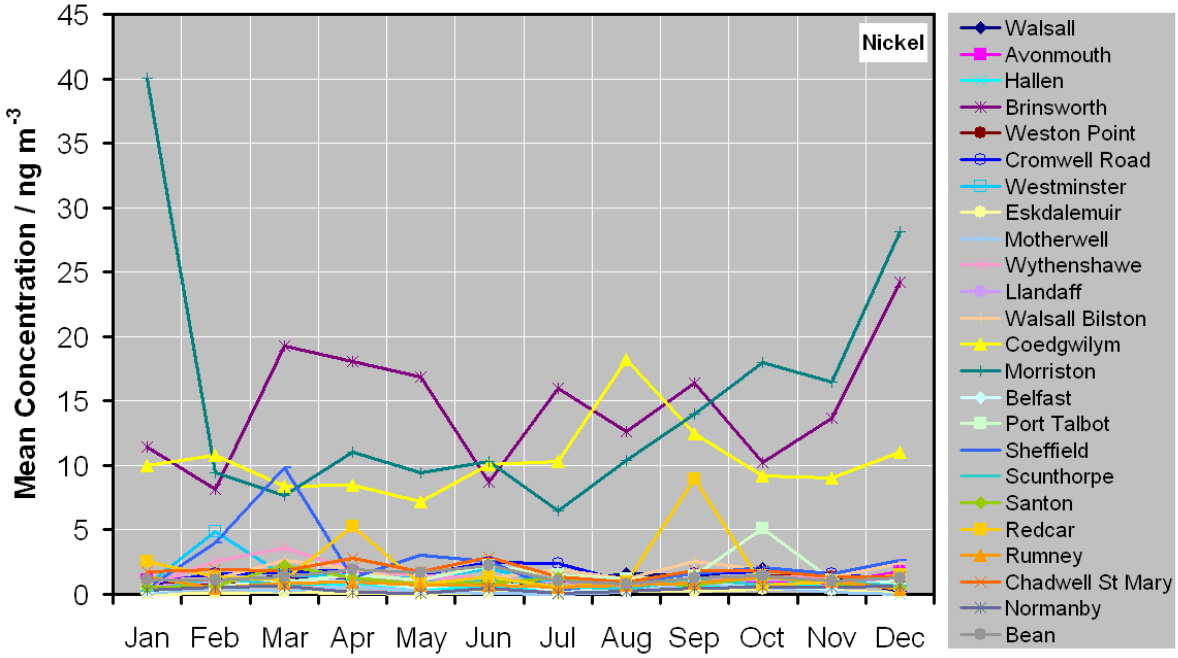


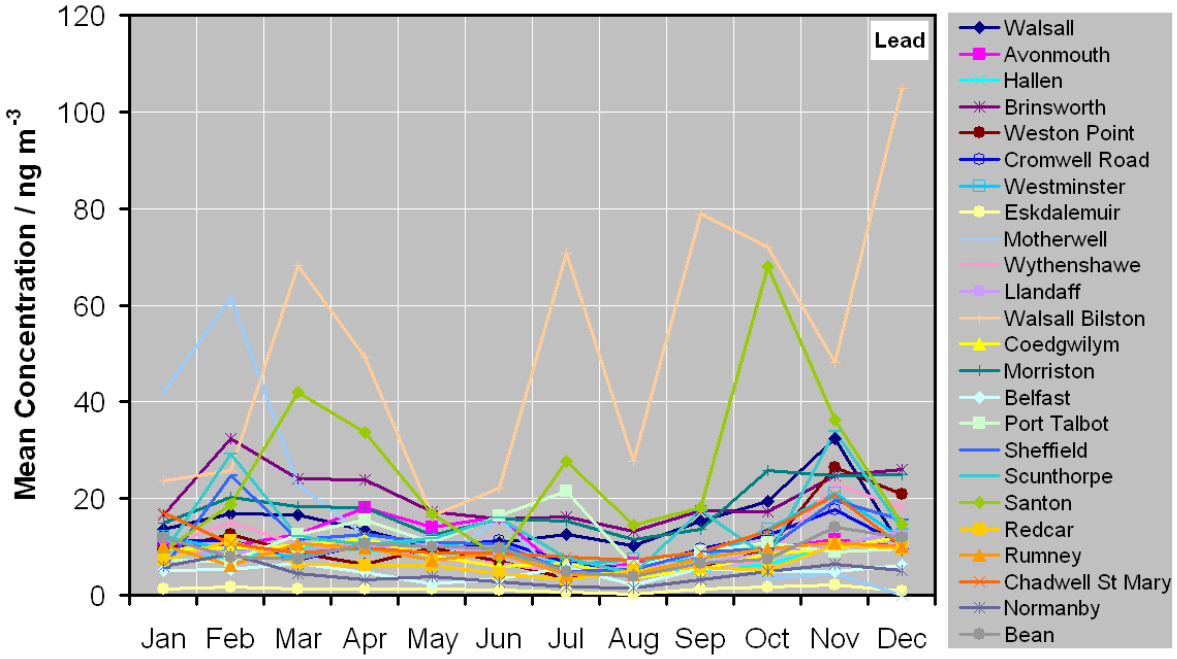

Chromium
Mean Concentration / ng m-3
65
60
55
50
45
40
35
30
25
20
15
10
5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Westminster
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Walsall Bilston
Coedgwilym
Morriston
Belfast
Port Talbot
Sheffield
Scunthorpe
Santon
Redcar
Rumney
Chadwell St Mary
Normanby
Bean

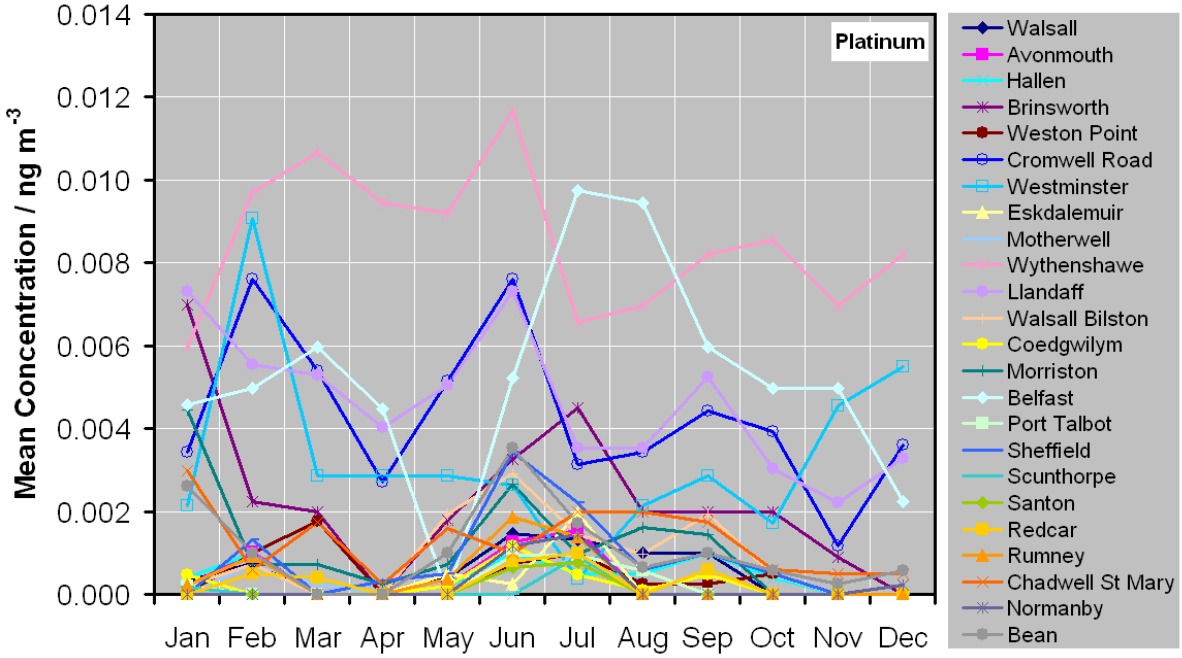

Copper
Mean Concentration / ng m-3
140
120
100
80
60
40
20
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Westminster
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Walsall Bilston
Coedgwilym
Morriston
Belfast
Port Talbot
Sheffield
Scunthorpe
Santon
Redcar
Rumney
Chadwell St Mary
Normanby
Bean


Iron
Mean Concentration / ng m-3
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Westminster
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Walsall Bilston
Coedgwilym
Morriston
Belfast
Port Talbot
Sheffield
Scunthorpe
Santon
Redcar
Rumney
Chadwell St Mary
Normanby
Bean


Manganese
Mean Concentration / ng m-3
180
160
140
120
100
80
60
40
20
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Westminster
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Walsall Bilston
Coedgwilym
Morriston
Belfast
Port Talbot
Sheffield
Scunthorpe
Santon
Redcar
Rumney
Chadwell St Mary
Normanby
Bean


Nickel
Mean Concentration / ng m-3
45
40
35
30
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Westminster
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Walsall Bilston
Coedgwilym
Morriston
Belfast
Port Talbot
Sheffield
Scunthorpe
Santon
Redcar
Rumney
Chadwell St Mary
Normanby
Bean


Lead
Mean Concentration / ng m-3
120
100
80
60
40
20
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Westminster
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Walsall Bilston
Coedgwilym
Morriston
Belfast
Port Talbot
Sheffield
Scunthorpe
Santon
Redcar
Rumney
Chadwell St Mary
Normanby
Bean


Platinum
Mean Concentration / ng m-3
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Westminster
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Walsall Bilston
Coedgwilym
Morriston
Belfast
Port Talbot
Sheffield
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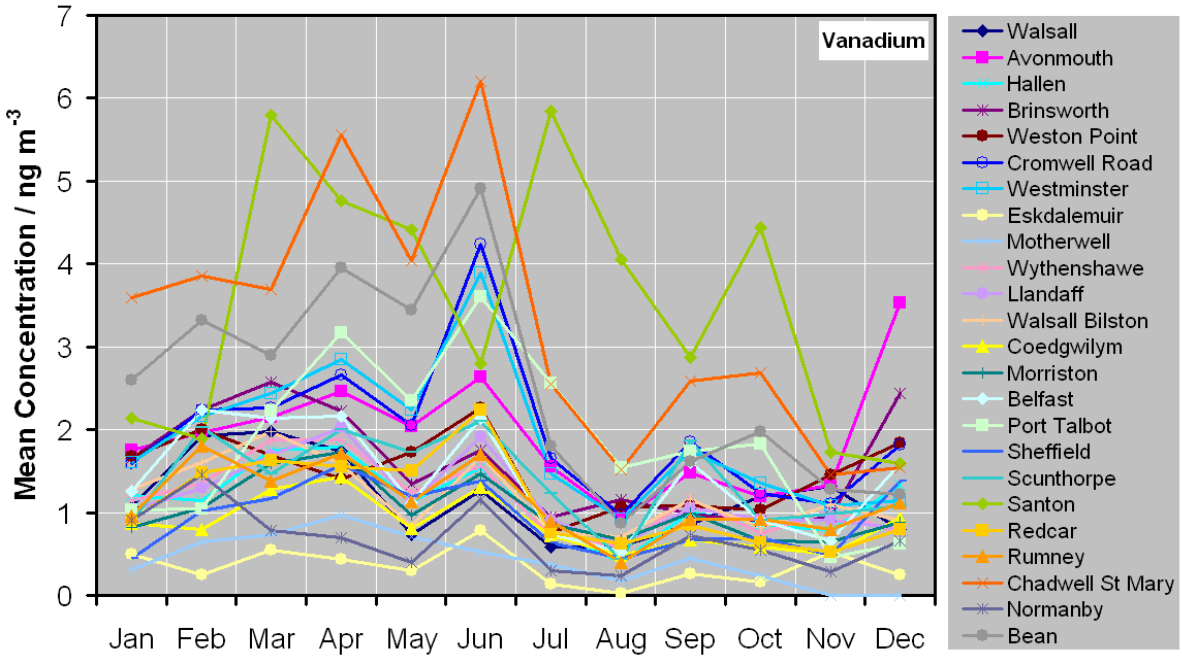
Redcar
Rumney
Chadwell St Mary
Normanby
Bean


Vanadium
Mean Concentration / ng m-3
7
6
5
4
3
2
1
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Westminster
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Walsall Bilston
Coedgwilym
Morriston
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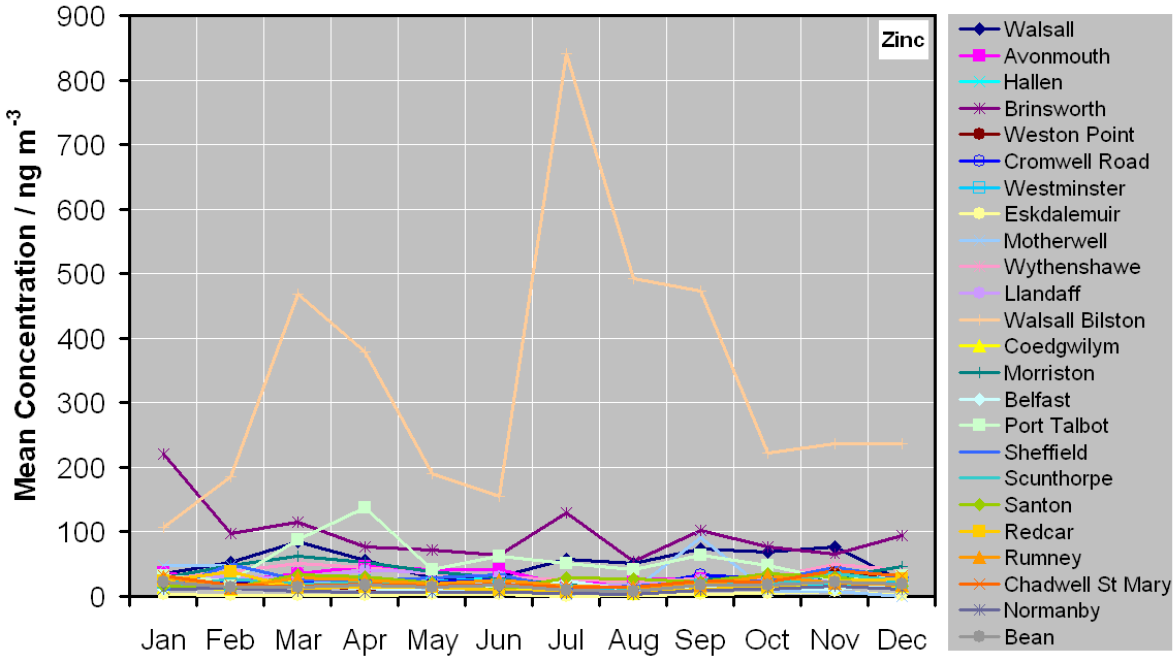
Sheffield
Scunthorpe
Santon
Redcar
Rumney
Chadwell St Mary
Normanby
Bean


Zinc
Mean Concentration / ng m-3
900
800
700
600
500
400
300
200
100
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Westminster
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Walsall Bilston
Coedgwilym
Morriston
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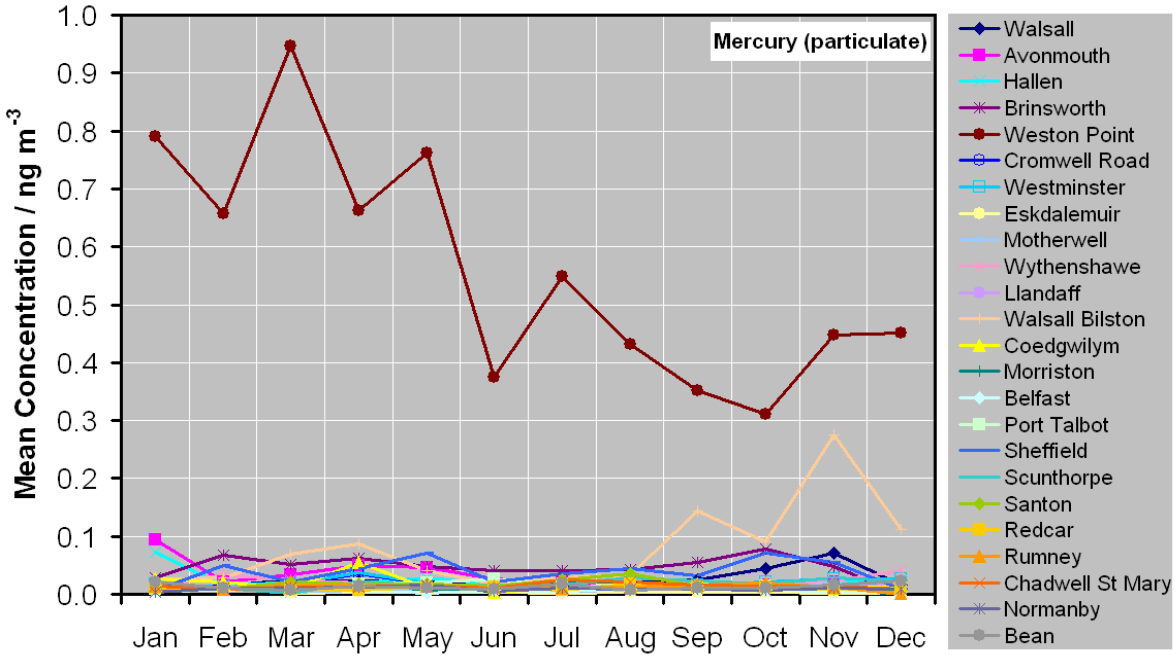
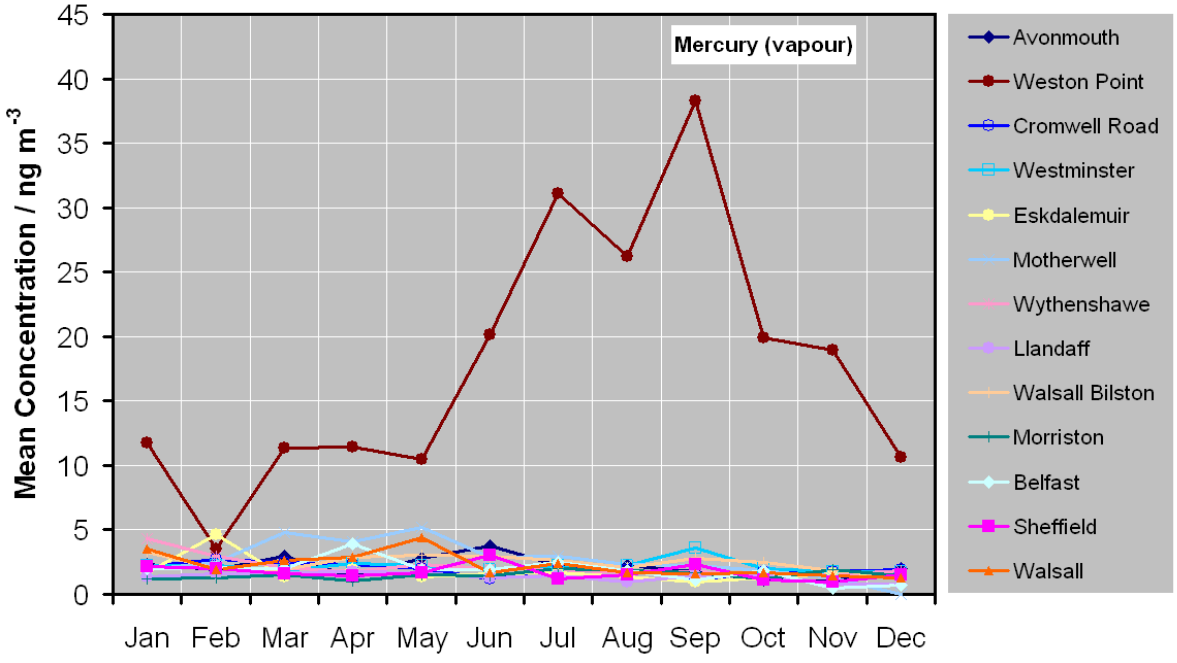
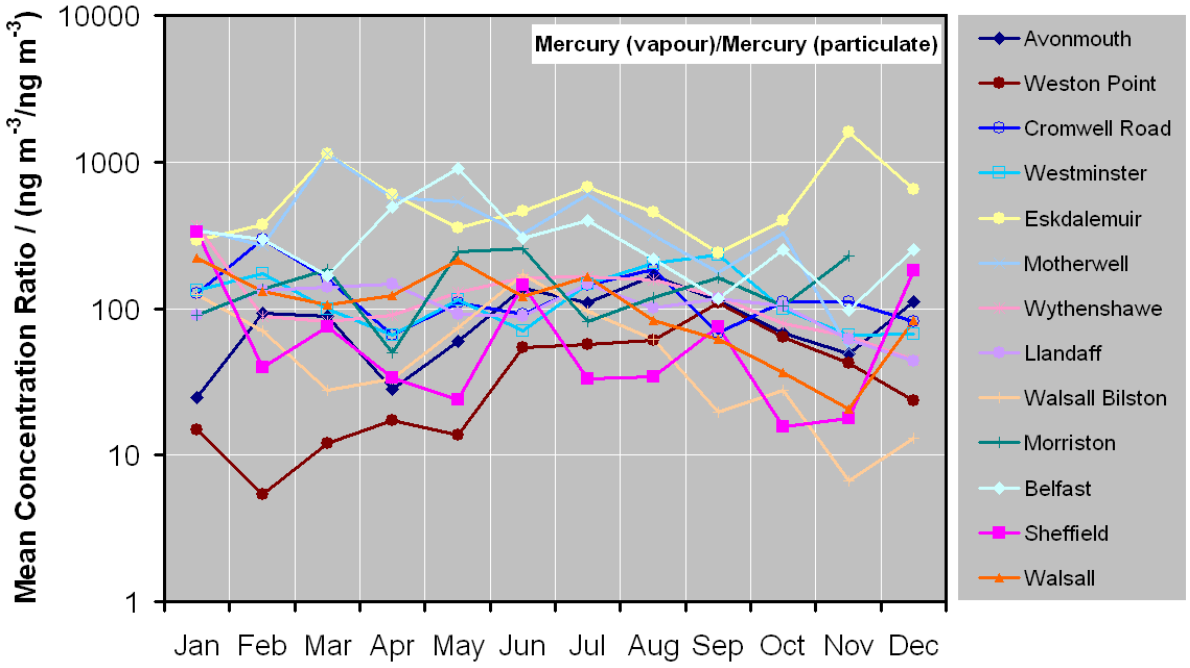
Port Talbot
Sheffield
Scunthorpe
Santon
Redcar
Rumney
Chadwell St Mary
Normanby
Bean


Mercury (particulate)
Mean Concentration / ng m-3
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Westminster
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Walsall Bilston
Coedgwilym
Morriston
Belfast
Port Talbot
Sheffield
Scunthorpe
Santon
Redcar
Rumney
Chadwell St Mary
Normanby
Bean


Mercury (vapour)
Mean Concentration / ng m-3
45
40
35
30
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Avonmouth
Weston Point
Cromwell Road
Westminster
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Walsall Bilston
Morriston
Belfast
Sheffield
Walsall


Mercury (vapour)/Mercury (particulate)
Mean Concentration Ratio / (ng m-3/ng m-3)
10000
1000
100
10
1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Avonmouth
Weston Point
Cromwell Road
Westminster
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Walsall Bilston
Morriston
Belfast
Sheffield
Walsall

ANNEX 3 AVERAGE MONTHLY CONCENTRATIONS MEASURED AT EACH NETWORK SITE

The following tables display the average monthly concentrations measured at each site (as indicated at the top of each table) for each element during 2010. Note: "N/A" denotes data not available.

Site 46: Walsall Centre

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.82	0.34	1.19	8.5	150	3.91	0.60	13.5	<0.001	1.07	34.6	0.016	3.49
Feb	1.06	0.37	0.86	12.9	325	8.63	1.16	16.9	0.001	1.93	52.2	0.015	1.96
Mar	1.01	0.47	1.92	13.3	406	17.0	1.34	16.7	0.000	1.98	84.2	0.025	2.61
Apr	1.10	0.40	3.74	14.6	522	15.2	1.12	13.4	0.000	1.74	55.5	0.024	2.91
May	0.76	0.23	2.29	10.1	288	7.63	0.50	9.9	0.000	0.73	29.0	0.021	4.40
Jun	0.60	0.28	2.84	12.2	298	6.54	0.90	10.9	0.001	1.27	31.1	0.014	1.71
Jul	0.47	0.23	3.68	12.9	352	12.5	0.93	12.6	0.001	0.58	57.8	0.015	2.42
Aug	0.55	0.31	2.81	11.4	253	7.30	1.62	10.1	0.001	0.60	51.2	0.020	1.71
Sep	1.19	0.39	2.97	14.2	374	12.2	1.47	15.4	0.001	0.85	73.0	0.025	1.56
Oct	1.52	0.74	3.90	16.8	397	12.2	2.01	19.4	0.000	1.19	68.9	0.045	1.64
Nov	1.67	0.77	2.46	25.7	326	8.96	1.38	32.4	0.000	1.32	76.3	0.072	1.46
Dec	0.60	0.23	0.51	4.2	104	3.88	0.21	9.6	0.000	0.80	23.9	0.015	1.26
Annual Average	**0.92**	**0.38**	**2.46**	**12.9**	**320**	**9.85**	**1.10**	**14.6**	**0.001**	**1.16**	**53.0**	**0.025**	**2.28**

Site 47: Bristol Avonmouth

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.79	0.21	0.15	5.1	249	4.30	1.11	10.5	<0.001	1.75	36.6	0.095	2.33
Feb	0.63	0.28	0.01	5.4	205	4.30	1.33	10.3	0.001	1.96	24.6	0.021	1.93
Mar	0.56	0.53	0.25	5.6	308	6.23	0.89	12.6	<0.001	2.15	35.1	0.033	2.97
Apr	0.97	0.84	4.05	7.5	467	10.58	1.64	18.2	<0.001	2.46	46.7	0.049	1.37
May	0.84	0.75	2.12	7.0	364	8.28	1.05	14.1	<0.001	2.04	40.9	0.046	2.77
Jun	0.55	0.51	1.85	5.3	385	9.44	1.18	16.1	0.001	2.63	41.2	0.027	3.77
Jul	0.11	0.08	1.43	2.5	199	4.77	0.73	4.4	0.002	1.56	16.8	0.020	2.20
Aug	0.32	0.15	2.58	3.6	287	5.44	0.58	6.6	<0.001	0.93	27.8	0.013	2.20
Sep	0.58	0.19	2.15	5.5	273	5.74	1.05	7.8	<0.001	1.48	27.8	0.016	1.78
Oct	0.81	0.19	1.54	5.3	243	7.44	1.03	9.6	<0.001	1.20	20.2	0.017	1.12
Nov	1.02	0.19	0.73	7.7	231	4.30	0.91	11.5	<0.001	1.33	27.5	0.022	1.07
Dec	1.06	0.24	0.67	5.3	181	4.07	1.74	10.0	<0.001	3.54	22.1	0.018	2.01
Annual Average	**0.69**	**0.35**	**1.47**	**5.5**	**283**	**6.24**	**1.10**	**11.0**	0.001	**1.92**	**30.6**	**0.032**	**2.13**

Site 56: Bristol Hallen

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.77	0.20	0.18	5.2	163	3.14	0.51	9.2	<0.001	1.21	22.2	0.072	N/A
Feb	0.59	0.19	0.10	4.7	133	2.40	0.57	7.7	0.001	1.14	11.8	0.013	N/A
Mar	0.55	0.39	0.36	5.7	206	4.28	0.78	9.7	<0.001	1.75	25.5	0.022	N/A
Apr	0.82	0.30	1.97	6.1	270	6.23	0.77	9.4	<0.001	1.79	17.9	0.020	N/A
May	0.73	0.47	0.88	4.3	206	4.74	0.39	8.4	<0.001	1.13	22.9	0.029	N/A
Jun	0.41	0.36	1.23	4.9	224	5.61	0.53	9.2	0.001	1.54	28.9	0.018	N/A
Jul	0.31	0.24	1.33	3.9	174	3.79	0.46	6.5	<0.001	0.80	21.2	0.012	N/A
Aug	0.34	0.23	1.49	4.1	132	2.53	0.25	4.2	<0.001	0.40	11.0	0.012	N/A
Sep	0.45	0.16	1.55	5.5	187	3.31	0.66	5.1	0.001	1.00	14.0	0.016	N/A
Oct	0.72	0.19	0.94	6.4	187	3.33	0.76	6.4	<0.001	0.86	14.1	0.017	N/A
Nov	1.15	0.22	0.95	8.6	179	3.15	0.57	10.3	<0.001	0.78	17.9	0.024	N/A
Dec	1.17	0.22	0.15	6.7	159	3.26	0.67	10.0	<0.001	1.33	18.4	0.024	N/A
Annual Average	**0.67**	**0.26**	**0.93**	**5.5**	**185**	**3.82**	**0.58**	**8.0**	0.001	**1.14**	**18.9**	**0.024**	**N/A**

Site 58: Sheffield Brinsworth

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	1.09	0.36	15.2	53.3	354	16.4	11.4	16.7	0.007	1.65	221	0.028	N/A
Feb	1.41	0.46	23.3	29.6	650	24.8	8.19	32.4	0.002	2.24	98.3	0.067	N/A
Mar	1.17	0.43	43.3	20.8	778	49.8	19.2	24.1	0.002	2.58	115	0.051	N/A
Apr	1.27	0.73	34.0	20.3	764	38.0	18.1	23.8	<0.001	2.22	76.5	0.061	N/A
May	0.86	0.27	30.4	21.3	538	29.4	16.8	17.3	0.002	1.35	71.7	0.049	N/A
Jun	0.61	0.38	20.8	11.4	429	21.9	8.67	15.8	0.003	1.75	64.1	0.041	N/A
Jul	0.58	0.31	50.4	12.6	418	44.8	16.0	16.2	0.004	0.95	129	0.040	N/A
Aug	0.85	0.18	25.6	9.0	345	17.8	12.6	13.2	0.002	1.15	54.3	0.043	N/A
Sep	1.04	0.37	34.8	13.4	458	31.9	16.4	17.6	0.002	0.98	102	0.056	N/A
Oct	1.18	0.29	29.8	13.1	394	24.7	10.2	17.2	0.002	0.90	76.7	0.078	N/A
Nov	1.56	0.46	27.4	17.2	353	17.8	14.2	25.6	0.001	0.87	65.4	0.054	N/A
Dec	2.16	0.51	39.15	28.0	604	28.6	24.2	26.0	0.002	2.44	93.9	0.047	2.16
Annual Average	**1.16**	**0.39**	**31.08**	**21.0**	**509**	**28.9**	**14.69**	**20.4**	**0.002**	**1.60**	**97.7**	**0.051**	**1.16**

Site 59: Runcorn Weston Point

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.86	0.17	0.35	5.4	145	3.57	1.07	9.3	<0.001	1.68	25.9	0.790	11.8
Feb	0.86	0.25	0.01	6.7	185	3.88	0.92	12.6	0.001	2.01	21.7	0.657	3.5
Mar	0.77	0.15	0.70	7.8	255	5.43	0.93	8.7	0.002	1.69	17.5	0.946	11.3
Apr	0.65	0.13	2.42	5.1	244	5.54	0.98	6.4	<0.001	1.41	11.1	0.662	11.4
May	0.64	0.15	3.27	6.7	264	5.78	1.05	9.7	<0.001	1.73	13.9	0.762	10.5
Jun	0.42	0.09	1.12	5.8	250	5.38	1.15	7.0	0.001	2.26	11.9	0.374	20.1
Jul	0.37	0.04	0.83	4.9	152	2.79	0.57	3.5	0.001	0.76	7.1	0.549	31.1
Aug	0.77	0.08	2.26	5.9	200	3.60	0.73	5.4	<0.001	1.07	10.9	0.431	26.2
Sep	0.74	0.10	1.30	5.7	182	3.47	0.94	5.6	<0.001	1.08	12.0	0.352	38.3
Oct	0.89	0.18	2.47	6.6	177	3.54	1.47	9.4	0.001	1.03	18.3	0.310	19.9
Nov	1.84	0.32	1.01	11.0	222	3.98	1.34	25.1	<0.001	1.42	35.1	0.451	18.9
Dec	1.09	0.44	1.17	7.7	200	4.0	1.14	20.8	<0.001	1.84	26.2	0.452	10.6
Annual Average	**0.84**	**0.17**	**1.39**	**6.7**	**205**	**4.22**	1.03	**10.4**	0.001	**1.50**	**17.88**	**0.561**	**17.9**

Site 61: London Cromwell Road 2

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.91	0.21	1.06	27.0	643	7.12	0.80	11.3	0.003	1.59	26.3	0.017	2.16
Feb	0.82	0.16	2.44	117	827	8.48	1.58	11.2	0.008	2.24	24.2	0.009	2.69
Mar	0.57	0.11	4.56	40.3	911	9.08	1.69	7.2	0.005	2.26	22.9	0.016	2.50
Apr	0.86	0.21	5.35	32.5	832	9.93	1.89	10.6	0.003	2.66	22.7	0.035	2.31
May	0.65	0.13	4.55	35.6	817	8.63	1.52	10.1	0.005	2.05	22.7	0.018	1.97
Jun	0.71	0.17	4.74	36.5	847	9.92	2.45	11.4	0.008	4.24	25.8	0.013	1.21
Jul	0.10	0.08	10.1	39.7	945	9.01	2.40	6.9	0.003	1.65	18.4	0.014	2.02
Aug	0.57	0.07	4.42	29.0	685	6.64	0.99	5.4	0.003	0.98	13.7	0.010	1.92
Sep	0.62	0.19	5.00	36.9	821	8.62	1.59	9.7	0.004	1.85	33.3	0.017	1.15
Oct	0.96	0.16	5.38	42.6	937	9.37	1.73	12.3	0.004	1.23	27.2	0.016	1.78
Nov	1.56	0.24	4.78	42.0	827	8.37	1.61	17.6	0.001	1.10	27.9	0.016	1.72
Dec	0.94	0.15	3.23	27.9	684	6.9	1.13	10.5	0.004	1.82	21.7	0.023	1.90
Annual Average	**0.77**	**0.15**	**4.72**	**42.1**	**818**	**8.5**	1.63	**10.3**	**0.004**	**1.97**	**23.8**	**0.017**	**1.94**

Site 62: London Westminster

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.91	0.21	0.14	15.5	375	5.32	0.70	12.1	0.002	1.61	26.6	0.017	2.27
Feb	0.71	0.15	0.03	15.3	382	5.72	4.84	9.3	0.009	2.17	16.5	0.013	2.22
Mar	0.64	0.11	1.67	15.3	407	5.29	1.47	7.9	0.003	2.44	14.7	0.019	1.85
Apr	0.85	0.22	1.86	16.5	514	7.96	1.49	10.4	0.003	2.85	23.3	0.037	2.41
May	0.60	0.13	1.96	17.7	480	6.24	1.20	11.2	0.003	2.24	18.5	0.020	2.25
Jun	0.56	0.17	2.74	16.4	461	6.61	1.98	8.6	0.003	3.89	19.9	0.027	1.93
Jul	0.09	0.07	2.02	13.4	408	4.77	0.83	6.2	<0.001	1.47	12.0	0.015	2.27
Aug	0.49	0.07	2.92	13.4	376	4.37	0.66	7.5	0.002	0.92	10.7	0.011	2.24
Sep	0.53	0.13	2.17	16.6	428	5.53	1.28	7.1	0.003	1.73	17.5	0.016	3.63
Oct	0.79	0.16	2.18	17.7	430	5.61	1.27	13.5	0.002	1.35	20.6	0.020	2.02
Nov	1.38	0.26	2.52	26.6	488	6.07	1.06	21.2	0.005	1.08	28.8	0.026	1.72
Dec	0.75	0.13	1.34	15.1	398	5.3	0.83	11.8	0.005	1.14	19.1	0.027	1.78
Annual Average	**0.69**	**0.15**	**1.84**	**16.6**	**430**	**5.73**	1.45	**10.53**	**0.003**	**1.91**	**18.84**	**0.021**	**2.21**

Site 65: Eskdalemuir

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.07	0.03	0.01	0.2	7	0.38	0.00	1.3	<0.001	0.49	2.7	0.006	1.65
Feb	0.08	0.03	0.10	0.2	12	0.36	0.07	1.8	<0.001	0.25	1.9	0.012	4.63
Mar	0.15	0.02	0.31	0.3	14	0.55	0.15	1.4	<0.001	0.54	1.8	0.001	1.38
Apr	0.25	0.03	1.79	0.5	92	2.20	0.08	1.4	<0.001	0.44	1.0	0.003	1.92
May	0.12	0.03	0.25	0.4	44	1.26	0.04	1.3	<0.001	0.29	2.6	0.004	1.39
Jun	0.05	0.02	1.15	0.6	85	1.90	0.18	1.1	<0.001	0.78	2.5	0.003	1.58
Jul	0.05	0.00	0.85	0.1	13	0.48	0.00	0.7	0.002	0.14	0.7	0.002	1.65
Aug	0.16	0.01	2.42	0.2	15	0.83	0.26	0.3	<0.001	0.02	1.1	0.003	1.34
Sep	0.19	0.02	1.13	0.7	47	1.33	0.25	1.4	<0.001	0.26	3.1	0.004	0.93
Oct	0.34	0.03	1.20	0.5	30	0.84	0.37	1.6	<0.001	0.17	4.4	0.003	1.24
Nov	0.13	0.04	0.01	1.1	15	0.80	0.34	2.2	<0.001	0.52	7.5	0.001	1.57
Dec	0.07	0.01	0.01	0.1	6	0.19	0.04	0.9	<0.001	0.25	1.5	0.002	1.28
Annual Average	**0.14**	**0.02**	**0.78**	**0.4**	**31**	**0.92**	**0.15**	**1.3**	0.001	**0.35**	**2.6**	**0.004**	**1.69**

Site 66: Motherwell South

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.98	0.19	0.06	8.2	99	1.91	0.05	41.9	<0.001	0.31	48.1	0.006	1.94
Feb	1.68	0.22	0.18	15.9	270	4.53	0.51	61.6	0.001	0.65	47.4	0.009	2.45
Mar	0.54	0.19	0.01	4.8	172	3.81	0.24	22.8	<0.001	0.74	24.8	0.004	4.81
Apr	1.23	0.37	0.61	3.8	236	5.49	0.62	12.3	<0.001	0.97	22.1	0.007	4.09
May	0.67	0.09	1.07	3.0	205	4.49	0.22	6.4	<0.001	0.71	11.1	0.010	5.16
Jun	0.70	0.34	1.15	4.2	156	3.90	0.10	15.7	<0.001	0.52	24.8	0.009	2.86
Jul	0.17	0.02	0.33	1.7	89	1.91	0.02	2.5	0.001	0.37	3.5	0.005	2.95
Aug	0.51	0.51	2.22	5.5	168	3.26	0.19	6.1	<0.001	0.18	9.2	0.007	2.32
Sep	0.75	0.53	4.11	4.3	158	3.06	0.86	8.2	<0.001	0.45	91.5	0.013	2.24
Oct	0.74	0.06	1.03	4.8	160	2.47	0.60	3.4	<0.001	0.24	7.8	0.006	1.86
Nov	0.46	0.15	0.01	11.8	199	4.41	0.14	4.4	<0.001	0.01	7.5	0.024	1.28
Dec	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Annual Average	**0.76**	**0.24**	**0.99**	**6.1**	**173**	**3.56**	**0.32**	**16.8**	0.001	**0.48**	**27.2**	**0.009**	**2.91**

Site 67: Manchester Wythenshawe

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	1.02	0.16	2.04	32.3	784	7.98	0.64	10.1	0.006	1.15	29.8	0.012	4.28
Feb	1.09	0.21	4.60	47.7	1150	12.2	2.53	15.2	0.010	1.36	37.9	0.033	2.97
Mar	0.83	0.21	6.12	58.0	1304	14.9	3.60	10.5	0.011	1.87	50.9	0.025	2.08
Apr	1.25	0.19	6.96	59.0	1545	18.4	1.93	10.0	0.009	1.87	45.1	0.019	1.73
May	0.81	0.15	6.46	50.7	1220	13.5	1.41	7.5	0.009	1.25	35.3	0.018	2.33
Jun	0.57	0.11	5.86	46.2	1069	11.6	1.31	6.5	0.012	1.57	29.8	0.012	1.98
Jul	0.21	0.07	4.16	39.4	941	9.05	0.83	4.7	0.007	0.72	25.1	0.012	1.95
Aug	0.85	0.10	5.95	38.4	913	8.97	0.98	5.9	0.007	0.58	24.0	0.011	1.67
Sep	0.59	0.09	5.86	44.8	1044	10.5	1.01	5.5	0.008	1.17	26.6	0.014	1.75
Oct	1.04	0.16	5.56	43.6	991	9.73	1.32	7.5	0.009	0.75	29.0	0.020	1.55
Nov	2.33	0.49	6.58	55.5	1075	10.9	1.33	23.0	0.007	1.02	49.0	0.024	1.55
Dec	1.57	0.27	5.44	44.6	1076	10.5	2.54	18.1	0.008	0.76	41.8	0.041	1.81
Annual Average	**0.99**	**0.18**	**5.43**	**46.5**	**1092**	**11.5**	**1.63**	**10.2**	**0.009**	**1.16**	**35.2**	**0.020**	**2.13**

Site 68: Cardiff Llandaff

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.90	0.17	1.93	20.5	625	7.50	0.54	8.6	0.007	1.03	26.8	0.015	1.38
Feb	0.91	0.15	2.21	25.4	754	10.4	1.03	8.9	0.006	1.29	30.5	0.012	1.62
Mar	0.58	0.15	2.23	23.6	665	9.66	0.96	9.2	0.005	1.68	28.8	0.012	1.66
Apr	1.09	0.28	3.63	27.3	905	15.9	1.45	10.0	0.004	2.02	39.7	0.012	1.77
May	0.58	0.21	3.22	25.4	822	13.0	1.01	10.4	0.005	1.12	38.3	0.018	1.66
Jun	0.55	0.21	3.21	25.0	749	11.6	1.27	8.6	0.007	1.92	30.6	0.014	1.25
Jul	0.42	0.08	2.38	20.0	555	7.32	0.70	4.2	0.004	0.91	17.1	0.010	1.41
Aug	0.53	0.08	5.02	19.5	576	7.29	0.63	4.2	0.004	0.61	17.8	0.009	0.93
Sep	0.67	0.13	4.42	25.4	707	9.31	1.10	6.3	0.005	1.06	25.9	0.012	1.40
Oct	0.93	0.18	2.68	26.6	734	8.88	1.15	8.8	0.003	0.92	24.1	0.015	1.51
Nov	1.01	0.19	2.92	26.8	698	8.00	1.00	10.2	0.002	0.90	27.0	0.013	0.83
Dec	1.40	0.33	2.73	20.5	722	8.4	1.18	13.1	0.003	0.81	25.3	0.018	0.79
Annual Average	**0.80**	**0.18**	**3.07**	**23.8**	**708**	**9.7**	**1.01**	**8.51**	**0.005**	**1.19**	**27.4**	**0.013**	**1.35**

Site 69: Walsall Bilston Lane

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	1.11	0.67	0.78	50.9	296	11.7	1.15	23.6	<0.001	1.28	107	0.026	3.30
Feb	1.13	0.95	1.26	24.0	363	10.2	1.22	25.7	0.001	1.61	185	0.029	2.01
Mar	1.30	2.67	11.57	69.3	466	16.6	2.64	68.2	<0.001	1.97	469	0.068	1.90
Apr	1.56	2.23	5.67	57.3	640	18.9	2.02	49.2	<0.001	1.58	373	0.087	2.86
May	0.87	1.02	2.87	24.2	360	9.23	0.86	16.4	0.002	0.83	190	0.041	3.01
Jun	0.68	1.30	2.69	24.3	404	9.30	1.31	22.1	0.003	1.68	155	0.017	2.98
Jul	0.62	3.81	5.06	62.0	338	15.1	1.95	70.8	0.001	0.76	841	0.028	2.67
Aug	0.55	1.32	4.25	36.0	314	9.08	1.19	27.7	0.001	0.71	493	0.033	2.04
Sep	1.12	2.83	6.39	46.0	481	12.3	2.57	78.9	0.002	1.16	474	0.143	2.81
Oct	1.36	1.22	2.87	38.8	431	13.4	1.92	72.0	<0.001	0.82	223	0.090	2.50
Nov	2.04	1.25	3.43	36.1	408	11.5	1.37	48.2	<0.001	1.09	236	0.276	1.85
Dec	2.98	6.57	4.81	56.8	508	15.5	2.43	105.0	<0.001	0.91	236	0.111	1.45
Annual Average	**1.16**	**1.87**	**4.29**	**43.1**	**411**	**12.6**	**1.68**	**47.2**	**0.001**	**1.22**	**340**	**0.077**	**2.46**

Site 100: Swansea Coedgwilym

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.87	0.24	1.71	3.5	125	2.62	10.0	9.5	<0.001	0.87	13.9	0.027	N/A
Feb	0.52	0.19	3.37	3.0	134	2.61	10.8	9.9	<0.001	0.80	10.9	0.021	N/A
Mar	0.58	0.26	2.97	3.4	248	5.62	8.43	10.3	<0.001	1.28	26.8	0.010	N/A
Apr	0.84	0.32	6.62	4.4	444	11.3	8.51	11.8	<0.001	1.43	24.9	0.055	N/A
May	0.44	0.21	1.97	3.0	177	4.38	7.22	8.0	<0.001	0.80	12.7	0.012	N/A
Jun	0.38	0.18	2.67	3.1	171	4.01	10.1	6.1	0.001	1.30	10.8	0.004	N/A
Jul	0.45	0.13	2.66	5.1	92	2.23	10.3	6.5	<0.001	0.72	8.1	0.013	N/A
Aug	0.41	0.09	5.08	3.1	78	2.15	18.2	3.7	<0.001	0.48	5.2	0.017	N/A
Sep	0.46	0.11	2.45	3.9	117	2.55	12.5	5.3	<0.001	0.67	10.4	0.018	N/A
Oct	0.92	0.14	3.01	4.9	156	3.93	9.18	8.5	<0.001	0.58	14.3	0.012	N/A
Nov	1.41	0.20	2.95	5.5	137	2.55	9.02	9.6	<0.001	0.49	13.6	0.011	N/A
Dec	1.78	0.26	3.51	4.7	160	3.4	11.02	12.1	<0.001	0.94	16.5	0.014	N/A
Annual Average	**0.76**	**0.19**	**3.25**	**3.98**	**168**	**3.91**	**10.48**	**8.4**	0.001	**0.85**	**13.8**	**0.018**	**N/A**

Site 101: Swansea Morriston

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.87	0.25	0.53	21.4	559	7.68	40.0	15.0	0.004	0.83	28.3	0.013	1.17
Feb	0.71	0.31	2.42	31.3	735	11.0	9.42	20.2	0.001	1.06	47.2	0.009	1.28
Mar	0.74	0.41	2.34	21.9	672	12.6	7.71	18.3	0.001	1.59	62.7	0.008	1.48
Apr	1.10	0.43	3.65	30.1	793	16.5	11.1	18.2	<0.001	1.73	52.6	0.020	1.00
May	0.65	0.31	3.17	23.0	508	7.82	9.45	12.3	0.001	0.97	38.8	0.006	1.53
Jun	0.47	0.28	1.81	31.0	427	7.19	10.3	15.9	0.003	1.46	29.2	0.006	1.41
Jul	0.70	0.21	3.00	29.0	334	5.18	6.48	15.3	0.001	0.86	17.0	0.024	1.97
Aug	0.48	0.12	3.86	32.3	371	4.70	10.4	11.4	0.002	0.67	12.5	0.015	1.84
Sep	0.78	0.18	2.77	39.4	540	8.49	14.0	13.6	0.001	1.00	26.1	0.010	1.64
Oct	0.91	0.23	2.12	58.0	540	8.36	18.0	25.7	<0.001	0.66	31.8	0.012	1.24
Nov	1.56	0.34	5.73	52.2	647	7.49	16.5	24.7	<0.001	0.65	28.9	0.008	1.90
Dec	1.50	0.46	3.05	76.4	825	9.8	28.15	24.9	0.001	0.88	46.1	0.011	1.44
Annual Average	**0.88**	**0.30**	**2.85**	**37.30**	**582**	**8.95**	**15.28**	**18.07**	**0.001**	**1.03**	**35.5**	**0.012**	**1.49**

Site 103: Belfast Centre

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.44	0.10	1.14	6.4	169	2.31	0.27	5.0	0.005	1.25	11.0	0.006	2.02
Feb	0.39	0.12	0.21	11.4	336	4.39	0.66	5.2	0.005	2.24	13.4	0.007	2.06
Mar	0.57	0.21	2.07	11.7	429	6.32	1.03	6.5	0.006	2.14	16.1	0.012	2.00
Apr	0.33	0.10	1.65	8.3	372	6.20	1.03	4.8	0.004	2.16	12.1	0.008	3.91
May	0.49	0.08	1.98	5.4	190	3.49	0.47	2.4	<0.001	1.12	8.6	0.002	1.94
Jun	0.19	0.08	2.55	6.5	289	5.03	1.00	3.3	0.005	2.14	15.6	0.006	1.95
Jul	0.43	0.09	1.83	5.1	179	2.67	0.34	5.8	0.010	0.74	24.0	0.006	2.44
Aug	0.38	0.06	1.90	5.9	188	2.88	0.39	2.2	0.009	0.52	9.8	0.008	1.84
Sep	0.70	0.10	2.26	10.4	303	5.02	1.11	5.6	0.006	1.60	13.9	0.010	1.13
Oct	0.82	0.12	1.82	11.4	249	3.34	0.62	5.0	0.005	0.91	13.3	0.007	1.81
Nov	0.35	0.28	0.62	8.4	225	3.38	0.39	4.9	0.005	0.66	11.6	0.005	0.46
Dec	0.95	0.18	0.44	8.1	216	3.51	1.23	6.1	0.002	1.59	20.6	0.003	0.69
Annual Average	**0.51**	**0.13**	**1.55**	**8.2**	**261**	**4.03**	**0.71**	**4.7**	**0.005**	**1.41**	**14.2**	**0.007**	**1.91**

Site 104: Port Talbot Margam

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.49	0.17	0.19	5.3	1328	16.8	0.59	7.2	<0.001	1.03	32.1	0.009	N/A
Feb	0.43	0.13	0.01	5.5	909	14.5	0.58	7.1	<0.001	1.04	24.2	0.010	N/A
Mar	0.52	0.64	1.14	7.1	1756	31.3	0.97	12.6	<0.001	2.22	87.2	0.012	N/A
Apr	0.93	0.65	4.57	8.8	3173	68.7	1.50	15.5	<0.001	3.17	136.9	0.019	N/A
May	1.13	0.23	2.20	6.8	3699	55.9	1.16	10.9	<0.001	2.35	42.2	0.019	N/A
Jun	0.56	0.61	2.83	8.1	3551	34.2	2.22	16.4	0.001	3.60	61.6	0.026	N/A
Jul	0.69	0.38	3.63	7.4	4262	58.9	1.51	21.4	0.001	2.56	50.5	0.014	N/A
Aug	0.52	0.20	2.86	6.8	2963	41.7	1.22	6.0	0.001	1.54	41.7	0.015	N/A
Sep	0.85	0.21	2.49	7.8	2916	44.0	1.41	8.9	<0.001	1.74	64.6	0.013	N/A
Oct	1.19	0.24	5.01	8.2	3739	59.3	5.09	10.9	<0.001	1.83	48.1	0.013	N/A
Nov	0.57	0.20	1.10	8.6	719	13.3	1.10	8.9	<0.001	0.46	26.1	0.008	N/A
Dec	0.69	0.25	0.37	6.8	679	10.8	0.71	9.5	<0.001	0.62	32.5	0.003	N/A
Annual Average	**0.72**	**0.33**	**2.21**	**7.3**	**2486**	**37.6**	**1.51**	**11.3**	0.001	**1.85**	**54.0**	**0.013**	**N/A**

Site 105: Sheffield Centre

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.33	0.07	1.30	4.5	114	3.83	0.47	5.4	<0.001	0.44	10.4	0.007	2.17
Feb	0.67	0.39	9.05	18.1	369	17.2	3.97	24.8	0.001	1.02	49.7	0.049	1.96
Mar	0.53	0.17	4.46	10.4	382	20.0	9.79	11.5	<0.001	1.17	26.0	0.022	1.63
Apr	0.95	0.19	6.74	10.5	440	22.2	1.30	12.5	<0.001	1.58	23.4	0.044	1.48
May	0.88	0.32	8.49	11.5	435	18.7	3.01	10.9	<0.001	1.20	28.0	0.070	1.69
Jun	0.43	0.13	7.01	9.7	405	14.9	2.56	10.6	0.003	1.38	33.1	0.021	3.07
Jul	0.31	0.07	3.71	7.6	220	6.99	0.35	4.8	0.002	0.64	11.6	0.036	1.20
Aug	0.47	0.07	5.02	7.4	238	7.20	0.95	5.3	0.001	0.44	15.9	0.044	1.51
Sep	0.51	0.13	4.93	11.1	331	9.75	1.56	9.0	0.001	0.67	21.8	0.031	2.32
Oct	0.84	0.19	4.73	11.7	332	10.2	2.11	9.5	<0.001	0.70	23.8	0.071	1.12
Nov	1.15	0.28	3.46	14.0	241	6.88	1.59	19.5	<0.001	0.49	44.9	0.055	0.97
Dec	1.17	0.25	5.38	14.4	324	9.5	2.66	15.7	<0.001	1.39	29.2	0.008	1.51
Annual Average	**0.69**	**0.18**	**5.25**	**10.7**	**318**	**12.13**	**2.49**	**11.25**	**0.001**	**0.92**	**25.8**	**0.038**	**1.72**

Site 106: Scunthorpe Town

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.67	0.13	1.89	2.9	223	12.1	0.27	8.7	<0.001	0.88	13.4	0.011	N/A
Feb	0.71	0.15	1.00	4.7	532	17.1	1.27	29.3	<0.001	2.03	26.7	0.011	N/A
Mar	0.66	0.12	2.77	4.8	555	20.2	0.71	12.1	<0.001	1.46	18.9	0.002	N/A
Apr	0.83	0.20	6.06	6.3	660	26.6	1.00	10.3	<0.001	2.00	21.0	0.021	N/A
May	0.67	0.15	2.50	5.5	675	31.2	0.85	11.7	<0.001	1.73	19.5	0.016	N/A
Jun	0.48	0.10	3.17	5.0	1175	32.9	1.18	16.0	<0.001	2.10	25.7	0.017	N/A
Jul	0.40	0.08	2.08	4.5	449	16.3	0.62	7.6	0.001	1.24	16.7	0.015	N/A
Aug	0.42	0.07	3.68	3.9	233	10.0	0.38	4.5	<0.001	0.43	12.7	0.029	N/A
Sep	0.92	0.13	3.42	5.1	1485	40.5	1.21	17.4	<0.001	1.86	25.0	0.024	N/A
Oct	1.24	0.11	2.71	5.1	300	12.4	0.73	7.9	<0.001	0.90	17.5	0.018	N/A
Nov	1.15	0.23	1.71	8.3	802	37.2	1.04	33.9	<0.001	0.98	35.0	0.028	N/A
Dec	1.21	0.21	1.86	5.7	290	8.3	0.66	13.6	<0.001	1.09	24.5	0.023	N/A
Annual Average	**0.78**	**0.14**	**2.68**	**5.1**	**610**	**21.9**	**0.81**	**14.3**	0.001	**1.37**	**21.3**	**0.018**	**N/A**

Site 107: Scunthorpe Low Santon

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.71	0.18	0.82	3.8	466	26.3	0.58	9.3	<0.001	2.14	16.4	0.008	N/A
Feb	0.55	0.14	0.18	2.7	355	21.1	0.64	18.8	<0.001	1.89	12.7	0.009	N/A
Mar	1.03	0.17	4.59	6.5	2889	130	2.27	42.0	<0.001	5.80	33.4	0.021	N/A
Apr	0.88	0.19	5.08	5.3	1928	116	1.29	33.6	<0.001	4.76	30.2	0.018	N/A
May	0.56	0.14	2.58	4.2	1235	91.6	0.84	16.8	<0.001	4.41	21.2	0.018	N/A
Jun	0.29	0.07	2.39	2.4	582	33.5	0.84	7.8	0.001	2.80	10.2	0.014	N/A
Jul	0.67	0.12	5.02	4.6	2449	135	1.26	27.8	0.001	5.84	29.4	0.024	N/A
Aug	0.80	0.11	5.19	3.6	1552	91.3	0.91	14.6	<0.001	4.06	27.7	0.036	N/A
Sep	0.79	0.09	2.75	3.5	1090	54.5	0.76	18.1	<0.001	2.87	22.9	0.015	N/A
Oct	1.42	0.22	4.43	5.0	1678	104	1.36	68.0	<0.001	4.44	35.9	0.015	N/A
Nov	1.03	0.23	1.64	5.6	1109	47.6	0.86	36.1	<0.001	1.73	31.0	0.009	N/A
Dec	0.87	0.13	1.38	3.2	703	31.9	0.48	14.7	<0.001	1.59	16.5	0.008	N/A
Annual Average	**0.80**	**0.15**	**3.03**	**4.2**	**1346**	**74.1**	**1.01**	**25.7**	0.001	**3.55**	**24.1**	**0.016**	**N/A**

Site 108: Redcar

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.62	0.14	3.86	3.5	216	15.9	2.52	7.2	<0.001	0.91	24.6	0.010	N/A
Feb	0.66	0.23	0.76	4.1	508	24.8	1.34	11.4	<0.001	1.48	37.7	0.010	N/A
Mar	0.67	0.13	0.60	3.7	418	10.2	1.13	6.3	<0.001	1.63	12.3	0.009	N/A
Apr	0.70	0.16	1.28	4.0	475	12.0	5.25	6.2	<0.001	1.55	14.3	0.008	N/A
May	0.55	0.12	0.10	3.4	519	13.1	0.83	6.2	<0.001	1.50	13.9	0.012	N/A
Jun	0.38	0.09	0.47	2.3	264	7.22	1.34	4.4	0.001	2.24	9.9	0.012	N/A
Jul	0.33	0.22	1.99	2.0	199	6.44	0.58	3.1	0.001	0.75	6.7	0.007	N/A
Aug	0.38	0.21	2.77	2.2	232	6.17	0.94	5.0	<0.001	0.62	6.9	0.018	N/A
Sep	0.57	0.17	2.20	3.4	284	7.36	8.97	5.8	0.001	0.84	12.0	0.013	N/A
Oct	0.55	0.10	0.89	2.6	179	4.14	0.72	5.2	<0.001	0.63	14.0	0.012	N/A
Nov	0.98	0.17	1.06	5.5	160	4.66	0.98	10.4	<0.001	0.52	23.5	0.009	N/A
Dec	0.96	0.15	1.32	3.9	277	5.6	1.56	9.5	<0.001	0.79	26.7	0.011	N/A
Annual Average	**0.62**	**0.15**	**1.41**	**3.4**	**313**	**9.83**	**2.22**	**6.8**	0.001	**1.13**	**17.1**	**0.011**	**N/A**

Site 109: Cardiff Rumney

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.72	0.21	0.18	4.9	195	3.88	1.35	10.2	<0.001	0.96	30.3	0.015	N/A
Feb	0.80	0.13	0.01	4.9	146	3.11	0.45	6.1	0.001	1.80	12.9	0.009	N/A
Mar	0.85	0.25	0.36	5.7	222	7.22	0.86	10.7	<0.001	1.39	28.2	0.016	N/A
Apr	1.00	0.23	2.44	6.0	386	12.9	0.96	9.7	<0.001	1.72	25.6	0.017	N/A
May	0.66	0.17	2.35	5.2	393	12.5	0.69	7.3	<0.001	1.13	20.0	0.015	N/A
Jun	0.45	0.24	1.88	5.2	311	9.50	0.75	8.7	0.002	1.71	25.6	0.012	N/A
Jul	0.30	0.08	0.91	3.6	166	4.82	0.56	4.3	0.001	0.90	15.8	0.011	N/A
Aug	0.53	0.08	2.61	3.8	164	4.04	0.69	4.3	<0.001	0.39	13.7	0.013	N/A
Sep	0.62	0.18	2.09	12.9	214	4.75	0.89	7.7	<0.001	0.92	17.5	0.017	N/A
Oct	1.17	0.19	3.17	9.2	285	7.06	1.32	9.5	<0.001	0.92	31.5	0.019	N/A
Nov	1.18	0.26	1.42	10.1	168	3.50	1.08	10.8	<0.001	0.79	20.6	0.012	N/A
Dec	1.05	0.25	0.14	5.8	201	3.65	0.43	10.0	<0.001	1.12	17.6	0.011	N/A
Annual Average	**0.78**	**0.19**	**1.50**	**6.5**	**239**	**6.47**	**0.83**	**8.3**	0.001	**1.14**	**21.5**	**0.014**	**N/A**

Site 110: Chadwell St. Mary

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	1.26	0.59	0.05	10.1	236	4.69	1.77	16.9	0.003	3.59	31.4	0.014	N/A
Feb	0.82	0.22	0.35	9.1	219	3.90	1.90	10.6	0.001	3.86	17.6	0.009	N/A
Mar	0.54	0.15	0.99	10.2	226	3.89	1.85	8.6	0.002	3.70	16.0	0.013	N/A
Apr	0.92	0.36	2.34	7.5	330	7.56	2.77	9.7	<0.001	5.56	19.9	0.012	N/A
May	0.56	0.15	0.43	7.4	240	4.82	1.77	8.7	0.002	4.04	16.1	0.014	N/A
Jun	0.47	0.21	0.02	7.4	265	5.60	2.88	8.8	0.001	6.20	19.2	0.010	N/A
Jul	0.10	0.27	2.02	8.3	309	4.51	1.37	8.0	0.002	2.55	14.9	0.025	N/A
Aug	0.60	0.13	3.43	8.4	244	3.74	0.95	7.2	0.002	1.52	13.9	0.022	N/A
Sep	0.81	0.15	2.22	9.1	257	4.92	1.85	8.9	0.002	2.58	24.7	0.015	N/A
Oct	0.71	0.23	1.60	10.0	263	4.65	1.84	13.2	0.001	2.68	21.9	0.015	N/A
Nov	1.70	0.40	1.36	17.1	235	4.53	1.33	20.6	<0.001	1.45	40.3	0.015	N/A
Dec	0.88	0.18	0.81	8.8	196	4.07	1.38	10.0	<0.001	1.54	31.5	0.009	N/A
Annual Average	**0.78**	**0.25**	**1.31**	**9.4**	**252**	**4.74**	**1.80**	**10.9**	**0.001**	**3.26**	**22.3**	**0.014**	**N/A**

Site 111: Redcar Normanby

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.27	0.13	0.01	2.1	85	3.87	0.28	6.1	<0.001	0.91	11.3	0.004	N/A
Feb	0.30	0.15	0.10	3.3	135	6.62	0.55	8.5	<0.001	1.46	13.3	0.011	N/A
Mar	0.35	0.07	0.03	2.4	138	3.69	0.61	4.5	<0.001	0.79	8.7	0.010	N/A
Apr	0.35	0.07	0.02	2.1	170	5.48	0.16	3.2	<0.001	0.70	5.7	0.012	N/A
May	0.35	0.11	0.17	2.2	135	4.17	0.11	3.8	<0.001	0.39	5.8	0.017	N/A
Jun	0.18	0.06	0.57	1.6	125	3.89	0.48	2.7	0.001	1.15	5.9	0.006	N/A
Jul	0.23	0.03	0.86	2.0	76	2.19	0.10	1.7	0.001	0.29	5.2	0.011	N/A
Aug	0.27	0.03	1.10	1.6	76	2.52	0.21	1.5	<0.001	0.24	4.0	0.010	N/A
Sep	1.13	0.05	1.04	2.3	87	2.95	0.46	3.2	<0.001	0.72	8.9	0.009	N/A
Oct	0.87	0.07	0.41	2.7	89	2.57	0.59	4.9	<0.001	0.54	11.7	0.007	N/A
Nov	0.53	0.10	0.58	2.7	64	2.09	0.53	6.3	<0.001	0.28	15.2	0.010	N/A
Dec	0.40	0.13	0.76	1.9	61	1.94	0.62	5.1	<0.001	0.66	11.3	0.009	N/A
Annual Average	**0.44**	**0.08**	**0.47**	**2.2**	**103**	**3.47**	**0.39**	**4.3**	0.001	**0.67**	**8.9**	**0.010**	**N/A**

Site 112: Dartford Bean

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	1.01	0.24	0.01	7.2	146	3.02	1.09	11.9	0.003	2.60	22.1	0.021	N/A
Feb	0.60	0.16	0.01	6.3	131	2.45	1.16	7.9	0.001	3.32	14.2	0.010	N/A
Mar	0.53	0.15	0.01	7.2	205	3.52	1.37	7.5	<0.001	2.89	13.8	0.007	N/A
Apr	0.88	0.30	2.69	9.1	288	6.01	1.93	10.7	<0.001	3.96	18.3	0.014	N/A
May	0.64	0.15	1.68	8.3	239	4.42	1.69	10.0	0.001	3.44	14.6	0.010	N/A
Jun	0.46	0.18	1.66	6.5	209	4.52	2.26	9.9	0.004	4.91	17.1	0.008	N/A
Jul	0.50	0.10	3.43	7.7	235	4.82	1.05	4.8	0.002	1.81	10.3	0.017	N/A
Aug	0.53	0.08	0.84	6.0	141	2.28	0.83	3.8	0.001	0.87	7.2	0.008	N/A
Sep	1.04	0.13	1.00	8.3	183	3.67	1.28	6.6	0.001	1.62	16.9	0.010	N/A
Oct	1.23	0.17	1.33	7.4	182	4.08	1.45	7.5	0.001	1.98	16.9	0.011	N/A
Nov	1.43	0.29	1.78	18.0	202	3.76	1.08	14.1	<0.001	1.29	22.7	0.015	N/A
Dec	0.98	0.21	0.99	10.4	221	4.19	1.30	12.0	0.001	1.22	18.9	0.023	N/A
Annual Average	**0.81**	**0.18**	**1.32**	**8.6**	**199**	**3.89**	**1.37**	**8.8**	**0.001**	**2.46**	**15.8**	**0.013**	**N/A**

Next page:

Image 7. The Network monitoring site at Motherwell South.