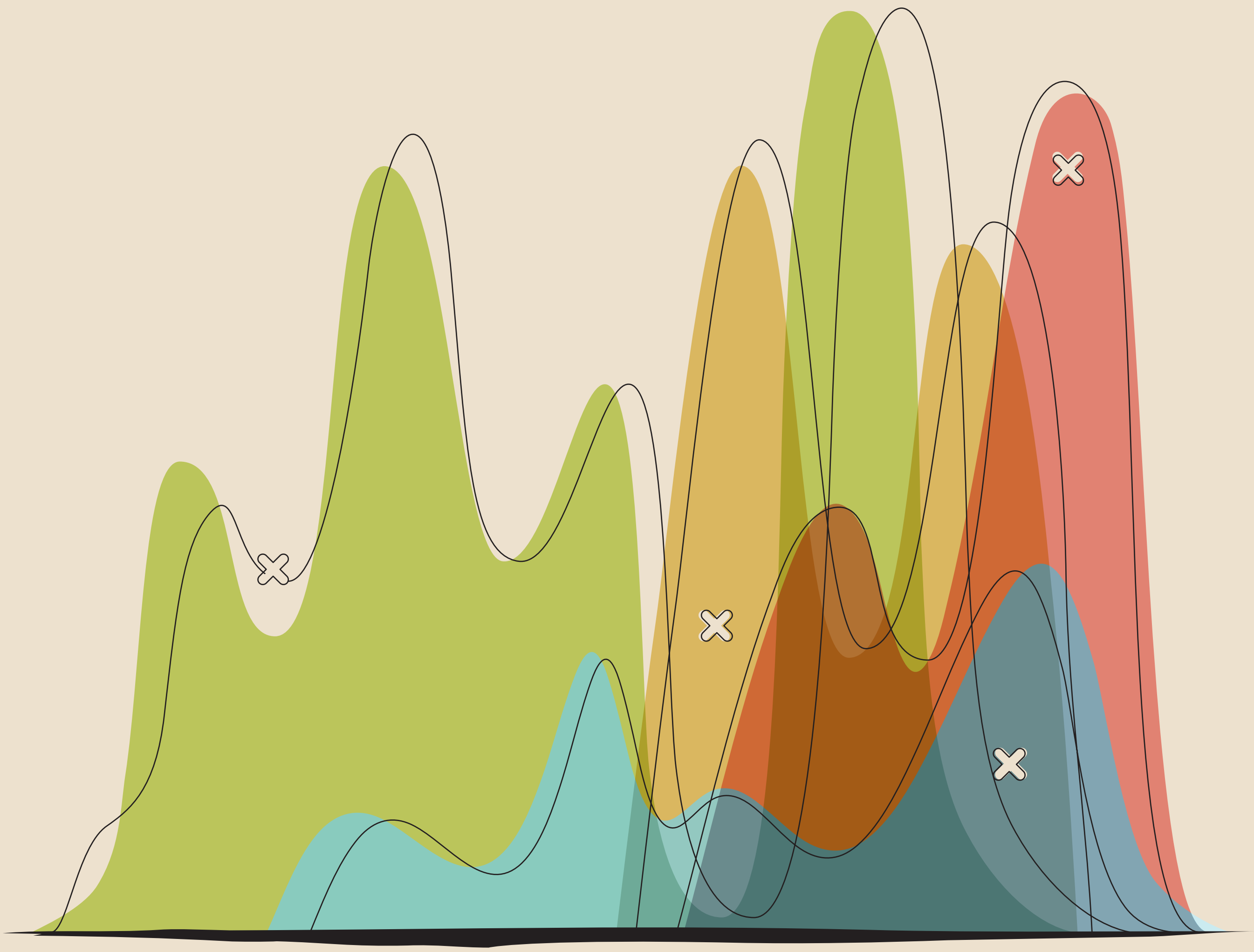
Review of Facts, Experiences, Achievements, and Challenges in Relation to Persistent Organic Pollutant Monitoring Activities



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ABBREVIATIONS

DDT	Dichlorodiphenyltrichloroethane
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe
FAO	Food and Agriculture Organization of the United Nations
GAPS	Global Atmospheric Passive Sampling Survey
GEF	Global Environment Facility
GMP	Global Monitoring Plan
GMP DWH	Global Monitoring Plan Data warehouse
HCBD	hexachlorobutadiene
HBCD	hexabromocyclododecane
HCH	hexachlorocyclohexane
IADN	Integrated Atmospheric Deposition Network
PAHs	Polyaromatic hydrocarbons
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyls
PCDD	polychlorinated dibenzo(p)dioxins
PCDF	polychlorinated dibenzofurans
PCN	polychlorinated naphthalene
PCP	pentachlorophenol
PeCBz	pentachlorobenzene
PFHxS	perfluorohexane sulfonic acid
PFOA	pentadecafluorooctanoic acid
PFOS	perflorooctan sulphonate
POPs	Persistent organic Pollutants
PUF	Polyurethane Foam
QA/QC	Quality assurance and quality control regimes
SC	Stockholm Convention on Persistent Organic Pollutants
SCCP	short chain chlorinated paraffins
SOP	Standard Operating Procedure
UN	United Nations
UNEP	United Nations Environment Program
WHO	World Health Organization
XAD	Styrene/divinylbenzene-co-polymer resin

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INTRODUCTION

1 SECTION

The Global Monitoring Plan (GMP) under the Stockholm Convention on Persistent Organic Pollutants (POPs) is a tool that collects information on POPs in the environment and in humans to identify changes and patterns of POPs concentrations over time and assesses regional and global transport of target chemicals.

With 15 years of experience in the implementation of several rounds of global POPs monitoring activities, a fact review of the experience, achievements and gaps of POPs monitoring was conducted in 2018 and 2019 to provide useful insight into a pragmatic and workable way forward for a long-term sustainable POPs monitoring in the future.

This review is based on the review of information from the implementation of the Global Monitoring Plan in core media (ambient air, human breast milk/blood, water) by strategic partnerships and by the United Nations Environment Programme and Global Environment Facility (UNEP/GEF) supported projects on strengthening the regional capacities in POPs monitoring carried out as UNEP/GMP1 and UNEP/GMP2 projects between 2010-2012 and 2016-ongoing respectively. Further information was provided from UNEP/GEF projects documents and reports provided at the various stages of the implementation of these projects and trainings. Additional input was also gathered via consultations with expert laboratories involved in the implementation of the UNEP/GEF projects in developing countries around the globe (UNEP n.d. a).

Moreover, inputs to this review were also provided through an "Expert Consultation Meeting for Sustainable Global Monitoring of Persistent Organic Pollutants under the Stockholm Convention" held in Ulaanbaatar, Mongolia, 8 August 2018 and Brno, Czech Republic, 12-14 February 2019 and during subsequent conference calls.

This report contains several chapters that cover activities that were undertaken, achievements and lessons learned, and also provides fact-based conclusions and expert recommendations regarding set up of the future of POPs monitoring in regions requiring support in carrying out further activities.

Gender Mainstreaming and efforts to enable women, men, youth, the elderly, vulnerable social groups, and other population sub-categories is crucial for UNEP's work. The development and implementation of gender-responsive strategies and eliciting gender responsive actions are an important aspect of UNEP's 2022-2025 midterm strategy (UNEP 2021). Furthermore, the Basel, Rotterdam, and Stockholm (BRS) Conventions take effort to consider gender issues in hazardous chemicals and wastes management through the BRS Gender Action Plan (Secretariat of the BRS 2023; Secretariat of the BRS n.d.).

Within the context of the safe and sound management of chemicals, including POPs, men, women and children differ in their physiological susceptibility to the effects of exposure to hazardous chemicals. For example, babies are especially vulnerable to some chemicals during pregnancy and lactation. Other contributing factors that can have a gendered impact on exposure include differences associated with family roles and occupations (UNEP 2019).

The GMP project has a focus on monitoring levels of POPs in environmental matrices and biotic samples which can reveal critical information on the human and environmental exposure to these hazardous chemicals. While the monitoring results are not differentiated by demographics, they provide a sound basis for further studies on health risks and exposure differences associated with gender, age, social role, etc. The third GMP report prepared by UNEP and the Secretariat of the Stockholm Convention summarizes the results from activities carried out under the GMP project, including the UNEP-coordinated interlaboratory assessments, which have become the largest exercise on POPs analysis on a global scale (UNEP and Secretariat of the Stockholm Convention 2023).

To keep the report at a manageable size, additional information is provided in annexes to the review.

Last but not least, we would like to acknowledge the valuable contributions provided by involved experts, UNEP Chemicals and Health Branch, and the Stockholm Convention Secretariat.

FACT REVIEW

2 SECTION

2.1. Background

Monitoring of POPs is embedded in the Stockholm Convention text (Articles 15, 16 and 19). The requirement to generate comparable, harmonized and validated POPs data to support the effectiveness evaluation and evaluation of trends is provided in Article 16 on effectiveness evaluation.

POPs monitoring data gathered through the global monitoring plan under the Stockholm convention (GMP) are compiled and analyzed every six years in the regional monitoring reports and then in a global POPs monitoring report. The global monitoring report is developed based on the regional monitoring reports and constitutes one of the major sources of information for the effectiveness evaluation under Article 16 of the Stockholm Convention.

Two sets of the Global Monitoring Plan regional reports were prepared so far (2008 and 2014) - approved by COP4 in 2009 and COP6 in 2015 (Secretariat of the Stockholm Convention n.d. a) and a third round of regional reports were prepared in 2023 (UNEP and Secretariat of the Stockholm Convention 2023; Secretariat of the Stockholm Convention n.d. a).

The effectiveness evaluation report of the Stockholm Convention (released for COP8) in 2017 also looked into progress in implementation and provided conclusions and some forward looking recommendations (Secretariat of the Stockholm Convention n.d. b).

The effectiveness evaluation report provided the following conclusions:

- Monitoring data suggest that the continued existence of targeted regulations, including those that predated the convention in some regions, is working towards reducing levels of POPs in the environment and in human populations.
- Recommendation: Global monitoring of POPs, as well as data sharing and modelling should be sustained in the long term to confirm decreasing concentrations of legacy POPs in the environment and in humans and to identify trends in the concentrations of the newly listed POPs.

Other findings in the same report:

- Systematic capacity-building activities have been carried out in developing countries, including strategic partnerships with well-established monitoring programmes. Despite these efforts, several regions still have limited capacity to monitor POPs. The addition of new POPs to the Convention creates additional demand for training to implement and sustain POPs monitoring activities.
- Limitations in sustained financial resources for existing monitoring programmes and new financial resources for programmes addressing data gaps are a major constraint in ensuring the sustainability of the GMP.
- Data quality, consistency and comparability is key to assess temporal trends and evaluate effectiveness of measures that have been undertaken.
- The growing list of POPs and chemicals proposed for listing adds pressure on monitoring programmes and analytical laboratories.

2.2. Main findings in relation to the POPs monitoring from global reports

The following paragraphs are from conclusions in the global monitoring report published in 2017 (COP8) (Secretariat of the Stockholm Convention 2016).

Since its entry into force, the Stockholm Convention has catalyzed POPs monitoring activities and research worldwide and triggered increased awareness and knowledge about these chemicals.

These developments have been underpinned by increased POPs monitoring data availability and coverage at the global scale, most notably due to the capacity-building activities carried out in the regions, strategic partnerships in place between emerging and well-established monitoring programmes, increased national commitment and sustained donor support.

Long term viability of existing monitoring programmes (air and human biomonitoring) was and continues to be essential to ensure that changes in concentrations over time can be investigated to support the evaluation of the effectiveness of the Convention.

The implementation of the GMP under the Convention channeled the development of harmonized guidance for monitoring activities worldwide, leading to enhanced comparability within and across monitoring programmes to evaluate changes in levels over time. Quality assurance/quality control practices (QA/QC) have been and continue to be essential for ensuring comparability, along with inter- laboratory comparison assessments.

A new tool supporting harmonized data handling for the collection, processing, storing and presentation of data was established (GMP data warehouse). All monitoring data obtained in the frame of the GMP under the Convention are publicly available and represent a valuable resource for both policy makers and researchers worldwide (Secretariat of the Stockholm Convention n.d. c).

Findings in relation to knowledge in core matrices:

- Ambient air: For most “legacy POPs” (those 12 substances listed when the Convention entered into force in 2004), concentrations in air have declined and continue to decline or remain at low levels. This is due to restrictions on POPs that predated the Stockholm Convention and have been maintained since. For many “newly listed POPs” (those POPs listed after the first COP1 2004) concentrations in air in some regions are beginning to show declining tendencies, although in a few instances, increasing and/or stable levels are observed.
- Human tissues: In regions with sufficient data to evaluate changes over time, levels of legacy POPs such as polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF), polychlorinated biphenyls (PCB), and DDT/DDE, including their transformation products, have generally declined in human tissues. For the newly listed POPs, information regarding changes over time is very limited. Based on studies available from the Western Europe and Others Group and from Asia Pacific, the levels of brominated diphenyl ethers (BDEs) and perfluorooctane sulfonic acid (PFOS) seem to be gradually declining.
- Water: Temporal trend information for PFOS in water is very limited. Differences in sampling locations and in detection limits preclude any robust assessment of trends for now.

Recommendations from the global monitoring report towards the third phase[1]

- The third phase of the global monitoring plan should continue to use the amended global monitoring plan, implementation plan and guidance document as its foundation.
- Ensure sustainability of ongoing monitoring activities in the long-term in all regions to provide the important information required supporting the effectiveness evaluation of the Stockholm Convention. Intensify and diversify efforts as required to address remaining gaps in data coverage and to monitor newly listed POPs as they are added to the Convention.
- Efforts should continue toward ensuring comparability and consistency in monitoring data at the global level. The regional and global monitoring reports should be broadly shared and the GMP data warehouse should be maintained to support GMP data handling and to provide on-line access to up-to-date POPs monitoring data.
- The latest version of the guidance should always be used as the reference document.
- Monitoring programmes should be encouraged to maintain long-term sample archives for retrospective analysis.

The above excerpt from the Global Monitoring Report shows we are on a borderline now.

Two rounds of large capacity building regional projects for POPs monitoring took place as described below in a greater detail. The first round is completed ("UNEP/GMP1"), the second round ("UNEP/GMP2") of four projects is ongoing until 2023 in three UN regions - Africa, Asia and Pacific and GRULAC, but it seems that the activities seeded do not always continue beyond the lifetime of a project (see lessons learned below).

Moreover, there are also sets of internal and external pressures that add to the overall complexity of finding the right way forward for a sustainable POPs monitoring.

Examples of pressures are:

- external pressures: GEF replenishment cycle, UNEA decisions, Minamata Convention and its effectiveness evaluation, synergies, funding cycles, global strategies, SDGs, preparation of a framework of global chemicals management beyond SAICM;
- internal pressures: Stockholm Convention is a dynamic convention and new chemicals are evaluated and listed = capacity and ability challenges for Parties, laboratories and monitoring programmes, updates of the guidance for POPs monitoring - ongoing

2.3. Capacity building regional projects undertaken with GEF support

UNEP Chemicals and Health Branch with financial assistance from the Global Environment Facility (GEF), SAICM Trust Fund, the Government of Norway, the European Union and the BRS Secretariat conducted the first Global Monitoring Plan (UNEP/GMP1) round of capacity building projects addressing POPs monitoring in 31 countries in the African, Latin American and the Caribbean, and the Pacific Islands Regions from 2009 to 2012 (see Table 1 below). Presently is implementing four UNEP/GEF-funded follow-up projects (UNEP/GMP2) strengthening the capacities in 42 countries in the African, Asian, Pacific Islands and Latin American and the Caribbean (GRULAC) Regions from 2016 to 2020 (Table 2). These projects were undertaken in close collaboration with (and with the support from) the BRS Secretariats and project partners.

All these projects aimed at building national capacities for provision of quality and comparable data on human and environmental concentrations of POPs for supporting the effectiveness evaluation and contribute to regional capacity-building through conducting interlaboratory comparison tests; providing training and guidance for sampling and analysis; strengthening capacity in existing laboratories to analyze the core media; and financial assistance to establish long term programmes and self-sufficient laboratories as well as networking.

Thus, the project components comprise(d) sampling of ambient air and subsequent analyses, sampling of human milk, sampling and analyses of matrices of national interest, capacity enhancement of project countries by training in laboratories and improving laboratory capacity.

In addition, ongoing GEF/UNEP/GMP2 projects also comprise sampling of water. Further, projects have also tested laboratory capacity and generated tools and contribute to the global implementation of the Article 16 of the Stockholm Convention.

1 Excerpt from the global monitoring report, third phase is considered as activities in preparation for the third monitoring report (not yet published).

In addition, this round of projects (UNEP/GMP2) also aims to create the environment for sustainable monitoring of POPs in the project countries in the future.

The outputs and results generated by the UNEP/GEF projects on POPs monitoring are described in section 3., lessons learned.

Table 1. Overview of the first round of UNEP/GEF projects Supporting the Implementation of the Global Monitoring Plan of POPs in Eastern and Southern African countries (ESA); in Latin America and Caribbean States (GRULAC); in West Africa (WA); and in the Pacific Islands Region (PI)

Objective	Build regional capacity on analysis and data generation for POPs in core matrices for the Global Monitoring Plan (GMP) of POPs to enable the participating countries of the four sub-regions (ESA, WA, GRULAC and PI) to contribute to the global report submitted to the Conference of the Parties of the Stockholm Convention			
Duration	2008-2012			
Countries	Eastern and Southern Africa (6)	Western Africa (6)	GRULAC (8) + 4 (SAICM)	Pacific (7)
	Egypt, Ethiopia, Kenya, Mauritius, Uganda and Zambia	DR of the Congo, Ghana, Mali, Nigeria, Senegal and Togo	Antigua and Barbuda, Brazil, Chile, Ecuador, Jamaica, Mexico, Peru, Uruguay SAICM: Bahamas, Barbados Haiti, and Cuba	Fiji, Kiribati, Niue, Samoa, Palau, Solomon Islands, and Tuvalu
Matrices sampled	Abiotic air Biotic human milk			
No. of countries sampling each matrix	27	17	27	
Project partners	UNEP; the Secretariat of the Basel, Rotterdam and Stockholm conventions; World Health Organization (WHO); MTM-Research Center, Örebro University; Chemisches und Veterinaeruntersuchungsamt Freiburg (CVUA, UNEP/WHO Reference Laboratory for Human Milk); Department of Environment and Health, Vrije Universiteit (Netherlands); Environment Canada; Research Centre for Toxic Compounds in the Environment (RECETOX, SCRC - Czech Republic); Spanish National Research Council (CSIC); participating countries and coordinators: Department of Chemistry, University of Nairobi, Kenya for ESA; Environmental Toxicology and Quality Control Laboratory of the Central Veterinary Laboratory (ETQCL), Bamako, Mali for WA; University of the South Pacific (USP), Fiji for PI; and the Basel Convention Coordinating Centre Stockholm Convention Regional Centre, Uruguay (BCCC-SCRC-LATU) for GRULAC			
Total project cost (USD)	**4,940,150**			

Table 2. Overview of the UNEP/GMP2 projects

Objective	To strengthen the capacity for implementation of the updated POPs Global Monitoring Plan (GMP) and to create the conditions for sustainable monitoring of POPs			
Duration	2016-2023			
Countries	Africa (15)	Asia (7)	Pacific (9)	GRUAC (11)
	DR of the Congo, Egypt, Ethiopia, Ghana, Kenya, Mali, Morocco, Mauritius, Nigeria, Senegal, UR of Tanzania, Togo, Tunisia, Uganda, Zambia	Cambodia, Indonesia, Lao PDR, Mongolia, Philippines, Thailand, Viet Nam	Fiji, Kiribati, Marshall Islands, Niue, Samoa, Solomon Islands, Palau, Tuvalu, Vanuatu	Antigua and Barbuda, Argentina, Barbados, Brazil, Chile, Colombia, Ecuador, Jamaica, Mexico, Peru, Uruguay
Matrices to be sampled	Abiotic: air and Water Biotic: human breast milk Matrices of national interest			
No. of countries sampling each matrices	42	22	40	41
Project partners	UNEP, Basel Convention Coordinating Centre, Stockholm Convention Regional Centre, for Capacity Building and Transfer of Technology hosted by Uruguay (BCCC-SCRC-LATU); the Secretariat of the Basel, Rotterdam and Stockholm conventions; World Health Organization (WHO); MTM-Research Center, Oerebro University; Chemisches und Veterinaeruntersuchungsamt Freiburg (CVUA, UN Environment/WHO Reference Laboratory for Human Milk); Department of Environment and Health, Vrije Universiteit (Netherlands); Research Centre for Toxic Compounds in the Environment (RECETOX, SCRC - Czech Republic); Spanish National Research Council (CSIC); Japan Environmental Sanitation Center (JESC); National Institute for Environmental Studies (NIES), Japan; participating countries			
Total project cost (USD)	**13,805,000**			

2.4. Review of activities generating long term POPs data

The chapter below provides a global overview of POPs monitoring activities performed by international strategic partnerships. The text is organized by the core media of the Global Monitoring Plan under the Stockholm Convention - ambient air, human tissues and water and comprises information on the POPs monitoring activities other than UNEP/GMP1 and UNEP/GMP2 projects described above in the section 2.3. and their outputs in section 3.

2.4.1. Ambient air

As of 2018, there were ten continuous air monitoring networks contributing to the GMP under the Stockholm Convention as shown in Table 3 below and on the map providing the spatial distribution. The longest time series are available from the active air monitoring programmes such as EMEP and IADN. However, the oldest passive sampling air monitoring networks (GAPS and MONET) were established before the 1st GMP data collection campaign in order to obtain background data from the regions lacking information, therefore they can currently provide time series covering a decade or longer.

Table 3. Air monitoring programmes contributing to the GMP under the Convention and their contact points

Name		Contact	Institution	Email
China National Network		Minghui Zheng	Chinese Academy of Sciences	zhengmh@rcees.ac.cn
POPs Monitoring in East Asian Countries		Yasuyuki Shibata	National Institute for Environmental Studies (Japan)	yshibata@nies.go.jp
EMEP	European Monitoring and Evaluation Program	Pernilla Bohlin-Nizzetto	Norwegian Institute for Air Research	pernilla.bohlin.nizzetto@nilu.no
GAPS	Global Atmospheric Passive Sampling Network	Tom Harner	Environment and Climate Change Canada	tom.harner@canada.ca
GLB	Monitoring & Surveillance in the Great Lakes Basin	Hayley Hung	Environment and Climate Change Canada	hayley.hung@canada.ca
IADN	Integrated Atmospheric Deposition Network	Ron Hites	Indiana University (United States)	hitesr@indiana.edu
LAPAN	Latin America Passive Air Network	Gilberto Fillmann	Universidade Federal do Rio Grande (Brazil)	gfillmann@gmail.com
MONET	Monitoring Network	Jana Klánová	RECETOX, Masaryk University (Czechia)	klanova@recetox.muni.cz
NCP	Northern Contaminants Program	Hayley Hung	Environment and Climate Change Canada	hayley.hung@canada.ca
TOMPS	Toxic Organic Micro Pollutants	Andrew Sweetman	Lancaster University United Kingdom of Great Britain & Northern Ireland	a.sweetman@lancaster.ac.uk

As of 2018, in total there were 255 global POPs air monitoring sites across the 10 monitoring networks:

- China Network: 17 national sites
- East Asia Network: 2 sites in Japan and Republic of Korea (+7 currently inactive sites in Cambodia, Indonesia, Laos, Malaysia, Mongolia, Philippines & Viet Nam; potential re-deployments for next GMP phase)
- EMEP: 7 European sites (it should be noted that the EMEP network contains 27 additional European sites but these only monitor PAHs)
- GAPS: 60 global sites (+18 new sites around the world part of the GAPS Megacities project being implemented later in 2018)
- GLB & IADN: 10 sites around the Great Lakes in Canada & the United States
- LAPAN: 59 Latin America sites (+5 planned 2018 deployments in Chile)
- MONET: 55 sites across Africa & Europe
- NCP: 8 community-based sites throughout Northern Canada
- TOMPS: 6 sites in the United Kingdom of Great Britain & Northern Ireland

In addition to these 10 monitoring networks, as of 2022 the DWH includes several other international, regional and national initiatives of POPs monitoring, namely:

- UNEP/GEF projects,
- Colombia – POPs monitoring,
- Russia (Department of the Environment, Moscow; Russian Academy of Science - grant RAS, and the Federal Service for Hydrometeorology and Environmental Monitoring of Russia - Rosgidromet monitoring),
- Europa Air PUF,

- Artic Monitoring and Assessment Programme (AMAP),
- Monitoring Network in the Alpine Region for persistent and other organic pollutants (MONARPOP), and
- PureAlps (see Figure 1 for the spatial distribution).

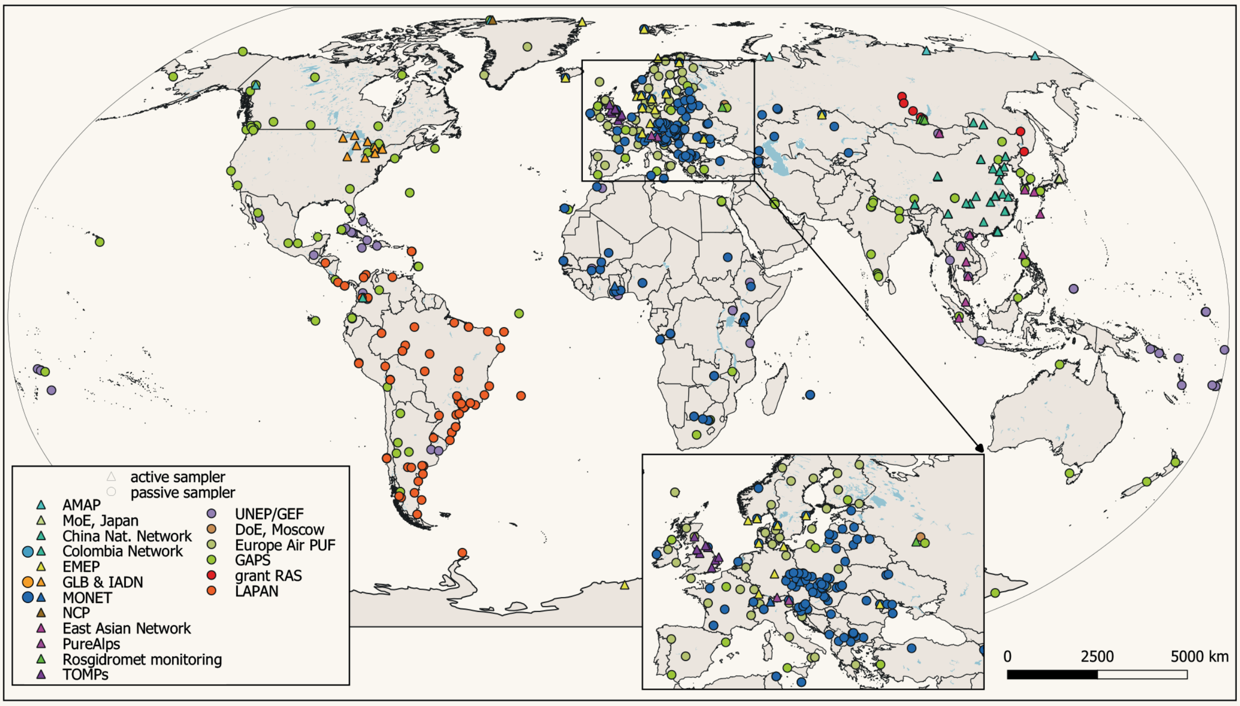

Figure 1. Map of the ambient air monitoring sites colour-coded according to the programmes as of 2022.

Table 4 shows how the changes in scope have been implemented into existing monitoring programmes and information on levels/trends available is discussed below.

Table 4. POPs analyses in air samples from existing networks as of [2017/2018]

					Aldrin	Chlordane	DDT	Dieldrin	Endrin	Heptachlor	HCB	Mirex	Toxaphene	PCBs	PCDDs	PCDFs	α-HCH	β-HCH	γ-HCH	Chlordecone	Endosulfan	PeCBz	HBB	HBCD	PBDEs	PFOS	HCBD	PCNs	PCP	DecaBDE[209]	SCCPs
Network	UN region	Country	Site Name	Sampler	Legacy POPs [COP-1]												New POPs [COP-4/5/6]										[COP-7/8]				
East Asia	Asia Pacific	Japan	Hedo	Active																											*
EMEP	WEOG	Norway	Andoya	Active																											
EMEP	WEOG	Sweden	Aspvreten	Active																											
EMEP	WEOG	Norway	Birkenes II	Active																											
EMEP	CEE	Czech Republic	Košetice	Active																											
EMEP	WEOG	Norway (Svalbard)	Ny-Alesund / Zeppelinfjel	Active																											
EMEP	WEOG	Finland	Pallas / Matorova	Active																											
EMEP	WEOG	Sweden	Rao	Active																											
GAPS	Global	Global	All Sites	Passive																								*			*
GLB & IADN	WEOG	Canada	Point petre	Active																											
GLB	WEOG	Canada	All Passive Sites	Passive																											
IADN	WEOG	United States	All Active Sites	Active																											
LAPAN	GRULAC	Latin America	All Sites	Passive																											*
MONET	Africa & Europe	Africa & Europe	All Sites	Passive																								*			*
TOPMPS	WEOG	United Kingdom of Great Britain & Northern Ireland	All Sites	Active																											

** Not routine, some pilot studies; green: analyzed; red: not analyzed.*

Monitoring data on the twelve "Legacy" POPs:

In brief, PCBs, HCB and DDT including metabolites are being monitored continuously in the majority of active and passive air monitoring programmes and there is enough data for assessment of the long-term trends. It has been demonstrated that for these compounds active and passive air sampling techniques provide comparable results including comparable time trends.

Dioxin and Furans (PCDDs/Fs) monitoring is not so common in the monitoring programmes due to the costs of analyses. Another complicating factor is that PCDDs/Fs are mostly particle bound which may limit the efficiency of the passive air sampling. Data are available for Europe (EMEP, MONET) and the UK (TOMPS), East Asia, Africa (MONET) and Latin America (LAPAN).

On the contrary, data on "drin" pesticides (aldrin, dieldrin, endrin, heptachlor), mirex and chlordane are reported from the North American programmes where these pesticides were more frequently used, and from GAPS. There are no systematic data reported for toxaphene, however, some background data can be found in the scientific literature.

Data on POPs listed to the Stockholm convention between COP4 and COP6 (2009-2013):

Enough data are available for HCHs which have often been a part of the monitoring programmes historically. PBDEs have been implemented into most programmes recently, often together with PFOS. However, due to their physicochemical properties, PFOS can present potential challenges for both active and passive air monitoring networks and some amendment may be needed (XAD or SIP samplers rather than PUF samplers should be used for passive air monitoring, for instance). Less data are available for PeCBz and PBB and there are no systematically reported data for chlordecone.

Data on POPs listed to the Stockholm convention by COP7 and COP8 (2015-2017):

Data will be collected for the first time during the third GMP data collection in 2019. Based on information provided from the monitoring programmes, there should be enough data for BDE-209 (c-decaBDE) as monitoring of this substance was implemented into many programmes together with other PBDEs. For some of the others, data are available from pilot studies. It is expected that final/updated recommendations for monitoring of the most recently listed POPs regarding the core matrices, analytes and techniques will be provided in 2019/2020. Thus, it can be expected that only pilot data will be provided for the 3rd GMP report for these chemicals (PCN, SCCP, PeCP).

2.4.2. Monitoring of POPs in human milk and blood

While data on air are coming from the large-scale (regional, continental or global) monitoring programmes which are easier to harmonize, the human biomonitoring programmes are established on a national basis. The only consistent human tissue data reported to the GMP so far are data from the UNEP/WHO surveys on human milk. They are based on pooled milk samples and provide background information on spatial as well as temporal variability of POPs in human tissues. In addition to the original POPs, PBDEs and PFOS were also added as target substances of these surveys. Further extension of the scope will be based on the recommendations of experts captured in the updated Guidance document (Secretariat of the Stockholm Convention 2019) for currently ongoing to support preparation of the third set of regional and global monitoring reports due in 2021 and beyond. Complete data from the UNEP/WHO studies are available through the GENASIS database and the GMP DWH.

More data on the concentrations of POPs in human tissues are available in national biomonitoring studies. A limited amount of these data was reported within the first and second GMP reports, however, none are currently visible in the GMP DWH. Steps should be taken towards making the aggregated form of these data available for assessment of the long-term trends in various regions. Additional data are also available from various human cohort studies, however, these data are spread through the scientific literature and are not available for reporting despite their potential value for the assessment of spatial distribution and providing background information on human exposure to less frequently monitored chemicals. This will be urgently needed especially for the newly listed POPs.

2.4.3. Monitoring of POPs in water

Water was added to the updated Guidance for the 2nd data collection campaign as an additional matrix for the assessment of PFOS (and other more water-soluble chemicals such as HCHs) following the COP4 decision to include PFOS. The parties were not encouraged to report water concentration data on remaining POPs. Although multiple international and national programmes are reporting POPs concentrations in the aquatic environment, due to the limited water solubility of these chemicals most programmes address their concentrations in biota or sediment instead. As previously discussed, extensive scientific data on the concentrations of poly- and per-fluorinated chemicals in water do exist and can be used for the assessment of background levels and spatial trends. Among them, the most valuable are data coming from cruises. To make them available for the 2nd GMP Report, these data were collected from the scientific literature and presented through the GENASIS (www.genasis.cz) and GMP DWHs (Secretariat of the Stockholm Convention n.d. c)).

2.4.4. Highlights in relation to global POPs monitoring activities in the future

A. Monitoring of POPs in air:

The main goals of current efforts should be to:

- assess the long-term trends of the original POPs based on data from the 1st and 2nd GMP report whenever possible (done in the 2nd Global GMP report submitted to COP8 in 2017);
- define the minimum set of requirements to secure representative data supporting the effectiveness evaluation of the SC on a long-term sustainable basis;
- support the collection of background information on substances added to the annexes of the SC between 2009-2017 if they were not reported in the first two data collection rounds;
- make steps towards collecting long-term data allowing for the assessment of temporal trends of these substances based on recommendations of the updated Guidance document and the lessons learnt from the 1st and 2nd rounds of the GMP.

The air chapter of the updated GMP SC Guidance document also addresses the comparability of data and presents the results of various QA/QC exercises and recent studies evaluating available data. It has been demonstrated that the uncertainty of data is largely given by the uncertainty of results provided by the participating laboratories. Such variability is greater than the one caused by various air sampling techniques. Based on these data it is strongly recommended to maintain several large-scale air monitoring programmes supported by central laboratories. Interlaboratory comparisons as well as comparisons of the results coming from various networks with their samplers co-employed at selected "super-sites" are also recommended.

B. Monitoring of POPs in human milk:

More data on the concentrations of POPs in human tissues are available in national biomonitoring studies and human cohort studies. Their importance rises especially for newly listed chemicals. The Regional Organization Groups (ROGs) should be encouraged to work together with the national human biomonitoring programmes on making the trend data available. Synergies with the on-going EU projects H2020 Co-Fund on Human Biomonitoring for Europe (HBM4EU, www.hbm4eu.eu) striving to consolidate all biomonitoring data from Europe in the newly developed IPCHEM database (https://ipchem.jrc.ec.europa.eu) should also be explored even though there is only a partial overlap between the HBM4EU project priority substances and the SC POPs (PBDEs, HBCDs, PFOS).

C. Monitoring of POPs in water:

A new strategy must be developed based on recommendations of the GMP Guidance document for the newly listed POPs. It is clear that there will be a demand for new water concentration data on other perfluorinated compounds such as PFOA and PFHxS, and potentially other more water-soluble compounds such as pentachlorophenol (PCP). On the other hand, the capacity of current water monitoring networks for providing such information on a global scale is limited and no regional or global passive water monitoring programmes currently exist. There have been on-going activities related to the establishment of such a programme with the pilot phase of the AQUA-GAPS network currently in progress (Lohmann *et al.* 2017; AQUA-gaps 2022).

RESULTS AND LESSONS LEARNED FROM UNEP/GEF PROJECTS ON POPS MONITORING

3

SECTION

The lessons learned below come from 20 years of experience and information generated through capacity building activities for POPs monitoring in regions requiring support in carrying out further activities. UNEP/GEF project components comprise sampling of ambient air and subsequent analyses, sampling of human milk, sampling and analyses of matrices of national interest, capacity enhancement of project countries by training and interlaboratory assessments. In addition, ongoing UNEP/GEF GMP2 projects also comprise sampling of water. Further, projects have also tested laboratory capacity and generated tools and contribute to the global implementation of the Article 16 of the Stockholm Convention.

3.1. Air sampling and analyses

Air sampling from UNEP/GEF Projects:

Passive sampling of ambient air by samplers containing polyurethane foam disks (PUF) was used in UNEP/GEF projects in all countries. The method is sensitive enough, robust and has been successfully implemented in project countries. The same method is also used by international POPs monitoring networks (GAPS, LAPAN, MONET) generating long-term POPs data, and have been included and described in the Guidance of the GMP under the SC (Secretariat of the Stockholm Convention 2019).

In addition, active samplers were used for the second round of UNEP/GEF projects in Africa (Ghana and Kenya, provided by MONET Africa programme) and a sampler was provided to GRULAC region (Brazil), to Asian region (Mongolia and Viet Nam) and another country in Africa (Mauritius) in 2018.

GMP/UNEP/GEF projects generated capacity for sampling and data (one year of data for the first round of UNEP/GMP projects (31 countries, 4 samples in 12 consecutive months 2010-2011) and two years of data in ongoing regional POPs monitoring projects in 42 countries, i.e. approximately 8 individual samples per project country collected seasonally.

Analyses

Until now, external expert laboratories were needed, most countries cannot perform the analyses themselves to generate globally comparable data. However the situation is gradually improving for PCB and OCPs. Newly listed POPs are a challenge, but the interlaboratory assessment shows there are improvements. There are several laboratories in developing countries that introduced instrumentation and analyses for brominated POPs and dioxins and are now introducing fluorinated POPs instrumentation (UNEP 2023).

3.2. Human breast milk sampling and analyses

Human breast milk survey is ongoing for almost 30 years since the first WHO-EURO human milk survey launched in 1987, later on jointly organized by WHO/UNEP and since 2008 by UNEP. It has a centralized and harmonized approach WHO protocol with ethical clearance at global level and analysis in one central laboratory (CVUA Freiburg).

With support from UNEP Chemicals and Health branch (implementing agency) through two rounds of UNEP/GEF projects there is increasing number of participating countries over time and time series and time trends are already available. 42 countries participated through UNEP/GEF GMP2 projects in 2018/2023 and 31 UNEP/GEF GMP projects 2008-2012 respectively.

Challenges have been encountered by participating countries in obtaining the necessary ethical clearance for conducting the survey and in the shipment of samples to the central laboratory. The most recent project round identified that shipment of samples to central laboratory currently represents a significant challenge and administrative support at national but also international level is critical.

The milk survey is a very cost-efficient, non-invasive and low-frequency (every five years) way to estimate the overall exposure of a local population identified by one pooled (=mixed) sample representative for a country / region. Experience shows that it is possible to get a rough estimate on the exposure in different regions of the world and time trends with only very few samples.

Analyses

Milk survey design uses a central laboratory concept (CVUA, Germany for all POPs but per fluorinated that are analyzed by another central laboratory in MTM Örebro, Sweden). Countries with existing capacities also conducted analysis of human milk samples at national laboratories.

3.3. Water sampling and analyses

Water as a core matrix was added to the GMP after the listing of PFOS and PFOSF into the annex B of the Stockholm Convention in 2009 (Secretariat of the Stockholm Convention 2009) and therefore water sampling is only part of the ongoing UNEP/GEF GMP2 projects round. A guidance for the water monitoring as to site selection, sampling method, frequency and analytes was elaborated (Weiss *et al*. 2015) and site-specific operations were further specified in a Standard Operating Procedure (SOP) developed through ongoing UNEP/GEF GMP2 projects (UNEP 2017).

There are 22 project countries sampling surface water (active sampling) every three months by using the SOP referenced above. The sampling procedure is easy, cost efficient, and practicable. For the GMP2 UNEP/GEF projects all samples were delivered, no problems experienced in the shipment and it was the least costly component of the monitoring part of the projects.

Analyses

Collected water samples are analysed in the MTM Research Centre's PFAS laboratory. Where national capacity is available, a second sample is taken and analysed in the local country laboratory. Analysis of PFAS is challenging and capacity slowly builds up. Harmonization of analytical approaches is still underway and not concluded. Expert laboratories from developed countries are still needed.

3.4. Sampling of matrices of national interest

This project component is unique to the UNEP/GEF projects rounds and it is not a requirement under the Stockholm Convention Guidance on the Global Monitoring Plan. The samples are selected by the national project coordinating committees and preferentially should include fish, butter or sediment. These samples do not only provide additional information about the presence of POPs in other matrices in each country; these samples also serve as so-called mirror samples to compare the "expert laboratory result" with the result from the national or local laboratory.

Participants experienced significant difficulties with custom clearance of the shipped national samples (i.e., soil and biota) in 2017 and 2018 and communication with project countries on the details of the sampling and shipment despite the availability of the SOP for the UNEP/GMP2 projects. Further, the communication with project countries is very cost intensive (more than for air passive sampling component or laboratory assessment). The communication part is about equal in time to the analysis time if not larger.

The comparisons in the first round of projects have shown that many laboratories are not at the desired level of comparability yet, for the UNEP/GMP2 project round, most results still need to be generated/calculated.

3.5. Enhancing laboratory capacity by training of experts

Both rounds of UNEP/GEF GMP/GMP2 projects featured training of experts as a main project component. Trainings were carried out by expert laboratories supporting project implementation and comprised theoretical part, demonstration of sampling, sample preparation and clean up and laboratory analyses including calculations and quality assurance and quality control measures (QA/QC).

At least 60 institutions participated in training courses, with 27 countries in the ongoing UNEP-GMP2 projects and overall, 50 developing countries received training in all UNEP-GMP capacity building activities organized since 2007.

In addition, a total exceeding 1,200 people from all over the world have received training so far including arrangements outside UNEP/GEF/GMP projects (i.e., RECETOX summer school (2007-2019) (about 610 in total out of which 85 from all regions were trained with the support of UNEP 2007-2015) and POPs EA programme (100 people) and Korean POPs training (about 80).

For the labs that received training for the first time it is difficult to judge the progress at this stage as the second round of UNEP/GEF projects is still ongoing and as of 2019 some trainings are yet to take place. Some laboratories have improved their analytical capacity and even accredited their methods, but many labs trained are not regularly doing POPs analysis. Some have a different function than analyzing POPs in the core matrices of the Stockholm Convention, so the POPs samples are complementary to the routine work of the lab and its purpose, and they only perform them during the execution of projects or upon specific requests. Nevertheless, regular workload/routine is important to maintain the training outcomes in the laboratories and the capacity building results in the country.

Experience also shows that many laboratories are still requesting a repetition of the training in analyses of OCPs and PCB, while much less request analyses for new POPs.

Many labs suffer from a lack of interest from their governments.

In addition to lack of a political support some also experience difficulties in consumables procurements, spare parts availability, shipment and customs clearance issues, personnel changes, and a lack of good management/organization of laboratories are mentioned.

Finally, to be able to run a laboratory providing analyses of the whole range of the SC listed chemicals, significant investments and maintenance costs are required. An overview of the investment and operational costs of a laboratory for POPs analyses is provided in Annex 1.

3.6. Quality of data generated

The biennial global interlaboratory assessment on POPs is an element of quality control/quality assurance (QC/QA) for any chemical analytical laboratory and has an important role under the UNEP/GEF GMP projects rounds.

To date, there were two GEF funded projects implemented by UNEP, Chemicals and Health branch that covered four rounds of such proficiency test (UNEP/GEF Project "Assessment of Existing Capacity and Capacity Building Needs to Analyse Persistent Organic Pollutants (POPs) in Developing Countries". The project was financed by the GEF and implemented by UNEP through UNEP Chemicals and Health branch. Co-financing of the project was provided through the governments of Canada, Germany, and Japan. It was implemented between January 2005 and mid-2007. Outcome of the project were a POPs laboratory databank available online (UNEP n.d. a) and Stockholm Convention website and criteria for analyses and laboratory infrastructure that were inserted into the Global monitoring plan guidance document adopted by COP3 of the Stockholm Convention in 2007 and updated as necessary.

There have been four rounds of laboratory assessments carried out between 2010 and 2019 organized and implemented by MTM Örebro University and E&H VU Amsterdam that prepare the test samples, ship them to registered participants and evaluate results. Through the years, the UNEP-coordinated interlaboratory assessments have become the largest exercise on POPs analysis and quite a wide spectrum of matrices. Participation in the assessment is not restricted to countries participating in the UNEP/GEF GMP projects their participation was free of charge, similarly to other developing countries (in the present arrangements).

The following results were achieved:

- The implemented global laboratory assessment scheme follows proficiency testing without special training component (no materials to facilitate analysis of test samples; no calibration mixes provided). Despite labor intensiveness due to number of matrices and increasing range of chemicals covered (mirrors the listing of chemicals in SC Annexes, laboratory assessment is an important tool for quality control and it is the only global blind test for laboratories on the analysis of POPs.
- There were 100-175 laboratories registered in each round and a total of 428 laboratories did register in at least one round of assessment. In total, more than 3,000 test samples were prepared and distributed by the two coordinating laboratories, MTM Örebro University and E&H VU Amsterdam.
- The largest number of participating laboratories was found in Round 3, followed by Round 4. In all rounds, Asia had most labs registered. The participation from Africa and WEOG is increasing; GRULAC remains quite constant. It shall be noted that not all laboratories that register and receive samples or report results.
- Performance by laboratories vary a lot among compounds: Experience has shown that some laboratories have improved their performance, with some from developing countries reporting impressive results. Meanwhile 20% of laboratories registered do not report and about 20% of the reported results are of unsatisfactory quality (UNEP 2023).

3.7. Tools developed through projects

In support of national sampling and analytical activities, the UNEP/GEF GMP2 projects supported the development and updating of SOPs (UNEP n.d. b) as well as tutorials in several languages (Table 5).

Table 5: Guidance and SOPs developed in support of national sampling and analytical activities.

Subject	Available languages**
Passive Sampling of Ambient Air: Methodology and Procedure	En. Fr. Sp.
Protocol for the Sampling of Water as a Core Matrix in the UNEP/GEF GMP2 Projects for the Analysis of PFOS	En.
Guidelines for Organization, Sampling and Analysis of Human Milk on Persistent Organic Pollutants	En. Fr. Sp.
Protocol for the Sampling and Pre-treatment of National Samples	En. Fr. Sp.
Active sampling of Ambient Air: Operation procedure and Methodology	En. Fr. Sp.
Video tutorial for the sampling of human milk	En. Fr. Sp.
Video tutorial for passive air sampling	En. Fr. Sp. Ru.
Video tutorial for active air sampling	En. Sp.
General procedure for analysis of PFOS	En. Fr. Sp
General procedure for analysis of PCB and OCP	En. Fr. Sp
General procedure for analysis of PBDE	En. Fr. Sp
General procedure for analysis of PFAS in water	En. Fr. Sp
General procedure for analysis of dl-POPs	En. Fr. Sp

***Note: En.-English; Fr.-French; Ru.- Russian, Sp.-Spanish*

Considerations of sustainability by project countries

In discussions in the midterm workshops of the UNEP/GMP2 projects regions (GRULAC, Africa, Asia and Pacific Islands in 2018 (June-December), a way to sustainability was discussed.

Each midterm-workshop held in 2017 was provided with a targeted information on the POPs monitoring activities in the region beyond the UNEP/GEF projects - existing networks, tools, data generation per matrix and recommendations from reports on global POPs monitoring and effectiveness evaluation. Several questions aiming at identification of key pillars nationally and elements of practical regional strategies were discussed by smaller groups on use of data, available capacity, and obstacles for continuation of the POPs monitoring activities.

General agreement across all regions were that key pillars of sustainability in the POPs monitoring are technical ability and capacity, political support and funding.

3.8. Summary

There is a wealth of capacity building activities that were carried out in developing countries with much of positive development via UNEP/GEF GMP projects rounds, in particular regarding data coverage, sampling, and availability, scope and quantity of trainings.

Moreover, systematic capacity-building activities covered sampling (air, water, human breast milk, matrices of national interest), sample handling/preparation, and laboratory analyses have been carried out in developing countries, including strategic partnerships with well-established monitoring programmes. Despite these efforts, several regions still have limited capacity to monitor POPs themselves. The addition of new POPs to the Convention creates additional demand for trainings to implement the necessary POPs monitoring activities.

Until now and for all core matrices, external expert laboratories were needed to generate results at the needed sensitivity or selectivity, with QA/QC in place. Analytical capacity for POPs analyses worldwide is increasing for OCPs and PCB is already available, for newly listed chemicals is gradually building up, and for dioxins/furans there is a limited number of laboratories due to high specificity of the materials/facilities and high operational costs. Newly listed POPs are a challenge, but the inter-laboratory assessment indicates that there are improvements.

Maintenance of created capacities in POPs analyses remains a challenge, because of the projects short span (2 years of sampling) and many external and internal pressures. Critical elements to maintain built capacities have been identified and are outlined in the next chapter.

Tools (guidance materials, SOPs, training videos) were developed through the projects to support facilitate implementation of POPs monitoring related activities. Available in languages (EN, FR, ES, RU (some)) and generally well received.

The experts highlighted however, that successful monitoring, both sampling and analysis of POPs, can be sustainable and high quality maintained only if they are linked to a solid infrastructure and routine monitoring operations.

It was also observed that in recent times, difficulties have been experienced with shipment of samples or laboratory materials to project countries. Custom clearance for the national samples sent abroad for testing, especially biota, has become a major challenge.

OVERALL CONCLUSIONS AND RECOMMENDATIONS

4 SECTION

The review in chapters 2 and 3 allows us to draw the following overall conclusions:

Substantial geographic differences existed in the availability of monitoring capacity to contribute comparable data and information for the purpose of the effectiveness evaluation of the Stockholm Convention in 2008. Systematic capacity building activities have been carried out in developing countries, including strategic partnerships with well-established monitoring programmes. Despite these efforts, several regions still have limited capacity to monitor all POPs. Throughout all regions, there is limited capacity to analyze dioxin-like POPs (PCDD/PCDF and dl-PCB), however, the situation is gradually improving for PCB and OCPs. The quality of dioxin analysis varies from good to very good but is restricted to a limited number of laboratories. Newly listed POPs are also a challenge, but the inter-laboratory assessment indicates that there are improvements.

The addition of new POPs to the Convention creates additional demand to implement and sustain POPs monitoring activities and monitoring programmes may need to adjust their protocols and resources to better align with new priorities. Some pressure can be relieved by reducing analysis frequency for legacy POPs (e.g. PCB, organochlorine pesticides) where declining trends have been established, optimizing analytical methods, and establishing partnerships among laboratories to address specialized analytical needs. It is not necessary for every laboratory to be an expert for every class of POPs. When enhancing POPs laboratory capacities in the future, a more efficient approach would be to support one or two laboratories from each region that are promising in performance, infrastructure and capacities to self-maintain beyond the initial efforts to serve as regional reference laboratories.

Monitoring of POPs in Ambient air.

Data availability in core matrices have improved over the years. Passive sampling of **ambient air** is sensitive enough, robust and has been successfully implemented in UNEP/GEF projects countries. The same method is also used by other POPs monitoring projects or programmes (e.g. GAPS, LAPAN, MONET). POPs air monitoring largely depends on networks outside of the UNEP/GMP projects so far, but the contribution from the UNEP/GEF projects to improvements of geographical distribution of data can be considered important and needs further assessment when all information from GMP2 projects rounds becomes available at the completion of projects in 2020.

Monitoring of POPs in human milk.

Organized **human milk monitoring programmes** have been ongoing for almost 30 years. It is a centralized and harmonized survey using a WHO protocol (2007) and analysis done at a central laboratory (CVUA, Germany; PFOS analyzed at MTM, Sweden). The survey is a cost-efficient, non-invasive and low-frequency (every five years) way to estimate the overall exposure of a certain population identified by one pooled sample representative for a country/

region and global data. Experience shows that the survey enables to generate comparable estimates on the POPs exposure in different regions of the world as well as to establish time trends with relatively small resources. Overall, there are 69 countries that participated in the survey to date of which 43 participated once, 21 twice, four three times and one country four times.

The survey is also very dynamic as the range of chemicals analyzed increases over time. The survey data also cover newly listed POPs as well as candidate POPs currently evaluated by the POPs Review committee and relative importance (share) of chemicals in the pooled sample indicate changes with the increasing number of listed chemicals. Moreover, the UNEP/GEF projects have shown to be instrumental in generating capacity for human milk sampling and allowing for analyses worldwide. The identification of highly exposed mothers is crucial towards improving maternal and child health further supporting the achievement of the sustainable development goal 3 target 3.9 which calls for the reduction of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.

Monitoring of POPs in water.

Water as a core matrix was added to the Global Monitoring Plan under SC after the listing of PFOS, its salts and PFOSF to Annex B of the Stockholm Convention in 2009 (Secretariat of the Stockholm Convention 2009). Therefore, water sampling is undertaken for the first time in the ongoing UNEP/GEF GMP2 projects. The results will serve as a starting point for future harmonized water monitoring and COP9 encouraged Parties to undertake monitoring of perfluorooctane sulfonate in surface water in support of future evaluations of the SC effectiveness.

Needs to strengthening capacities for laboratory analyses will continue to exist in the future due to widening scope of the SC. Future, however, requires a different approach in providing support. Moreover, quality control of generated data in core matrices needs to be in place and inter-laboratory assessments are important tools to test the performance of a chemical laboratory. Costs and efforts are high for inter-laboratory assessments, but they deliver timely information as to the performance of the laboratories and improved/quality infrastructures globally.

4.1. Suggestions

Proposed future consolidated activities that would significantly contribute to continuity of the POPs monitoring are based on the following principles:

Long term availability and comparability of data in core media is crucial for successful implementation of the Global Monitoring Plan under SC in the future;

A successful monitoring, sampling and analysis of POPs, can be sustainable and high quality maintained only if they are linked to a solid infrastructure and routine monitoring operations;

Dynamic nature of the Stockholm Convention and its widening scope will require pragmatic actions to relieve pressures on global analytical abilities and capacities.

There are gender and age-differentiated windows of susceptibility and exposure. Future research efforts should assess the gender- and age-differentiated impacts of POPs on populations at different stages of life and in different roles to better understand the pathways for exposure to these harmful chemicals.

Capacity building efforts carried out by partners and expert laboratories supporting project implementation. It is important that future efforts are made to strive for gender parity within the within the groups that are trained and by extension within the laboratories that participate.

Proposal

1) Centralized human milk monitoring survey and maintenance of existing strategic partnerships operated air networks are a priority for sustainable global POPs data generation

For human milk survey POPs monitoring future set up need to comprise the following elements/criteria/steps

- Global funding support is necessary to carry out the survey.
- For generation of long-term information on POPs levels in human milk (i.e., for next 20-30 years), the same protocol and set up should be used and it is recommended that there are about five years intervals between surveys in a particular country;

- Continued use of centralized laboratories for the analysis of the pooled sample is instrumental for future consistency and comparability of generated data.
- Preferential support in the survey participation should be granted to countries that took part in previous rounds, so that time trends can be observed;
- Initiation of each round by an implementing agency (UNEP) with the support of the BRS Secretariat, WHO and facilitation/support at the national level;
- Collaboration between agencies at national level between environment and health is critical for the ethical clearance, sample collection and cooperation with national customs authorities facilitates sample shipment

2) Maintenance of existing strategic partnerships for POPs monitoring in other core matrices:

Global POPs monitoring in air largely depends on networks operated by strategic partnerships in particular in the developed countries and regions. Inclusion of sampling sites in developing countries and regions via the UNEP/GEF capacity building projects has covered significant gaps in geographical distribution of data and should be further explored.

Water monitoring was only recently introduced, and COP9 encourages Parties to undertake monitoring of perfluorooctane sulfonate (PFOS) in surface water in support of future evaluations

3) Reduction of pressures on global analytical abilities and capacities:

The addition of new POPs to the Convention creates additional demand to implement and strengthen scope of POPs monitoring activities. It is not necessary for every laboratory to be an expert for every class of POPs. A more efficient approach would be to support one or two laboratories from each region that are promising in performance, infrastructure and capacities to self-maintain beyond the initial efforts to serve as regional reference laboratories.

Availability and comparability and quality of data in core matrices is crucial and inter-laboratory assessments are essential to test the performance of a chemical laboratory. Even if the costs and efforts for such assessments are high, it is recommended that UNEP regularly initiates each round and raises funding for its implementation. Laboratories that are contributing POPs data to the Global Monitoring Plan under SC to successfully participate in these inter-laboratory assessments; Interval between assessments is recommended for two or three years.

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ANNEX 1

INITIAL INVESTMENT AND OPERATIONAL COSTS FOR POPS ANALYSES

This annex provides overview of the initial investment and operational cost associated with the routine activity of the laboratories analyzing POPs (substances listed in the Stockholm Convention). In this regard, some key points should be addressed before any economic balance is attempted to be proposed. For example:

- Group of substances subject of study (i.e. full set of SC chemicals or a subset of these)
- Analytical capacity of the laboratory. In other words, how many samples are expected to be analyzed per year and human resources available.
- Geographic location of the laboratory. Experience shows a large variability in terms of costs observed for same products, instruments, trainings etc. - depending on the geographical area where the analysis to be performed is performed.

Further, the information included in this annex is based on the assumption that the laboratory is fully operational and well equipped for POPs analyses

Bearing this in mind, the initial investment required, and **operational costs** could be divided and summarized as follows:

- Personnel cost
- Instrumentation
- Procurements
- Other
- Overheads

Frequently, points 1 to 4 are also known as direct costs.

1) Personnel cost

This is related to the cost associated to cover the necessary personnel. This includes not only permanent staff but also hired people. Without a doubt, the cost of employees is the highest and considerably varies depending on the country and the background and tasks of the hired people. Early estimations may give rise about 50-60% of total **operational cost**

2) Instrumentation

Taking into account previous assumptions, in this section are uniquely considered those costs related with operating costs, maintenance contracts, repair cost, depreciation of instruments, etc. In this topic it is very important to consider large differences in terms of costs depending of the analysis of POPs to be performed. Typically, basic POPs or even marker PCBs can be performed with relatively lower cost instrumentation in comparison to other types POPs, in which the use of particular instrumentation such as the high resolution mass spectrometry for dl-POPs or the use of state of the art LC-MS for PFAS is unavoidable. Again, the cost derived from instrumentation show a wide range, accounting from 15-30% of the operational costs depending on the area of study.

3) Procurements

Typically, procurement is associated with all the expenses derived from the acquisition of reagents, solvents, standards, materials (e.g. filters) and small apparatus that cannot be considered as instrumentation. Similarly, to the above-mentioned, procurables are important item for the laboratory and may varied depending on the type of the analysis and also de geographical area. At this point, it is important to mention that many of the analytical workflow for the analysis of certain families of POPs require the use of labeled standards which are indeed of a high cost. In line with this, solvents and reagents must comply some minimum requirements in terms of purity and efficiency for an adequate analysis.

In addition to that, it should have highlighted the tedious processes to acquire these materials to follow in some countries, in some occasions extremely time-consuming (up to several months). More, in some cases, many products require internal national permits at the customs which are also so long and grueling process. This item could account up to 25% **operational cost.**

4) Other

In this section are included all required for the proper functioning of analytical laboratories that cannot be included in previous sections but they are critical and unavoidable expenses. This could include for instance travelling for technical meetings, dissemination in scientific journals, congresses and marketing, trainings and capacity building of staff.

Last but not least are the application of quality assurance and quality control (QA/QC) measures. Some theories supported by different authors revealed that about 50-60% of the tasks carried in a laboratory for organic trace analysis are QA/QC. In this topic are included the cost associated to blanks, duplicate samples, solvent check (batches), instrument checks (sensitivity, selectivity), analysis of certified reference materials (CRM) but also the costs derived for the accreditation (audits, etc.).

5) Overheads

The overheads are items internally defined by the institutions and might significantly vary, but as an example the range would be from 18% to 36% in some cases of the total budget for **operational costs.**

Table A. Overview of an estimated investment costs and fees for analyses of POPs

Instrumentation - Analytical laboratory	Unit	Estimated cost (USD)
GC-ECD with autosampler	Investment	40,000
GC-LRMS with autosampler	Investment	140,000
GC-HRMS with autosampler	Investment	700,000
LC-MS/MS with autosampler	Investment	200,000
Air samplers		
Low-volume sampler	per piece	10,000
Passive air sampler	per piece	150
Grab water sampling bottle with cap (500 mL)	per piece	5
Analysis to third parties (cost per sample)	Preferred method	
PCDD/PCDF	HRGC-HRMS	900
dl-PCB (when in addition to PCDD/Fs)	HRGC-HRMS	350
TEQ (total)	HRGC-HRMS	1,150
POPs pesticides+indicator PCB+ endosulfan (without toxaphene)	HRGC-HRMS, HRGC-LRMS, HRGC-ECD	700
Toxaphene	HRGC-LRMS, HRGC-HRMS	350
PBDE+PBB153+HBCD screen	HRGC-LRMS, HRGC-HRMS	450
HBCD isomers (LC)	LC-MS/MS	350
PFOS (air, blood)	LC-MS/MS	350
PFOS (water)		250
Materials and consumables		
Pre-cleaned PUF plugs/disks	per disk	20
HRGC columns (60 m)	per piece	880
Native pesticides standard mix	per unit	200
Labelled LRMS pesticides standard mix (calibration, clean-up, syringe)	per set	5,200
Labelled indicator PCB standard mix (calibration, clean-up, syringe)	per set	1,500
Labelled LRMS PCDD/PCDF standard mix (EPA 8280, calibration, clean-up, syringe)	per set	4,200
Labelled HRMS PCDD/PCDF standard mix (EPA 1613, calibration, clean-up, syringe)	per set	2,820
Labelled HRMS dl-PCB standard mix (WHO-TEF mix, calibration, clean-up, syringe)	per set	2,100

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