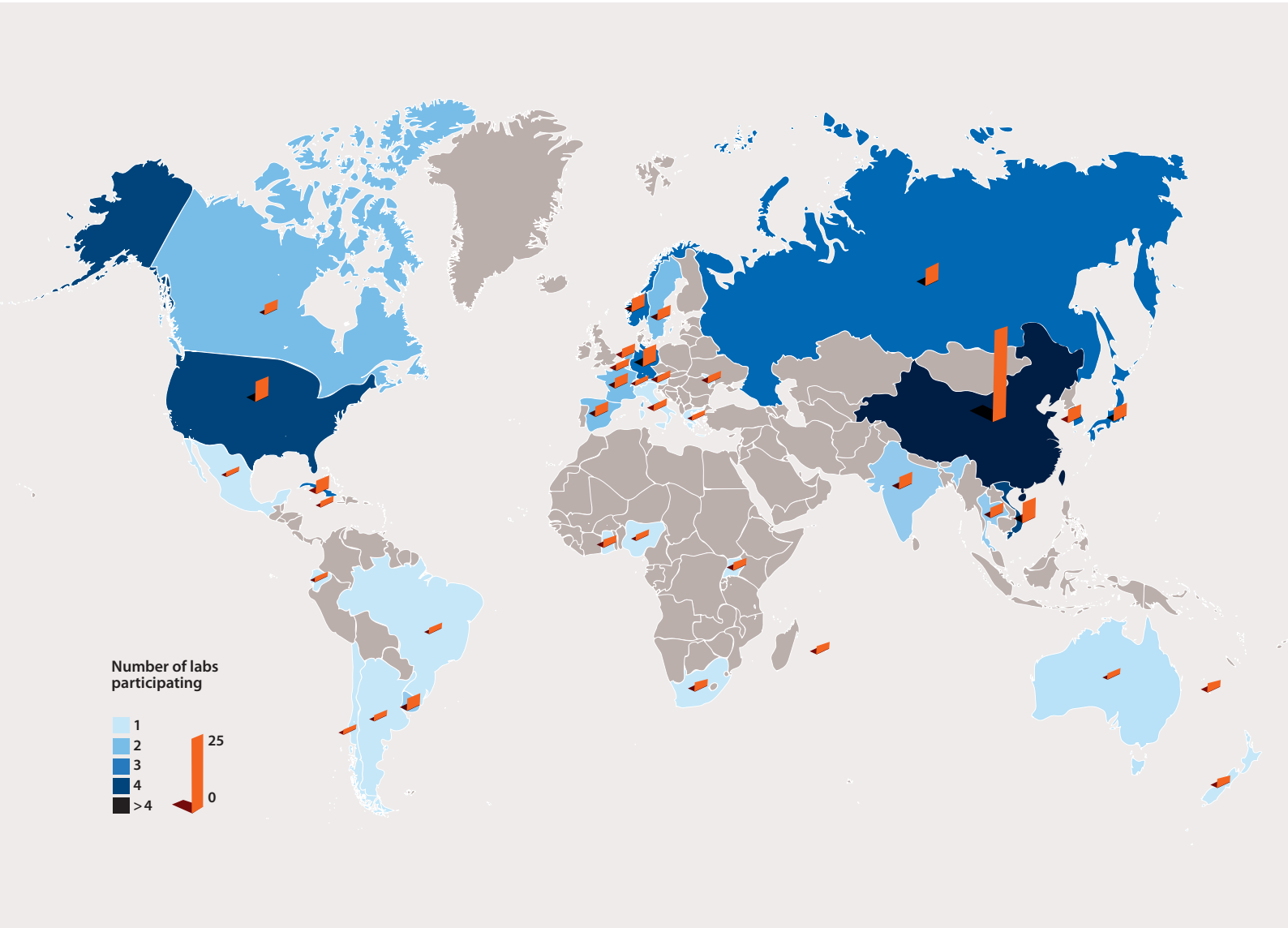
Bi-ennial Global Interlaboratory Assessment on Persistent Organic Pollutants

Second Round 2012/2013



June 2014

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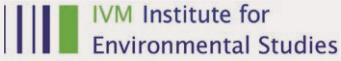

Sketch on title page:

World map displaying countries and number of laboratories participating in the Biennial Global Interlaboratory Assessment on Persistent Organic Pollutants, Second Round; prepared by Dr. Heidelore Fiedler, UNEP, Division of Technology, Industry and Economics, Chemicals Branch.

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Second Round 2012/2013

UNEP

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Division of Technology, Industry and Economics
United Nations Environment Programme

Table of Contents

List of Tables

Page

List of Figures

Acronyms and Abbreviations

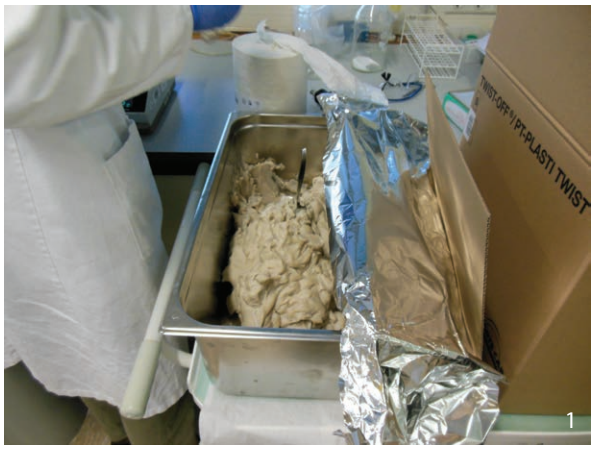
AV	Assigned value
CEE	Central and Eastern Europe
CV	Coefficient of variation
DDT	Dichlorodiphenyltrichloroethane
dl-PCB	Dioxin-like polychlorinated biphenyl(s)
dl-POPs	Dioxin-like persistent organic pollutants
ENRTP	Thematic Programme for Environment and Sustainable Management of Natural Resources Including Energy
GC/ECD	Gas chromatograph(y) with electron capture detection
GC/MS	Gas chromatograph(y) with mass spectrometric detection
GRULAC	Latin American and Caribbean Group
HCH(s)	Hexachlorocyclohexane(s)
LB	Lower-bound
LC/MS	Liquid chromatograph(y) with mass spectrometric detection
LCV(s)	Left-censored value(s)
LOD	Limit of detection
NA	Not applicable
ND	Not detected
NEtFOSA	N-ethyl perfluorooctane sulfonamide
NEtFOSE	N-ethyl perfluorooctane sulfonamidoethanol
NMeFOSA	N-methyl perfluorooctane sulfonamide
NMeFOSE	N-methyl perfluorooctane sulfonamidoethanol
OCP(s)	Organochlorine pesticide(s)
OECD	Organisation for Economic Co-operation and Development
PBB	Polybrominated biphenyl(s)
PBDE	Polybrominated diphenyl ether(s)
PCB	Polychlorinated biphenyl(s)
PCDD	Polychlorinated dibenzo-*para*-dioxins
PCDF	Polychlorinated dibenzofurans
PFAS(s)	Perfluorinated alkyl substance(s)
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonic acid
PFOSA	Perfluorooctane sulfonamide
PFCA(s)	Perfluorinated alkyl carboxylic acids
POP(s)	Persistent organic pollutant(s)
QUASIMEME	Quality Assurance of Information for Marine Environmental Monitoring in Europe
RSD	Relative standard deviation
TEQ	Toxicity equivalent
UB	Upper-bound
UN	United Nations
UNEP	United Nations Environment Programme
WEOG	Western European and Other Groups

Definitions:

Basic POPs include organochlorine pesticides (aldrin, chlordane, chlordecone, DDT, dieldrin, endosulfan, endrin, heptachlor, hexachlorobenzene, hexachlorocyclohexanes (α-, β-, γ-), mirex, pentachlorobenzene, toxaphene, and polychlorinated biphenyls

Dioxin-like POPs include 29 congeners that were assigned a toxicity equivalency factor by a WHO/IPCS expert group, namely polychlorinated dibenzo-*para*-dioxins, polychlorinated dibenzofurans, and polychlorinated biphenyls

Summary



Interlaboratory assessments are an important part of the capacity building programme of the United Nations Environment Programme (UNEP) for laboratories analysing persistent organic pollutants (POPs). The first UNEP-coordinated study started in 2005 as a pilot activity with Global Environment Facility funding as a support to developing countries; it had seven laboratories from five participating countries. From 2009 UNEP has implemented regional capacity building and training programmes in three UN regions to assist laboratories to improve the quality of their analyses. As part of this activity, the first round of the Global Interlaboratory Assessment on Persistent Organic Pollutants was organized in 2011/2012 (UNEP, 2012). In total, 103 laboratories worldwide participated in the first round; of these, 83 laboratories submitted data on at least one of the POPs and one of the test samples.

Under article 16 of the Stockholm Convention, a Global Monitoring Plan was established for POPs and guidance has been developed. In chapter 4, the guidance document states that "[i]nterlaboratory exercises are often used to assess the effectiveness of QA/QC practices among several participating labs and to provide a measure of interlaboratory comparability. This usually involves the circulation and analysis of a common standard or reference sample, often at two or more concentration levels". In order to determine the "true" concentration of (here) POPs in a sample, a chemical laboratory must be able to prove that it is capable of identifying and quantifying chemicals (analytes) of interest at concentrations of interest. Such accuracy and precision in the determination of POPs is required by article 16 of the Stockholm Convention and subsequent guidance developed for the Global Monitoring Plan.

The Global Monitoring Plan requires that POP laboratories must be capable – at any time – of analysing samples for POPs within a variation of ±25%. The statistical model used provided z-scores based on which the performance of each laboratory for each analyte in each matrix can be assessed. Successful analysis results in a z-score of $<|2|$. z-scores between $|2|$ and $|3|$ indicate a questionable performance and a z-score of $>|3|$ is unsatisfactory.

This second Biennial Global Interlaboratory Assessment on Persistent Organic Pollutants was organized in 2012/2013 and was implemented with funds from the European Union through ENRTP and the Global Environment Facility. The degree of participation (105 laboratories from 48 countries) showed the high interest of laboratories to participate in this assessment. All test materials were prepared and distributed. New POPs (polybrominated diphenyl ethers (PBDE), polybrominated biphenyls (PBB), chlordecone (kepone), endosufan, hexachlorocyclohexanes (HCHs) and several perfluorinated alkyl substances (PFASs) were added to the scheme of the initial twelve groups of POPs. The listing of perfluorooctane sulfonic acid (PFOS) and precursors in annex B of the Stockholm Convention necessitated that water was added to the test samples, in addition, an air extract and a transformer oil. High interest for capacity-building resulted in a wealth of information on POP analysis and an enormous data set for this report from which the laboratories can evaluate their methods. Suggestions are given for improvement of methods.

The results show that, compared to the first assessment, more laboratories analysed the environmental test samples such as sediment and fish. In the first round many laboratories only analysed the standard solutions. This shows the ongoing development in many laboratories. In addition, the introduction of PFASs and PBDE/PBB was successful, as a substantial number of laboratories delivered results – and often good results – for these classes of compounds. The inclusion of the air extract test sample also proved to respond to the countries' needs.

1. Introduction

This interlaboratory assessment accompanies the capacity building programme of the United Nations Environment Programme (UNEP) for laboratories analysing persistent organic pollutants (POPs), which started in 2005 with Global Environment Facility funding. The assessment implements the recommendations by the Conference of the Parties to the Stockholm Convention as expressed in the guidance of the Global Monitoring Plan for POPs (hereinafter referred to as the guidance document) in article 16 of the Convention (UNEP, 2013a). In chapter 4, the guidance document states that "[i]nterlaboratory exercises are often used to assess the effectiveness of QA/QC [quality assurance/quality control] practices among several participating laboratories and to provide a measure of interlaboratory comparability. This usually involves the circulation and analysis of a common standard or reference sample, often at two or more concentration levels".

In order to determine the "true" concentration of (in this case) POPs in a sample, a chemical laboratory must be able to prove that it is capable of identifying and quantifying chemicals (analytes) of interest at concentrations of interest. Such accuracy and precision in the determination of POPs is required by article 16 of the Stockholm Convention and is outlined in the guidance document. The needs and support are documented in the Conference of the Parties decisions SC-3/16, SC-4/31, SC-5/18 and SC-6/23 (UNEP, 2013b) and in chapter 3 of the guidance document. To provide reliable monitoring information for the Parties to the Stockholm Convention, the guidance document aims to "confirm a 50% decline in the levels of POPs within a 10-year period" (UNEP, 2013a). This means that POP laboratories must be capable – at any time – of analysing samples for POPs within a margin of ±25% (Abalos *et al.,* 2013).

In an interlaboratory assessment, laboratories analyse the same sample, within a limited time frame, for previously determined analytes and report the results to the coordinator of the intercalibration assessment. All results are evaluated together according to international standards, such as established by the International Organization for Standardization (ISO) or the International Laboratory Accreditation Cooperation, thus allowing a performance classification.

Whereas proficiency tests or "round robins" on polychlorinated biphenyls (PCB), organochlorine pesticides (OCPs), and dioxin-like POPs (dl-POPs) are well established for laboratories in countries belonging to the Organisation for Economic Co-operation and Development (OECD), challenges can be expected for developing country laboratories since they do not yet have the necessary experience to analyse a large number of POPs in biotic and abiotic matrices at the requested accuracy and time limits.

To assist laboratories to improve the quality of their analysis, UNEP has organized regional capacity building and training programmes, which started in 2009. As part of this activity, the first round of the Global Interlaboratory Assessment on Persistent Organic Pollutants was organized in 2011/2012 (Abalos *et al.,* 2013; van Leeuwen *et al.,* 2013).

The Report on *International Intercalibration Studies* (UNEP, 2005) emphasizes the importance of accurate results in POP analysis, with an analytical variance to be as small as possible in order to make data acceptable and comparable between laboratories, countries and regions. Participation in international intercalibration studies is considered a prerequisite for existing, well-established as well as for newly set-up laboratories because there is a need to permanently check the laboratories' performances and prove their capabilities. From an international quality-assurance point of view, worldwide international studies are preferred but national initiatives could also improve the analytical quality in just that country or region.

Detailed information on scoring criteria is available in the *Handbook for POPs Laboratory Databank* (UNEP, 2007). In the scoring system to rank the performance of POP laboratories, successful participation in international interlaboratory studies ranks highest, namely with 50% on a 100% scale.

Within the framework of the capacity-building project of UNEP for training laboratory staff on POP analysis in developing countries, the Institute for Environmental Studies of VU University, Amsterdam, the Netherlands and the Man-Technology-Environment Research Centre, School of Science and Technology at the University of Örebro, Sweden, have organized this second Biennial Global Interlaboratory Assessment on Persistent Organic Pollutants. The results of the assessment are presented in this report.

The POPs studied include polychlorinated dibenzo-*para*-dioxins (PCDD), polychlorinated dibenzofurans (PCDF), polychlorinated biphenyls (PCB) and organochlorine pesticides (OCPs), *i.e.,* dichlorodiphenyltrichloroethane (DDT) and its transformation products (thereafter referred to as DDTs), aldrin, dieldrin, endrin, chlordanes, hexachlorobenzene, heptachlors, *cis*- and *trans*- heptachlorepoxide, and mirex. As in the first assessment, toxaphene was not included since no or limited capacity was available among the participating laboratories. However, in contrast with the first study, polybrominated diphenyl ethers (PBDE), polybrominated biphenyls (PBB), hexachlorocyclohexanes (HCHs), chlordecone (kepone), pentachlorobenzene, α- and β-endosulfan, endosulfan sulphate and perfluorinated alkyl substances (PFASs) were included.

In total, seven matrices were offered for analysis: standard solutions for OCPs, indicator PCB and dl-POPs in sediment, fish, mothers' milk, human blood serum, water (for PFASs only) and transformer oil (for indicator PCB only). The test solutions were sealed in amber glass ampoules with the target compounds in undisclosed concentrations. The sediment was air-dried, the fish was sterilized in glass jars, and the mothers' milk was homogenized, frozen and stored at -20 °C prior to shipment. Water was sent in high-density polyethylene bottles. One hundred and five laboratories from 48 countries participated (see Appendix I: List of Participants for their names and addresses). All codes are confidential and are kept with the organizers; they will only be revealed to third parties with permission from the participants.

2. Materials and Methods

2.1 Identification and Preparation of the Test Samples

2.1.1 Naturally Contaminated Test Samples

All samples were naturally contaminated with the target analytes. The following samples were offered for POP analysis:

1. The sediment sample was a marine sediment from the Netherlands. It was dried at 40 °C and sieved (at 0.5 mm pore size). After homogenization, individual plastic containers were filled with the test matrix and stored at room temperature until shipment. The samples were obtained from the Wageningen Evaluating Programmes for Analytical Laboratories.
2. The fish material consisted of a pike-perch filet from the Netherlands. After cutting and homogenizing, individual glass jars were filled with the material. The jars were sterilized by autoclaving, which made it possible to store the fish sample at room temperature.
3. The mothers' milk test material consisted of homogenized human milk from the Swedish human milk bank in the Örebro region. The milk was packaged in 50 ml samples in polypropylene bottles and frozen prior shipment.
4. The human blood serum sample consisted of pooled human blood serum of both people occupationally exposed to perfluorinated compounds (professional ski wax technicians) and the general population. This sample was intended for the analysis of perfluorooctane sulfonic acid (PFOS) with the option of analysing other PFASs. One millilitre from the homogenized serum was transferred to a glass vial with a polymer cap. This sample was also frozen until shipment.
5. The air extract was a toluene extract of polyurethane foam taken near one of Sweden's largest hazardous waste incinerations. The extract was diluted in 100 ml of toluene. Of this extract, 1 ml was packaged in a sealed glass ampoule for the analysis of PCB, PCDD, PCDF and dioxin-like PCB (dl-PCB). For the analysis of OCPs, PBDE and PFASs, the same extract was spiked with these analytes and placed into 1 ml ampoules before shipment.
6. The water sample was of surface water taken from Amsterdam harbour in the Netherlands. After bottling the water in high-density polyethylene bottles, the material was sterilized by irradiation.
7. The transformer oil was a dilution of an Aroclor 1254 PCB oil and Supelco lot LB77779l, in toluene. One millilitre of the original solution was diluted in 100 ml of toluene and then 1 ml of this solution was packaged in a sealed glass ampoule.

2.1.2 Standard Solutions

1. The standard solution for OCPs consisted of a mixture of OCPs in the concentration range of 1 µg/kg to 1,000 µg/kg. This solution was prepared by the Institute for Environmental Studies, VU University, Amsterdam from crystals obtained from Da Vinci Laboratory Solutions (Rotterdam, the Netherlands). After preparation, the solution was ampouled, labelled and stored at room temperature. The OCPs present in the solution were aldrin, dieldrin, endrin, endrin ketone, *cis*-chlordane (alpha), *trans*-chlordane (gamma), oxychlordane, *cis*-nonachlor, *trans*-nonachlor, heptachlor, *cis*-heptachloroepoxide, *trans*-heptachloroepoxide, *o,p'*-DDT, *p,p'*-DDT, *o,p'*-DDD, *p,p'*-DDD, *o,p'*-DDE, *p,p'*-DDE, hexachlorobenzene, mirex, α-HCH, β-HCH, γ-HCH, α-endosulfan, β-endosulfan, chlordecone, and pentachlorobenzene.
2. The standard solution for PCB consisted of a mixture of the indicator PCB (six congeners) in the concentration range of 1 µg/kg to 10 µg/kg. This standard solution was prepared, ampouled and labelled by Cambridge Isotope Laboratories (Andover, USA).
3. The standard solution for PCDD/PCDF consisted of a mixture of 17,2,3,7,8 - substituted PCDD/PCDF congeners in the concentration range of 35 µg/kg to 180 µg/kg. This standard solution was prepared and labelled by Wellington Laboratories (Guelph, Canada).
4. The standard solution for dl-PCB consisted of a mixture of dl-PCB in the concentration range of 170 µg/kg to 300 µg/kg. This standard solution was prepared, ampouled and labelled by Wellington Laboratories (Guelph, Canada).
5. The standard solution for PBDE/PBB consisted of a mixture of PBDE and PBB 153 in nonane in the concentration range of 70 µg/kg to 570 µg/kg. This standard solution was prepared, labelled and packaged by Wellington Laboratories (Guelph, Canada).
6. The standard solution for PFOS consisted of a mixture of perfluorinated alkyl substances (PFASs, such as perfluoroalkylsulfonatesPFCAs, PFSAs and perfluorooctane sulphonamide (PFOSA)), with PFOS and PFOSA in the concentration range of 125 µg/kg to 320 µg/kg in methanol. This standard solution was prepared, ampouled and labelled by Wellington Laboratories (Guelph, Canada).
7. The standard solution for PFASs consisted of a mixture of PFOS precursors and included N-methyl perfluorooctane sulfonamidoethanol (MeFOSE), N-ethyl perfluorooctane sulfonamidoethanol (EtFOSE), N-methyl perfluorooctane sulfonamide (MeFOSA), and N-ethyl perfluorooctane sulfonamide (EtFOSA) in the concentration range of 630 µg/kg to 1,260 µg/kg. This standard solution, too, was prepared, ampouled and labelled by Wellington Laboratories (Guelph, Canada).

2.1.3 Distribution of Test Samples

The mothers' milk, human blood serum and air extracts for the PCB, PCDD, PCDF and dl-PCB analyses, the transformer oil samples and the standard solutions of PCDD/PCDF, dl-PCB, PBDE, PFOS, and PFASs were distributed by the Man-Technology-Environment Research Centre, Örebro University, Örebro, Sweden.

The sediment, fish and air extracts for the OCP, PBDE and PFAS analyses, and the water and standard solutions for the OCP and PCB analyses were distributed by the Institute for Environmental Studies, VU University, Amsterdam, the Netherlands. All shipments containing mothers' milk or blood samples were packed in a polystyrene container with frozen plastic ice blocks.

2.2 Methods Used by Participants

All participating laboratories used in-house methods for sample preparation, clean up, extraction and instrumental analysis. This included modified or adapted standard methods including, for example, EPA 1613 and EU 1948 for the dl-POP analysis. For the PCDD/PCDF and dl-PCB analyses, most laboratories reported that high resolution gas chromatography with mass spectrometric detection (HRGC/MS) systems were used (except for four laboratories which used ion trap or low resolution HRGC/HRMS). For the other compound classes, gas chromatography with electron capture detection (GC/ECD) (including GCxGC/ECD) and low and high resolution GC/MS were used. For OCP analysis, more and more laboratories are using mass spectrometry detection, including ^{13}C-labelled internal standards. However although this was expected to improve the analysis, this was not directly reflected in the results. De Boer and Wells (2006) observed that in spite of better availability of analytical standards and ^{13}C-labelled standards, many laboratories need a substantial period of time in order to establish a new analytical method.

The sample extraction was performed using a variety of techniques and methods. Soxhlet extraction was still the most popular extraction method although more and more laboratories used pressurized liquid extraction. For liquid samples, liquid-liquid extraction or solid phase extraction was used, although some laboratories also used Soxhlet or pressurized liquid extraction (after freeze drying). Several organic solvents such as toluene or dichloromethane, including isopropanol/hexane or hexane/acetone, were used in different combinations for the extraction of the fish samples. Furthermore, a wide variety of sample clean-up open-column chromatography was used, where acid- or base-loaded silica was most commonly used, followed by Florisil and AlOx (especially for the OCPs). For the analysis of dioxin-like POPs, the majority of the laboratories included a carbon column as the final separation step in agreement with standard methods. Gel permeation chromatography was used by a number of laboratories especially for the more fatty samples (fish and mothers' milk). Activated copper was used as an extra clean up for the sediment sample.

The participants were encouraged to use appropriate GC columns for the analysis, preferably dual-column sets. Although several co-elution issues are known, especially when using ECD as the final detection technique, only a few laboratories reported that two columns or a confirmation column were used. This was also true for PCDD/PCDF analysis, where the use of a confirmation column is described in standard methodology. One reason might be the development of custom-made GC columns for dl-POPs, the use of GCxGC (one laboratory) and the improvement in GC columns also for other compound classes.

For the new POPs listed in the Stockholm Convention and included in this assessment, the methodology for the PBDE was similar to that of the OCPs and PCB. The clean up and extraction was similar and the final analysis was performed on similar instrumentation including high and low resolution GC/MS systems. No electron capture detection of the PBDE was reported.

The sample extraction, clean up and detection of the more polar PFAS compounds, the perfluoroalkyl carboxylic and sulfonic acids, including PFOS, is completely different from that of the traditional POPs. Ion pair and liquid-liquid extraction is used and, more recently, solid phase extraction (SPE) for liquid samples (water, serum and milk). Liquid-liquid extraction and ion pair extraction were also used for the fish and sediment samples; and for the sediment samples, pressurized liquid extraction and Soxhlet extraction were also used. Methanol and acetonitrile were mainly used as the extraction solvent. Solid phase extraction was most commonly used for clean up or fractionation but dispersed active carbon was also used. For the water and serum samples, on-line solid phase extraction was used or (for the human serum sample) it was simply diluted. Surprisingly, no laboratories reported using the existing international standard method (ISO 25101) for water samples.

A major difference can be found in the detection of the PFAS compounds. Most of the participating laboratories used liquid chromatography coupled to two mass spectrometers in line (LC/MS/MS) for detection in combination with the usage of labelled standards of the target compounds. LC/MS/MS coupled to triple quadrupole systems was used by all laboratories, except one using high resolution time-of-flight mass spectrometer and another using an ion-trap LC/MS system. Normally, a C_{18} based column was used; however, two laboratories used a C_8 based reversed column. Only ten results were submitted for PFOSA and even fewer for MeFOSE, EtFOSE, MeFOSA and EtFOSA). All compounds were measured with LC/MS/MS systems with the exception of one laboratory analysing MeFOSE, EtFOSE and PFOSA using low resolution GC/MS (quadrupole).

2.3 Data Assessment

The data assessment was carried out according to the principles employed in the Quality Assurance of Information for Marine Environmental Monitoring in Europe (QUASIMEME) proficiency testing. All data received

from the participants were entered into a database and assessed using a standard procedure to allow direct comparison between participants. The approach of the assessment is based on the standard ISO 13528 (2005) and the International Union of Pure and Applied Chemistry *International Harmonised Protocol for Proficiency Testing* (Advanced Draft) by Thompson *et al*. (2006). Additions or differences in the assessment from these standards are given or referred to in this report. However, the assigned value, the between-laboratory coefficient of variation (CV) values and the laboratory assessment using z-scores are based on the Cofino model (Cofino *et al.,* 2000). The last column of the even-numbered tables from 2 to 56 and 92 to 104 and all of tables 64 to 91 shows the "inclusion rate". This value is a percentage that reflects how many of the data are included in the between-laboratory CV, shown in the column to the left of the inclusion rate column. The higher the inclusion rate, the lower the number of outliers. A higher inclusion rate also tells that the between-laboratory relative standard deviation (RSD) is more representative of the entire group of participants that produced that specific matrix-determinant combination.

The Cofino model provides a highly reliable estimate of the measurement relating to the method. It is generally acknowledged that robust statistics cannot cope if extreme values comprise more than 10% of the data set, particularly with a skewed distribution. The Cofino model is able to routinely cope with these types of distribution and provides the best estimate of the consensus value, which may be used as the assigned value.

The Cofino model has been developed for the routine QUASIMEME assessments and uses a normal distribution assumption (NDA). The assigned value is based on this model without any trimming of the data. This approach includes all data in the evaluation. This model has been further developed to include left-censored values (LCVs) . The development of these models has been fully documented and published (Cofino *et al.,* 2000; Wells *et al.,* 2004; Cofino *et al.,* 2005). An overview of the assessment with explanation and examples is given in *the Assessment Rules for the Evaluation of the QUASIMEME Laboratory Performance Studies Data* (Wells and Scurfield, 2004).

The details of the Cofino model are provided elsewhere (Wells *et al.,* 2004; Wells and Scurfield, 2004) but in summary the approach is as follows:

- All data are included in the assessment
- No data are trimmed or down weighted
- Assigned values (AV) are based on the Cofino normal distribution assumption model
- All LCVs are also included, provided c ertain criteria are met

2.3.1 Plots

The performance of the laboratories in this assessment is illustrated in the z-score histograms. Where the assigned value for an analyte is indicative, the values are plotted as their original reported concentrations. The rules for confirming whether the consensus value should be an assigned value or an indicative value are given in the *Assessment Rules for the Evaluation of the QUASIMEME Laboratory Performance Studies Data* (Wells and Scurfield, 2004) with relevant examples.

Normally, four plots are given for each analyte (Figure 1). The upper left plot provides an impression of the probability density function for all data (black) and for the first mode (blue dotted) (probability main mode 1) of the data. Superimposed on these probability density functions is a histogram of the individual measurements (in grey). This plot shows the distribution of the data as a whole, and of the data in the main mode (probability main mode 1) on which the assigned value is based.

The "kilt plot" (overlap matrix) (upper right plot) provides an overview of the degree of overlap of each pair of data. It gives a clear indication of the degree of homogeneity of the data. As a key, the white areas indicate maximum overlap of the probability density functions and, therefore, highest agreement (an overlap of one implies that the two laboratories of the pair report exactly the same results), while the black area show the pairs in poor agreement.

The lower left plot is a ranked overview of all data with a standard deviation of ±2. The numerical values are given in blue and the left-censored values are given in red.

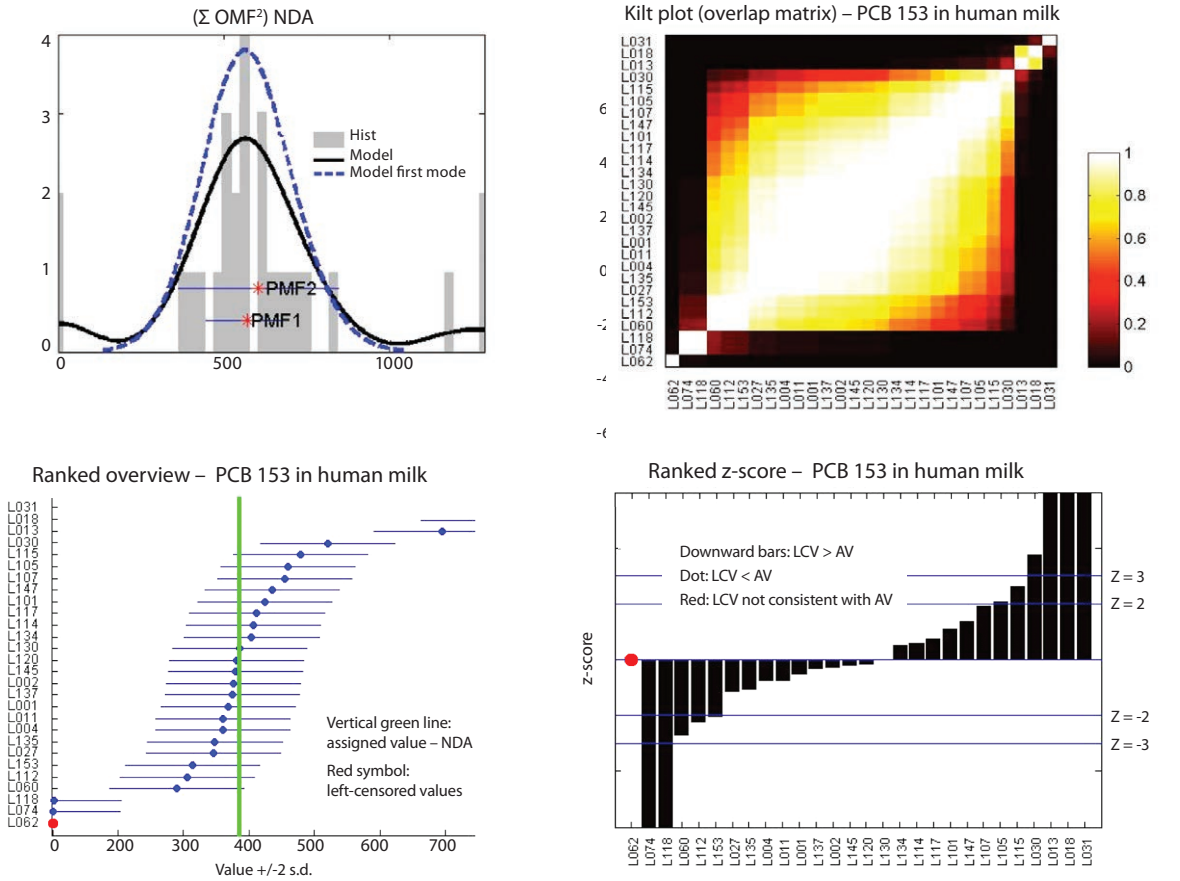


Figure 1: Graphical output of the Cofino model statistics for PCB 153 in the mothers' milk sample
PMF is probability main mode; NDA is normal distribution assumption.

The ranked z-score plot (lower right) is based on the mean of the data, which is normally also the assigned value. However, if any adjustment is required to the assigned value as a result of the assessment, *e.g.,* use of the nominal concentration or a trimmed value, then the final z-score given in the z-score histograms will reflect these changes. In this assessment, no such adjustments are made and therefore the z-score plot (lower right) is the definite plot for obtaining the individual laboratory z-scores.

For each matrix-determinant combination, a set of these four graphs is available. These can be found in Appendix IV.

2.3.2 The Assigned Values and the Indicative Values

The assigned value is obtained from the main mode of the data using the Cofino model (blue dotted line in upper left panel in Figure 1) and is centred around the highest density of values. Unless otherwise stated, the assigned value is based on this consensus value of all data. Although all data are included in the assessment, those values that lie some distance from assigned values contribute less to the mean than values which occur at or near the mean.

In some instances, it is not possible to set an assigned value and an indicative value is given. No assessment of laboratory performance is given where an indicative value is set. An overview of the assessment, with explanation, decision flowcharts and examples, is given in the paper *Assessment Rules for the evaluation of the QUASIMEME Laboratory Performance Studies Data,* available on the QUASIMEME website, www.quasimeme.org. A summary of the categories is given below:

Category 1
For data where the number of numerical observations is ≥ 7.

An assigned value is based on the mean when ≥ 33% of values have a z-score of |z| < 2. Where < 33% of the data have |z| < 2, the value is indicative, *i.e.,* at least 33% must be in good agreement.

Category 2
For data where the number of numerical observations is > 3 and < 7.

An assigned value is based on the mean when ≥ 70% of values have a z-score of |z| < 3 and a minimum of 4 observations have |z| < 2. Otherwise, the value is indicative,. *i.e.,* for small data sets, n > 3 and n < 7, there needs to be very good agreement and a maximum of one extreme value before an assigned value can be given.

Category 3
For data where the number of numerical observations is < 4.

No assigned value is given. Normally, the median value is given as an indicative value.

Category 4
For data where the high total error > 100% in combination with bad performance, no assigned value is given.

2.3.3 The z-score Assessment

A z-score (Thompson and Wood, 1993) is calculated for each participant's data for each matrix/analyte combination which is given an assigned value. The z-score is calculated as follows:

$$\text{z-score} = \frac{\text{Mean from Laboratory} - \text{Assigned Value}}{\text{Total Error}}$$

It is emphasized that in many assessments the between-laboratory standard deviation obtained from the statistical evaluation of the assessment is used as the total error in the formula above.

In the QUASIMEME data assessment, the total error is estimated independently, taking the needs of present-day international monitoring programmes as starting point. For each analyte in a particular matrix, a proportional error (PE) and a constant error (CE) have been defined. The total error depends on the magnitudes of these errors and on the assigned value:

$$\text{Total Error} = \frac{\text{Assigned Value} \times \text{Proportional Error \%}}{\text{Total Error}} + 0.5 \times \text{Constant Error}$$

The values for the proportional error and the constant error were developed by QUASIMEME. The values are based on the following criteria:

- Consistency of the required standard of performance to enable participating laboratories to monitor their assessment over time.
- Achievable targets in relation to the current state of the art and the level of performance needed for national and international monitoring programmes.

The assessment is based on ISO 17043 as z-scores. The QUASIMEME model is designed to provide a consistent interpretation over the whole range of concentration of analytes provided, including an assessment where LCVs are reported.

The proportional error in this assessment was set at 12.5% for all matrices. This applies to all analytes. The constant error has been set for each analyte or analyte group (*e.g.,* PCB). This value was initially set to reflect the limit of determination, but is at present more closely related to the overall laboratory performance.

The magnitude of the constant error is set to provide a constant assessment in terms of z-score regardless of concentration. Therefore, at low concentrations the level of accuracy required to obtain a satisfactory z-score is less stringent than at a high concentrations.

Following usual practices, *e.g.,* ISO 17043, the z-scores can be interpreted as follows to assure the quality of their data:

$\|z\| < 2$	Satisfactory performance
$2 < \|z\| < 3$	Questionable performance
$\|z\| > 3$	Unsatisfactory performance

Figure 2 illustrates the interpretation of the z-scores.

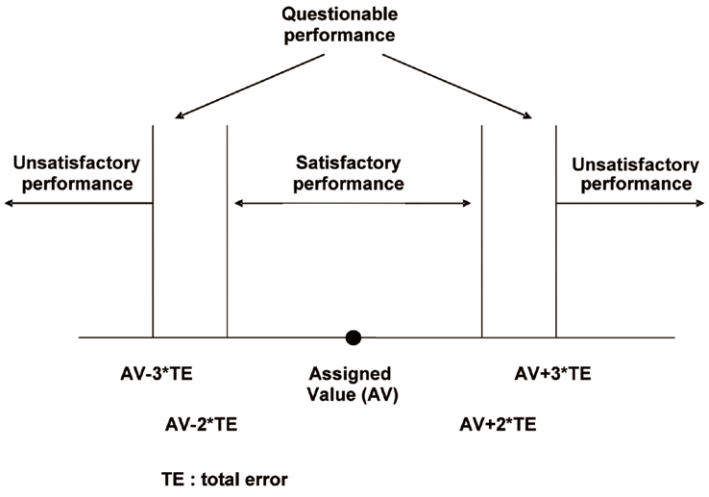


Figure 2: Interpretation of z-scores

|z| > 6 frequently points to gross errors (mistakes with units during reporting, calculation or dilution errors, *etc.*).
It is not possible to calculate a z-score for a LCV. QUASIMEME provides a simple quality criterion:

- LCV/2 < (concentration corresponding to |z| = 3): LCV consistent with assigned value
- LCV/2 > (concentration corresponding to |z| = 3): LCV inconsistent with assigned value, *i.e.,* LCV reported by laboratory much higher than numerical values reported by other laboratories.

z score key	S – Satisfactory Q – Questionable U – Unsatisfactory
LCV key	C – Consistent I – Inconsistent
No data	B – Blank

2.4 UNEP Criteria for Data Assessment

During a workshop in Hong Kong (26–28 February 2010) on the preliminary results of the first interlaboratory study, a criterion of a maximum 25% equivalent to z = 2 for maximum variability in the data of the laboratories was set by UNEP to assure that the target decrease of POP concentrations in core matrices can be monitored.

The Global Monitoring Plan (GMP) aims to show a 50% decline in levels of POPs over a 10-year period. Demonstrating this decline is one of the decisive factors in the evaluation of the effectiveness of the Stockholm Convention (Article 16).

When there is a large variation in the data set and removal of outliers does not improve the coefficient of variations, or this is not possible due to the distribution of the data, it is important to calculate the assigned values as accurately as possible.

This importance of this is illustrated in section 2.3, where the Cofino statistical approach is explained. A detailed discussion on the different statistical approaches, outlier removal and set of floating RSD values to calculate z-scores is given by Abalos *et al.* (2013) using the data of the first biennial interlaboratory assessment as an example.

3. Results

The complete results of the individual laboratories are given in Appendix II. The z-scores are given in Appendix III. As mentioned in section 2.3.1, Appendix IV shows the four plots that characterize the results for each matrix-determinant combination. Finally, Appendix V gives all regional z-score plots. The submitted results were evaluated statistically and whenever the data met the requirements (as mentioned in chapter 2), an assigned value was established. z-scores were calculated based on the assigned value except for some of the sum parameters, where this is indicated. Summaries of the assigned values and the percentage of satisfactory to unsatisfactory z-scores are presented below. Whenever numerical LCVs were reported, their consistency with the assigned value was clarified.

The results based on sum-parameters are summarized in section 3.4 for the OCPs, PBDE and PFASs.

3.1 Participation from United Nations Regions

In total, 105 laboratories from all five UN regions – Africa, Asia-Pacific, Central and Eastern Europe, Latin America and Caribbean, as well as West European and other groups - participated in the present assessment. Of these, 89 laboratories submitted data on the standard solutions, the sediment, fish, mothers' milk, human blood serum, air extract, water or transformer oil samples.

The participating laboratories were divided into the five UN regions: Africa (n = 6), Asia-Pacific (n = 42), Central and Eastern Europe (CEE) (n = 4), Latin American and Caribbean Group (GRULAC) (n = 10) and Western European and Other Groups (WEOG) (n = 27). In Table 58 to Table 63, the number of participating laboratories *per* region *per* compound group and *per* matrix is given.

Table 1 shows the degree of participation by laboratories *per* compound class and matrix. Clearly, the PFAS analysis is still relatively new for many participants; however, the numbers are encouraging in particular for the water sample. For all other chemical groups, approximately 50 laboratories are working on these, although a few of them only analysed the standard solution and a limited number of other matrices. The differences between the number of analyses that were carried out for the standard solution and the analyses on other matrices is smaller than in the first study, which is also encouraging and shows that laboratories are still improving their methods.

Table 1: Number of laboratories participating *per* compound group

Group	Standard solution	Sediment	Fish	Mothers' milk	Air extract	Water	Human serum	Transformer oil
OCP	50	27	36	21	23	-	-	-
PCB	47	38	43	28	25	-	-	19
dl-POPs	48	34	41	29	37	-	-	-
PBDE	42	30	34	19	21	-	-	-
PFAS	22	18	19	8	8	30	8	-

3.2 Compound Group–Specific Results

3.2.1 Organochlorine Pesticides

Table 2: Summary results for OCP analyses - standard solution

Standard solution	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(ng/kg)					(%)	
Aldrin	47	26	27	26	0.00004	78	25	71
Dieldrin	42	31	31	31	0.00003	259	22	70
Endrin	40	35	35	35	0.00004	364	25	68
Endrin ketone	5	NA	3	3	0.625	15	113	61
α-Chlordane	36	37	38	37	9.98	72	23	73
γ-Chlordane	37	39	39	39	0.00006	62	22	73
Oxychlordane	29	16	17	16	5.93	25	15	63
cis-Nonachlor	28	72	70	72	1.79	99	26	75
trans-Nonachlor	30	20	21	20	3.41	47	20	65
Heptachlor	46	31	31	31	0.00004	226	22	69
cis-Heptachlorepoxide	33	12	12	12	1.77	57	15	60
trans-Heptachlorepoxide	29	13	14	13	1.41	30	41	77
o,p'-DDT	41	30	30	30	9.50	231	23	68
p,p'-DDT	46	60	61	60	0.0003	216	30	69
o,p'-DDD	42	32	32	32	6.25	605	16	66
p,p'-DDD	44	34	34	34	0.0001	183	27	73
o,p'-DDE	41	30	30	30	2.79	41	12	61
p,p'-DDE	50	33	32	33	0.00004	46	17	69
Hexachlorobenzene	44	7	7	7	0.25	14	19	67
Mirex	32	122	123	122	2.67	196	16	69
α-HCH	43	5	5	5	1.11	702	24	68
β-HCH	44	6	7	6	0.00001	746	30	71
γ-HCH	44	5	5	5	0.878	891	22	67
α-Endosulfan	36	57	58	57	0.0001	514	25	66
β-Endosulfan	32	66	65	66	0.00004	353	23	65
Endosulfan sulfate	24	60	63	60	0.00006	474	41	61
Chlordecone	4	NA	689	626	500	1454	27	54
Pentachlorobenzene	21	4	4	4	0.44	5.34	15	72

Table 3: Summary of laboratory performances for OCP analyses - standard solution

Standard solution	% of the data received	Performance according to z-scores (percent of laboratories)			
		|z| < 2	3 > |z| > 2	6 > |z| > 3	|z| > 6
Analyte		Satisfactory	Questionable	Unsatisfactory	Extreme
Aldrin	46	67	13	10	8
Dieldrin	41	72	7	9	9
Endrin	40	62	17	7	10
Endrin Ketone	9	NA	NA	NA	NA
α-Chlordane	34	75	8	14	3
γ-Chlordane	35	76	5	16	3
Oxychlordane	29	73	7	17	0
cis-Nonachlor	28	72	7	10	7
trans-Nonachlor	30	69	6	6	13
Heptachlor	44	65	11	17	7
cis-Heptachlorepoxide	32	68	3	12	15
trans-Heptachlorepoxide	28	48	17	24	10
o,p'-DDT	40	60	21	10	7
p,p'-DDT	44	57	13	20	11
o,p'-DDD	40	71	10	12	7
p,p'-DDD	42	61	18	14	7
o,p'-DDE	39	71	17	10	2
p,p'-DDE	49	76	8	8	6
Hexachlorobenzene	43	71	9	9	9
Mirex	30	75	13	3	9
α-HCH	42	61	16	14	7
β-HCH	43	58	20	9	11
γ-HCH	44	70	7	11	9
α-Endosulfan	34	61	14	8	17
β-Endosulfan	32	59	15	12	9
Endosulfan sulfate	24	36	24	8	28
Chlordecone	5	NA	NA	NA	NA
Pentachlorobenzene	22	83	4	0	4

Table 4: Summary results for OCP analyses - sediment

Sediment	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg/kg)					(%)	
Aldrin	24	NA	12	11	0.000003	2790	133	61
Dieldrin	24	NA	14	13	0.00001	65	54	72
Endrin	13	NA	2	1	0.66	8.3	97	48
Endrin ketone	3	NA	14	14	11.9	17	20	63
α-Chlordane	12	0.07	0.1	0.1	0.008	1	73	61
γ-Chlordane	14	0.13	0.2	0.1	0.000002	0	73	61
Oxychlordane	4	NA	1.0	0.1	0.18	3	246	46
cis-Nonachlor	12	0.04	0.0	0.0	0.02	4	46	60
trans-Nonachlor	11	0.06	0.1	0.1	0.03	1	41	64
Heptachlor	9	NA	0.6	0.1	0.000003	65	309	41
cis-Heptachlorepoxide	7	NA	0.1	0.1	0.01	542908	290	49
trans-Heptachlorepoxide	4	NA	0.9	0.3	0.01	2	245	46
o,p'-DDT	15	NA	0.4	0.2	0.06	27	204	49
p,p'-DDT	24	NA	0.9	0.8	0.10	16	98	67
o,p'-DDD	20	0.58	0.7	0.6	0.19	43	93	65
p,p'-DDD	27	1.87	1.9	1.9	0.00003	41	62	69
o,p'-DDE	22	0.22	0.3	0.2	0.09	6	76	62
p,p'-DDE	27	2.51	2.6	2.5	0.000004	5	31	58
Hexachlorobenzene	28	4.95	5.4	4.9	0.75	18	34	66
Mirex	24	33.4	32	33	3.99	67	18	59
α-HCH	20	0.22	0.3	0.2	0.07	6	107	61
β-HCH	21	0.36	0.4	0.4	0.000001	331	92	62
γ-HCH	22	NA	0.3	0.2	0.000001	5	104	67
α-Endosulfan	8	NA	0.5	0.3	0.000003	36	144	53
β-Endosulfan	11	NA	0.7	0.4	0.000001	49	187	56
Endosulfan sulfate	9	NA	7.0	3.8	0.000002	77	235	49
Chlordecone	2	NA	NA	NA	0.41	2	NA	NA
Pentachlorobenzene	15	1.93	1.9	1.9	0.10	4	61	74

Table 5: Summary results for OCP analyses - sediment

Sediment	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
Aldrin	26	0	0	0	0
Dieldrin	24	0	0	0	0
Endrin	19	0	0	0	0
Endrin ketone	4	0	0	0	0
α-Chlordane	17	33	6	17	11
γ-Chlordane	18	37	5	21	11
Oxychlordane	13	0	0	0	0
cis-Nonachlor	16	53	0	0	18
trans-Nonachlor	15	56	0	0	13
Heptachlor	20	0	0	0	0
cis-Heptachlorepoxide	15	0	0	0	0
trans-Heptachlorepoxide	11	0	0	0	0
o,p'-DDT	21	0	0	0	0
p,p'-DDT	27	0	0	0	0
o,p'-DDD	22	26	13	17	30
p,p'-DDD	29	37	3	23	27
o,p'-DDE	26	37	7	15	22
p,p'-DDE	29	57	3	13	17
Hexachlorobenzene	28	52	10	21	14
Mirex	24	60	8	12	16
α-HCH	23	29	8	17	29
β-HCH	23	29	4	13	42
γ-HCH	25	0	0	0	0
α-Endosulfan	15	0	0	0	0
β-Endosulfan	16	0	0	0	0
Endosulfan sulfate	13	0	0	0	0
Chlordecone	3	0	0	0	0
Pentachlorobenzene	15	38	6	31	19

Table 6: Summary results for OCP analyses - fish (wet weight basis)

Fish	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg/kg)					(%)	
Aldrin	13	0.028	0.052	0.028	0.000002	12	240	52
Dieldrin	19	0.127	0.161	0.127	0.00002	199	78	64
Endrin	11	NA	0.258	0.179	0.000005	5.2	186	44
Endrin ketone	0	NA	NA	NA	NA	NA	NA	NA
α-Chlordane	26	0.723	0.807	0.723	0.16	784	51	73
γ-Chlordane	28	NA	1.037	0.816	0.000002	1121	66	69
Oxychlordane	7	NA	0.011	0.007	0.004	0.9	138	50
cis-Nonachlor	9	0.021	0.026	0.021	0.02	0.4	51	69
trans-Nonachlor	23	0.437	0.543	0.437	0.01	1.6	66	78
Heptachlor	6	NA	0.177	0.013	0.000003	11	571	36
cis-Heptachlorepoxide	23	0.578	0.640	0.578	0.15	882	65	72
trans-Heptachlorepoxide	5	NA	0.360	0.051	0.0007	115	256	42
o,p'-DDT	9	NA	0.889	0.211	0.0017	3.5	348	35
p,p'-DDT	14	NA	0.123	0.063	0.000004	58	234	42
o,p'-DDD	28	0.144	0.185	0.144	0.02	176	66	60
p,p'-DDD	33	0.583	0.650	0.583	0.00004	687	62	68
o,p'-DDE	20	0.087	0.116	0.087	0.03	74	81	52
p,p'-DDE	36	3.255	3.514	3.255	0.00004	3313	45	64
Hexachlorobenzene	30	0.765	0.842	0.765	0.001	11	50	67
Mirex	22	0.161	0.192	0.161	0.032	147	81	65
α-HCH	21	0.028	0.032	0.028	0.003	23	115	66
β-HCH	22	0.247	0.286	0.247	0.000009	293	58	74
γ-HCH	14	NA	0.012	0.005	0.00004	16	241	52
α-Endosulfan	5	NA	0.615	0.049	0.000003	1.1	368	48
β-Endosulfan	3	NA	0.003	0.001	0.000002	0.7	244	64
Endosulfan sulfate	4	NA	0.055	0.023	0.000009	10	274	47
Chlordecone	1	NA	NA	NA	0.42	0.4	NA	NA
Pentachlorobenzene	16	0.076	0.079	0.076	0.004	34	23	57

Table 7: Summary of laboratory performance for OCP analyses - fish

Fish	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
Aldrin	27	25	0	4	18
Dieldrin	25	27	12	19	15
Endrin	24	0	0	0	0
Endrin ketone	6	0	0	0	0
α-Chlordane	27	50	14	18	11
γ-Chlordane	28	0	0	0	0
Oxychlordane	18	0	0	0	0
cis-Nonachlor	16	47	0	0	6
trans-Nonachlor	24	28	36	16	12
Heptachlor	25	0	0	0	0
cis-Heptachlorepoxide	24	24	20	32	16
trans-Heptachlorepoxide	17	0	0	0	0
o,p'-DDT	23	0	0	0	0
p,p'-DDT	30	0	0	0	0
o,p'-DDD	31	45	3	9	27
p,p'-DDD	31	33	21	18	27
o,p'-DDE	27	36	7	4	25
p,p'-DDE	35	38	22	11	27
Hexachlorobenzene	30	38	13	25	19
Mirex	26	41	7	11	22
α-HCH	26	48	4	7	19
β-HCH	26	48	7	22	4
γ-HCH	25	0	0	0	0
α-Endosulfan	20	0	0	0	0
β-Endosulfan	18	0	0	0	0
Endosulfan sulfate	12	0	0	0	0
Chlordecone	3	0	0	0	0
Pentachlorobenzene	20	52	0	10	14

Table 8: Summary results for OCP analyses - mothers' milk (wet weight basis)

Mothers' milk	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(ng/kg)					(%)	
Aldrin	3	NA	0.07	0.04	0.000000002	27.7	245	64
Dieldrin	10	34.4	40.0	34.4	0.000000008	290	62	63
Endrin	4	NA	0.88	0.56	0.000000007	1730	134	55
Endrin ketone	0	NA	NA	NA	NA	NA	NA	NA
α-Chlordane	6	NA	18.9	8.35	0.28	170	235	40
γ-Chlordane	4	NA	0.72	0.33	0.000000002	219	161	44
Oxychlordane	10	NA	34.6	34.7	11.0	66.0	57	67
cis-Nonachlor	7	13.7	14.0	13.7	2.75	16.0	26	46
trans-Nonachlor	13	59.5	59.1	59.5	25.0	84.0	6	49
Heptachlor	4	NA	13.09	0.38	0.000000001	170	927	41
cis-Heptachlorepoxide	11	25.9	25.0	25.9	0.051	34.0	11	61
trans-Heptachlorepoxide	0	NA	NA	NA	NA	0.0	NA	NA
o,p'-DDT	5	6.89	7.00	6.89	6.20	10.3	9	49
p,p'-DDT	10	46.7	47.6	46.7	31.6	87.9	18	43
o,p'-DDD	2	NA	NA	NA	0.40	2.8	NA	NA
p,p'-DDD	10	NA	4.05	3.25	0.00000003	986	139	64
o,p'-DDE	7	1.65	1.70	1.65	0.09	6	24	41
p,p'-DDE	21	961	1004	961	0.000000001	2720	25	59
Hexachlorobenzene	20	200	199	200	0.49	340	33	64
Mirex	11	5.60	5.86	5.60	0.34	9	34	62
α-HCH	10	NA	6.11	3.92	0.33	440	134	58
β-HCH	13	80.1	84.1	80.1	0.39	690	35	58
γ-HCH	12	NA	5.35	4.48	0.000000001	1210	75	63
α-Endosulfan	4	NA	6.76	4.12	1.36	389	95	38
β-Endosulfan	2	NA	NA	NA	0.000000003	0.7	NA	NA
Endosulfan sulfate	2	NA	NA	NA	0.00000002	0.02	NA	NA
Chlordecone	0	NA	NA	NA	NA	NA	NA	NA
Pentachlorobenzene	10	11.3	12.5	11.3	4.10	89	69	66

Table 9: Summary of laboratory performance for OCP analyses - mothers' milk

Mothers' milk	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
Aldrin	16	0	0	0	0
Dieldrin	16	24	0	18	18
Endrin	14	0	0	0	0
Endrin ketone	5	0	0	0	0
α-Chlordane	14	0	0	0	0
γ-Chlordane	15	0	0	0	0
Oxychlordane	13	0	0	0	0
cis-Nonachlor	11	33	0	17	8
trans-Nonachlor	14	60	13	13	0
Heptachlor	16	0	0	0	0
cis-Heptachlorepoxide	14	47	13	0	13
trans-Heptachlorepoxide	10	0	0	0	0
o,p'-DDT	12	31	0	8	0
p,p'-DDT	18	32	5	11	5
o,p'-DDD	14	0	0	0	0
p,p'-DDD	16	0	0	0	0
o,p'-DDE	15	25	0	0	19
p,p'-DDE	22	57	4	13	17
Hexachlorobenzene	20	57	10	14	14
Mirex	15	38	13	13	6
α-HCH	16	0	0	0	0
β-HCH	16	35	12	18	12
γ-HCH	17	0	0	0	0
α-Endosulfan	16	0	0	0	0
β-Endosulfan	14	0	0	0	0
Endosulfan sulfate	10	0	0	0	0
Chlordecone	2	0	0	0	0
Pentachlorobenzene	12	38	0	15	23

Table 10: Summary results for OCP analyses - air extract (µg/kg)

Air extract	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg/kg)					(%)	
Aldrin	19	23.2	24.4	23.2	0.00002	31.0	33	49
Dieldrin	14	27.4	27.6	27.4	0.00002	117	21	44
Endrin	15	24.9	24.9	24.9	0.00003	42.9	58	60
Endrin ketone	1	NA	NA	NA	0.98	0.98	NA	NA
α-Chlordane	19	34.5	35.0	34.5	1.69	68.4	17	62
γ-Chlordane	20	36.0	35.1	36.0	0.00004	63.3	14	58
Oxychlordane	10	13.7	14.1	13.7	10.9	22.2	13	61
cis-Nonachlor	14	71.7	69.6	71.7	7.99	168	15	51
trans-Nonachlor	15	20.2	20.0	20.2	6.90	42.7	13	50
Heptachlor	20	24.2	25.6	24.2	0.00002	38.7	42	59
cis-Heptachlorepoxide	14	10.3	10.6	10.3	0.73	166	14	50
trans-Heptachlorepoxide	10	9.51	9.70	9.51	7.99	22.0	21	59
o,p'-DDT	19	24.6	26.0	24.6	2.95	51.3	45	60
p,p'-DDT	21	51.5	52.5	51.5	0.0003	103	26	51
o,p'-DDD	18	29.6	29.3	29.6	0.03	53.9	8	44
p,p'-DDD	19	27.6	28.0	27.6	0.43	96.9	46	55
o,p'-DDE	20	27.0	27.0	27.0	9.72	48.1	27	58
p,p'-DDE	22	29.3	29.5	29.3	0.00002	106	22	53
Hexachlorobenzene	23	880	968	880	11.6	1425	68	81
Mirex	17	98.3	105	98.3	1.35	182	41	62
α-HCH	16	4.67	4.72	4.67	1.46	11879	30	58
β-HCH	12	6.60	6.62	6.60	2.37	22.5	16	45
γ-HCH	16	4.81	4.64	4.81	0.000002	13.5	18	49
α-Endosulfan	12	47.5	51.1	47.5	0.00008	99.0	71	62
β-Endosulfan	8	NA	58.3	58.4	40.1	140	49	37
Endosulfan sulfate	8	65.9	67.4	65.9	0.00004	150	91	63
Chlordecone	1	NA	NA	NA	0.92	0.9	NA	NA
Pentachlorobenzene	10	52.8	53.5	52.8	33.3	124	8	54

Table 11: Summary of laboratory performance for OCP analyses – air extract

Air extract	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
Aldrin	22	43	9	17	13
Dieldrin	17	44	0	17	17
Endrin	19	25	15	20	15
Endrin ketone	6	0	0	0	0
α-Chlordane	19	65	15	0	15
γ-Chlordane	20	67	0	10	19
Oxychlordane	12	69	0	8	0
cis-Nonachlor	15	56	0	19	13
trans-Nonachlor	17	56	0	22	6
Heptachlor	24	32	20	24	4
cis-Heptachlorepoxide	15	50	6	13	19
trans-Heptachlorepoxide	10	55	9	9	18
o,p'-DDT	22	39	4	30	9
p,p'-DDT	24	48	8	4	24
o,p'-DDD	22	48	4	17	9
p,p'-DDD	23	33	13	17	17
o,p'-DDE	23	50	13	17	4
p,p'-DDE	25	50	8	12	15
Hexachlorobenzene	22	35	4	39	22
Mirex	17	50	6	17	22
α-HCH	19	45	10	20	5
β-HCH	18	42	5	11	5
γ-HCH	21	45	9	9	9
α-Endosulfan	15	31	6	6	31
β-Endosulfan	13	0	0	0	0
Endosulfan sulfate	10	40	0	0	40
Chlordecone	2	0	0	0	0
Pentachlorobenzene	10	64	18	0	9

3.2.2 Polychlorinated Biphenyls

Table 12: Summary results for indicator PCB analyses - standard solution

Standard solution	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
PCB 28	44	2.71	2.80	2.71	0.850	21.9	23	69
PCB 52	46	3.35	3.46	3.35	0.230	85.6	23	66
PCB 101	47	5.23	5.41	5.23	0.350	361	22	65
PCB 138	47	5.50	5.60	5.50	0.550	345	28	70
PCB 153	46	6.57	6.71	6.57	3.488	475	20	69
PCB 180	45	7.92	7.92	7.92	2.380	235	21	70
Sum Indicator PCB LB (ND = 0)	41	32.7	33.0	32.7	0.025	1524	18	67
Sum Indicator PCB UB (ND = LOD)	38	32.5	32.9	32.5	0.025	1524	18	66

Table 13: Summary of laboratory performance for indicator PCB analyses - standard solution

Standard solution	% of the data received	Performance according to z-scores (percent of laboratories)			
		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
Analyte					
PCB 28	43	71	7	13	7
PCB 52	45	66	9	11	13
PCB 101	45	66	11	9	15
PCB 138	46	58	19	10	10
PCB 153	44	67	17	9	7
PCB 180	43	71	16	7	7
Sum Indicator PCB LB (ND = 0)	39	66	17	7	10
Sum Indicator PCB UB (ND = LOD)	36	66	16	8	11

Table 14: Summary results for indicator PCB analyses - sediment

Sediment	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
PCB 28	35	9.43	9.38	9.43	2.30	73.3	37	68
PCB 52	35	7.38	7.40	7.38	2.18	28.9	16	60
PCB 101	37	9.94	9.83	9.94	0.000001	15.1	17	66
PCB 138	37	10.7	10.3	10.7	0.000002	157	36	67
PCB 153	38	14.3	14.6	14.3	0.000002	95.6	36	76
PCB 180	37	7.31	7.24	7.31	0.00001	45.5	24	65
Sum Indicator PCB LB (ND = 0)	*34*	*59.6*	*59.8*	*59.6*	*0.13*	*91.2*	*21*	*70*
Sum Indicator PCB UB (ND = LOD)	*31*	*60.0*	*60.2*	*60.0*	*0.37*	*91.2*	*20*	*71*

Table 15: Summary of laboratory performance for indicator PCB analyses - sediment

Sediment	% of the data received	Performance according to z-scores (percent of laboratories)			
		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
Analyte					
PCB 28	35	46	19	22	8
PCB 52	35	65	11	14	5
PCB 101	35	73	5	14	8
PCB 138	36	50	8	26	13
PCB 153	36	50	21	18	11
PCB 180	36	61	11	16	11
Sum Indicator PCB LB (ND = 0)	32	71	9	12	9
Sum Indicator PCB UB (ND = LOD)	30	77	3	13	6

Table 16: Summary results for indicator PCB analyses - fish (wet weight basis)

Fish	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
PCB 28	41	1.28	1.43	1.28	0.000019	23.7	48	68
PCB 52	42	5.89	5.89	5.89	0.000006	43.1	34	63
PCB 101	43	11.0	12.2	11.0	0.000012	134	54	71
PCB 138	43	11.8	13.0	11.8	0.000034	226	70	68
PCB 153	43	22.1	23.7	22.1	0.000014	226	48	66
PCB 180	40	7.12	7.23	7.12	0.000015	110	63	74
Sum Indicator PCB LB (ND = 0)	37	67.3	67.8	67.3	1.02	755	28	65
Sum Indicator PCB UB (ND = LOD)	36	66.5	65.9	66.5	1.02	755	32	68

Table 17: Summary of laboratory performance for indicator PCB analyses - fish

Fish	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
PCB 28	40	40	17	24	17
PCB 52	41	53	5	19	21
PCB 101	42	30	9	41	18
PCB 138	43	27	18	13	38
PCB 153	42	41	14	16	27
PCB 180	40	40	5	26	24
Sum Indicator PCB LB (ND = 0)	35	62	8	11	19
Sum Indicator PCB UB (ND = LOD)	34	56	14	11	19

Table 18: Summary results for indicator PCB analyses - mothers' milk (wet weight basis)

Mothers's milk	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(ng /kg)					(%)	
PCB 28	24	78.6	80.4	78.6	0.000000004	450	30	57
PCB 52	22	10.5	11.6	10.5	0.000000002	195	77	61
PCB 101	24	7.4	9.00	7.41	0.000000005	220	85	61
PCB 138	28	308	304	308	0.000000007	1250	28	59
PCB 153	27	572	561	572	0.000000005	1734	22	64
PCB 180	26	319	317	319	0.000000001	797	17	64
Sum Indicator PCB LB (ND = 0)	24	1399	1436	1399	1056	4081	26	75
Sum Indicator PCB UB (ND = LOD)	23	1396	1418	1396	1056	4081	26	75

Table 19: Summary of laboratory performance for indicator PCB analyses - mothers' milk

Mothers's milk	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
PCB 28	26	52	4	11	22
PCB 52	25	27	12	15	31
PCB 101	26	30	11	7	41
PCB 138	27	61	0	11	29
PCB 153	27	57	18	4	18
PCB 180	27	71	11	4	7
Sum Indicator PCB LB (ND = 0)	23	71	13	8	8
Sum Indicator PCB UB (ND = LOD)	22	70	13	13	4

Table 20: Summary results for indicator PCB analyses - air extract

Air extract	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
PCB 28	24	0.16	0.21	0.16	0.000001	5.47	95	65
PCB 52	24	0.15	0.16	0.15	0.05	29.59	88	63
PCB 101	25	NA	0.24	0.25	0.10	3.71	75	62
PCB 138	25	0.26	0.29	0.26	0.18	30.59	60	58
PCB 153	25	NA	0.33	0.28	0.11	12.10	112	58
PCB 180	26	0.17	0.19	0.17	0.09	1.13	70	64
Sum Indicator PCB LB (ND = 0)	23	1.19	1.33	1.19	0.17	18.57	71	64
Sum Indicator PCB UB (ND = LOD)	25	NA	1.80	1.64	0.17	11.56	83	69

Table 21: Summary of laboratory performance for indicator PCB analyses - air extract

Air extract	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
PCB 28	29	30	20	7	23
PCB 52	29	23	20	10	27
PCB 101	30	0	0	0	0
PCB 138	30	45	0	6	29
PCB 153	30	0	0	0	0
PCB 180	30	42	6	16	19
Sum Indicator PCB LB (ND = 0)	24	36	12	8	36
Sum Indicator PCB UB (ND = LOD)	25	0	0	0	0

Table 22: Summary results for indicator PCB analyses - transformer oil

Transformer oil	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
PCB 28	19	480	517	480	0.0001	3500	73	66
PCB 52	19	14231	13579	14231	0.0004	34233	45	72
PCB 101	19	20869	20540	20869	0.0010	43749	43	66
PCB 138	19	14360	14300	14360	0.0020	27680	59	79
PCB 153	19	10989	10714	10989	0.0010	21505	49	73
PCB 180	19	2023	1973	2023	0.00002	4120	40	71
Sum Indicator PCB LB (ND = 0)	15	68316	67466	68316	47140	131644	36	80
Sum Indicator PCB UB (ND = LOD)	15	64472	64306	64472	15835	131644	36	74

Table 23: Summary of laboratory performance for indicator PCB analyses - transformer oil

Transformer oil	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
PCB 28	18	26	16	16	42
PCB 52	18	42	11	32	16
PCB 101	18	47	11	16	26
PCB 138	18	37	11	32	21
PCB 153	18	32	26	26	16
PCB 180	18	58	5	26	11
Sum Indicator PCB LB (ND = 0)	14	47	33	13	7
Sum Indicator PCB UB (ND = LOD)	14	60	13	13	13

3.2.3 Dioxin-like Persistent Organic Pollutants

Table 24: Summary results for dioxin-like POPs analyses - standard solution

Standard solution / Analyte	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
		(µg /kg)					(%)	
2,3,7,8-TeCDD	47	33.9	34.1	33.9	0.020	65.1	13	65
1,2,3,7,8-PnCDD	47	67.3	65.6	67.3	0.041	128	11	66
1,2,3,4,7,8-HxCDD	47	68.5	68.2	68.5	0.040	133	14	66
1,2,3,6,7,8-HxCDD	47	112	112	112	0.051	205	17	72
1,2,3,7,8,9-HxCDD	47	67.8	66.7	67.8	0.041	126	21	77
1,2,3,4,6,7,8-HpCDD	47	135	134	135	0.092	258	10	63
OCDD	47	141	140	141	0.101	254	15	72
2,3,7,8-TeCDF	47	34.2	34.9	34.2	0.021	61.7	13	68
1,2,3,7,8-PnCDF	47	67.9	66.6	67.9	0.040	128	15	74
2,3,4,7,8-PnCDF	47	68.8	68.7	68.8	0.040	132	11	68
1,2,3,4,7,8-HxCDF	47	69.7	68.1	69.7	0.042	131	14	70
1,2,3,6,7,8-HxCDF	47	68.5	68.0	68.5	0.041	133	13	70
1,2,3,7,8,9-HxCDF	47	67.6	70.0	67.6	0.040	132	19	64
2,3,4,6,7,8-HxCDF	47	106	107	106	0.070	214	20	71
1,2,3,4,6,7,8-HpCDF	47	139	138	139	0.097	259	15	71
1,2,3,4,7,8,9-HpCDF	47	181	179	181	0.101	347	11	66
OCDF	47	140	140	140	0.097	266	20	74
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND = 0)	46	206	202	206	0.123	388	8	62
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND = LOD)	46	206	202	206	0.123	388	8	62
PCB 77	48	151	155	151	0.114	6573	21	71
PCB 81	46	160	165	160	0.108	9278	21	71
PCB 126	48	222	223	222	0.178	2630	22	72
PCB 169	48	155	160	155	0.106	664	22	73
PCB 105	46	286	283	286	0.206	18110	20	71
PCB 114	46	164	168	164	0.111	874	16	65
PCB 118	46	160	162	160	0.109	32501	18	70
PCB 123	46	284	287	284	0.206	7632	19	70
PCB 156	46	159	164	159	0.110	3708	21	70
PCB 157	43	161	165	161	0.114	682	17	66
PCB 167	46	155	160	155	0.101	672	20	70
PCB 189	44	160	164	160	0.106	632	21	73
WHO_{1998}-TEQ_{PCB} LB (ND = 0)	44	24.0	24.3	24.0	0.019	273	22	71
WHO_{1998}-TEQ_{PCB} UB (ND = LOD)	44	24.0	24.3	24.0	0.019	274	22	71
WHO_{1998}-TEQ_{total} LB (ND = 0)	43	229	228	229	0.142	495	14	66
WHO_{1998}-TEQ_{total} UB (ND = LOD)	43	229	228	229	0.142	495	14	66


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Table 25: Summary of laboratory performance for dioxin-like POPs analyses - standard solution

Standard solution	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
2,3,7,8-TeCDD	45	74	15	2	9
1,2,3,7,8-PnCDD	45	83	6	2	9
1,2,3,4,7,8-HxCDD	45	70	17	4	9
1,2,3,6,7,8-HxCDD	45	72	17	2	9
1,2,3,7,8,9-HxCDD	45	79	13	0	9
1,2,3,4,6,7,8-HpCDD	45	79	13	0	9
OCDD	45	83	6	2	9
2,3,7,8-TeCDF	45	79	11	2	9
1,2,3,7,8-PnCDF	45	83	9	0	9
2,3,4,7,8-PnCDF	45	79	13	0	9
1,2,3,4,7,8-HxCDF	45	79	13	0	9
1,2,3,6,7,8-HxCDF	45	79	13	0	9
1,2,3,7,8,9-HxCDF	45	66	13	6	15
2,3,4,6,7,8-HxCDF	45	72	13	6	9
1,2,3,4,6,7,8-HpCDF	45	77	15	0	9
1,2,3,4,7,8,9-HpCDF	45	79	9	4	9
OCDF	45	77	11	4	9
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND = 0)	44	78	11	2	9
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND = LOD)	44	78	11	2	9
PCB 77	46	69	19	2	10
PCB 81	44	70	17	2	11
PCB 126	46	67	17	6	10
PCB 169	46	79	10	0	10
PCB 105	44	74	9	7	11
PCB 114	44	74	13	2	11
PCB 118	44	76	7	7	11
PCB 123	44	70	15	4	11
PCB 156	44	67	15	4	13
PCB 157	41	67	21	5	7
PCB 167	44	72	13	4	11
PCB 189	42	73	18	2	7
WHO_{1998}-TEQ_{PCB} LB (ND = 0)	42	64	18	7	11
WHO_{1998}-TEQ_{PCB} UB (ND = LOD)	42	64	18	7	11
WHO_{1998}-TEQ_{total} LB (ND = 0)	41	77	9	2	12
WHO_{1998}-TEQ_{total} UB (ND = LOD)	41	77	9	2	12

Table 26: Summary results for dioxin-like POPs analyses - sediment

Sediment	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(ng /kg)					(%)	
2,3,7,8-TeCDD	34	9.18	9.12	9.18	0.019	22.1	16	71
1,2,3,7,8-PnCDD	34	2.54	2.54	2.54	0.003	10.5	28	67
1,2,3,4,7,8-HxCDD	33	3.23	3.27	3.23	0.003	11.2	20	72
1,2,3,6,7,8-HxCDD	34	6.92	7.03	6.92	0.006	19.3	16	72
1,2,3,7,8,9-HxCDD	33	4.75	4.85	4.75	0.005	13.3	16	69
1,2,3,4,6,7,8-HpCDD	34	83.9	85.0	83.9	0.076	220	16	72
OCDD	34	848	851	848	0.770	2480	18	73
2,3,7,8-TeCDF	33	15.0	15.0	15.0	0.015	26.1	10	62
1,2,3,7,8-PnCDF	34	15.0	14.9	15.0	0.007	33.3	12	70
2,3,4,7,8-PnCDF	34	17.2	17.5	17.2	0.015	73.1	20	72
1,2,3,4,7,8-HxCDF	34	52.4	53.1	52.4	0.048	102	21	74
1,2,3,6,7,8-HxCDF	34	26.2	26.7	26.2	0.025	73.7	12	60
1,2,3,7,8,9-HxCDF	32	NA	6.68	6.35	0.002	40.9	101	69
2,3,4,6,7,8-HxCDF	34	16.5	15.5	16.5	0.014	72.7	36	76
1,2,3,4,6,7,8-HpCDF	34	171	171	171	0.155	326	23	76
1,2,3,4,7,8,9-HpCDF	34	28.5	28.4	28.5	0.030	60.1	17	75
OCDF	34	741	723	741	0.456	2086	21	75
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND = 0)	34	37.3	38.0	37.3	0.044	98.5	12	69
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND = LOD)	34	37.4	38.0	37.4	0.044	98.5	11	68
PCB 77	30	746	747	746	0.677	2654	15	64
PCB 81	30	9.14	9.55	9.14	0.005	79.4	41	62
PCB 126	32	28.2	27.9	28.2	0.024	88.1	18	58
PCB 169	27	6.02	5.80	6.02	0.005	17.9	23	62
PCB 105	32	1284	1287	1284	1.209	2498	18	68
PCB 114	29	60.3	62.6	60.3	0.050	338	31	63
PCB 118	32	6102	6137	6102	5.714	10786	17	69
PCB 123	28	64.3	90.0	64.3	0.053	1605	91	56
PCB 156	34	923	876	923	0.803	1687	22	67
PCB 157	31	162	171	162	0.150	826	24	65
PCB 167	32	484	489	484	0.412	1571	19	67
PCB 189	32	183	186	183	0.156	514	20	64
WHO_{1998}-TEQ_{PCB} LB (ND = 0)	33	4.22	4.28	4.22	0.004	10.3	22	62
WHO_{1998}-TEQ_{PCB} UB (ND = LOD)	33	4.20	4.28	4.20	0.004	10.3	23	63
WHO_{1998}-TEQ_{total} LB (ND = 0)	32	41.2	41.4	41.2	0.048	67.8	11	60
WHO_{1998}-TEQ_{total} UB (ND = LOD)	32	41.3	41.4	41.3	0.048	67.8	10	60

Table 27: Summary of laboratory performance for dioxin-like POPs analyses - sediment

Sediment	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
2,3,7,8-TeCDD	32	79	6	6	9
1,2,3,7,8-PnCDD	32	56	9	15	21
1,2,3,4,7,8-HxCDD	32	74	6	9	9
1,2,3,6,7,8-HxCDD	32	79	12	0	9
1,2,3,7,8,9-HxCDD	32	71	9	3	15
1,2,3,4,6,7,8-HpCDD	32	82	6	6	6
OCDD	32	82	9	3	6
2,3,7,8-TeCDF	32	79	12	3	3
1,2,3,7,8-PnCDF	32	85	3	6	6
2,3,4,7,8-PnCDF	32	76	12	6	6
1,2,3,4,7,8-HxCDF	32	74	15	6	6
1,2,3,6,7,8-HxCDF	32	74	9	9	9
1,2,3,7,8,9-HxCDF	32	0	0	0	0
2,3,4,6,7,8-HxCDF	32	56	24	6	15
1,2,3,4,6,7,8-HpCDF	32	74	15	6	6
1,2,3,4,7,8,9-HpCDF	32	85	6	3	6
OCDF	32	76	12	3	9
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND = 0)	32	82	6	6	6
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND = LOD)	32	82	6	6	6
PCB 77	30	74	6	3	13
PCB 81	31	39	15	9	27
PCB 126	32	56	6	12	21
PCB 169	29	57	3	13	17
PCB 105	30	72	13	3	13
PCB 114	30	50	16	3	22
PCB 118	30	78	6	6	9
PCB 123	30	26	10	13	42
PCB 156	32	65	12	6	18
PCB 157	30	65	6	6	23
PCB 167	30	72	6	6	16
PCB 189	30	66	9	13	13
WHO_{1998}-TEQ_{PCB} LB (ND = 0)	31	55	15	12	18
WHO_{1998}-TEQ_{PCB} UB (ND = LOD)	31	55	18	9	18
WHO_{1998}-TEQ_{total} LB (ND = 0)	30	75	3	6	16
WHO_{1998}-TEQ_{total} UB (ND = LOD)	30	75	3	6	16

Table 28: Summary results for dioxin-like POPs analyses - fish (wet weight basis)

Fish	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
2,3,7,8-TeCDD	32	NA	0.00062	0.00064	0.000006	0.0010	26	63
1,2,3,7,8-PnCDD	26	NA	0.00005	0.00004	0.000004	0.0010	70	68
1,2,3,4,7,8-HxCDD	16	NA	0.00001	0.00001	0.0000001	0.0014	159	52
1,2,3,6,7,8-HxCDD	22	NA	0.00004	0.00003	0.000002	0.0005	73	58
1,2,3,7,8,9-HxCDD	18	NA	0.00002	0.00001	0.0000006	0.0068	150	55
1,2,3,4,6,7,8-HpCDD	26	NA	0.00007	0.00006	0.000016	0.0009	112	63
OCDD	31	NA	0.00030	0.00026	0.000035	131.673	90	66
2,3,7,8-TeCDF	36	NA	0.00084	0.00085	0.000006	2.727	30	60
1,2,3,7,8-PnCDF	34	NA	0.00022	0.00020	0.000008	3.407	31	58
2,3,4,7,8-PnCDF	33	NA	0.00026	0.00027	0.000016	0.0013	31	59
1,2,3,4,7,8-HxCDF	31	NA	0.00007	0.00007	0.000007	8.343	51	67
1,2,3,6,7,8-HxCDF	27	NA	0.00003	0.00003	0.000007	0.0023	91	65
1,2,3,7,8,9-HxCDF	15	NA	0.00006	0.00004	0.000001	0.0009	167	51
2,3,4,6,7,8-HxCDF	18	NA	0.00002	0.00002	0.000003	0.0007	92	52
1,2,3,4,6,7,8-HpCDF	23	NA	0.00006	0.00004	0.000005	0.0083	140	57
1,2,3,4,7,8,9-HpCDF	18	NA	0.00002	0.00002	0.0000001	0.0008	147	52
OCDF	22	NA	0.00005	0.00004	0.000006	0.0023	125	57
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND = 0)	38	NA	0.00089	0.00079	0.0000000	1.291	62	70
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND = LOD)	37	NA	0.00098	0.00093	0.000046	6.249	45	64
PCB 77	37	0.1	0.05400	0.05480	0.001189	3.970	39	65
PCB 81	31	NA	0.00141	0.00128	0.000013	1.600	107	65
PCB 126	36	NA	0.01185	0.01062	0.000024	0.1706	39	63
PCB 169	28	NA	0.00123	0.00115	0.000134	0.0056	57	66
PCB 105	41	0.9	0.96000	0.94535	0.016930	3.8000	45	69
PCB 114	37	0.1	0.07300	0.07201	0.0000000	0.648	29	57
PCB 118	38	5.9	6.06750	5.89420	0.253729	9.043	45	74
PCB 123	38	0.1	0.07900	0.06112	0.003326	11.20	97	62
PCB 156	39	0.9	0.85000	0.88008	0.042064	1.500	46	76
PCB 157	37	0.1	0.15000	0.14534	0.004013	1.254	44	65
PCB 167	39	0.5	0.54000	0.53131	0.037745	1.725	40	71
PCB 189	38	0.1	0.12030	0.12314	0.008696	0.190	44	77
WHO_{1998}-TEQ_{PCB} LB (ND = 0)	41	NA	0.00240	0.00230	0.0000000	4.240	44	69
WHO_{1998}-TEQ_{PCB} UB (ND = LOD)	40	NA	0.00250	0.00241	0.0000000	8.455	37	66
WHO_{1998}-TEQ_{total} LB (ND = 0)	39	NA	0.00369	0.00324	0.000119	4.241	53	68
WHO_{1998}-TEQ_{total} UB (ND = LOD)	39	NA	0.00371	0.00335	0.000143	8.460	51	67

Table 29: Summary of laboratory performance for dioxin-like POPs analyses - fish

Fish	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
2,3,7,8-TeCDD	34	0	0	0	0
1,2,3,7,8-PnCDD	34	0	0	0	0
1,2,3,4,7,8-HxCDD	31	0	0	0	0
1,2,3,6,7,8-HxCDD	33	0	0	0	0
1,2,3,7,8,9-HxCDD	32	0	0	0	0
1,2,3,4,6,7,8-HpCDD	33	0	0	0	0
OCDD	35	0	0	0	0
2,3,7,8-TeCDF	36	0	0	0	0
1,2,3,7,8-PnCDF	36	0	0	0	0
2,3,4,7,8-PnCDF	35	0	0	0	0
1,2,3,4,7,8-HxCDF	34	0	0	0	0
1,2,3,6,7,8-HxCDF	34	0	0	0	0
1,2,3,7,8,9-HxCDF	31	0	0	0	0
2,3,4,6,7,8-HxCDF	30	0	0	0	0
1,2,3,4,6,7,8-HpCDF	34	0	0	0	0
1,2,3,4,7,8,9-HpCDF	33	0	0	0	0
OCDF	32	0	0	0	0
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND = 0)	36	0	0	0	0
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND = LOD)	35	0	0	0	0
PCB 77	36	71	16	3	8
PCB 81	38	0	0	0	0
PCB 126	37	0	0	0	0
PCB 169	35	0	0	0	0
PCB 105	39	49	15	17	20
PCB 114	37	69	5	13	8
PCB 118	37	38	18	28	13
PCB 123	39	49	12	2	29
PCB 156	37	49	10	28	13
PCB 157	36	58	11	21	8
PCB 167	37	51	21	18	10
PCB 189	37	67	18	13	0
WHO_{1998}-TEQ_{PCB} LB (ND = 0)	39	0	0	0	0
WHO_{1998}-TEQ_{PCB} UB (ND = LOD)	38	0	0	0	0
WHO_{1998}-TEQ_{total} LB (ND = 0)	37	0	0	0	0
WHO_{1998}-TEQ_{total} UB (ND = LOD)	37	0	0	0	0

Table 30: Summary results for dioxin-like POPs analyses - mothers' milk (wet weight basis)

Mothers' milk	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(ng /kg)					(%)	
2,3,7,8-TeCDD	18	NA	0.010	0.008	0.0003	0.47	46	65
1,2,3,7,8-PnCDD	25	0.0	0.027	0.026	0.0112	0.15	34	71
1,2,3,4,7,8-HxCDD	19	NA	0.011	0.011	0.0003	0.06	89	69
1,2,3,6,7,8-HxCDD	27	0.1	0.079	0.078	0.0066	0.17	23	67
1,2,3,7,8,9-HxCDD	21	0.0	0.020	0.019	0.0038	0.09	42	68
1,2,3,4,6,7,8-HpCDD	27	0.1	0.131	0.130	0.0560	0.48	38	73
OCDD	28	0.9	0.869	0.860	0.2895	1.44	13	61
2,3,7,8-TeCDF	23	0.0	0.015	0.015	0.0006	0.08	69	64
1,2,3,7,8-PnCDF	19	NA	0.010	0.008	0.0055	0.06	42	57
2,3,4,7,8-PnCDF	28	0.1	0.081	0.080	0.0504	0.14	20	69
1,2,3,4,7,8-HxCDF	28	0.0	0.033	0.032	0.0150	0.16	33	64
1,2,3,6,7,8-HxCDF	29	0.0	0.033	0.031	0.0160	0.09	20	63
1,2,3,7,8,9-HxCDF	13	0.0	0.019	0.015	0.0002	0.05	134	60
2,3,4,6,7,8-HxCDF	24	0.0	0.021	0.018	0.0020	0.09	68	64
1,2,3,4,6,7,8-HpCDF	28	0.1	0.078	0.075	0.0225	0.62	38	68
1,2,3,4,7,8,9-HpCDF	16	NA	0.007	0.005	0.0024	0.09	125	56
OCDF	17	0.0	0.046	0.037	0.0070	0.39	123	67
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND = 0)	29	0.1	0.107	0.100	0.0215	0.67	23	65
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND = LOD)	28	0.1	0.110	0.103	0.0320	0.67	21	66
PCB 77	21	0.2	0.280	0.244	0.0370	0.81	85	73
PCB 81	17	0.0	0.027	0.027	0.0049	0.09	91	76
PCB 126	27	0.5	0.439	0.453	0.1837	0.82	25	73
PCB 169	25	0.3	0.297	0.285	0.0725	5.02	37	69
PCB 105	28	16.7	17.34	16.73	8.1751	45.1	23	79
PCB 114	28	4.0	3.918	3.978	1.8950	5.17	18	78
PCB 118	28	88.8	90.10	88.75	39.95	221	20	76
PCB 123	28	0.9	0.971	0.941	0.2897	38.5	25	63
PCB 156	29	54.6	53.80	54.62	9.7341	105	14	68
PCB 157	29	9.4	9.360	9.425	4.9828	63.7	21	73
PCB 167	29	14.0	14.39	14.02	3.5143	31.1	20	76
PCB 189	28	6.1	6.042	6.065	2.3018	9.59	14	66
WHO_{1998}-TEQ_{PCB} LB (ND = 0)	28	0.1	0.089	0.094	0.0329	0.16	29	75
WHO_{1998}-TEQ_{PCB} UB (ND = LOD)	27	0.1	0.093	0.095	0.0416	0.73	26	74
WHO_{1998}-TEQ_{total} LB (ND = 0)	28	0.2	0.195	0.192	0.0695	0.37	24	72
WHO_{1998}-TEQ_{total} UB (ND = LOD)	27	0.2	0.209	0.203	0.0703	1.30	25	70

Table 31: Summary of laboratory performance for dioxin-like POPs analyses - mothers' milk

Mothers' milk	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
2,3,7,8-TeCDD	25	0	0	0	0
1,2,3,7,8-PnCDD	26	81	4	4	4
1,2,3,4,7,8-HxCDD	27	0	0	0	0
1,2,3,6,7,8-HxCDD	27	82	7	7	0
1,2,3,7,8,9-HxCDD	26	70	4	4	0
1,2,3,4,6,7,8-HpCDD	27	71	18	0	7
OCDD	28	76	3	17	0
2,3,7,8-TeCDF	27	79	0	4	0
1,2,3,7,8-PnCDF	27	0	0	0	0
2,3,4,7,8-PnCDF	28	90	7	0	0
1,2,3,4,7,8-HxCDF	28	76	10	7	3
1,2,3,6,7,8-HxCDF	28	90	3	7	0
1,2,3,7,8,9-HxCDF	24	48	4	0	0
2,3,4,6,7,8-HxCDF	27	64	0	21	0
1,2,3,4,6,7,8-HpCDF	28	72	10	3	10
1,2,3,4,7,8,9-HpCDF	26	0	0	0	0
OCDF	23	46	8	8	8
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND = 0)	28	79	10	3	7
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND = LOD)	27	79	7	4	11
PCB 77	25	31	4	38	8
PCB 81	26	52	7	4	0
PCB 126	26	78	15	7	0
PCB 169	26	56	15	15	7
PCB 105	27	82	7	4	7
PCB 114	27	86	11	4	0
PCB 118	27	82	11	4	4
PCB 123	27	61	4	18	18
PCB 156	28	79	7	7	7
PCB 157	28	76	7	14	3
PCB 167	28	79	10	7	3
PCB 189	27	79	7	14	0
WHO_{1998}-TEQ_{PCB} LB (ND = 0)	27	86	14	0	0
WHO_{1998}-TEQ_{PCB} UB (ND = LOD)	26	89	4	4	4
WHO_{1998}-TEQ_{total} LB (ND = 0)	27	82	11	7	0
WHO_{1998}-TEQ_{total} UB (ND = LOD)	26	78	4	11	7

Table 32: Summary results for dioxin-like POPs analyses - air extract

Air extract	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
2,3,7,8-TeCDD	37	0.0	0.038	0.037	0.019	0.613	14	63
1,2,3,7,8-PnCDD	37	0.2	0.231	0.233	0.065	0.751	14	64
1,2,3,4,7,8-HxCDD	37	0.4	0.400	0.397	0.027	1.239	9	63
1,2,3,6,7,8-HxCDD	37	0.7	0.650	0.650	0.051	0.904	10	66
1,2,3,7,8,9-HxCDD	37	0.6	0.665	0.643	0.029	1.551	12	65
1,2,3,4,6,7,8-HpCDD	37	7.1	7.100	7.147	0.292	8.489	6	69
OCDD	37	13.5	13.470	13.55	0.58	16.08	7	67
2,3,7,8-TeCDF	36	0.1	0.108	0.107	0.087	0.641	11	72
1,2,3,7,8-PnCDF	37	0.2	0.227	0.223	0.130	1.793	13	66
2,3,4,7,8-PnCDF	37	0.5	0.532	0.516	0.203	0.869	23	77
1,2,3,4,7,8-HxCDF	36	0.6	0.642	0.649	0.132	1.448	14	72
1,2,3,6,7,8-HxCDF	37	0.8	0.791	0.796	0.148	1.019	7	65
1,2,3,7,8,9-HxCDF	37	NA	0.204	0.202	0.031	1.845	102	71
2,3,4,6,7,8-HxCDF	37	1.5	1.499	1.538	0.042	1.986	13	70
1,2,3,4,6,7,8-HpCDF	37	4.7	4.653	4.723	0.251	5.502	8	70
1,2,3,4,7,8,9-HpCDF	37	0.9	0.840	0.854	0.101	0.997	8	66
OCDF	37	4.3	4.300	4.302	1.988	6.637	12	70
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND = 0)	37	1.2	1.187	1.197	0.749	1.917	9	70
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND = LOD)	37	1.2	1.187	1.199	0.749	1.917	9	70
PCB 77	32	0.2	0.170	0.166	0.110	13.30	23	73
PCB 81	29	0.1	0.069	0.068	0.040	3.350	14	63
PCB 126	32	0.2	0.188	0.185	0.070	4.800	18	67
PCB 169	28	0.1	0.098	0.097	0.016	0.126	13	68
PCB 105	32	0.2	0.192	0.186	0.082	11.40	23	67
PCB 114	26	0.0	0.044	0.042	0.022	0.132	25	65
PCB 118	33	0.3	0.310	0.290	0.160	5.900	34	67
PCB 123	27	0.0	0.029	0.024	0.016	3.100	56	58
PCB 156	31	0.2	0.160	0.159	0.016	10.90	22	67
PCB 157	28	0.1	0.089	0.086	0.053	5.900	18	70
PCB 167	27	0.1	0.055	0.054	0.012	0.170	22	66
PCB 189	29	0.1	0.139	0.136	0.099	4.750	15	73
WHO_{1998}-TEQ_{PCB} LB (ND = 0)	32	0.0	0.019	0.020	0.000	0.029	22	70
WHO_{1998}-TEQ_{PCB} UB (ND = LOD)	32	0.0	0.020	0.020	0.000	0.029	18	69
WHO_{1998}-TEQ_{total} LB (ND = 0)	32	1.2	1.198	1.206	0.005	1.936	11	68
WHO_{1998}-TEQ_{total} UB (ND = LOD)	32	1.2	1.202	1.210	0.005	1.936	12	71

Table 33: Summary of laboratory performance for dioxin-like POPs analyses - air extract

Air extract	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
2,3,7,8-TeCDD	35	95	0	3	3
1,2,3,7,8-PnCDD	35	78	14	5	3
1,2,3,4,7,8-HxCDD	35	81	3	14	3
1,2,3,6,7,8-HxCDD	35	89	3	3	5
1,2,3,7,8,9-HxCDD	35	78	5	11	5
1,2,3,4,6,7,8-HpCDD	35	95	0	3	3
OCDD	35	92	3	3	3
2,3,7,8-TeCDF	34	94	0	3	3
1,2,3,7,8-PnCDF	35	89	8	0	3
2,3,4,7,8-PnCDF	35	84	3	14	0
1,2,3,4,7,8-HxCDF	34	86	8	3	3
1,2,3,6,7,8-HxCDF	35	92	3	5	0
1,2,3,7,8,9-HxCDF	35	0	0	0	0
2,3,4,6,7,8-HxCDF	35	81	3	5	11
1,2,3,4,6,7,8-HpCDF	35	92	5	0	3
1,2,3,4,7,8,9-HpCDF	35	89	5	3	3
OCDF	35	86	5	8	0
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND = 0)	35	89	8	3	0
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND = LOD)	35	86	11	3	0
PCB 77	30	81	6	3	9
PCB 81	30	84	3	3	3
PCB 126	30	81	6	3	9
PCB 169	29	87	3	3	0
PCB 105	31	76	3	3	15
PCB 114	29	77	3	7	0
PCB 118	31	64	9	6	21
PCB 123	30	53	3	16	13
PCB 156	31	73	3	9	9
PCB 157	29	83	3	3	3
PCB 167	28	76	10	3	3
PCB 189	29	93	0	0	3
WHO_{1998}-TEQ_{PCB} LB (ND = 0)	30	100	0	0	0
WHO_{1998}-TEQ_{PCB} UB (ND = LOD)	30	100	0	0	0
WHO_{1998}-TEQ_{total} LB (ND = 0)	30	84	6	3	6
WHO_{1998}-TEQ_{total} UB (ND = LOD)	30	84	6	3	6

3.2.4 Polybrominated Diphenyl Ethers and Polybrominated Biphenyl

Table 34: Summary results for PBDE and PBB analyses - standard solution

Standard solution	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
PBDE 17	26	63.6	69.2	64	0.045	310	27	65
PBDE 28	40	123	135	123	0.090	560	32	72
PBDE 47	42	326	336	326	0.247	2600	28	69
PBDE 99	42	534	550	534	0.399	3100	22	64
PBDE 153	41	130	140	130	0.098	818	25	68
PBDE 154	41	135	140	135	0.097	1610	27	69
PBDE 183	39	67.4	69.8	67	0.040	779	39	69
PBDE 100	41	197	199	197	0.130	769	33	71
PBB 153	12	206	203	206	65.30	269	12	59

Table 35: Summary of laboratory performance for PBDE and PBB analyses - standard solution

Standard solution	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
PBDE 17	25	54	23	0	23
PBDE 28	38	58	18	8	18
PBDE 47	40	60	14	12	14
PBDE 99	40	60	10	19	12
PBDE 153	39	68	7	0	24
PBDE 154	39	63	10	7	20
PBDE 183	37	46	18	13	23
PBDE 100	39	54	15	15	17
PBB 153	11	67	17	17	0

Table 36: Summary results for PBDE and PBB analyses - sediment

Sediment	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
PBDE 17	21	0.34	0.34	0.3	0.010	3.69	40	67
PBDE 28	30	0.44	0.45	0.4	0.065	4.45	23	61
PBDE 47	30	2.81	2.84	2.8	0.582	64.9	18	61
PBDE 99	29	2.33	2.50	2.3	0.579	132	22	67
PBDE 153	29	0.48	0.49	0.5	0.050	1.93	22	63
PBDE 154	29	0.28	0.29	0.3	0.040	1.10	26	64
PBDE 183	27	0.27	0.28	0.3	0.040	1.80	42	70
PBDE 100	29	0.56	0.61	0.6	0.053	2.34	27	62
PBB 153	8	0.07	0.07	0.1	0.018	0.11	18	61

Table 37: Summary of laboratory performance for PBDE and PBB analyses - sediment

Sediment	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
PBDE 17	21	55	14	18	9
PBDE 28	29	63	3	17	17
PBDE 47	29	63	10	7	20
PBDE 99	28	72	3	7	17
PBDE 153	28	72	0	10	17
PBDE 154	28	66	3	21	10
PBDE 183	26	56	19	11	15
PBDE 100	28	66	3	7	24
PBB 153	8	88	13	0	0

Table 38: Summary results for PBDE and PBB analyses - fish (wet weight basis)

Fish	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
PBDE 17	16	0.03	0.02	0.0	0.006	0.08	88	81
PBDE 28	33	0.06	0.06	0.1	0.011	0.50	71	67
PBDE 47	34	2.21	2.40	2.2	0.090	15.8	51	73
PBDE 99	33	0.76	0.84	0.8	0.131	26.8	57	74
PBDE 153	32	0.19	0.22	0.2	0.033	1.50	57	70
PBDE 154	32	0.18	0.21	0.2	0.036	1.80	56	72
PBDE 183	18	NA	0.01	0.0	0.000	2.07	91	63
PBDE 100	33	0.69	0.75	0.7	0.107	4.80	63	72
PBB 153	8	0.04	0.05	0.0	0.032	0.07	25	76

Table 39: Summary of laboratory performance for PBDE and PBB analyses - fish

Fish	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
PBDE 17	16	82	6	6	0
PBDE 28	32	56	15	12	15
PBDE 47	32	35	21	24	21
PBDE 99	31	30	27	30	12
PBDE 153	31	42	30	6	18
PBDE 154	31	39	33	15	9
PBDE 183	26	0	0	0	0
PBDE 100	32	29	21	35	12
PBB 153	9	89	0	0	0

Table 40: Summary results for PBDE and PBB analyses - mothers' milk (wet weight basis)

Mothers' milk	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(ng /kg)					(%)	
PBDE 17	3	NA	1.21	0.3	0.137	211	230	46
PBDE 28	15	1.31	1.44	1.3	0.526	8219	52	68
PBDE 47	18	14.8	16.0	14.8	7.220	3145	31	73
PBDE 99	18	3.96	4.50	4.0	2.010	17857	45	69
PBDE 153	19	16.3	17.6	16.3	2.290	408	28	71
PBDE 154	14	0.32	0.42	0.3	0.069	9.34	81	67
PBDE 183	13	NA	1.48	1.1	0.180	47.8	80	67
PBDE 100	16	3.07	3.18	3.1	2.140	264	35	67
PBB 153	5	NA	1.43	1.3	0.060	3.00	132	88

Table 41: Summary of laboratory performance for PBDE analyses - mothers' milk

Mothers' milk	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
PBDE 17	10	0	0	0	0
PBDE 28	19	35	5	20	15
PBDE 47	21	55	9	9	9
PBDE 99	21	36	9	18	18
PBDE 153	21	64	5	5	14
PBDE 154	20	19	14	19	14
PBDE 183	18	0	0	0	0
PBDE 100	21	41	14	9	9
PBB 153	6	0	0	0	0

Table 42: Summary results for PBDE analyses - air extract

Air extract	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
PBDE 17	15	0.43	0.48	0.4	0.194	85.1	73	58
PBDE 28	20	2.06	2.26	2.1	0.249	316	49	61
PBDE 47	21	10.7	11.3	10.7	3.340	120	32	66
PBDE 99	21	4.21	4.66	4.2	0.507	60.1	44	62
PBDE 153	21	0.93	1.00	0.9	0.044	32.0	46	62
PBDE 154	20	0.95	1.01	1.0	0.023	16.0	39	64
PBDE 183	18	0.83	0.97	0.8	0.019	26.5	42	62
PBDE 100	19	0.46	0.47	0.5	0.083	4.80	54	71
PBB 153	0	NA	NA	NA	NA	NA	NA	NA

Table 43: Summary of laboratory performance for PBDE analyses - air extract

Air extract	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
PBDE 17	16	35	12	6	35
PBDE 28	20	38	10	19	29
PBDE 47	20	57	10	14	19
PBDE 99	20	57	0	5	38
PBDE 153	20	48	10	10	33
PBDE 154	19	50	10	15	25
PBDE 183	19	50	10	0	30
PBDE 100	19	45	10	25	15
PBB 153	3	0	0	0	0

3.2.5 Perfluorinated Alkyl Substances

Table 44: Summary results for PFASs analyses - standard solution

Standard solution	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
L-PFOS anion	22	175	176	175	12	210	8	73
PFOSA	13	320	320	320	255	446	3	65
PFBA	13	122	120	122	108	158	11	75
PFPeA	10	130	131	130	107	167	16	81
PFHxA	16	249	249	249	215	295	3	64
PFHpA	16	130	129	130	107	264	10	69
PFOA	18	128	128	128	106	142	9	80
PFNA	17	129	126	129	93	146	11	80
PFDA	17	247	250	247	220	288	5	64
PFUnDA	15	124	125	124	111	145	7	70
PFDoDA	12	128	125	128	112	190	13	73
PFTrDA	10	131	131	131	78	148	9	71
PFTeDA	10	136	139	136	105	159	14	78
L-PFBS	13	265	259	265	110	311	12	71
L-PFHxS	17	174	177	174	142	240	8	68
L-PFHpS	4	181	180	181	168	199	9	80
L-PFDS	11	172	173	172	160	203	8	78
MeFOSA	7	807	838	807	489	1300	41	78
EtFOSA	4	NA	1164	1035	596	2500	44	67
MeFOSE	5	NA	1207	1202	584	2500	3	56
EtFOSE	5	NA	658	632	599	1130	11	58

Table 45: Summary of laboratory performance for PFASs analyses - standard solution

Standard solution	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
L-PFOS anion	21	95	0	0	5
PFOSA	12	92	0	8	0
PFBA	12	92	8	0	0
PFPeA	10	90	10	0	0
PFHxA	15	100	0	0	0
PFHpA	15	88	6	0	6
PFOA	17	100	0	0	0
PFNA	16	94	6	0	0
PFDA	16	100	0	0	0
PFUnDA	14	100	0	0	0
PFDoDA	11	92	0	8	0
PFTrDA	10	90	0	10	0
PFTeDA	10	100	0	0	0
L-PFBS	12	85	0	15	0
L-PFHxS	16	94	0	6	0
L-PFHpS	4	100	0	0	0
L-PFDS	10	100	0	0	0
MeFOSA	7	57	0	43	0
EtFOSA	4	0	0	0	0
MeFOSE	5	0	0	0	0
EtFOSE	5	0	0	0	0

Table 46: Summary results for PFASs analyses - sediment

Sediment	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
L-PFOS anion	18	7.99	8.00	7.99	6.00	11.8	15	71
PFOSA	10	0.28	0.31	0.28	0.16	0.85	46	68

Table 47: Summary of laboratory performance for PFASs analyses - sediment

Sediment	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
L-PFOS anion	17	89	0	11	0
PFOSA	11	42	17	8	17

Table 48: Summary results for PFASs analyses - fish (wet weight basis)

Fish	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
L-PFOS anion	19	13.4	13.3	13.4	10.2	20.1	13	71
PFOSA	13	2.25	2.28	2.25	1.67	3.00	18	74

Table 49: Summary of laboratory performance for PFASs analyses - fish

Fish	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
L-PFOS anion	18	84	11	5	0
PFOSA	13	86	7	NA	NA

Table 50: Summary results for PFASs analyses - mothers' milk (wet weight basis)

Mothers' milk	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(ng /kg)					(%)	
L-PFOS anion	8	44.9	45.0	44.9	13.5	130	25	62
PFOSA	0	NA	NA	NA	NA	NA	NA	NA

Table 51: Summary of laboratory performance for PFASs analyses - mothers' milk

Mothers' milk	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
L-PFOS anion	8	63	0	25	13
PFOSA	3	0	0	0	0

Table 52: Summary results for PFASs analyses - human serum

Human serum	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(ng /kg)					(%)	
L-PFOS anion	8	7.89	7.85	7.89	5.53	12.51	34	76
PFOSA	0	NA	NA	NA	NA	0.00	NA	NA
PFBA	3	NA	2.60	2.63	2.23	3.10	19	86
PFPeA	0	NA	NA	NA	NA	NA	NA	NA
PFHxA	6	0.28	0.28	0.28	0.22	0.36	26	82
PFHpA	7	1.15	1.20	1.15	0.84	1.36	22	78
PFOA	9	72.7	71.0	72.7	50.5	80.0	10	75
PFNA	7	5.31	5.40	5.31	5.25	7.00	4	57
PFDA	7	3.44	3.40	3.44	3.16	4.60	10	72
PFUnDA	7	0.50	0.51	0.50	0.39	0.69	21	78
PFDoDA	7	0.67	0.71	0.67	0.56	1.07	26	83
PFTrDA	4	0.18	0.19	0.18	0.13	0.23	32	67
PFTeDA	5	NA	0.35	0.44	0.20	0.76	55	75
L-PFBS	2	NA	NA	NA	0.02	0.10	NA	NA
L-PFHxS	7	0.90	0.87	0.90	0.78	1.20	16	72
L-PFHpS	1	NA	NA	NA	0.29	0.29	NA	NA
L-PFDS	0	NA	NA	NA	0.00	0.00	NA	NA

Table 53: Summary of laboratory performance for PFASs analyses - human serum

Human serum	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		$\|z\| < 2$ Satisfactory	$3 > \|z\| > 2$ Questionable	$6 > \|z\| > 3$ Unsatisfactory	$\|z\| > 6$ Extreme
L-PFOS anion	8	50	25	25	0
PFOSA	4	0	0	0	0
PFBA	3	0	0	0	0
PFPeA	4	0	0	0	0
PFHxA	7	86	0	0	0
PFHpA	7	100	0	0	0
PFOA	9	89	11	0	0
PFNA	7	71	29	0	0
PFDA	7	86	14	0	0
PFUnDA	7	86	14	0	0
PFDoDA	7	86	0	14	0
PFTrDA	6	67	0	0	0
PFTeDA	6	0	0	0	0
L-PFBS	5	0	0	0	0
L-PFHxS	7	86	14	0	0
L-PFHpS	2	0	0	0	0
L-PFDS	3	0	0	0	0

Table 54: Summary results for PFASs analyses - air extract

Air extract	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
L-PFOS anion	8	10.7	11.9	10.7	4.74	99.2	39	59
PFOSA	7	6.40	6.00	6.40	0.15	9.32	27	60
MeFOSA	3	NA	23.5	23.0	18.0	26.6	19	82
EtFOSA	3	NA	27.3	27.5	19.0	27.8	2	64
MeFOSE	3	NA	63.4	62.6	53.9	68.0	11	79
EtFOSE	3	NA	61.7	62.3	51.5	63.0	3	64

Table 55: Summary of laboratory performance for PFASs analyses - air extract

Air extract	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
L-PFOS anion	9	44	11	11	22
PFOSA	7	57	0	29	14
MeFOSA	3	0	0	0	0
EtFOSA	3	0	0	0	0
MeFOSE	3	0	0	0	0
EtFOSE	3	0	0	0	0

Table 56: Summary results for PFASs analyses - water

Water	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(ng /kg)					(%)	
L-PFOS anion	20	4.28	4.34	4.28	3.20	31.0	21	65
PFOSA	5	NA	0.31	0.26	0.10	1.08	115	61

Table 57: Summary of laboratory performance for PFASs analyses - water

Water	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
L-PFOS anion	19	70	0	15	15
PFOSA	10	0	0	0	0

3.3 Regional Performance

3.3.1 Number of Reporting Laboratories

Table 58: Number of reporting laboratories for OCPs *per* region

OCPs Region	*Total*	Standard solution	Sediment	Fish	Mothers' milk	Air extract
ASIA-PACIFIC	25	24	17	16	10	11
WEOG	16	16	13	14	9	8
GRULAC	9	9	7	7	5	4
AFRICA	4	4	2	4	2	2
CEE	2	2	2	2	1	2
Total	56	55	41	43	27	27

Table 59: Number of reporting laboratories for indicator PCB *per* region

PCB Region	*Total*	Standard solution	Sediment	Fish	Mothers' milk	Air extract	Transformer oil
ASIA-PACIFIC	28	22	18	20	14	15	10
WEOG	21	20	15	17	12	14	7
GRULAC	9	9	8	6	5	3	2
AFRICA	4	3	2	4	2	2	1
CEE	3	2	2	2	1	3	2
Total	65	56	45	49	34	37	22

Table 60: Number of reporting laboratories for PCDD/PCDF *per* region

PCDD/PCDF Region	*Total*	Standard solution	Sediment	Fish	Mothers' milk	Air extract
ASIA-PACIFIC	31	27	21	22	18	22
WEOG	18	16	12	13	10	13
GRULAC	2	2	0	2	0	1
AFRICA	0	0	0	0	0	0
CEE	3	3	3	3	1	3
Total	54	48	36	40	29	39

Table 61: Number of reporting laboratories for dl-PCB *per* region

dl-PCB Region	*Total*	Standard solution	Sediment	Fish	Mothers' milk	Air extract
ASIA-PACIFIC	28	25	20	25	20	18
WEOG	21	18	14	15	11	13
GRULAC	2	2	0	2	0	1
AFRICA	0	0	0	0	0	0
CEE	3	3	3	3	1	3
Total	54	48	37	45	32	35

Table 62: Number of reporting laboratories for PBDE *per* region

PBDE Region	*Total*	Standard solution	Sediment	Fish	Mothers' milk	Air extract
ASIA-PACIFIC	22	23	15	22	13	10
WEOG	18	16	13	14	10	10
GRULAC	1	1	1	1	1	1
AFRICA	1	1	1	1	1	0
CEE	2	2	1	1	1	1
Total	44	43	31	39	26	22

Table 63: Number of reporting laboratories for PFASs *per* region

PFAS Region	*Total*	Standard solution	Sediment	Fish	Mothers' milk	Human serum	Air extract	Water
ASIA-PACIFIC	16	15	13	12	6	7	7	13
WEOG	15	11	9	10	6	6	6	12
GRULAC	0	0	0	0	0	0	0	0
AFRICA	0	0	0	0	0	0	0	0
CEE	0	0	0	0	0	0	0	0
Total	31	26	22	22	12	13	13	25

3.3.2 Summary of Laboratory Performances

3.3.2.1 OCPs

Table 64: Regional summary of laboratory performance for OCPs - standard solution

Standard solution	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
Aldrin	22	22	72	12	14	68	9	45	72	2	NA	NA	2	NA	NA
Dieldrin	19	19	74	11	19	75	9	52	73	2	NA	NA	1	NA	NA
Endrin	19	20	71	11	13	66	8	74	77	1	NA	NA	1	NA	NA
Endrin ketone	3	45	64	1	NA	NA	1	NA	NA	0	NA	NA	0	NA	NA
α-Chlordane	18	21	75	11	14	65	6	25	64	0	NA	NA	1	NA	NA
γ-Chlordane	17	23	78	11	10	71	7	64	82	1	NA	NA	1	NA	NA
Oxychlordane	13	13	75	11	19	76	4	34	57	0	NA	NA	1	NA	NA
cis-Nonachlor	14	17	80	8	36	81	5	111	72	0	NA	NA	1	NA	NA
trans-Nonachlor	14	15	73	10	23	64	5	100	67	0	NA	NA	1	NA	NA
Heptachlor	21	14	66	12	10	64	9	58	79	2	NA	NA	2	NA	NA
cis-Heptachlorepoxide	14	12	84	10	9	60	8	97	73	0	NA	NA	1	NA	NA
trans-Heptachlorepoxide	15	38	76	6	33	71	7	53	79	0	NA	NA	1	NA	NA
o,p'-DDT	22	19	69	11	9	58	5	17	60	1	NA	NA	2	NA	NA
p,p'-DDT	21	21	62	14	17	68	7	53	66	2	NA	NA	2	NA	NA
o,p'-DDD	21	19	69	11	5	69	7	63	82	1	NA	NA	2	NA	NA
p,p'-DDD	19	23	75	13	17	79	9	59	74	1	NA	NA	2	NA	NA
o,p'-DDE	19	11	60	12	6	69	7	72	82	1	NA	NA	2	NA	NA
p,p'-DDE	21	16	75	16	14	74	9	44	75	2	NA	NA	2	NA	NA
Hexachlorobenzene	18	13	67	16	21	74	7	59	66	1	NA	NA	2	NA	NA
Mirex	14	14	80	10	23	74	7	72	81	0	NA	NA	1	NA	NA
α-HCH	19	13	59	13	27	84	8	64	78	1	NA	NA	2	NA	NA
β-HCH	19	19	69	13	20	74	8	59	76	2	NA	NA	2	NA	NA
γ-HCH	19	13	64	13	21	76	9	72	75	1	NA	NA	2	NA	NA
α-Endosulfan	16	21	74	11	19	57	6	24	61	2	NA	NA	1	NA	NA
β-Endosulfan	15	22	74	9	48	72	6	24	73	1	NA	NA	1	NA	NA
Endosulfan sulfate	8	75	66	10	30	67	5	17	53	1	NA	NA	0	NA	NA
Chlordecone	2	NA	NA	2	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
Pentachlorobenzene	10	9	74	9	29	78	1	NA	NA	0	NA	NA	1	NA	NA

Table 65: Regional summary of laboratory performance for OCPs - sediment

Standard solution	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
Aldrin	11	119	77	7	78	65	4	27	54	2	NA	NA	0	NA	NA
Dieldrin	8	46	74	9	61	79	5	20	59	2	NA	NA	0	NA	NA
Endrin	4	19	66	4	104	45	4	58	66	1	NA	NA	0	NA	NA
Endrin ketone	1	NA	NA	2	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
α-Chlordane	8	89	64	3	55	88	0	NA	NA	0	NA	NA	1	NA	NA
γ-Chlordane	8	78	77	4	23	47	0	NA	NA	1	NA	NA	1	NA	NA
Oxychlordane	2	NA	NA	0	NA	NA	2	NA	NA	0	NA	NA	0	NA	NA
cis-Nonachlor	6	49	72	3	84	48	2	NA	NA	0	NA	NA	1	NA	NA
trans-Nonachlor	5	16	58	3	29	65	2	NA	NA	0	NA	NA	1	NA	NA
Heptachlor	2	NA	NA	3	582	43	2	NA	NA	2	NA	NA	0	NA	NA
cis-Heptachlorepoxide	4	228	52	1	NA	NA	1	NA	NA	1	NA	NA	0	NA	NA
trans-Heptachlorepoxide	4	131	54	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
o,p'-DDT	9	160	61	3	1	48	3	69	56	0	NA	NA	0	NA	NA
p,p'-DDT	9	106	71	8	69	74	5	42	71	1	NA	NA	1	NA	NA
o,p'-DDD	8	72	76	8	49	64	3	19	48	0	NA	NA	1	NA	NA
p,p'-DDD	10	93	79	10	43	74	4	57	51	2	NA	NA	1	NA	NA
o,p'-DDE	10	93	65	8	12	53	2	NA	NA	0	NA	NA	2	NA	NA
p,p'-DDE	11	31	53	11	10	66	2	NA	NA	1	NA	NA	2	NA	NA
Hexachlorobenzene	9	22	60	12	29	69	5	6	48	0	NA	NA	2	NA	NA
Mirex	8	15	65	8	12	61	6	72	69	0	NA	NA	2	NA	NA
α-HCH	8	38	55	8	72	62	4	79	75	0	NA	NA	0	NA	NA
β-HCH	10	70	69	7	43	76	3	103	89	1	NA	NA	0	NA	NA
γ-HCH	9	71	75	8	60	69	4	75	82	1	NA	NA	0	NA	NA
α-Endosulfan	6	80	69	0	NA	NA	1	NA	NA	1	NA	NA	0	NA	NA
β-Endosulfan	7	131	65	1	NA	NA	2	NA	NA	1	NA	NA	0	NA	NA
Endosulfan sulfate	3	127	67	3	132	64	1	NA	NA	2	NA	NA	0	NA	NA
Chlordecone	2	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
Pentachlorobenzene	4	23	78	9	22	61	1	NA	NA	0	NA	NA	1	NA	NA

Table 66: Regional summary of laboratory performance for OCPs - fish

Fish	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
Aldrin	6	218	60	4	165	47	2	NA	NA	1	NA	NA	0	NA	NA
Dieldrin	9	46	77	7	133	66	2	NA	NA	1	NA	NA	0	NA	NA
Endrin	4	68	66	1	NA	NA	3	51	80	3	233	64	0	NA	NA
Endrin ketone	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
α-Chlordane	15	42	86	9	99	79	1	NA	NA	0	NA	NA	1	NA	NA
γ-Chlordane	15	31	61	9	102	79	1	NA	NA	2	NA	NA	1	NA	NA
Oxychlordane	5	102	58	1	NA	NA	1	NA	NA	0	NA	NA	0	NA	NA
cis-Nonachlor	6	29	63	3	122	64	0	NA	NA	0	NA	NA	0	NA	NA
trans-Nonachlor	12	53	80	9	96	81	1	NA	NA	0	NA	NA	1	NA	NA
Heptachlor	2	NA	NA	0	NA	NA	2	NA	NA	2	NA	NA	0	NA	NA
cis-Heptachlorepoxide	11	51	86	8	113	69	3	87	64	1	NA	NA	0	NA	NA
trans-Heptachlorepoxide	2	NA	NA	1	NA	NA	2	NA	NA	0	NA	NA	0	NA	NA
o,p'-DDT	3	38	49	1	NA	NA	2	NA	NA	1	NA	NA	2	NA	NA
p,p'-DDT	7	197	73	1	NA	NA	2	NA	NA	2	NA	NA	2	NA	NA
o,p'-DDD	14	33	71	9	114	72	2	NA	NA	1	NA	NA	2	NA	NA
p,p'-DDD	15	32	73	11	95	80	2	NA	NA	3	2	64	2	NA	NA
o,p'-DDE	7	61	61	8	87	57	2	NA	NA	1	NA	NA	2	NA	NA
p,p'-DDE	15	35	80	13	58	67	3	28	48	3	126	86	2	NA	NA
Hexachlorobenzene	13	41	79	11	71	78	3	121	55	1	NA	NA	2	NA	NA
Mirex	11	51	74	8	90	61	1	NA	NA	1	NA	NA	1	NA	NA
α-HCH	9	61	68	8	76	71	3	28	74	1	NA	NA	0	NA	NA
β-HCH	12	38	80	8	65	69	0	NA	NA	2	NA	NA	0	NA	NA
γ-HCH	7	36	64	3	491	42	2	NA	NA	2	NA	NA	0	NA	NA
α-Endosulfan	2	NA	NA	1	NA	NA	0	NA	NA	2	NA	NA	0	NA	NA
β-Endosulfan	1	NA	NA	1	NA	NA	0	NA	NA	1	NA	NA	0	NA	NA
Endosulfan sulfate	1	NA	NA	1	NA	NA	0	NA	NA	2	NA	NA	0	NA	NA
Chlordecone	1	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
Pentachlorobenzene	6	3	83	8	120	60	1	NA	NA	0	NA	NA	1	NA	NA

Table 67: Regional summary of laboratory performance for OCPs - mothers' milk

Mothers' milk	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
Aldrin	1	NA	NA	1	NA	NA	0	NA	NA	1	NA	NA	0	NA	NA
Dieldrin	5	24	64	3	33	69	1	NA	NA	1	NA	NA	0	NA	NA
Endrin	2	NA	NA	0	NA	NA	0	NA	NA	2	NA	NA	0	NA	NA
Endrin ketone	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
α-Chlordane	5	179	54	0	NA	NA	1	NA	NA	0	NA	NA	0	NA	NA
γ-Chlordane	3	89	57	0	NA	NA	0	NA	NA	1	NA	NA	0	NA	NA
Oxychlordane	7	65	88	3	76	89	0	NA	NA	0	NA	NA	0	NA	NA
cis-Nonachlor	7	26	60	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
trans-Nonachlor	7	4	69	4	38	63	1	NA	NA	0	NA	NA	1	NA	NA
Heptachlor	3	263	40	0	NA	NA	0	NA	NA	1	NA	NA	0	NA	NA
cis-Heptachlorepoxide	7	6	73	2	NA	NA	1	NA	NA	1	NA	NA	0	NA	NA
trans-Heptachlorepoxide	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
o,p'-DDT	4	8	67	1	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
p,p'-DDT	5	7	72	4	33	64	0	NA	NA	0	NA	NA	1	NA	NA
o,p'-DDD	2	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
p,p'-DDD	5	87	67	2	NA	NA	2	NA	NA	1	NA	NA	0	NA	NA
o,p'-DDE	4	24	67	2	NA	NA	0	NA	NA	1	NA	NA	0	NA	NA
p,p'-DDE	9	17	71	8	39	76	1	NA	NA	2	NA	NA	1	NA	NA
Hexachlorobenzene	8	78	82	9	33	81	2	NA	NA	0	NA	NA	1	NA	NA
Mirex	7	10	68	3	56	55	0	NA	NA	1	NA	NA	0	NA	NA
α-HCH	9	121	73	0	NA	NA	0	NA	NA	1	NA	NA	0	NA	NA
β-HCH	8	24	75	4	19	67	0	NA	NA	1	NA	NA	0	NA	NA
γ-HCH	8	75	70	2	NA	NA	0	NA	NA	2	NA	NA	0	NA	NA
α-Endosulfan	4	82	67	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
β-Endosulfan	1	NA	NA	0	NA	NA	0	NA	NA	1	NA	NA	0	NA	NA
Endosulfan sulfate	1	NA	NA	0	NA	NA	0	NA	NA	1	NA	NA	0	NA	NA
Chlordecone	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
Pentachlorobenzene	6	17	69	3	147	64	1	NA	NA	0	NA	NA	0	NA	NA

Table 68: Regional summary of laboratory performance for OCPs - air extract

Air extract	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
Aldrin	9	5	56	4	51	58	4	77	83	1	NA	NA	1	NA	NA
Dieldrin	6	4	62	4	17	45	2	NA	NA	1	NA	NA	1	NA	NA
Endrin	7	62	77	4	19	57	3	69	66	1	NA	NA	0	NA	NA
Endrin ketone	1	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
α-Chlordane	10	13	68	6	8	62	2	NA	NA	0	NA	NA	1	NA	NA
γ-Chlordane	10	5	59	6	17	72	2	NA	NA	1	NA	NA	1	NA	NA
Oxychlordane	5	4	65	3	11	51	1	NA	NA	0	NA	NA	1	NA	NA
cis-Nonachlor	7	15	79	4	13	53	2	NA	NA	0	NA	NA	1	NA	NA
trans-Nonachlor	7	8	66	5	4	48	2	NA	NA	0	NA	NA	1	NA	NA
Heptachlor	9	13	61	5	70	65	3	46	58	1	NA	NA	2	NA	NA
cis-Heptachlorepoxide	6	8	65	4	22	65	4	58	67	0	NA	NA	0	NA	NA
trans-Heptachlorepoxide	5	11	51	1	NA	NA	3	9	64	0	NA	NA	1	NA	NA
o,p'-DDT	9	66	78	6	6	52	2	NA	NA	1	NA	NA	1	NA	NA
p,p'-DDT	9	82	80	6	6	53	3	5	48	1	NA	NA	2	NA	NA
o,p'-DDD	9	15	52	5	4	51	2	NA	NA	0	NA	NA	2	NA	NA
p,p'-DDD	9	37	57	5	15	42	3	65	56	0	NA	NA	2	NA	NA
o,p'-DDE	9	17	58	7	15	60	2	NA	NA	0	NA	NA	2	NA	NA
p,p'-DDE	9	21	59	7	12	54	3	5	48	1	NA	NA	2	NA	NA
Hexachlorobenzene	9	41	84	7	44	84	4	87	67	1	NA	NA	2	NA	NA
Mirex	7	16	56	5	38	65	3	6	48	0	NA	NA	2	NA	NA
α-HCH	8	15	70	5	41	64	3	109	64	0	NA	NA	0	NA	NA
β-HCH	5	11	71	4	7	54	3	13	48	0	NA	NA	0	NA	NA
γ-HCH	7	4	49	5	28	61	3	58	64	1	NA	NA	0	NA	NA
α-Endosulfan	6	82	85	3	28	41	2	NA	NA	1	NA	NA	0	NA	NA
β-Endosulfan	4	45	66	3	44	48	1	NA	NA	0	NA	NA	0	NA	NA
Endosulfan sulfate	3	3	48	3	14	64	1	NA	NA	1	NA	NA	0	NA	NA
Chlordecone	1	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
Pentachlorobenzene	4	4	67	5	28	84	0	NA	NA	0	NA	NA	1	NA	NA

3.3.2.2 PCB

Table 69: Regional summary of laboratory performance for indicator PCB - standard solution

Standard solution	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
PCB 28	18	21	75	17	32	77	7	10	55	0	NA	NA	2	NA	NA
PCB 52	20	22	66	17	18	64	7	6	53	0	NA	NA	2	NA	NA
PCB 101	20	30	70	17	21	69	7	8	55	1	NA	NA	2	NA	NA
PCB 138	20	19	66	18	29	76	7	34	58	0	NA	NA	2	NA	NA
PCB 153	18	23	70	18	20	74	7	16	59	1	NA	NA	2	NA	NA
PCB 180	18	14	65	18	20	73	7	10	54	0	NA	NA	2	NA	NA
Sum Indicator PCB LB (ND = 0)	18	16	64	15	19	68	5	2	58	1	NA	NA	2	NA	NA
Sum Indicator PCB UB (ND = LOD)	15	14	63	15	19	68	5	2	58	1	NA	NA	2	NA	NA

Table 70: Regional summary of laboratory performance for indicator PCB - sediment

Sediment	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
PCB 28	14	34	80	13	17	62	6	57	59	0	NA	NA	2	NA	NA
PCB 52	14	20	74	13	10	65	6	60	66	0	NA	NA	2	NA	NA
PCB 101	14	18	65	13	5	60	7	61	87	1	NA	NA	2	NA	NA
PCB 138	14	43	74	13	26	68	6	44	59	2	NA	NA	2	NA	NA
PCB 153	15	45	74	13	16	82	7	84	79	1	NA	NA	2	NA	NA
PCB 180	14	32	77	13	11	61	7	41	57	1	NA	NA	2	NA	NA
Sum Indicator PCB LB (ND = 0)	13	26	72	12	12	65	7	50	81	0	NA	NA	2	NA	NA
Sum Indicator PCB UB (ND = LOD)	10	24	75	12	12	65	7	40	76	0	NA	NA	2	NA	NA

Table 71: Regional summary of laboratory performance for indicator PCB - fish

Fish	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
PCB 28	17	31	77	16	68	76	3	26	48	3	201	66	2	NA	NA
PCB 52	18	25	68	16	47	71	3	123	48	3	243	64	2	NA	NA
PCB 101	18	50	79	16	42	71	4	137	54	3	147	71	2	NA	NA
PCB 138	18	33	65	16	57	75	4	98	53	3	245	64	2	NA	NA
PCB 153	18	21	59	16	35	67	4	100	53	3	158	69	2	NA	NA
PCB 180	18	30	66	16	69	82	3	43	48	1	NA	NA	2	NA	NA
Sum Indicator PCB LB (ND = 0)	16	18	68	15	41	64	3	31	64	1	NA	NA	2	NA	NA
Sum Indicator PCB UB (ND = LOD)	15	19	67	15	41	64	3	31	64	1	NA	NA	2	NA	NA

Table 72: Regional summary of laboratory performance for indicator PCB - mothers' milk

Mothers' milk	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
PCB 28	12	16	65	10	50	75	0	NA	NA	1	NA	NA	1	NA	NA
PCB 52	11	40	68	8	93	63	1	NA	NA	1	NA	NA	1	NA	NA
PCB 101	12	43	67	8	79	63	2	NA	NA	1	NA	NA	1	NA	NA
PCB 138	12	14	63	11	33	74	2	NA	NA	2	NA	NA	1	NA	NA
PCB 153	12	11	64	11	15	76	1	NA	NA	2	NA	NA	1	NA	NA
PCB 180	12	7	61	11	10	72	1	NA	NA	1	NA	NA	1	NA	NA
Sum Indicator PCB LB (ND = 0)	12	11	67	10	15	71	1	NA	NA	0	NA	NA	1	NA	NA
Sum Indicator PCB UB (ND = LOD)	11	8	67	10	18	75	1	NA	NA	0	NA	NA	1	NA	NA

Table 73: Regional summary of laboratory performance for indicator PCB - air extract

Air extract	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
PCB 28	11	118	57	10	47	76	0	NA	NA	1	NA	NA	1	NA	NA
PCB 52	9	78	54	10	49	69	3	213	64	0	NA	NA	1	NA	NA
PCB 101	11	98	82	10	38	71	2	NA	NA	0	NA	NA	1	NA	NA
PCB 138	11	101	72	10	29	70	2	NA	NA	0	NA	NA	1	NA	NA
PCB 153	11	112	73	10	43	67	2	NA	NA	0	NA	NA	1	NA	NA
PCB 180	11	63	75	11	43	68	2	NA	NA	0	NA	NA	1	NA	NA
Sum Indicator PCB LB (ND = 0)	9	107	79	11	23	63	1	NA	NA	0	NA	NA	1	NA	NA
Sum Indicator PCB UB (ND = LOD)	9	99	89	12	44	63	1	NA	NA	1	NA	NA	1	NA	NA

Table 74: Regional summary of laboratory performance for indicator PCB - transformer oil

Transformer oil	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
PCB 28	8	81	76	6	29	68	2	NA	NA	1	NA	NA	1	NA	NA
PCB 52	8	21	60	6	8	61	2	NA	NA	1	NA	NA	1	NA	NA
PCB 101	8	56	78	6	15	71	2	NA	NA	1	NA	NA	1	NA	NA
PCB 138	8	37	70	6	29	69	2	NA	NA	1	NA	NA	1	NA	NA
PCB 153	8	34	72	6	21	78	2	NA	NA	1	NA	NA	1	NA	NA
PCB 180	8	40	78	6	12	67	2	NA	NA	1	NA	NA	1	NA	NA
Sum Indicator PCB LB (ND = 0)	6	28	73	6	19	72	1	NA	NA	0	NA	NA	1	NA	NA
Sum Indicator PCB UB (ND = LOD)	6	48	74	6	19	72	1	NA	NA	0	NA	NA	1	NA	NA

3.3.2.3 dl-POPs

Table 75: Regional summary of laboratory performance for dl-POPs - standard solution

Standard solution	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
2,3,7,8-TeCDD	27	12	62	16	10	62	2	NA	NA	0	NA	NA	2	NA	NA
1,2,3,7,8-PnCDD	27	12	71	16	6	63	2	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,7,8-HxCDD	27	13	70	16	16	66	2	NA	NA	0	NA	NA	2	NA	NA
1,2,3,6,7,8-HxCDD	27	17	73	16	19	70	2	NA	NA	0	NA	NA	2	NA	NA
1,2,3,7,8,9-HxCDD	27	22	78	16	15	70	2	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,6,7,8-HpCDD	27	8	61	16	12	63	2	NA	NA	0	NA	NA	2	NA	NA
OCDD	27	16	71	16	16	74	2	NA	NA	0	NA	NA	2	NA	NA
2,3,7,8-TeCDF	27	9	63	16	13	65	2	NA	NA	0	NA	NA	2	NA	NA
1,2,3,7,8-PnCDF	27	12	69	16	16	71	2	NA	NA	0	NA	NA	2	NA	NA
2,3,4,7,8-PnCDF	27	12	70	16	8	64	2	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,7,8-HxCDF	27	13	70	16	13	69	2	NA	NA	0	NA	NA	2	NA	NA
1,2,3,6,7,8-HxCDF	27	13	70	16	13	67	2	NA	NA	0	NA	NA	2	NA	NA
1,2,3,7,8,9-HxCDF	27	22	60	16	8	57	2	NA	NA	0	NA	NA	2	NA	NA
2,3,4,6,7,8-HxCDF	27	31	77	16	6	61	2	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,6,7,8-HpCDF	27	16	73	16	13	65	2	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,7,8,9-HpCDF	27	15	72	16	6	62	2	NA	NA	0	NA	NA	2	NA	NA
OCDF	27	23	74	16	10	60	2	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND=0)	27	9	68	15	7	58	2	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND=LOD)	27	9	68	15	7	58	2	NA	NA	0	NA	NA	2	NA	NA
PCB 77	25	21	70	18	22	74	2	NA	NA	0	NA	NA	3	26	80
PCB 81	24	18	66	17	15	63	2	NA	NA	0	NA	NA	3	1	64
PCB 126	25	23	69	18	24	76	2	NA	NA	0	NA	NA	3	17	73
PCB 169	25	20	71	18	28	79	2	NA	NA	0	NA	NA	3	9	65
PCB 105	25	21	73	16	25	72	2	NA	NA	0	NA	NA	3	3	64
PCB 114	25	11	58	16	19	69	2	NA	NA	0	NA	NA	3	2	64
PCB 118	25	22	72	16	16	70	2	NA	NA	0	NA	NA	3	3	64
PCB 123	25	17	69	16	23	70	2	NA	NA	0	NA	NA	3	15	87
PCB 156	25	17	66	16	27	69	2	NA	NA	0	NA	NA	3	6	64
PCB 157	23	16	67	15	23	71	2	NA	NA	0	NA	NA	3	2	64
PCB 167	25	20	69	16	19	67	2	NA	NA	0	NA	NA	3	5	64
PCB 189	23	19	71	16	21	71	2	NA	NA	0	NA	NA	3	8	71
WHO_{1998}-TEQ_{PCB} LB (ND=0)	25	23	70	15	25	74	2	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-TEQ_{PCB} UB (ND=LOD)	25	23	70	15	25	74	2	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-TEQ_{total} LB (ND=0)	25	14	68	14	11	61	2	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-TEQ_{total} UB (ND=LOD)	25	14	68	14	11	61	2	NA	NA	0	NA	NA	2	NA	NA

Table 76: Regional summary of laboratory performance for dl-POPs - sediment

Sediment	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
2,3,7,8-TeCDD	20	14	71	12	22	79	0	NA	NA	0	NA	NA	2	NA	NA
1,2,3,7,8-PnCDD	20	35	67	12	16	67	0	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,7,8-HxCDD	19	28	72	12	6	69	0	NA	NA	0	NA	NA	2	NA	NA
1,2,3,6,7,8-HxCDD	20	19	72	12	10	74	0	NA	NA	0	NA	NA	2	NA	NA
1,2,3,7,8,9-HxCDD	19	30	64	12	5	63	0	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,6,7,8-HpCDD	20	18	69	12	13	74	0	NA	NA	0	NA	NA	2	NA	NA
OCDD	20	18	72	12	20	72	0	NA	NA	0	NA	NA	2	NA	NA
2,3,7,8-TeCDF	20	14	67	11	8	67	0	NA	NA	0	NA	NA	2	NA	NA
1,2,3,7,8-PnCDF	20	18	71	12	6	72	0	NA	NA	0	NA	NA	2	NA	NA
2,3,4,7,8-PnCDF	20	26	73	12	12	76	0	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,7,8-HxCDF	20	23	74	12	11	69	0	NA	NA	0	NA	NA	2	NA	NA
1,2,3,6,7,8-HxCDF	20	21	65	12	5	67	0	NA	NA	0	NA	NA	2	NA	NA
1,2,3,7,8,9-HxCDF	19	112	80	11	44	54	0	NA	NA	0	NA	NA	2	NA	NA
2,3,4,6,7,8-HxCDF	20	47	73	12	29	84	0	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,6,7,8-HpCDF	20	24	74	12	28	86	0	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,7,8,9-HpCDF	20	20	72	12	9	73	0	NA	NA	0	NA	NA	2	NA	NA
OCDF	20	25	70	12	17	81	0	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND=0)	20	17	68	12	8	79	0	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND=LOD)	20	16	66	12	8	80	0	NA	NA	0	NA	NA	2	NA	NA
PCB 77	16	20	69	12	9	75	0	NA	NA	0	NA	NA	2	NA	NA
PCB 81	17	89	69	12	14	58	0	NA	NA	0	NA	NA	1	NA	NA
PCB 126	18	43	63	12	8	55	0	NA	NA	0	NA	NA	2	NA	NA
PCB 169	14	22	61	12	10	58	0	NA	NA	0	NA	NA	1	NA	NA
PCB 105	16	17	66	13	12	70	0	NA	NA	0	NA	NA	3	55	89
PCB 114	15	33	59	12	17	66	0	NA	NA	0	NA	NA	2	NA	NA
PCB 118	16	20	66	13	12	80	0	NA	NA	0	NA	NA	3	27	64
PCB 123	15	142	67	10	43	52	0	NA	NA	0	NA	NA	3	108	80
PCB 156	18	23	62	13	22	84	0	NA	NA	0	NA	NA	3	15	87
PCB 157	16	34	61	12	7	65	0	NA	NA	0	NA	NA	3	24	64
PCB 167	16	22	67	13	15	74	0	NA	NA	0	NA	NA	3	78	71
PCB 189	16	28	70	13	16	75	0	NA	NA	0	NA	NA	3	81	83
WHO_{1998}-TEQ_{PCB} LB (ND=0)	18	27	58	13	22	70	0	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-TEQ_{PCB} UB (ND=LOD)	18	27	58	13	22	72	0	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-TEQ_{total} LB (ND=0)	18	23	60	12	4	62	0	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-TEQ_{total} UB (ND=LOD)	18	25	63	12	4	62	0	NA	NA	0	NA	NA	2	NA	NA

Table 77: Regional summary of laboratory performance for indicator PCB - fish

Fish	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
2,3,7,8-TeCDD	20	23	67	11	46	64	1	NA	NA	0	NA	NA	0	NA	NA
1,2,3,7,8-PnCDD	15	60	62	10	62	71	1	NA	NA	0	NA	NA	0	NA	NA
1,2,3,4,7,8-HxCDD	10	199	50	17	19	69	1	NA	NA	0	NA	NA	0	NA	NA
1,2,3,6,7,8-HxCDD	14	66	59	7	186	58	1	NA	NA	0	NA	NA	0	NA	NA
1,2,3,7,8,9-HxCDD	12	151	54	5	180	55	1	NA	NA	0	NA	NA	0	NA	NA
1,2,3,4,6,7,8-HpCDD	15	138	62	10	106	69	1	NA	NA	0	NA	NA	0	NA	NA
OCDD	18	115	67	11	66	70	1	NA	NA	0	NA	NA	1	NA	NA
2,3,7,8-TeCDF	21	22	65	12	62	67	1	NA	NA	0	NA	NA	2	NA	NA
1,2,3,7,8-PnCDF	20	44	66	11	5	48	1	NA	NA	0	NA	NA	2	NA	NA
2,3,4,7,8-PnCDF	20	29	59	11	71	78	1	NA	NA	0	NA	NA	1	NA	NA
1,2,3,4,7,8-HxCDF	18	34	58	11	61	73	1	NA	NA	0	NA	NA	1	NA	NA
1,2,3,6,7,8-HxCDF	17	105	58	9	97	69	1	NA	NA	0	NA	NA	0	NA	NA
1,2,3,7,8,9-HxCDF	11	158	56	3	268	42	1	NA	NA	0	NA	NA	0	NA	NA
2,3,4,6,7,8-HxCDF	11	145	55	6	124	55	1	NA	NA	0	NA	NA	0	NA	NA
1,2,3,4,6,7,8-HpCDF	16	185	57	6	73	55	1	NA	NA	0	NA	NA	0	NA	NA
1,2,3,4,7,8,9-HpCDF	13	137	54	4	293	44	1	NA	NA	0	NA	NA	0	NA	NA
OCDF	13	124	52	8	128	60	1	NA	NA	0	NA	NA	0	NA	NA
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND=0)	21	36	66	13	118	81	2	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND=LOD)	20	35	62	13	42	62	2	NA	NA	0	NA	NA	2	NA	NA
PCB 77	20	26	68	13	43	65	2	NA	NA	0	NA	NA	2	NA	NA
PCB 81	20	96	66	9	127	75	1	NA	NA	0	NA	NA	1	NA	NA
PCB 126	20	27	67	13	71	64	2	NA	NA	0	NA	NA	1	NA	NA
PCB 169	16	48	68	10	76	73	1	NA	NA	0	NA	NA	1	NA	NA
PCB 105	22	35	68	14	25	63	2	NA	NA	0	NA	NA	3	59	64
PCB 114	19	19	63	14	87	71	2	NA	NA	0	NA	NA	2	NA	NA
PCB 118	19	33	73	14	24	63	2	NA	NA	0	NA	NA	3	9	64
PCB 123	21	54	58	13	128	64	2	NA	NA	0	NA	NA	2	NA	NA
PCB 156	20	17	67	14	29	68	2	NA	NA	0	NA	NA	3	79	65
PCB 157	20	25	61	13	43	69	2	NA	NA	0	NA	NA	2	NA	NA
PCB 167	20	29	72	14	16	66	2	NA	NA	0	NA	NA	3	45	64
PCB 189	20	28	68	14	12	59	2	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-TEQ_{PCB} LB (ND=0)	22	29	71	15	76	79	2	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-TEQ_{PCB} UB (ND=LOD)	21	29	71	15	50	65	2	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-TEQ_{total} LB (ND=0)	22	33	69	14	83	71	1	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-TEQ_{total} UB (ND=LOD)	21	37	68	14	71	69	2	NA	NA	0	NA	NA	2	NA	NA

Table 78: Regional summary of laboratory performance for dl-POPs - mothers' milk

Mothers' milk	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
2,3,7,8-TeCDD	11	77	69	7	18	56	0	NA	NA	0	NA	NA	0	NA	NA
1,2,3,7,8-PnCDD	16	27	70	9	26	53	0	NA	NA	0	NA	NA	0	NA	NA
1,2,3,4,7,8-HxCDD	12	66	63	7	121	80	0	NA	NA	0	NA	NA	0	NA	NA
1,2,3,6,7,8-HxCDD	16	28	68	11	7	54	0	NA	NA	0	NA	NA	0	NA	NA
1,2,3,7,8,9-HxCDD	13	28	58	8	51	74	0	NA	NA	0	NA	NA	0	NA	NA
1,2,3,4,6,7,8-HpCDD	16	39	71	11	34	82	0	NA	NA	0	NA	NA	0	NA	NA
OCDD	17	17	69	10	10	57	0	NA	NA	0	NA	NA	1	NA	NA
2,3,7,8-TeCDF	16	67	79	7	74	68	0	NA	NA	0	NA	NA	0	NA	NA
1,2,3,7,8-PnCDF	14	38	66	5	89	57	0	NA	NA	0	NA	NA	0	NA	NA
2,3,4,7,8-PnCDF	17	17	67	10	26	73	0	NA	NA	0	NA	NA	1	NA	NA
1,2,3,4,7,8-HxCDF	17	27	63	10	47	74	0	NA	NA	0	NA	NA	1	NA	NA
1,2,3,6,7,8-HxCDF	17	18	63	11	22	64	0	NA	NA	0	NA	NA	1	NA	NA
1,2,3,7,8,9-HxCDF	9	95	64	4	209	51	0	NA	NA	0	NA	NA	0	NA	NA
2,3,4,6,7,8-HxCDF	14	74	60	9	46	74	0	NA	NA	0	NA	NA	1	NA	NA
1,2,3,4,6,7,8-HpCDF	16	43	65	11	29	73	0	NA	NA	0	NA	NA	1	NA	NA
1,2,3,4,7,8,9-HpCDF	11	132	54	5	100	59	0	NA	NA	0	NA	NA	0	NA	NA
OCDF	9	132	57	8	85	70	0	NA	NA	0	NA	NA	0	NA	NA
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND=0)	17	11	64	11	47	76	0	NA	NA	0	NA	NA	1	NA	NA
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND=LOD)	16	14	69	11	31	71	0	NA	NA	0	NA	NA	1	NA	NA
PCB 77	15	75	78	6	72	51	0	NA	NA	0	NA	NA	0	NA	NA
PCB 81	12	87	82	5	99	66	0	NA	NA	0	NA	NA	0	NA	NA
PCB 126	16	25	78	11	33	82	0	NA	NA	0	NA	NA	0	NA	NA
PCB 169	15	54	75	10	19	63	0	NA	NA	0	NA	NA	0	NA	NA
PCB 105	16	17	68	12	11	63	0	NA	NA	0	NA	NA	0	NA	NA
PCB 114	16	20	82	12	13	70	0	NA	NA	0	NA	NA	0	NA	NA
PCB 118	16	19	73	12	13	69	0	NA	NA	0	NA	NA	0	NA	NA
PCB 123	16	17	61	11	30	63	0	NA	NA	0	NA	NA	1	NA	NA
PCB 156	16	12	65	12	13	70	0	NA	NA	0	NA	NA	1	NA	NA
PCB 157	16	24	74	12	17	76	0	NA	NA	0	NA	NA	1	NA	NA
PCB 167	16	20	75	12	11	65	0	NA	NA	0	NA	NA	1	NA	NA
PCB 189	16	21	74	12	11	71	0	NA	NA	0	NA	NA	0	NA	NA
WHO_{1998}-TEQ_{PCB} LB (ND=0)	16	20	67	11	26	81	0	NA	NA	0	NA	NA	1	NA	NA
WHO_{1998}-TEQ_{PCB} UB (ND=LOD)	15	18	67	11	26	82	0	NA	NA	0	NA	NA	1	NA	NA
WHO_{1998}-TEQ_{total} LB (ND=0)	16	23	76	11	26	73	0	NA	NA	0	NA	NA	1	NA	NA
WHO_{1998}-TEQ_{total} UB (ND=LOD)	15	21	71	11	27	77	0	NA	NA	0	NA	NA	1	NA	NA

Table 79: Regional summary of laboratory performance for dl-POPs - air extract

Air extract	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
2,3,7,8-TeCDD	22	12	63	12	13	63	1	NA	NA	0	NA	NA	2	NA	NA
1,2,3,7,8-PnCDD	22	19	72	12	9	62	1	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,7,8-HxCDD	22	10	68	12	7	63	1	NA	NA	0	NA	NA	2	NA	NA
1,2,3,6,7,8-HxCDD	22	11	66	12	13	74	1	NA	NA	0	NA	NA	2	NA	NA
1,2,3,7,8,9-HxCDD	22	11	64	12	11	66	1	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,6,7,8-HpCDD	22	4	63	12	7	74	1	NA	NA	0	NA	NA	2	NA	NA
OCDD	22	8	70	12	8	73	1	NA	NA	0	NA	NA	2	NA	NA
2,3,7,8-TeCDF	22	11	73	12	9	69	0	NA	NA	0	NA	NA	2	NA	NA
1,2,3,7,8-PnCDF	22	19	75	12	8	58	1	NA	NA	0	NA	NA	2	NA	NA
2,3,4,7,8-PnCDF	22	26	76	12	24	81	1	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,7,8-HxCDF	22	16	69	12	12	77	0	NA	NA	0	NA	NA	2	NA	NA
1,2,3,6,7,8-HxCDF	22	8	67	12	6	67	1	NA	NA	0	NA	NA	2	NA	NA
1,2,3,7,8,9-HxCDF	22	134	74	12	65	62	1	NA	NA	0	NA	NA	2	NA	NA
2,3,4,6,7,8-HxCDF	22	13	66	12	14	72	1	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,6,7,8-HpCDF	22	9	73	12	7	72	1	NA	NA	0	NA	NA	2	NA	NA
1,2,3,4,7,8,9-HpCDF	22	10	67	12	6	62	1	NA	NA	0	NA	NA	2	NA	NA
OCDF	22	13	74	12	11	70	1	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-$TEQ_{PCDD/PCDF}$ LB (ND=0)	22	11	70	12	5	61	1	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-$TEQ_{PCDD/PCDF}$ UB (ND=LOD)	22	11	70	12	5	61	1	NA	NA	0	NA	NA	2	NA	NA
PCB 77	18	27	72	11	10	63	1	NA	NA	0	NA	NA	2	NA	NA
PCB 81	15	12	66	12	11	57	0	NA	NA	0	NA	NA	2	NA	NA
PCB 126	18	22	70	11	16	71	1	NA	NA	0	NA	NA	2	NA	NA
PCB 169	15	11	69	11	26	80	1	NA	NA	0	NA	NA	1	NA	NA
PCB 105	18	21	63	11	18	76	0	NA	NA	0	NA	NA	3	137	64
PCB 114	15	22	64	10	16	62	0	NA	NA	0	NA	NA	1	NA	NA
PCB 118	18	35	65	11	23	75	1	NA	NA	0	NA	NA	3	102	86
PCB 123	15	42	59	10	58	58	0	NA	NA	0	NA	NA	2	NA	NA
PCB 156	18	28	64	11	8	62	0	NA	NA	0	NA	NA	2	NA	NA
PCB 157	15	17	69	11	9	64	0	NA	NA	0	NA	NA	2	NA	NA
PCB 167	16	28	68	10	21	72	0	NA	NA	0	NA	NA	1	NA	NA
PCB 189	16	17	82	11	7	63	0	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-TEQ_{PCB} LB (ND=0)	18	20	68	11	15	71	1	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-TEQ_{PCB} UB (ND=LOD)	18	25	74	11	15	71	1	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-TEQ_{total} LB (ND=0)	18	15	68	11	3	57	1	NA	NA	0	NA	NA	2	NA	NA
WHO_{1998}-TEQ_{total} UB (ND=LOD)	18	15	68	11	3	57	1	NA	NA	0	NA	NA	2	NA	NA

3.3.2.4 PBDE and PBB

Table 80: Regional summary of laboratory performance for PBDE and PBB - standard solution

Standard solution	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
PBDE 17	12	17	60	11	21	63	1	NA	NA	1	NA	NA	1	NA	NA
PBDE 28	23	26	64	14	25	75	1	NA	NA	1	NA	NA	1	NA	NA
PBDE 47	23	22	60	15	14	58	1	NA	NA	1	NA	NA	2	NA	NA
PBDE 99	23	25	66	15	7	57	1	NA	NA	1	NA	NA	2	NA	NA
PBDE 153	23	25	62	15	22	70	1	NA	NA	1	NA	NA	1	NA	NA
PBDE 154	23	20	60	15	20	66	1	NA	NA	1	NA	NA	1	NA	NA
PBDE 183	23	46	68	13	28	67	1	NA	NA	1	NA	NA	1	NA	NA
PBDE 100	23	23	64	15	19	64	1	NA	NA	1	NA	NA	1	NA	NA
PBB 153	9	15	66	3	21	71	0	NA	NA	0	NA	NA	0	NA	NA

Table 81: Regional summary of laboratory performance for PBDE and PBB- sediment

Sediment	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
PBDE 17	9	23	64	9	21	61	1	NA	NA	1	NA	NA	1	NA	NA
PBDE 28	14	22	66	13	12	60	1	NA	NA	1	NA	NA	1	NA	NA
PBDE 47	14	34	67	13	6	59	1	NA	NA	1	NA	NA	1	NA	NA
PBDE 99	14	24	67	13	15	68	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 153	14	51	66	13	11	62	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 154	14	52	70	13	8	66	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 183	13	54	72	12	17	65	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 100	14	46	68	13	13	67	0	NA	NA	1	NA	NA	1	NA	NA
PBB 153	6	38	75	2	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA

Table 82: Regional summary of laboratory performance for PBDE and PBB- fish

Fish	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
PBDE 17	6	60	69	8	71	77	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 28	20	67	66	11	83	78	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 47	20	57	74	12	37	74	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 99	19	60	72	12	36	70	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 153	18	60	66	12	46	73	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 154	18	59	67	12	55	81	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 183	12	56	65	5	32	49	0	NA	NA	1	NA	NA	0	NA	NA
PBDE 100	20	74	75	11	43	71	0	NA	NA	1	NA	NA	1	NA	NA
PBB 153	5	22	78	3	14	64	0	NA	NA	0	NA	NA	0	NA	NA

Table 83: Regional summary of laboratory performance for PBDE and PBB- mothers' milk

Mothers' milk	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
PBDE 17	1	NA	NA	1	NA	NA	0	NA	NA	1	NA	NA	0	NA	NA
PBDE 28	9	36	80	5	56	64	0	NA	NA	1	NA	NA	0	NA	NA
PBDE 47	10	23	74	6	29	65	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 99	9	39	82	7	73	74	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 153	10	18	69	7	11	56	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 154	8	64	84	5	132	52	0	NA	NA	1	NA	NA	0	NA	NA
PBDE 183	8	38	60	4	69	50	0	NA	NA	1	NA	NA	0	NA	NA
PBDE 100	9	14	67	5	35	62	0	NA	NA	1	NA	NA	1	NA	NA
PBB 153	4	150	70	1	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA

Table 84: Regional summary of laboratory performance for PBDE and PBB- air extract

Air extract	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
PBDE 17	6	60	69	8	71	77	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 28	20	67	66	11	83	78	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 47	20	57	74	12	37	74	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 99	19	60	72	12	36	70	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 153	18	60	66	12	46	73	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 154	18	59	67	12	55	81	0	NA	NA	1	NA	NA	1	NA	NA
PBDE 183	12	56	65	5	32	49	0	NA	NA	1	NA	NA	0	NA	NA
PBDE 100	20	74	75	11	43	71	0	NA	NA	1	NA	NA	1	NA	NA
PBB 153	5	22	78	3	14	64	0	NA	NA	0	NA	NA	0	NA	NA

3.3.2.5 PFAS

Table 85: Regional summary of laboratory performance for PFASs analyses - standard solution

Standard solution	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
L-PFOS anion	12	6	73	10	8	67	0	NA	NA	0	NA	NA	0	NA	NA
FOSA	5	5	78	8	2	63	0	NA	NA	0	NA	NA	0	NA	NA
PFBA	6	2	60	7	12	81	0	NA	NA	0	NA	NA	0	NA	NA
PFPeA	6	17	78	4	11	81	0	NA	NA	0	NA	NA	0	NA	NA
PFHxA	8	3	59	8	4	71	0	NA	NA	0	NA	NA	0	NA	NA
PFHpA	8	16	70	8	7	72	0	NA	NA	0	NA	NA	0	NA	NA
PFOA	9	9	77	9	7	81	0	NA	NA	0	NA	NA	0	NA	NA
PFNA	8	5	62	9	8	69	0	NA	NA	0	NA	NA	0	NA	NA
PFDA	8	2	66	9	6	67	0	NA	NA	0	NA	NA	0	NA	NA
PFUnDA	6	7	65	9	6	73	0	NA	NA	0	NA	NA	0	NA	NA
PFDoDA	5	3	64	7	11	67	0	NA	NA	0	NA	NA	0	NA	NA
PFTrDA	5	2	58	5	9	68	0	NA	NA	0	NA	NA	0	NA	NA
PFTeDA	5	10	80	5	7	70	0	NA	NA	0	NA	NA	0	NA	NA
L-PFBS	6	28	67	7	7	71	0	NA	NA	0	NA	NA	0	NA	NA
L-PFHxS	8	5	68	9	11	73	0	NA	NA	0	NA	NA	0	NA	NA
L-PFHpS	1	NA	NA	3	2	64	0	NA	NA	0	NA	NA	0	NA	NA
L-PFDS	4	3	69	7	9	74	0	NA	NA	0	NA	NA	0	NA	NA
MeFOSA	4	19	66	3	29	64	0	NA	NA	0	NA	NA	0	NA	NA
EtFOSA	2	NA	NA	2	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
MeFOSE	2	NA	NA	3	5	64	0	NA	NA	0	NA	NA	0	NA	NA
EtFOSE	2	NA	NA	3	4	64	0	NA	NA	0	NA	NA	0	NA	NA

Table 86: Regional summary of laboratory performance for PFASs analyses - sediment

Sediment	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
L-PFOS anion	9	15	83	9	17	69	0	NA	NA	0	NA	NA	0	NA	NA
PFOSA	4	64	84	6	46	80	0	NA	NA	0	NA	NA	0	NA	NA

Table 87: Regional summary of laboratory performance for PFASs analyses - fish

Fish	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
L-PFOS anion	9	19	87	10	10	67	0	NA	NA	0	NA	NA	0	NA	NA
PFOSA	5	3	58	8	17	65	0	NA	NA	0	NA	NA	0	NA	NA

Table 88: Regional summary of laboratory performance for PFASs analyses - mothers' milk

Mothers' milk	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
L-PFOS anion	3	13	72	5	72	74	0	NA	NA	0	NA	NA	0	NA	NA
PFOSA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA

Table 90: Regional summary of laboratory performance for PFASs analyses - human serum

Standard solution	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
L-PFOS anion	4	37	80	4	25	81	0	NA	NA	0	NA	NA	0	NA	NA
PFOSA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
PFBA	1	NA	NA	2	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
PFPeA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
PFHxA	3	5	64	3	2	64	0	NA	NA	0	NA	NA	0	NA	NA
PFHpA	3	1	64	4	22	83	0	NA	NA	0	NA	NA	0	NA	NA
PFOA	4	2	66	5	14	67	0	NA	NA	0	NA	NA	0	NA	NA
PFNA	3	0	64	4	13	80	0	NA	NA	0	NA	NA	0	NA	NA
PFDA	3	1	64	4	8	66	0	NA	NA	0	NA	NA	0	NA	NA
PFUnDA	3	2	64	4	13	73	0	NA	NA	0	NA	NA	0	NA	NA
PFDoDA	3	5	64	4	18	68	0	NA	NA	0	NA	NA	0	NA	NA
PFTrDA	3	19	66	1	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
PFTeDA	3	5	64	2	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
L-PFBS	1	NA	NA	1	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
L-PFHxS	3	16	75	4	17	73	0	NA	NA	0	NA	NA	0	NA	NA
L-PFHpS	0	NA	NA	1	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
L-PFDS	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA

Table 91: Regional summary of laboratory performance for PFASs analyses - air extract

Mothers' milk	Asia-Pacific group			WEOG			GRULAC			Africa			CEE		
Analyte	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate	n	Btw-lab. CV	Inclusion rate
		(%)			(%)			(%)			(%)			(%)	
L-PFOS anion	3	55	81	5	13	46	0	NA	NA	0	NA	NA	0	NA	NA
PFOSA	2	NA	NA	5	98	86	0	NA	NA	0	NA	NA	0	NA	NA
MeFOSA	1	NA	NA	2	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
EtFOSA	1	NA	NA	2	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
MeFOSE	1	NA	NA	2	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA
EtFOSE	1	NA	NA	2	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA

3.4 Performance of Laboratories for Sum Parameters

3.4.1 Organochlorine Pollutants

Table 92: Summary results for sum OCPs - standard solution

Standard solution	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
Sum drins	44	92.0	92.7	92.0	0.0001	686	26	70
Sum chlordanes	40	199	201	199	11.9	311	40	79
Sum DDTs	47	215	218	215	0.0005	997	27	71
Sum HCHs	44	16.0	16.3	16.0	0.00001	2339	22	71
Sum endosulfans	35	155	149	155	0.0002	867	31	64

Table 93: Summary of laboratory performance for sum OCPs - standard solution

Standard solution	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		$\|z\| < 2$ Satisfactory	$3 > \|z\| > 2$ Questionable	$6 > \|z\| > 3$ Unsatisfactory	$\|z\| > 6$ Extreme
Sum drins	42	70	5	18	7
Sum chlordanes	38	48	23	25	5
Sum DDTs	45	57	19	15	9
Sum HCHs	43	71	7	11	9
Sum endosulfans	33	57	9	9	26

Table 94: Summary results for sum OCPs - sediment

Sediment	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
Sum drins	23	NA	30.9	35.5	0.000009	2804	86	73
Sum chlordanes	15	0.342	0.420	0.342	0.07	64.9	113	61
Sum DDTs	28	5.67	6.15	5.67	0.00003	67.5	79	68
Sum HCHs	23	NA	1.10	0.888	0.00000015	21.0	111	71
Sum endosulfans	11	NA	1.05	0.675	0.00001	124	182	67

Table 95: Summary of laboratory performance for sum OCPs - sediment

Sediment	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
Sum drins	23	0	0	0	0
Sum chlordanes	19	25	0	20	30
Sum DDTs	28	34	3	24	34
Sum HCHs	25	0	0	0	0
Sum endosulfans	15	0	0	0	0

Table 96: Summary results for sum OCPs - fish (wet weight basis)

Fish	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
Sum drins	18	0.182	0.249	0.182	0.042	211	111	63
Sum chlordanes	29	2.42	2.80	2.42	0.619	2787	57	71
Sum DDTs	34	3.75	4.31	3.75	0.00008	4262	66	69
Sum HCHs	21	0.276	0.331	0.276	0.00005	332	68	65
Sum endosulfans	6	NA	0.374	0.413	0.00001	1.44	128	70

Table 97: Summary of laboratory performancefor sum OCPs - fish

Fish	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
Sum drins	23	25	13	13	25
Sum chlordanes	29	27	7	47	17
Sum DDTs	33	31	6	31	29
Sum HCHs	26	37	7	11	22
Sum endosulfans	18	0	0	0	0

Table 98: Summary results sum for OCPs - mothers' milk (wet weight basis)

Mothers' milk	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
Sum drins	10	35.1	40.7	35.1	0.608	1730	59	68
Sum chlordanes	16	NA	104	98.9	0.051	389	77	75
Sum DDTs	17	929	966	929	0.0000000031	2180	43	63
Sum HCHs	14	89.7	95.8	89.7	0.0000000001	1650	37	64
Sum endosulfans	4	NA	3.94	2.52	2.3E-08	389	151	67

Table 99: Summary of laboratory performance for sum OCPs - mothers' milk

Mothers' milk	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
Sum drins	15	25	0	19	19
Sum chlordanes	16	0	0	0	0
Sum DDTs	16	47	12	12	29
Sum HCHs	17	39	6	11	22
Sum endosulfans	13	0	0	0	0

Table 100: Summary results for sum OCPs - air extract

Air extract	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
Analyte		(µg /kg)					(%)	
Sum drins	16	80.0	76.8	80.0	5.78	117	26	62
Sum chlordanes	22	188	191	188	3.43	377	32	66
Sum DDTs	22	177	193	177	0.0003	369	50	73
Sum HCHs	18	14.5	15.6	14.5	0.000002	11879	40	65
Sum endosulfans	12	110	123	110	0.0001	353	71	65

Table 101: Summary of laboratory performance for sum OCPs – air extract

Air extract	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
Sum Drins	19	45	5	15	15
Sum chlordanes	23	54	4	13	21
Sum DDTs	24	40	8	20	20
Sum HCHs	21	41	9	14	18
Sum endosulfans	13	29	0	21	36

3.4.2 Polybrominated Diphenyl Ethers

Table 102: Summary results for sum PBDE - Concentrations in µg/kg except for mothers' milk, which is ng/kg

Matrix	n	AV	Median	Mean	Min.	Max.	Btw-lab. CV	Inclusion rate
							(%)	
Standard solution	41	1511	1586	1511	1.15	9470	31	66
Sediment	30	7.74	7.99	7.74	1.59	198	23	65
Fish	34	4.28	4.58	4.28	0.754	30	51	73
Mothers' milk	20	38.0	41.3	38.0	17.4	30140	36	73
Air extract	21	20.2	21.6	20.2	4.96	434	31	61

Table 103: Summary of laboratory performance for sum PBDE - Concentrations in µg/kg except for mothers' milk, which is ng/kg

Sediment	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
Standard solution	39	59	7	15	20
Sediment	29	67	3	10	20
Fish	32	26	32	26	15
Mothers' milk	21	50	14	14	14
Air extract	20	52	10	10	29

3.4.3 Perfluorinated Alkyl Substances

Table 104: Summary results for sum PFASs - Concentrations in µg/kg except for human serum, which is ng/ml

							Btw-lab. CV	Inclusion rate
Matrix	n	AV	Median	Mean	Min.	Max.	(%)	
Standard solution	15	2308	2695	2308	1797	6379	40	70
Human serum	7	94.4	93.8	94.4	68.7	103	3	62
Air extract	7	NA	20.1	13.8	0.150	186	175	55

Table 105: Summary of laboratory performance for sum PFAS - Concentrations in µg/kg except for human serum, which is ng/ml

Sediment	% of the data received	Performance according to z-scores (percent of laboratories)			
Analyte		|z| < 2 Satisfactory	3 > |z| > 2 Questionable	6 > |z| > 3 Unsatisfactory	|z| > 6 Extreme
Standard solution	14	73	0	0	27
Human serum	7	86	14	0	0
Air extract	7	0	0	0	0

4. Discussion

4.1 Methodological Considerations

Identifying trends in an interlaboratory assessment data set and explaining the underlying methodological causes is challenging. The number of laboratories submitting results for each group of analytes, the concentrations of the target compounds in the test materials, and variations in the analytical methods used by the participants are factors that may influence the interpretation and the outcome (de Boer and Wells, 2006). Calculation and dilution errors are other factors that may impede understanding of the data. Nonetheless, based on the results and previous experience with interlaboratory studies, several problems could be elucidated for this report.

The POP concentrations in mothers' milk and fish tissue are presented on a wet weight basis. The interlaboratory comparison of lipid weight concentrations is rather vulnerable to interlaboratory variation in determining lipid content (Karl *et al.*, 2012). Furthermore, the combination of high lipid content and low concentrations tend to cause higher RSD values (de Boer and Wells, 2006). Participants were asked, however, to report the lipid content so it could be used when needed for interpretation of the data.

The overall performance of laboratories measuring the test solution (certified standard solutions) was satisfactory for more than 60% of the submitted data for the OCPs, PCB and PCDD/PCDF (Figure 3). However, in comparison with the previous study, the performance for all other contaminant classes deteriorated (PCDD/PCDF: 97% satisfactory z-scores in first study, 74% in the present study; indicator PCB: 86% in the first study, 66% in the present study; OCPs: 68%–77% in the first study, 61% in the present study). PBDE showed a comparable score of just below 60%, which was an acceptable outcome given that this group was included for the first time. Only 15% of the PFAS results had acceptable z-scores. Clearly, several participants do not have this analysis under control even for the standard solutions. The result for the standard solutions for the current study might indicate poor quality of quantification standards used by the participants or, possibly even more importantly, problems with the long-term storage of stock solutions. Long-term storage in closed glass ampoules is therefore always strongly suggested.

For the other test materials, the between-laboratory CV values were larger and fewer satisfactory z-scores were obtained using the same criteria (z = 2). The results for the sediment sample were good for all compounds except the OCPs. For the fish sample, the results were not satisfactory for any analysis except for the PFAS (> 80% satisfactory z-scores). For several of the compound classes no assigned value could be calculated. For the mothers' milk sample, the results were somewhat better (for a smaller number of laboratories) but too few satisfactory results were submitted for the OCPs and the new POPs, including the PBDE and PFASs. The same was true for the air extract, where the number of satisfactory results was less than 50% except for the PCDD/PCDF TEQ. The results for PFASs in the water and human serum sample were promising but still below 50%. Moreover, the results for the transformer oil sample (PCB only) were promising but not satisfactory.

There was no clear indication of a Horwitz trend in the data-set, *i.e.,* lower concentrations inducing higher RSD values (Horwitz *et al.*, 1980). On the contrary, there appeared to be a greater bias, especially for the fish tissue and mothers' milk samples with relatively high concentrations.

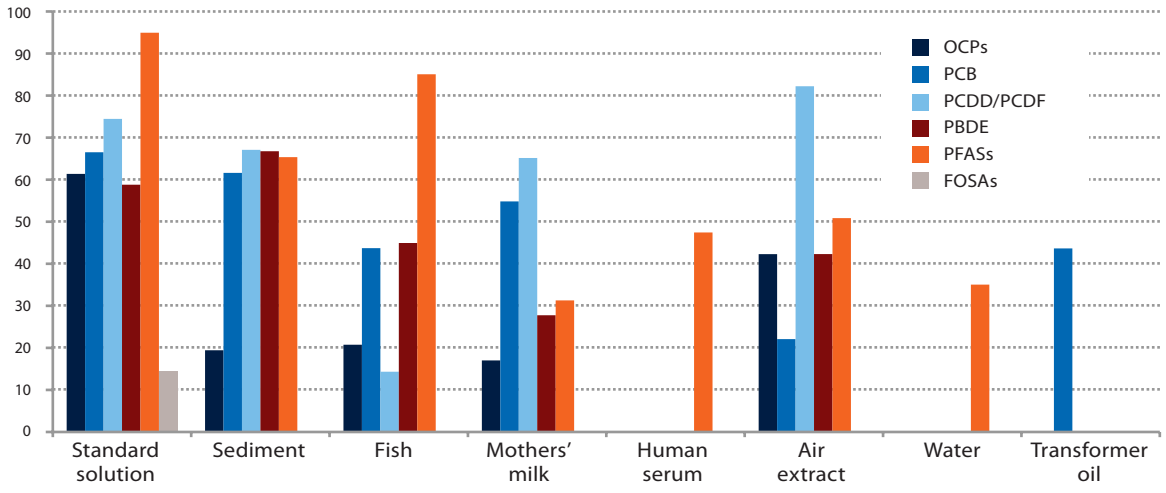

Figure 3: Percentage of laboratories with satisfactory z-scores in the analysis of OCPs, PCB, PCDD/PCDF, PFASs and PFOS precursors

A similar trend was identified in a previous interlaboratory assessment analysing sediment, herring and a test solution in seven developing countries (de Boer *et al.,* 2008).

Training was provided to a selected number of regional laboratories worldwide in developing countries in 2011, *i.e.,* after the first round of the UNEP-coordinated interlaboratory assessments (Fiedler *et al.,* 2013, van Leeuwen *et al.,* 2013, Leslie *et al.,* 2013). This resulted in improvement of the quality of analysis in some regions; however, on a global level this progress was not extended to the current round. Overall, there are still too few laboratories submitting satisfactory results, although for the standard solution and sediment sample the results are good for most of the target compounds including the new POP class of PBDE. Surprisingly, the results for the fish sample were very disappointing in relation to the UNEP criteria (CV = 12.5%, z = 2). For mothers' milk (a recommended core matrix in the Global Monitoring Plan), there is still only limited capacity for most compound classes especially outside the WEOG and Asian regions. For PFAS compounds this is even worse, as only laboratories from WEOG and Asia participated.

4.2 Analyte Group: Specific Performance

4.2.1 Organochlorine pesticides

The individual results for the OCPs for the standard solution show between-laboratory model CV values of 22%–25% for the drins, 15%–41% for the chlordanes and 12%–30% for DDT and its metabolites (Table 2). This is illustrated in Figure 4 for dieldrin (22%), in which the individual results from each laboratory are given in addition to the consensus value as calculated by the Cofino statistics and the UNEP criteria of 12.5% (z = 1) and 25% (z = 2). With only just over 60% satisfactory z-scores (Figure 3), this result is somewhat disappointing. Laboratories should all be able to determine OCPs in a standard solution without any matrix within ±25%. Possibly some calculation errors could have influenced the results as not all laboratories may be used to the calculation on a weight/weight basis. This is, however, necessary to avoid errors due to evaporation, particularly in warm countries. Only 50 out of the 105 participating laboratories analysed this solution, whereas it was expected that most laboratories would be interested in the OCP analysis.

The results for OCPs in the air extract showed between-laboratory model CV values of 21%–58% for the drins, 13%–42% for the chlordanes and 8%–46% for the DDTs (Table 10). Relatively poor results were obtained for hexachlorobenzene (CV = 68%), endrin (CV = 58%) and endosulphan sulphate (CV = 91%). The latter result is understandable as this compound was added for the first time and is not very easy to analyse. Only eight laboratories analysed it, whereas a maximum of 20 laboratories analysed the other OCPs in air. This number should also increase in the near future as air is a prime matrix in the Global Monitoring Program.

The results for the other test materials also showed a large variation (sometimes more than 200%) and in some cases it was not possible to calculate an assigned value at all (some drins and DDTs in the sediment, some chlordanes and DDTs in the fish, and some drins, chlordanes and DDTs in the

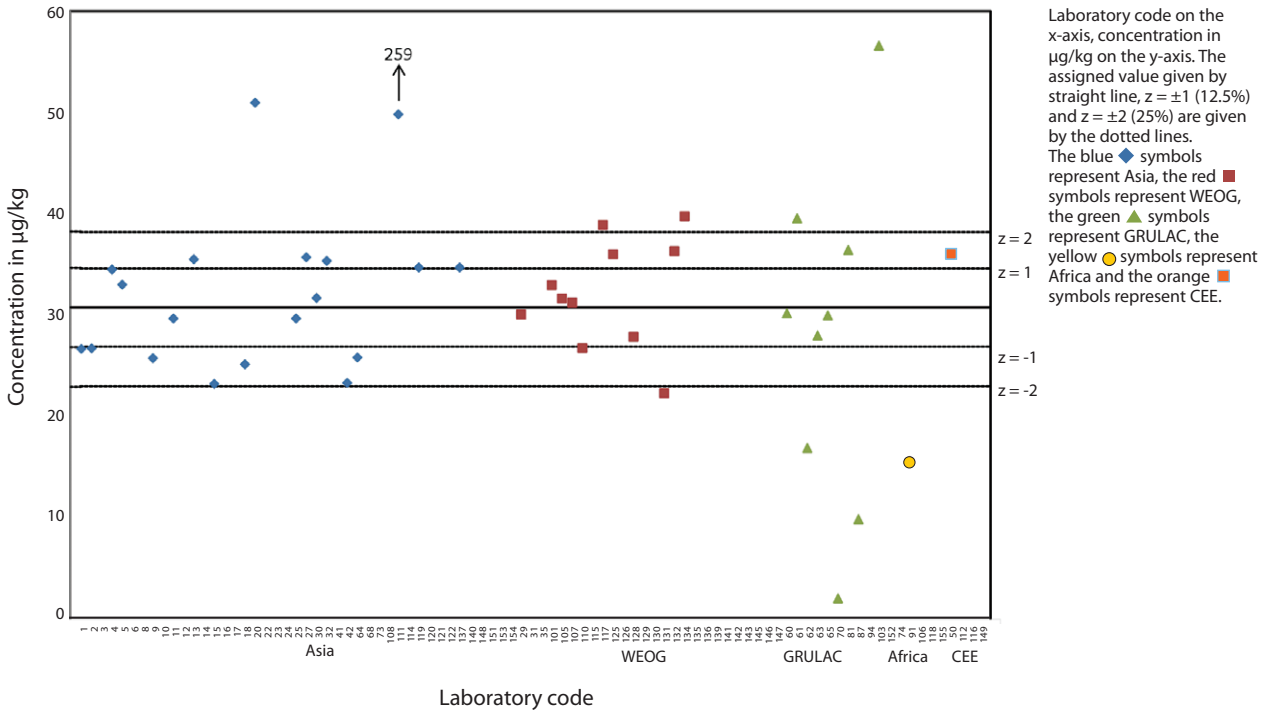

Figure 4: Results for dieldrin in the standard solution

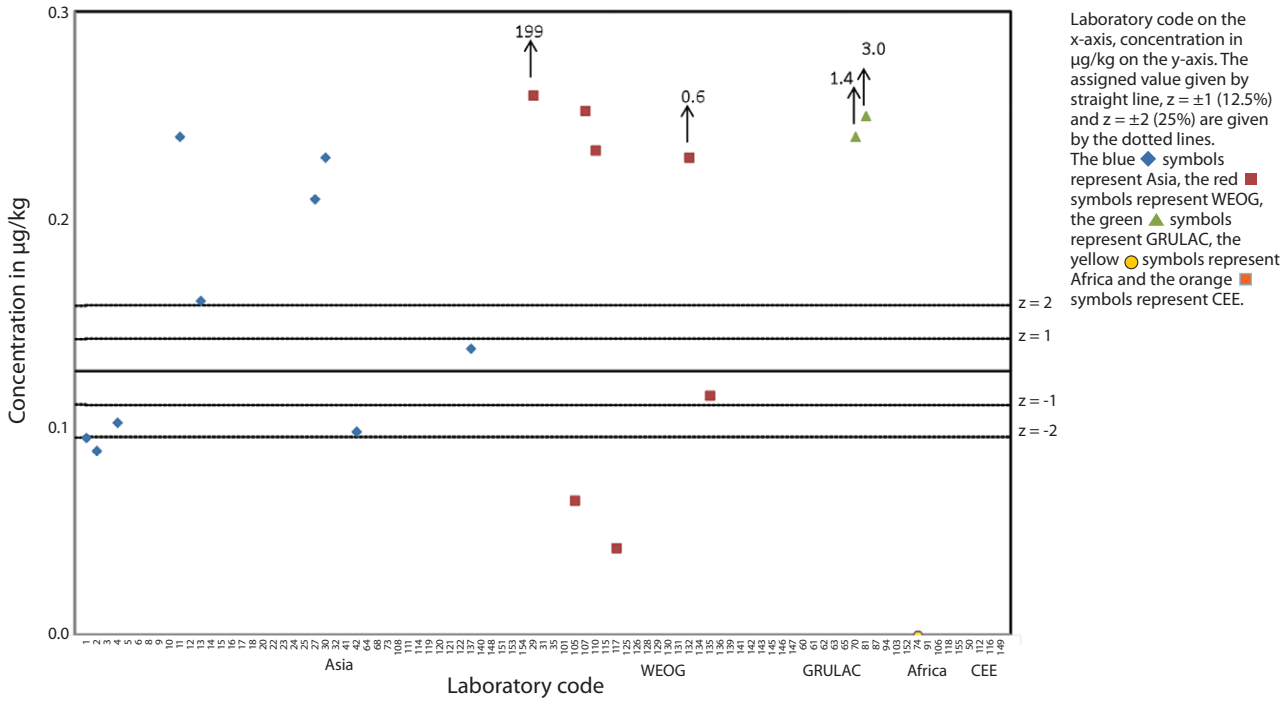

Figure 5: Results for dieldrin in the fish sample

mothers' milk). As an example of the large interlaboratory variation, the results of dieldrin in the fish sample (CV = 78%) are given in Figure 5. The outliers on the high side are most likely caused by interferences in the chromatogram. To determine dieldrin, sulphuric acid treatment is not allowed as it degrades dieldrin (as well as endrin and some other OCPs). Consequently, the dieldrin peak in GC/ECD chromatograms is often hindered by interferences. The use of a mass spectrometric detector would overcome this problem.

The largest variation was seen for the OCPs in sediment, fish and mothers' milk: often less than 50% of the data showed

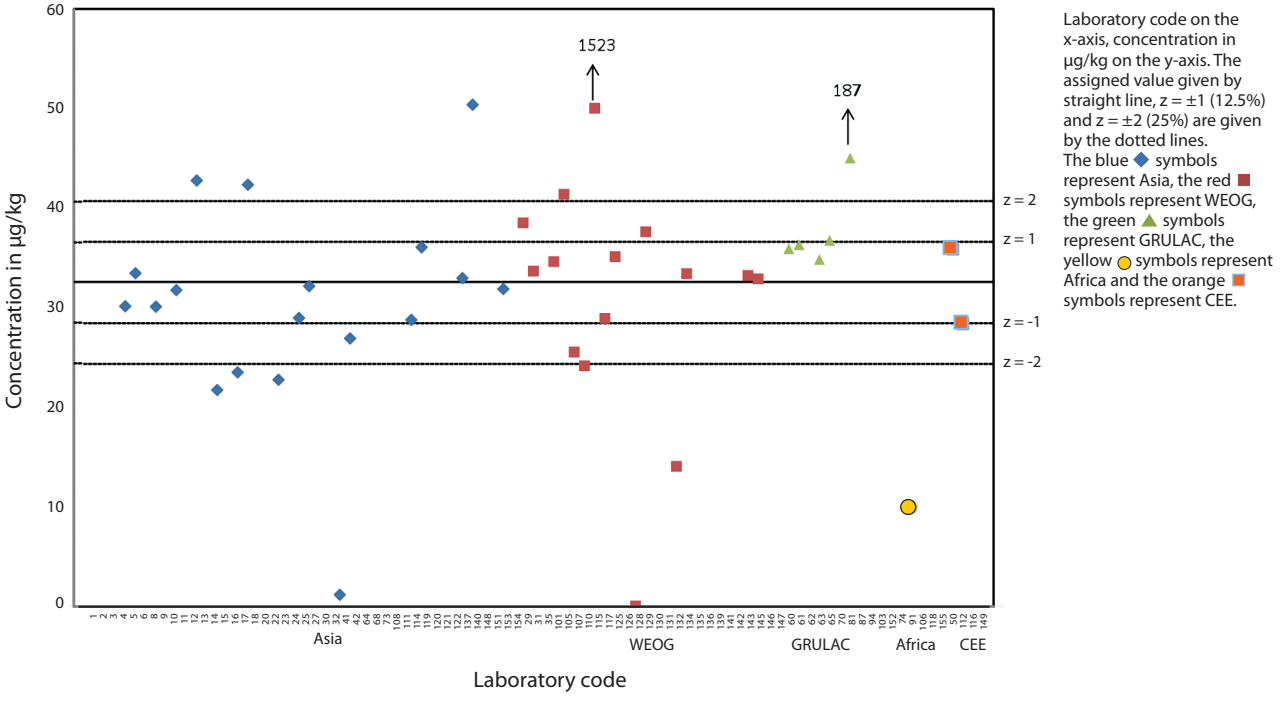

Figure 6: Results for sum of indicator PCB in the standard solution

satisfactory z-scores (see Table 5, Table 7 and Table 9).

There are numerous challenges that may hamper the OCP analysis, from decomposition in the injector (*e.g.,* if it has a dirty liner) to interfering substances and co-elution in combination with the non-selective electron capture detection (de Boer and Wells, 1997). Possibly, some laboratories may have used sulphuric acid to remove lipids and other interferences; however, this may disintegrate some OCPs such as dieldrin (de Boer and Wells, 1997). Moreover, some OCPs, like DDT, are easily degraded in the gas chromatography when it is not in the optimum condition (e.g., if it has a dirty liner or an old column), resulting in inaccurate results.

For individual OCPs in the sediment sample, only 19% of the laboratories showed an acceptable z-score. This was 62% for the individual indicator PCB. In the QUASIMEME interlaboratory studies, the general performance of laboratories analysing POPs in sediment was also found to be lower for OCPs than PCB (de Boer and Wells, 1997). The authors noted that the vast majority of the participating laboratories were not able to the determine OCP levels with an acceptable accuracy. Even though this was sixteen years ago, it pinpoints some of the challenges encountered by several laboratories participating in the present assessment as many of them are still building up experience. The major problem with OCP analysis is in the GC/ECD part of the analysis (used by 28% of the participants). The electron capture detection is not specific, the baseline is rather noisy, separation of early eluting compounds is not very good, and internal standards may not compensate for all losses. The use of GC/MS, even with low resolution mass spectrometry, together with ^{13}C-labelled standards would improve this performance substantially.

4.2.2 Polychlorinated Biphenyls

For the indicator PCB, the best results were obtained for the standard solution for which between-laboratory CV values of 20%–28% were found, with a between-laboratory CV of 18% for the sum of indicator PCB (Table 12). As can be seen from Figure 6, the data contains two obvious outliers and without removal of them by the model the interlaboratory variation would have been much higher. The present value is acceptable and in agreement with those from other studies.

The results for the other test materials show a larger variation: the between-laboratory CV values for the sediment were moderate at 16%–37% (Table 14). The CV values for fish, mothers' milk, and transformer oil were higher (34%–70%, 17%–85% and 40%–73%, respectively (Table 16, Table 18 and Table 22)). The variation for the sum of indicator PCB upper-bound (UB) in the air extract was so high (Table 20 and Figure 7) that no assigned value could be calculated by the model. For the individual PCB in the air extract for which an assigned value was calculated, the majority of the participating laboratories were not able to achieve satisfactory z-scores. This may be due to the low concentrations of PCB in the air extract (0.15 µg/kg–0.33 µg/kg).

4.2.3 Dioxin-like Persistent Organic Pollutants

Overall, good results were obtained for the dl-POPs, although - especially the PCDD/PCDF - are often present in lower concentrations (of two to three orders of magnitude) compared to the indicator PCB or OCPs. High resolution GC/MS systems are often used for both dioxin and dl-PCB analysis and the availability of a variety of ^{13}C-labelled standards and

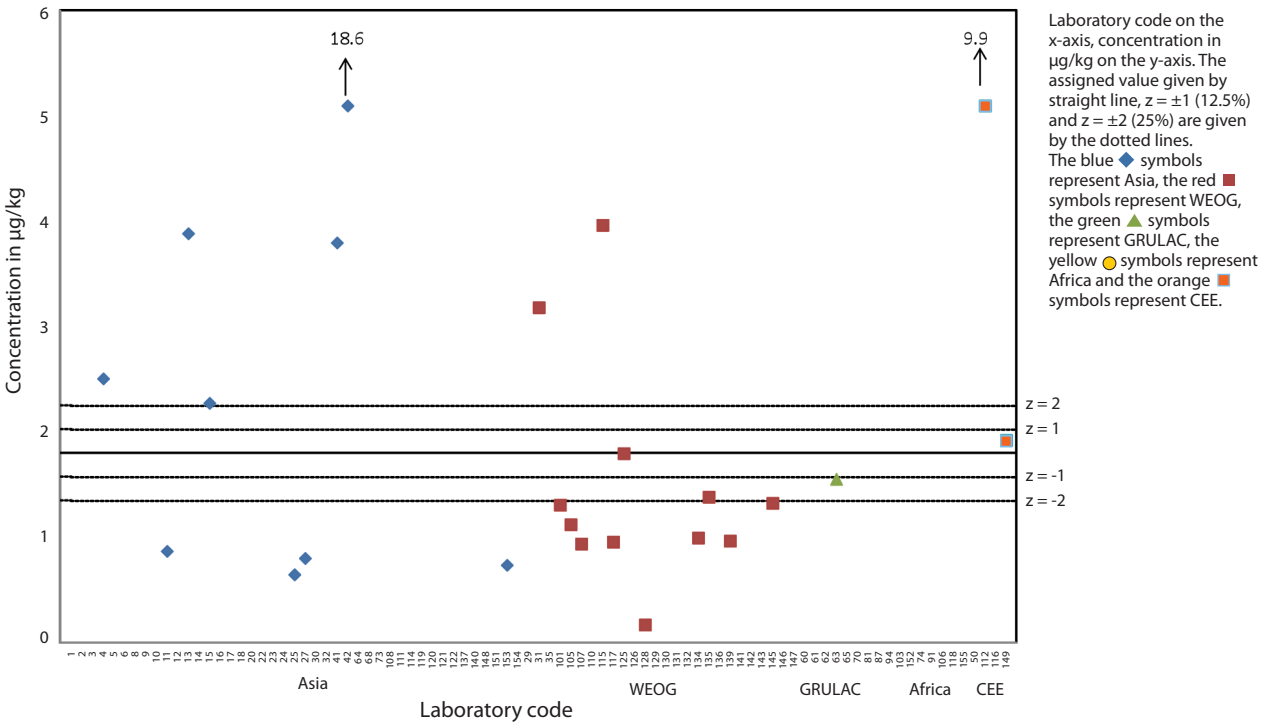

Figure 7: Results for sum of indicator PCB in the air extract

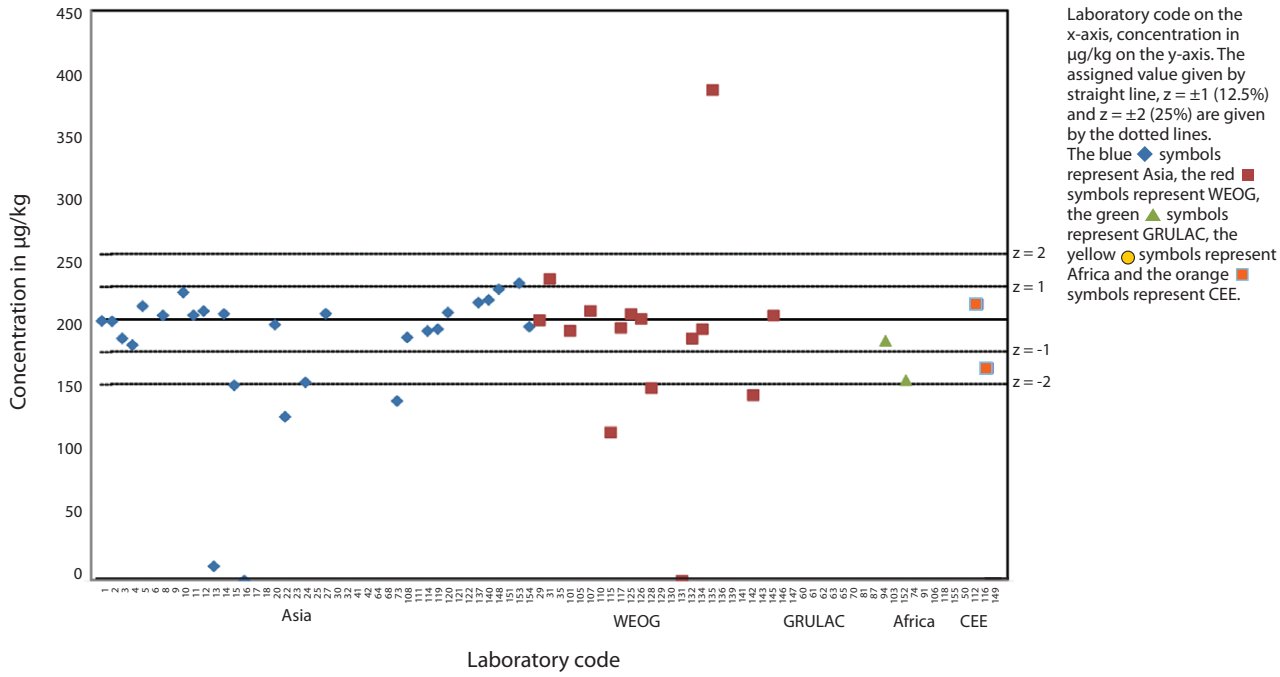

Figure 8: Results for the PCDD/PCDF TEQ in the standard solution

several well-validated and well-used standard methods clearly improves the quality of the results. For the standard solution, the results were very good, showing a CV of only 8% for the PCDD/PCDF TEQ. However, the individual CVs for the different congeners varied from 10% to 21%. For the dl-PCB TEQ the between-laboratory CV was 22%. The CVs of the individual congeners were in line with this, ranging from 16% to 22%. The results for the PCDD/PCDF TEQ are given in Figure 8. Here, the distribution of the results clearly shows four obvious outliers, of which some might be due to calculation errors or reporting in the wrong unit. Figure 8 and Table 25 also show that nearly 80% of the submitted data were satisfactory according to the criteria set by UNEP. For the dl-PCB the percentage of satisfactory z-scores is somewhat lower, with 64% of the results having a z-score < 2. This is illustrated in Figure 10, where five obvious outliers

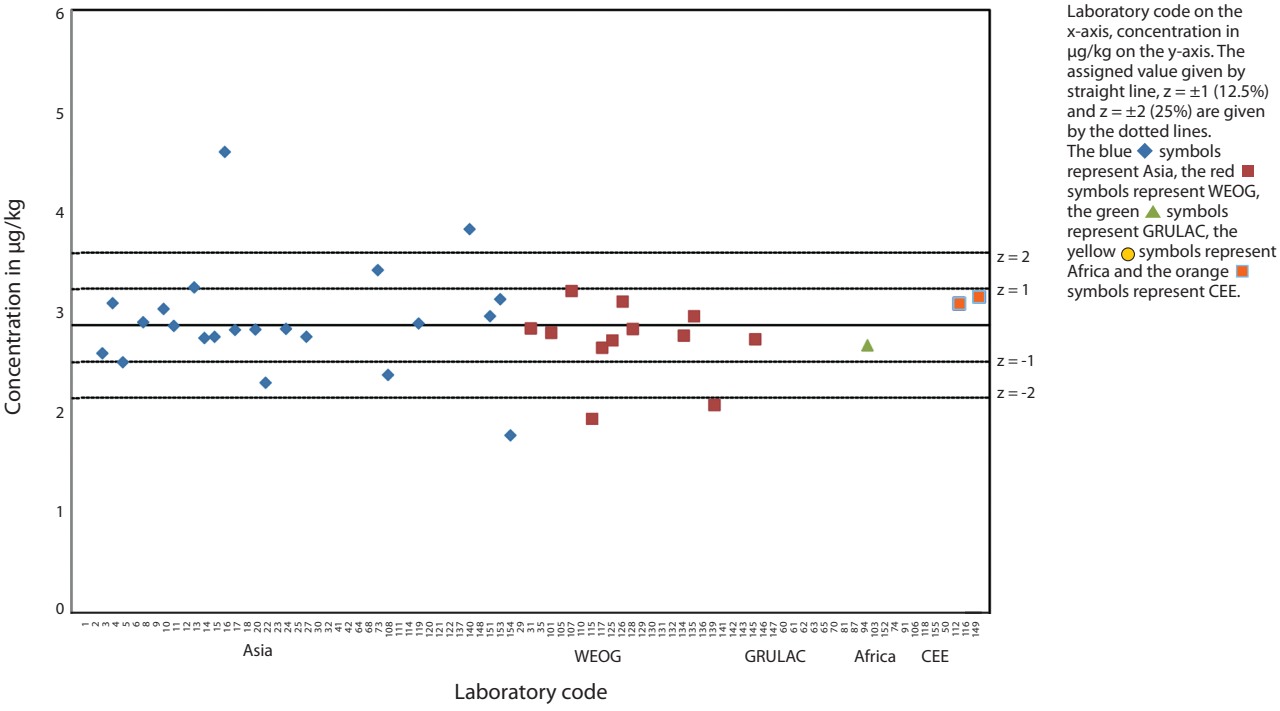

Figure 9: Results for the PCDD/PCDF TEQ in the air extract

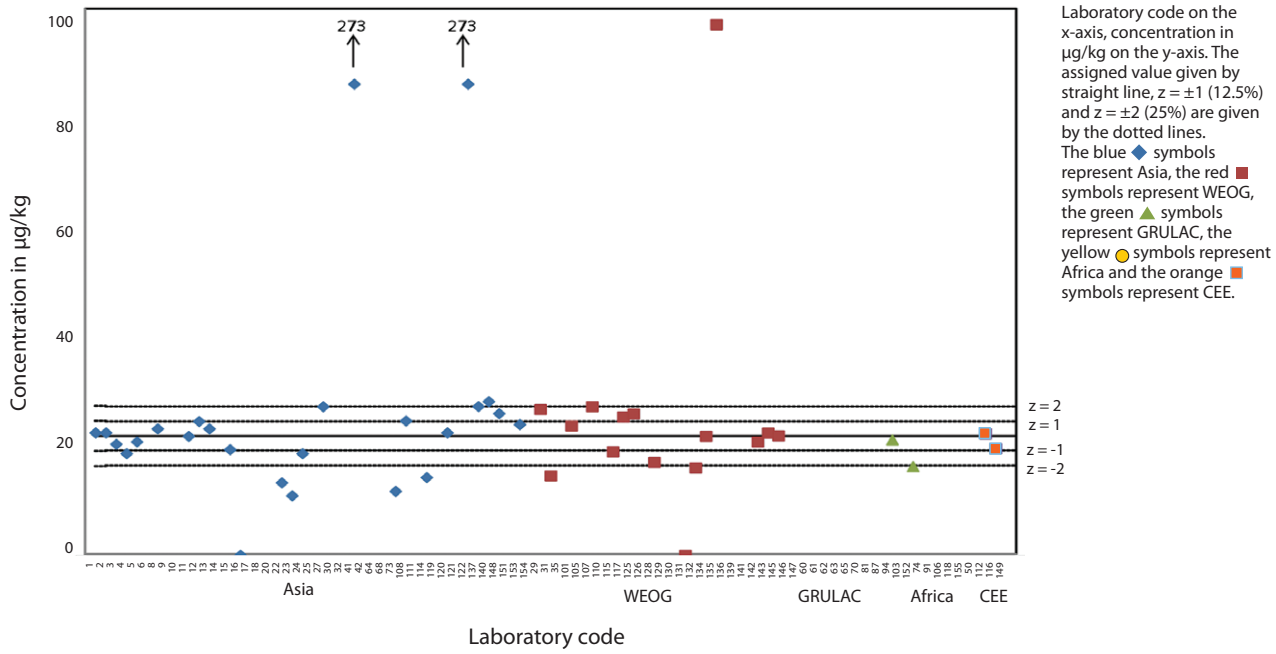

Figure 10: Results for the dl-PCB TEQ in the standard solution

can also be identified. The values for the dioxins are in agreement with other studies (although different statistical analyses were used). The values for the dl-PCB are somewhat lower than would be expected from the literature (van Bavel, 2008).

The results for the sediment samples (Table 26) were also excellent for the PCDD/PCDF TEQ, with a between-laboratory CV of 12%. The CVs of all individual congeners were within 10%–30% except for two HxCDF isomers, of which 1,2,3,7,8,9-HxCDF showed CVs of more than 100% and no consensus value could be calculated. The results for the dl-PCB TEQ were very good and similar to the CV of the standard solution. Individual results for the different congeners vary between 15% and 90%, with the highest variation caused by the very low levels of PCB 123, which elutes very close to PCB 118. PCB 118 is present at a concentration 10-times higher than that of PCB 123 and correct integration is crucial. The same is true for PCB 81, which is present at very low levels just above the detection limit. For the PCDD/PCDF TEQ, 82% of the results of the sediment samples were satisfactory. The corresponding percentage for the dl-PCB was 55%.

The fish sample caused major problems and no consensus value could be statistically calculated from the 38 entries for the PCDD/PCDF TEQ or the 41 entries for the dl-PCB (Table 27). The levels in the fish (for PCDD/PCDF) were relatively low; however, this should be overcome by the use of high resolution GC/MS systems. A problem might be that dl-POP levels are often reported on a lipid basis, although in the instructions it was clearly stated that levels should be reported on wet weight to avoid error introduced by the lipid determination. For several of the dl-PCB (present at higher levels) a consensus value could be calculated: the CV varied from 29% to nearly 100%, again with the higher values for levels just above the limit of detection of most laboratories.

The results for the other fatty sample, *i.e.,* mothers' milk, (Table 30) were good and better than for the fish sample. The CVs for the PCDD/PCDF TEQ of the 29 laboratories reporting was 23%, which is acceptable but might need a little improvement given the UNEP criteria. For the dl-PCB the results were similar, with a CV of 29% for the 28 entries. Here, individual RSDs were larger, or no consensus values could be determined ,for some congeners very close to the limit of detection of most laboratories. For the mothers' milk sample, nearly 80% of the results were satisfactory for the PCDD/PCDF TEQ and 86% for the dl-PCB TEQ.

The results for the air extract (Table 32) were excellent. The 37 entries for the PCDD/PCDF TEQ showed a CV of only 9%, which is well in agreement with the UNEP criteria and even better than the results for the standard solution. This is illustrated in Figure 9, where only five entries are located outside the z = ±2 region. The results for the individual congeners are also excellent, with CVs ranging from 7% to 23%, with the exception of 1,2,3,7,8,9-HxCDF (102%). As for the standard solution, problems were seen for 1,2,3,7,8,9-HxCDF as no consensus value could be calculated for this congener.

The results for both the dl-PCB TEQ (CV = 22%) and the individual congeners (13%–35%) were good with the exception of PCB 123 (which had low levels, see explanation above). The results for the dl-PCB are illustrated in Figure 11, where eight results show a z-score > 2. For the air extract, nearly 90% of the results for the PCDD/PCDF TEQ of the participating laboratories (35) were satisfactory and close to 100% for the dl-PCB. Although the extract was not going through the extraction stage of the analytical procedure, these results are very promising.

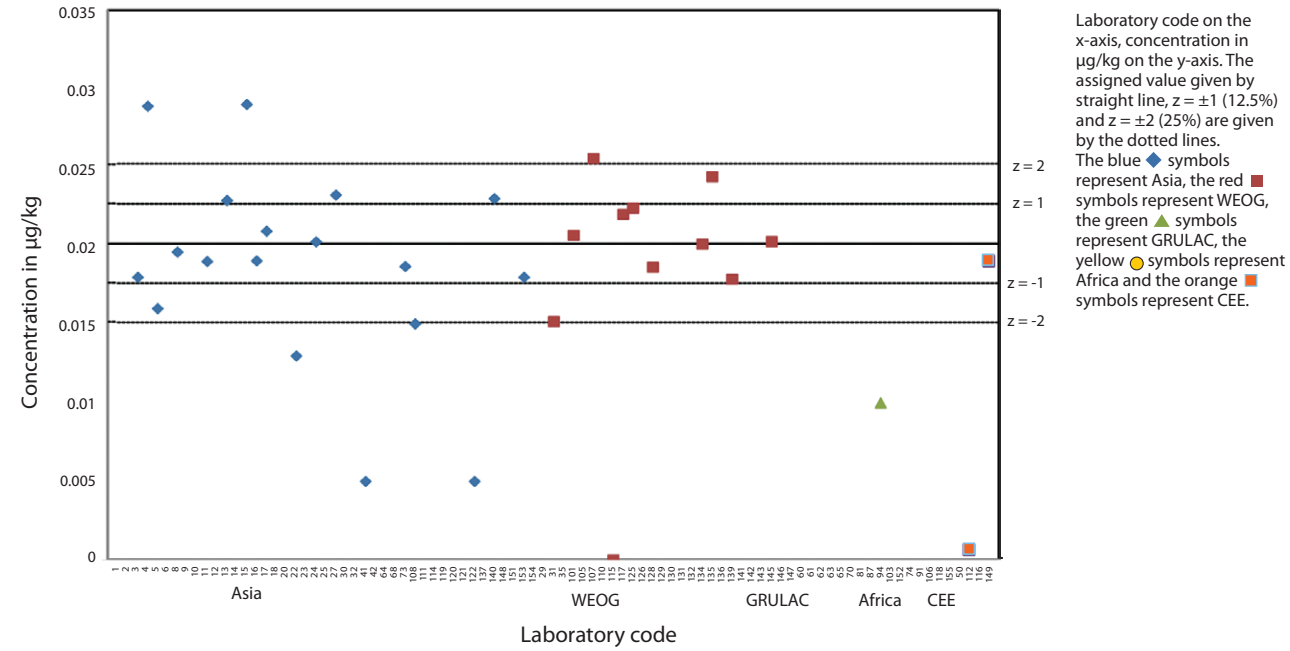

Figure 11: Results for the dl-PCB TEQ in the air sample

The variation in the dl-POP data is in agreement with or, in some cases, even better than that reported in the literature (where more than 15 years of dioxin quality assurance/ quality control studies were evaluated to establish fit-for-purpose RSDs (van Bavel *et al.*, 2008) for the standard solution, the air extract and the sediment samples).

The RSD values for PCDD/PCDF and higher-chlorinated PCB in the mothers' milk were good but need further improvement to comply with the criteria of UNEP (12.5%). However, for the fish sample, a substantial number of laboratories produced unacceptable results and so no consensus value could be calculated. Further training and attention to quality assurance/quality control is needed in this area.

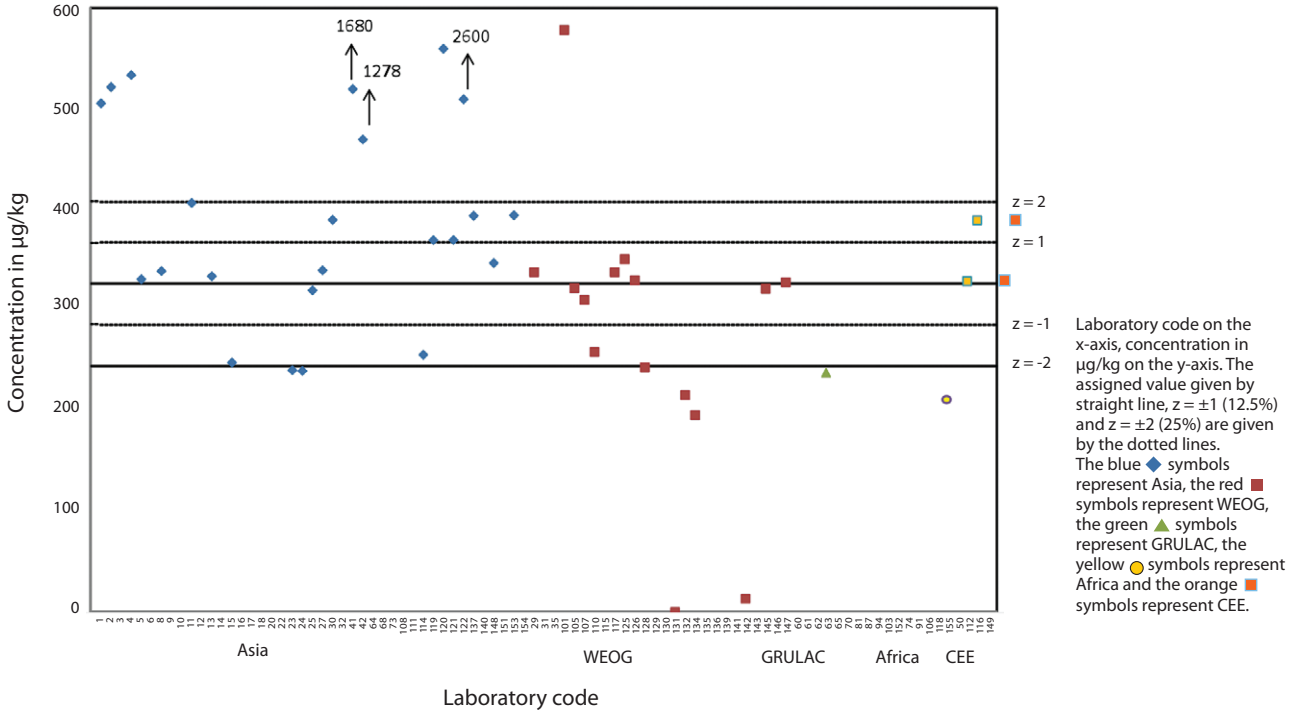

Figure 12: Results for PBDE 47 in the standard solution

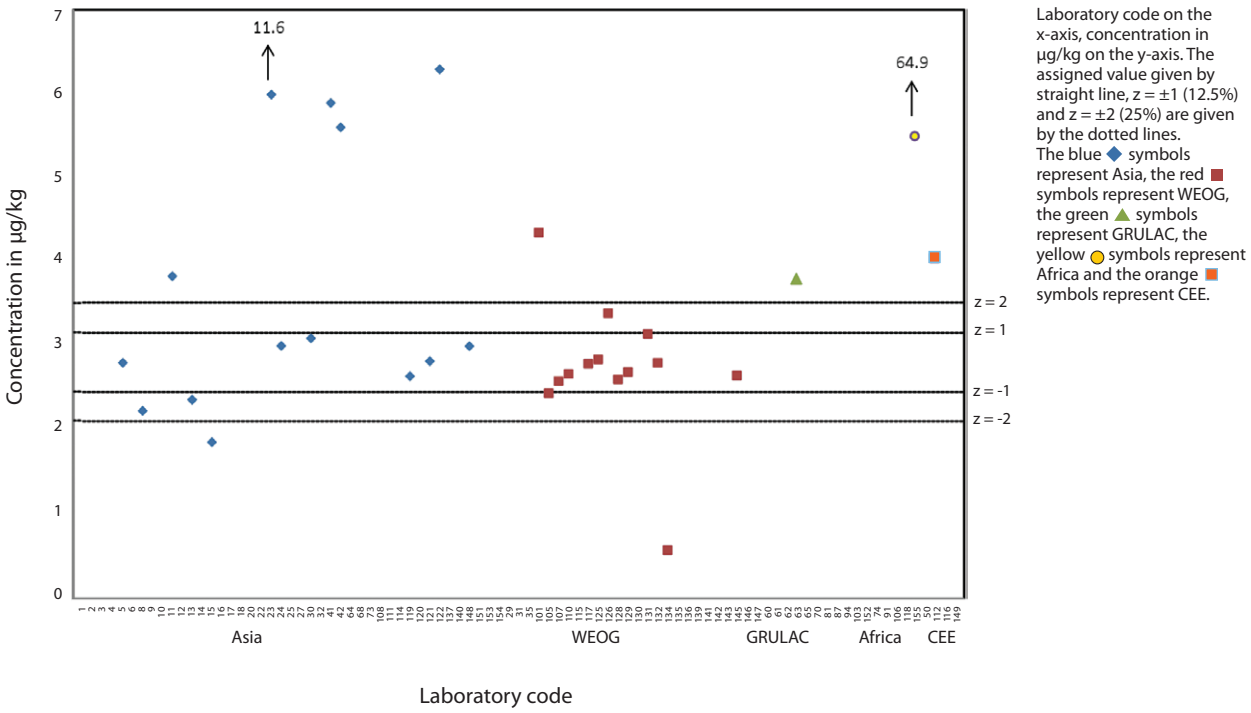

Figure 13: Results for PBDE 47 in the sediment sample

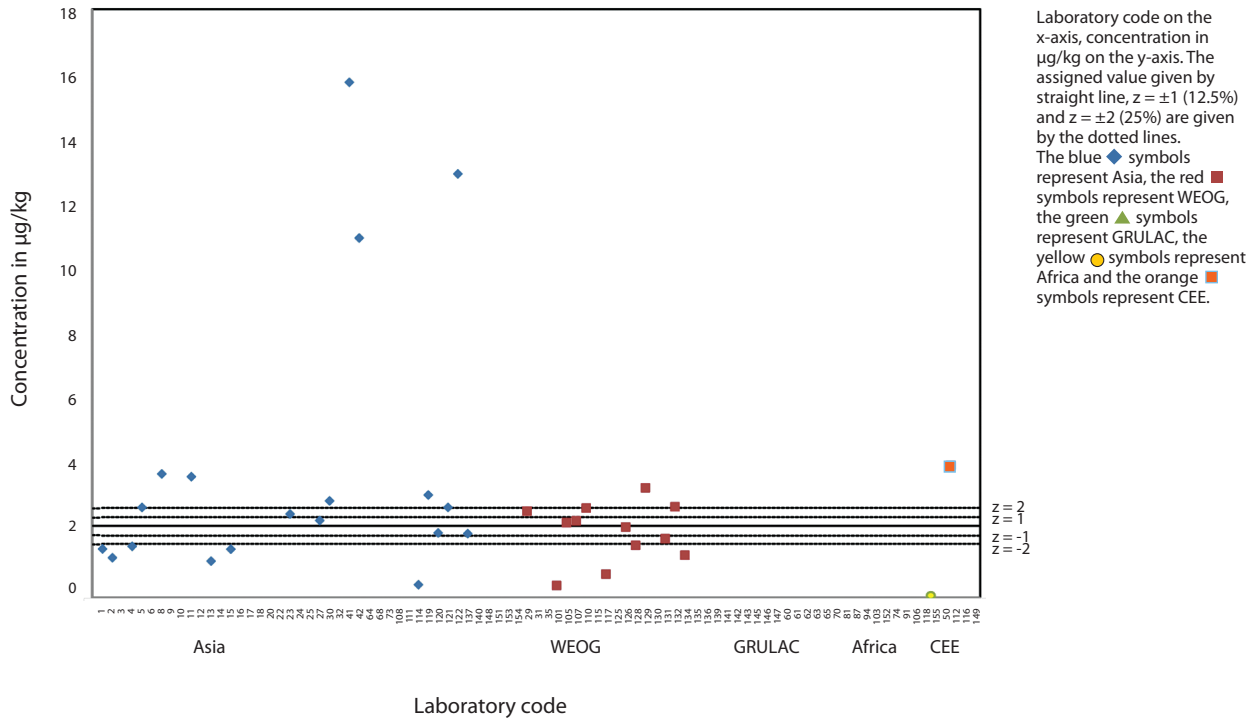

Figure 14: Results for PBDE 47 in the fish sample

4.2.4 Polybrominated Diphenyl Ethers

The individual results for the PBDE in the standard solution showed between-laboratory CV values of 22%–39% (Table 34). This is illustrated for PBDE 47 (28%) in Figure 12, in which the individual results from each laboratory are given in addition to the consensus value calculated by the Cofino statistics and the UNEP criteria of 12.5 % (z = 1) and 25% (z = 2).

Results of PBDE in the sediment (CVs = 18%–42%, Table 36) were relatively good and comparable with the results of the standard solution, although the matrix was more complex and the concentrations in the sediment sample were 200–300 times lower. An average of 64% of the participants achieved satisfactory z-scores for PBDE in the sediment sample. The results for PBDE in the fish sample, the mothers' milk sample and the air extract were less satisfying, with variations of 51%–91% (Table 38), 28%–81% (Table 40) and 32%–73% (Table 42), respectively.

Individual results from each laboratory for PBDE 47 in sediment (CV = 18%) and for PBDE 47 in fish (CV = 51%) are shown in Figure 13 and Figure 14, respectively.

4.2.5 Perfluorinated Alkyl Substances

The results for the PFAS compounds in the standard solution (Table 44) were excellent for the perfluorinated sulfonic and carboxyl acids, especially for the target compound L-PFOS. The variation between 22 laboratories was 8% for PFOS. Similarly, for the other optional PFAS compounds, the CV of the submitted results was excellent and ranged from 3% for PFOSA (n = 13) to 16% for PFPeA (n = 10). The CV for perfluorooctanoic acid (PFOA) was 9% (n = 18). This is reflected in the percentage of results with satisfactory z-scores, which was 95% for L-PFOS and over 90% for nearly all other sulfonic and carboxyl acids. This is illustrated in Figure 15, where all results are located within z = ±2 (25%) except for one obvious outlier.

The variation for another group of precursor PFAS compounds – the sulphonamides – was significantly higher and no consensus values could be calculated for EtFOSA, MeFOSE and EtFOSE. Between five and seven results were submitted for chemicals in this compound class (except for PFOSA (n = 13)), indicating that analysis of the precursor compound is more difficult and not so commonly performed.

For the sediment samples, only PFOS and its precursors were analysed (Table 46). Here, the results for L-PFOS were excellent, with a between-laboratory CV of 15% (n = 17). However, problems were experienced for PFOSA (CV = 46%, n = 10) for the limited number of laboratories analysing this compound. From the 17 participating laboratories, nearly 90% showed satisfactory z-scores for L-PFOS, and of the 11 entries for PFOSA, 42% were satisfactory.

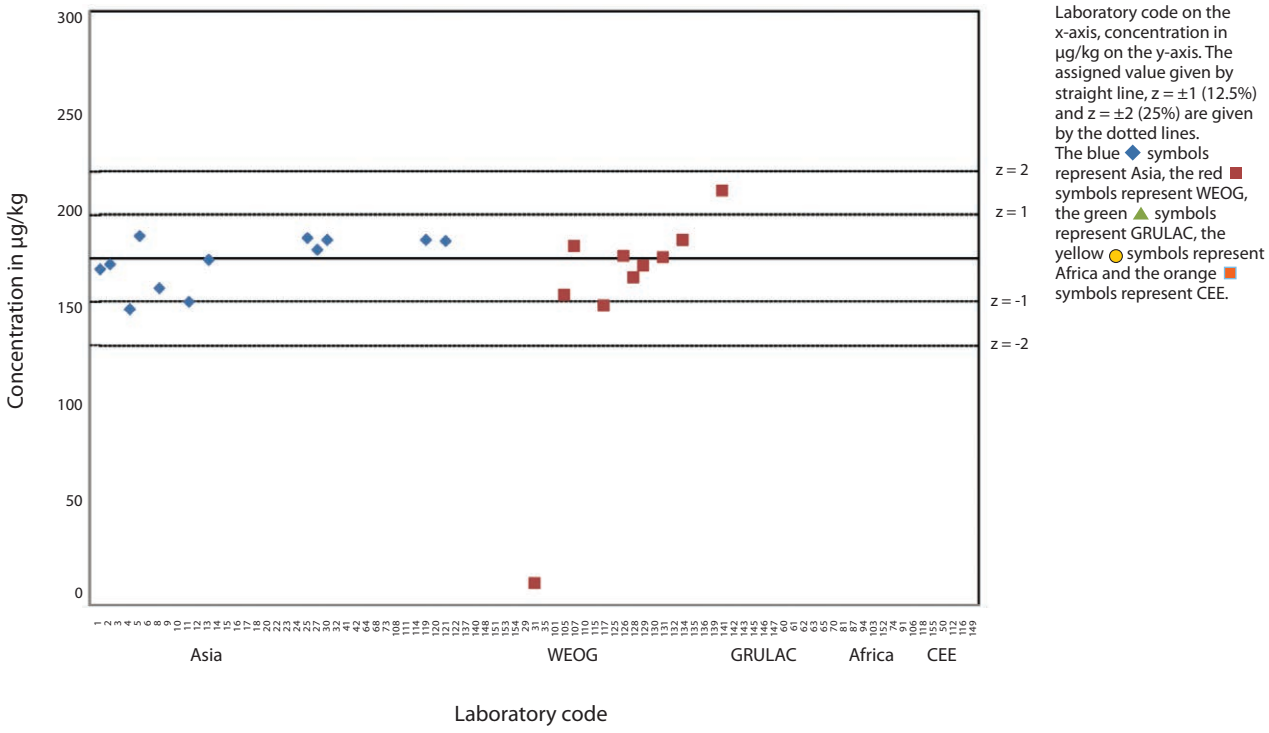

Figure 15: Results for the L-PFOS anion in the standard solution

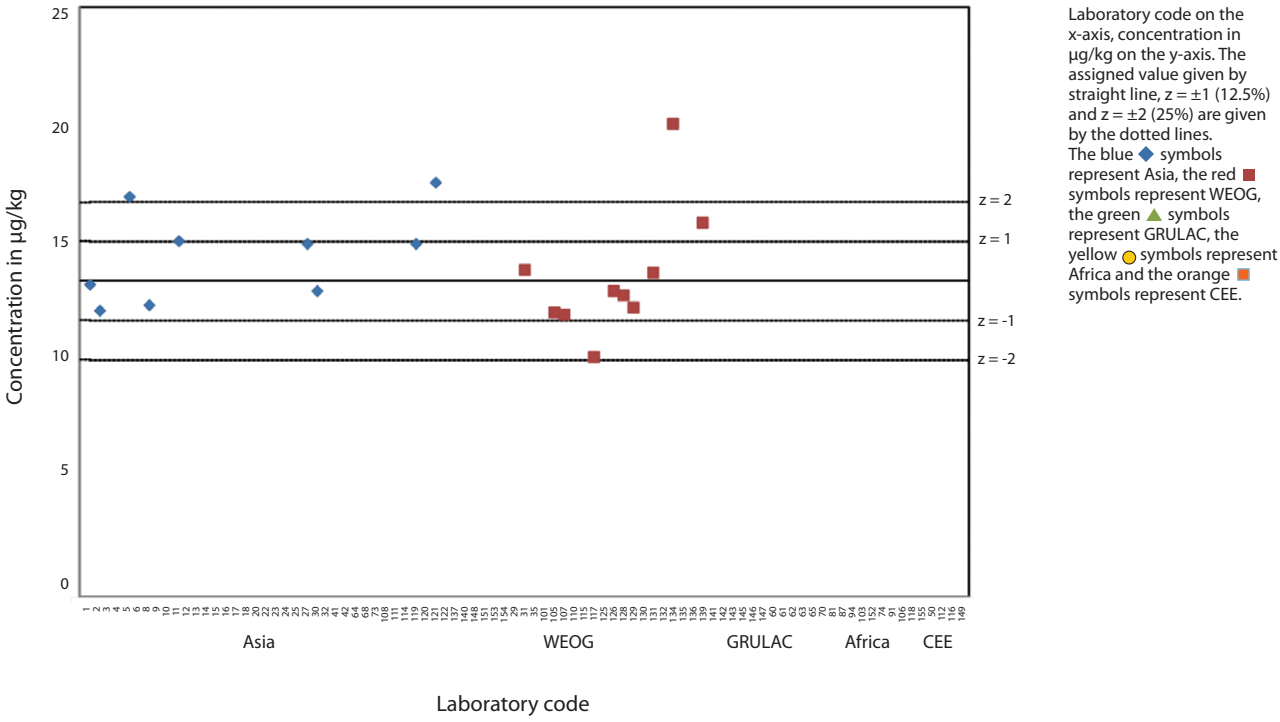

Figure 16: Results for the L-PFOS anion in the fish sample

Results for the fish samples were also excellent, with between-laboratory CVs of 13% for L-PFOS (n =19) and 18% for PFOSA (n =13). As can be seen from Figure 16, more than 80% of the results were satisfactory.

Only a limited number of laboratories analysed the mothers' milk sample for L-PFOS and no results were submitted for PFOSA. The interlaboratory variation was acceptable, with a CV of 25% for this complex analysis and levels just above the detection limit of most expert laboratories.

For the human serum sample (Table 52) – a matrix more commonly used than mothers' milk – a total of 14 PFASs were analysed but by a limited number of laboratories (two to nine depending on the compound). The between-laboratory CVs were reasonable, varying from 4% to 55% (L-PFOS 34%, n = 8; PFOA 10%, n = 10). These results are in agreement with earlier studies (Lindström *et al.*, 2009).

The results for the L-PFOS and sulfonamide precursors of the fortified air extract varied between the (limited) number of entries, showing larger variation for both L-PFOS (34%, n = 8) and PFOSA (27%, n = 7). Only three results were submitted for the PFOS precursors (MeFOSA, EtFOSA, MeFOSE, and EtFOSE), which made statistical evaluation unfeasible.

For the water sample, 20 laboratories submitted results for L-PFOS. The results were good, with a interlaboratory variation of 21%. For PFOSA only five results were submitted. These showed a larger variation (115%). No further statistical evaluation was performed on these data.

4.3 Regional Performance

In the following section the performance *per* region (Africa, Asia-Pacific, CEE, GRULAC and WEOG) is discussed with respect to the regional model CVs. Although such an evaluation gives valuable data on the analytical performance in each region, these data should be used with care because only a limited number of laboratories from some regions submitted data. For example, most data for the dl-POPs and for the PFASs were submitted by laboratories from Asia and WEOG, while in the other regions a maximum of five (and sometimes zero) laboratories submitted data (Table 58–Table 63).

4.3.1 Organochlorine Pesticides

Results for OCPs were mainly received from Asia (n = 25), WEOG (n = 16), and GRULAC (n = 9). From Africa and CEE, too few results for OCP analyses were received for calculation of most of the CV values.

The performance of laboratories from Asia and WEOG was acceptable and in good agreement for OCPs in the standard solution. However, the variation for GRULAC was higher in most cases.

This is illustrated in Figure 17 for DDT and its metabolites in the standard solution, and in Figure 18 for chlordanes in the standard solution. For DDTs in the standard solution, the results were acceptable for WEOG and Asia (CVs < 23%); however, the CVs were somewhat large for the GRULAC region (17%–72%). Similar results were seen for the chlordanes, drins and other OCPs in the standard solution.

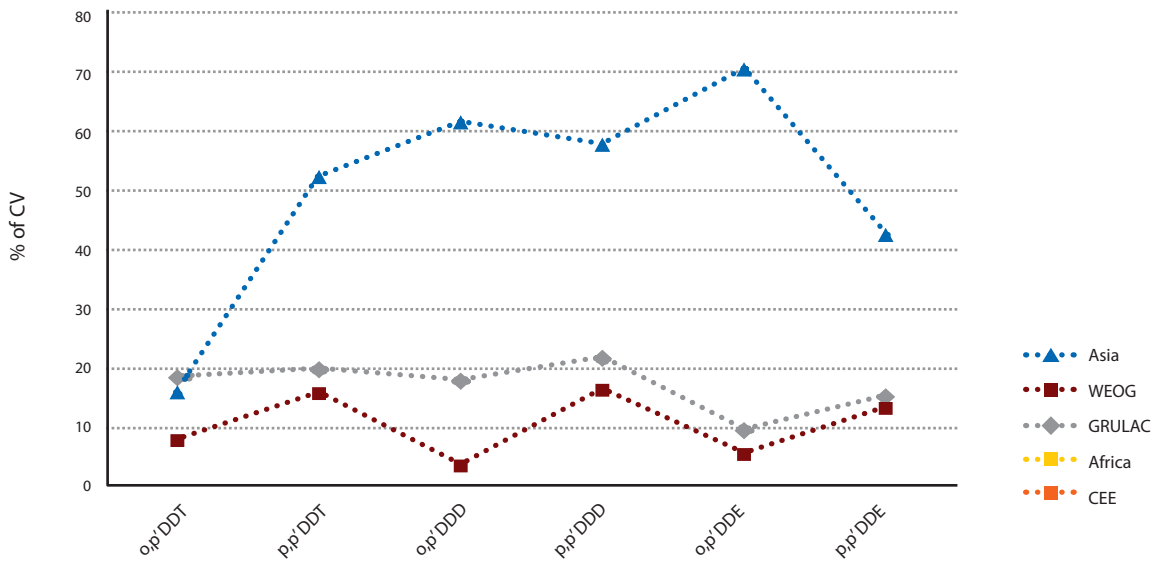

Figure 17: Regional CV values for DDTs in the standard solution

For real matrices – except for the air extract, the results are worse than in the standard solutions for OCPs, as illustrated in Figure 19 for the DDTs in the sediment sample. For the naturally contaminated test samples, the laboratories from WEOG performed better than the laboratories from Asia. Most of the DDTs showed CV values of more than 90% for laboratories from Asia, while most of the CV values for the WEOG laboratories were less than 50%.

A similar trend was observed for DDTs in the air extract, where CVs from Asia were 15%–82% while the variation for WEOG was only 4%–15%. For chlordanes in the air extract the performances of the Asian laboratories (4%–15%) and the WEOG laboratories (4%–22%) were good and comparable except for heptachlor, for which the CV value for the WEOG region was 70%.

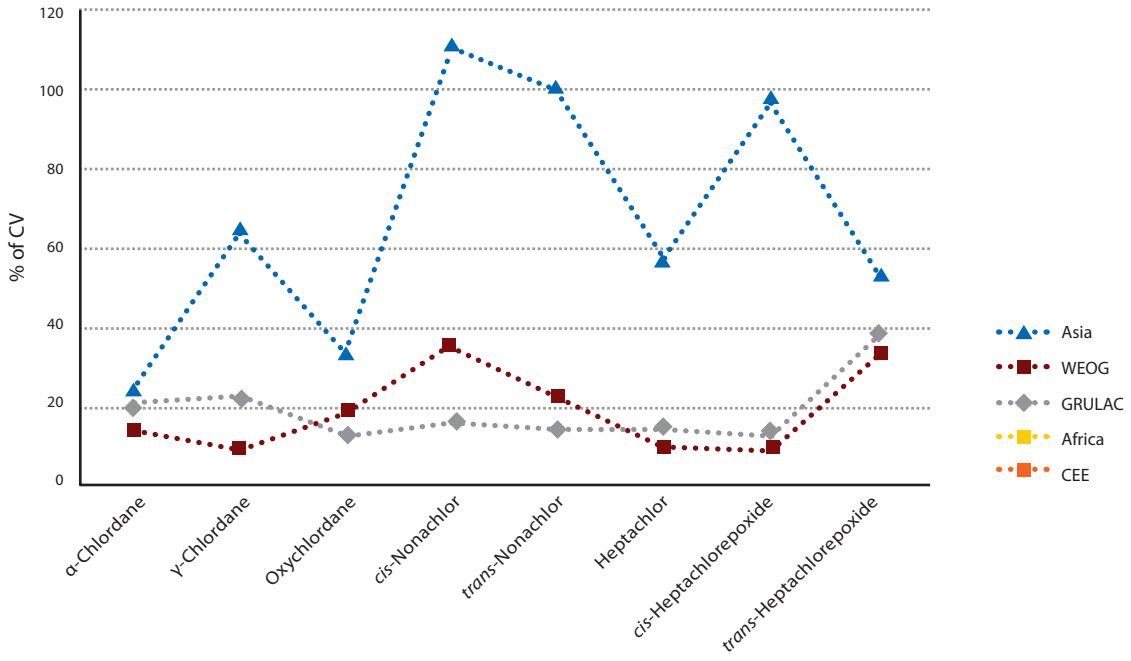

Figure 18: Results for the L-PFOS anion in the standard solution

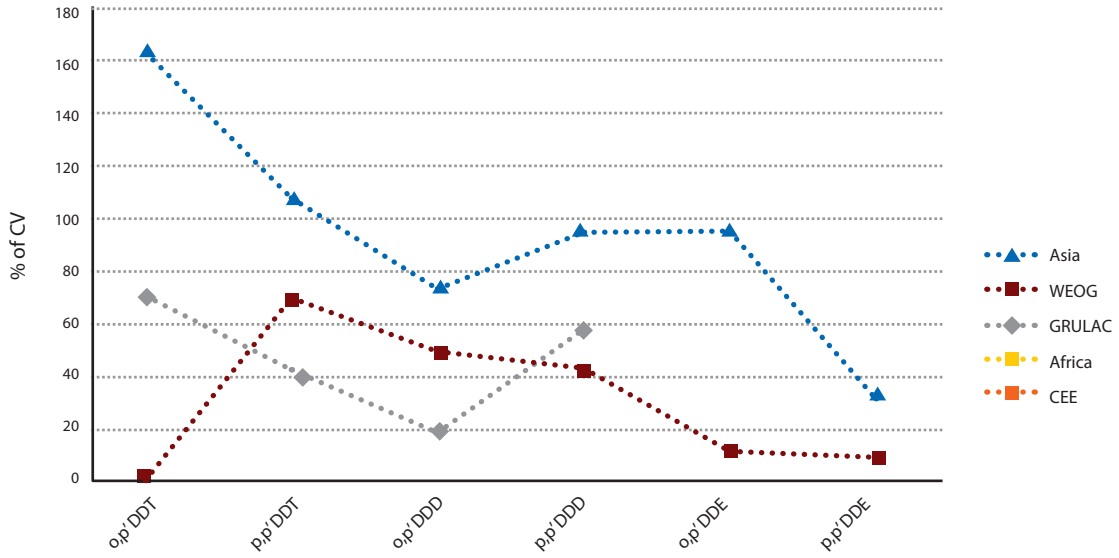

Figure 19: Regional CV values for DDTs in the sediment sample

For OCPs other than drins, chlordanes and DDTs, the performances of WEOG and Asia were quite similar for the standard solution and the sediment sample. However, for the fish the performance of Asian laboratories (3%–61%) was much better than for the WEOG laboratories (65%–491%) (Figure 21). CVs that could be calculated for the GRULAC laboratories were, in most cases, higher than for the laboratories from Asia and WEOG.

4.3.2 Polychlorinated Biphenyls

Results for indicator PCB were mainly received from Asia (n = 28), WEOG (n = 21), and GRULAC (n = 9). From Africa and CEE too few results were received for calculation of most of the CV values. The results of the indicator PCB for the standard solution were almost acceptable for Asia (14%–30%) and WEOG (18%–32%). In contrast with the results for OCPs, the variation for GRULAC (2%–32%) was lower than for Asia and WEOG for most of the compounds in the standard solution (Figure 21).

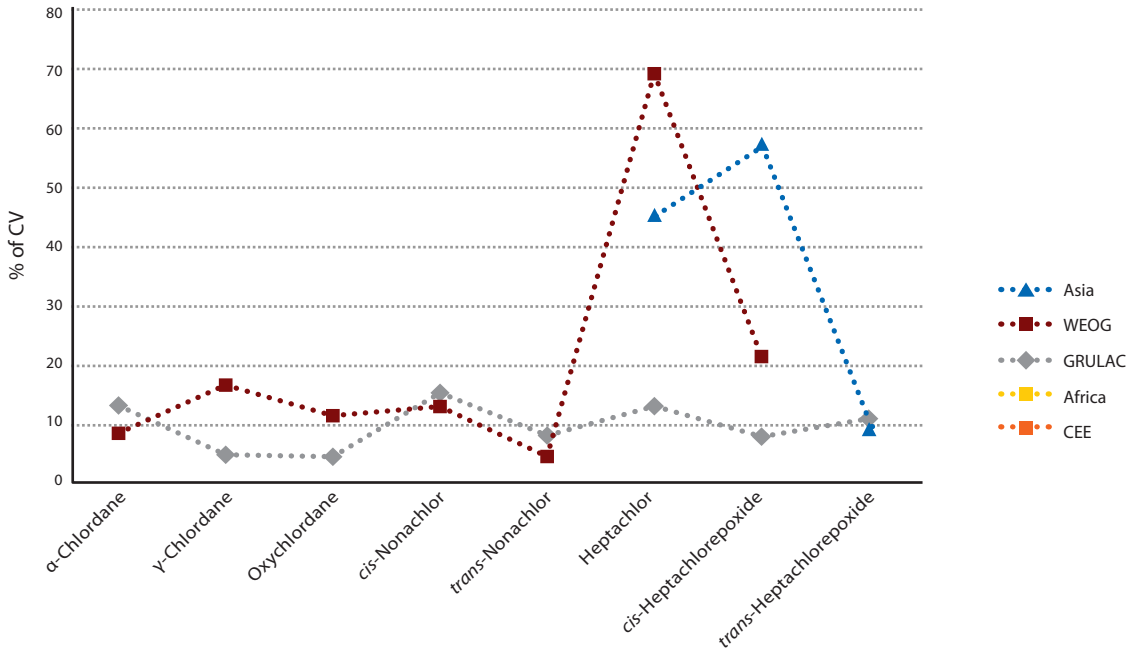

Figure 20: Regional CV values for chlordanes in the air extract

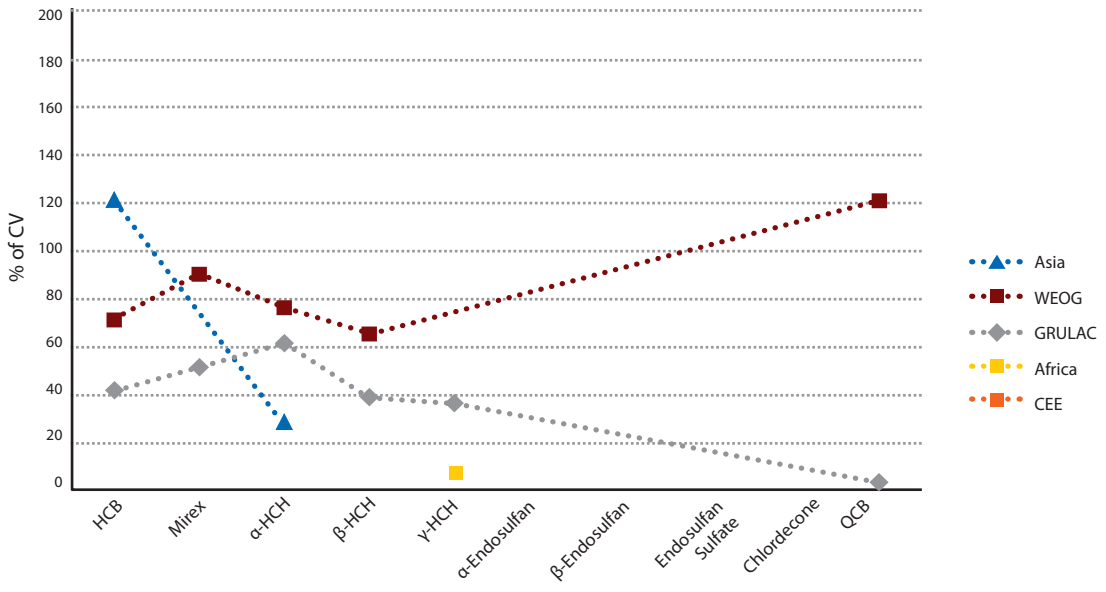

Figure 21: Regional CV values for OCPs in the fish sample

For the fish and the sediment samples, the performance for GRULAC was worse than for Asia and WEOG.

For the fish and the mothers' milk analysis of PCB, Asian laboratories performed better (CVs = 18%–50% and 7%–43%, respectively) than WEOG laboratories (CVs = 35%–69% and 10%–93%, respectively). In contrast, for the sediment, air extract and transformer oil samples, WEOG laboratories performed better than Asian ones (CVs = 5%–26%, 23%–49% and 8%–29%, respectively) as a large variation was seen for Asia (CVs = 18%–45%, 63%–118% and 21%–81%, respectively). To show the large interlaboratory variation for Asia, the results of PCB analysis in the air extract are given per region in Figure 22.

Since four participating laboratories from Africa handed in results for PCB in fish, it was possible to make a comparison of the regional differences between Asia, WEOG, GRULAC and Africa (Figure 23). The results for Asia are reasonable, with CVs below 50%, while the CVs for WEOG were somewhat larger (35% –69%). The results for GRULAC deviated more, and a large individual variation was particularly seen for some of the PCB CVs (PCB 52, 101, 138 and 153). Results for Africa are worse with very large CVs (147% –245%).

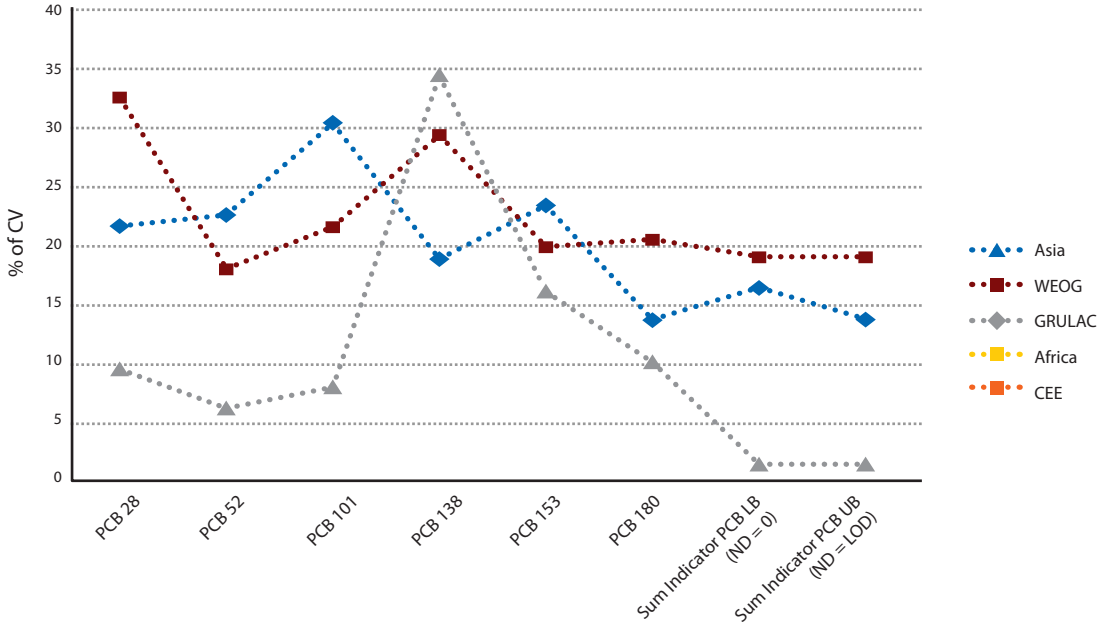

Figure 22: Regional CV values for PCB in the standard solution

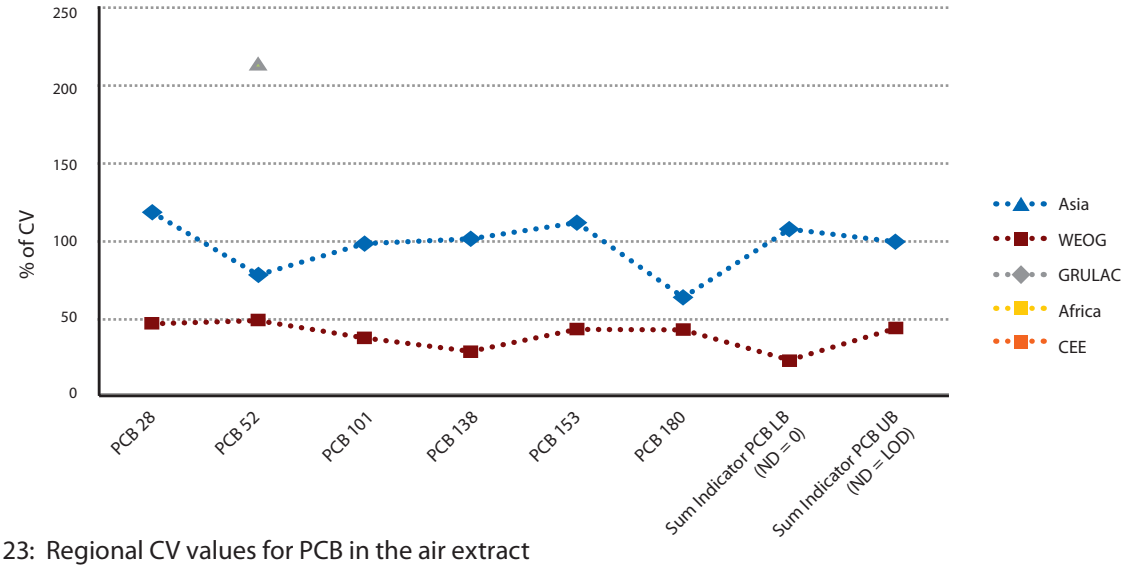

Figure 23: Regional CV values for PCB in the air extract

4.3.3 Dioxin-like Persistent Organic Pollutants

The overall results for the dl-POPs were good, in particular for the standard solution (summarized in Table 60 and Table 75). The CV for the PCDD/PCDF TEQ was under 10% for all participants from Asia (n = 27), WEOG (n = 16), GRULAC (n = 2) and CEE (n = 3) including three entries from Viet Nam and one from India. No results for Africa were submitted. Looking closer at the individual results, no RSDs were calculated for the CEE and GRULAC regions because too few laboratories submitted data. The RSD for Asia was 9% and WEOG, 7%. Four and five results, respectively, for Asia and WEOG were outside z = ±2. All results for GRULAC and CEE were within z = ±2.

The results for the dl-PCB analyses showed a similar regional variation to the analysis of the standard solution (Table 61and Table 75). Three entries were submitted for the CEE region and the CVs for the individual dl-PCB congeners was somewhat better than the other two regions, as can be seen in Figure 25. If the analysis of the standard solution (the least complex sample matrix) is an indication of the capacity in the regions, there is still a lack of capacity outside WEOG and Asia, and especially so for Africa. It should also be noted that only limited capacity is available in Asia outside China and Japan.

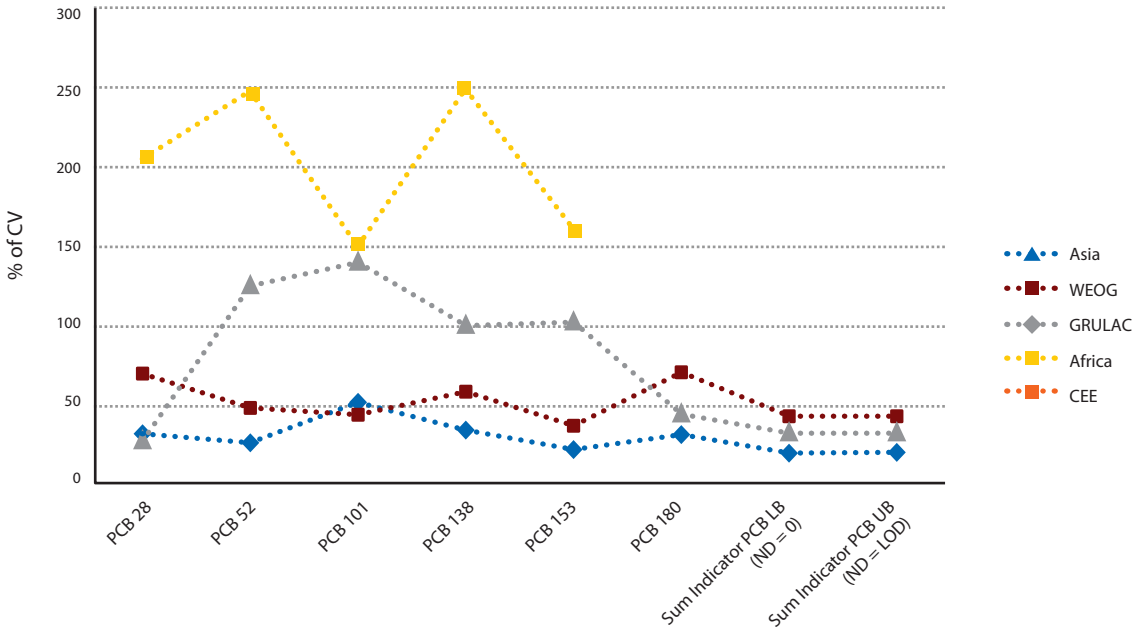

Figure 24: Regional CV values for PCB in the fish sample

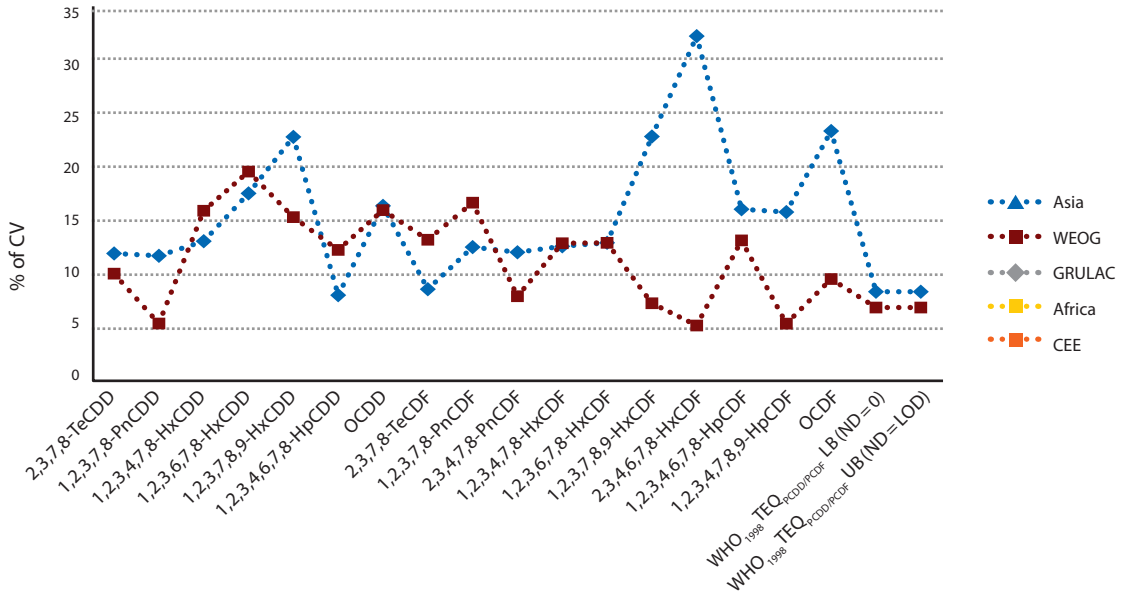

Figure 25: Regional CV values for PCDD/PCDF in the standard solution

For the sediment sample, the results of the PCDD/PCDF analyses were excellent, especially for the total TEQ (CV < 15% for all regions). Similar CV values were seen for Asia and WEOG. The other regions were not evaluated in detail due to the limited number of results submitted. The individual results for the different congeners were good with the exception of 1,2,3,7,8,9-HxCDF in Asia. Because of the low TEF value of this congener, this did not influence the dioxin or total TEQ. The results for the dl-PCB analyses for the sediment sample were good and similar for both Asia and WEOG. No evaluation of the other regions was performed due to the limited number of results submitted.

However, the two results submitted from the CEE region were within the UNEP criteria (z = ±2).

The results for the air sample were excellent for all regions and fell within the UNEP criteria. The 13 WEOG laboratories performed somewhat better for the PCDD/PCDF TEQ than the 22 laboratories in Asia (CVs = 5% and 11%, respectively). One result was submitted from the GRULAC region and three from CCE. These were not further evaluated. The results for the individual congeners were good with the exception of, again, 1,2,3,7,8,9-HxCDF. Results for the PCB analyses were similar for Asia and WEOG, with CV values of 20% and 15%, respectively.

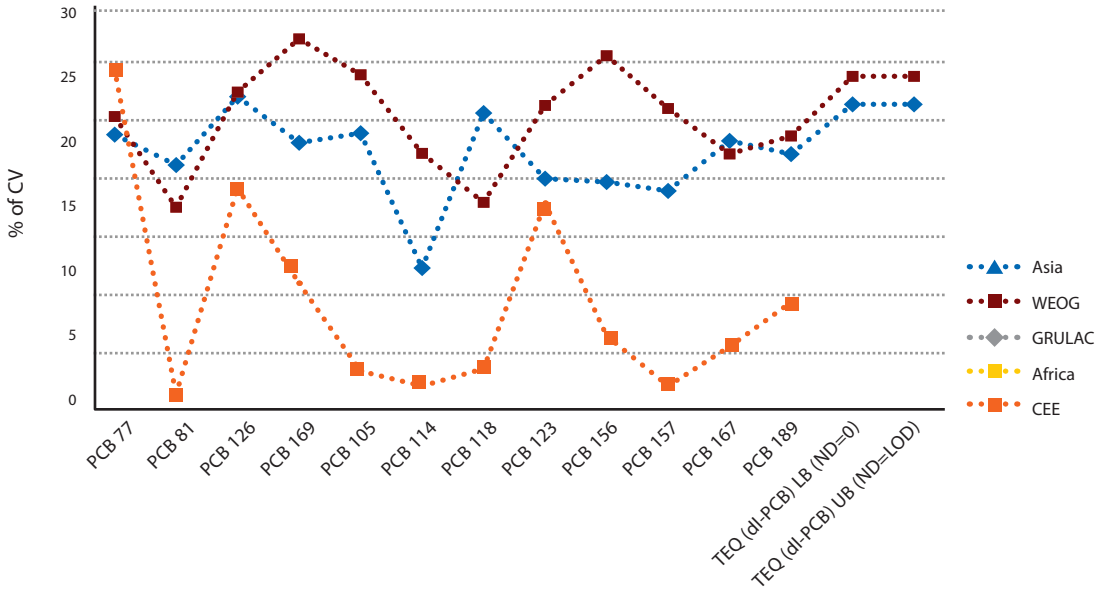

Figure 26: Regional CV values for dl-PCB in the standard solution

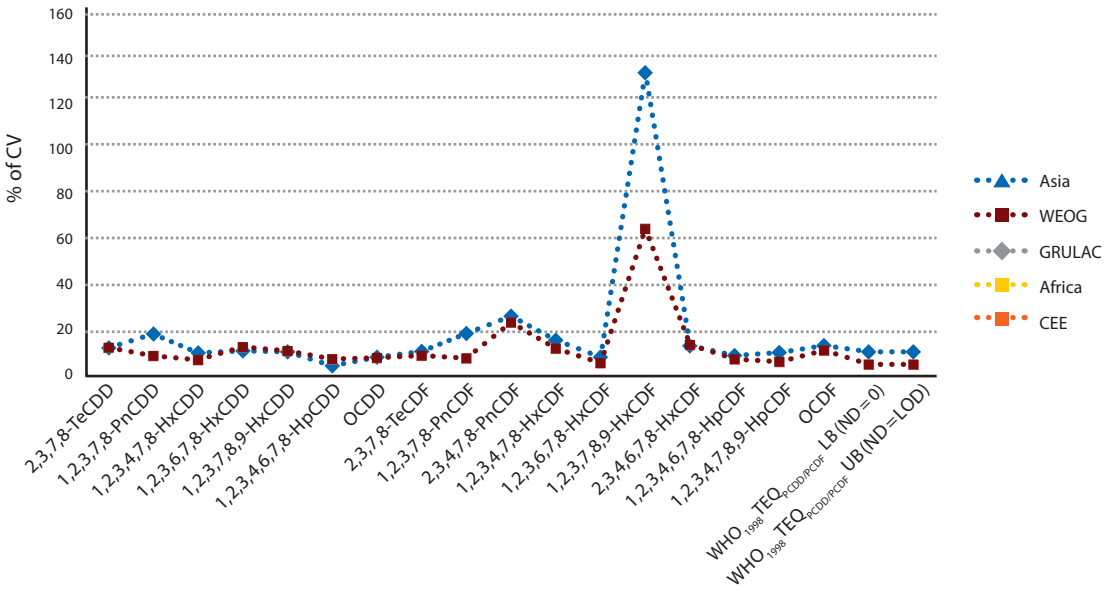

Figure 27: Regional CV values for PCDD/PCDF in the air extract

Due to the large variation in the original data for the fish PCDD/PCDF results, no consensus value could be calculated for the fish sample or for all results and for the different regions. The dioxin levels in the fish were low but should have been detectable using high resolution GC/MS instrumentation. It seems that confusion on the units might have caused the large variation. In order to remove the influence of error for lipid determination (a common way to normalize the concentrations), the laboratories were asked to report on a wet weight basis. Twenty-two results were submitted from Asia, twelve from WEOG and three from CEE. The interlaboratory variation for the PCDD/PCDF TEQ was surprisingly large for the WEOG region (118%).

The results for the Asian region were better (PCDD/PCDF TEQ = 38%) but still not in line with the UNEP criteria. No variation for the CEE region was calculated due to the limited number of results submitted. The results per region for the dl-PCB looked better, especially for Asia (CV = 29%, n = 20), but the variation among laboratories in the WEOG region was still large (CV = 76%, n = 15). Three results were submitted from the CEE region.

The overall results for the mothers' milk sample were good and promising for both the dioxin and dl-PCB analyses, with a variation among all results of 23% and 28%, respectively. Breaking down these results on a regional basis for both Asia and WEOG (no laboratories from Africa

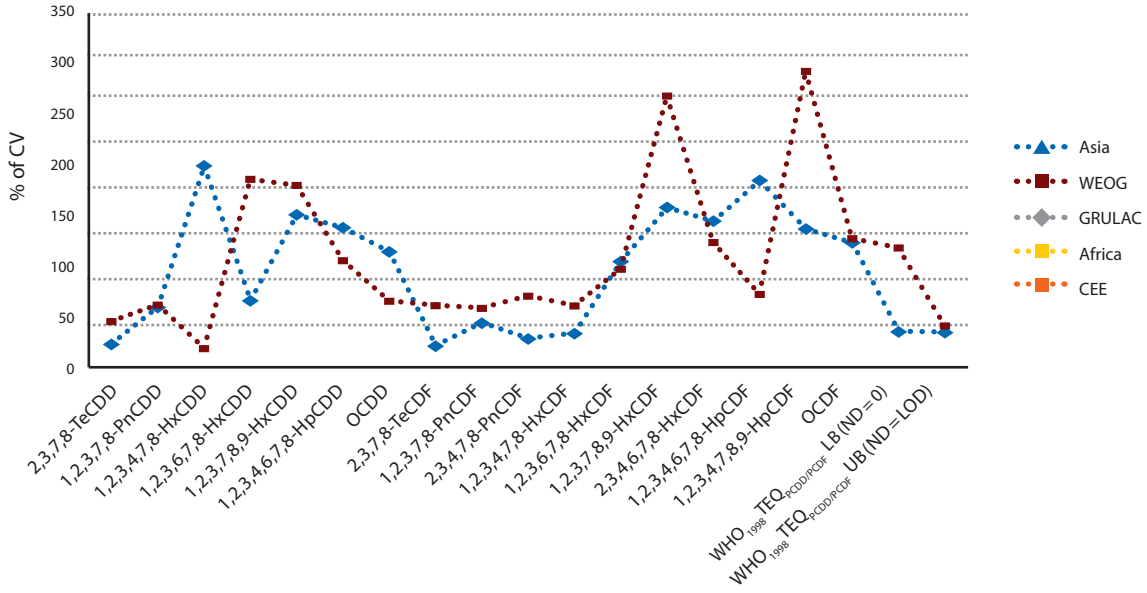

Figure 28: Regional CV values for PCDD/PCDF in the fish sample

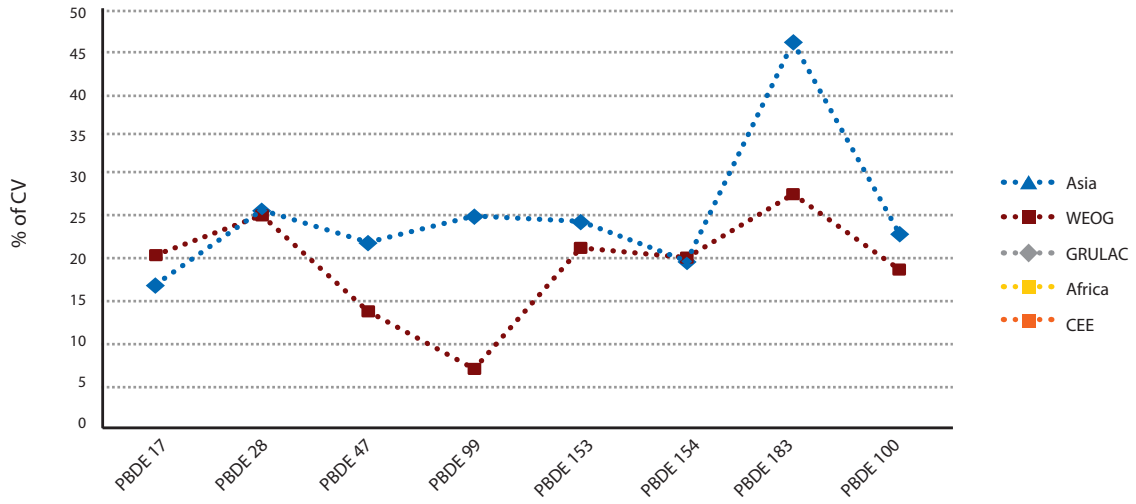

Figure 29: Regional CV values for PBDE in the standard solution

and GRULAC and only one from CEE submitted data), Asia performed especially well for the PCDD/PCDF TEQ (CV = 11% compared with 47% for WEOG). The results for both regions for the dl-PCB analyses were similar (20% and 26%, respectively). It should be noted that large variation could be seen for individual congeners, especially in the WEOG region (> 100%). However, this only marginally affected the total TEQ values.

4.3.4 Polybrominated Diphenyl Ethers

PBDE results were mainly received from Asia (n = 22) and WEOG (n = 18). From GRULAC, Africa and CEE only one or two participants submitted results for PBDE. It was therefore only possible to compare the regional variation between Asia and WEOG. The performance of these laboratories were acceptable for the standard solution (Figure 28). For the other matrices, WEOG laboratories generally performed better than Asian laboratories, except for the mothers' milk sample (CV = 11%–132% and CV = 14%–64% respectively).

Although sediment is a more complex matrix than a standard solution, WEOG laboratories performed well for the sediment analyses (CV = 8%–21%) and even better than for the standard solution (CV = 7%–28%). For fish and mothers' milk the highest variation was observed for WEOG (Figure 30).

For Asia, the variation was higher for the sediment sample (22%–54%) than for WEOG (Figure 30).

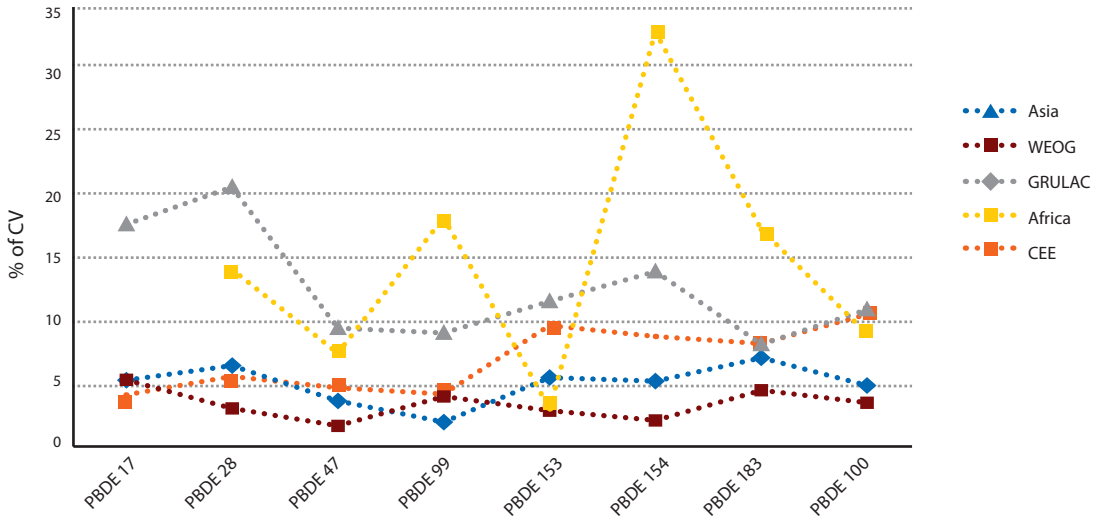

Figure 30: WEOG CV values for PBDE per matrix

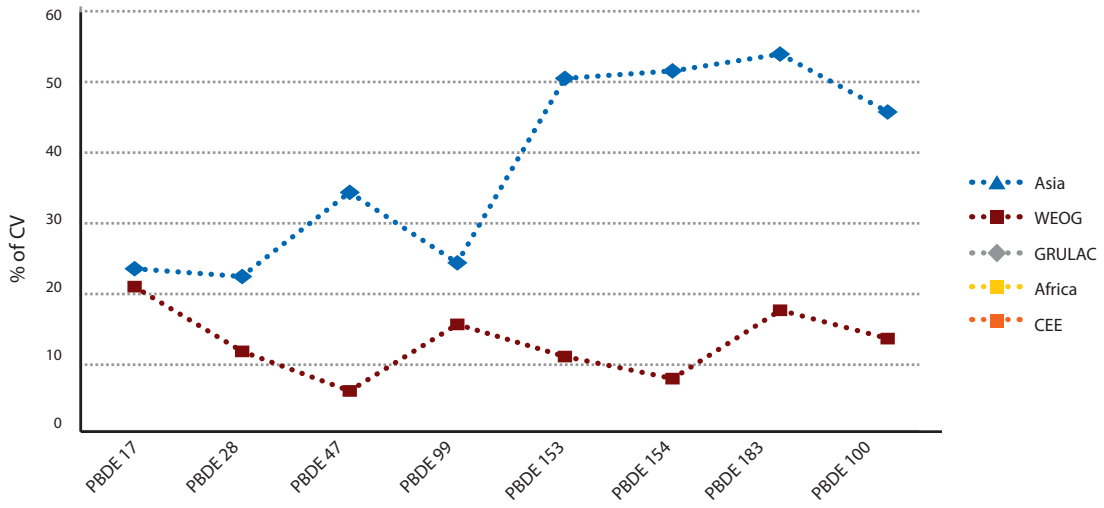

Figure 31: Regional CV values for PBDE in the sediment sample

4.3.5 Perfluorinated Alkyl Substances

More than 30 laboratories submitted results for the PFAS compounds but these were only from Asia and WEOG indicating that still very little or no capacity is available in Africa, CEE and GRULAC (Table 63). The results for the standard solution were excellent, showing a CV of less than 10% for PFOS for both regions (Table 85). Results for the sediment were also good, with CV values of 15% and 17% for Asia and WEOG, respectively (Table 86). The results for the fish samples for PFOS were also promising for both regions (WEOG, CV = 10%, n = 10; Asia, CV = 19%, n = 9 (Table 87)). The limited results for the mothers' milk sample (Table 88) were good for Asia (CV = 13%, n = 3), but not satisfactory for WEOG (CV = 72%, n = 5) due to one outlier. The results for the fortified air extract were good for WEOG (CV = 13%, n = 5), and although only three results were submitted for PFOS for Asia, the variation was relatively large (CV = 81%). In both regions, less than two results for the precursor compounds were submitted and no further regional evaluation was performed for these compounds.

For the PFAS compounds, water and human blood serum samples were included in addition to the samples above. In total, 13 laboratories reported for the human blood serum sample and 25 for the water sample (Table 63). For the human blood serum the results were somewhat disappointing in both regions, with a relatively large variation in both Asia (CV = 37%, n = 4) and WEOG (CV = 25%, n = 4) (Table 89) for PFOS. In other studies better results were achieved (Lindström *et al.*, 2009). The results for the water sample were excellent for Asia for PFOS (CV = 7%, n = 10) but not satisfactory for WEOG (CV = 38%, n = 10).

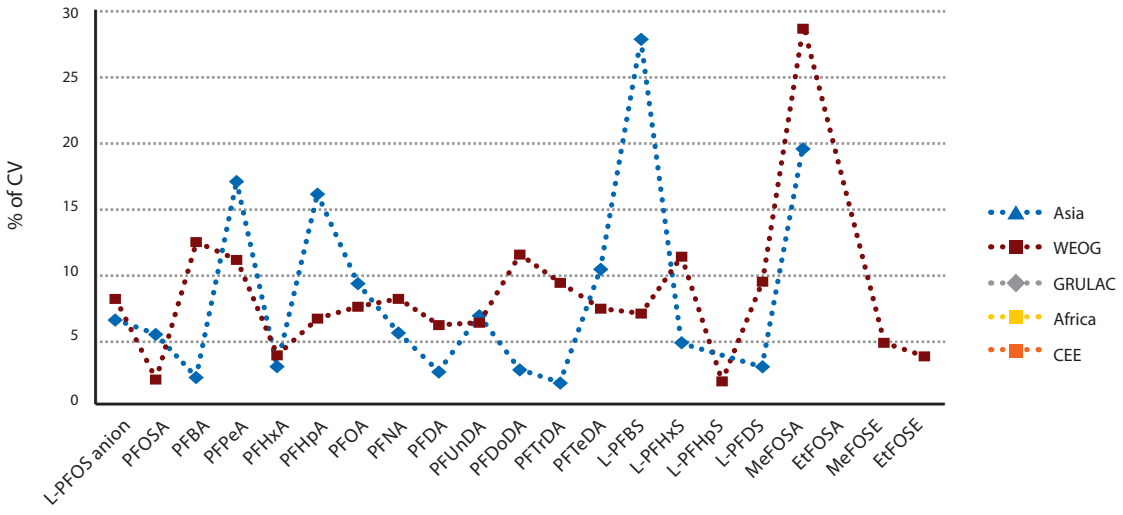

Figure 32: Regional CV values for PFASs in the standard solution

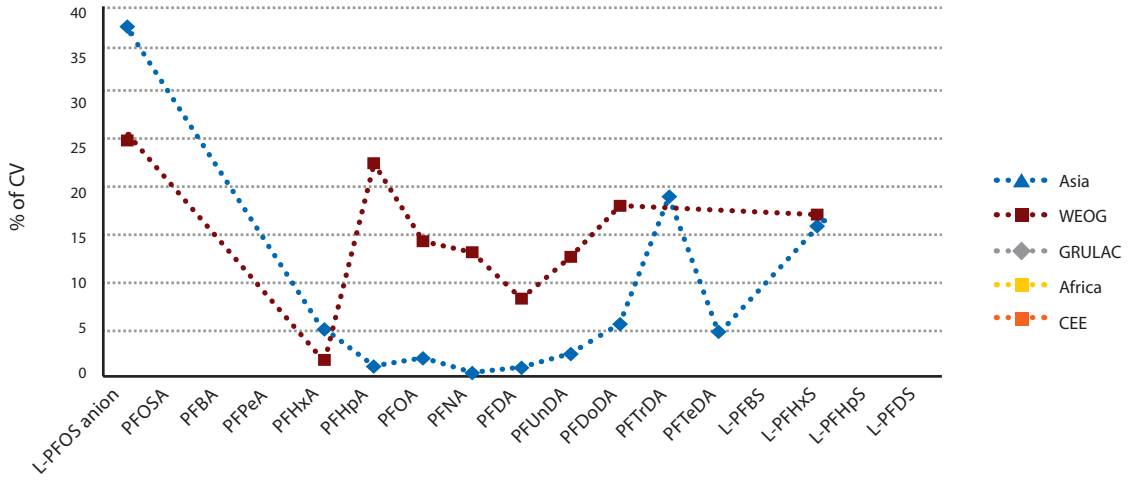

Figure 33: Regional CV values for PFASs in the human blood serum sample

4.4 Performance for Sum Parameters

4.4.1 Sum Organochlorine Pesticides

In this section, the performance of participants on the sums of drins, chlordanes, DDTs, HCHs and endosulfans (Table 92-Table 101) is discussed. Although such an evaluation provides valuable data, it should be noted that the results of the statistical evaluation of the sum parameters is only indicative, as some participants only reported on one or two compounds of a compound group, while others reported results for all OCPs.

For the analyses of the sum OCPs in the standard solution, CV values varied between 22% and 40% (Table 92) and the majority of participants ((48%–71%) obtained satisfactory z-scores (Table 93). For all other matrices, except for sum chlordanes in the air extract, less than 50% of the participants received satisfactory z-scores (Figure 34).

As can be seen in Figure 35, the largest variation from the assigned value was observed for the sum endosulfans, with CV values of 71%–182%. Concentrations were largely comparable for all OCPs. The CV value for the sum drins in fish was very high (111%), with only 25% of the participants obtaining a satisfactory z-score. Meanwhile, for the air extract, lower CV values were received for the sum of drins than for the other OCPs. For the individual drins in the air extract, the CV values varied from 21% for aldrin to 58% for endrin. This is explained by lower matrix effects in the air extract compared to, *e.g.,* in the sediment and fish.

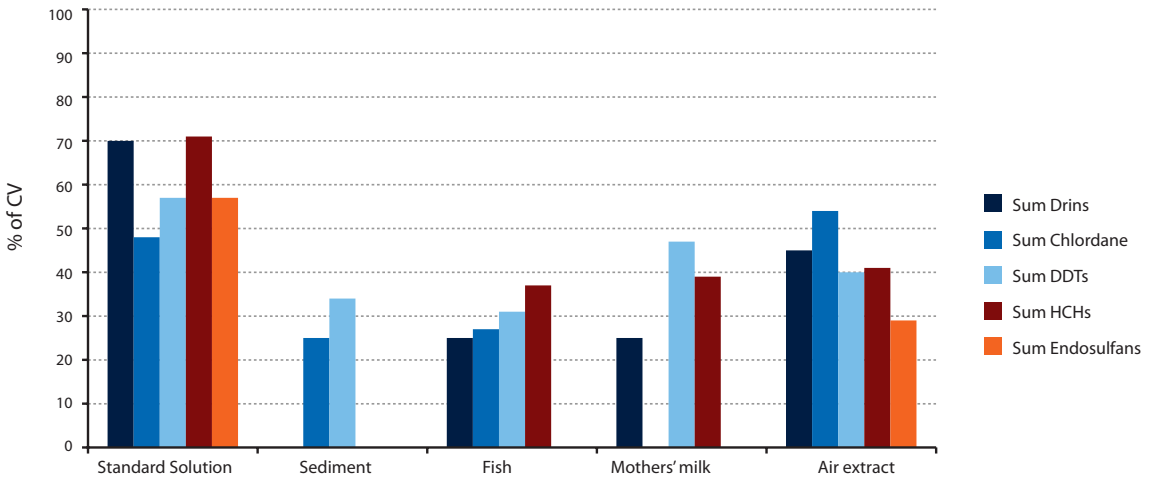

Figure 34: Percentage of laboratories with satisfactory z-scores for sum OCPs

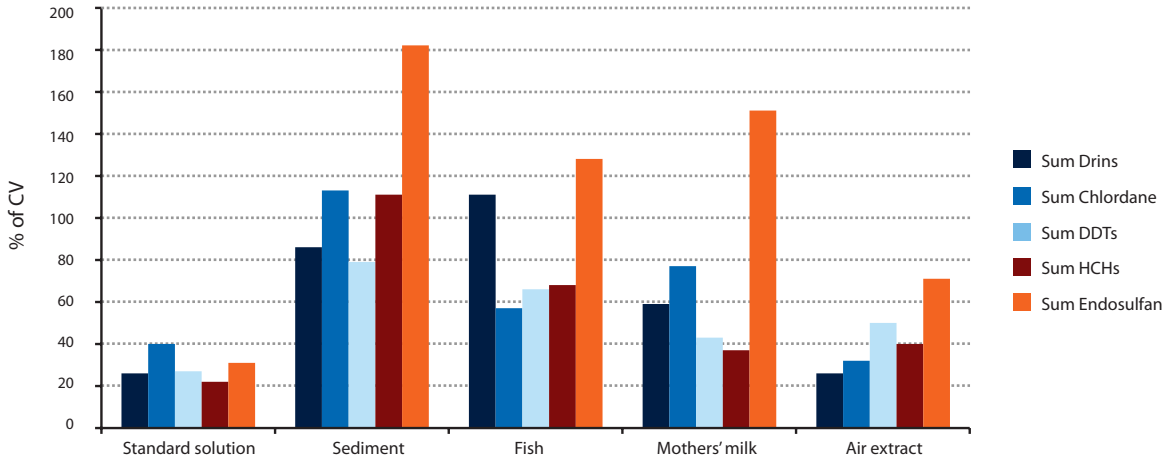

Figure 35: Variation in CV values for sum OCPs

4.4.2 Sum Polybrominated Diphenyl Ethers

In Figure 36 and Figure 37, the performance of the participants on the sum PBDE (Table 102 and Table 103) is shown. It should again be noted that the results of the statistical evaluation of the sum parameters is only indicative as several participants only reported on one or two PBDE congeners.

Just over 50% of the participants obtained satisfactory z-scores for the sum PBDE except for the fish sample, where only 26% of participants had satisfactory z-scores. (Figure 36). Of those participants obtaining a z-score > 2 for the fish sample, 86% used low resolution mass spectrometry. By contrast, 90% of the participants with a satisfactory z-score used high resolution mass spectrometry.

In conclusion, the high variation for the sum of PBDE might be due to interfering compounds in the fish matrix, which could be separated from some of the target congeners with high resolution mass spectrometry but not with low resolution mass spectrometry. Column selection might also be an issue.

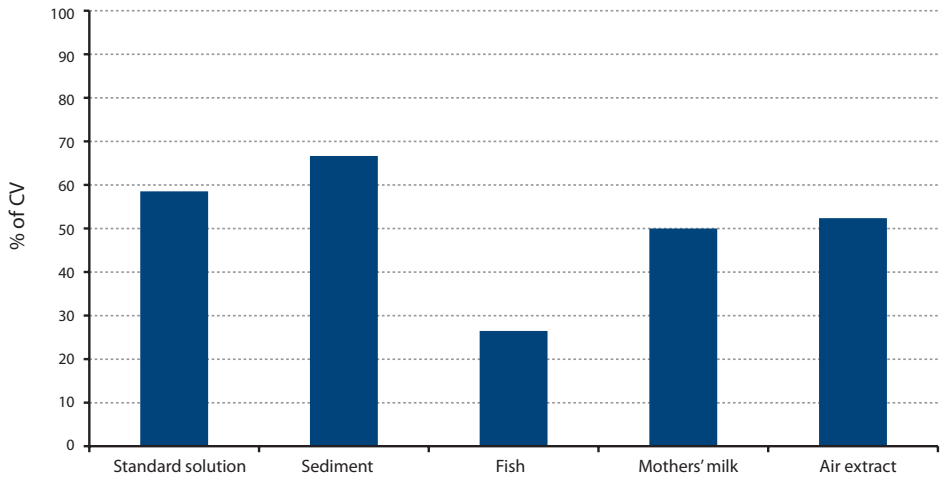

Figure 36: Percentage of laboratories with satisfactory z-scores for sum PBDE

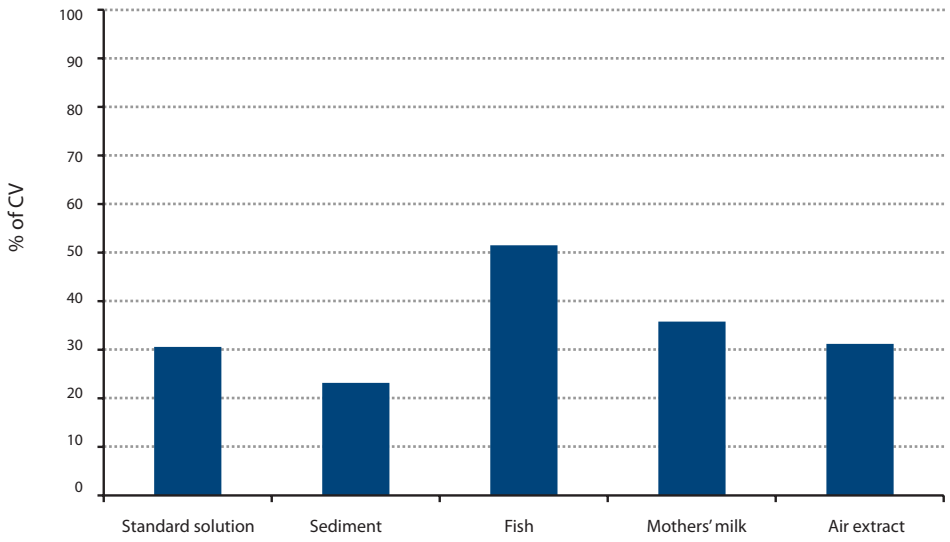

Figure 37: CV values for sum PBDE

Just over 50% of the participants obtained satisfactory z-scores for the sum PBDE except for the fish sample, where only 26% of participants had satisfactory z-scores. (Figure 36). Of those participants obtaining a z-score > 2 for the fish sample, 86% used low resolution mass spectrometry. By contrast, 90% of the participants with a satisfactory z-score used high resolution mass spectrometry.

In conclusion, the high variation for the sum of PBDE might be due to interfering compounds in the fish matrix, which could be separated from some of the target congeners with high resolution mass spectrometry but not with low resolution mass spectrometry. Column selection might also be an issue.

4.4.3 Sum Perfluorinated Alkyl Substances

Most laboratories did not report all PFAS compounds and no sum of PFAS compounds was included in the reporting file. When using the sum of PFASs the results are clearly not as good for individual compounds as, for example, for PFOS. While the variation for PFOS for the standard solution was only 8%, with 95% of the data being satisfactory, the variation for the sum parameter was 40%, with 73% of the data being satisfactory (Table 104 and Table 105). The sum parameter for the human blood serum showed better agreement (CV = 3%, n = 7); however, this parameter was dominated by the PFOA level in the human blood serum sample, which contained nearly 80% PFOA. For the air extract, the variation for the sum parameter was large and did not reflect the variance of the individual results. This indicates that the sum parameter has to be clearly defined before being used for validating laboratory performances.

5. Comparison with the First Round of the UNEP Interlaboratory Assessment

In 2010/2011, UNEP organized the first global interlaboratory assessment on POPs (Abalos et al., 2013; van Leeuwen *et al.*, 2013). In the first assessment, standard solutions, sediment, fish, mothers' milk and fly ash samples were tested but only for OCPs, PCB and dl-POPs. Overall, the performance obtained from the standard solutions was reasonable to good but a substantial number of laboratories struggled with the analysis of the other matrices.

The overall goal of UNEP is to reach a maximum analytical variation of 25% between the participating laboratories ($z < |2|$). Comparison of the present assessment and the assessment of 2010/2011 shows that participants now performed much better in the analyses of PCB in sediment, fish and mothers' milk (Figure 38). CV values for PCB in the standard solution in the present assessment (18%–28%) were considerably larger than in the assessment of 2010/2011 (8%–19%). Meanwhile, concentrations were 100–300 times lower in the present assessment. PCB concentrations in the fish and mothers' milk were 60–800 and 20–800 times lower, respectively.

The performance of laboratories participating in the present assessment for OCP analyses in the standard solution, the fish and the mothers' milk were worse than in the assessment of 2010/2011. Lower CV values were only found for the sediment sample, even though concentrations were up to 40 times lower. For drins in fish, CV values and concentrations between the two studies were comparable. For the chlordanes and DDTs in fish, CV values in the present assessment are much higher. Yet if heptachlor (CV = 571%), *p,p'*-DDT and *o,p'*-DDT are removed from the calculation, the average CV values are in line with the interlaboratory assessment of 2010/2011.

For OCPs in mothers' milk, the performance in the assessment of 2012/2013 (CV = 62%–245%) was better for the drins than in 2010/2011 (CV = 34%–332%) notwithstanding that CV values are still much larger than the target value of 25% (Figure 40). The average of CV values of chlordanes was much larger in 2012/2013, but with removal of heptachlor (CV = 927%), the average CV is reduced to 83% in the present assessment compared to 92% in the assessment of 2010/2011. The laboratory performance for sum DDT in the mothers' milk sample showed a clear improvement, from an average CV of 92% in the previous assessment to an average of 43% in the present assessment.

Analytical interlaboratory variability in POPs analysis is well documented (*e.g.*, Mizikiewicz and Gibbs, 1992; Rimkus *et al.*, 1993; de Boer *et al.*, 1996; de Boer and Wells, 1997). The present results are slightly better than those of an interlaboratory assessment led by the International Atomic Energy Agency, which reported RSD values of between 30% and 150% for PCB and OCPs in mussel homogenate (Villeneuve *et al*., 2004). However, when compared to recent (mainly European) studies such as those of QUASIMEME, the present results are poorer (de Boer and Wells, 1997; and references herein).

The CV values for the standard solution for the PCDD/PCDF TEQ were good in both studies — below 10% — and thus in agreement with the UNEP criteria of 12.5%. The results for the air samples improved substantially, from over 20% in 2011/2012 to less than 10% for this, second, assessment. However, it should be noted that the sample for the second assessment was an extract whereas in the first round it comprised fly ash. It was difficult to find a sample which would mimic a passive sampler of polyurethane foams

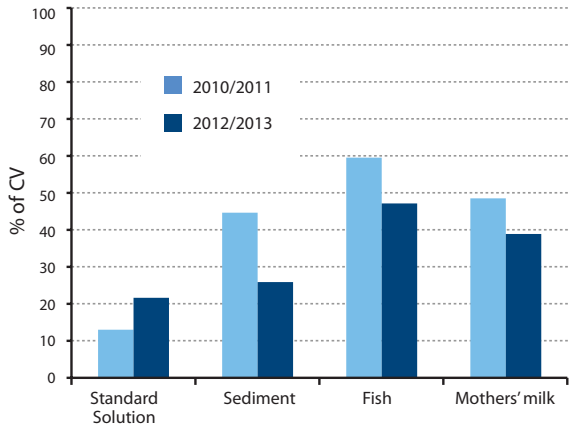

Figure 38: Comparison of performances between two UNEP-coordinated interlaboratory assessments for the PCB analyses

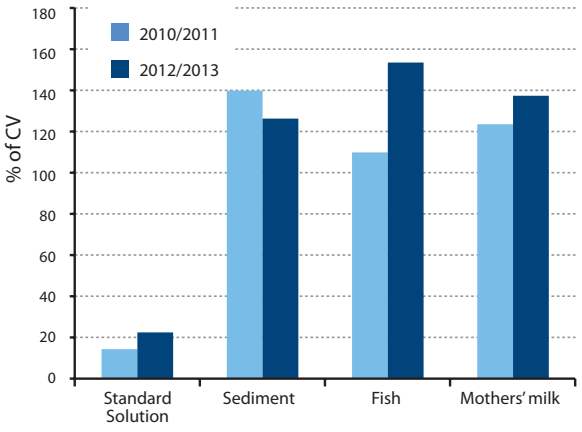

Figure 39: Comparison of performances between interlaboratory assessments for the OCP analyses

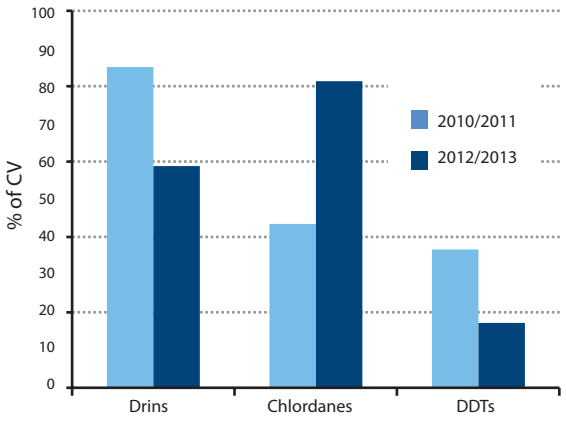

Figure 40: Comparison of performances between interlaboratory assessments for the sum of selected groups of OCP analyses in mothers' milk

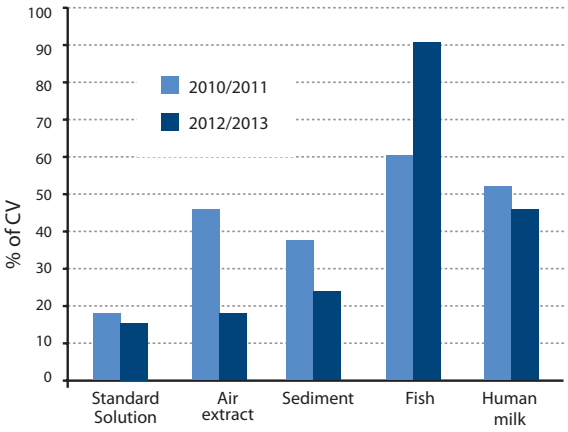

Figure 41: Comparison of the performance between interlaboratory assessments for the PCDD/PCDF TEQ analyses

and which could be distributed to a large number of laboratories.

The results for the sediment sample were substantially better and improved to 12% in this, second, assessment to fall in line with the UNEP criteria. These results are in accord with several other studies on PCDD/PCDF in standard solutions, sediments and incineration-related samples (van Bavel and Abad, 2008). However, for the fish sample, the already large variation in analysis consistency observed in the first round became even larger in the second round. The 45% variation is both disappointing and far from the UNEP guidelines. These results are not in line with other studies using fish samples (Becher *et al.,* 2004), where better results were observed. No obvious reason could be found for the large variation in both studies. The PCDD/PCDF levels were high in the 2011/2012 fish samples and medium to high in this assessment. In an attempt to avoid variation of the lipid determination, all results were reported on a wet weight basis. However, this did not seem to have any influence in either study. It was further noted that dl-POPs in fish are often reported in different units (with or without lipid normalisation) and some misunderstandings might have resulted in reporting in the wrong unit. However, all laboratories were allowed to change the unit after an initial inspection of the results.

The results of the milk sample were good given the low levels of dioxins present in the sample from Sweden (which indicates a decreasing trend in PCDD/PCDF concentrations in the general population of western countries). The results are promising also given that 12 additional laboratories analysed the milk sample thus totalling 29. Although the results improved somewhat for a large number of laboratories, the CV was still 23% and needs to be improved to meet the UNEP criteria.

The variation between the laboratories for the dl-PCB analysis in this assessment was somewhat larger than in the first round. Although a larger number of laboratories participated, the results for the standard solution, the sediment and the air extract were, at just over 20%, above the UNEP criteria.

A larger variation in the results for dl-PCB analyses have been observed in other studies (van Bavel and Abad, 2008). The fish samples in both assessments showed a large variation between laboratories (up to 44% for this, second, round). Likewise, the results for the milk sample did not improve and dropped from 24% to 29% for the 28 participating laboratories.

The results for the analyses of the individual PFAS compounds are discussed in the analyte group (section 4.2.5) and are in agreement with earlier studies. The sum parameter for all PFAS compounds is not often used and, possibly with the exception of human blood serum, only a limited number of PFAS compounds are generally analysed in a specific sample. No comparable data were available for comparison for the sum parameter from other studies. This is reflected in the low RSD for the human blood serum sample (CV = 3%), dominated by perfluorooctanoic acid, and the larger variation for both the air extract and the standard solution.

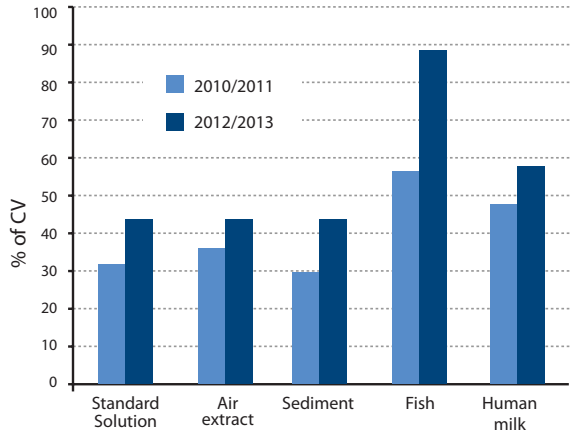

Figure 42: Comparison of performances between interlaboratory assessments for the dl-PCB TEQ analyses

6. Conclusions and Recommendations

6.1 Technical Conclusions

The results for the analysis of the POPs originally covered by the Stockholm Convention, including dl-POPs, PCB and OCPs, did not improve as expected. Although improvement in some areas was made for some sample types or the already-good results were consolidated for a number of compound classes and sampling types, the interlaboratory variation was often still far from the UNEP criteria of a CV value of 12.5%. Not even all the results for the standard solution were within the UNEP criteria and only the CV for the PCDD/PCDF and PFOS were below 12.5% (although the results of more than 50% of the participants were satisfactory (z = 2, CV = 25%) for all compounds). Other analyses meeting the UNEP criteria included the PCDD/PCDF TEQ for the sediment sample, the PFOS analysis in the fish sample, and the PCDD/PCDF analyses in the air extract.

Results for the PCDD/PCDF TEQ were good and within the UNEP criteria for the standard solution, the air extract and the sediment. Results for the fish sample were unsatisfactory for both the PCDD/PCDF and dl-PCB TEQ. The results for the dl-POP in the milk sample were promising but still not within the UNEP criteria. For the dl-POPs it should, however, be noted that the majority of the participating laboratories were located in Japan and China and in WEOG, while only two laboratories from GRULAC and CEE, and no laboratory from Africa, participated.

The results for the PCB analyses were good for the standard solution (CV = 18%), the sediment sample (CV = 21%), the fish sample (CV = 28%) and the milk sample (CV = 26%). An improvement was seen compared to the first round and if this trend continues, the UNEP criteria might be met by a large number of the participating laboratories. The results for the transformer oil were somewhat less impressive (CV = 38%), but this was the first time this matrix was included and some laboratories might have experienced problems with the high concentration of PCB in the samples. More surprising was the large variation of the PCB results for the air extract (CV = 71%).

For the OCPs, the sum of drins results were promising for the standard solution (CV = 26%), and the air extract (CV = 26%), but relatively large variations were seen for the sediment sample (CV = 86%), the fish sample (CV = 111%) and the milk sample. The result for the sum of the chlordanes, too, showed a large variation (CV = 40%–113%) for all sample types except for the air extract (CV = 32%). range for the results sum of DDTs were was also relatively large for all sample types (CV = 43%–79%) except for the standard solution (CV = 22%). The results for the sum of HCHs were similar and only the standard solution showed a CV of below 25%. The results for the sum of drins and DDTs showed some improvement compared to the first assessment, but not enough to get approach the UNEP criteria.

With respect to the new POPs covered by the Stockholm Convention, the results were promising but, as for the dl-POPs, capacity is located in the Asian and WEOG regions. The results for the PBDE analyses were good for the standard solution (CV = 31%), the air extract (CV = 31%) and the sediment samples (CV = 23%), and promising for the milk sample (CV = 38%). The results for the fish sample were less impressive (CV = 51%). A relatively large number of laboratories participated in this new analysis although much capacity was located in Asia and WEOG.

The results were good for specific PFAS compounds, including PFOS, but only a limited number of results were submitted for other PFAS compounds, including the precursor compounds. For the analysis of the group of PFAS compounds, LC/MS/MS is needed, which at the moment only seems to be available in developed countries in Asia and WEOG.

None of the 105 participating laboratories were able to carry out all the analyses that were offered in this assessment. This shows that none of the laboratories have methods at their disposal for all Stockholm Convention POPs for all samples types, and the laboratories are often specialized in analysing a certain compound class or sample type. This is especially true for the class of PFAS compounds, which need both a different laboratory set up and analytical instrumentation.

Several regions and countries were under-represented in the analysis of several of the compound classes or sample types.

It is likely that some of the laboratories had never analysed some of the matrices included in the present assessment before, and thus did not have sufficient time to adapt properly to the new methodology or, because of time constraints, chose to stick to methods they were already familiar with.

With respect to logistics, the overall delivery of the samples by an international carrier went well except for minor hold ups of samples at customs in some countries – some of the samples had to be re-sent, which resulted in delays.

The results of this assessment emphasize the need for all laboratories to pay more attention to quality assurance and more extensive method validation. It is imperative that authorities, management and others provide the resources necessary for an adequate quality assurance scheme in each laboratory. Regular routine analyses instead of one-off projects would help to build up the required level of experience for this type of analysis.

Based on the results achieved in this assessment, it is concluded that a long-term commitment to organize similar assessments on a regular basis (every 1–2 years) will be needed to obtain a reasonable-to-good comparability

of POP laboratories worldwide. Further, a larger number of participants from several CEE, Africa and GRULAC will be necessary to cover all sample types and compound classes. Results have to be discussed at workshops and mutual exchange programmes (*e.g.,* per continent). In some regions, provision of training and information on methods and quality assurance/quality control will still be needed, especially for the new POPs added to the Stockholm Convention, to achieve the UNEP criteria for all regions.

6.2 Recommendations

Based on the results of this assessment, the following recommendations are proposed:

1. Regular interlaboratory studies are needed to monitor and improve the overall level of performance for POP analysis of analytical laboratories worldwide, including in developing countries.
2. Training, instruction and capacity-building is necessary in the developing regions (CEE, Africa, GRULAC and parts of Asia) for the new POPs added to the Stockholm Convention, especially for PFAS and PBDE analysis.
3. The poor results for the fish samples need to be investigated in more detail. The levels of POPs in the fish samples (both in the first and second assessments) were relatively high and the large variation is not explained by instrumental issues. More care has to be taken with the units used and with normalization.
4. Laboratories analysing OCPs are encouraged to use GC/MS and ^{13}C-labelled standards to improve their analyses.
5. Participating laboratories are encouraged to train their own technicians by repeatedly analysing certified reference materials and internal laboratory reference materials.
6. The results for the air extract in this round of the inter-laboratory assessment was good for all compounds except PFASs and PCB. It was found difficult to mimic polyurethane foam or other air extracts, but subsequent rounds of the assessment should include an air sample or an extract from an air filter as ambient air is one of the target matrices of the Stockholm Convention's Global Monitoring Programme.
7. Interactive workshops – through Webinars or on-site with the participating laboratories – might be an easy and cost-effective way to improve understanding and interpretation of the results and to dissimilate the lessons learned.
8. The first results on several of the new POPS were promising for HCHs, PBDE and PFAS. However, only limited data was acquired for endosulfan and hexa-brominated biphenyl and the PFAS precursors and no data for chlordecone. Special efforts have to be taken to improve and increase the data for these classes of compounds.

7. References

Abalos, M., Abad, E., van Leeuwen, S. P. J., Lindström, G., Fiedler, H., de Boer, J., van Bavel, B. (2013). First worldwide interlaboratory study on persistent organic pollutants: Chlorinated dibenzo-p-dioxins and dibenzofurans. *TrAC Trends Anal Chem*, **46**, 99–109.

Becher, G., Haug, L. S., Thomsen, C. (2004). World-wide comparison on the quality of analytical determinations of PCDDs/PCDFs and dioxin-like PCBs in food. *Talanta*, **63**, 1115–1122.

Cofino, W. P., Wells, D. E., Ariese, F., van Stokkum, I. H. M., Wegener, J.-W., Peerboom R. J. (2000). *Chemometrics and Intelligent Laboratory Systems*, **53**, 37–55.

Cofino, W. P., van Stokkum, I. H. M., van Steenwijk, J., Wells, D. E. (2005). *Anal Chim Acta* **533**, 31–39.

De Boer, J., van der Meer, J., Brinkman, U. A. T. (1996). Determination of chlorobiphenyls in seal blubber, marine sediment and fish: interlaboratory study. *J Assoc Off Anal Chem*, **79**, 83–96.

De Boer, J., Wells, D. E. (1997). Chlorobiphenyls and organochlorine pesticides in fish and sediments – three years of QUASIMEME laboratory performance studies. *Mar Pollut Bull*, **35**, 52–63.

De Boer, J., Wells, D. E. (2006). Pitfalls in the analysis of brominated flame retardants in environmental, human and food samples – including results of three international interlaboratory studies. *TrAC Trends Anal Chem*, **25**, 364–372.

De Boer, J., Leslie, H., van Leeuwen, S. P. J., Wegener, J. W., van Bavel, B., Lindström, G., Lahoutifard, N., Fiedler, H. (2008). United Nations Environment Programme Capacity Building Pilot Project—training and interlaboratory study on persistent organic pollutant analysis under the Stockholm Convention. *Anal Chim Acta*, **617**, 208–215.

Fiedler, H., Abad, E., van Bavel, B., De Boer, J., Bogdal, C., Malisch, R. (2013). The need for capacity building and first results for the Stockholm Convention Global Monitoring Plan. *TrAC Trends Anal Chem*, **46**, 72–84.

Horwitz, W., Kamps, L. R., Boyer, K. W. (1980). Quality assurance in the analysis of foods for trace constituents. *J Assoc Off Anal Chem*, **63**, 1344–1354.

ISO 13528. (2005). Statistical methods for use in proficiency testing by interlaboratory comparisons.

Karl, H., Oehlenschläger, J., Bekaert, K., Bergé, J. P., Cadun, A., Duflos, G., Poli, B. M., Tejada, M., Testi, S., Timm-Heinrich, M. (2012). WEFTA interlaboratory comparison on total lipid determination in fishery products using the Smedes method. *J Assoc Off Anal Chem*, **95**, 489–493.

Leslie, H. A., van Bavel, B., Abad, E., De Boer, J. (2013). Towards comparable POPs data worldwide with global monitoring data and analytical capacity building in Africa, Central and Latin America, and the South Pacific. *TrAC Trends Anal Chem*, **46**, 85–97.

Lindström, G., Kärrman, A., van Bavel, B. (2009). Accuracy and precision in the determination of perfluorinated chemicals in human blood verified by interlaboratory comparisons. *J Chromatogr A*, **1216**, 394–400.

Miskiewicz, A. G., Gibbs, P. J. (1992). Variability in organochlorine analysis in fish: An interlaboratory study and its implications for environmental monitoring and regulatory standards. *Arch Environ Contam Toxicol*, **23**, 45–53.

Rimkus, G. G., Rexilius, L., Heidemann, G., Vogts, A., Hedderich, J. (1993). Results of an interlaboratory study on organochlorine compounds (PCB, DDT, DDE) in seal blubber (*Phoeca vitulina*). *Chemosphere*, **26**, 1099–1108.

Thompson, M., Wood, R. (1993). International harmonised protocol for proficiency testing of (chemical) analytical laboratories. *J Assoc Off Anal Chem*, **76**, 926–940.

Thompson, M., Ellison, S. L. R., Wood, R. (2006). The international harmonised protocol for profi-ciency testing of analytical chemistry laboratories. IUPAC Technical Report. Interdivisional Working Party for Harmonization of Quality Assurance Schemes. *Pure Appl Chem*, **78**, 145–196.

UNEP (2013a). Guidance on the global monitoring plan for persistent organic pollutants. Document UNEP/POPS/COP.6/INF at http://chm.pops.int/TheConvention/ConferenceoftheParties/Meetings/COP6/tabid/3074/mctl/ViewDetails/EventModID/870/EventID/396/xmid/10240/Default.aspx.

UNEP (2013b). Report of the Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants on the work of its sixth meeting. Document UNEP/POPS/COP.6/33 at http://chm.pops.int/Convention/ConferenceoftheParties(COP)/Meetings/COP6/COP6Documents/tabid/3075/Default.aspx.

UNEP (2012). Bi-ennial Global Interlaboratory Assessment on Persistent Organic Pollutants – First Round 2010/2011. UNEP/DTIE Chemicals Branch, Geneva at http://www.chem.unep.ch/Pops/GMP/Global/Bi-ennial%20Global%20Interlaboratory%20Assessment%20on%20POPs-Round%201.pdf

UNEP (2007). *Handbook: POPs Laboratory Databank*. *Handbook for Databank of Existing POPs Laboratories*. UNEP Chemicals Branch, DTIE, Geneva, Switzerland.

UNEP (2005). *International Intercalibration Studies: A Global QA/QC Tool for the Analysis of POPs under the Stockholm Convention.* UNEP Chemicals Branch, DTIE, Geneva, Switzerland.

Uthe, J. F., Musial, C. J., Misra, R. K. (1998). Multi-laboratory study of measurement of chlorobiphenyls and other organochlorines in fish oil. *J Assoc Off Anal Chem*, **71**, 369–372.

van Bavel, B., Abad, E. (2008). Long-term worldwide QA/QC of dioxins and dioxin-like PCB in environmental samples. *Anal Chem*, **80**, 3956–3964.

van Bavel, B. (2008). *Final Report 13th Round of the International Intercalibration Study*. Intercal AB Report, Örebro, Sweden.

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Villeneuve, J. P., Carvalho, F. P., Horvat, M., Cattini, C. (2004). Worldwide intercomparison on the determination of chlorinated pesticides, PCB and petroleum hydrocarbons in a mussel tissue homogenate, IAEA-142. *Intern J Environ Studies*, **61**, 437–452.

von Holst, C., Müller, A. (2001). Intercomparison study for the determination of selected poly-chlorinated biphenyls (PCB) in feed matrices. *Fres J Anal Chem*, **371**, 994–1000.

Wells, D. E., Cofino, W. P., Scurfield, J. A. (2004). *The Application of the Cofino Model to Evaluate Laboratory Performance Study Data using the BandWidth Estimator*. Collaborative Report No. 04/04 (2004), FRS Marine Laboratory, Aberdeen, UK.

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8. Appendices

Appendix I – List of Participants

Appendix II – Original Data

Appendix III –z-scores

Appendix IV – Statistical Evaluation

Appendix V – Regional z-scores

Note: Appendices II to V are electronically available from the UNEP Chemicals Branch website.

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10. Appendix II: Detailed Instructions as Sent to the Participants

PCDD/PCDF Standard G

The PCDD/PCDF standard consist of a mixture of **PCDD/PCDF** in nonane in the concentration range of **10 µg/kg-350 µg/kg**. Please take an appropriate aliquot of this solution depending on the detection technique and determine the concentration with the help of your own calibration standard solution(s). The concentration of the standard solution has to be reported in **µg/kg**.

dl-PCB Standard H

The dioxin-like PCB standard consist of a mixture of **dl-PCB** in nonane in the concentration range of **50 µg/kg-700 µg/kg**. Please take an appropriate aliquot of this solution depending on the detection technique and determine the concentration with the help of your own calibration standard solution(s). The concentration of the standard solution has to be reported in **µg/kg**.

PBDE Standard F

The PBDE standard consists of a mixture of **polybrominated diphenyl ethers (PBDE)** and **PBB #153** in nonane in the concentration range of **30 µg/kg-100 µg/kg**. Please take an appropriate aliquot of this solution depending on the detection technique and determine the concentration with the help of your own calibration standard solution(s). The concentration of the standard solution has to be reported in **µg/kg**.

PFOS Standard I

The PFOS standard consists of a mixture of **polyfluorinatedalkyl substances (PFCAs, PFASs, FOSA) including PFOS and FOSA** in methanol in the concentration range of **10 µg/kg-65 µg/kg**. Please take an appropriate aliquot of this solution depending on the detection technique and determine the concentration with the help of your own calibration standard solution(s). The concentration of the standard solution has to be reported in **µg/kg**.

PFAS Standard J

The PFAS standard consists of a mixture of **polyfluorinatedalkyl substances (Me-FOSA, Et- ME-FOSE, Et-FOSE)** in methanol in the concentration range of **100 µg/kg-2500 µg/kg**. Please take an appropriate aliquot of this solution depending on the detection technique and determine the concentration with the help of your own calibration standard solution(s). The concentration of the standard solution has to be reported in **µg/kg**.

Sediment Sample

The sediment is dried and should be extracted as it is; be careful to store the sediment dry before usages and reduce exposure of the sediment to high humidity. Results can be reported for **OCPs, PCB, PCDD, PCDF, dl-PCB, PBDE** and **PFASs**. The results for the PCDD, PCDF and dl-PCB should be reported as **ng/kg**. Results for all other compounds should be reported as **µg/kg**. Note that separation of the target compounds on two GC columns might be necessary, especially for the OCPs, indicator PCB, PCDD/PCDF and dl-PCB.

Fish Sample

The Fish sample consists of a pike-perch filet from the Netherlands. After processing the material is sterilized by autoclaving, which makes it possible to store the fish sample at room temperature before opening of the jar. Results can be reported for **OCPs, PCB, PCDD, PCDF, dl-PCB, PBDE** and **PFASs**. All values should be reported in **µg/kg wet weight (note that also the dioxin-like POPs – PCDD, PCDF, dl-PCB - are reported on wet weight).** Please also determine the percentage of extracted lipids.

Mothers' Milk Sample

The mothers' milk sample consists of a homogenised milk sample from Sweden. Results can be reported for **OCPs, PCB, PCDD, PCDF, dl-PCB, PBDE** and **PFASs**. All values should be reported in **ng/kg wet weight (note that also the dioxin-like POPs – PCDD, PCDF, dl-PCB - are reported on wet weight).** Please also determine the percentage of extracted lipids.

Human Blood Serum Sample

The human blood serum sample consists of pooled human blood serum of occupationally exposed and serum from the general population and results can be reported for **polyfluorinatedalkyl substances (PFCAs, PFSAs, FOSAs) including PFOS and FOSA, which are the target compounds** to be reported for **PFASs**. All values should be reported in **ng/mL.**

Air Extract for OCP, PBDE and PFASs Analyses

The air extract is a raw polyurethane foam extract in toluene to which OCPs, PBDE and PFASs are spiked. As a suggestion for the analysis of PFASs on LC/MS systems the extract could be diluted 1:10 with methanol or with methanol: water (1:1) before injection. Results can be reported for **OCPs, PBDE** and **PFASs.** All values should be reported in **µg/kg.**

Air Extract for PCB, PCDD, PCDF and dl-PCB Analyses

The air extract is a raw PUF extract in toluene, taken near a HWI to assure measurable amounts of the target compounds. Results can be reported for **indicator PCB, PCDD, PCDF** and **dl-PCB.** All values should be reported in **µg/kg.**

Water Sample

The water sample is a surface water from the canal "het IJ" in Amsterdam, The Netherlands. After bottling, the material is sterilized by irradiation. Please store the sample at 4 °C until it will be extracted for analyses. Results can only be reported for **PFASs** only. All values should be reported in **ng/kg.**

Transformer Oil

The transformer oil is dilution of an Aroclor oil in toluene. Results can be reported for **indicator PCB** only**.** Values should be reported in **µg/kg.**

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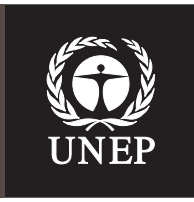

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