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Matters related to the implementation of the Convention: effectiveness evaluation

Global monitoring plan for effectiveness evaluation

Addendum

Executive summary of the third global monitoring report

Note by the Secretariat

As referred to in document UNEP/POPS/COP.11/20, the annex to the present note sets out the executive summary of the third global monitoring report prepared by the global coordination group. The third global monitoring report in full is set out in document UNEP/POPS/COP.11/INF/38. The present note, including its annex, has not been formally edited.

* UNEP/POPS/COP.11/1.

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Annex

Third Global Monitoring Report[1]

Executive Summary

I. Introduction

1. The third global monitoring plan (GMP) report synthesizes information from the first, second, and third phase of the GMP and presents the current findings on concentrations of persistent organic pollutants (POPs) at the global scale.

2. The third phase of the GMP focused on the following three key areas: (i) incorporating all newly listed POPs in ongoing monitoring activities to cover the full scope of the chemicals listed under the Convention as of 2019; (ii) enhancing harmonized data handling through the GMP Data Warehouse to support the collection, processing, storing and presentation of monitoring data in regions with limited capacity; (iii) enhancing the comparability within and across monitoring programmes to evaluate changes in concentrations of POPs over time and their regional and global transport.

Key message:

The ability of the Stockholm Convention to determine on-the-ground effectiveness of actions to reduce global burden of POPs critically relies on continuation of international and national monitoring programmes.

II. Results of the global monitoring

A. Data availability

3. The availability of information on the changes in POPs concentrations over time is improving but remains limited for newer analytes in most regions. In regions such as Asia-Pacific, Eastern Europe (EE) and Western Europe and Others Group (WEOG), long-term monitoring programmes cover part of the region with some notable spatial gaps within the region. Continuity in data generation and increasing spatial coverage in certain geographical areas are important areas of focus.

B. Data consistency and comparability

4. Enhancing the comparability of data within and across monitoring programmes to evaluate the changes in POPs levels over time and to understand the regional and global transport of POPs was one of the focal areas of the third phase of the GMP. Quality assurance and quality control (QA/QC) including inter-laboratory exercises and intercalibration studies have been and continue to be essential for ensuring data consistency and comparability. The interlaboratory assessments coordinated by the United Nations Environment Programme (UNEP) have been a large contributing exercise. In addition, new inter-calibration studies have been conducted. For example, an international intercomparison exercise for polyurethane foam disks samplers including 15 laboratories was carried out in 2016 and 2017. The results highlighted the advantage of using a central laboratory for monitoring programmes.

5. For some media, particularly water and other media, as well as air to a lesser degree, differences in sampling approaches (e.g., passive vs. active; gas-phase, particle-phase or total concentrations), sites and strategies (e.g., time-integrated sampling or intermittent sampling) and sampling matrix (e.g., use of filtered vs. non-filtered water samples) continue to mean that comparison of data may be complex. Water data appears to be rarely taken from “background” sites and in many cases are near to or within urban catchments. Together with year-to-year differences in sampling sites and wide differences in detection limits among studies, this greatly limits the ability to make meaningful comparisons across countries or between years.

C. Data handling

6. The five regional organization groups for the GMP are tasked to identify and report the best available POPs monitoring data on core media (air and human tissues) and other media, as available, considering three types of information: primary GMP data (the results of measurements of POPs

[1] The executive summary is reproduced as set out in the third global monitoring report contained in document UNEP/POPS/COP.11/INF/38, which has not been formally edited.

concentrations in core matrices collected for the GMP or other monitoring programmes that are compatible with the goals of the GMP); GMP metadata (information or data that describe the primary GMP data, for example information on the methodologies employed); and supplementary data (other data or information that may be accepted, for example data from published sources).

7. Providing enhanced support to the regional organization groups for harmonized data handling for the compilation, processing, storing and presentation of their data in the regional reports has been a large focus of third phase of the GMP. The GMP Data Warehouse has been further developed to add a new data visualization tool and support data handling to assist the regional organization groups and the global coordination group in preparing the regional and global monitoring reports.

D. Monitoring results

Key messages from monitoring results:

There are sufficient data to determine trends for many of the listed POPs but not all. In general, concentrations are declining and are starting to level off where regulatory action was taken decades ago. It is noted, however, that in some cases, such as hexachlorobenzene, there are slight increases, likely due to releases from secondary sources and the effects of climate change.

The patterns for chemicals listed since 2009 are complex and variable across chemicals, media and areas. For example, certain chemicals showed mostly declining or no change in trends, while others showed increasing trends followed by decreasing trends, or consistent decreasing trends depending on the location. Analysis linking to localized actions could assist in understanding such variability. There are insufficient data to detect trends for many of the newly listed POPs.

It is important that data and samples be maintained in a coordinated and sustainable way, such as through environmental specimen banks, and that monitoring programmes operate efficiently and collaboratively to address challenges.

1. Measurements in air

8. New air monitoring activities, including high-volume sampling programmes and a large number of passive sampling stations implemented during the last reporting period have now accumulated enough data to provide temporal trend information on POPs. It is noted, however, that reporting of POPs in air is still limited in some regions.

9. Most of the POPs that were listed under the Convention before 2009 and several that were listed after 2009 have shown continued declining trends or the trends have levelled off at most monitoring stations worldwide with some exceptions. Slight increases have been noted for hexachlorobenzene, likely associated with secondary sources and effects of climate change. Most of the polychlorinated biphenyls (PCB) data sets in core media showed decreasing trend, while increasing trend was observed in some areas. Hexachlorobutadiene (HCBD) on the other hand appeared to be increasing in some parts of Asia-Pacific.

10. In most regions, some of the listed polybromodiphenyl ethers (PBDE) showed declining trends, while other listed PBDE did not, with the exception of Latin America and the Caribbean (GRULAC), where trends for PBDE were unclear and potentially increasing. Perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) were variable depending on the location and the region, with declines reported in Asia-Pacific and WEOG.

11. Air measurements of water soluble and ionizable POPs such as PFOS and PFOA are limited and could be supplemented by including monitoring data for those chemicals in precipitation.

12. There were limited data in some regions for decabromodiphenyl ether, hexabromobiphenyl, hexabromocyclododecane (HBCD) and toxaphene, and insufficient data to conclude on trends for dicofol, chlordecone, pentachlorophenol/pentachloroanisole (PCP/PCA), polychlorinated naphthalenes (PCN) and short-chain chlorinated paraffins (SCCP) in all regions.

2. Measurements in human media

13. For the majority of POPs, including some of the newly listed organochlorine compounds, the levels in human milk and/or blood have generally fallen over the last 20 years with higher levels seen only in sporadic cases. The levels of several initial POPs such as chlordane, dieldrin, DDT, hexachlorobenzene and toxaphene are decreasing over time in human milk and/or blood. PCP seems to be on a downward trend, although time series data are scarce. The levels of PCB and polychlorinated dibenzo-*p*-dioxins/polychlorinated dibenzofurans (PCDD/PCDF) in human milk have fallen steadily

from their earlier high levels. Some of the newly listed POPs showed an increase over time followed by a decrease, including for hexabromocyclododecane (HBCD), PBDE, PFOS and PFOA.

14. No monitoring data could be found for chlordecone and HCBD in human milk or blood. No clear trend over time could be observed for heptachlor, hexachlorocyclohexanes, mirex and pentachlorobenzene. Due to insufficient data, no clear trend could be determined for endosulfan, polybromobiphenyls including hexabromobiphenyl and PCN.

3. Measurements in water

15. Data were available from ongoing monitoring programmes in Asia-Pacific and EE, as well as from the UNEP/GEF GMP II project in 22 countries in 2017–2019. Otherwise, data were taken mainly from the scientific literature. No specific studies of temporal trends of each chemical in water were found. Therefore, median concentrations for combined data from specific regions with the periods 2000–2009, 2010–2014 and 2015–2019 were compared. A challenge with these comparisons was that variation could be introduced due to differences in sampling locations and effects of seasonality.

16. In general, significant declines of PFOS were found in inland waters of several countries or regions including the Elbe and Rhine in Europe, lakes in Japan, and the North American Great Lakes. In oceans, PFOS concentrations declined significantly in the North Atlantic Sea and in the Mediterranean Sea, but not in the North Sea. Significant declines were observed in the Bohai Sea, the Yellow Sea and the South China Sea.

17. Median PFOA concentrations showed fewer declines compared to PFOS, although large differences from the mid-2000s to 2019 were seen at most sites in the Danube, as well as in the Elbe and the Rhine.

18. Median PFOS concentrations exceeded the European Union environmental quality standard (EQS) for inland surface waters of 0.65 ng/L in 21 of the 45 country sites for samples from 2015–2019 and earlier time periods. Median concentrations of PFOA did not exceed a proposed EQS of 100 ng/L in any of the 45 country sites, although some individual results exceeded this level.

19. Assessment of temporal trends at most locations was challenging due to year-to-year differences in sampling sites and to wide differences in detection limits among studies.

4. Measurements in other media

20. A significant body of data on POPs in non-core-media such as snow, ice, sediment, soil and biota are available for some parts of the world such as the Great Lakes, the Arctic, the Baltic, and Japan.

21. The changes over time, where available, indicate that for the POPs listed before 2009 (e.g., DDT, hexachlorobenzene, PCB, PCDD/PCDF), significant decreases have been observed over the past three decades. Levels of some of those initial POPs may still be at levels of concern in some species and regions (e.g., PCB in polar bears and whales). Chemicals such as HBCD, HCBD, PBDE, PCN, PFOS and SCCP are slowing in their increase and in some cases decreasing since they were listed.

22. Given the wide spread of media and methodologies, more standardized data reporting would improve comparability.

23. Environmental specimen banks including biological samples and analytical extracts from sampling media have been shown to be cost effective for the establishment of temporal trends and could be used for future listed POPs.

5. Long-range environmental transport

24. The analysis of airflow back trajectories and monitoring data on initial POPs and newly listed POPs in Africa suggested that elevated air concentrations measured at some sites of the Monitoring Network for POPs (MONET) were primarily due to sustained local emissions. At the same time, low concentrations observed at the sites in Mt. Kenya represented the continental background levels, largely affected by long-range environmental transport (LRET) of POPs from distant sources.

25. In Asia-Pacific, decreasing trends of DDT and increasing trends of HCBD were observed at monitoring sites of the East Asian Monitoring Programme which supported the view that these changes were affected by LRET rather than local emissions.

26. Potential sources and LRET pathways of POPs in GRULAC were analyzed using the Hybrid Single-Particle Lagrangian Integrated Trajectory-National Oceanic and Atmospheric Administration (HYSPLIT-NOAA) model in 2018 at three sites in Barbados, Jamaica and Uruguay. Back trajectories indicated potential effect of marine emissions and emissions from small vessels on the site in

Barbados, effect of emissions from nearby sources of the Dominican Republic, Haiti, Puerto Rico and the Caribbean islands on the site in Jamaica, and effect of LRET from the sources in Argentina, Brazil, Chile and Paraguay on the site in Uruguay.

27. LRET of POPs within the EE region was assessed by the application of multi-compartment modelling for hexachlorobenzene, PCB and PCDD/PCDF. Predicted levels of pollution and emissions of all studied POPs have decreased significantly between 1990 and 2018 (hexachlorobenzene by 90%, PCB by up to 80%, PCDD/PCDF by 40–75%). Model simulations indicated changes in the spatial distributions within the region and changes in the significance of imports from lower latitudes.

III. Evaluation of the global monitoring plan and recommendations for the next phase

Cross-cutting conclusions across all media:

The levels of many POPs, even those that have been regulated and managed, remain of concern. Existing monitoring programmes as well as ad hoc monitoring programmes such as those for water need to continue in order to determine trends. Large scale repeated monitoring programmes and sharing of metadata would allow comparison of data and enhance the ability to assess LRET.

Coordination with other programmes (e.g., ad hoc surveillance work on indoor air and urban and industrial emissions; monitoring and research programmes aiming to understand current exposure levels and emissions to the broader environment including urban areas and waste sectors) as well as development of environmental fate and exposure models would enable more comprehensive understanding of exposure and effectiveness of actions to protect human health and the environment.

Opportunities exist to link with climate science and biodiversity to better understand and interpret monitoring data in a broader context.

A. Arrangements

1. Further updating of the guidance and implementation plan

28. The third phase of the GMP was conducted in accordance with the amended GMP for POPs,[2] the amended implementation plan for the GMP for POPs[3] and the updated guidance on the GMP.[4] Along with the outcomes of the effectiveness evaluation report,[5] the areas for possible revision and addition have been identified and recommended for updating in the fourth round.

2. Data comparability and quality assurance and quality control

29. Recommended areas of future work to improve data comparability and quality assurance and quality control include the following:

(a) Encourage Parties to continue to participate in interlaboratory assessment activities organized by UNEP and to further explore and participate in such activities organized by other organizations, for example the International Atomic Energy Agency (IAEA), where applicable;

(b) Make further efforts to have databases easily searchable, openly accessible (e.g., data downloadable) and to integrate and make link with other databases;

(c) Further develop simple visualization tools such as those implemented under the GMP Data Warehouse;

(d) Enhance the ability to archive large data files in view of the advancement of high-resolution and non-target analytical methods, including for example in collaboration with NORMAN digital sample freezing platform which focuses on water data archiving. These approaches generate large data files that require sufficient and secure storage and provide an opportunity for retrospective analysis targeting newly listed POPs and related chemicals including precursors and transformation products.

[2] UNEP/POPS/COP.6/INF/31/Add.1.

[3] UNEP/POPS/COP.6/INF/31/Add.2.

[4] UNEP/POPS/COP.9/INF/36; UNEP/POPS/COP.10/INF/42.

[5] UNEP/POPS/COP.11/INF/36.

B. Challenges to implementation

1. Need for further capacity enhancement on a regional basis

30. For most regions, monitoring activities have been put in place and have produced data for the development of the third regional monitoring reports. The GEF projects conducted to date have been extremely useful in enabling developing regions to participate in the GMP and the effectiveness evaluation under the Convention. Nevertheless, all regions have experienced limitations in the availability of data, including limited spatial coverage, limited temporal trend data and limited analytical capacity. For some regions, there are multiple limitations. Tackling such limitations will remain a key focus for the fourth round.

31. Data to date demonstrated that ongoing and sustained strategic monitoring programmes maximize utility of data and enable conclusions to be drawn. Increases in the number of such monitoring programmes will be a valuable future contribution.

2. Efficiencies of monitoring programmes

32. Enhanced coordination would be essential in order to be able to respond to the growing demand for information on POPs.

33. In order to manage pressures for analysing more newly listed POPs, monitoring programmes may need to adjust their protocols and resources to better align with new priorities. Possible strategies include reduced frequency of analysis of initial POPs such as organochlorine pesticides and PCB, optimized analytical methods and partnerships among laboratories to address specialized analytical needs.

34. It is not necessary for every laboratory to be an expert for analysis of all classes of POPs. Many monitoring programmes are incorporating the latest advancements in the field of science such as high-resolution and non-targeted analysis and associated data archiving for future reference. Future reporting may be able to draw on data generated through such advancements.

3. Sample archiving and specimen banks

35. Investing resources to ensure the integrity and sustainability of specimen banks could provide a highly cost-effective tool for understanding the effectiveness of regulatory and policy interventions as they enable retrospective analysis on current and future POPs, as well as for screening studies on candidate POPs.

4. Data archiving and accessibility

36. Databases and compilations such as the GMP reports play an important role in identifying, documenting and making accessible reliable and comparable data sets of POPs. These data are needed for assessing environmental levels and trends of POPs and for combining with emission estimates and models in integrated assessments of sources, fate and transport of POPs.

5. Challenges with POPs listed after 2009

37. Certain high molecular weight POPs including polar/ionizable chemicals (e.g., PFOS) exist in air primarily on the particle-phase. To improve understanding of regional and global transport of particle-associated POPs, it is necessary to improve performance of fate models to interpret temporal trend information from monitoring data, obtain more information on gas-particle partitioning properties of POPs and conduct studies on transport and fate of particle-associated POPs.

6. Chemical mixtures

38. Human health and the environment are impacted by exposure to chemical mixtures which includes known and unknown POP-like chemicals and their transformation products. Research in this area is advancing rapidly thanks to increased accessibility to high-resolution analytical equipment (e.g., GC/MS/MS, LC/MS/MS).

39. Future reporting under the GMP would benefit from information on the levels of all listed POPs and potential candidate POPs in the same samples, where available, as this enhances understanding of co-occurrences, thus co-exposure and environmental loads. Similarly, reporting of the concentrations of precursors of listed PFAS, for example through “total” methods, could enhance understanding of environmental loads.

C. Media-specific recommendations for the next phase

1. Air

40. Recommendations on the air monitoring are as follows:

(a) Continue passive air sampling and capacity-building in a sustainable manner to enhance information on temporal trends and to improve spatial coverage;

(b) Develop a strategy for POPs monitoring using passive and active air sampling in order to better address data gaps in some regions in the long-term and growing needs of the Convention. The strategy should be developed through regional commitment and expertise, as well as through consultation with established programmes;

(c) Ensure the continuity of newly established sampling programmes and activities to generate long-term measurement data in order to assess the changes in POPs levels over time. Continue air monitoring using active and passive samplers according to QA/QC protocols to ensure data consistency for trend development;

(d) Continue air monitoring of newly listed POPs. Enhance collaboration with expert laboratories that have existing and recognized analytical methodologies to assist in the measurement of newly listed POPs found in air that lack analytical methods. Further develop GMP guidance to address those challenges;

(e) Regional experts should define monitoring priorities based on available resources and information on POPs concentrations in air and emissions, taking into account the GMP guidance;

(f) Maintain and update databases to ensure data quality, consistency, data continuity and ease of access. Improve compatibility among databases to facilitate data exchange and compilation;

(g) Improve waste management practices, management of contaminated sites, elimination of obsolete stockpiles and public education in order to further reduce intentional emissions of POPs from commercial use present in stockpiles and waste streams and unintentional emissions via open burning.

41. Furthermore, it is suggested to include in the work of the next phase of the GMP to develop a monitoring strategy such that the long-term temporal trends of POPs can still be assessed with a reduced sampling or analytical schedule.

42. Archived air samples or extracts can be used for retrospective analysis of POPs to rebuild temporal trends when funding and resources become available in the future. An example of this is the Australian Monitoring Programme, Passive Air (XAD) Monitoring and Archiving Network (PAXMAN), which has archived passive air samples over the period 2010–2020. The Government of Australia commissioned analysis of a subset of those samples for POPs, including chlorinated paraffins, HBCD, PBDE, PCB and PCN in samples spanning the period 2010–2020.

43. Those new developments have implications beyond the scope of the GMP but are important for understanding hazards and risks associated with POPs which may inform regulation of chemicals and the effectiveness evaluation of the Convention. Monitoring programmes and studies on POPs should consider urban sources of POPs and employ high-resolution analysis (non-target and suspect screening) to investigate chemical mixtures in air, including transformation products of POPs. Advances in in-silico approaches and assays for assessing toxicity should be explored as a complementary means for tracking the toxicity of the entire air mixture of POPs and related POP-like chemicals in air.

44. Future reporting should consider bridging this data gap with available long-term precipitation data and historical records found in ice cores which solely reflects atmospheric deposition over time.

45. Beyond the current scope of the GMP, but relevant to future work on effectiveness of the Convention towards the protection of human health and the environment from POPs, includes the development of strategies for linking the information on POPs concentration in air with toxicity. In vitro methods such as transcriptomics and bioassays to assess various toxicity end-points are now available with the required sensitivity to be applied to air sample extracts.

2. Human media

46. Recommendations on the human media monitoring are as follows:

(a) The global, regional and national monitoring programmes should continue to evaluate temporal trends of both POPs and other environmental pollutants in blood and/or milk. This would allow following the effectiveness of the Convention and to evaluate whether regulations and other actions taken in order to reduce the exposure to POPs were purposive and efficient;

(b) Continue the UNEP/WHO Human Milk Survey with a timing synchronized with the cycle of the effectiveness evaluation of the Convention to enable the GMP to use the latest available data. Participation from more countries in this survey would increase its representativeness;

(c) Continue and expand monitoring of newly listed POPs to provide the information necessary to assess the changes over time. In order to be able to follow up on those chemicals over time, it is important to start monitoring them now. In addition to the initial POPs that are already regulated, it is important to monitor possible substitutions;

(d) Encourage archiving of human samples as a cost-effective means for conducting retrospective analysis of newly listed POPs to generate baseline information and temporal trends of newly listed POPs as they are added to the Convention.

3. Water

47. Recommendations on the water monitoring are as follows:

(a) Continue water monitoring at established sites. As noted in the third regional monitoring report for Africa (UNEP 2021a), this would be critical to allow the establishment of concentration trends in future assessments;

(b) Future GMP assessments of PFAS in water should consider using the successful study design of the UNEP/GEF GMP II project (Baabish et al. 2021). The multiple sampling times at the same site and use of the same analytical laboratory yielded an excellent set of results;

(c) Repeat the UNEP/GEF GMP project prior to the next global assessment, ideally in a larger number of sites, but at a minimum at the same sites as those used in 2017–2019;

(d) Carefully design future sampling programmes as PFAS levels in river water may be influenced by wastewater and surface runoff in urban areas. Multiple sampling points preferably at sites that are well characterized in terms of flow and proximity to sources are needed;

(e) Conduct a global campaign for inland freshwater and coastal seawater sampling prior to each GMP assessment involving all regions. This would provide a more robust set of data than the current mix of national data and published scientific articles;

(f) Set lower detection limits in future assessments of temporal trends at all locations, especially in open oceans, coastal seas and lake waters. Detection limits in the range of 1–5 pg/L for perfluorohexane sulfonic acid (PFHxS), PFOS, and PFOA have been demonstrated by several monitoring programmes and should be universally adopted;

(g) Make efforts for more widespread measurements of precursors of PFHxS, PFOS and PFOA in waters by “total” methods (e.g., total oxidizable precursor, total extractable organic fluorine) or by targeting specific known precursor compounds;

(h) Conduct an integrated analysis of data including other media such as air, sediments and biota with global models. This would improve understanding of the fate of PFAS in the environment and estimation of future trends of PFAS particularly in top predators and human beings in remote areas, thus supporting the implementation and effectiveness evaluation of the Convention.

4. Other media

48. Recommendations on the monitoring of other media are as follows:

(a) Facilitate cooperation and enhance capacity to maintain long-term monitoring plans and programmes and environmental specimen banks integrating multiple media and to ensure robust QA/QC and reporting in a coherent transparent service in order to improve the accuracy for estimating the changes over time;

(b) Report evidence of the success of past regulations in decreasing the exposure to POPs in order to consolidate the need for further work on chronically low levels of initial POPs (e.g., hexachlorobenzene, PCB) and the growing threat of partially regulated POPs (e.g., HCBD, PBDE, PFOS, PFOA, SCCP) and other chemicals with POP characteristics sometimes used as alternatives;

(c) Make best efforts to integrate POPs monitoring work and its resulting data of abiotic media and macroscopic organisms, with climate data and molecular biology/toxicology in curated and accessible repositories;

(d) Make best efforts to establish and maintain conditions that facilitate common understanding and cooperation between local agents and scientists to develop effective strategies in public health and environmental policies on POPs.

5. Long-range environmental transport

49. The followings are needed to better understand the LRET of POPs:

(a) The monitoring data in Africa revealed POPs contamination of ambient air at remote sites suggesting potential contribution of LRET. Additional meteorological data, information on climatological conditions and modelling tools are needed to establish the contribution of LRET on the distribution of POPs in the region;

(b) The existing data for several sites in Africa were collected over a short period of time. Additional monitoring data are needed to verify the modelling predictions with the monitoring results;

(c) Regional capacity for application and interpretation of LRET modelling results is needed to support policy makers to incorporate the modelling predictions in their national and regional POPs management interventions;

(d) Measurements of HCBD in air are available in a limited sites in East Asia. Additional monitoring data on long-term variations of HCBD concentrations in other locations are needed to reveal the sources and the scale of this increase;

(e) More detailed assessment of LRET in Asia-Pacific, including back trajectory analysis, modelling studies and compilation of information on emission sources is needed to analyze the trend data and to clarify their LRET and possible sources;

(f) Currently in the Asia-Pacific regions, monitoring data are available only in East Asia and Pacific Islands. There is a strong need to establish environmental monitoring in the south, west and central Asia, so as to expand the monitoring network to cover all Asia-Pacific;

(g) The first analysis of back trajectories in the sites in the GRULAC region indicated the necessity for temporally disaggregated data to establish seasonality in order to relate and understand the observed concentrations and possible sources that contributed to those concentrations. Such information would allow evaluating those possible sources and defining local or regional reduction and mitigation actions;

(h) More systematic studies should be designed and implemented to address LRET of POPs in GRULAC. Passive air monitoring and active sampling along with modelling could be used to analyze the transport of POPs between sources and receptor areas. POPs modelling capabilities and training should be stimulated in the region;

(i) The satellite images of the fires reported in 2018 in the GRULAC region indicated possible generation of some POPs. It is highly recommended to review those contributions in detail to identify the types of burning that was taking place in the region (agricultural, waste or vegetation);

(j) Although not currently in the scope of the GMP, uncertainties in emission inventories of POPs can be reduced in a targeted way within an integrated assessment approach by applying models to estimate ranges of plausible emissions that are necessary to account for observed POP levels (“top-down” approach). More effective methods to identify and characterize emissions of POPs are needed to assess the impact of transport of goods and waste, in particular e-waste, all over the world;

(k) Improved modelling capabilities within the integrated assessment approach will enable the vast corpus of environmental monitoring data that has been established over the past decades to be leveraged to achieve a more quantitative and predictive understanding of the levels and trends of POPs and POP candidates in the environment;

(l) Shorter-term effects of climate change and climate variability that vary by regions or by chemicals should be taken into account when interpreting POPs levels in environmental media;

(m) It is important to understand how climate change induced changes in the ecosystems affect the temporal trends of POPs in other media including biota through, e.g., changes in diet, in order to separate the effects of changes in ecosystems on temporal trends of POPs from the effects of global regulation and bans on the POPs through listing under the Convention;

(n) Research studies are needed as existing models are often not adequate for assessing new compounds that behave differently in the environment (e.g., polar/ionizable POPs). For instance, studies of partitioning to particles and particle-associated transport and fate are needed for high molecular weight POPs and polar/ionizable chemicals that exist in air primarily on the particle-phase;

(o) Monitoring programmes need to be flexible and adaptable to deal with the challenges presented by newly listed POPs;

(p) Enhancing modelling capabilities, especially by improving emission inventories and estimates of POP degradability, and by improving understanding of air-surface exchange, will help to reduce uncertainties about the extent of LRET of POPs and POP candidates. This is of great importance to interpret trends and ascertain the effectiveness of actions that have been undertaken, and to forecast impacts of current action or inaction;

(q) Improved integration between monitoring programmes and modelers may help to identify gaps in information and optimize future study designs and ongoing monitoring efforts.

6. Recommendations beyond the scope of the GMP for the effectiveness evaluation

50. Recommendations on the future work for evaluating the effectiveness of the Convention towards the protection of human health and the environment from POPs include the following:

(a) Link the GMP work with data from monitoring and research programmes aiming to understand current exposure levels and emissions to the broader environment including urban areas and waste sectors, given that newly listed POPs can be found in household and commercial products. Declines in environmental background concentrations are likely to be slower if listed POPs have exemptions to allow continued use or presence in recycled materials;

(b) Strengthen cooperation to integrate GMP and other data with numerical models to estimate spatial and temporal trends of POP emissions and to link with human and environmental burdens. This could enhance understanding of the effectiveness of actions to protect human health and the environment;

(c) Enhance cooperation with other monitoring efforts under the Basel Convention, the Rotterdam Convention, the Minamata Convention, the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity. The information reviewed to provide baselines and to determine current trends in the WEOG region was predominantly drawn from a relatively small number of existing international programmes, which can in turn depend on contributing national programmes or ad hoc programmes. The ability to compare POPs levels over time makes the long-term viability of international and national programmes of critical importance.

Concluding message:

Sixteen years after the Stockholm Convention coming into force, the GMP has shown that primary sources of POPs listed before 2009 have been substantially reduced and current low levels can be attributed to effectiveness of policies and regulations. Baseline concentrations of many but not all POPs listed after 2009 are becoming available through monitoring programmes for core and other media. Additional data in the future will enable the evaluation of trends to inform effectiveness of management actions. The Convention and its GMP have raised awareness, triggered action and provided a framework for collaboration and integration at the national, regional and global levels.