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Report to the Department of Environment, Food and Rural Affairs, and the Devolved Administrations, by the National Physical Laboratory:

Annual Report for 2009 on the UK Heavy Metals Monitoring Network

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Annual Report for 2009 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 for the Environment, Food and Rural Affairs and the Devolved Administrations.

This is the Annual Report for 2009 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 2009.
- A summary of scientific research, publications, international representation and other activities related to the Network.

In summary, during 2009:

- None of the relevant 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**: One annual average site concentration above the Fourth Daughter Directive Upper Assessment Threshold was recorded.

- **Cadmium**: One annual average site concentration above the Fourth Daughter Directive Lower Assessment Threshold was recorded.

- **Arsenic**: No annual average site concentrations above the Fourth Daughter Directive 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 **95.5 %** for the year.

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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 for the Environment, Food and Rural Affairs and the Devolved Administrations[1].

This is the Annual Summary Report for the UK Heavy Metals Monitoring Network (the 'Network') for 2009 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 2009.

- 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.

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

[1] The devolved administrations are as follows: the National Assembly for Wales (NAW), the Northern Ireland Executive, represented by the Department of the Environment in Northern Ireland (DoENI), and the Scottish Executive, represented by the Scottish Executive Environment and Rural Affairs Department (SEERAD).
[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.
[5] The term 'concentration' is used in this report to refer to mass concentration.

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 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 to the assessment of the accuracy of emissions inventories for metals. 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)].

[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.

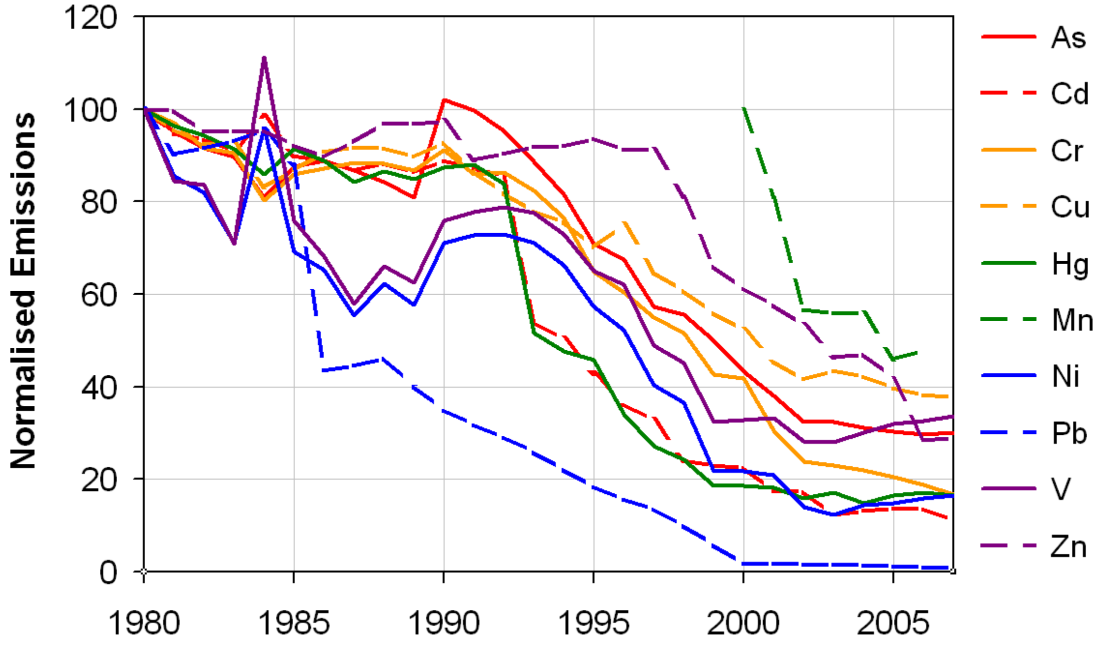

Figure 1. Estimated UK annual emissions of the metals from 1980 to 2007, normalised to their values in 1980 such that 1980 = 100 (except for Mn where values are only available since 2000 and therefore have been normalised to this year). The absolute levels of emissions in 1980, in tonnes, were: Cd, 26; 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 current UK Heavy Metals Monitoring Network comprises 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 absorption 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 2009 is detailed below.

2.1 Overview

NPL's management of the UK Heavy Metals Monitoring Network in 2009 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.

- The monitoring site in Motherwell was re-located to correct a micro-siting non-compliance. The monitoring site at Scunthorpe Santon has been renamed to Scunthorpe Low Santon to maintain consistency with the names of local authority monitoring sites in the area.

- Additional mercury vapour monitoring was initiated at four Network sites to bring the total number of sites performing this measurement to 13 – the number prior to the extensive Network re-organisation of 2008.

- 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 2009 – details are given in Section 8.

2.2 Site Audits

During 2009 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 2009, with locations, site codes, site names, site designations, identified point sources in the vicinity where applicable, is given in Annex 1. Following the reorganisation of the Network during 2008 the names of some sites changed to ensure consistency and avoid confusion, and to adopt the names of sites co-located with existing monitoring sites – the details of these changes, listing old and new site names, are also 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).

The audit data recorded at each site may be found in Annexes 2 and 3. This flow data is used to correct the flows recorded by the Partisol instruments 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 on the Partisol samplers and the mercury vapour sampling equipment were satisfactory and no remedial action was required. The difference from set point determined at the audit visit is used at the data ratification stage to adjust the volume of air recorded for each sample.
- Nearly all of the LSOs audited were carrying out all of their functions correctly. However, there were a few cases where the audit procedure found that best practice was not being followed and corrective action was recommended related to:
    - Excessive grease on o-rings that seal the Partisol PM_{10} head onto the sampler. This results in a build up of grease on the inside of the main sampling orifice, which can remove particles from the sample air stream. The grease was removed and the LSO was instructed to remove regularly any grease build up in future.
    - Partisol sampler operating in standard flow control mode rather than volumetric flow control mode. This was corrected during the audit visit.
    - Misalignment of filter cartridge causing small leaks in the sample train. This was corrected during the audit visit.

[9] NPL Report AS (RES) 037, "UK Heavy Metals Monitoring Network Audit Report For 2009", Beccaceci, S, Butterfield, D M, Sweeney, B, NPL, October 2009.

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 –1.7 %, which is well within the uncertainty of the flow measurement itself.

Image 1. A site audit in progress at the London Horseferry Road Network site.

2.3 Equipment Servicing and Breakdowns

During 2009 the ESU twice fully serviced, carried out preventative maintenance and calibrated the flow of the Partisol samplers at all Network sites.

During 2009, NPL called-out the ESU to deal with Partisol sampler faults at:

- Belfast Centre AURN (sampler locking-up during sampling)
- Cardiff Rumney (low valid hours reported)
- Cardiff Llandaff (machine display corrupted)
- Dartford Bean (faulty spring on filter holder)
- London Cromwell Road (twice: sampler locking-up during sampling)
- Manchester Wythenshawe (instrument display panel replaced)
- Redcar AURN (low flow rate)
- Runcorn Weston Point (twice: low flow rate and continually tripping residual-current device)
- Scunthorpe Town AURN (low valid hours)
- Walsall Centre (three times: low valid hours, twice, and low flow rate)

During 2009, failed mercury vapour sampling pumps at Belfast Centre AURN and Eskdalemuir were replaced by NPL.

Following the installation of new pumps for sampling total gaseous mercury across the Network in 2006, there have only been four failures of mercury vapour sampling pumps in the last four years.

2.4 Site Infrastructure and Network Re-organisation

There were no significant issues to report with regard to site infrastructure during 2009. Minor changes to the operation of the Network during the year are detailed below.

Site 66: Motherwell
The Network site in Motherwell was moved at the beginning of 2009 to ensure the micro-siting requirements of the Fourth Air Quality Daughter Directive were met, as the existing monitoring station was sited too far above the breathing zone. Moreover, the original site in Motherwell was set up to monitor the Ravencraig steel works and metals processing plant, which ceased production in 1993, and is soon to be replaced with a new urban development. The new site is also much more representative of local urban exposure. It is less than half a mile from the old site. The details of the new site, called 'Motherwell South', are given in Annex 1.

Image 2. The renamed Network monitoring site at Scunthorpe Low Santon. The Network sampler is in the grey cage on the left of the picture.

Site 107: Scunthorpe Low Santon
Following discussions with North Lincolnshire Council as a result of NPL's involvement in the working party examining the particulate matter (PM) issues in the

Scunthorpe area, the Network monitoring site at Scunthorpe Santon was renamed 'Scunthorpe Low Santon' ('Low Santon', for short) in the final quarter of 2009 (see Image 2). This was to maintain consistency with the naming of local authority sites in the Santon area, and to avoid any confusion about which location is being referred to when reporting data.

Mercury vapour monitoring
Following the Network reorganisation in 2008, NPL committed to install four new mercury vapour monitoring sites to replace those lost at Network sites that were closed as part of the reorganisation.

In 2008 mercury vapour monitoring equipment was installed at the Network sites at Belfast Centre AURN and Swansea Morriston.

In the second quarter of 2009 the final two sets of mercury vapour monitoring equipment were installed at Sheffield Centre AURN (see Image 3) and Bristol Avonmouth bringing the total number of mercury vapour monitoring sites on the Network to 13, matching the pre-reorganisation levels. The current mercury vapour monitoring Network provides excellent urban coverage directly relevant to population exposure.

Annex 1 lists details of the Network sites that undertake mercury vapour measurements.

Image 3. The Network monitoring site at Sheffield Centre AURN where mercury vapour monitoring equipment was installed in June 2009.

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 4). Samples were taken for a period of one week onto 47 mm diameter GN Metricel membrane filters.

Image 4. 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 4). A schematic diagram of the mercury vapour sampling equipment is given in Figure 2.

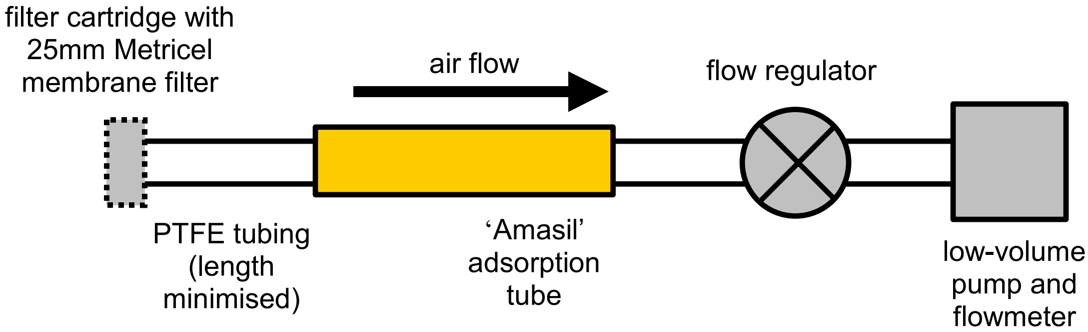

Figure 2. Schematic diagram of the total gaseous mercury sampling apparatus. The 25 mm diameter filter was used to remove any particulate material.

3.3 Analytical Methodology: Particulate-phase Metals

Analysis for particulate-phase metals took place at NPL using a PerkinElmer Elan DRC II ICP-MS, following NPL's procedure, accredited by UKAS to ISO 17025, which is fully compliant with the requirements of EN 14902 (see Image 5).

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.

Image 5: One of two dedicated ICP-MS instruments comprising the UK ambient metals analysis facility at NPL.

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 based on the draft standard method FprEN 15852 (see Image 6). 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.

Image 6: One of two thermal desorption-atomic fluorescence analysers comprising the UK total gaseous mercury analysis facility at NPL

3.5 Measurement Units

Results produced by the Network are expressed as mass concentrations, in nanograms (of the relevant metal) per cubic metre (of 'as sampled' ambient air): 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.

4 Method Performance Characteristics and Quality Control

UKAS carried out an assessment visit to NPL in November 2009. Both 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) were audited by UKAS, and both retained accreditation to ISO 17025 with no mandatory corrective actions.

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	1.0	50	0.3
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 that mass concentration values for these very low level pollutants may now be quoted with pg g^{-1} sensitivity for the first time.

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 draft standard method FprEN 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 2009 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	13 %	40 %
Cr	18 %	-
Cu	13 %	-
Fe	11 %	-
Mn	12 %	-
Ni	13 %	40 %
Pb	11 %	25 %
Pt	40 % ‡	-
V	13 %	-
Zn	12 %	-
Hg(p)	35 %	-
Hg(v)	17 %	50 %

Table 2. Average measurement uncertainties achieved at NPL during 2009. 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. ‡ The majority of Pt measurements are below the limit of detection, the 40% uncertainty 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.)

Data capture across the entire Network during 2009 was **95.5 %**. Of the data lost approximately:

- 60 % was excluded because the minimum number of valid sampling hours was not achieved during the sampling period;
- 35 % was lost owing to equipment failure or site operation problems, and;
- 5 % was excluded at the analytical stage (owing to contamination of samples, instrument failure, exclusion during data ratification).

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.

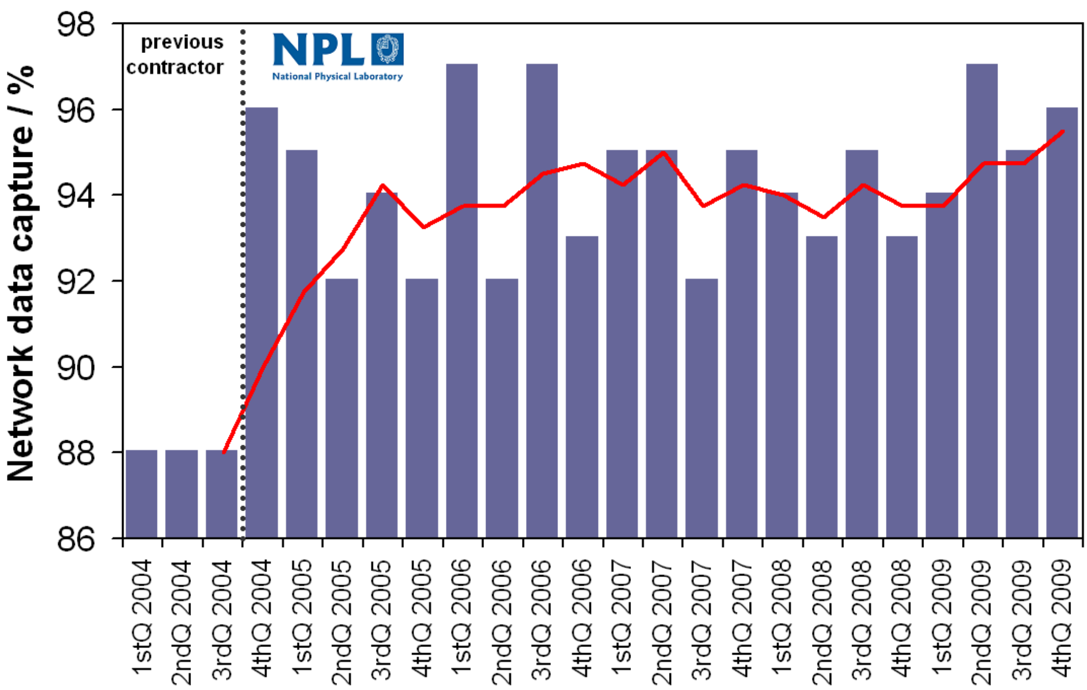

Figure 3. Network data capture from 2004-2009 (inclusive). Quarterly data capture is indicated by the blue-grey bars, whilst the rolling annual average data capture is given by the red line. Data to the right of the dotted vertical line is associated with NPL's current operation of the Network; data 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	**95 %**	**98 %**
46: Walsall Centre	90 %	100 %
47: Bristol Avonmouth	98 %	80 %
56: Bristol Hallen	100 %	*N/A*
58: Sheffield Brinsworth	96 %	*N/A*
59: Runcorn Weston	90 %	100 %
61: London Cromwell Road	90 %	92 %
62: London Horseferry Road	98 %	100 %
65: Eskdalemuir	98 %	100 %
66: Motherwell South	92 %	92 %
67: Manchester Wythenshawe	94 %	100 %
68: Cardiff Llandaff	98 %	92 %
69: Walsall Willenhall	94 %	100 %
100: Swansea Coedgwilym	96 %	*N/A*
101: Swansea Morriston	98 %	92 %
103: Belfast Centre AURN	92 %	92 %
104: Port Talbot Margam AURN	92 %	*N/A*
105: Sheffield Centre AURN	98 %	100 %
106: Scunthorpe Town AURN	96 %	*N/A*
107: Scunthorpe Low Santon	96 %	*N/A*
108: Redcar AURN	94 %	*N/A*
109: Cardiff Rumney	90 %	*N/A*
110: Chadwell St Mary	98 %	*N/A*
111: Redcar Normanby	94 %	*N/A*
112: Dartford Bean	96 %	*N/A*

Table 3. Data capture across the UK Heavy Metals Monitoring Network during 2009. Data capture for new mercury vapour Network sites at Bristol Avonmouth and Sheffield Centre AURN has been counted from the commencement of monitoring.

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. 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 novel 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

[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, **doi:10.1080/03067310903094545**

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.

5.3 Measurement Uncertainty of Annual Average

Data capture across the Network has been 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 uncertainty, with only small uncertainty contributions due to less than 100% time coverage. (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”.)

New mercury monitoring sites that have been monitoring for less than the full year have had their contribution to the UK Network annual average and annual uncertainty weighted accordingly in proportion to the fraction of the year for which they have produced data.

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	**Expanded Relative Uncertainty**	
	Annual Mean	Daughter Directive maximum
As	22 %	40 %
Cd	14 %	40 %
Ni	14 %	40 %
Pb	12 %	25 %
Hg(v)	19 %	50 %

Table 4. Expanded uncertainties, quoted at the 95% confidence interval, for the annual mean concentration values of the relevant Daughter Directive metals. 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), the 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. The UK annual mean concentration for each element has been calculated as the mean of all Network sites.

Analyte	2009 UK Annual Mean Concentration / ng m^{-3}	2009 Maximum Annual Mean Concentration / ng m^{-3}	EC limit or target value (UK objective) / ng m^{-3}
As	0.69	1.14	6
Cd	0.30	2.78	5
Cr	3.55	25.3	-
Cu	15.3	61.7	-
Fe	510	2406	-
Mn	14.1	109	-
Ni	2.56	16.0	20
Pb	14.9	76.8	500 (250)
Pt	0.002	0.007	-
V	2.00	5.21	-
Zn	54.5	652	-
Hg(p)	0.039	0.486	-
Hg(v)	4.84	28.9	-

Table 5. The 2009 annual mean concentrations averaged over all sites on the UK Heavy Metals Monitoring Network, 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 2009 are shown in Figure 4. Monthly data for each element at each monitoring site are given in Annexes 4 and 5.

2009 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	1.08	0.48	2.49	16.3	329	9.1	0.82	19.0	0.001	1.40	60.5	0.019	4.54
47: Bristol Avonmouth	0.66	0.22	1.88	9.3	257	5.8	1.27	11.9	0.002	3.71	33.1	0.045	1.47
56: Bristol Hallen	0.61	0.25	1.28	5.6	170	3.6	0.78	9.6	<0.001	2.01	28.0	0.025	N/A
58: Sheffield Brinsworth	1.02	0.36	25.3	21.3	441	26.0	9.81	23.7	0.003	1.94	72.3	0.045	N/A
59: Runcorn Weston Point	0.50	0.11	1.70	5.7	149	3.0	0.88	7.1	0.001	2.05	12.1	0.486	28.9
61: London Cromwell Road	0.77	0.16	5.10	42.6	913	9.2	1.64	12.8	0.004	2.70	29.1	0.014	1.92
62: London Horseferry Road	0.76	0.17	2.46	19.8	466	5.8	1.14	11.4	0.004	2.51	22.7	0.021	2.17
65: Eskdalemuir	0.13	0.03	0.88	0.6	24	0.8	0.14	1.4	0.001	0.50	5.8	0.009	1.56
66: Motherwell Centre	0.35	0.07	2.04	4.9	86	1.8	0.45	3.9	<0.001	0.50	8.2	0.006	2.62
67: Manchester Wythenshawe	0.86	0.16	5.88	43.9	987	10.6	1.52	9.8	0.007	1.47	32.6	0.014	2.49
68: Cardiff Llandaff	0.81	0.17	3.47	28.8	771	10.0	1.18	11.4	0.006	1.40	31.1	0.014	1.93
69: Walsall Willenhall	1.14	2.78	3.26	61.7	420	10.4	2.97	76.8	0.002	1.28	652	0.066	6.82
100: Swansea Coedgwilym	0.61	0.20	3.59	4.3	144	3.2	16.0	10.2	<0.001	1.10	13.8	0.022	N/A
101: Swansea Morriston	0.87	0.30	2.98	26.8	508	7.5	9.34	17.4	0.001	1.30	27.6	0.020	1.73
103: Belfast Centre AURN	0.35	0.10	1.35	8.6	258	4.0	1.77	5.7	0.004	1.78	18.1	0.007	1.77
104: Port Talbot Margam AURN	0.52	0.24	2.31	8.0	2406	37.4	1.42	12.6	0.001	2.26	55.4	0.018	N/A
105: Sheffield Centre AURN	0.61	0.16	3.79	14.5	297	10.0	1.69	12.1	0.001	1.29	23.7	0.016	1.64
106: Scunthorpe Town AURN	0.83	0.20	2.21	6.1	490	21.7	0.84	16.1	0.001	1.83	23.1	0.018	N/A
107: Scunthorpe Low Santon	0.94	0.21	4.07	5.6	1849	109	1.27	34.1	0.001	4.98	32.1	0.022	N/A
108: Redcar AURN	0.53	0.21	3.17	3.5	460	27.8	1.00	9.3	0.001	1.47	35.4	0.010	N/A
109: Cardiff Rumney	0.64	0.16	1.92	6.5	198	6.3	0.74	10.1	0.001	1.06	26.9	0.012	N/A
110: Chadwell St Mary	0.81	0.24	1.34	11.0	265	4.5	2.42	12.7	0.002	5.21	23.7	0.012	N/A
111: Redcar Normanby	0.34	0.10	1.40	3.1	143	6.5	0.55	7.1	<0.001	0.94	17.8	0.009	N/A
112: Dartford Bean	0.78	0.20	1.35	9.9	210	3.7	1.68	10.3	0.001	3.38	22.5	0.007	N/A

Table 6. The 2009 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 5. 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**.

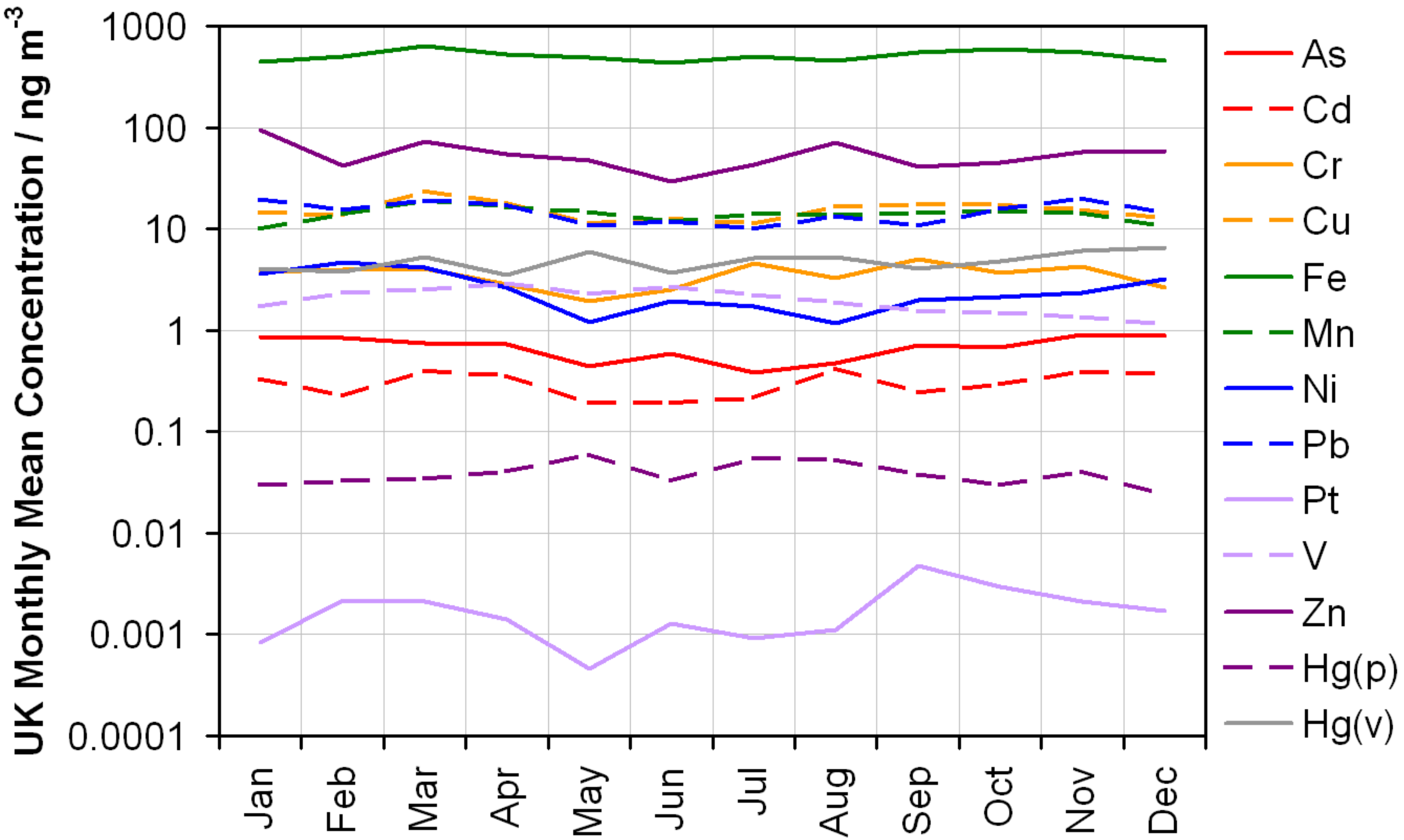

Figure 4. The measured UK monthly mean concentrations of each metal during 2009. Hg(p) and Hg(v) are particulate phase mercury, and total gaseous mercury, respectively.

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:

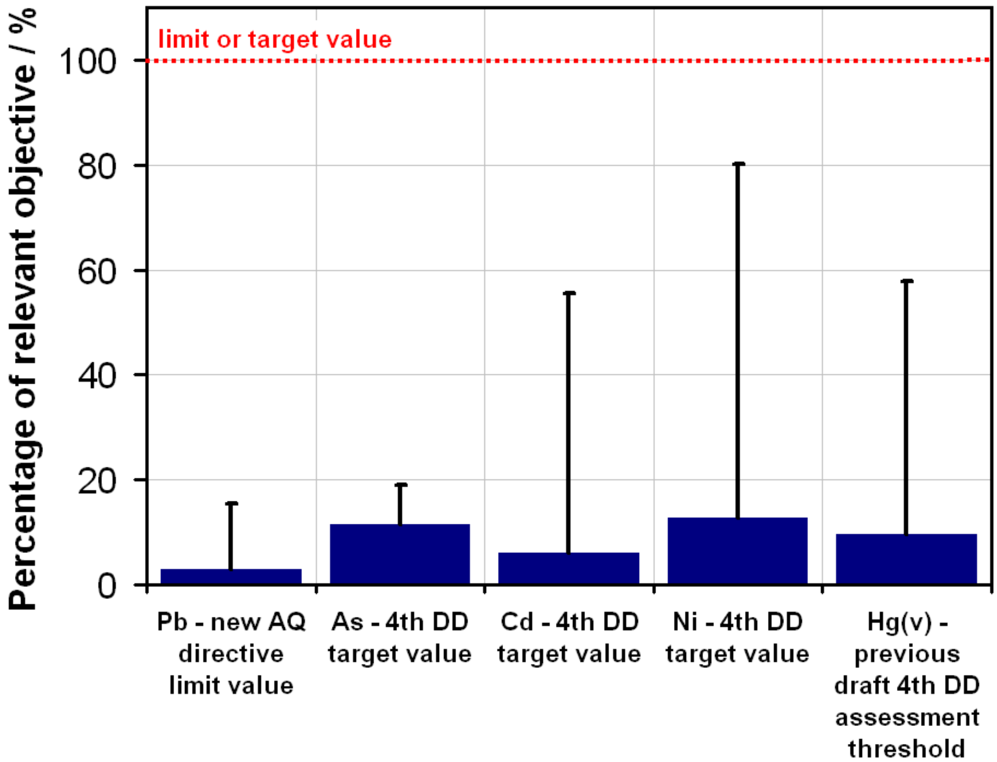

Figure 5. A summary of the annual mean measured concentrations of the heavy metals relevant to the New Air Quality Directive and Fourth Daughter Directives on the UK Heavy Metals Monitoring Network in 2009 as a percentage of the relevant air quality objectives. The bars indicate the annual mean of all 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 100: Swansea Coedgwliym. The highest annual mean values for cadmium, arsenic and lead are found at Site 69: Walsall Willenhall. The highest annual mean value for total gaseous mercury has been found at Site 59: Runcorn Weston Point.

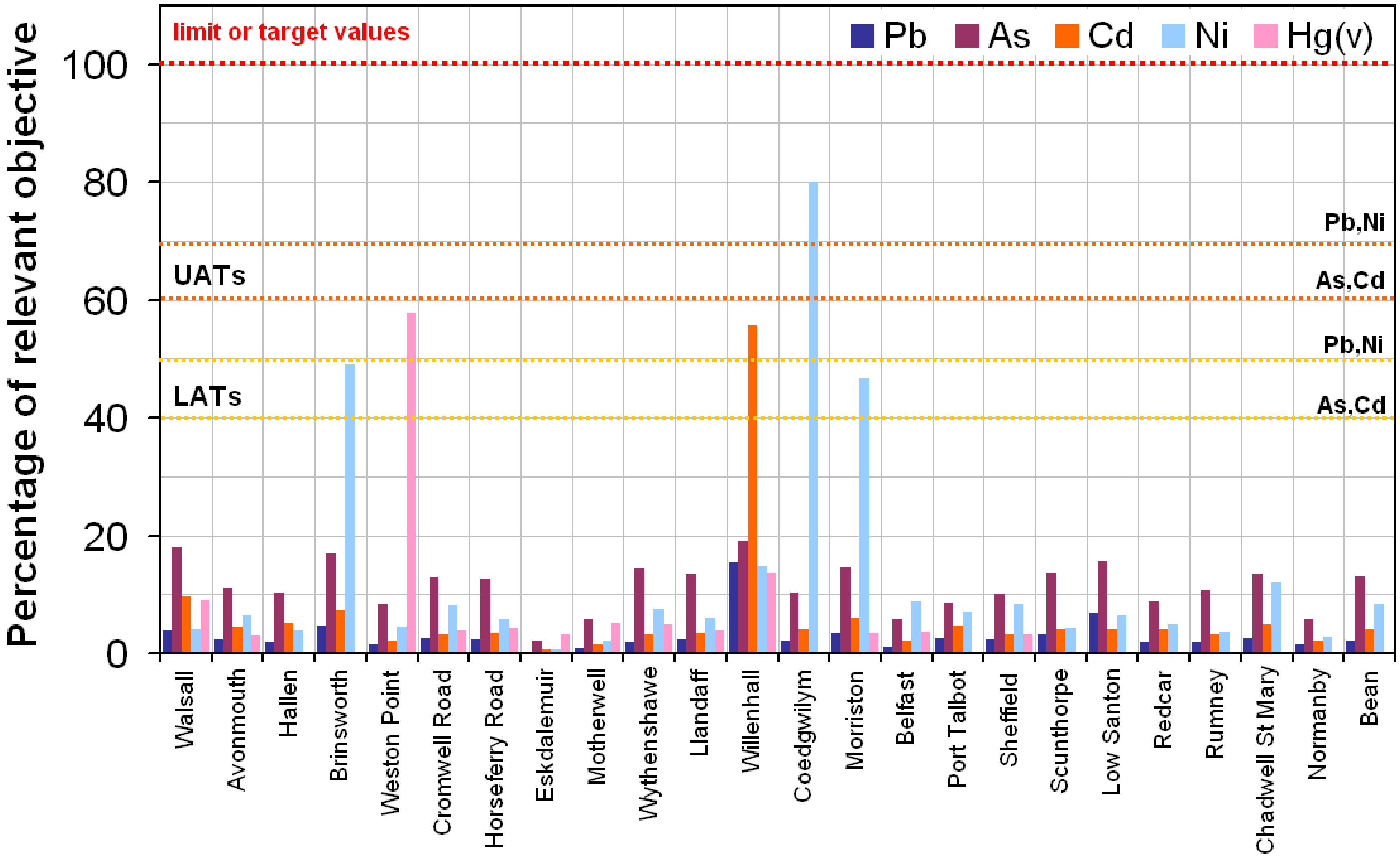

Figure 6. A summary of the annual mean measured concentrations of the heavy metals relevant to the New Air Quality Directive and Fourth DD at all sites on the UK Heavy Metals Monitoring Network in 2009 as a percentage of the relevant target values, lower assessment thresholds (LATs) and upper assessment 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 two instances do the measured annual mean values exceed the relevant lower assessment thresholds:

Annual Mean Concentrations above the Upper Assessment Threshold:

- Nickel at Site 100: Swansea Coedgwliym: 80 % of the target value.

Annual Mean Concentrations above the Lower Assessment Thresholds:

- Cadmium at Site 69: Walsall Willenhall: 56 % of the target value.

Other Notable Concentrations:

- Nickel at Site 58: Sheffield Brinsworth: 49 % of the target value, and very close to the lower assessment threshold.
- Nickel at Site 101: Swansea Morriston: 47 % of the target value, and very close to the lower assessment threshold.
- Total gaseous mercury at Site 59: Runcorn Weston Point. The measured concentration represents 58 % of the target value of 50 ng m^{-3} quoted in a draft version of the Fourth DD.
- Total gaseous mercury at Site 46: Walsall Centre and Site 69: Walsall Willenhall. High concentrations were recorded in the final quarter of the year, especially at Willenhall in December, which recorded 47 ng m^{-3} – the highest monthly value of the year. The reasons for these high concentrations are not clear but the annual averages for both sites remain less than a quarter of the concentrations recorded at Weston Point.

The site at Swansea Coedgwliym is situated near to the Vale Inco nickel refinery in Clydach, producing speciality nickel products and nickel-coated materials. The site at Swansea Morriston is the upwind pair of the Swansea Coedgwliym site but may also be exposed to relatively high concentrations when the wind is not in the prevailing direction.

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

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 Runcorn Weston Point is in the vicinity of a chlor-alkali facility formerly using mercury-based technology.

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

6.3 Measured concentrations of non-directive metals

Figure 8 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. 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 in excess of two and a half times the national average concentrations are usually owing to specific process close to the monitoring sites concerned. For instance:

- Copper at roadside sites such as London Cromwell Road, 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 former chlor-alkali plant;
- Copper and zinc at Walsall Willenhall close to a metal refining works.

6.4 Comparison with EPAQS Guidelines

In 2009 guidelines were produced by the Expert Panel on Air Quality Standards (EPAQS) relating to metals and metalloids in ambient air for the protection of human health[12]. The summary of this report's recommendations concerning air quality guidelines for the species considered was:

- As: 3 ng m^{-3} total inorganic arsenic in the PM_{10} fraction, as an annual mean.
- Ni: 20 ng m^{-3} total nickel compounds in the PM_{10} fraction, as an annual mean.
- Be: 0.2 ng m^{-3} total beryllium in the PM_{10} fraction, as an annual mean.
- Cr: 0.2 ng m^{-3} in the Cr(VI) oxidation state in the PM_{10} fraction as an annual mean.

Comparing these guidelines with the concentrations measured in the PM_{10} fraction by the Network:

The Network currently measures total arsenic in the PM_{10} fraction. In 2009, the highest annual mean value measured was 1.1 ng m^{-3}. Therefore, the Network meets the EPAQS recommendation since inorganic arsenic will be less than or equal to total arsenic.

The nickel recommendation mirrors the requirements of the Fourth DD discussed above in Section 6.1 and 6.2. The 20 ng m^{-3} recommendation has been exceeded 3 times in the last 7 years, at one location on the Network. Recently installed emission abatement equipment and reduced production volumes at the point sources near to the monitoring sites with the highest measured nickel concentrations in the Swansea Valley seem to have reduced measured concentrations.

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[11] AEAT Report AEAT/ENV/2243 "Preliminary Assessment of PAH and heavy metal levels in the UK", Bush, T, AEAT, February 2007.
[12] Expert Panel on Air Quality Standards, "Guidelines for metals and metalloids in ambient air for the protection of human health", PB13263, Defra, London, May 2009.

The Network does not currently measure beryllium. However it is hoped that an assessment of its concentrations across the Network may be undertaken in future.

The Network currently measures total chromium. The EPAQS report states that in the UK it is likely that less than 20% of Cr emissions are of Cr(VI), however, the proportion of Cr(VI) in the PM_{10} fraction of ambient air may be lower than that measured in emissions – recent data suggesting that Cr(VI) may constitute between 3 and 8% of total airborne chromium. These ratios will, of course, depend on the sources and processes being measured at each monitoring site and will vary between monitoring sites across the Network. However, based on this range of Cr(VI) to total Cr proportions, an assessment of the likely concentration of Cr(VI) at Network sites has been made using the annual average total Cr concentrations measured in 2009. This analysis is displayed in Figure 7 below.

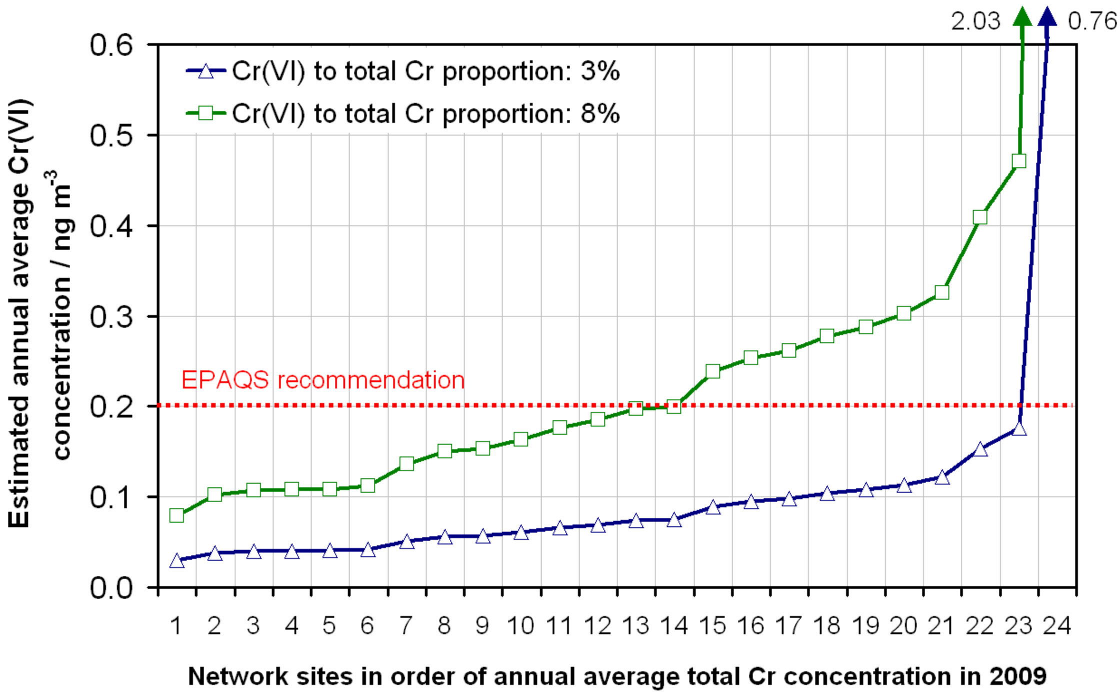

Figure 7. Estimated annual average concentration of Cr(VI) across the Network, based on the proportion of Cr(VI) in the total Cr measured during 2009 being either 3 % or 8 %. The values for site 24, the site with the highest predicted Cr(VI) concentration, are off-scale and their numerical values are shown at the top of the chart.

At a Cr(VI) proportion of 3 % only one of the 24 Network sites – Sheffield Brinsworth, which records very high total chromium – would be in excess of the EPAQS recommendation. However, at a proportion of 8 % then 10 of the 24 Network sites would be in excess of this recommendation. If the Cr(VI) to total Cr proportion was 20 %, which is thought to be the upper limit for UK emissions of Cr according to the EPAQS report, then 23 of the 24 Network sites would be in excess of the EPAQS recommendation, with only Eskdalemuir which records very low total Cr concentrations, below 0.2 ng m^{-3} for estimated Cr(VI) concentrations. It is hoped that an assessment of Cr(VI) concentrations across the Network may be undertaken in the near future to elucidate the proportion of Cr(VI) in total Cr across the UK.

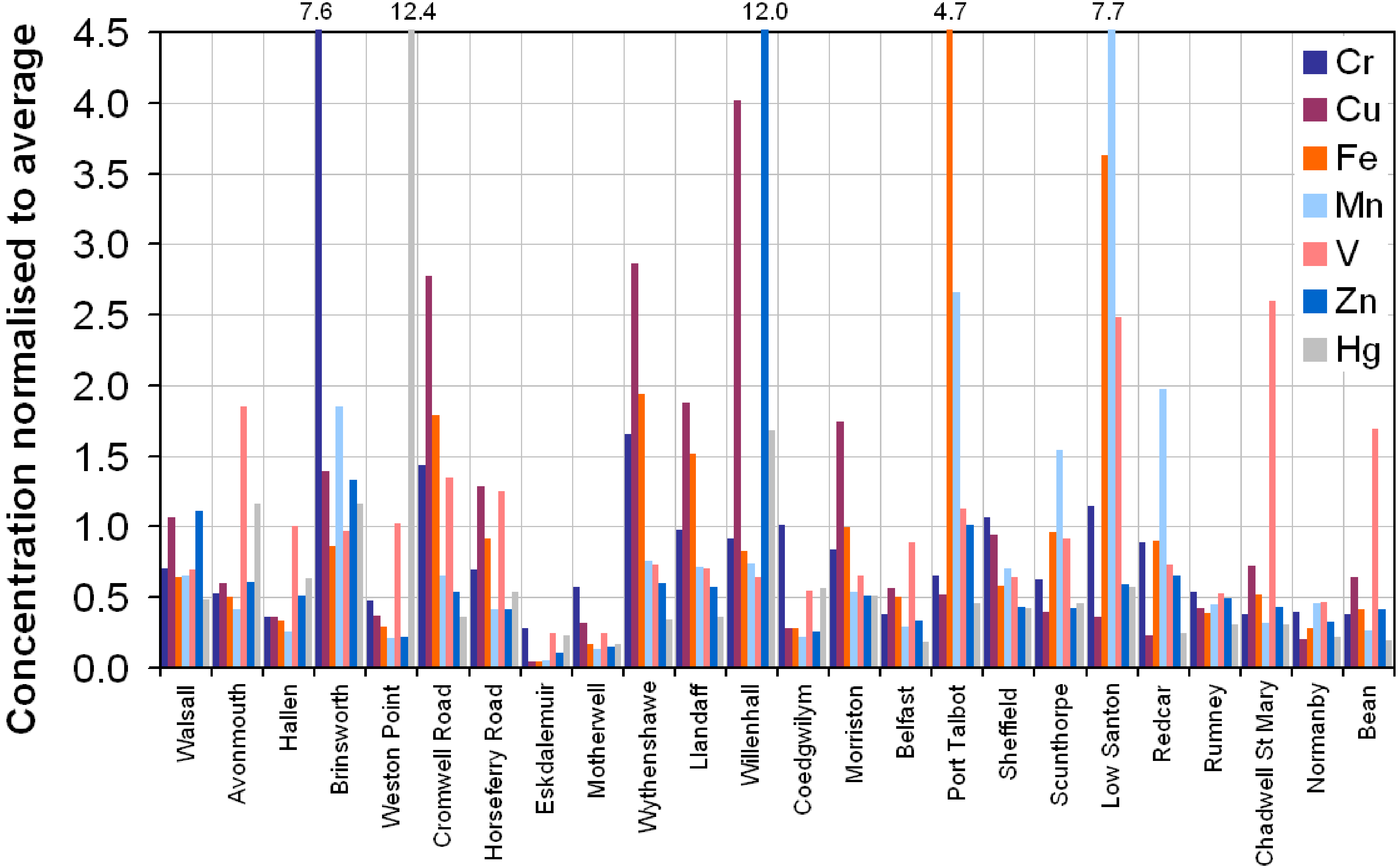

Figure 8. A summary of the annual mean measured concentrations of the non-directive metals at all sites on the UK Heavy Metals Monitoring Network in 2009, normalised to the UK annual average concentration for the relevant element. Bars that are off-scale have their values indicated at the top of the chart. Hg refers to particulate phase mercury.

6.5 Ratio of total gaseous mercury to particulate phase mercury

Figure 9 shows the relationship between particulate and vapour phase mercury measurements during 2009 where these are measured together on the Network.

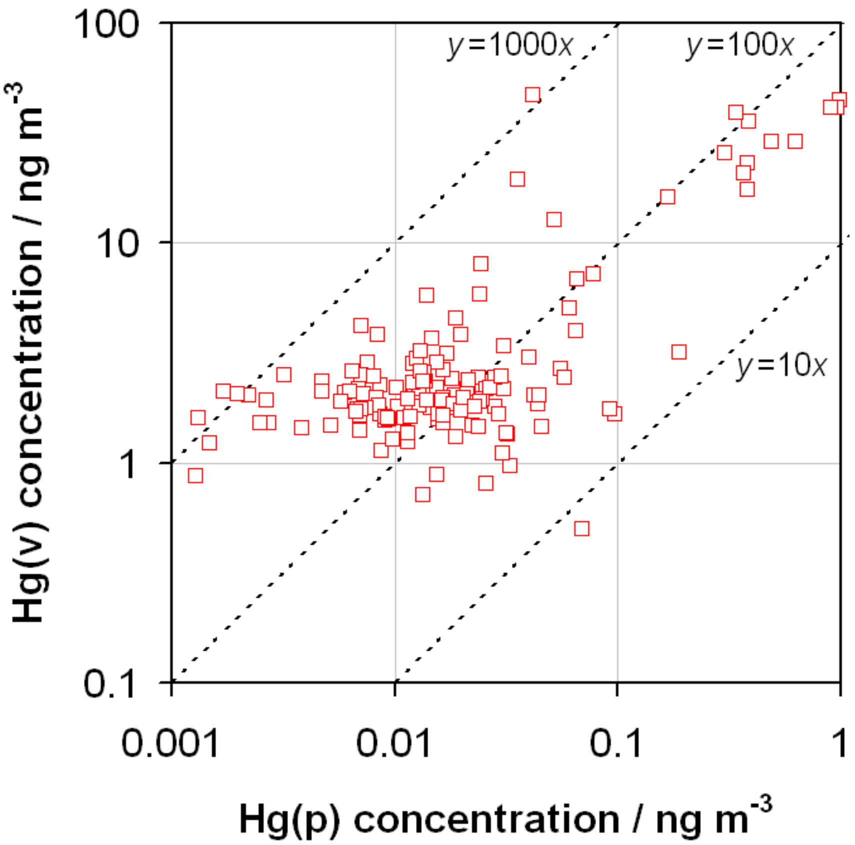

Figure 9. The relationship between monthly particulate [Hg(p)] and total gaseous [Hg(v)] mercury measurements during 2009 where these are made together. The dotted diagonal lines represent the locus of points for which the total gaseous mercury concentration (*y*) are 10, 100 and 1000 times greater than the measured particulate phase mercury concentrations (*x*), as indicated.

Figure 9 shows that in almost all cases the total gaseous to particulate mercury concentration ratio during 2009 was greater than 10 (>99 % of all data points), with the majority of measurements displaying a ratio of between 10 and 100 (32 % of all data points) or between 100 and 1000 (64 % of all data points). Some ratios (about 4 % 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.

6.6 Seasonality of observed concentrations

Usually, small seasonal variations in metals concentrations are expected and observed. The reason for this is that the emissions rates of metallic pollutants from industrial point sources, around which many of the Network sites are located, are not expected to vary significantly during the year. However, any small observed trends may be caused by fewer car journeys made in cities, and decreased residential and power station fuel combustion for heating and energy in the summer months. Meteorological conditions may also have small effects on the seasonal variation of measured metal concentrations. An assessment of the seasonal variation of concentrations in 2009 has been produced by normalising the results for each metal at each Network site with respect to the site average for that metal. This normalised concentration has then been averaged over all sites to produce an overall normalised average concentration for each metal. An average of the overall normalised average concentrations for each metal may then be produced to yield a Network average. This analysis is shown in Figure 10.

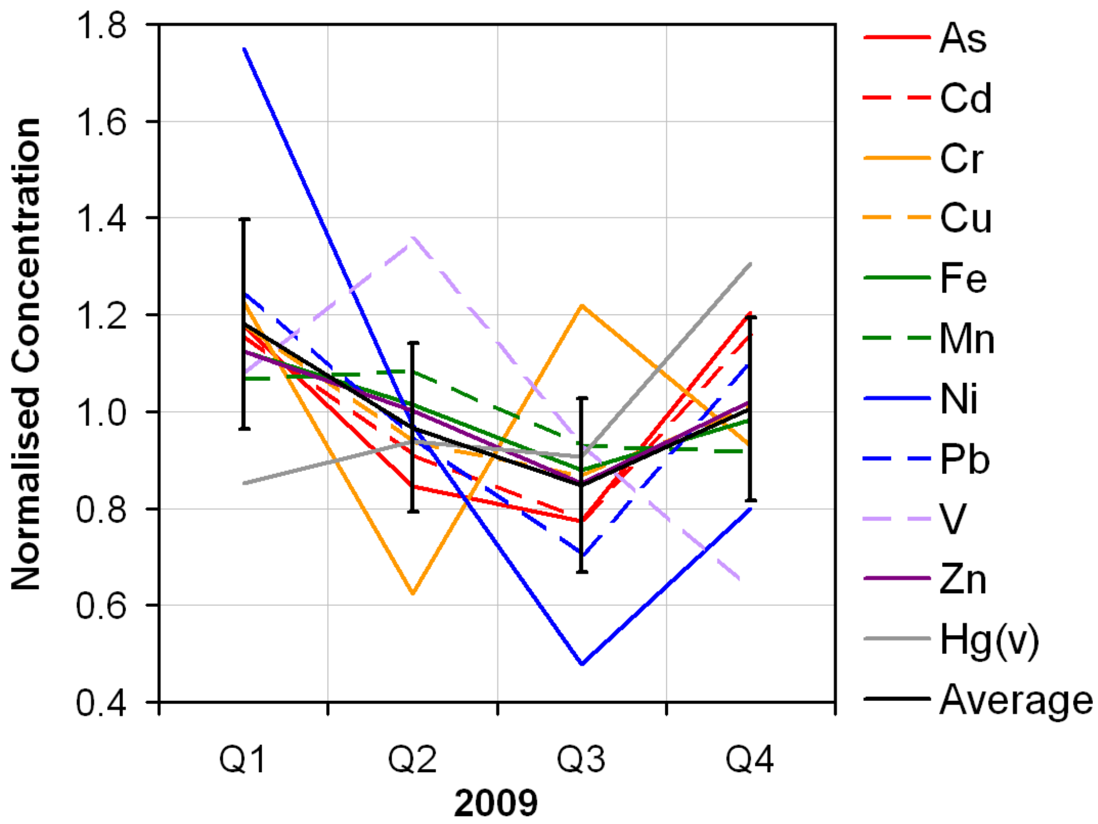

Figure 10. The overall normalised concentrations for each metal (excluding Hg(p) and Pt) across all Network sites for each quarter of 2009 (Q1: January-March inclusive; Q2: April-June inclusive; Q3: July-September inclusive; Q4: October-December inclusive). The average value across all metals is also shown (labelled 'Average') with the error bars presenting the standard deviation of the values comprising each average.

As can be seen from Figure 10 the seasonal response between metals is somewhat variable. However in general there is a trend in observed concentrations such that Q1 > Q2 ≈ Q4 > Q3. This general trend is also reflected in the average across all metals, although the standard deviation associated with these values is large relative to this trend – mainly as a result of some metals, such as Cr and V displaying different seasonal characteristics.

7 Trends in Measured Concentrations

7.1 UK Trends

Changes in the annual average metals concentrations measured, across the Network, over the past 25 years are shown in the table below:

Analyte	Changes in measured concentrations over the:			
	Last 25 Years	Last 10 Years	Last 5 Years	Last Year
As	not measured	not measured	- 39 %	+ 9 %
Cd	- 88 %	- 61 %	- 53 %	- 11%
Cr	- 37 %	+ 14 %	- 47 %	0 %
Cu	- 31 %	- 26 %	- 26 %	- 2 %
Fe	- 36 %	- 26 %	+ 10 %	- 5 %
Hg(p)	not measured	not measured	- 94 %	- 61 %
Hg(v)	not measured	not measured	+ 31 %	- 17 %
Mn	- 52 %	+ 34 %	+ 40 %	+ 7 %
Ni	- 78 %	- 44 %	- 52 %	- 20 %
Pt	not measured	not measured	N/A*	N/A*
V	- 94 %	- 41 %	- 5 %	- 1 %
Zn	- 47 %	+ 26 %	- 48 %	- 24 %
Pb	- 97 %	- 92 %	- 40 %	- 7 %

Table 7. 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 for Pt began in 2003, average annual concentrations levels have remained generally below the detection limit, although the improvement in detection limits this year means than producing robust trend data in future years should be possible.)

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[13]. This trend has, in the most part, continued over the last year. The trends for individual elements are discussed in more detail below:

[13] 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

Arsenic: Levels continue are uniformly low across the Network but showed a small increase in 2009. However, concentrations have fallen by almost 40 % in the last 5 years.

Cadmium: Concentrations are low across the Network, with the exception of Walsall Willenhall, and have decreased further in 2009.

Chromium: Levels are very similar to those measured in 2008. Whilst concentrations remain low across the Network chromium is a metal that has not shown as dramatic decreases in concentrations over the last 25 years as many of the other metals. The annual average is dominated by the levels measured at Sheffield Brinsworth.

Copper: Concentrations of this metal remained relatively stable in 2009 following sharp decreases over the last 7 years. The highest values are recorded at roadside sites.

Iron: Following the increase in levels in 2008, primarily because the Network re-organisation encompassed a large number of point sources located around steel plants, levels have decreased slightly in 2009, but are still in excess of concentrations 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 continued to fall sharply during 2009. Hg(p) average 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 decrease over the last year, and are now comparable with concentrations in 2005. Trends, and average recorded concentrations, for total gaseous mercury are strongly influenced by the very high levels at Runcorn Weston Point. This site aside, concentrations measured at other Network sites for this pollutant are consistently between 1 and 3 ng m^{-3}. 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 2009 was over 100 times that of Hg(p).

Manganese: Concentrations increased in 2008, primarily because the Network re-organisation encompassed a large number of point sources located around steel plants, and have shown another smaller increase in 2009. Average concentrations are now similar to those measured 12 to 14 years ago.

Nickel: Concentrations showed a decrease in 2009, and 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 trends, and average recorded concentrations, for this element across the Network. The decrease in the average value observed this year was mostly owing to the decrease observed at the sites in Swansea because of reduced outputs at the Nickel facilities in the vicinity.

Platinum: Average annual values remain extremely 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.

The recent improvement in detection limits this year means than producing robust trend data in future years should be possible.

Vanadium: Concentrations changed very little in 2009, and remain generally low across the Network. Levels are similar to those measured in 2000 but are at only 6 % of their value 25 years ago.

Zinc: Concentrations decresed in 2009, continuing a general downward trend over the last 8 years. Trends and average recorded concentrations for this element, the second most abundant measured by the Network, are influenced substantially by the high measured concentrations at Walsall Willenhall.

Lead: Lead levels showed a small increase 2009 but 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 3 % of their values 25 years ago.

Concentration trends over the last 29 years for the metals relevant to the EU Air Quality Directives are summarised in Figures 11 and 12. The trends observed for the other metals measured by the Network are shown in Figures 13 and 14. Pt has been omitted from these graphs as its levels up to now have been below the prevailing detection limits until these were recently improved.

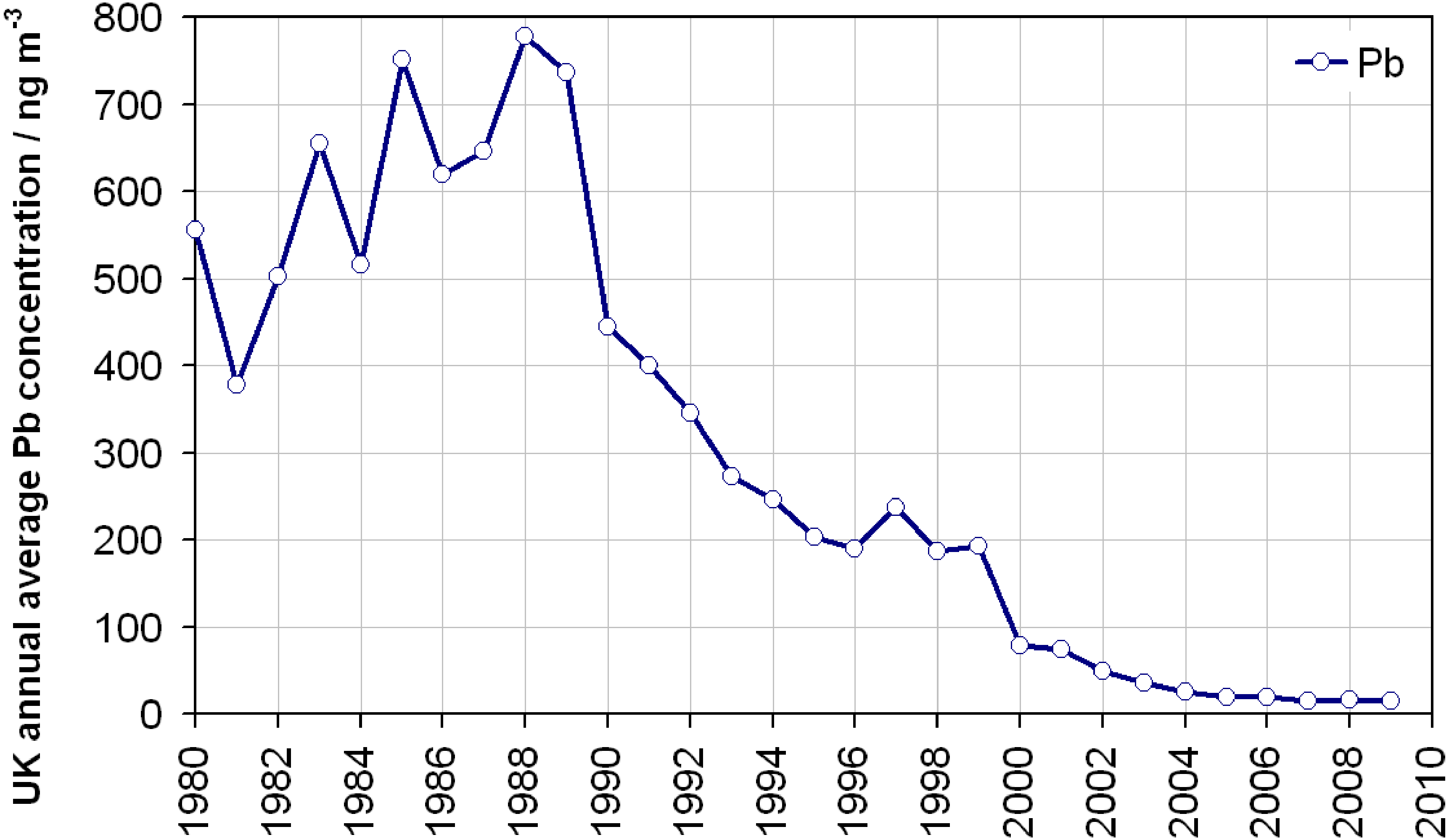

Figure 11. The UK annual average concentrations of Pb measured on the UK Heavy Metals Monitoring Network over the last 29 years. The EC limit value for lead is 500 ng m^{-3} and the UK Air Quality Objective for lead is 250 ng m^{-3}.

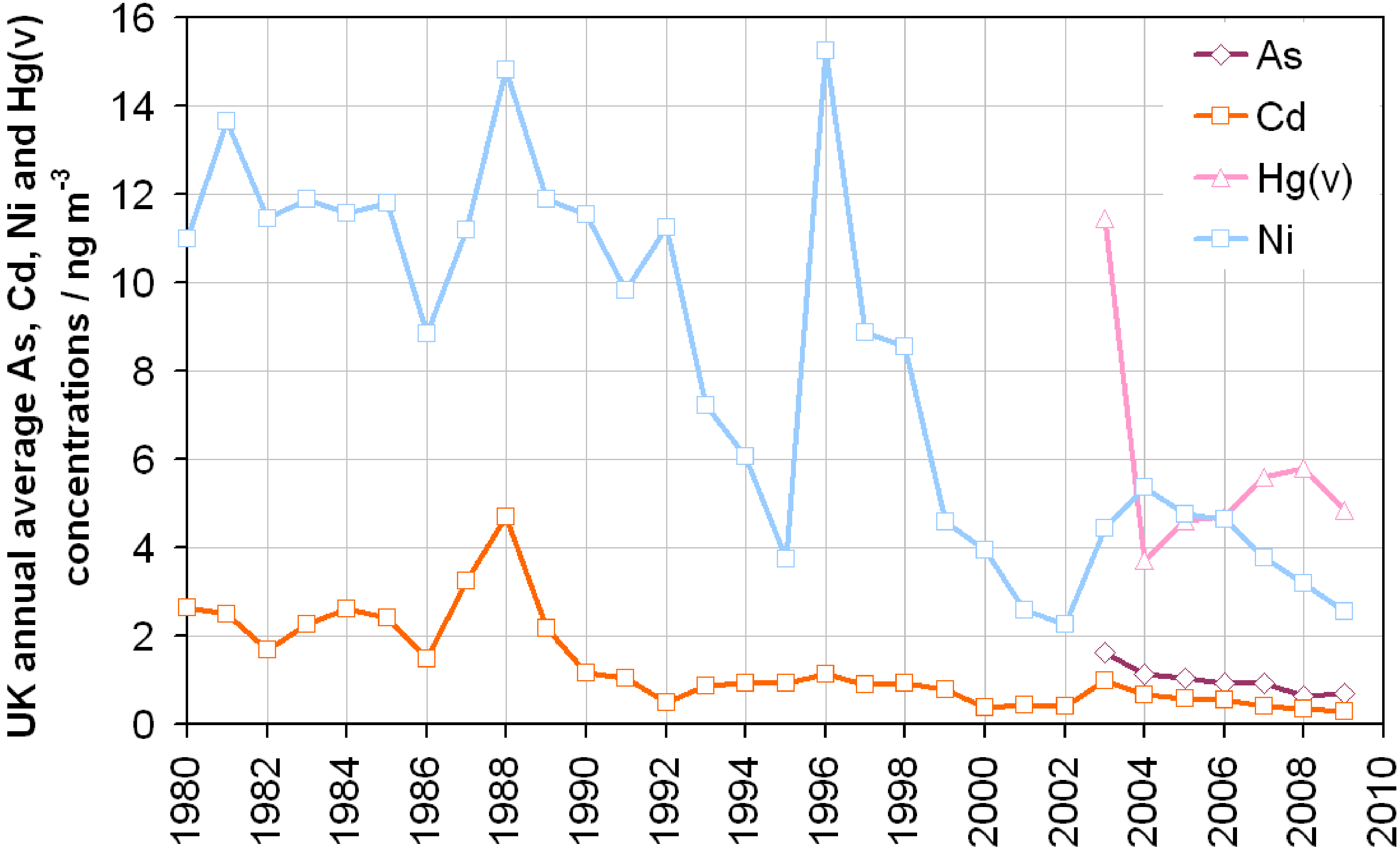

Figure 12. The UK annual average concentrations of Ni, As, Cd and total gaseous mercury [Hg(v)] measured on the UK Heavy Metals Monitoring Network over the last 29 years. The EC targets values for Ni, As and Cd are 20 ng m^{-3}, 6 ng m^{-3} and 5 ng m^{-3} respectively.

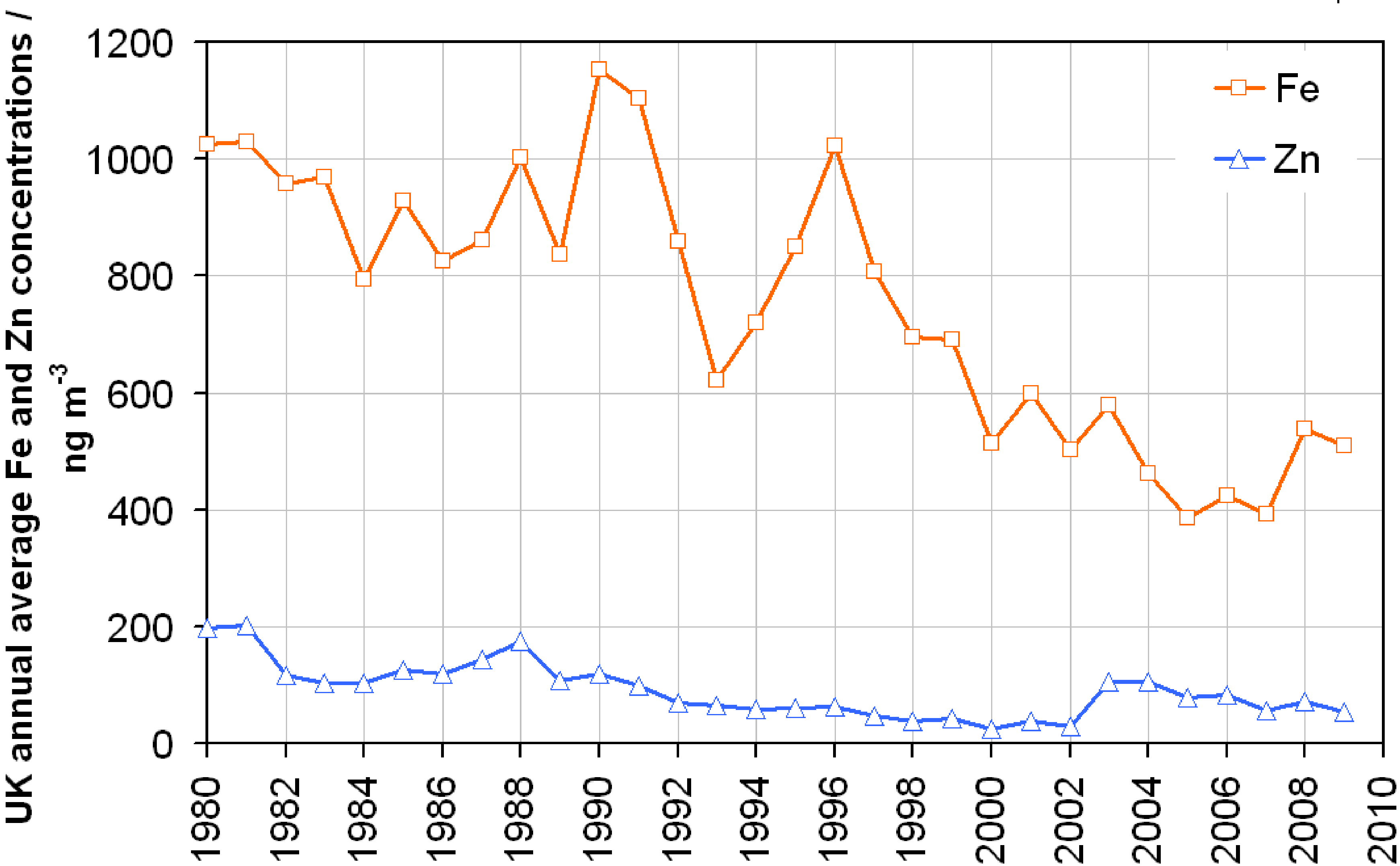

Figure 13. The UK annual average concentrations of Fe and Zn measured on the UK Heavy Metals Monitoring Network over the last 29 years.

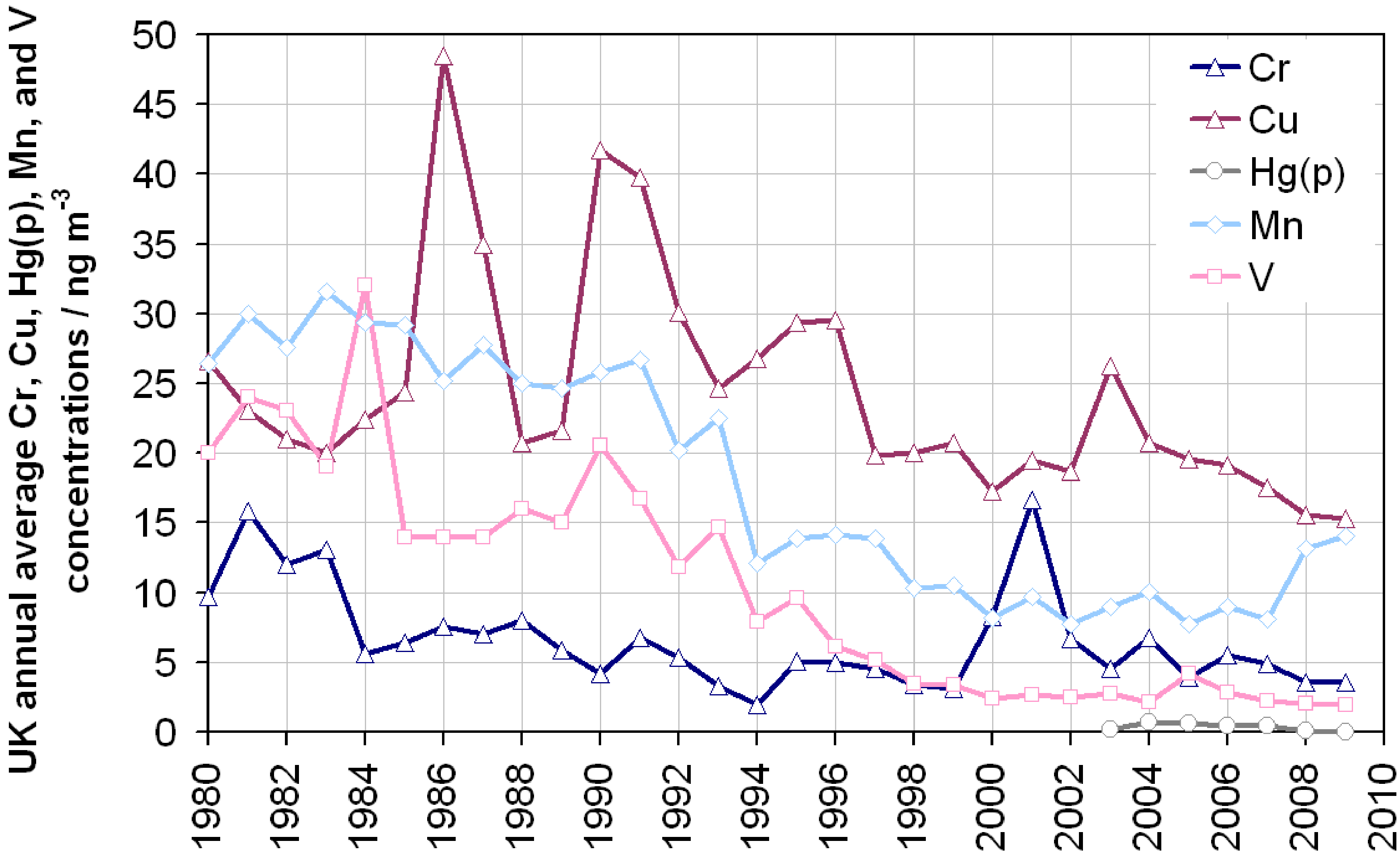

Figure 14. The UK annual average concentrations of Cr, Cu, Hg(p), Mn and V measured on the UK Heavy Metals Monitoring Network over the last 29 years.

7.2 Trends in nickel in the Swansea Valley

The annual average concentration of Nickel at Swansea measured over the last 7 years is shown in Figure 15.

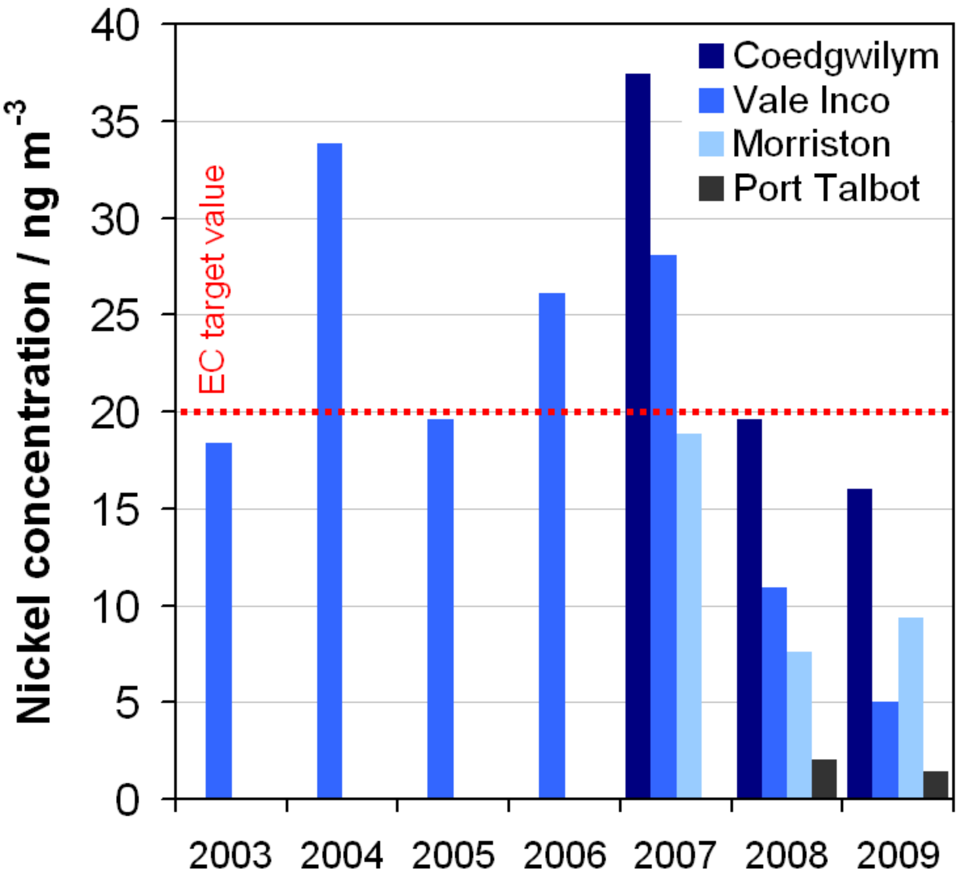

Figure 15. The annual average nickel concentration measured at monitoring sites in the Swansea area (indicated by the key) over the last 7 years. Nickel concentrations at Port Talbot (since monitoring began in 2008) have also been included to indicate the regional background level. The red dotted line indicates the Fourth DD target value for nickel. (The data for Vale Inco in 2008 and 2009, and Coedgwilym and Morriston in 2007 is 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 2009 was only 71 % owing to repeated sampler failure in the first two months 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 showed a significant decrease in measured concentrations from 2007 to 2008. This correlates with abatement technologies being installed in late 2007 in order to reduce particle emissions from the point source in question. Moreover, this drop in measured concentrations continued between 2008 and 2009. The reason for this decrease is most likely to have been the significantly decreased output of Vale Inco during 2009: indeed the monthly concentrations measured correlate very closely with periods of partial or complete shutdown of the facility in the second and third quarters of 2009 (see the Nickel plot in Annex 4 for Swansea Coedgwilym).

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[14]. Further monitoring is required at the new Network sites to determine the likely annual concentrations of nickel measured during a year of full capacity operation at Vale Inco, although the concentrations measured in 2008 suggest that these will be less than prior to the abatement measures introduced in 2007, but possibly still close to the target value.

During 2009, it became clear from the results at the Neath and Port Talbot County Borough Council monitoring site at Pontadawe (location: Pontadawe Leisure Centre, Pontadawe, SA8 4EG) further up the Swansea valley, that the measured concentrations were not decreasing to the extent seen at the Swansea sites as a result of the decreased output of Vale Inco.

A concentration verses wind direction analysis by NPL highlighted that two sources were contributing to the measured concentrations at Pontadawe. The second source was thought to be an industrial process in Pontadawe. In order to test this hypothesis a further local authority site was set-up at Tawe Terrace, Pontadawe, to measure the nickel concentrations much closer to the process. NPL are currently providing the analysis for these samples. The initial results indicate that there is an additional a significant source of ambient nickel in Pontadawe.

A working group comprising all relevant stakeholders has been established to investigate further nickel levels in the Swansea valley. The implications of the preliminary monitoring results, other additional monitoring carried out by local authorities in the area and dispersion modelling of potential sources are being used to assess possible options for modifying the Network and to address the high nickel concentrations in the area through control strategies at the relevant industrial sites.

[14] 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 during 2009 that feature the data, analytical procedures and operation of the Network. These articles are detailed below.

8.1.1 Articles in learned journals

"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. doi:10.1039/b920843g.

> This key publication provides a unique comparison of the measured annual ambient concentrations of metals by the Network and the estimates of the emissions of these metals within the UK. This provides for the first time an opportunity to benchmark of the accuracy of estimates of metals emissions in the UK and also assess the sensitivity of receptors to each pollutant.

"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, doi:10.1080/03067310903094545.

> This paper details a novel method developed to use principal component analysis in order to detect outliers in the very large data sets produced by the Network. The technique uses the correlation between the concentrations of metals at individual sites as a baseline to look for outlying data.

"Spatial inhomogeneity of metals in particulate matter on ambient air filters determined by LA-ICP-MS and comparison with acid digestion ICP-MS", Brown, R J C, Jarvis, K E, Disch, B A, Goddard, S L, Brown, A S, *Journal of Environmental Monitoring*, 2009, **11**, 2022-2029, doi:10.1039/b911441f.

> Laser ablation inductively coupled plasma-mass spectrometry (LA-ICP-MS) has been used to examine the spatial distribution of metals in particulate matter on ambient air filters collected by the Network, for the first time. This work has major implications of for the sub-sampling of such filters for multiple analyses.

"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, doi:10.1007/s00769-010-0645-1.

> This paper publishes the validation data underpinning the accuracy of the Dumarey equation, which is the relationship to describe the mass concentration of saturated mercury vapour in air, to which all measurements of mercury vapour are traceable. This work helps to ensure the consistency and accuracy of data sets of mercury vapour measurement in the UK and elsewhere.

"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. doi:10.1039/B924955A.

&

"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, doi:10.1007/s00769-010-0636-2.

These two papers, lead authored by NPL, describe the work undertaken by CEN TC264 WG25 to produce and validate standard methods for the measurement of total gaseous mercury in ambient air and mercury in deposition, with a view to these becoming reference methods in support of the requirements of the Fourth DD.

8.1.2 Articles in Trade Journals

"Recent changes to the monitoring of heavy metals in ambient air in the UK"
Brown, R J C
AWE International Magazine, 2009, Issue 18, June 2009, 36-41.

This article has increased the visibility of the operation and outputs of the Network in the environmental measurement community and describes in particular the re-organisation of the Network to meet the requirements of the Fourth DD.

"Determination of total mercury in ambient air using amalgamation with atomic fluorescence spectrometry"
Corns, W T, Stockwell, P B, Brown, R J C, Brown, A S
International Environmental Technology, 2009, Volume 19, Issue 5, Sept/Oct 2009, 26-27.

This article gives an overview of the equipment used to sample and measure mercury vapour on the Network and illustrates this with examples data sets obtained at Network sites.

8.2 International and Standardisation Activity

8.2.1 Standardisation Activities

In 2009, 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", CEN TC264 WG20 "Deposition measurements of heavy metals", and CEN TC264 WG15 "Reference gravimetric method for particulate matter".

The WG20 standard has now been published[15] and the two WG25 standards[16,17] are currently undergoing the formal vote process. The results of the WG25 field trials used to validate the proposed standard methods and determine their uncertainties and working ranges have been published in peer-reviewed journals with NPL as the lead author (see Section 8.1.1).

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’.

8.2.2 International Activities

The report on the EC-JRC-IES organised intercomparison exercise for heavy metals in PM10 was published[18] at the end of 2008. NPL’s performance was in the top three Air Quality Reference Laboratories across the whole of Europe. This report has now been re-worked into a journal article, co-authored by NPL, to be submitted for peer-reviewed publication in 2010.

NPL continues 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 2009, was key partner in the analytical work to characterise the long term stability of the candidate material, and provide the final value assignment for the relevant legislative metals in order to certify the material.

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[15] BS EN 15841:2009 Ambient air quality – Standard method for determination of arsenic, cadmium, lead and nickel in atmospheric deposition, CEN, Brussels, 2009.
[16] FprEN 15852:2010 Ambient air quality - Standard method for the determination of total gaseous mercury, 2010, CEN, Brussels.
[17] FprEN 15853:2010 Ambient air quality - Standard method for the determination of mercury deposition, 2010, CEN, Brussels.
[18] Intercomparison exercise for heavy metals in PM10, Gerboles, M, Buzica, D, EUR 23219 EN – 2008.
http://ies.jrc.ec.europa.eu/uploads/fileadmin/Documentation/Reports/Emissions_and_Health/EUR_2006-2007/EUR_23219_EN.pdf

Annex 1 Location and Details of Sites Comprising the UK Heavy Metals Network

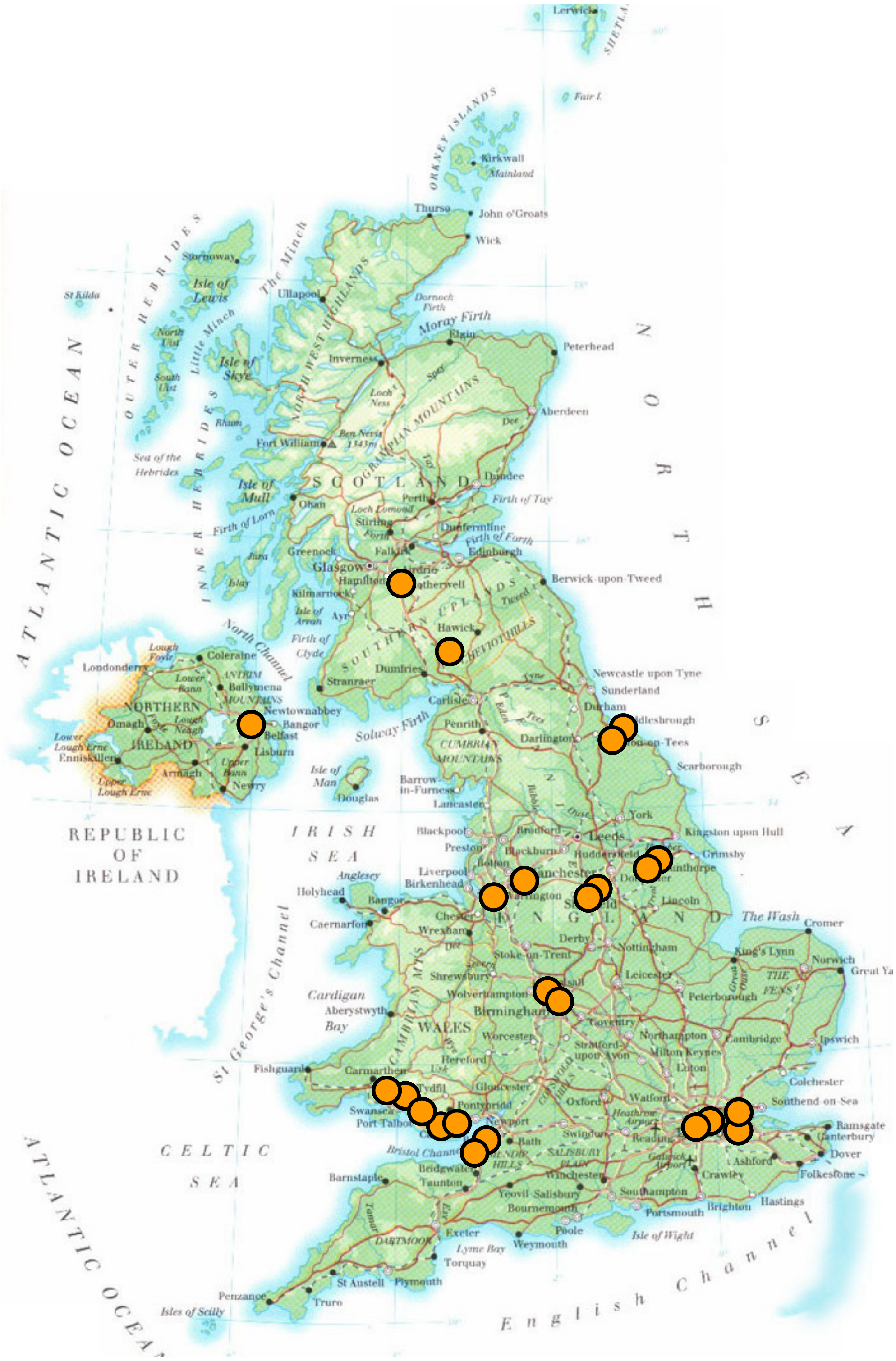


Figure A1. Location of monitoring sites comprising the UK Heavy Metals Monitoring Network during 2009 (indicated by the orange circles) – details of which are given in Table A1 below.

NEW Site Code: Site Name (Abbreviated Site Name)	OLD Site Code: Site Name (Abbreviated Site Name)	Site Address	Site Classification (with identified point source, where applicable)	Pollutants measured
46: Walsall Centre (Walsall)	46: IMI Refiners Ltd, Walsall (IMI Walsall)	74 Primley Avenue, Walsall, WS2 9UW	Industrial Background (IMI Refiners Ltd, Walsall)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
47: Bristol Avonmouth (Avonmouth)	47: BZL Ltd, Avonmouth (BZL Avonmouth)	Avonmouth Medical Centre, Collins Street, Bristol, BS11 9JJ	Urban Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
56: Bristol Hallen (Hallen)	56: BZL Ltd, Avonmouth, Hallen Village (BZL Hallen)	West Country Caravans Ltd., Moorhouse Lane, Hallen, Bristol, BS10 7RU	Urban Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
58: Sheffield Brinsworth (Brinsworth)	58: Avesta Steel, Sheffield (Sheffield)	BOC Gases, Bawtry Road, Brinsworth, Sheffield, S60 5NT	Industrial Background (Outokumpu Stainless Ltd, Sheffield)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
59: Runcorn Weston Point (Weston Point)	59: ICI Weston Point, Runcorn (Weston Point)	Weston Point County Primary School, Caster Avenue, Weston Point, Runcorn, WA7 4EQ	Industrial Background (INEOS Enterprises Ltd, Weston Point)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
61: London Cromwell Road (Cromwell Road)	61: London, Cromwell Road (London Cromwell (Rd))	Natural History Museum, Cromwell Road, London, SW7 5BD	Roadside	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
62: London Horseferry Road (Horseferry Road)	62: London, Horseferry Road (London Horseferry (Rd))	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)	65: Eskdalemuir, Met Office (Eskdalemuir)	Met Office, Eskdalemuir, Langholm, Dumfrieshire, DG13 0QW	Rural	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
66: Motherwell South (Motherwell)	66: Motherwell, Civic Centre (Motherwell) – moved April 2009	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)	67: Manchester M56, Junction 4 (Manchester)	Junction 4, M56, Newhall Green, Wythenshawe, Manchester, M22 8	Roadside	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
68: Cardiff Llandaff (Llandaff)	68: Cardiff, Waungron Road (Cardiff)	Cleansing Depot, Waungron, Fairwater, Cardiff, CF5 2JJ	Roadside / Urban background (Celsa UK Ltd, Tremorfa)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
69: Walsall Willenhall (Willenhall)	69: Brookside Metals, Bilston Lane, Walsall (Brookside Metals)	Adult Training Centre, Bilston Lane, Shepwell Green, Willenhall, Walsall, WV13 2QJ	Industrial Background (Brookside Metals Ltd, Willenhall)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
100: Swansea Coedgwilym (Coedgwilym)	100: Coedgwilym Cemetery (Swansea)	Coedgwilym Cemetery, Pontardawe Road, Clydach, Swansea, SA6 5PB	Industrial Background (Vale Inco Ltd, Swansea)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
101: Swansea Morriston (Morriston)	101: Morriston Groundhog (Swansea)	Morriston Groundhog, Wychtree Street, Morriston, Swansea, SA6 8EX	Urban Background (Vale Inco Ltd, Swansea)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
103: Belfast Centre AURN (Belfast)	103: Belfast Centre (Belfast)	Lombard Street, Belfast, BT1 1RB	Urban Centre	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
104: Port Talbot Margam AURN (Port Talbot)	104: Port Talbot	Port Talbot Fire Station, Commercial Road, Port Talbot, West Glamorgan, SA13 1LG	Industrial Background (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)	OLD Site Code: Site Name (Abbreviated Site Name)	Site Address	Site Classification (with identified point source, where applicable)	Pollutants measured
105: Sheffield Centre AURN (Sheffield)	105: Sheffield Centre (Sheffield)	Charter Square, Sheffield, S1 4JD	Urban Centre (Outokumpu Stainless Ltd, Sheffiled)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
106: Scunthorpe Town AURN (Scunthorpe)	106: Scunthorpe Town	Rowlands Road, Scunthorpe, North Lincolnshire, DN16 1TJ	Urban Background (Corus Group Ltd, Scunthorpe)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
107: Scunthorpe Low Santon (Low Santon)	107: Scunthorpe Santon – renamed December 2009	Dawes Lane, Santon, Scunthorpe, North Lincolnshire, DN16 1XH	Industrial Background (Corus Group Ltd, Scunthorpe)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
108: Redcar AURN (Redcar)	108: Redcar	Further Education Centre, Corporation Road, Redcar, TS10 1HA	Industrial Background (Corus Group Ltd, Redcar)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
109: Cardiff Rumney (Rumney)	109: Cardiff Rumney	Greenway Primary School, Llanstephen Road, Rumney, Cardiff, CF3 3JG	Industrial Background (Celsa UK Ltd, Tremorfa)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
110: Chadwell St Mary (Chadwell St Mary)	110: Chadwell St Mary	Council Area Housing Office, Linford Road, Chadwell St Mary, Essex, RM16 4JY	Industrial Background (Britannia Refined Metals, Gravesend)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
111: Redcar Normanby (Normanby)	111: Redcar Flatts Lane	Tees, Esk and Wear Valleys NHS Trust, Flatts Lane, Normanby, Middlesbrough, TS6 0SZ	Urban Background (Corus Group Ltd, Redcar)	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
112: Dartford Bean (Bean)	112: Bean	Bean Primary School, Bean, Dartford, Kent, DA2 8AW	Urban 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 name changes, site locations, site classification, point source monitored (where applicable) and pollutants measured.

Annex 2 Results of Partisol 2000 PM_{10} Sampler Flow Audits

The sample flow for each sampler was measured using a BIOS Flow Calibrator, which was previously calibrated at NPL against weight loss from a cylinder, thus giving direct traceability to national standards. The reported flow rate is measured and reported at ambient conditions. A leak test was also performed on each sampler. The following table details the results of the Partisol 2000 PM_{10} sampler flow audits.

Site	Measured flow, $l\ min^{-1}$	Difference from set point (16.67 $l\ min^{-1}$) / %	Leak Test
Belfast Centre AURN	16.84	0.8	Passed
Bristol Avonmouth	15.61	-6.0	Passed
Bristol Hallen	17.15	2.7	Passed
Cardiff Rumney	16.67	-0.2	Passed
Cardiff Llandaff	16.68	-0.1	Passed
Chadwell St Mary	16.84	1.4	Passed
Dartford Bean	16.24	-2.2	Passed
Eskdalemuir	17.34	3.8	Passed
London Cromwell Road	16.81	0.7	Passed
London Horseferry Road	16.57	-0.2	Passed
Manchester Wythenshawe	17.05	2.1	Passed
Motherwell South	17.01	1.9	Passed
Port Talbot Margam AURN	17.38	4.1	Passed
Redcar AURN	17.27	3.4	Passed
Redcar Normanby	17.16	2.8	Passed
Runcorn Weston Point	16.87	1.0	Passed
Scunthorpe Low Santon	16.84	0.8	Passed
Scunthorpe Town AURN	17.08	2.3	Passed
Sheffield Brinsworth	16.75	0.9	Passed
Sheffield Centre AURN	17.46	4.6	Passed
Swansea Coedgwilym	18.68	12.5	Passed
Swansea Morriston	16.22	-2.3	Passed
Walsall Centre	16.85	0.9	Passed
Walsall Willenhall	16.14	-2.8	Passed

Table A2. Results of Partisol 2000 PM_{10} sampler flow audits for 2009.

The expanded uncertainty (k=2) in the flow measurements is 5.8 % expressed at the 95 % confidence interval. The average difference between the measured flows and the set point was 1.5 %. This is within the uncertainty of the measurement. The difference from set point determined from the audits of the Partisol 2000 samplers is used at ratification to adjust the volume recorded by the Partisol for each sample. If the difference from set point is greater than 10 % then remedial action would be taken, for example calling out the Equipment Support Unit (ESU). The Swansea Coedgwilym site was found to be in error by 12.5%; this site was serviced by the ESU a week after the audit was performed and the flow sensor was recalibrated.

Annex 3 Results of Total Gaseous Mercury Pump Flow Audits

The sample flow for each total gaseous mercury pump was measured using a BIOS Flow Calibrator, which was previously calibrated at NPL against weight loss from a cylinder, thus giving direct traceability to national standards. The reported flow rate is measured and reported at ambient conditions. A leak test was also performed on each sampler. The following table details the results of the total gaseous mercury pump flow audits.

Site	Set point / ml min^{-1}	Measured flow / ml min^{-1}	Difference from set point / %	Leak Test
Belfast Centre AURN	135	153.0	13.3	Passed
Cardiff, Llandaff	90	88.5	-1.7	Passed
Eskdalemuir	82	84.4	2.9	Passed
London Cromwell Road	100	107.7	7.7	Passed
London Horseferry Road	145	148.2	2.2	Passed
Manchester Wythenshawe	100	97.1	-2.9	Passed
Motherwell South	115	111.4	-3.1	Passed
Runcorn Weston Point	100	100.5	-2.8	Passed
Swansea Morriston	92	93.7	1.8	Passed
Walsall Centre	103	100.5	-2.8	Passed
Walsall Willenhall	102	104.1	2.6	Passed
Avonmouth	107	102.2	-4.5	Passed
Sheffield Centre	100	98.5	-1.5	Passed

Table A3. Results of total gaseous mercury pump flow audits for 2009.

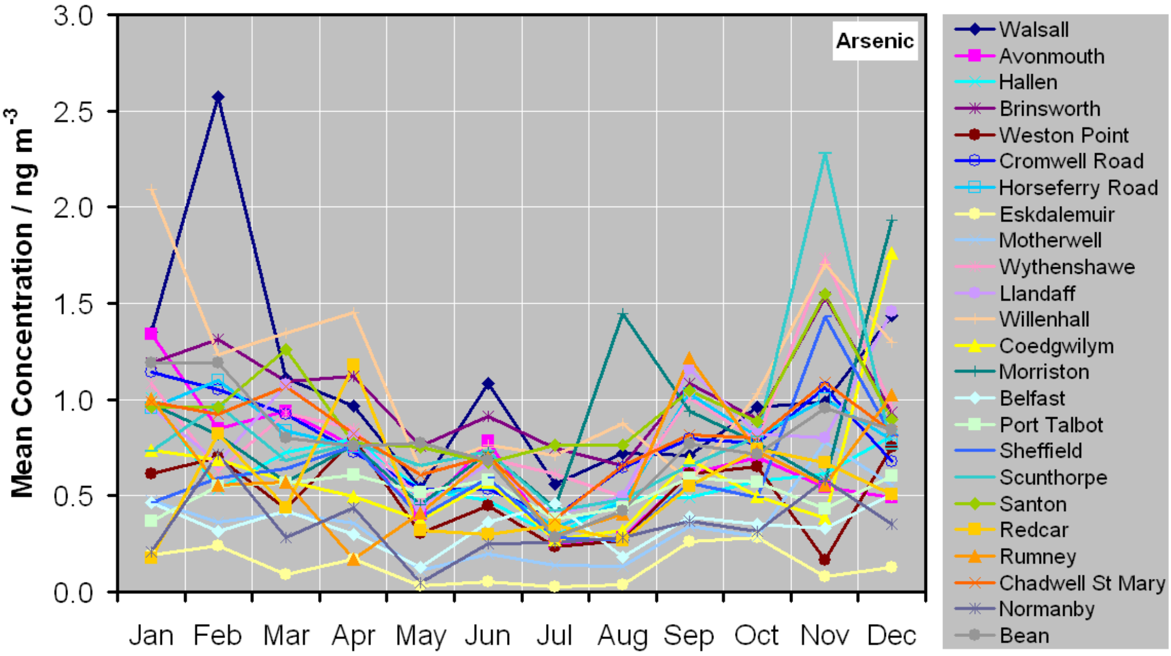
The expanded uncertainty (k=2) in the flow measurements is 5 % expressed at the 95 % confidence interval.

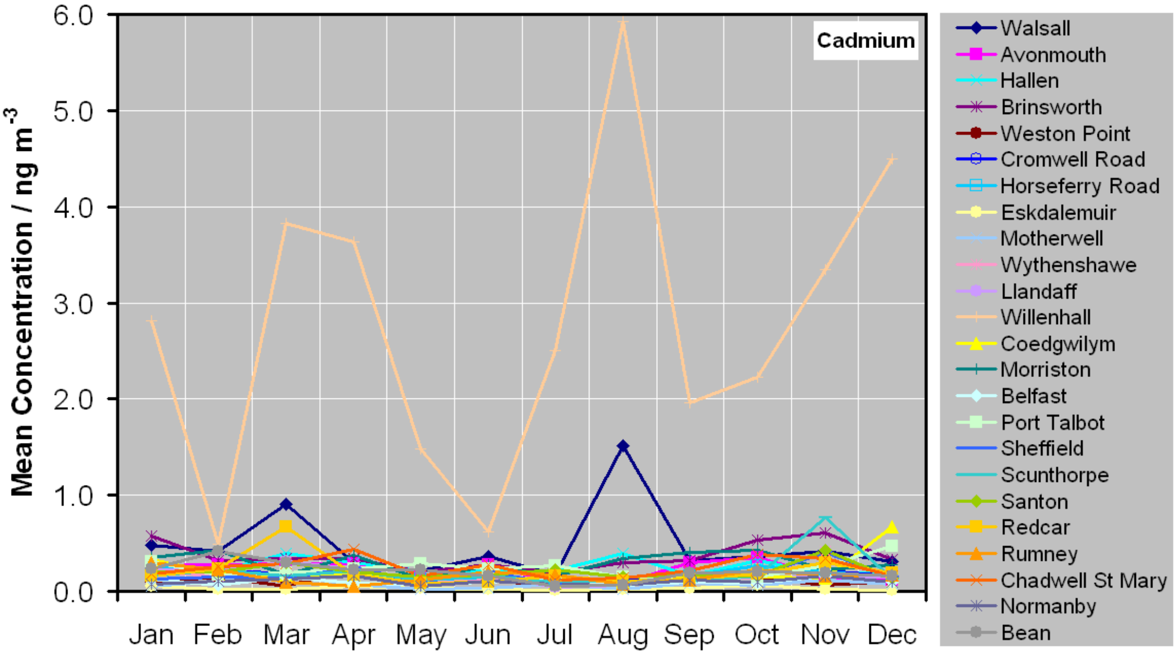
The average difference between the measured flows and the set point was 0.9 %.

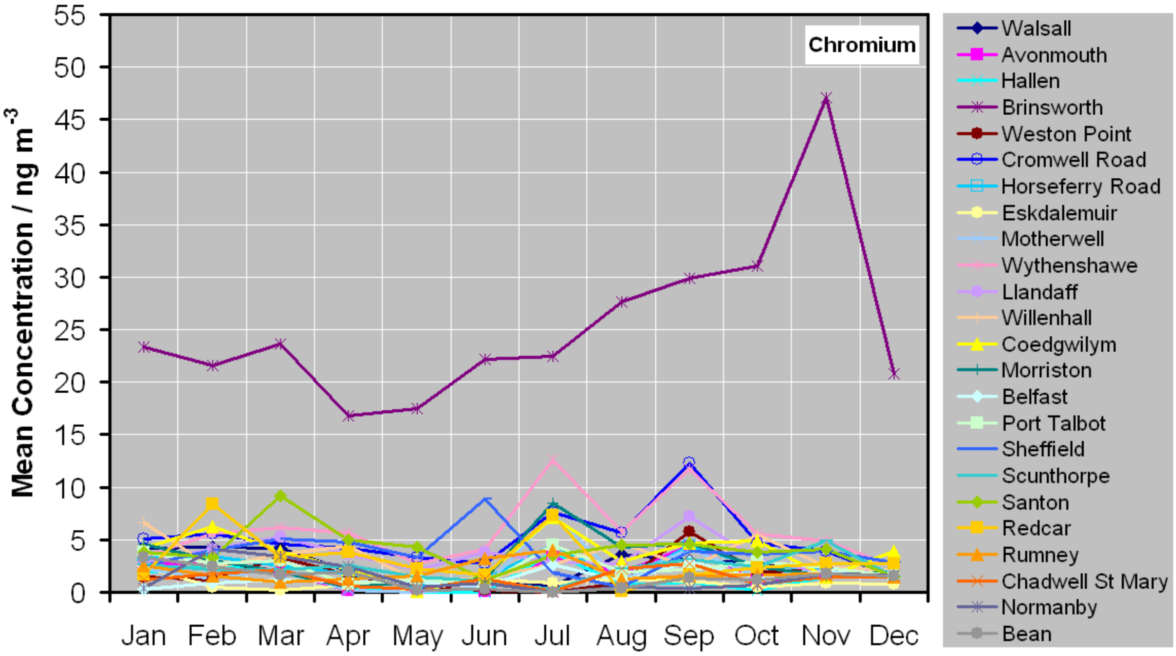
The difference from set point determined from the audits of the mercury vapour sampler pumps is used at ratification to adjust the volume recorded by the LSO for each sample. There is no threshold for remedial action on the mercury vapour samplers as the flow is adjusted by the LSO on a weekly basis and the flow can drift by more than 10 % in one week.

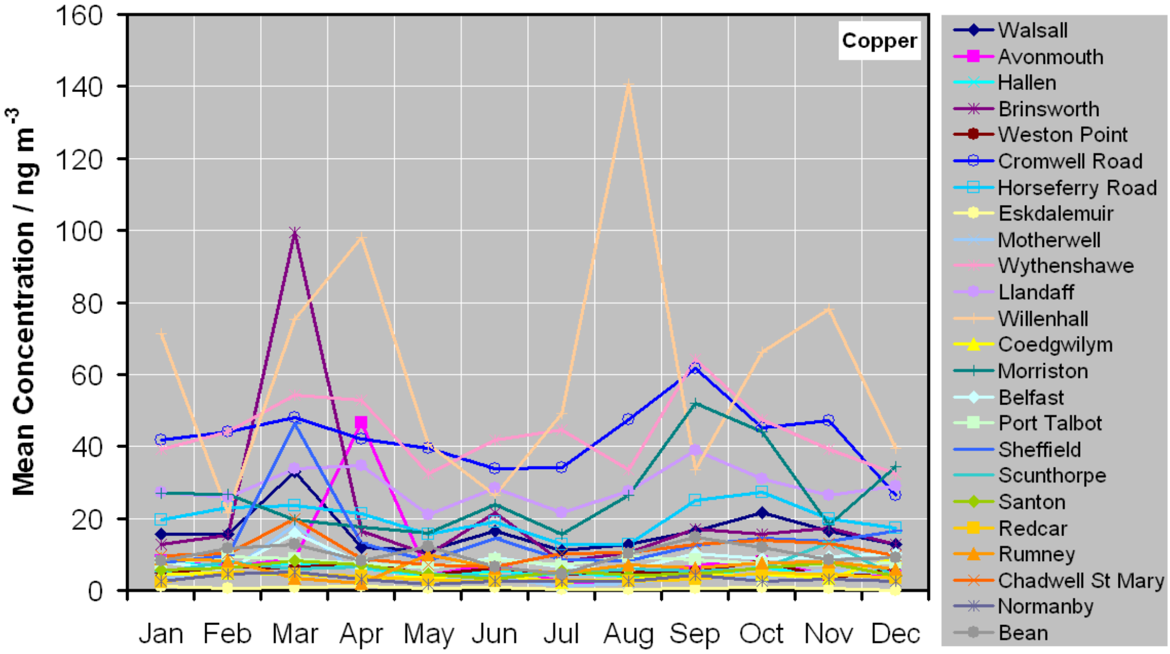
Annex 4 Average Monthly Concentrations Measured for Each Element

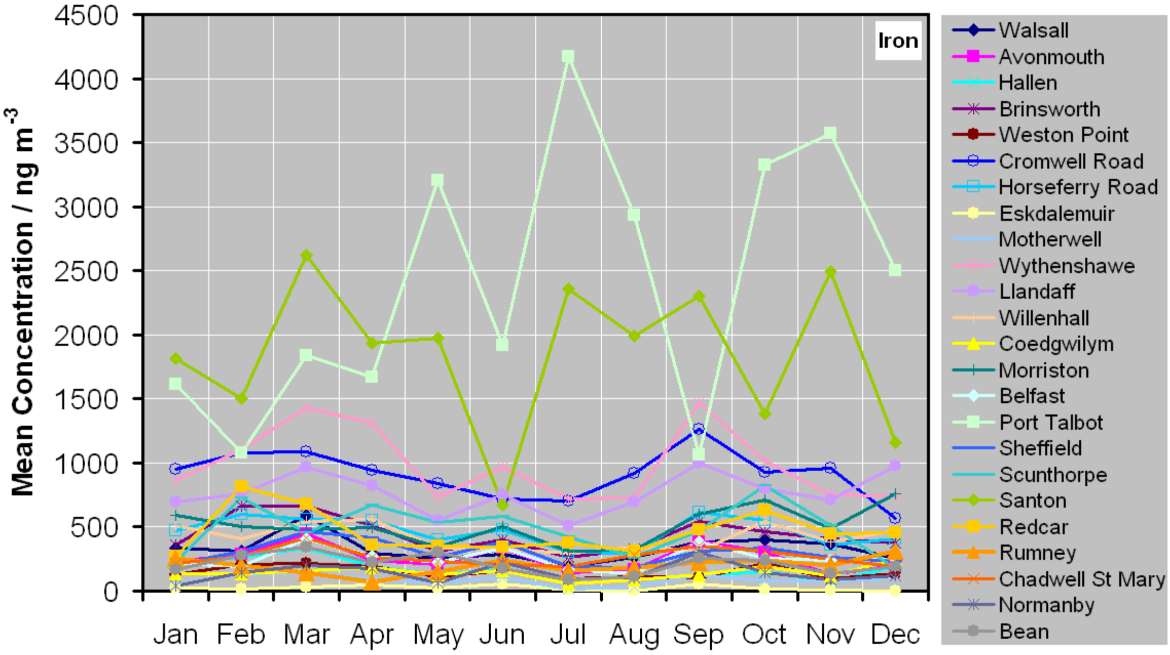
The following figures display the average monthly concentrations of each metal (as indicated in the top right-hand corner of each plot) measured at each site during 2009.






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


Copper
Mean Concentration / ng m-3
0
20
40
60
80
100
120
140
160
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Horseferry Road
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Willenhall
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
Horseferry Road
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Willenhall
Coedgwilym
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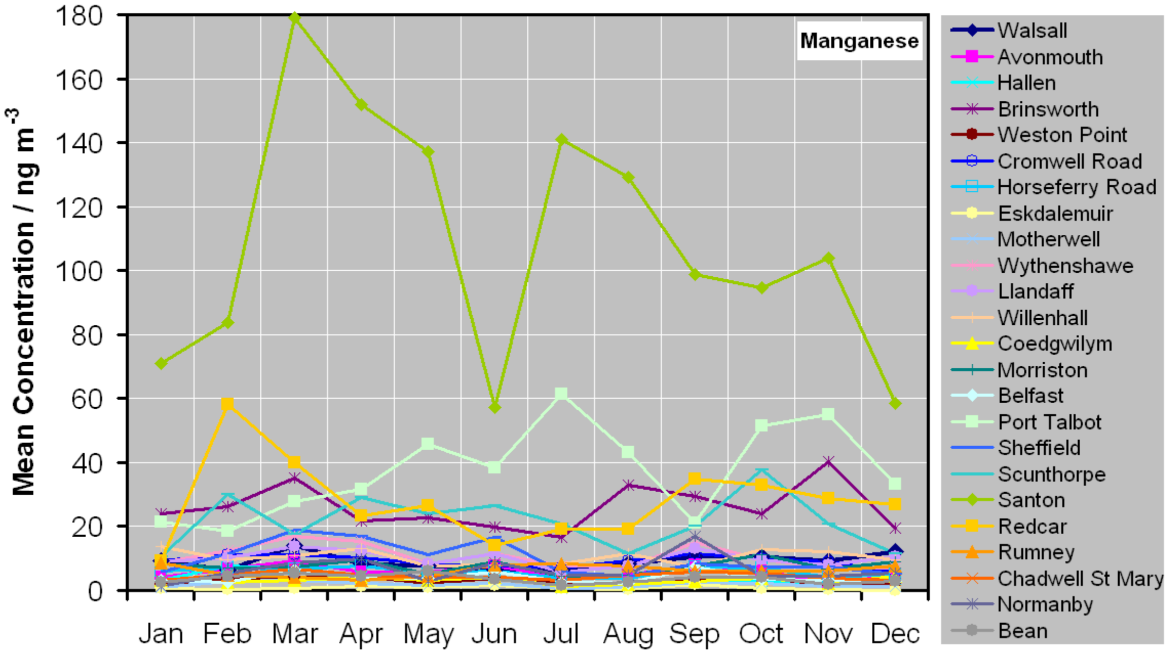
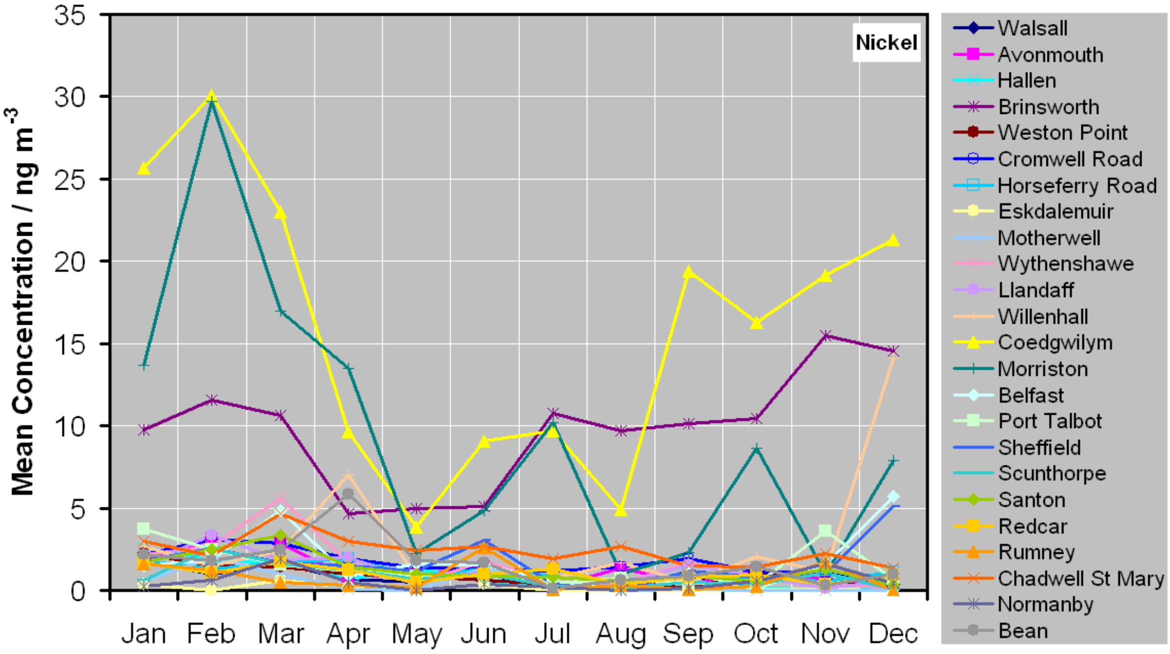
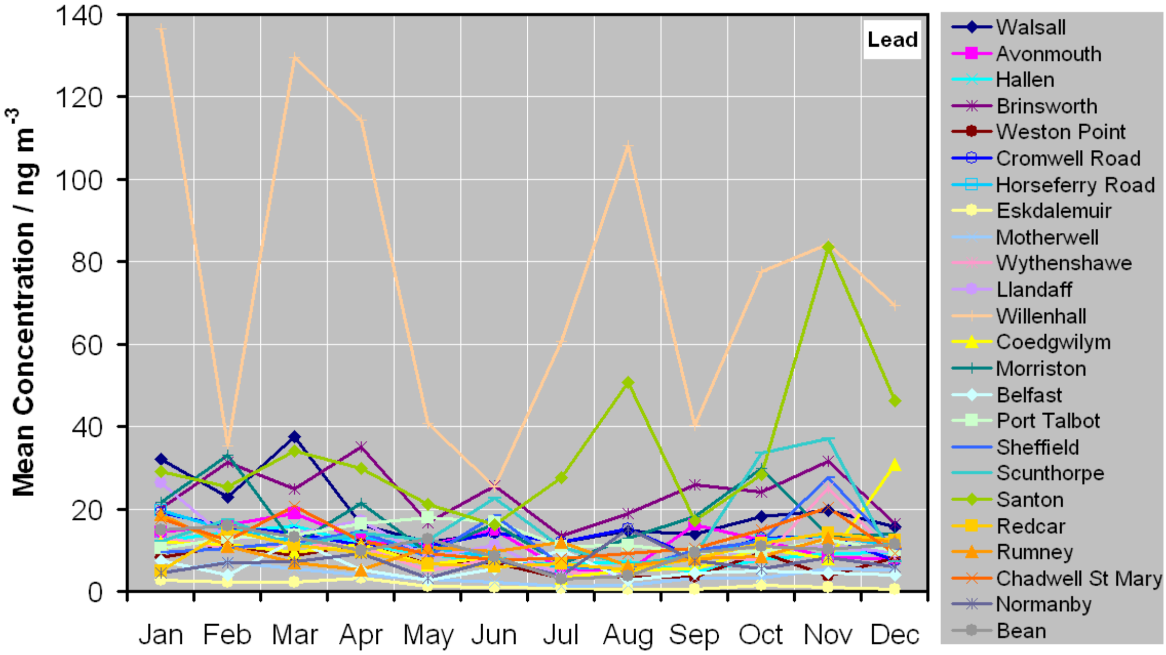
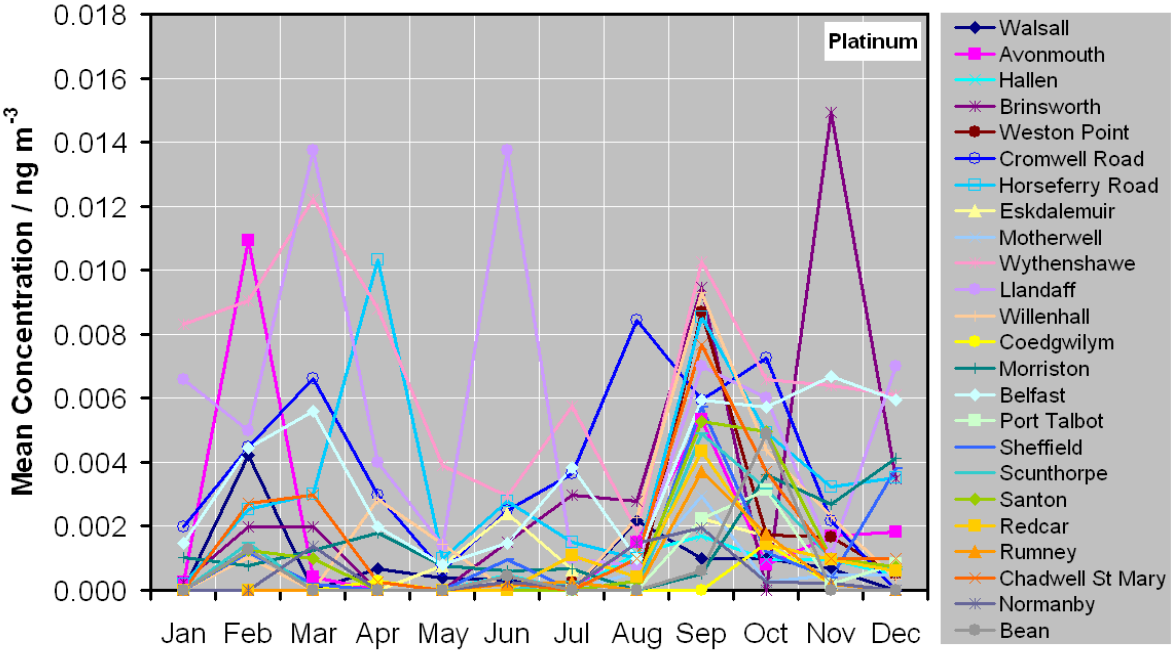
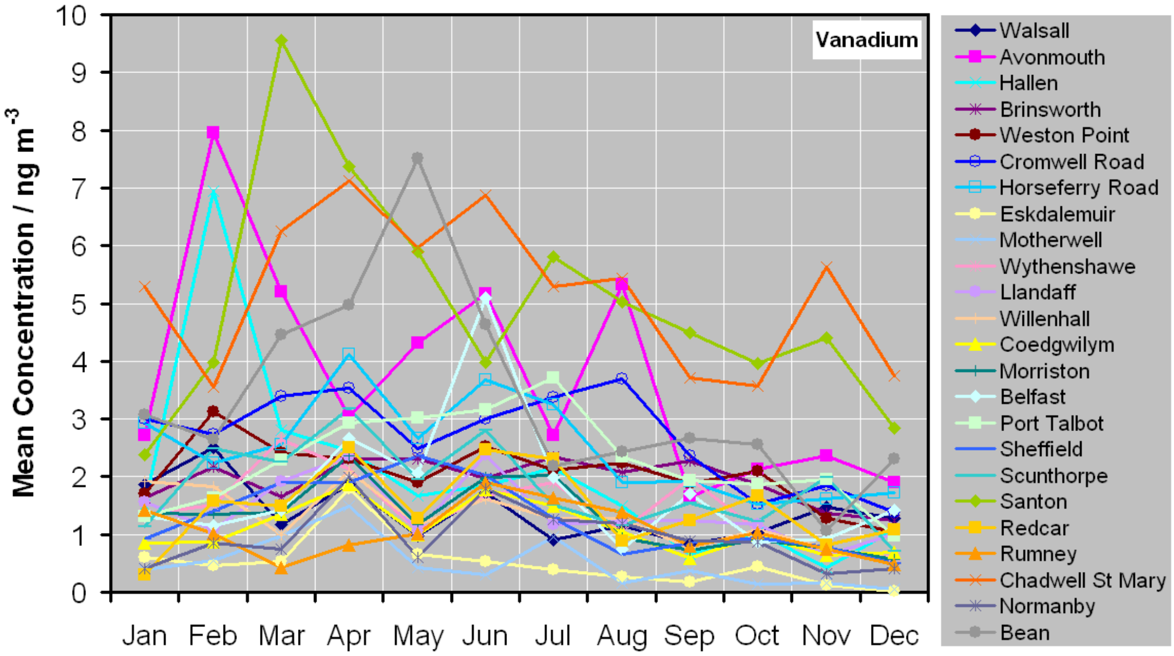
Chadwell St Mary
Normanby
Bean

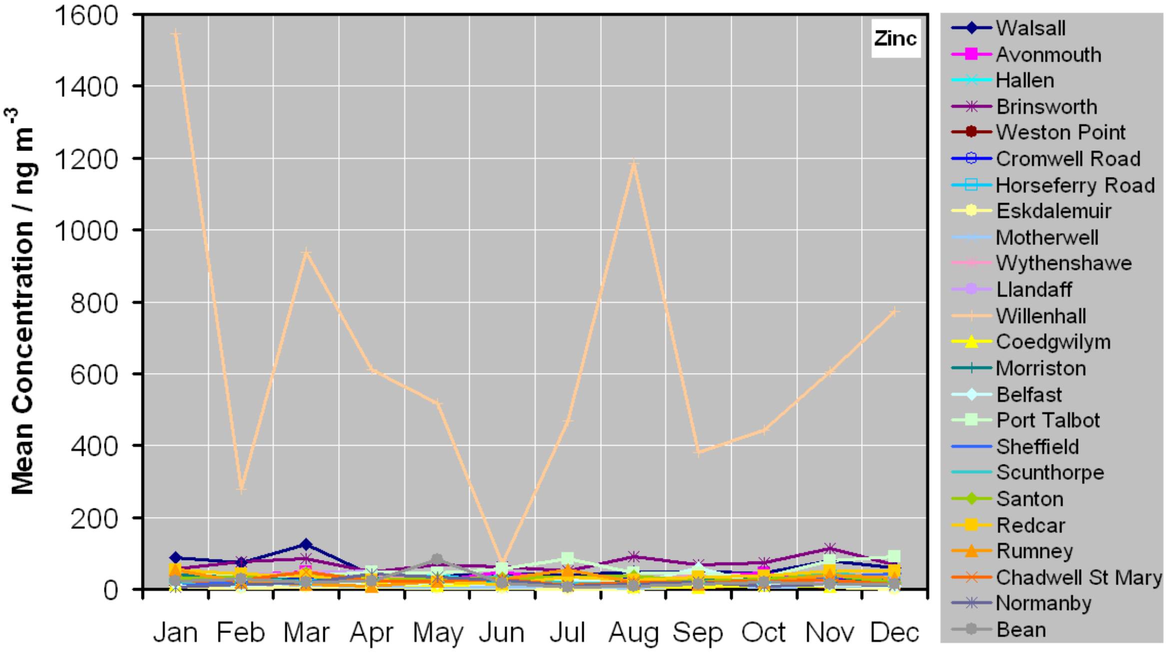

Manganese
Mean Concentration / ng m-3
180
160
140
120
100
80
60
40
20
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Horseferry Road
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Willenhall
Coedgwilym
Morriston
Belfast
Port Talbot
Sheffield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

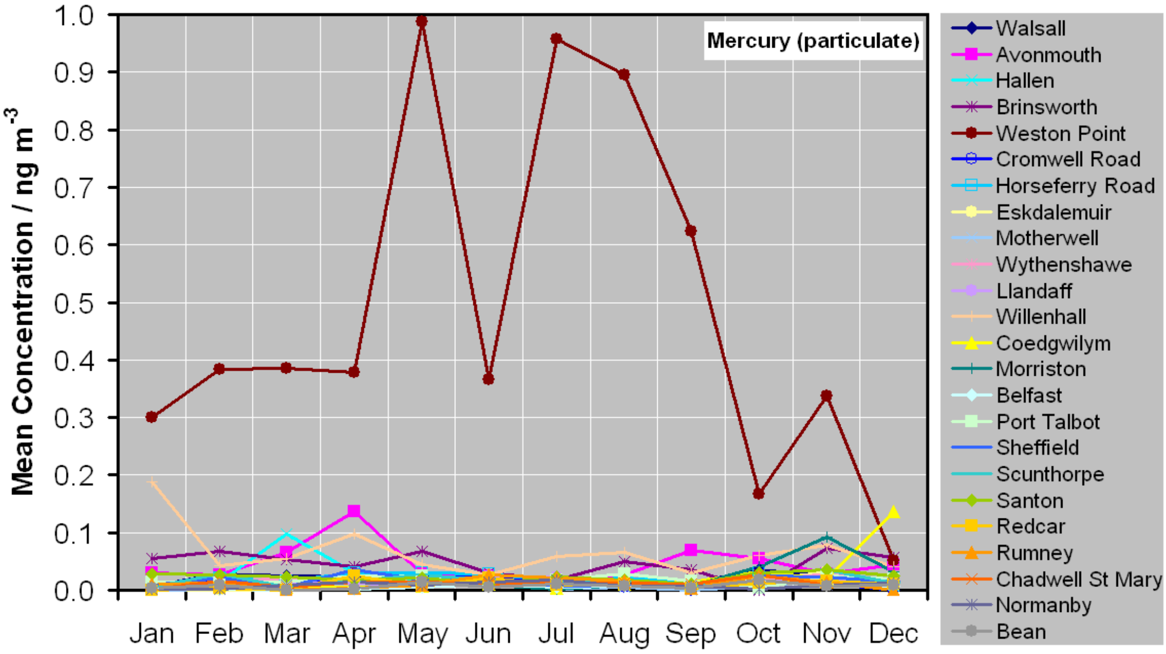

Nickel
Mean Concentration / ng m-3
35
30
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Horseferry Road
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Willenhall
Coedgwilym
Morriston
Belfast
Port Talbot
Sheffield
Scunthorpe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

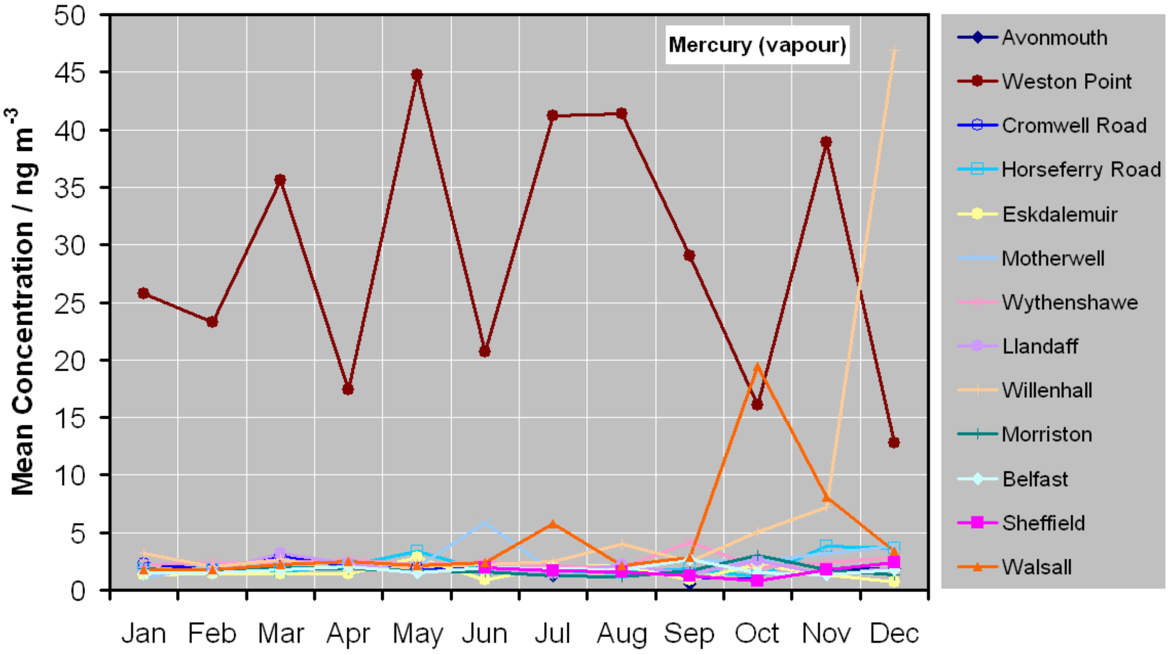

Lead
Mean Concentration / ng m-3
140
120
100
80
60
40
20
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Horseferry Road
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Willenhall
Coedgwilym
Morriston
Belfast
Port Talbot
Sheffield
Scunthorpe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


Platinum
Mean Concentration / ng m-3
0.018
0.016
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
Horseferry Road
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Willenhall
Coedgwilym
Morriston
Belfast
Port Talbot
Sheffield
Scunthorpe
Santon
Redcar
Rumney
Chadwell St Mary
Normanby
Bean


Vanadium
Mean Concentration / ng m-3
10
9
8
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
Horseferry Road
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Willenhall
Coedgwilym
Morriston
Belfast
Port Talbot
Sheffield
Scunthorpe
Santon
Redcar
Rumney
Chadwell St Mary
Normanby
Bean


Zinc
Mean Concentration / ng m-3
1600
1400
1200
1000
800
600
400
200
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Walsall
Avonmouth
Hallen
Brinsworth
Weston Point
Cromwell Road
Horseferry Road
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Willenhall
Coedgwilym
Morriston
Belfast
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
Horseferry Road
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Willenhall
Coedgwilym
Morriston
Belfast
Port Talbot
Sheffield
Scunthorpe
Santon
Redcar
Rumney
Chadwell St Mary
Normanby
Bean


Mercury (vapour)
Mean Concentration / ng m-3
50
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
Horseferry Road
Eskdalemuir
Motherwell
Wythenshawe
Llandaff
Willenhall
Morriston
Belfast
Sheffield
Walsall

Annex 5 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 2009.

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	1.35	0.48	4.22	15.6	337	9.3	1.83	32.0	<0.001	1.86	87.9	0.008	1.78
Feb	2.57	0.42	4.34	15.7	313	6.5	1.02	22.8	0.004	2.50	73.2	0.028	1.80
Mar	1.11	0.91	4.24	33.0	592	14.2	1.63	37.5	<0.001	1.18	125	0.025	2.20
Apr	0.97	0.30	2.02	12.1	298	8.3	0.71	16.2	0.001	1.86	39.8	0.024	2.46
May	0.54	0.21	0.39	11.2	254	7.6	0.49	11.8	<0.001	0.98	36.9	0.026	2.16
Jun	1.09	0.36	0.83	16.5	285	6.4	0.98	14.1	<0.001	1.72	42.6	0.018	2.41
Jul	0.56	0.17	0.61	11.2	193	6.2	0.19	11.9	<0.001	0.90	38.9	0.014	5.79
Aug	0.72	1.51	3.61	12.7	266	8.3	0.34	14.6	0.002	1.16	49.3	0.012	2.09
Sep	0.71	0.31	2.99	16.5	383	10.7	0.77	14.0	0.001	0.84	48.0	0.012	2.81
Oct	0.96	0.37	2.83	21.6	403	10.6	0.87	18.1	0.001	1.03	46.6	0.036	19.5
Nov	0.99	0.42	2.34	16.6	364	9.1	0.70	19.6	0.001	1.47	78.4	0.024	8.07
Dec	1.43	0.31	1.48	12.9	256	12.3	0.36	15.7	<0.001	1.27	59.1	<0.001	3.39
Annual Average	**1.08**	**0.48**	**2.49**	**16.3**	**329**	**9.1**	**0.82**	**19.0**	**0.001**	**1.40**	**60.5**	**0.019**	**4.54**

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	1.34	0.26	2.69	8.4	230	4.2	1.80	14.5	<0.001	2.71	27.7	0.030	N/A
Feb	0.85	0.27	2.77	6.5	285	6.8	3.10	16.1	0.011	7.96	40.8	0.027	N/A
Mar	0.94	0.29	2.07	8.8	447	9.4	2.89	19.0	<0.001	5.20	48.5	0.066	N/A
Apr	0.76	0.28	0.22	46.7	241	5.8	0.81	12.4	<0.001	3.04	27.7	0.136	N/A
May	0.40	0.21	0.51	4.4	211	5.8	0.96	11.2	<0.001	4.31	22.8	0.029	N/A
Jun	0.78	0.28	0.08	7.5	336	7.8	1.43	14.8	<0.001	5.16	49.5	0.024	1.94
Jul	0.25	0.08	3.46	2.2	145	4.1	0.18	5.5	<0.001	2.72	22.6	0.011	1.25
Aug	0.28	0.09	1.88	2.7	170	4.7	1.39	4.9	0.001	5.34	20.1	0.027	N/A
Sep	0.61	0.30	4.37	7.2	390	7.9	0.39	16.2	0.005	1.65	37.3	0.069	0.50
Oct	0.70	0.35	1.15	8.0	306	6.2	1.18	12.5	0.001	2.13	46.3	0.055	N/A
Nov	0.55	0.15	1.71	4.3	127	2.5	0.71	8.3	0.002	2.36	29.2	0.028	1.80
Dec	0.49	0.12	1.60	4.3	197	4.4	0.35	7.9	0.002	1.90	25.1	0.044	1.85
Annual Average	**0.66**	**0.22**	**1.88**	**9.3**	**257**	**5.8**	**1.27**	**11.9**	**0.002**	**3.71**	**33.1**	**0.045**	**1.47**

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	1.01	0.25	1.85	8.3	213	3.2	2.60	12.2	<0.001	1.52	22.5	0.008	N/A
Feb	0.54	0.21	2.62	6.1	266	7.6	1.83	14.3	<0.001	6.94	38.3	0.015	N/A
Mar	0.73	0.40	1.99	7.7	334	6.8	1.73	15.8	<0.001	2.81	39.8	0.097	N/A
Apr	0.80	0.30	0.35	6.3	189	4.2	0.67	11.4	<0.001	2.45	50.5	0.030	N/A
May	0.53	0.22	<0.01	4.0	127	3.0	1.31	9.1	<0.001	1.68	39.3	0.018	N/A
Jun	0.48	0.21	<0.01	5.3	168	3.6	0.60	7.3	<0.001	1.85	18.3	0.031	N/A
Jul	0.29	0.22	3.81	5.0	93	2.4	0.15	6.5	<0.001	2.15	22.7	0.011	N/A
Aug	0.49	0.39	0.65	3.9	103	2.4	0.15	7.3	0.001	1.49	21.6	0.021	N/A
Sep	0.49	0.16	0.94	3.8	123	2.7	0.05	4.7	0.002	0.65	14.8	0.014	N/A
Oct	0.58	0.32	0.19	6.7	155	2.9	0.19	7.7	0.001	1.04	30.7	0.026	N/A
Nov	0.61	0.18	1.46	3.8	72	1.2	0.01	9.3	0.001	0.43	20.0	0.020	N/A
Dec	0.81	0.19	1.47	5.9	195	3.4	0.12	9.6	<0.001	1.09	18.0	0.007	N/A
Annual Average	**0.61**	**0.25**	**1.28**	**5.6**	**170**	**3.6**	**0.78**	**9.6**	**<0.001**	**2.01**	**28.0**	**0.025**	**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	1.19	0.57	23.4	12.7	362	23.8	9.75	20.1	<0.001	1.63	56.2	0.054	N/A
Feb	1.31	0.32	21.6	15.5	659	26.3	11.5	31.4	0.002	2.17	77.0	0.068	N/A
Mar	1.09	0.34	23.7	99.5	666	35.2	10.6	24.8	0.002	1.65	85.9	0.054	N/A
Apr	1.12	0.34	16.8	16.4	514	21.6	4.64	35.0	<0.001	2.30	48.8	0.041	N/A
May	0.76	0.20	17.5	9.9	310	22.6	4.98	16.6	<0.001	2.31	68.5	0.067	N/A
Jun	0.91	0.27	22.2	21.5	402	19.7	5.12	25.7	0.001	1.97	62.1	0.030	N/A
Jul	0.75	0.19	22.4	7.9	267	16.7	10.8	13.4	0.003	2.34	52.5	0.019	N/A
Aug	0.66	0.29	27.7	10.5	325	32.8	9.69	18.9	0.003	2.08	91.8	0.049	N/A
Sep	1.08	0.32	29.9	16.9	545	29.4	10.1	26.0	0.009	2.28	68.5	0.035	N/A
Oct	0.90	0.53	31.1	15.6	466	24.1	10.5	24.0	<0.001	1.87	74.6	<0.001	N/A
Nov	1.53	0.61	47.1	17.2	406	40.4	15.5	31.7	0.015	1.37	113	0.072	N/A
Dec	0.93	0.33	20.8	12.7	374	19.4	14.6	16.4	0.003	1.25	68.5	0.056	N/A
Annual Average	**1.02**	**0.36**	**25.3**	**21.3**	**441**	**26.0**	**9.81**	**23.7**	**0.003**	**1.94**	**72.3**	**0.045**	**N/A**

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	0.61	0.10	1.43	4.7	131	2.0	2.23	8.2	<0.001	1.71	12.3	0.300	25.8
Feb	0.70	0.15	1.19	6.6	205	3.9	1.47	11.1	<0.001	3.13	20.8	0.383	23.2
Mar	0.43	0.05	3.28	6.4	219	4.0	1.44	8.8	<0.001	2.41	14.3	0.385	35.6
Apr	0.80	0.24	1.64	8.0	193	4.4	1.01	11.5	<0.001	2.31	20.0	0.379	17.4
May	0.30	0.10	0.44	4.1	110	2.3	0.86	6.7	<0.001	1.90	6.5	0.988	44.7
Jun	0.45	0.12	0.23	6.3	162	3.8	0.59	7.1	<0.001	2.53	13.1	0.366	20.7
Jul	0.23	0.06	<0.01	4.6	100	2.4	0.35	3.3	<0.001	2.11	6.5	0.957	41.2
Aug	0.27	0.09	0.89	5.1	115	2.2	0.59	3.5	<0.001	2.24	13.1	0.896	41.4
Sep	0.61	0.12	5.75	5.1	102	3.1	0.09	3.5	0.009	1.89	4.2	0.624	29.0
Oct	0.65	0.14	1.96	8.2	218	4.3	1.11	9.4	0.002	2.09	15.4	0.167	16.1
Nov	0.17	0.06	2.01	3.5	97	1.6	0.37	3.9	0.002	1.28	7.0	0.337	38.9
Dec	0.75	0.11	1.55	6.0	139	2.3	0.42	8.3	<0.001	1.04	12.0	0.052	12.8
Annual Average	**0.50**	**0.11**	**1.70**	**5.7**	**149**	**3.0**	**0.88**	**7.1**	**0.001**	**2.05**	**12.1**	**0.486**	**28.9**

Site 61: London Cromwell Road

Month	Concentration / ng m-3												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	1.14	0.23	5.06	41.8	954	9.4	2.19	19.0	0.002	3.01	33.6	0.005	2.34
Feb	1.05	0.23	5.55	44.1	1078	11.1	3.10	15.6	0.004	2.74	34.8	0.018	1.79
Mar	0.92	0.18	4.64	48.1	1089	11.1	2.85	14.1	0.007	3.39	30.8	0.013	2.99
Apr	0.73	0.17	4.24	42.0	944	10.3	1.95	11.1	0.003	3.54	50.5	0.019	2.02
May	0.54	0.12	3.36	39.5	842	8.3	1.35	10.9	0.001	2.49	26.7	0.023	1.91
Jun	0.54	0.13	2.70	33.8	717	7.6	1.28	14.1	0.002	3.00	19.8	0.025	1.94
Jul	0.39	0.09	7.66	34.2	705	7.0	1.16	12.0	0.004	3.37	23.6	0.015	1.78
Aug	0.65	0.15	5.65	47.6	919	9.2	1.46	15.2	0.008	3.70	31.4	0.006	2.10
Sep	0.80	0.10	12.3	61.7	1260	11.5	1.95	8.1	0.006	2.36	27.1	<0.001	1.05
Oct	0.77	0.18	4.68	45.2	925	9.9	1.11	12.9	0.007	1.53	25.0	0.033	0.97
Nov	1.06	0.21	3.90	47.1	959	9.1	1.06	13.4	0.002	1.84	28.6	0.012	N/A
Dec	0.68	0.16	1.49	26.3	567	5.8	0.27	7.5	<0.001	1.39	17.2	<0.001	2.17
Annual Average	**0.77**	**0.16**	**5.10**	**42.6**	**913**	**9.2**	**1.64**	**12.8**	**0.004**	**2.70**	**29.1**	**0.014**	**1.92**

Site 62: London Horseferry Road

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.95	0.25	3.33	19.6	472	5.9	1.80	19.6	<0.001	2.93	29.2	0.010	1.81
Feb	1.10	0.21	3.40	22.9	596	7.0	1.30	14.8	0.003	2.24	26.9	0.022	1.80
Mar	0.84	0.17	2.55	23.6	556	6.8	1.70	12.6	0.003	2.56	24.2	0.016	1.57
Apr	0.75	0.21	1.79	21.3	549	7.7	1.92	13.2	0.010	4.13	38.3	0.031	2.16
May	0.49	0.12	0.66	15.7	398	5.3	0.86	10.7	0.001	2.66	16.9	0.031	3.39
Jun	0.56	0.14	1.26	19.2	478	6.1	1.32	8.2	0.003	3.68	16.5	0.029	1.67
Jul	0.33	0.08	4.49	12.7	307	3.9	0.87	6.0	0.002	3.25	19.0	0.016	1.66
Aug	0.46	0.08	1.04	12.7	292	3.9	0.44	5.5	0.001	1.90	13.8	0.022	1.48
Sep	1.03	0.16	4.41	25.0	619	7.5	1.03	9.2	0.009	1.92	23.3	0.013	1.84
Oct	0.81	0.27	2.56	27.2	552	6.9	0.72	12.4	0.005	1.53	23.8	0.031	1.11
Nov	1.00	0.20	2.29	20.0	363	4.1	0.57	13.8	0.003	1.62	22.7	0.020	3.83
Dec	0.79	0.15	1.75	17.5	409	5.0	1.13	10.9	0.004	1.72	17.3	0.015	3.68
Annual Average	**0.76**	**0.17**	**2.46**	**19.8**	**466**	**5.8**	**1.14**	**11.4**	**0.004**	**2.51**	**22.7**	**0.021**	**2.17**

Site 65: Eskdalemuir

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.19	0.05	2.48	1.0	24	0.6	0.35	2.8	<0.001	0.60	5.1	<0.001	1.37
Feb	0.24	0.02	0.48	0.5	15	0.4	0.02	2.3	<0.001	0.47	3.0	<0.001	1.44
Mar	0.09	0.02	0.18	0.8	29	0.8	0.60	2.3	<0.001	0.54	4.5	<0.001	1.38
Apr	0.17	0.05	0.68	1.1	50	1.4	0.21	3.3	<0.001	1.79	5.3	0.004	1.44
May	0.03	0.03	0.24	0.6	28	1.0	<0.01	1.3	0.001	0.65	2.0	0.007	2.86
Jun	0.06	0.02	1.22	0.8	54	1.5	0.36	0.9	0.002	0.53	3.5	0.015	0.88
Jul	0.03	0.02	0.90	0.3	10	0.7	<0.01	0.7	0.001	0.39	0.8	0.012	2.08
Aug	0.03	0.03	1.24	0.2	2	0.5	<0.01	0.4	<0.001	0.27	1.0	0.007	2.16
Sep	0.26	0.03	1.04	0.7	54	1.8	<0.01	0.4	0.002	0.18	9.4	0.001	0.87
Oct	0.28	0.06	0.51	0.9	13	0.7	0.08	1.4	0.002	0.44	29.3	0.015	2.20
Nov	0.08	0.02	0.87	0.5	5	0.2	0.08	1.0	<0.001	0.13	5.1	0.032	1.34
Dec	0.13	0.01	0.77	0.1	2	0.1	<0.01	0.5	<0.001	0.01	0.6	0.013	0.72
Annual Average	**0.13**	**0.03**	**0.88**	**0.6**	**24**	**0.8**	**0.14**	**1.4**	**0.001**	**0.50**	**5.8**	**0.009**	**1.56**

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	0.48	0.05	2.20	3.0	52	0.9	0.57	4.4	<0.001	0.39	6.7	<0.001	1.03
Feb	0.36	0.10	1.27	5.2	133	2.7	1.99	7.1	<0.001	0.54	17.3	0.002	2.13
Mar	0.41	0.16	2.34	18.2	156	3.1	1.00	5.4	<0.001	0.98	11.1	0.002	2.02
Apr	0.36	0.07	0.21	4.1	93	2.3	0.06	4.1	<0.001	1.49	7.2	0.003	2.51
May	0.11	0.03	<0.01	3.0	65	1.6	<0.01	3.0	<0.001	0.42	4.9	0.007	2.06
Jun	0.20	0.03	0.51	3.6	103	2.3	1.38	2.2	<0.001	0.31	5.9	0.024	5.84
Jul	0.14	0.08	7.45	1.1	15	0.5	0.26	1.3	<0.001	0.95	8.9	0.001	1.60
Aug	0.14	0.02	1.06	2.1	29	1.1	0.01	1.5	0.001	0.16	3.5	0.005	2.12
Sep	0.34	0.09	4.22	3.9	131	2.6	0.09	3.2	0.003	0.37	10.4	<0.001	2.61
Oct	0.29	0.06	1.48	3.6	81	2.2	0.01	3.3	<0.001	0.13	4.4	0.007	2.51
Nov	0.78	0.12	2.13	5.8	78	1.4	<0.01	5.6	<0.001	0.16	9.1	0.017	3.16
Dec	0.55	0.07	1.55	4.6	95	1.4	0.01	5.2	<0.001	0.06	8.7	0.008	3.82
Annual Average	**0.35**	**0.07**	**2.04**	**4.9**	**86**	**1.8**	**0.45**	**3.9**	**<0.001**	**0.50**	**8.2**	**0.006**	**2.62**

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	1.09	0.20	3.45	39.2	866	8.8	2.15	13.2	0.008	1.35	32.5	0.009	2.25
Feb	0.63	0.16	5.60	43.9	1107	12.3	2.65	10.5	0.009	1.51	37.1	0.014	2.36
Mar	0.93	0.18	6.20	54.4	1433	16.8	5.62	11.5	0.012	2.65	47.9	0.022	2.37
Apr	0.85	0.19	5.65	52.9	1311	15.4	1.69	10.9	0.009	2.13	43.1	0.016	2.66
May	0.48	0.09	2.73	32.5	733	8.2	0.35	5.0	0.004	1.06	23.4	0.013	2.18
Jun	0.70	0.11	4.12	41.7	968	11.6	1.78	7.9	0.003	1.66	30.3	0.008	2.48
Jul	0.61	0.09	12.6	44.6	719	7.6	0.52	4.7	0.006	1.91	25.7	0.006	2.12
Aug	0.50	0.08	5.75	33.6	724	7.4	0.47	4.1	0.002	1.06	20.8	0.008	1.98
Sep	1.01	0.14	11.7	64.3	1473	15.2	1.69	9.0	0.010	1.97	39.3	0.007	4.21
Oct	0.79	0.14	5.53	47.5	1014	9.7	0.72	7.4	0.007	1.07	28.5	0.016	1.98
Nov	1.74	0.41	4.84	39.2	751	7.5	0.45	25.0	0.006	0.64	38.7	0.028	2.43
Dec	0.96	0.13	2.40	32.4	741	7.2	0.14	8.2	0.006	0.63	23.7	0.015	2.86
Annual Average	**0.86**	**0.16**	**5.88**	**43.9**	**987**	**10.6**	**1.52**	**9.8**	**0.007**	**1.47**	**32.6**	**0.014**	**2.49**

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	0.96	0.23	2.81	27.3	696	8.9	1.54	26.4	0.007	1.57	33.7	0.009	1.66
Feb	0.67	0.21	4.07	26.0	763	10.2	3.34	12.7	0.005	1.08	40.4	0.011	1.60
Mar	1.08	0.31	5.27	33.8	966	13.8	1.87	14.0	0.014	1.91	45.4	0.013	3.23
Apr	0.81	0.24	3.62	34.7	826	12.6	2.01	17.3	0.004	2.37	51.7	0.012	2.31
May	0.44	0.11	2.13	21.0	555	8.3	0.63	8.1	0.001	1.06	25.7	0.009	1.58
Jun	0.67	0.18	3.76	28.3	754	11.5	1.09	11.1	0.014	2.39	37.2	0.024	1.89
Jul	0.40	0.05	2.94	21.5	515	5.8	0.16	3.5	0.001	1.18	14.0	0.024	1.45
Aug	0.50	0.07	2.74	27.6	693	7.7	0.40	4.4	0.001	1.23	18.2	0.010	2.20
Sep	1.16	0.16	7.25	38.8	1001	13.2	1.58	8.9	0.007	1.24	30.2	0.007	1.40
Oct	0.82	0.15	3.14	31.0	801	9.6	0.87	10.0	0.006	1.17	26.4	0.013	2.58
Nov	0.80	0.15	1.85	26.5	709	7.9	0.11	11.0	0.001	0.63	24.0	0.019	1.31
Dec	1.46	0.15	2.09	28.9	976	10.6	0.62	9.4	0.007	1.01	26.4	0.016	1.92
Annual Average	**0.81**	**0.17**	**3.47**	**28.8**	**771**	**10.0**	**1.18**	**11.4**	**0.006**	**1.40**	**31.1**	**0.014**	**1.93**

Site 69: Walsall Willenhall

Month	Concentration / ng m-3												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	2.09	2.81	6.60	71.3	512	13.6	2.68	137	<0.001	1.91	1547	0.189	3.17
Feb	1.23	0.49	2.38	21.5	405	9.6	1.52	35.2	0.001	1.82	279	0.042	2.03
Mar	1.35	3.83	3.62	75.3	541	10.9	2.44	130	<0.001	1.00	934	0.055	2.67
Apr	1.45	3.64	4.39	98.0	558	13.2	7.03	114	0.003	2.10	611	0.097	1.67
May	0.63	1.49	1.07	40.5	337	7.8	0.83	40.8	0.001	1.16	516	0.044	2.02
Jun	0.76	0.62	1.38	26.4	329	8.0	0.89	25.4	<0.001	1.61	72.1	0.027	2.19
Jul	0.71	2.51	2.68	49.1	300	8.2	0.77	60.7	<0.001	1.29	469	0.058	2.46
Aug	0.88	5.92	4.67	140.8	344	11.4	1.66	108	0.002	1.28	1184	0.065	3.98
Sep	0.57	1.96	2.32	33.5	314	7.3	0.53	40.3	0.009	0.77	380	0.030	2.48
Oct	1.03	2.23	5.51	66.1	541	12.7	2.04	77.5	0.004	1.09	444	0.061	5.07
Nov	1.70	3.34	2.47	78.2	386	12.1	1.12	84.4	0.002	0.76	606	0.078	7.20
Dec	1.30	4.50	2.05	39.5	476	9.5	14.1	69.3	<0.001	0.59	774	0.042	46.9
Annual Average	**1.14**	**2.78**	**3.26**	**61.7**	**420**	**10.4**	**2.97**	**76.8**	**0.002**	**1.28**	**652**	**0.066**	**6.82**

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	0.74	0.33	4.20	4.5	133	3.4	25.7	11.8	<0.001	0.86	15.3	0.009	N/A
Feb	0.69	0.18	6.23	5.0	139	2.6	30.1	11.3	<0.001	0.87	19.3	0.009	N/A
Mar	0.58	0.17	3.89	4.5	158	3.3	23.0	9.5	<0.001	1.34	14.0	0.006	N/A
Apr	0.50	0.17	2.19	3.3	186	4.2	9.60	11.5	<0.001	1.87	15.4	0.005	N/A
May	0.38	0.13	0.06	3.8	124	3.1	3.86	6.6	<0.001	1.00	11.2	0.007	N/A
Jun	0.57	0.19	1.52	4.4	157	4.3	9.10	8.5	<0.001	1.78	13.7	0.010	N/A
Jul	0.27	0.08	7.14	2.4	52	1.4	9.68	3.2	<0.001	1.49	14.9	0.004	N/A
Aug	0.32	0.09	2.98	3.1	88	2.0	4.93	5.2	<0.001	1.04	9.2	0.011	N/A
Sep	0.69	0.16	4.66	3.9	126	3.0	19.4	5.5	<0.001	0.59	6.9	0.014	N/A
Oct	0.50	0.14	4.86	4.5	190	3.7	16.3	10.4	0.001	0.97	12.4	0.033	N/A
Nov	0.38	0.14	1.48	3.5	121	2.4	19.1	7.9	<0.001	0.65	9.4	0.020	N/A
Dec	1.76	0.68	3.91	9.2	250	4.6	21.4	30.9	<0.001	0.69	24.2	0.137	N/A
Annual Average	**0.61**	**0.20**	**3.59**	**4.3**	**144**	**3.2**	**16.0**	**10.2**	**<0.001**	**1.10**	**13.8**	**0.022**	**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	0.98	0.36	4.63	27.1	589	8.2	13.7	21.7	0.001	1.37	38.5	0.008	1.84
Feb	0.82	0.42	2.98	26.7	500	7.2	29.7	32.9	0.001	1.35	38.3	0.012	1.63
Mar	0.57	0.17	1.92	19.6	483	7.2	17.0	11.5	0.001	1.38	24.1	0.003	1.93
Apr	0.76	0.37	0.50	17.5	497	9.6	13.5	21.4	0.002	2.36	31.5	0.018	1.85
May	0.46	0.13	0.95	16.0	341	5.2	2.25	9.4	0.001	1.17	15.9	0.007	1.68
Jun	0.72	0.26	1.31	23.8	501	9.1	4.88	16.5	0.001	1.99	27.5	0.009	1.63
Jul	0.44	0.16	8.53	15.5	312	4.6	10.2	6.8	0.001	2.03	19.5	0.001	1.24
Aug	1.45	0.34	4.28	26.3	323	4.8	1.03	12.9	<0.001	0.95	20.7	0.009	1.13
Sep	0.94	0.41	4.66	51.9	602	7.6	2.30	18.1	0.001	0.73	29.1	0.007	1.65
Oct	0.77	0.42	2.46	44.2	707	11.1	8.62	30.0	0.004	0.91	37.4	0.040	3.01
Nov	0.57	0.23	1.54	18.2	488	6.7	0.97	13.4	0.003	0.76	22.1	0.092	1.76
Dec	1.93	0.28	1.94	34.4	758	9.0	7.93	13.9	0.004	0.56	27.0	0.032	1.36
Annual Average	**0.87**	**0.30**	**2.98**	**26.8**	**508**	**7.5**	**9.34**	**17.4**	**0.001**	**1.30**	**27.6**	**0.020**	**1.73**

Site 103: Belfast Centre AURN

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.46	0.13	0.27	7.9	219	3.3	1.46	7.5	0.001	1.32	13.7	0.003	1.52
Feb	0.31	0.06	0.83	5.8	193	2.6	1.85	4.0	0.004	1.16	8.2	0.002	1.52
Mar	0.42	0.15	1.16	15.8	407	6.8	4.83	12.3	0.006	1.42	19.3	<0.001	1.75
Apr	0.30	0.08	0.98	7.7	271	4.2	0.89	5.2	0.002	2.66	11.4	0.002	2.06
May	0.13	0.07	0.93	6.2	222	3.8	1.63	2.8	0.001	2.07	17.3	0.005	1.47
Jun	0.36	0.10	0.59	9.1	337	5.9	1.57	5.5	0.001	5.11	14.5	0.011	1.94
Jul	0.46	0.14	2.69	6.5	165	2.9	0.53	9.8	0.004	1.98	28.0	0.006	1.90
Aug	0.18	0.06	1.04	5.7	139	2.3	0.07	2.7	0.001	0.74	12.8	0.007	1.76
Sep	0.39	0.10	2.88	10.3	387	7.2	1.04	4.5	0.006	1.70	58.7	0.013	2.62
Oct	0.35	0.08	1.37	8.7	258	3.5	0.14	5.0	0.006	0.87	12.1	0.016	1.53
Nov	0.33	0.17	1.94	9.5	242	3.2	1.58	4.4	0.007	0.92	11.5	0.011	1.36
Dec	0.50	0.10	1.48	10.3	250	3.0	5.71	4.0	0.006	1.41	9.9	0.007	1.77
Annual Average	**0.35**	**0.10**	**1.35**	**8.6**	**258**	**4.0**	**1.77**	**5.7**	**0.004**	**1.78**	**18.1**	**0.007**	**1.77**

Site 104: Port Talbot Margam AURN

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.37	0.30	3.82	7.3	1611	21.4	3.70	10.3	<0.001	1.31	50.3	0.013	N/A
Feb	0.55	0.17	2.73	9.5	1078	18.7	2.52	12.8	<0.001	1.63	40.1	0.012	N/A
Mar	0.57	0.20	3.00	8.8	1837	27.7	1.57	13.6	<0.001	2.29	37.5	0.015	N/A
Apr	0.61	0.24	0.82	7.4	1669	31.7	1.21	16.3	<0.001	2.92	48.7	0.025	N/A
May	0.52	0.29	1.31	6.7	3202	45.7	0.87	17.8	<0.001	3.01	46.7	0.025	N/A
Jun	0.58	0.23	0.75	8.6	1919	38.3	0.92	17.0	<0.001	3.17	56.6	0.015	N/A
Jul	0.38	0.26	4.52	7.2	4169	61.4	0.44	11.0	<0.001	3.72	84.9	0.018	N/A
Aug	0.44	0.14	1.94	9.5	2931	43.1	0.77	11.3	<0.001	2.34	46.7	0.028	N/A
Sep	0.59	0.13	2.13	8.5	1060	21.2	0.43	9.4	0.002	1.94	44.8	0.016	N/A
Oct	0.57	0.15	2.89	7.5	3325	51.4	0.40	9.6	0.003	1.86	35.4	0.003	N/A
Nov	0.43	0.26	2.32	7.0	3574	55.1	3.59	12.4	<0.001	1.95	80.8	0.025	N/A
Dec	0.60	0.47	1.53	7.7	2502	33.3	0.66	10.1	0.001	0.98	92.0	0.020	N/A
Annual Average	**0.52**	**0.24**	**2.31**	**8.0**	**2406**	**37.4**	**1.42**	**12.6**	**0.001**	**2.26**	**55.4**	**0.018**	**N/A**

Site 105: Sheffield Centre AURN

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.46	0.13	2.59	7.8	205	5.8	1.77	9.5	<0.001	0.92	16.0	0.009	N/A
Feb	0.59	0.15	4.03	9.8	312	11.6	2.53	10.5	0.001	1.40	20.6	0.022	N/A
Mar	0.64	0.14	5.06	46.4	461	18.8	1.70	11.9	<0.001	1.89	22.6	0.005	N/A
Apr	0.76	0.25	4.83	13.2	417	17.0	1.49	14.5	<0.001	1.91	29.7	0.036	N/A
May	0.39	0.10	3.36	8.1	266	11.2	1.20	8.4	<0.001	2.36	18.4	0.017	N/A
Jun	0.59	0.21	8.94	14.4	382	16.8	3.07	18.4	0.001	2.03	34.8	0.020	1.97
Jul	0.28	0.07	1.90	8.5	192	5.7	0.38	6.5	<0.001	1.28	15.0	0.007	1.71
Aug	0.27	0.07	0.47	8.2	183	4.4	<0.01	5.2	<0.001	0.66	9.1	0.009	1.60
Sep	0.57	0.14	3.88	12.4	315	8.4	1.18	10.0	0.006	0.86	21.9	0.010	1.28
Oct	0.49	0.16	3.58	14.4	336	7.5	0.79	12.1	0.001	0.94	20.2	0.026	0.80
Nov	1.43	0.40	3.92	13.8	263	7.4	1.05	27.6	<0.001	0.77	33.9	0.023	1.80
Dec	0.81	0.15	2.86	16.5	233	5.1	5.09	10.2	0.004	0.50	41.9	0.013	2.36
Annual Average	**0.61**	**0.16**	**3.79**	**14.5**	**297**	**10.0**	**1.69**	**12.1**	**0.001**	**1.29**	**23.7**	**0.016**	**1.64**

Site 106: Scunthorpe Town AURN

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.73	0.16	2.62	5.0	230	10.5	0.64	12.2	<0.001	1.14	16.6	0.006	N/A
Feb	0.97	0.23	2.16	8.0	728	30.1	2.53	17.3	0.001	2.49	30.4	0.028	N/A
Mar	0.68	0.15	2.12	6.1	459	17.7	1.63	10.8	<0.001	2.25	19.4	0.005	N/A
Apr	0.77	0.21	2.54	6.5	674	29.0	1.27	14.1	<0.001	3.18	22.2	0.016	N/A
May	0.66	0.12	1.51	4.5	532	23.9	0.68	12.5	<0.001	1.95	19.2	0.028	N/A
Jun	0.73	0.16	1.11	4.0	580	26.6	1.02	22.6	<0.001	2.81	35.7	0.018	N/A
Jul	0.42	0.10	0.27	4.4	426	20.6	0.28	10.8	<0.001	1.51	16.2	0.015	N/A
Aug	0.48	0.11	2.28	5.8	266	11.4	0.12	6.4	<0.001	1.15	14.4	0.014	N/A
Sep	0.65	0.10	3.14	5.4	475	20.1	0.49	8.8	0.005	1.55	16.3	0.007	N/A
Oct	0.81	0.16	2.41	5.9	821	37.9	0.40	33.5	0.003	1.22	20.6	0.030	N/A
Nov	2.28	0.76	4.88	13.3	511	20.7	1.03	37.1	0.001	1.99	50.8	0.036	N/A
Dec	0.74	0.13	1.46	4.0	175	11.4	0.04	7.3	0.001	0.72	15.9	0.012	N/A
Annual Average	**0.83**	**0.20**	**2.21**	**6.1**	**490**	**21.7**	**0.84**	**16.1**	**0.001**	**1.83**	**23.1**	**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	0.96	0.21	3.83	5.7	1818	71.0	1.71	29.1	<0.001	2.39	31.9	0.028	N/A
Feb	0.96	0.20	3.36	6.3	1500	83.8	2.49	25.3	0.001	3.98	33.4	0.027	N/A
Mar	1.26	0.30	9.21	8.2	2623	179	3.35	34.0	0.001	9.55	46.2	0.023	N/A
Apr	0.77	0.21	5.00	7.2	1933	152	1.46	29.7	<0.001	7.38	29.3	0.017	N/A
May	0.76	0.15	4.25	4.6	1972	137	1.01	21.2	<0.001	5.89	27.2	0.022	N/A
Jun	0.67	0.17	1.21	3.0	667	57.3	0.85	16.1	<0.001	3.98	32.1	0.011	N/A
Jul	0.76	0.22	3.48	5.3	2354	141	0.78	27.5	<0.001	5.81	35.1	0.023	N/A
Aug	0.76	0.15	4.51	4.2	1988	129	0.55	50.8	<0.001	5.03	36.9	0.018	N/A
Sep	1.05	0.17	4.56	4.4	2303	98.8	0.84	17.2	0.005	4.50	24.0	0.010	N/A
Oct	0.88	0.17	3.83	6.3	1380	94.6	0.58	28.4	0.005	3.96	28.3	0.031	N/A
Nov	1.55	0.42	4.07	7.7	2492	104	1.30	83.4	0.001	4.41	40.2	0.035	N/A
Dec	0.90	0.13	1.48	4.0	1156	58.5	0.34	46.3	0.001	2.83	20.1	0.025	N/A
Annual Average	**0.94**	**0.21**	**4.07**	**5.6**	**1849**	**109**	**1.27**	**34.1**	**0.001**	**4.98**	**32.1**	**0.022**	**N/A**

Site 108: Redcar AURN

Month	Concentration / ng m^{-3}												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg(p)	Hg(v)
Jan	0.18	0.16	1.66	2.3	269	9.3	1.71	5.0	<0.001	0.31	52.9	<0.001	N/A
Feb	0.82	0.24	8.37	5.1	817	58.1	1.04	14.8	<0.001	1.58	43.1	0.003	N/A
Mar	0.44	0.67	3.33	4.5	679	39.8	1.75	11.2	<0.001	1.49	37.0	<0.001	N/A
Apr	1.18	0.17	3.76	3.9	363	23.4	1.25	9.4	<0.001	2.50	25.8	0.025	N/A
May	0.32	0.09	2.28	2.8	354	26.5	0.52	6.7	<0.001	1.29	19.9	0.007	N/A
Jun	0.30	0.10	1.71	2.5	341	14.2	0.97	6.1	<0.001	2.48	14.4	0.021	N/A
Jul	0.35	0.16	7.28	3.0	378	19.1	1.31	6.7	0.001	2.31	34.1	0.008	N/A
Aug	0.27	0.11	0.11	2.5	315	19.1	0.39	5.2	<0.001	0.88	24.4	0.010	N/A
Sep	0.55	0.13	1.62	3.1	478	35.0	0.78	8.0	0.004	1.24	32.8	0.004	N/A
Oct	0.74	0.19	2.33	4.8	628	33.0	0.95	11.7	0.001	1.66	38.3	0.012	N/A
Nov	0.67	0.30	2.78	4.5	446	28.9	0.40	14.1	0.001	0.82	51.5	0.017	N/A
Dec	0.51	0.19	2.78	3.4	456	26.8	0.92	12.5	0.001	1.08	51.0	0.010	N/A
Annual Average	**0.53**	**0.21**	**3.17**	**3.5**	**460**	**27.8**	**1.00**	**9.3**	**0.001**	**1.47**	**35.4**	**0.010**	**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	1.00	0.29	2.55	8.8	253	8.6	1.63	18.6	<0.001	1.43	54.9	0.012	N/A
Feb	0.55	0.23	1.61	8.3	201	4.8	1.26	10.8	<0.001	1.02	20.1	0.012	N/A
Mar	0.57	0.10	0.98	3.3	143	4.0	0.47	6.9	<0.001	0.42	15.1	<0.001	N/A
Apr	0.17	0.06	1.30	1.9	70	3.2	0.31	5.1	<0.001	0.82	8.6	0.004	N/A
May	0.41	0.11	1.54	10.0	155	4.5	0.17	10.7	<0.001	1.01	22.1	0.009	N/A
Jun	0.70	0.20	3.26	6.2	239	8.0	2.64	9.6	<0.001	1.90	27.3	0.027	N/A
Jul	0.29	0.17	4.03	4.8	158	8.3	0.05	12.0	<0.001	1.63	53.1	0.021	N/A
Aug	0.40	0.08	1.28	7.0	180	7.8	0.29	6.1	<0.001	1.38	19.7	0.015	N/A
Sep	1.22	0.12	1.53	6.2	222	6.2	0.06	8.0	0.004	0.80	14.0	0.003	N/A
Oct	0.73	0.22	1.67	7.7	241	6.2	0.23	8.5	0.002	1.03	19.9	0.026	N/A
Nov	0.55	0.16	1.78	8.0	201	6.2	1.76	12.9	<0.001	0.75	38.4	0.015	N/A
Dec	1.03	0.17	1.50	6.0	310	7.7	0.01	12.2	<0.001	0.48	30.1	<0.001	N/A
Annual Average	**0.64**	**0.16**	**1.92**	**6.5**	**198**	**6.3**	**0.74**	**10.1**	**0.001**	**1.06**	**26.9**	**0.012**	**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	0.99	0.18	1.16	9.5	215	3.2	2.97	17.7	<0.001	5.29	23.6	0.001	N/A
Feb	0.92	0.25	1.74	10.2	269	4.7	2.13	12.4	0.003	3.56	24.5	0.016	N/A
Mar	1.07	0.28	2.17	19.9	415	6.7	4.64	20.7	0.003	6.25	49.3	0.006	N/A
Apr	0.82	0.44	0.60	8.7	267	4.9	2.99	12.2	<0.001	7.12	22.5	0.013	N/A
May	0.61	0.16	0.31	7.0	230	4.0	2.42	9.3	<0.001	5.97	23.1	0.014	N/A
Jun	0.70	0.27	1.29	6.5	208	4.1	2.70	7.8	<0.001	6.87	28.4	0.011	N/A
Jul	0.38	0.11	0.11	10.3	193	3.1	1.92	8.0	<0.001	5.30	11.5	0.013	N/A
Aug	0.65	0.14	2.27	10.7	277	4.7	2.66	9.2	0.001	5.43	19.4	0.012	N/A
Sep	0.82	0.21	2.70	12.9	353	5.6	1.50	10.3	0.008	3.72	20.4	0.011	N/A
Oct	0.80	0.38	0.81	13.8	308	5.5	1.44	15.0	0.004	3.57	21.9	0.027	N/A
Nov	1.09	0.34	1.48	13.1	249	3.7	2.27	20.4	0.001	5.63	25.0	0.009	N/A
Dec	0.83	0.16	1.48	9.6	195	3.2	1.36	9.3	0.001	3.75	14.6	0.012	N/A
Annual Average	**0.81**	**0.24**	**1.34**	**11.0**	**265**	**4.5**	**2.42**	**12.7**	**0.002**	**5.21**	**23.7**	**0.012**	**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	0.21	0.08	0.35	2.6	43	1.2	0.26	4.4	<0.001	0.41	7.0	0.002	N/A
Feb	0.72	0.10	4.14	4.5	147	5.6	0.63	7.0	<0.001	0.84	13.2	0.001	N/A
Mar	0.28	0.13	3.41	5.0	203	8.6	1.96	7.2	0.001	0.74	16.3	0.009	N/A
Apr	0.44	0.16	2.45	3.1	176	9.8	0.48	9.3	<0.001	1.98	41.4	0.015	N/A
May	0.05	0.05	0.51	1.6	66	3.0	<0.01	3.2	<0.001	0.60	32.9	0.009	N/A
Jun	0.25	0.11	0.88	2.5	226	8.7	0.39	7.7	<0.001	1.79	25.2	0.013	N/A
Jul	0.26	0.07	<0.01	2.4	98	4.9	0.21	3.6	<0.001	1.27	9.5	0.017	N/A
Aug	0.29	0.07	0.49	2.5	101	4.7	<0.01	15.1	0.001	1.19	13.9	0.007	N/A
Sep	0.37	0.11	0.42	4.2	300	16.8	0.10	7.6	0.002	0.88	18.5	0.008	N/A
Oct	0.32	0.09	0.72	2.5	143	4.3	0.54	5.4	<0.001	0.88	9.3	0.002	N/A
Nov	0.58	0.16	1.75	3.1	90	4.6	1.63	8.1	<0.001	0.32	14.0	0.008	N/A
Dec	0.35	0.09	1.63	2.6	123	5.5	0.45	6.0	<0.001	0.41	12.1	0.012	N/A
Annual Average	**0.34**	**0.10**	**1.40**	**3.1**	**143**	**6.5**	**0.55**	**7.1**	**<0.001**	**0.94**	**17.8**	**0.009**	**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	1.19	0.23	3.37	8.2	167	2.5	2.18	14.9	<0.001	3.08	23.7	0.004	N/A
Feb	1.19	0.41	2.49	11.7	279	4.6	1.81	16.0	0.001	2.64	27.7	0.009	N/A
Mar	0.80	0.30	1.63	12.8	341	5.5	2.51	13.1	<0.001	4.46	21.0	<0.001	N/A
Apr	0.76	0.22	1.93	8.3	221	4.4	5.81	9.9	<0.001	4.97	24.1	0.003	N/A
May	0.77	0.23	0.24	12.3	307	6.1	1.82	12.7	<0.001	7.52	83.7	0.013	N/A
Jun	0.68	0.16	0.27	6.5	177	3.7	1.65	8.4	<0.001	4.64	16.7	0.005	N/A
Jul	0.28	0.05	<0.01	4.6	85	1.7	0.13	3.1	<0.001	2.19	6.0	0.010	N/A
Aug	0.42	0.07	0.43	10.3	115	2.5	0.59	3.8	<0.001	2.43	7.3	0.007	N/A
Sep	0.77	0.19	1.40	14.7	258	4.3	0.87	9.4	0.001	2.67	13.7	0.004	N/A
Oct	0.72	0.20	1.20	12.0	240	4.2	1.43	11.0	0.005	2.55	18.6	0.017	N/A
Nov	0.95	0.19	1.74	8.6	139	2.1	0.34	10.2	<0.001	1.06	14.0	0.007	N/A
Dec	0.84	0.16	1.54	9.0	192	2.9	1.00	11.3	<0.001	2.31	13.8	0.009	N/A
Annual Average	**0.78**	**0.20**	**1.35**	**9.9**	**210**	**3.7**	**1.68**	**10.3**	**0.001**	**3.38**	**22.5**	**0.007**	**N/A**

Note: “N/A” denotes data not available.

Next page: **Image 7.** The Network monitoring site at Scunthorpe Town AURN.