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Conference of the Parties to the Minamata Convention on Mercury
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Item 4 (k) of the provisional agenda*

Matters for consideration or action by the Conference of the Parties: effectiveness evaluation

The first effectiveness evaluation of the Minamata Convention on Mercury (article 22)

Draft plans developed by the Open-ended Scientific Group to support the first effectiveness evaluation of the Minamata Convention

Note by the secretariat

1. At its fourth meeting, in decision MC-4/11, the Conference of the Parties to the Minamata Convention on Mercury agreed to begin the first effectiveness evaluation of the Convention and adopted a framework, as set out in annex I to the decision. In the same decision, the Conference of the Parties established the Open-ended Scientific Group to develop a scientific report and draw conclusions thereon for the consideration of the Effectiveness Evaluation Group.

2. As is provided for in the adopted framework for the first effectiveness evaluation and in its adopted terms of reference,[1] the Open-ended Scientific Group will deliver its expected outputs in two stages, with stage 1 foreseen for completion by the fifth meeting of the Conference of the Parties and stage 2 foreseen for completion in time for submission of the outputs to the Effectiveness Evaluation Group, taking into account the overall timeline for the first effectiveness evaluation, which the Conference of the Parties has agreed to consider at its fifth meeting.

3. The expected outputs of the Open-ended Scientific Group for each stage are:

(a) Stage 1:

(i) Plan for the compilation and summary of monitoring data;

(ii) Plan for the summary of available data on emissions and releases;

(iii) Plan for data analysis;

(b) Stage 2:

(i) Compilation and summary of monitoring data;

(ii) Summary of available data on emissions and releases;

* UNEP/MC/COP.5/1.

[1] Annex II to decision MC-4/11.

(iii) Data analysis addressing the guiding questions outlined in the monitoring guidance.

4. A detailed description of the work of the Open-ended Scientific Group is presented in its progress report to the fifth meeting of the Conference of the Parties, as contained in document **Error! No text of specified style in document.**.

5. The present note contains drafts of the plan for the compilation and summary of monitoring data (annex I), the plan for the summary of available data on emissions and releases (annex II) and the plan for data analysis (annex III). The annexes are presented without formal editing.

6. Additional information on the work of the Open-ended Scientific Group during the intersessional period will be available in document UNEP/MC/COP.5/INF/37.

Annex I*

"Plan for Monitoring Data Compilation and Summary" to inform the Effectiveness Evaluation of the Minamata Convention

Draft (14 August 2023)

Table of Contents

* The annex has not been formally edited.

Executive summary

The purpose of the "plan for monitoring data compilation and summary" (hereafter "monitoring data plan") is to structure and guide the process for the submission, collection, quality control check, management, and accessibility of existing data on mercury levels in humans and the environment to inform the first effectiveness evaluation of the Minamata Convention.[1] In accordance with decision MC-4/11 of the Conference of the Parties to the Minamata Convention, the monitoring data that is compiled through the process set out in this plan will subsequently be compared and analysed, as per a separate "data analysis plan", for consideration of the Effectiveness Evaluation Group.

The work of the OESG to inform the first effectiveness evaluation will focus on existing sources of monitoring data while an analysis of gaps related to monitoring data, including potential scientific actions to address the identified gaps, will be included in the scientific report of the OESG. Mercury observations in the different matrices, ancillary observations and metadata will be collected from a broad range of sources and the quality of the collected data will be assessed (more details below). Main available sources of mercury monitoring data for air, biota, humans, and "other matrices" (soil, water, and sediment) have been identified and include monitoring programs, both ongoing and completed, as well as independent studies.

An overview of the characteristics and type of information contained in each identified set of data were compiled in spreadsheets[2] that also include, in addition to providing a snapshot of the type of mercury measurements in each dataset, examples of metadata available, such as the type of data collected, geographic coverage, monitoring period, relevant publications, etc. In addition, summaries of the available sources of data for each matrix are presented as addenda to this document.

The identified sources of monitoring data will serve as a starting point for the collection of data through an invitation to parties and other data providers to submit their datasets containing observational mercury data and metadata. The identified data gaps will be summarised in the OESG final report to inform future effectiveness evaluation cycles.

A data dictionary was developed, as contained in Annex 2, to facilitate the work of the OESG in collecting, comparing and analysing mercury levels in air, humans, biota, and other matrices. The data dictionary lists possible descriptors that can be used to describe each dataset, and identifies the minimum required data elements.

The objective of the data dictionary is to help those who wish to contribute to the first effectiveness evaluation of the Minamata Convention in identifying and structuring the necessary mercury observations, ancillary observations, and descriptive elements, or metadata. To support the OESG's analysis of comparable mercury monitoring data, a shared data dictionary will be necessary to facilitate standardization by documenting common data structures and providing the precise definitions, agreed nomenclature, units of measurement, time scales and formats, as well as further information and external references that are needed to compare and analyse mercury measurements.

Several types of data elements are included in the data dictionary: the mercury observations, ancillary observations of other relevant contaminants or environmental parameters, and descriptive data elements (or metadata) that are necessary for interpretation of the observations. The data elements contained in the data dictionary are grouped into nine sections, from A to I. Sections A-C, H and I contain categories of data elements that are common to all monitoring matrices, whereas sections D through G contain data elements that are specific for each matrix. The data elements are further grouped by categories and, where relevant, sub-categories.

The data dictionary will be used to develop matrix-specific standardized formats to facilitate the submission and compilation of data in a harmonized manner. The standardized formats will identify the minimally essential data elements to be submitted. It is recognized that many of the existing monitoring datasets do not necessarily include all the elements identified in the data dictionary and that, particularly during the first effectiveness evaluation cycle, data providers will not be able to provide all the data elements in the proposed data dictionary. Nevertheless, the data dictionary may be useful to guide the generation of data in the future with the aim of having data that is more comparable and detailed for future effectiveness evaluation cycles.

Once the data dictionary has been finalized, standardised data formats for data collection will be developed for each matrix to facilitate data submissions and subsequent comparison and analyses. The standardized formats will be aligned, to the extent possible, with existing formats in use by established monitoring programmes to minimize the

[1] In the context of this document, "monitoring data" includes: (a) mercury observations which have associated parameters including units, time, location, etc.; (b) ancillary observations, which are observations of environmental parameters other than mercury that are needed to interpret the mercury observations, and (c) metadata, which includes information that describes the observational datasets, include such things as the data provider, data formats, number of sites, frequency of observations, time period covered, operating procedures and quality assurance methods employed, etc.

[2] Available online through the OESG document review folder as separate supplemental materials in their original format.

workload and to facilitate the use of existing data. A long-term vision of this plan is to cooperate with established monitoring programmes for the generation of data in formats that can best respond to the OESG needs. Matrix-specific standard formats will ensure that datasets, including those from different sources, will share a consistent structure, i.e., they will share the same sequence of data fields. It will also be possible to harmonize the units of measurement, time, and location to enable the comparison of multiple sets of data.

Parties and other data holders will be invited to submit monitoring data by using the standardised formats. Datasets submitted in their native nomenclature and formats will also be accepted and will be included in the compilation following a reorganization of the data in accordance with the standardized formats. Datasets from all sources will be welcome during the data collection phase but, during the analysis phase, prioritization and/or weighting of data to support the effectiveness evaluation will be necessary. In addition, active searching for relevant and publicly available data may also be carried out, where necessary, in an attempt to improve the data quality and coverage, both temporal and spatial.

Data providers or copyright holders will retain the ownership and rights over their data, including mercury and ancillary observations and metadata. For datasets that are not publicly available or that have use restrictions, the Secretariat will establish data use agreements with the individual data providers, as appropriate, and guidance will be provided to the OESG members and the experts in the roster to ensure that the data is used only for the purpose of supporting the effectiveness evaluation. The original sources of all data used by the OESG will be duly acknowledged in the OESG outputs. Lessons learned from data ownership and data use licensing will be summarised in the OESG final report to inform future effectiveness evaluation cycles.

As part of the quality check, the collected data will first be evaluated for completeness, followed by a quality control process that will include an assessment of the reliability and relevance of the data. A set of data quality flagging criteria will be developed by the OESG once a preliminary analysis of the collected metadata has been performed. This will be done, for example, on the basis of the validation of sampling and analytical methods, the quality assurance and quality control (QA/QC) measures that were applied, the generalizability or representativeness of the data (e.g., whether samples were randomly selected or there is some bias; considerations of the sample size, etc), as well as taking into account the type of monitoring programme (e.g., long term or isolated study). Data quality flags will be added to help the OESG, during the analysis phase, to assign different weights to the different datasets depending on the purpose of the analysis or questions being addressed.

The OESG will prioritize the use of data that have been subjected to QA/QC protocols. Only in the absence of such data (e.g., for specific areas where no other data is available), data without proper QA/QC, and flagged as such, may be included on a case-by-case basis in a preliminary analysis of mercury levels and in the identification of gaps.

To enable analyses of the data, the OESG members and experts in the roster will be able to access the compiled datasets remotely. A range of possible options for data storage were considered during the development of the present plan. For the first effectiveness evaluation, a simple data management system will be implemented (e.g., with manual input of data and without machine-to-machine data transfer protocols between repositories). With an eye to improving the data management infrastructure for future effectiveness evaluations, the OESG will continue to explore best practices for data providers to make their data accessible electronically for analysis, to facilitate submission of data to regional or global repositories that can make the data available electronically, and to facilitate the implementation of common machine-to-machine data transfer protocols between existing national, regional, or global data repositories. Lessons learned from these efforts will be included in the final OESG report.

Considerations on the contributions of Indigenous Peoples to global efforts to monitor mercury are contained in annex 3, including examples of best practices and identified Knowledge and capacity gaps.

Acknowledgements

This document would not have been possible without the commitment and contribution of the OESG members and the experts in the roster, particularly the Leads and participants of the “small groups” on air, biota, humans and other matrices, who have volunteered much of their time to drafting and reviewing this plan. The lists of OESG members and roster of experts who are supporting the OESG are available through the Convention’s website.

The OESG co-Chairs shared a vision and provided guidance on how to translate decision MC-4/11 and the OESG terms of reference into action. Support to the OESG and its co-Chairs was provided by Secretariat.

Parties and organizations who have nominated and allowed experts to participate in this process have also played an important supportive role by enabling their nominees to dedicate time to tasks that often go beyond their duty of service. Parties are also acknowledged for having allocated sufficient funds to enable the OESG to meet face-to-face during the intersessional period with participation of OESG members from all regions.

List of Abbreviations

COP	Conference of the Parties
CSV	Comma-separated values
DOI	Digital Object Identifier
EEG	Effectiveness Evaluation Group
FAIR	Findable, accessible, interoperable, reusable
OESG	Open-Ended Scientific Group
QA	Quality assurance
QC	Quality control

1. Objective

The purpose of the "plan for monitoring data compilation and summary" (hereafter "monitoring data plan") is to structure and guide the process for the submission, collection, quality control check, management, and accessibility of existing data on mercury levels in humans and the environment to inform the first effectiveness evaluation of the Minamata Convention.[3]

The monitoring data plan includes considerations on:

(a) How existing mercury and ancillary observations and associated metadata will be sought and collected from Parties and other relevant stakeholders

(b) How data will be submitted, flagged, stored, and made available to the Open-Ended Scientific Group (OESG) for further analysis

(c) Roles and responsibilities of different players to execute specific tasks

(d) Schedule for the identified tasks

The monitoring data that is compiled through the process set out in this plan will subsequently be compared and analysed by the OESG for consideration of the Effectiveness Evaluation Group (EEG). The "Plan for Monitoring Data Compilation and Summary" will not elaborate on how the monitoring data will be analyzed because, as per decision MC-4/11, this will be addressed in a separate plan ("Plan for Data Analysis") to be drafted by the OESG . Please refer to the paragraph 4 of the OESG terms of reference.

The monitoring data plan may need to be reviewed and adapted as progress is made and experience is gained through the collection of monitoring data and planning for data analysis, as well as to account for feedback provided by the EEG.

2. Background

2.1 Framework for the first effectiveness evaluation of the Minamata Convention

Article 22 of the Minamata Convention states that the Conference of the Parties (COP) will evaluate the effectiveness of the Convention, beginning no later than six years after the Convention's entry into force and periodically thereafter at intervals to be decided by the COP.[4] The effectiveness evaluation is to be conducted on the basis of, among other things, available information on the presence and movement of mercury and mercury compounds in the environment, as well as trends in levels of mercury and mercury compounds observed in biotic media and vulnerable populations.

The need for an effectiveness evaluation framework that included a strategic, cost-effective approach to provide appropriate and sufficient data was recognized by the COP at its first meeting and further discussed at its second meeting. At its third meeting, the COP considered the report of the ad hoc technical expert group for effectiveness evaluation, which included a description of a proposed effectiveness evaluation framework, as well as the following policy questions aimed at supporting an assessment of whether the control measures, as implemented, would lead to the achievement of the Convention's objective:

(a) Have the Parties taken actions to implement the Minamata Convention?

(b) Have the actions taken resulted in changes in mercury supply, use, emissions and releases into the environment?

(c) Have those changes resulted in changes in levels of mercury in the environment, biotic media and vulnerable populations that can be attributed to the Minamata Convention?

(d) To what extent are existing measures under the Minamata Convention meeting the objective of protecting human health and the environment from mercury?

[3] In the context of this document, "monitoring data" includes: (a) mercury observations which have associated parameters including units, time, location, etc.; (b) ancillary observations, which are observations of environmental parameters other than mercury that are needed to interpret the mercury observations, and (c) metadata, which includes information that describes the observational datasets, include such things as the data provider, data formats, number of sites, frequency of observations, time period covered, operating procedures and quality assurance methods employed, etc.

[4] The Minamata Convention entered into force on 16 August 2017.

(e) The report of the ad hoc technical expert group also contained technical information on monitoring and a proposal on monitoring arrangements pursuant to article 22; proposed reports to be used to formulate findings/recommendations for the consideration of the COP; and a set of indicators developed based on an article-by-article review for assessing progress and impact of the measures. In decision MC-3/10, the COP continued the preparation for the first effectiveness evaluation by requesting the drafting of guidance on monitoring and a report on trade, supply and demand of mercury and mercury compounds and by inviting further discussion of effectiveness indicators.

At its fourth meeting, in decision MC-4/11, the COP agreed to begin the first effectiveness evaluation of the Convention. In the same decision, the COP adopted a framework for the first effectiveness evaluation, as reproduced in Figure 1, and established the OESG. In accordance with its terms of reference outlined in annex II to the decision, the OESG shall work in two stages to develop a scientific report for consideration by the EEG. The OESG report shall be composed of the following elements:

Stage 1:

(i) Plan for the Monitoring Data Compilation and Summary *(this document)*

(ii) Plan for the summary of available emissions and releases data

(iii) Plan for Data Analysis consistent with the Monitoring Guidance[5]

Stage 2:

(i) Monitoring Data Compilation and Summary

(ii) Emissions and Releases Data Summary

(iii) Data Analysis addressing the guiding questions outlined in the Monitoring Guidance

Furthermore, the OESG shall provide an analysis of data gaps, including the identification of existing gaps as well as potential scientific actions to address identified gaps in information and knowledge related to monitoring, and lessons learned to be submitted to the Effectiveness Evaluation Group.

The process laid out in the OESG terms of reference also foresees support by the Secretariat, contribution of a roster of scientific and technical experts, input from different stakeholder groups, various rounds of review by Parties, and face-to-face meetings of the OESG, including one meeting during the current intersessional period.

To achieve its expected outputs, the OESG will assess the data and coordinate the analysis to be included in the scientific report, taking into consideration the monitoring guidance and its guiding questions,[6] as well as differences in scientific capacities, national circumstances, environmental conditions and demographic characteristics across parties and regions. The expected outputs of the OESG and the framework for the first effectiveness evaluation of the Convention, as adopted in decision MC-4/11, are shown in Figure 1 below. The first effectiveness evaluation will also be informed by other sources of information, including a set of indicators, a synthesis of national reports submitted under article 21, and a report on trade, supply and demand of mercury and mercury compounds.

Based on the framework for the effectiveness evaluation that was adopted in decision MC-4/11 (Figure 1), the OESG has been working under the assumption that the first effectiveness evaluation would be completed by the sixth meeting of the COP, which is expected in 2025.[7]

In accordance with the adopted framework, the OESG's scientific report must be completed in time for consideration by the EEG, whose terms of reference are expected to be agreed upon at COP-5 in 2023. Thus, the majority of the OESG's work (including data collection, analysis, report writing, as well as the associated opportunities for review by Parties) must be completed in 2023 and 2024. A draft schedule for the process is shown in Figure 2. It must be emphasized that in order to achieve its expected outcomes under the assumption that the first effectiveness evaluation will end at COP-6, the draft schedule as shown below is very ambitious, particularly because a significant amount of time will be needed for collecting existing monitoring data from multiple data providers, which will require

[5] The "Monitoring Guidance" referenced in decision MC-4/11 is the "Guidance on monitoring of mercury and mercury compounds to support evaluation of the effectiveness of the Minamata Convention" available as document UNEP/MC/COP.4/18/Add.2.

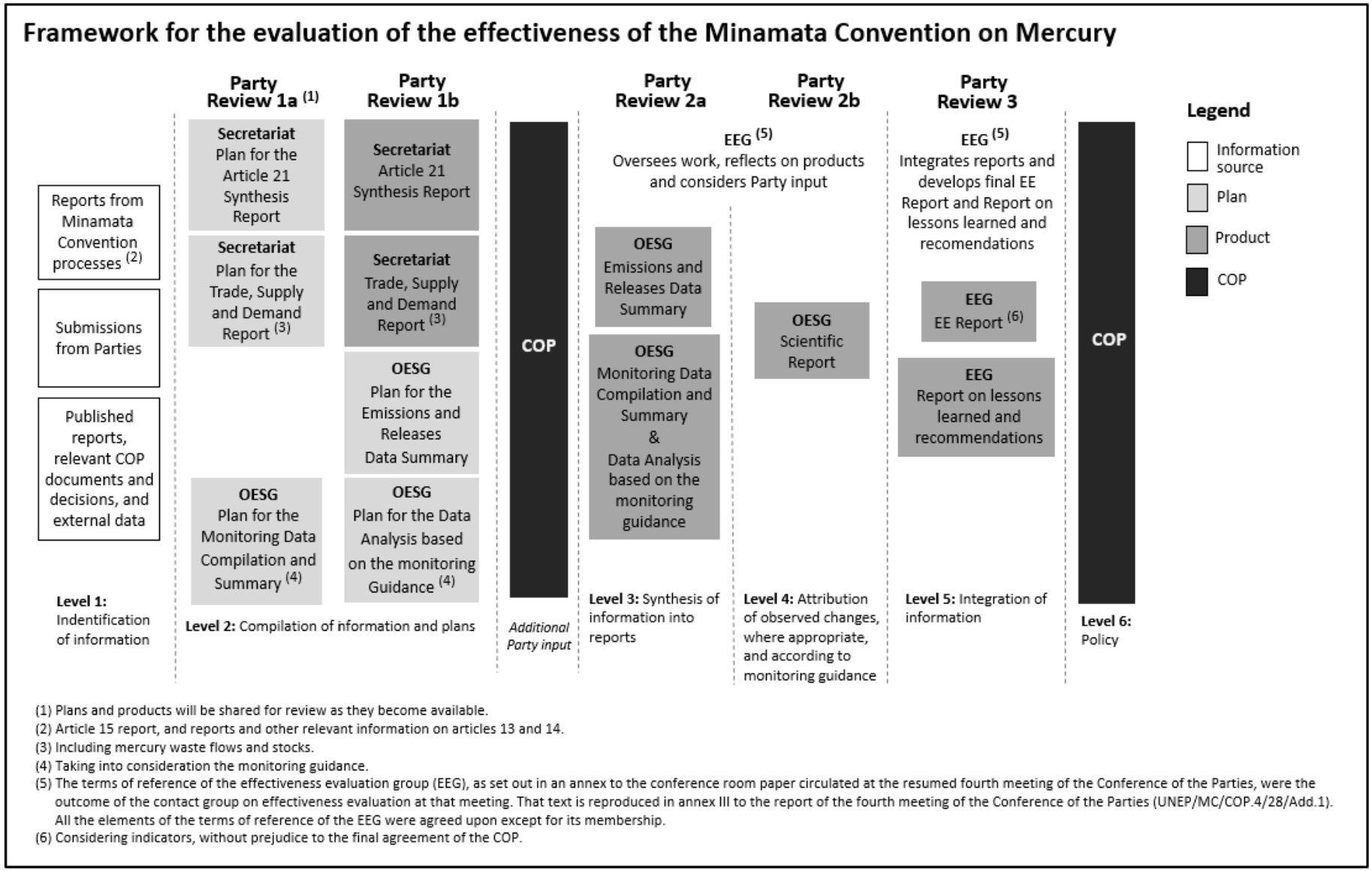
[6] As set out in documents UNEP/MC/COP.4/18/Add.2 and UNEP/MC/COP.4/INF/12.

[7] Pending further consideration by the COP, at its fifth meeting, of the timeline for the first effectiveness evaluation.

entering data use agreements with each data provider, before data analysis can begin. With the current draft schedule, it is possible that only part of the available monitoring data will have been collected and harmonized in time to be analysed by the OESG.

Figure 1

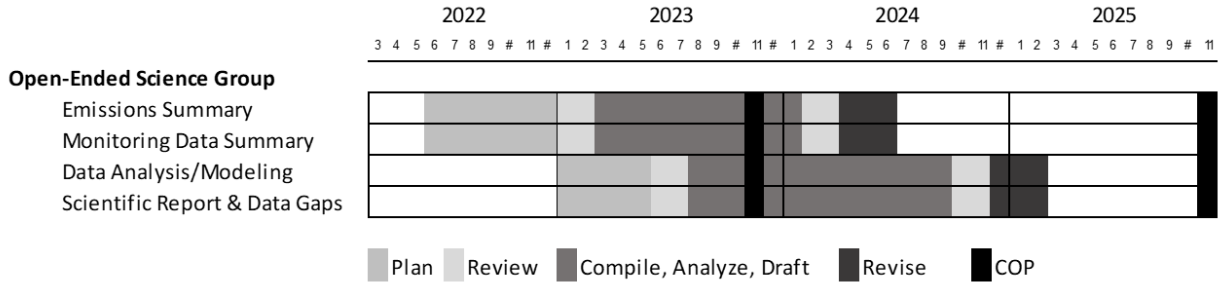
Annex I to decision MC-4/11 on the framework for the effectiveness evaluation.



(1) Plans and products will be shared for review as they become available.
(2) Article 15 report, and reports and other relevant information on articles 13 and 14.
(3) Including mercury waste flows and stocks.
(4) Taking into consideration the monitoring guidance.
(5) The terms of reference of the effectiveness evaluation group (EEG), as set out in an annex to the conference room paper circulated at the resumed fourth meeting of the Conference of the Parties, were the outcome of the contact group on effectiveness evaluation at that meeting. That text is reproduced in annex III to the report of the fourth meeting of the Conference of the Parties (UNEP/MC/COP.4/28/Add.1). All the elements of the terms of reference of the EEG were agreed upon except for its membership.
(6) Considering indicators, without prejudice to the final agreement of the COP.

Moreover, the time available to gather and analyse the available scientific information is very limited, especially given that: this is the first effectiveness evaluation for the Convention; the necessary data management infrastructure does not yet exist; there are limited financial resources available from the Convention to fund the work; and multiple opportunities for review by Parties have been built into the process to improve transparency, credibility and ownership. Therefore, the approach proposed by the OESG is to provide the EEG, and subsequently the COP, the best information possible within the limited time and resources available and to outline how the scientific basis of effectiveness evaluation could be improved in future evaluation cycles.

Figure 2
A draft schedule for completion of OESG tasks by COP-6.



2.2 Key points from the Monitoring Guidance and its Supplementary Material

In decision MC-3/10, on the arrangements for the first effectiveness evaluation, the COP requested the Secretariat to advance the work on the effectiveness evaluation by securing services for drafting guidance on monitoring to maintain harmonized, comparable information on mercury levels in the environment. In response to the request and working with the consultants and supported by the experts identified by Parties and organizations, the Secretariat launched a process for the development of draft guidance which comprised reviews by Parties and other stakeholders. The resulting "Guidance on monitoring of mercury and mercury compounds to support evaluation of the effectiveness of the Minamata Convention" (hereafter "Monitoring Guidance") and its "Supplementary material – Guidance on monitoring of mercury and mercury compounds to support evaluation of the effectiveness of the Minamata Convention" (hereafter "Supplementary Material") were developed and submitted to the fourth meeting of the COP.

The Monitoring Guidance describes the scientific and technical processes and guiding principles for compiling and/or generating comparable monitoring data with a focus on atmospheric air, humans and biota. It also suggests methods that can be used for understanding the presence, trends, and sources of mercury in the environment and humans based on monitoring data, to inform the effectiveness evaluation. Throughout the guidance, monitoring activities have been grouped to achieve six objectives with associated guiding questions, which were developed based on the four policy questions (see above), to support the collection and analysis of the relevant monitoring data and to inform the effectiveness evaluation in complementary ways. The six monitoring objectives and associated guiding questions are reproduced below in Annex 1.

The Monitoring Guidance also describes a tiered approach for monitoring the three matrices (air, biota and humans), where each tier builds upon the former tier to provide a better overall weight of evidence. Overall, the tiered approach is as follows:

Tier 1 is intended to provide guidance on baseline mercury monitoring under a limited set of parameters for circumstances where available resources are limited. The methods in tier 1 are cost-effective, practical, feasible and sustainable. The tier 1 methods are intended to provide information that is useful in identifying and characterizing gaps and needs of national, regional or local interest and to provide information that is useful to the collective effort for the effectiveness evaluation. While the implementation of tier 1 actions may not fully address all of the monitoring objectives, it will contribute valuable information and create a foundation for tier 2 monitoring.

Tier 2 is intended to build upon tier 1 methods and create a basis for assessing source attribution at the local, national and global scales. The methods and approaches in this tier may be more expensive or complex than those under tier 1. The more tier 2 approaches are implemented, the better the weight of evidence for the effectiveness evaluation will be.

Tier 3 identifies research methods and approaches that may play a vital role in supporting the tier 1 and tier 2 programmes and the effectiveness evaluation, primarily by improving understanding of key

processes that link sources to environmental concentrations and exposures (see monitoring objective 6). Tier 3 focuses on processes; thus, the results would likely yield insights that are broadly applicable and strengthen the weight of scientific evidence used to support the other monitoring objectives. Tier 3 information should therefore be taken into consideration in the effectiveness evaluation where available.

The Monitoring Guidance notes that, to the extent possible and in accordance with requirements of individual data providers, data used in the effectiveness evaluation should follow the FAIR principles (findable, accessible, interoperable and reusable) for data management and stewardship.[12] Elements of the FAIR principles that are applicable to the effectiveness evaluation are shown below (box 1). The Monitoring Guidance also discusses ethical considerations for the use of data, including the need to follow guidance provided by Indigenous Peoples with regards to self-determination of research, research ethics, data considerations, utilization of Indigenous Knowledge, and communication of results as guided by principles such as the "CARE Principles for Indigenous Data Governance".[1]

Box 1. *Elements of the FAIR principles for data management and stewardship in the context of the effectiveness evaluation*

Findable:
- A searchable and interoperable database acting as a repository of available data;
- Unique identification systems (e.g., "Digital Object Identifiers" or "DOIs") and controlled vocabulary to facilitate searching and retrieval of information;
- Detailed metadata associated with each data record to facilitate the submission, searching,
- location and retrieval of information;

Accessible:
- Free and open access to the data to Governments, Indigenous Peoples, and relevant stakeholders, taking into account the relevant ethical considerations;

Interoperable:
- An interoperability mechanism to facilitate the exchange of information across different programmes and databases;

Reusable:
- Data usage license/agreement identifying the terms and conditions for further use of the data;
- Metadata including enough information describing how the data were collected/produced to enable an assessment of the quality and comparability of the data, reproducibility and further analyses.

The Monitoring Guidance also notes that different types of observations and sources of data may be most appropriate for addressing different questions during the effectiveness evaluation. National and multi-country monitoring programmes, including, but not limited to, those identified in the Supplementary Material, as well as programmes and projects overseen by international organizations, may be prioritized as the preferred sources of monitoring data. In the absence of those, additional sources of data may also provide valuable information to the effectiveness evaluation. Below, Chapter 3 of the current document extends the list of potential sources of data for each of the key media.

To help structure the process to compile and analyse mercury monitoring data, the Monitoring Guidance lists mercury and ancillary observations for air, biota and humans across the three tiers (see page 94 of the Monitoring Guidance). It also proposes a preliminary format for the submission of monitoring data based on the minimum mercury and ancillary observations and metadata that would need to accompany each dataset that is submitted to support the work of the OESG (see annex 2 of the Supplementary Material). Moreover, lists of data quality control measures that will help to assess the usefulness and validity of different monitoring data sets and maximize scientific weight of evidence to support the effectiveness evaluation are also included in the Monitoring Guidance and its Supplementary Material. Chapter 4 of the current document builds upon this information to provide a data dictionary for the mercury and ancillary observations and metadata. Chapter 5 explains how data will be collected, checked for quality and stored.

3. Planning for the compilation of monitoring data

3.1 Sources of data

The work of the OESG to inform the first effectiveness evaluation will focus on existing sources of monitoring data. An analysis of gaps related to monitoring data, including potential scientific actions

[1] CARE Principles for Indigenous Data Governance: https://www.gida-global.org/care.

to address the identified gaps, will be included in the scientific report of the OESG and will not be part of the present plan for monitoring data.

Mercury observations in the different matrices, ancillary observations and metadata will be collected from a broad range of sources and the quality of the collected data will be assessed (more details below). Working in small groups focused on air, biota, humans, and "other matrices" (soil, water and sediment), the OESG and experts in the roster, have identified the main available sources of monitoring data for each matrix. The sources include monitoring programs, both ongoing and completed, as well as independent studies.

Spreadsheets were developed for the different matrices to provide an overview of the characteristics and type of information contained in each set of data. In addition to providing a snapshot of the type of mercury measurements in each dataset, the spreadsheets also include examples of metadata available, such as the type of data collected, geographic coverage, monitoring period, relevant publications, etc. Some of the categories of metadata included in the spreadsheets are common to all matrices while others are matrix specific.

Summaries of the available sources of data for each matrix are presented as addenda to this document, as follows: addendum 1 (air), 2 (biota), 3 (human biomonitoring) and 4 (soil, water and sediment).[2] Due to the size of the resulting spreadsheets for sources of mercury data in biota, human biomonitoring and other matrices, they are being made available online through the OESG document folder as separate supplemental materials in their original format.

The identified sources of monitoring data will serve as a starting point for the collection of data through an invitation to parties and other data providers to submit their datasets containing observational mercury data and metadata (see Chapter 5).

3.2 Data elements to be collected: the data dictionary

A data dictionary was developed to facilitate the work of the OESG in collecting, comparing and analysing mercury levels in air, humans, biota, and other matrices (soil, water and sediment).

Data dictionaries are used to catalogue and communicate the structure and content of data and provide descriptions for individual data elements. Shared dictionaries help to ensure that the meaning, relevance, and quality of data elements are the same for all users. Data dictionaries also provide information needed downstream to build systems and applications to support the comparison and analysis of monitoring data.[3]

The objective of the data dictionary, as contained in Annex 2 below, is to identify and structure the necessary mercury observations, ancillary observations, and descriptive elements, or metadata, to be submitted by those who wish to contribute to the first effectiveness evaluation of the Minamata Convention on Mercury. To support the OESG's analysis of comparable mercury monitoring data, a shared data dictionary will be necessary to facilitate standardization by documenting common data structures and providing the precise definitions, agreed nomenclature, units of measurement, time scales and formats, as well as further information and external references that are needed to compare and analyse mercury measurements.

Several types of data elements are included in the data dictionary: the mercury observations, ancillary observations of other relevant contaminants or environmental parameters, and descriptive data elements (or metadata) that are necessary for interpretation of the observations. The data elements contained in the data dictionary are grouped into nine sections, from A to I. Sections A-C, H and I contain categories of data elements that are common to all monitoring matrices, whereas sections D through G contain data elements that are specific for each matrix. The data elements are further grouped by categories and, where relevant, sub-categories.

The data dictionary provides a detailed overview of possible elements that may be useful in the analysis of data. It is recognized that many of the existing monitoring datasets do not necessarily include all the elements identified in the data dictionary and that, particularly during the first effectiveness evaluation cycle, data providers will not be able to provide all the data elements in the proposed data dictionary. Nevertheless, the data dictionary may be useful to guide the generation of

[2] For existing sources of mercury monitoring data in air, please refer to pages 4-12 of the Supplementary Material, contained in document UNEP/MC/COP.4/INF/25, which are being reproduced as addendum 1 to this document.

[3] From the US Geological Survey (USGS) website. For more background information on data dictionaries, see https://www.usgs.gov/data-management/data-dictionaries.

data in the future with the aim of having data that is more comparable and detailed for future effectiveness evaluation cycles.

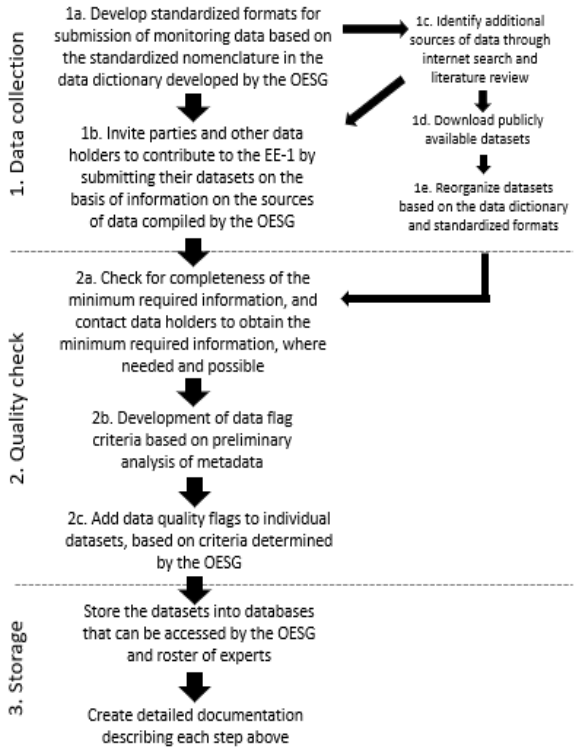
The data dictionary will be used to develop matrix-specific standardized formats to facilitate the submission and compilation of data in a harmonized manner. The standardized formats will identify the minimally essential data elements to be submitted.

To maximize the comparability of data while providing the flexibility during the submission of information, the use of controlled vocabulary (a standardized, pre-defined set of terms to describe the mercury and ancillary observations and metadata) will be favoured in the formats for data submission but free text fields will also be offered to describe data elements where the use of a controlled vocabulary is not possible or desirable.

3.3 Data collection, quality check and storage

Putting the monitoring data plan into practice will require action for data collection, quality control and storage as detailed below and shown in Figure 3. The aim here is to present the mercury monitoring data in as concise and clear way as possible to enable users to understand and interpret the data. Provision of concise relevant background information and explanations of submitted data helps to ensure that the mercury monitoring data is transparent.

Figure 3
Implementation of the monitoring data plan: overview of the steps for data collection, quality check and storage



(a) Data collection

Once the data dictionary has been finalized, standardised data formats for data collection will be developed for each matrix to facilitate data submissions and subsequent comparison and analyses. The standardized formats will be aligned, to the extent possible, with existing formats in use by established monitoring programmes to minimize the workload and to facilitate the use of existing data. A long-term vision of this plan is to cooperate with established monitoring programmes for the generation of data in formats that respond to the OESG needs. Matrix-specific standard formats will ensure that datasets, including those from different sources, will share a consistent structure, i.e., they will share the same sequence of data fields. It will also be possible to harmonize the units of measurement, time, and location to enable the comparison of multiple sets of data.

Parties and other data holders will be invited to submit monitoring data as "CSV" files using the standardised formats.[4] Datasets submitted in their native nomenclature and formats will also be accepted and will be included in the compilation following a reorganization of the data in accordance with the standardized formats. Submissions of monitoring datasets from all sources will be welcome during the data collection phase but, during the analysis phase, prioritization and/or weighting of data to support the effectiveness evaluation will likely be necessary (see further detail below).

In addition to inviting parties and other data holders to submit monitoring data, an active mining for relevant and publicly available data will also be necessary. This will be achieved through internet searches and literature review. The extent to which this approach will contribute to the overall data collection efforts will likely vary from matrix to matrix, and it will depend on the quality and coverage, both temporal and spatial, of data submitted upon invitation.

Both aggregated and raw data will be obtained from a variety of sources, including from data providers as well as from scientific publications. Where appropriate and available, aggregated data and published reviews that pass quality checks will be used to ensure effectiveness and reduce the workload of the OESG and to avoid duplicative work.

Data providers or copyright holders will retain the ownership and rights over their data, including mercury and ancillary observations and metadata. For datasets that are not publicly available or that have use restrictions, the Secretariat will establish data use agreements with the individual data providers, as appropriate, and guidance will be provided to the OESG members and the roster of experts to ensure that the data is used only for the purpose of supporting the effectiveness evaluation and that it is not shared outside the OESG members and experts in the roster. The original sources of all data used by the OESG will be duly acknowledged in the OESG outputs. Lessons learned from data ownership and data use licensing will be summarised in the OESG final report to inform future effectiveness evaluation cycles.

(b) Quality check

As part of the quality check, the collected data will first be evaluated for completeness, followed by a quality control process that will include an assessment of the reliability and relevance of the data.

The first task to check the quality of the data is to ensure that each dataset contains the minimally required data elements in accordance with the data dictionary. If any data elements are missing, the data providers will be contacted and invited to supply the missing information. As noted above, minimally essential data elements will be indicated in the data formats but flexibility will be applied when the submitted datasets do not meet the minimally required data elements, especially for areas where mercury observations and metadata are scarce.

A set of data quality flagging criteria will be developed by the OESG once a preliminary analysis of the collected metadata has been performed. This will be done, for example, on the basis of the validation of sampling and analytical methods; the quality assurance and quality control (QA/QC) measures that were applied; and the generalizability or representativeness of the data (e.g., whether samples were randomly selected or there is some bias; considerations of the sample size, etc). Data quality flags will be added to help the OESG, during the analysis phase, to assign different weights to the different datasets depending on the purpose of the analysis or questions being addressed.

The OESG will prioritize the use of data that have been subjected to QA/QC protocols. Only in the absence of such data (e.g., for specific areas where no other data is available), data without proper QA/QC, and flagged as such, may be included on a case-by-case in a preliminary analysis of mercury levels[5] and in the identification of gaps. How data will be prioritized or weighted in specific analyses as a result of the data quality flags will be discussed during the analysis phase and included in the "plan for data analysis" and are not the focus of the present document.

[4] "Comma-separated values" or "CSV" is a common data exchange format that is widely supported by databases and spreadsheets. As such, CSV files can also be used to transfer data across different data management platforms.

[5] One member of the roster of experts supporting the OESG suggested to utilize monitoring data with insufficient QA/QC only for the purpose of identifying gaps rather than including such data sets in the actual analysis to support the OESG.

(c) Data storage

The compiled datasets will be stored in a manner that will support access to the data by the OESG and experts in the roster via the internet so that it can be analysed. A range of possible options for data storage were considered during the development of the present plan.

At the conclusion of the tasks covered by this plan, the compiled data for each matrix, along with the original submissions from data providers, will be stored in databases (for example, MySQL) that will be accessible to the OESG and experts in the roster.

For the first effectiveness evaluation, a simple data management system will be implemented (e.g., with manual input of data and without machine-to-machine data transfer protocols between repositories). Based on the experience gained in the first effectiveness evaluation, a more elaborated data management infrastructure may be considered for future effectiveness evaluation cycles at a frequency to be decided by the Conference of the Parties.

How the compiled databases will be used to address specific questions to inform the effectiveness evaluation, including considerations for the development of tools that will enable the newly compiled data to be searched, analysed, modelled and visualised will be included in the forthcoming plan for data analysis and is not the focus of the present document.

With an eye to improving the data management infrastructure for future effectiveness evaluations, the OESG will continue to explore best practices for data providers to make their data accessible electronically for analysis, to facilitate submission of data to regional or global repositories that can make the data available electronically, and to facilitate the implementation of common machine-to-machine data transfer protocols between existing national, regional, or global data repositories. Lessons learned from these efforts will be included in the final OESG report.

(d) Roles and responsibilities

The OESG, with input from the roster of experts, will provide overall guidance and have oversight of all steps involved in the different phases – data collection, quality check and storage – which are needed to implement the monitoring data plan. In addition, the OESG will be directly responsible for developing criteria for data quality flagging (step 2b).

To help the implementation of this plan, the Secretariat will engage and supervise one or more data management consultants. The data management consultant(s) will be responsible for the day-to-day tasks to collect, organize and store data in accordance with the guidance provided by the OESG. The specific tasks of the data management consultants will include: assisting the OESG in developing standardized formats for data collection (step 1a); assisting the Secretariat in inviting Parties and data holders to submit data (step 1b); searching for additional sources of data; downloading publicly available datasets and reorganising them as per the standardized formats (steps 1c-e); ensuring that each dataset contains the minimum required data elements (step 2a); summarizing collected metadata to inform the development of data quality flags (step 2b); adding data quality flags based on criteria developed by the OESG (step 2c); storing the datasets so that they are accessible to the OESG (step 3a); and documenting all steps to enable traceability during further data handling and analysis (step 3b). The cost of consultancy services will be borne by the Convention’s budget.

Furthermore, to maximize the current and future efforts to compile and analyse monitoring data, considerations on the contributions of Indigenous Peoples to global efforts to monitor mercury are contained in annex 3, including examples of best practices and identified Knowledge and capacity gaps.

4. Implementation of the Plan for Monitoring Data Compilation and Summary

The main milestones for the implementation of the plan monitoring data compilation and summary are summarized below with associated tentative timelines.

Milestones	*Tentative timeline*
Review by Parties of the draft plan for monitoring data compilation and summary	3 February – 1 March 2023
Revision of the monitoring data plan, including the data dictionary, following the face-to-face meeting of the OESG, 27-31 March 2023	April 2023
Development/Selection of matrix-specific common formats for the submission and compilation of monitoring data	May-October 2023
Invitation to Parties and other data providers to express their intent to submit data to support the first effectiveness evaluation	September 2023
Invitation to Parties and other data providers to submit data to support the first effectiveness evaluation	October 2023
Deadline for submission by Parties and other data providers to submit data to support the first effectiveness evaluation	January 2024
Progress report on the status the data submitted to support the first effectiveness evaluation	March 2024
Party review of draft report on compilation of monitoring data and summary	April 2024
Submission of the report on monitoring data compilation and summary to the Effectiveness Evaluation Group (EEG)	TBD (pending decision at COP-5)

Annex 1

Monitoring objectives and associated guiding questions[1]

Monitoring objectives and associated guiding questions
1. Estimation of mercury concentrations for areas without (i.e., background sites) or with (i.e., affected sites) local anthropogenic sources
1.1 What are the levels and form of mercury found in sites that are considered to be remote from anthropogenic sources?
1.2 What are the levels and form of mercury found in sites that are expected to be affected by local anthropogenic point sources?
2. Identification of temporal trends
2.1. Do the levels and form of mercury in the observed matrix (air, biota, human) at a given location change over time – for example, in the short term (< 5 years), medium term (5 to 20 years) and long term (> 20 years)? Is there a long-term trend or trajectory (a signal) that can be separated from the temporal variability (noise)?
2.2. How do observed temporal variations and trends differ spatially, and how do they differ among matrices?
2.3. How do observed temporal variations and trends in mercury compare to, or co-vary with, variations and trends of mercury in different forms (chemical species) or within other matrices?
2.4. How do observed temporal variations and trends in mercury compare to, or co-vary with, variations and trends of mercury emissions and releases?
2.5. How do observed temporal variations and trends in mercury compare to, or co-vary with, variations and trends of related pollutants/emissions or environmental variables?
3. Characterization of spatial patterns
3.1. What are the levels and form of mercury in the observed matrix (air, biota, human) at a given location and time?
3.2. Taken together, what does the available data suggest about spatial variability in environmental mercury concentrations?
3.3. Taken together, what does the available data suggest about Variability in mercury concentrations within and among human populations, wildlife populations and their habitats, and ecosystems?
3.4. Do the observed spatial variations and patterns differ among forms (chemical species) of mercury?
3.5. Do the observed spatial variations and patterns differ among air, biota and human matrices?
3.6. How do the observed spatial variations and patterns or gradients compare to those of mercury emissions and releases?
3.7. How do the observed spatial variations and patterns or gradients compare to those of related pollutants/emissions or environmental variables?

[1] As per table 2.1 of the Monitoring Guidance (document UNEP/MC/COP.4/18/Add.2).

4. Estimation of source attribution of anthropogenic mercury

4.1. Using models and statistical analyses consistent with observational data, how can the observed levels, spatial patterns, temporal trends and adverse impacts on species, ecosystem services, biodiversity and human populations be attributed to changes in anthropogenic, natural and legacy mercury?

4.2. Using models and statistical analyses consistent with observational data, how can the observed levels, spatial patterns, temporal trends and adverse impacts on species, ecosystem services, biodiversity and human populations be attributed to changes in anthropogenic sources (local, regional, global) of mercury?

4.3. Using models and statistical analyses consistent with observational data, how can the observed levels, spatial patterns, temporal trends and adverse impacts on species, ecosystem services, biodiversity and human populations be attributed to changes influenced by the Convention?

4.4. Using models and statistical analyses consistent with observational data, how can the observed levels, spatial patterns, temporal trends and adverse impacts on species, ecosystem services, biodiversity and human populations be attributed to changes not influenced by the Convention?

5. Estimation of exposure and adverse impacts

5.1. How do the observed levels of mercury in air, biota and humans compare to established national and international benchmark levels associated with adverse effects on human health, wildlife and environmental sustainability?

5.2. How significant are the observed changes in exposures for different types of impacts on humans and wildlife in regions that are remote from sources, as well as those that are locally impacted by anthropogenic sources?

5.3. Are observed changes in exposure attributable to mitigation measures or changes influenced by the Convention?

6. Quantification of key environmental processes to improve understanding of cause-effect relationships

6.1. How ancillary measurements contribute to establishing the level, spatial pattern or temporal trends of mercury and improve understanding about the relative importance of environmental processes and parameters driving transport and fate?

6.2. How consistent are the observed levels, temporal trends and spatial patterns with the modelled estimates and what lessons can be learned from them to improve the existing models?

Annex 2

Data dictionary to facilitate the submission and analysis of mercury monitoring observations and metadata[1]

This document presents a data dictionary that defines common data structures and provides the precise vocabulary needed to facilitate the work of the Open-Ended Scientific Group in collecting, comparing and analysing mercury levels in air, humans, biota, and other matrices (soil, water and sediment).

As shown below, the data dictionary contains information that will be applicable for the collection of datasets containing individual observations as well as aggregated data. For example, for many of the information categories, allowing the selection of multiple options for descriptive terms will be necessary for describing aggregated data but will not be applicable for an individual observation. The standardized formats, which will be developed for each matrix on the basis of formats already in use by established monitoring programs and nomenclature shown in the data dictionary, will be adjusted to accommodate both sets of individual observations as well as aggregated datasets.

Three types of data elements are defined: mercury observations, ancillary observations that are necessary to interpret the mercury observations, and descriptive data elements (or metadata) that are useful for evaluating and managing the data. The data elements contained in this document are grouped into seven sections, from A to G. Sections A, B, G and H contain categories of data elements that are common to all monitoring matrices, whereas sections C through F contain data elements that are specific for each matrix. The data elements are further grouped by categories and, where relevant, sub-categories. For each data element a set of possible options, using controlled vocabulary, or free text entries are offered. For each data element, one or multiple options may be relevant.

Different types of metadata may be relevant, including quantitative information that may be provided using the "number fields" or qualitative and semi-quantitative information that may be added in the "text fields". Quantitative fields, where a value is indicated, will be accompanied by a field where the unit is indicated.

While the data dictionary lists many descriptors that could be used to describe the datasets, these are all possible selections which may or may not apply to specific datasets. The minimum required data elements are identified by an asterisk (*).

CATEGORY	SUB-CATEGORY	OPTIONS / FORMAT
A. SUBMISSION OR ACCESS DETAILS *(ALL MATRICES)*		
A.1. Date of submission or access:*		<Text entry>
A.2. Contact details of the person submitting or accessing the data :*	Name:*	<Text entry>
	Affiliation:*	<Text entry>
	Address:*	<Text entry>
	Email:*	<email field>
	Country:*	<list of countries>
A.3. Contact details of the data owner or originator :*	Name:	<Text entry>
	Affiliation:	<Text entry>
	Address:	<Text entry>
	Email:	<email field>
	Country:	<list of countries>
A.4. Data use restrictions:	Data is publicly available:	□ Yes □ No If yes, please indicate where: <Text entry>
	Data subject to a specific use license:	□ Yes □ No If yes, please explain conditions for allowable use: <Text entry>

[1] An earlier version of this form was published as annex 2 to document UNEP/MC/COP.4/INF/25. The current draft builds on the original form and incorporates input from the OESG and experts in the roster.

CATEGORY	SUB-CATEGORY	OPTIONS / FORMAT
B. AIM AND SCOPE OF THE STUDY (ALL MATRICES)		
B.1. Aim of the study:*		□ Identification of temporal trends □ Characterization of spatial patterns □ Estimation of source attribution □ Exposure assessment □ Impact / Health assessment □ Quantification of particular environmental processes □ Other, please specify: <Text entry>
B.2. Brief description of the study:*		<Text entry – max. 150 words >
B.3. Geographic scope:		□ Sub-national □ National □ Multi-Country Details on the geographic scope: <Text entry>
B.4. Type of organization carrying out the study:		□ Government agencies □ Universities or research institutions □ Non-governmental organizations □ Other, please specify: <Text entry>
C. SITE CHARACTERISTICS *(ALL MATRICES)*		
C.1. Characteristics of the monitoring site(s):	Human settlements:	□ Remote or unpopulated areas □ Low population density areas (<500 persons per square Km) □ Medium population density areas (500-1000 persons per square Km) □ High population density areas (>1,000 persons per square Km)
	Geographic coordinates:*[2]	Latitude: <Number entry> Longitude: <Number entry> Unit: □ decimal degrees *OR* □ degrees / minutes / seconds
	Elevation of site:	<Number entry> Unit: □ Metres *OR* □ Feet
	Proximity to point sources:	Distance: <Number entry> Unit: □ Metres *OR* □ Kilometres
		□ ASGM site □ Large-scale gold mining site □ Mercury mine □ Chlor-alkali plant □ Coal-fired power plant □ Hydroelectric power plant □ Non-ferrous metal processing/smelting facilities □ Oil and natural gas processing facilities □ Cement clinker production facilities □ Vinyl chloride monomer (VCM) production □ Acetaldehyde production □ Manufacturing of mercury containing products/devices □ Waste disposal, recycling or incineration facilities □ Forestry site

[2] It may be necessary to reduce the accuracy of geographic coordinates to protect privacy (e.g., when the samples were collected in private properties) while still allowing the data to carry spatial information that is relevant for the work of the OESG.

CATEGORY	SUB-CATEGORY	OPTIONS / FORMAT
		□ No local sources identified (i.e., long-range mercury transport) □ Other, please specify: <Text entry>
	Type of ecosystem(s):	Terrestrial ecosystems: □ Agricultural area □ Forest □ Inland wetland □ Savanna □ Steppe □ Desert Freshwater ecosystems: □ River □ Lake Marine and coastal ecosystems: □ Estuary □ Coastal area □ Open ocean □ Other, please specify: <Text entry>
	Details on the monitoring site(s): <Text entry>	
C.2. Co-location of other monitoring activities:		□ Co-located with other Hg monitoring networks or other relevant measurement activities (e.g., monitoring in other matrices) – please explain: <Text entry> □ Not applicable
C.3. Monitoring frequency:		□ Single time point □ Continuous □ Daily □ Weekly □ Monthly □ Yearly □ Seasonal, please specify: <Text entry> □ Other, please specify: <Text entry>
C.4. Monitoring period:*		From: <Date> To: <Date>
C.5. Ongoing monitoring:		□ Yes □ No
C.6. Monitoring matrix:*		□ Air **» Section D** □ Biota (animals and plants) **» Section E** □ Human biomonitoring **» Section F** □ Other matrices **» Section G**
D. AIR		
D.1. Sampling method:*		□ Continuous analysers □ Manual trap methods □ Passive samplers □ Wet deposition samplers □ Dry deposition samplers □ Bulk deposition samplers □ Litterfall □ Other, please specify: <Text entry>
D.2. Height of sample collection from ground:		<Number entry> Unit: □ Metres *OR* □ Feet
D.3. Sample collection date:*		□ Single date: <YYYY-MM-DD> *OR* □ Period: From <YYYY-MM-DD> To <YYYY-MM-DD
		Frequency: □ Automated measurements (in minutes): <Number entry>

CATEGORY	SUB-CATEGORY	OPTIONS / FORMAT
		□ Manual measurements (in hours): <Number entry>
D.4. Mercury observations:*	Mercury species:*	□ Gaseous Elemental Mercury (Hg^0, GEM) □ Gaseous Oxidized Mercury (Hg^{II}, GOM) □ Total Gaseous Mercury (TGM = GEM + GOM) □ PM10 □ PM2.5 □ Total mercury in precipitation □ Methyl mercury in precipitation □ Total mercury in litterfall □ Methyl mercury in litterfall □ Mercury isotopes□ Other, please specify: <Text entry>
	Unit of concentration measurement:*	□ ng/m3 □ pg/m3 □ Other, please specify: <Text entry>
	Unit of deposition measurement:	□ ng/m2*week □ µg/m2*week □ ng/m2*year □ µg/m2*year □ ng/ha*year □ µg/ha*year □ Other, please specify: <Text entry>
	Measurement values:*	□ Attach file in CSV format: <File name> *OR* □ Provide URL: <Text entry>
	Have the observations been aggregated?*	□ Yes □ No If yes, please explain the data aggregation process: <Text entry>
D.5. Ancillary observations:	Precipitation & meteorological data (value and unit):	□ Air Temperature □ % relative humidity □ Wind speed □ Wind direction □ Pressure □ Other, please specify: <Text entry>
	Emission inventories:	<Text entry>
	Air quality tracers (value and unit):	□ SO_2 □ CO_2 □ CO □ O_3 □ PM10 □ PM2.5 □ Sea salt sulphate (SSF) □ Non-sea salt sulphate (NSSF) □ Radon □ Other, please specify: <Text entry>
	Land cover:	<Text entry>
	Land use:	<Text entry>
	Leaf area index:	<Text entry>
	Other:	Please specify: <Text entry>
	Measurement values:*	□ Attach file in CSV format: <File name> *OR* Provide URL: <Text entry>

CATEGORY	SUB-CATEGORY	OPTIONS / FORMAT
D.6. Additional information regarding sampling, mercury measurement or ancillary information:		<Text entry>
E. BIOTA		
E.1. Type:*		Aquatic: □ Invertebrates □ Fish □ Reptiles □ Birds □ Mammals (marine) □ Mammals (fresh water) □ Plants Terrestrial: □ Invertebrates □ Amphibian □ Reptiles □ Birds □ Mammals □ Plants □ Other, please specify: <Text entry>
E.2. Species name(s):		<Text entry>
E.3. Brief description of the study population in terms of mercury exposure:		<Text entry – max. 150 words >
E.4. Number of individuals sampled:		<Number entry> Further detail on sample size: <Text entry>
E.5. Sampling strategy:		□ Random □ Not random, please describe the level of representativeness: <Text entry> □ Other, please specify: <Text entry>
E.6. Characteristics of the samples:	Sample collection date:	□ Single date: <YYYY-MM-DD> *OR* □ Period: From <YYYY-MM-DD> To<YYYY-MM-DD>
	Type of sample:	□ Whole specimen □ Whole organ(s) □ Specific tissue(s), please specify: <Text entry>
	Sampled tissue(s):	□ Blood □ Kidney □ Liver □ Muscle □ Blubber □ Fur / Hair □ Feathers □ Eggs □ Brain □ Nails and others keratinoid tissues □ Leaves □ Shoots □ Roots □ Other, please specify: <Text entry>
	Sample digestion / extraction:	□ Direct analysis (no digestion) □ Aqua regia □ Nitric acid □ Hydrochloric acid □ Other, please specify: <Text entry>

CATEGORY	SUB-CATEGORY	OPTIONS / FORMAT
E.7. Mercury observations:*	Mercury species:*	□ Total mercury □ Inorganic mercury □ Methyl mercury □ Other, please specify: <Text entry>
	Unit of measurement:*	□ µg/g (or mg/kg) □ ng/g □ µg/L □ Other, please specify: <Text entry>
	Data reporting:*	□ Dry weight □ Wet weight
	Measurement values:*	□ Attach file in CSV format: <File name> *OR* Provide URL: <Text entry>
	Have the observations been aggregated?*	□ Yes □ No If yes, please explain the data aggregation process: <Text entry>
E.8. Ancillary observations:	Biota:	□ Species name(s) □ Weight □ Length □ Age □ Sex □ Maturity stage (e.g. juvenile, adult) □ Fatty acids □ Protein □ Selenium □ Other, please specify: <Text entry>
	Trophic level:	□ Primary Producers □ Primary consumers □ Primary carnivores □ Secondary carnivores □ Tertiary carnivores □ Other, please specify: <Text entry>
	Surrounding seawater, freshwater, soil and sediment:	□ Temperature (value/unit) □ Depth (value/unit) □ pH (value) □ Salinity (value/unit) □ Conductivity (value/unit) □ Dissolved oxygen (value/unit) □ Total organic carbon (value/unit) □ Dissolved organic carbon (value/unit) □ Particle size distribution (sand, clay, etc) □ Total oxidized nitrogen (value/unit) □ Sulfur (species/value/unit) □ Trace elements (species/value/unit) □ Organic pollutants (species/value/unit) □ Other, please specify: <Text entry>
	Inland areas:	□ Landscape/watershed characteristics (e.g., lake and catchment morphology) □ Local data on mercury deposition □ Local pollution history □ Other, please specify: <Text entry>
	Stable isotopes (value and unit):	□ Carbon ($\delta^{13}C$) □ Nitrogen ($\delta^{15}N$) □ Mercury ($\delta^{202}Hg$) □ Mercury ($\delta^{199}Hg$)

CATEGORY	SUB-CATEGORY	OPTIONS / FORMAT
		□ Sulfur ($\delta^{34}S$) □ Compound specific stable isotopes □ Other, please specify: <Text entry>
	Other:	□ Please specify: <Text entry>
	Measurement values:*	□ Attach file in CSV format: <File name> *OR* Provide URL: <Text entry>
E.9. Additional information regarding sampling, mercury measurement or ancillary information:		<Text entry>
F. HUMAN BIOMONITORING		
F.1. Ethics certificate:		Institutional Review Board (IRB): <Text entry> Date issued: <YYYY-MM-DD> *Please attach copy of ethics certificate.*
F.2. Study population exposure/vulnerability:*	Demographics:	□ General population □ Early life (fetus, newborn, children: 0-11 years old) □ Adolescents (12-17 years old) □ Adult men (18+ years old) □ Pregnant women □ Women in child-bearing age (<50 years old) □ Women past child-bearing age (>50 years old) □ Workers □ Subsistence fishers/hunters □ Recreational fishers/hunters □ Other, please specify: <Text entry>
	Environmental or dietary exposure:	□ Indigenous Peoples □ Local communities □ People living in islands or coastal areas □ People living alongside freshwater ecosystems (e.g., rivers, lakes) □ People living near ASGM sites □ People living near mercury sources other than ASGM sites, please specify: <Text entry> □ People living in the arctic and subarctic □ Other, please specify: <Text entry>
	Occupational exposure:	□ Primary mercury mining □ Artisanal and small-scale gold mining (ASGM) □ Non-ferrous ore mining (e.g., zinc, lead, copper) □ Chlor-alkali production □ Vinyl chloride monomer (VCM) production □ Acetaldehyde production □ Coal-fired power plants □ Oil and natural gas processing □ Healthcare (using mercury-containing measuring and control devices) □ Dentistry □ E-waste recyclers □ Healthcare waste processors □ Manufacture of mercury containing devices (e.g., mirrors, paint, fluorescent lights, batteries, barometers) □ Agriculture (using certain pesticides) □ Other, please specify: <Text entry>

CATEGORY	SUB-CATEGORY	OPTIONS / FORMAT
F.3. Study population sample size:		<Number entry> Details regarding the sample size: <Text entry>
F.4. Study population sampling strategy:		□ Random □ Not random, please describe the level of representativeness: <Text entry> □ Other, please specify: <Text entry>
F.5. Study population sex:		% male: <Number entry> % female: <Number entry>
F.6. Study population age:	Interval:	Min.: <Number entry> Max.: <Number entry>
	Percentage:	% 0 – 5 years of age: <0-100> % 6 – 11 years of age: <0-100> % 12 – 17 years of age: <0-100> % 18 – 49 years of age: <0-100> % 50 years of age and older: <0-100>
F.7. Characteristics of the samples:*	Sample collection date:	□ Single date: <YYYY-MM-DD> *OR* □ Period: From <YYYY-MM-DD> To <YYYY-MM-DD>
	Sampled tissue(s):*	□ Whole blood □ Cord blood □ Urine □ Specific Gravity Correction □ Osmolality Correction □ Creatine Correction□ Hair □ Other, please specify: <Text entry>
	Sample digestion / extraction:	□ Direct analysis (no digestion) □ Aqua regia □ Nitric acid □ Hydrochloric acid □ Other, please specify: <Text entry>
F.8. Mercury observations:*	Mercury species:*	□ Total mercury □ Methyl mercury □ Inorganic mercury □ Other, please specify: <Text entry>
	Unit of measurement:*	□ µg/g □ ng/g □ µg/L □ Other, please specify: <Text entry>
	Data reporting:*	□ Dry weight □ Wet weight
	Measurement values:*	□ Attach file in CSV format: <File name> *OR* Provide URL: <File name>
	Have the observations been aggregated?*	□ Yes □ No If yes, please explain the data aggregation process: <Text entry>
F.9. Ancillary observations:	Mercury isotopes:	□ δ^{202}Hg □ δ^{199}Hg □ Other, please specify: <Text entry>
	Measurement values:*	□ Attach file in CSV format: <File name> *OR* Provide URL: <File name>

CATEGORY	SUB-CATEGORY	OPTIONS / FORMAT
F.10. Additional information:	General:	□ Occupational exposure □ Dental amalgam status □ Use of skin-lightening creams □ Use of traditional medicine / homeopathy □ Education □ Socio-economic status □ Indigenous knowledge or local knowledge[3] Please provide details: <Text entry> and/or attach file: <Text entry>
	Dietary habits:	□ Freshwater fish □ Marine fish □ Marine mammal □ Subsistence or recreational fishing □ Commercial purchase □ Rice □ Other, please specify: <Text entry> Please provide details: <Text entry> and/or attach file: <Text entry>
	Dietary survey:	□ Available (please attach) □ Not available
F.11. Additional information regarding sampling, mercury measurement or ancillary information:		<Text entry>
G. OTHER MATRICES		
G.1. Matrix:*		□ Soil □ Sediment □ Freshwater □ Estuary/brackish water □ Seawater □ Snow □ Geologic □ "Natural archives"[4] □ Other, please specify: <Text entry>
G.2. Brief description of the matrix:*		<Text entry – max. 150 words >
G.3. Characteristics of the samples:*	Sample collection date:	□ Single date: <YYYY-MM-DD> *OR* □ Period: From <YYYY-MM-DD> To <YYYY-MM-DD>
	Sample filtration	□ Yes, please explain: <Text entry> □ No
	Sample digestion / extraction:	□ Direct analysis (no digestion) □ Aqua regia □ Nitric acid □ Hydrochloric acid □ Other, please specify: <Text entry>
G.4. Mercury observations:*	Mercury species:*	□ Total mercury □ Inorganic mercury □ Monomethyl mercury □ Dimethyl mercury □ Dissolved Gaseous Mercury (DGM) □ Other, please specify: <Text entry>

[3] Further information on indigenous knowledge and local knowledge, including similarities and differences, may be found at Houde et al. (2022).

[4] Measurements from "natural archives", such as peat bogs and tree rings, may be used as a tool to aid the characterization of sites with no background information.

CATEGORY	SUB-CATEGORY	OPTIONS / FORMAT
	Fractions:	□ Reactive Mercury (R-Hg) □ Dissolved □ Suspended □ Extractable □ Recoverable □ Filtered □ Non-filtered □ Integrated
	Unit of measurement:*	□ µg/g (or mg/kg) □ ng/g □ µg/L □ Other, please specify: <Text entry>
	Data reporting:*	□ Dry weight □ Wet weight
	Measurement values:*	□ Attach file in CSV format: <File name> *OR* Provide URL: <File name>
	Have the observations been aggregated?*	□ Yes □ No If yes, please explain the data aggregation process: <Text entry>
G.5. Ancillary observations:	General information:	□ Landscape/watershed characteristics (e.g., lake and catchment morphology) □ Local data on mercury deposition □ Local pollution history □ Other, please specify: <Text entry>
	Sampling methodology and characteristics of the sampled area:	Please describe: <Text entry>
	Measured parameters:	□ Temperature (value/unit) □ Depth (value/unit) □ pH (value) □ Salinity (value/unit) □ Conductivity (value/unit) □ Dissolved oxygen (value/unit) □ Total organic carbon (value/unit) □ Dissolved organic carbon (value/unit) □ Particle size distribution (sand, clay, etc) □ Total oxidized nitrogen (value/unit) □ Sulfur (species/value/unit) □ Trace elements (species/value/unit) □ Organic pollutants (species/value/unit) □ Other, please specify: <Text entry>
	Measurement values:*	□ Attach file in CSV format: <File name> *OR* Provide URL: <File name>
G.6. Additional information regarding sampling, mercury measurement or ancillary information:		<Text entry>
H. DETECTION AND QUALITY CONTROL *(ALL MATRICES)*		
H.1. Detection method:*		□ Cold-vapor atomic fluorescence spectroscopy (CVAFS) □ Cold-vapour atomic absorption spectroscopy (CVAAS) □ Inductively coupled plasma mass spectrometry (ICP-MS) □ Multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS)

CATEGORY	SUB-CATEGORY	OPTIONS / FORMAT
		□ Combustion and CVAAS □ Direct mercury analyser □ Other, please specify: <Text entry>
H.2. Equipment used (e.g., producer and model):		□ Please specify: <Text entry>
H.3. Performance parameters for analytical method validation:*[5]	Sensitivity:*	□ Limit of detection (LOD): <Number entry> □ Limit of Quantification (LOQ): <Number entry> □ Not available
	Analytical or linear range:*	<Text entry> □ Not available
	Trueness / systematic error:*	<Text entry> □ Not available
	Precision / random error:*	<Text entry> □ Not available
	Robustness:*	<Text entry> □ Not available
	Accuracy / measurement uncertainty:*	□ Quantitative estimation of uncertainty (in %): <Number entry> □ Description of accuracy or measurement of uncertainty: <Text entry> □ Not available
	Other:	<Text entry>
H.4. QA/QC measures:	Quality scheme in place in the laboratory:*	□ ISO/IEC 17025 □ ASTM-D6784 □ Accreditation, please explain the scope (matrix, concentration range): <Text entry> □ Other, please specify: <Text entry> □ Not available
	Use of traceable calibration reference standards:*	□ Yes, please explain: <Text entry> □ Not available
	Use of matrix-matched (certified) reference material(s):*	□ Yes, please explain: <Text entry> □ Not available
	Inter-laboratory comparisons:*	□ Yes, please explain: <Text entry> □ Not available
	Duplicate analysis:*	□ Yes, please explain: <Text entry> □ Not available
	Matrix spike:*	□ Yes, please explain: <Text entry> □ Not available
	Proficiency testing:*	□ Yes, please explain: <Text entry> □ Not available
	Other:	<Text entry>
H.5. Methods, manuals or standard operating procedures which were applied:	Sample collection and handling:	□ Please attach method, manual or SOP or indicate publicly available source <Web address> □ Not available
	Sample digestion / extraction:	□ Please attach method, manual or SOP or indicate publicly available source <Web address> □ Not available
	Analytical measurement:	□ Please attach method, manual or SOP or indicate publicly available source <Web address>

[5] See https://link.springer.com/article/10.1007/s00769-014-1093-0#ref-CR11 for an explanation on how the terms are being used.

CATEGORY	SUB-CATEGORY	OPTIONS / FORMAT
		□ Not available
	Data validation and QA/QC:	□ Please attach method, manual or SOP or indicate publicly available source <Web address> □ Not available
	Data analysis and reporting:	□ Please attach method, manual or SOP or indicate publicly available source <Web address> □ Not available
H.6. Additional information regarding detection methods, validation, QA/QC and standard procedures:		<Text entry>
I. ADDITIONAL INFORMATION *(ALL MATRICES)*		
I.1. Relevant publications:		Please attach document and/or provide URL or DOI: <Text entry>
I.2. Relevant analytical methods and/or SOPs		Please attach document and/or provide URL or DOI: <Text entry>
I.3. Additional information:		Please attach document and/or provide URL: <Text entry>

Annex 3

Indigenous contributions to global efforts to monitor mercury

Background

1. Indigenous Peoples have the highest mercury levels globally and have been noted by the Minamata Convention on Mercury as particularly vulnerable (Basu et al. 2022). Therefore, information about mercury levels in Indigenous Peoples and the ecosystems they depend upon needs to be highlighted in the monitoring reports. Indigenous Peoples need to be taken into account separately from national populations since they are often a small part of the population but greatly exceed national average mercury levels. Therefore, data disaggregation is key in order to make Indigenous Peoples visible in statistics. Furthermore, Indigenous Peoples have a lot of knowledge about their ecosystems that needs to be utilized for a holistic understanding of mercury movement in the environment and processes affecting mercury levels in various media (Houde et al 2022). This knowledge should be appropriately included and recognized in OESG monitoring reports.

Examples of best practices

2. Examples of equitable partnership approaches between Indigenous Peoples and scientists are available that produce mercury data and where Indigenous Knowledge is appropriately utilized. This includes monitoring programs such as the Northern Contaminants Program (NCP) in Canada, such as the beluga monitoring in the Inuvialuit Settlement Region (ISR), and many others (Houde et al. 2022). Several additional examples for the Arctic are provided in Chapter 9 of the Mercury Assessment of the Arctic Monitoring and Assessment Programme (AMAP, available at www.amap.no). There are also some peer reviewed publications on mercury concentrations available that can be used for OESG reports, and on how Indigenous Peoples should be engaged (preliminary list added below). These publications should be taken in consideration to well-inform the first round of the effectiveness evaluation. In several cases these are non-government publications. Gaps that are identified need to be outlined in the first round and addressed in the following rounds.

Knowledge and capacity gaps

3. Many countries in the southern hemisphere are currently lacking satisfactory mercury monitoring activities, particularly those that work with Indigenous Peoples on a partnership approach. Such an approach would be of particular importance in countries/regions with ASGM activities, with emphasis on the Amazon. While observing particularities within each region, it is recommended to use existing examples such as the NCP in Canada to help build capacity in other regions in order to support mercury monitoring which is carried out with Indigenous Peoples, in an equitable and ethical way.

4. In many cases scientists may not be aware of proper procedures on how to work with Indigenous Peoples. Therefore, the following points need to be taken into account with regards to ethical and equitable engagement of Indigenous Peoples in monitoring efforts:

(a) Free, prior and informed consent, a basic human right, is needed. Indigenous Peoples need to be aware of and support the project.

(b) Scientists need to educate themselves about realities of Indigenous Peoples and their territories in the region they want to work in, apply for any authorization or licences that are needed to be obtained for research, follow research guidance/protocols that the particular region/community may have in place, build contacts and trust. The right contacts need to be established to ensure that proper representation of Indigenous Peoples is included in any decision making. The legal status and legitimate Indigenous representation and its forms of self-government has to be acknowledged and followed.

(c) Research needs to be of value for the Indigenous Peoples who are part of the research.

(d) Time is needed to build trust before the project is started. It is important to respect Indigenous Peoples' own time in decision-making, in the whole process.

(e) The project needs to be developed with the effective participation of Indigenous Peoples from the very beginning (pre-proposal stage) and throughout all stages of the project. Communication needs to be continuous throughout the project. Indigenous Peoples need to be part of decision making on all levels: where, what, and when to sample (and what happens to leftovers from

sampling matrices), results analysis, determining what kind of communication products are created, when and how communication is done. Any publications are to be discussed with the involved Indigenous Peoples first.

(f) Capacity sharing is crucial. Indigenous Peoples need to be recognized for the knowledge they hold and contribute. They need to be appropriately compensated for their participation, and at the same level that scientists are compensated for their work.

Literature

Basu N., Abass K., Dietz R., Krümmel E., Rautio A., Weihe P. 2022. The impact of mercury contamination on human health in the Arctic: A state of the science review. Science of the Total Environment 831, 154793.

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Annex II*

"Plan for the summary of available emissions and releases data" to inform the Effectiveness Evaluation of the Minamata Convention

Draft (14 August 2023)

Table of Contents

* This present annex has not been formally edited.

Executive summary

The purpose of the “Plan for the summary of available emissions and releases data” (hereafter “emissions and releases data plan”) is to structure and guide the process for the collection, management and compilation of data on the emissions and releases of mercury and mercury compounds to the environment, in support of the first effectiveness evaluation of the Minamata Convention.

The work of the Open-Ended Scientific Group (OESG) to inform the first effectiveness evaluation will focus on existing sources of emissions and releases data while an analysis of gaps related to those data, including potential scientific actions to address the identified gaps, will be included in the scientific report of the OESG.

Available emissions and releases data will support the effectiveness evaluation in multiple ways through two sets of tasks that will proceed mostly in parallel. One set of tasks will look into whether and to what extent the actions taken to implement the Minamata Convention resulted in changes in mercury emissions and releases. This plan is intended primarily to provide a structure and a process on which to build a summary of available emissions and releases data over the period beginning prior to the Convention (circa 2010) and extending to as close as possible to the present to support this first set of tasks.

A second set of tasks involves the use of emissions and releases data to examine whether and to what extent the changes in emissions and releases resulted in changes in levels of mercury in the environment, biotic media and vulnerable populations. How emissions and releases data will be used in such analyses will be addressed in the separate forthcoming "data analysis plan".

The compilation and comparison of available data for emissions and releases from anthropogenic sources is the main focus of this plan. For purposes of the effectiveness evaluation, sources that are specifically addressed by articles of the Convention (including Articles 4, 5, 7, 8 and 9) are to be distinguished from the sources that are not addressed by the Convention. The OESG will also consider the influence of natural and legacy emissions and releases based on available information in the forthcoming analysis plan.

Sources of available emissions and releases data include:

- National reports under Article 21 of the Convention
- National action plans for artisanal and small-scale gold mining
- Minamata Initial Assessment (MIA) reports
- Pollutant Release and Transfer Registries (PRTR)
- Emissions database under the Convention on Long-Range Transboundary Air Pollution
- National emissions and releases inventories
- Scientific assessments and research literature

Based on an initial review of these data sources, a draft format to facilitate the data comparison will be developed. This data format and an initial list of available datasets collected will be circulated to Parties and other data providers along with an invitation to submit additional datasets for consideration by the OESG. The emissions and releases data including the available data from the initial list of sources and the submission by parties and other data providers will be stored in open-source databases on a data server that will be accessible to the OESG and experts in the roster. The original sources of all data used by the OESG will be duly acknowledged in the OESG outputs. Data providers or copyright holders will retain the ownership and rights over their data.

Based on this dataset, the OESG will develop an emissions and data summary that describes the following:

- Summary of available emissions and releases data for the period circa 2010 to present, with consideration of their comparability
- Challenges in obtaining the data
- Perceived data gaps within and across data sets
- Potential for supplemental data to be added to the existing information, and
- Data inconsistencies and the work needed to resolve these for future effectiveness evaluation

Acknowledgements

This document would not have been possible without the commitment and contribution of the OESG members and the experts in the roster, particularly the Leads and participants of the “small groups” on emissions and releases, who have volunteered much of their time to drafting and reviewing this plan. The lists of OESG members and roster of experts who are supporting the OESG are available through the Convention’s website.

The OESG co-Chairs shared a vision and provided guidance on how to translate decision MC-4/11 and the OESG terms of reference into action. Support to the OESG and its co-Chairs was provided by Secretariat.

Parties and organizations who have nominated and allowed experts to participate in this process have also played an important supportive role by enabling their nominees to dedicate time to tasks that often go beyond their duty of service. Parties are also acknowledged for having allocated sufficient funds to enable the OESG to meet face-to-face during the intersessional period with participation of OESG members from all regions.

List of Abbreviations

AMAP	Arctic Monitoring and Assessment Programme
ASGM	Artisanal and Small-Scale Gold Mining
COP	Conference of Parties
DOI	Digital Object Identifier
EDGAR	Emissions Database for Global Atmospheric Research
EEG	Effectiveness Evaluation Group
GMA	Global Mercury Assessments
FAIR	Findable, accessible, interoperable, reusable
LRTAP	Long-Range Transboundary Air Pollution
MIA	Minamata Initial Assessment
OESG	Open-Ended Science Group
PRTR	Pollutant Release and Transfer Register
UNECE	UN Economic Commission for Europe
UNEP	United Nations Environment Programme

1. Introduction: Objective and scope

The purpose of the "Plan for Emissions and Releases Data Summary" (hereafter "emissions and releases data plan") is to structure and guide the process for the collection, management and compilation of data on the emissions and releases of mercury and mercury compounds to the environment, in support of the first effectiveness evaluation of the Minamata Convention. The emissions and releases data plan includes considerations on:

(a) How available emissions and releases data will be sought and collected from Parties and other relevant stakeholders

(b) How data will be submitted, managed, and made available to the Open-Ended Science Group (OESG) for further analysis

(c) Roles and responsibilities of different players to execute specific tasks

(d) Schedule for the identified tasks

This plan is one of three plans that are being developed by the OESG to contribute to a scientific report to inform the first effectiveness evaluation of the Minamata Convention per decision MC-4/11. The other two plans will address (1) the collection, management, and compilation of available data on observed levels of mercury in air, biota, humans and other matrices, and (2) the analysis of the trends and patterns in the emissions, releases, and observation data, based on the guiding questions laid out in the monitoring guidance (UNEP/MC/COP.4/INF/12). The emissions and releases data plan may need to be revisited and adapted as progress is made and experience is gained through the collection of emissions and releases data and planning for data analysis, as well as to account for feedback provided by the EEG.

2. Background

2.1 Framework for the first effectiveness evaluation of the Minamata Convention

Article 22 of the Minamata Convention states that the Conference of the Parties (COP) will evaluate the effectiveness of the Convention, beginning no later than six years after the Convention's entry into force and periodically thereafter at intervals to be decided by the COP.[1] The effectiveness evaluation is to be conducted on the basis of, among other things, available information on the presence and movement of mercury and mercury compounds in the environment, as well as trends in levels of mercury and mercury compounds observed in biotic media and vulnerable populations.

The need for an effectiveness evaluation framework that included a strategic, cost-effective approach to provide appropriate and sufficient data was recognized by the COP at its first meeting and further discussed at its second meeting. At its third meeting, the COP considered the report of the ad hoc technical expert group for effectiveness evaluation, which included a description of a proposed effectiveness evaluation framework, as well as the following policy questions aimed at supporting an assessment of whether the control measures, as implemented, would lead to the achievement of the Convention's objective:

(a) Have the Parties taken actions to implement the Minamata Convention?

(b) Have the actions taken resulted in changes in mercury supply, use, emissions and releases into the environment?

(c) Have those changes resulted in changes in levels of mercury in the environment, biotic media and vulnerable populations that can be attributed to the Minamata Convention?

(d) To what extent are existing measures under the Minamata Convention meeting the objective of protecting human health and the environment from mercury?

The report of the ad hoc technical expert group also contained technical information on monitoring and a proposal on monitoring arrangements pursuant to article 22; proposed reports to be used to formulate findings/recommendations for the consideration of the COP; and a set of indicators developed based on an article-by-article review for assessing progress and impact of the measures. In decision MC-3/10, the COP continued the preparation for the first effectiveness evaluation by requesting the drafting of guidance on monitoring and a report on trade, supply and demand of mercury and mercury compounds and by inviting further discussion of effectiveness indicators.

[1] The Minamata Convention entered into force on 16 August 2017.

At its fourth meeting, in decision MC-4/11, the COP agreed to begin the first effectiveness evaluation of the Convention. In the same decision, the COP adopted a framework for the first effectiveness evaluation as reproduced in Figure 1 and established the OESG. In accordance with its terms of reference outlined in annex II to the decision, the OESG shall work in two stages to develop a scientific report for consideration by the EEG. The OESG report shall be composed of the following elements:

Stage 1:

(i) Plan for the Monitoring Data Compilation and Summary

(ii) Plan for the summary of available emissions and releases data *(this document)*

(iii) Plan for Data Analysis consistent with the Monitoring Guidance[2]

Stage 2:

(i) Monitoring Data Compilation and Summary

(ii) Emissions and Releases Data Summary

(iii) Data Analysis addressing the guiding questions outlined in the Monitoring Guidance

Furthermore, the OESG shall provide an analysis of data gaps, including the identification of existing gaps as well as potential scientific actions to address identified gaps in information and knowledge related to monitoring, and lessons learned to be submitted to the Effectiveness Evaluation Group.

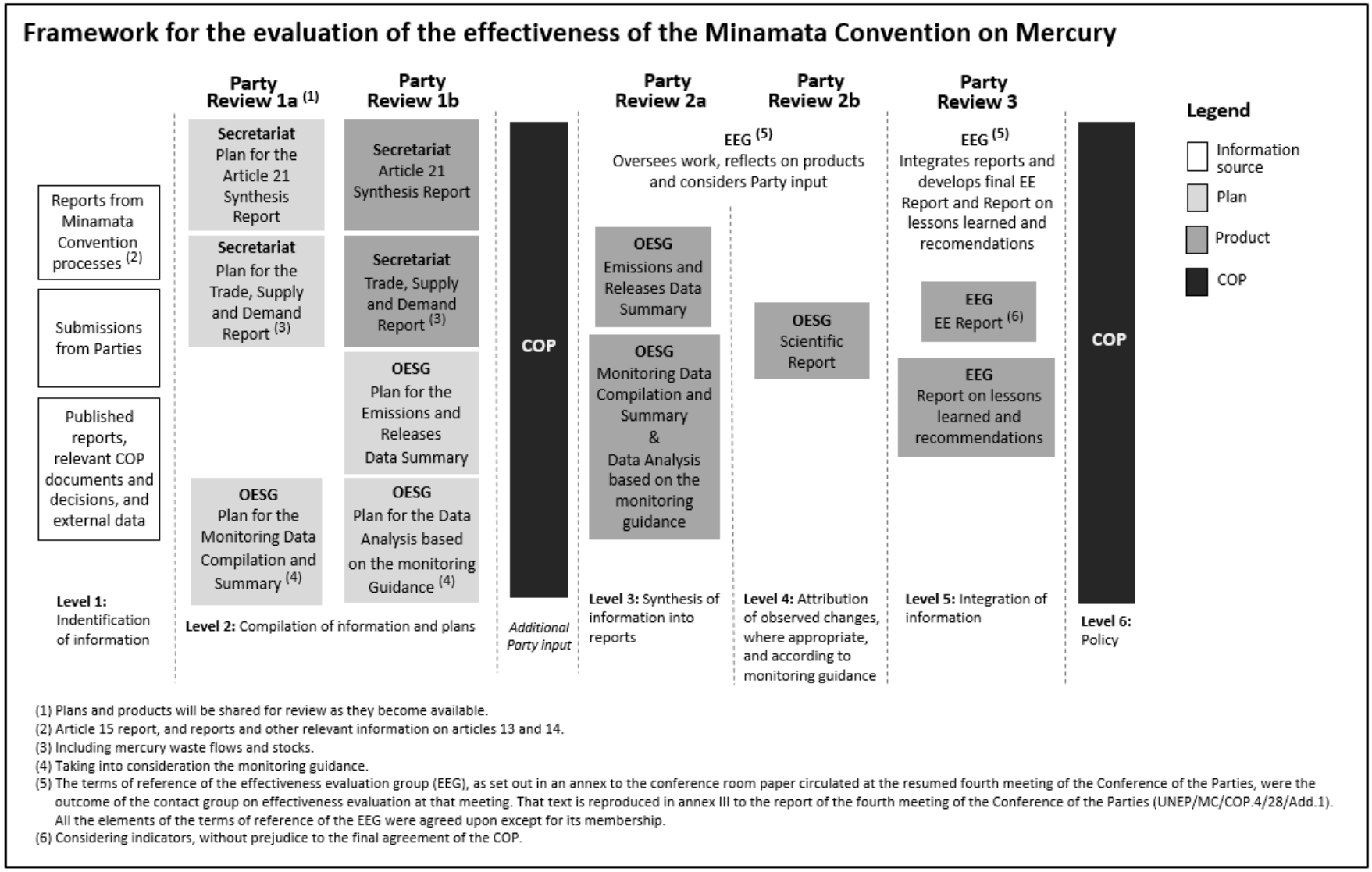
The process laid out in the OESG terms of reference also foresees support by the secretariat, contribution of a roster of scientific and technical experts, input from different stakeholder groups, various rounds of review by Parties, and face-to-face meetings of the OESG, including one meeting during the current intersessional period.

To achieve its expected outputs, the OESG will assess the data and coordinate the analysis to be included in the scientific report, taking into consideration the monitoring guidance and its guiding questions,[3] as well as differences in scientific capacities, national circumstances, environmental conditions and demographic characteristics across parties and regions. The expected outputs of the OESG and the framework for the first effectiveness evaluation of the Convention, as adopted in decision MC-4/11, are shown in Figure 1 below. The first effectiveness evaluation will also be informed by other sources of information, including a set of indicators, a synthesis of national reports submitted under article 21, and a report on trade, supply and demand of mercury and mercury compounds.

[2] The “Monitoring Guidance” referenced in decision MC-4/11 is the “Guidance on monitoring of mercury and mercury compounds to support evaluation of the effectiveness of the Minamata Convention” available as document UNEP/MC/COP.4/18/Add.2.

[3] As set out in documents UNEP/MC/COP.4/18/Add.2 and UNEP/MC/COP.4/INF/12.

Figure 1. Annex I to decision MC-4/11 on the framework for the effectiveness evaluation.



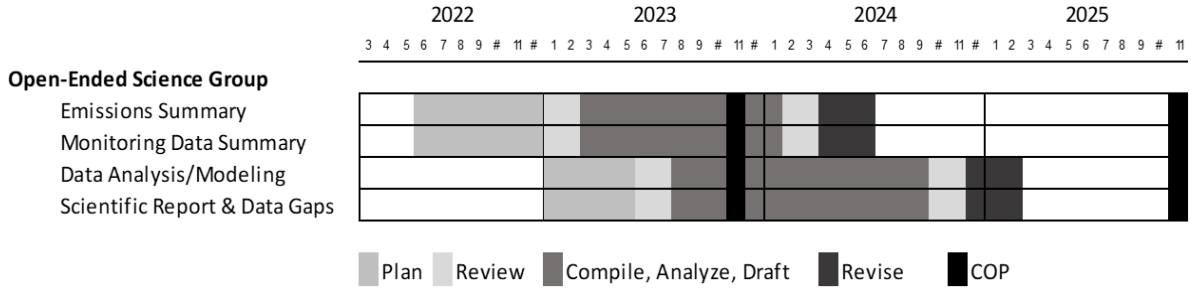
(1) Plans and products will be shared for review as they become available.
(2) Article 15 report, and reports and other relevant information on articles 13 and 14.
(3) Including mercury waste flows and stocks.
(4) Taking into consideration the monitoring guidance.
(5) The terms of reference of the effectiveness evaluation group (EEG), as set out in an annex to the conference room paper circulated at the resumed fourth meeting of the Conference of the Parties, were the outcome of the contact group on effectiveness evaluation at that meeting. That text is reproduced in annex III to the report of the fourth meeting of the Conference of the Parties (UNEP/MC/COP.4/28/Add.1). All the elements of the terms of reference of the EEG were agreed upon except for its membership.
(6) Considering indicators, without prejudice to the final agreement of the COP.

Based on the framework for the effectiveness evaluation that was adopted in decision MC-4/11 (Figure 1), the OESG has been working under the assumption that the first effectiveness evaluation would be completed by the sixth meeting of the COP, which is expected in 2025.[1]

In accordance with the adopted framework, the OESG's scientific report must be completed in time for consideration by the EEG, whose terms of reference are expected to be agreed upon at COP-5 in 2023. Thus, the majority of the OESG's work (including data collection, analysis, report writing, as well as the associated opportunities for review by Parties) must be completed in 2023 and 2024. A draft schedule for the process is shown in Figure 2. It must be emphasized that in order to achieve its expected outcomes under the assumption that the first effectiveness evaluation will end at COP-6, the draft schedule as shown below is very ambitious, particularly because a significant amount of time will be needed for collecting existing monitoring data from multiple data providers, which will require entering data use agreements with each data provider, before data analysis can begin. With the current draft schedule, it is possible that only part of the available emissions and releases data will have been collected and harmonized in time to be analysed by the OESG.

Moreover, the time available to gather and analyse the available scientific information is very limited, especially given that: this is the first effectiveness evaluation for the Convention; the necessary data management infrastructure does not yet exist; there are limited financial resources available from the Convention to fund the work; and multiple opportunities for review by Parties have been built into the process to improve transparency, credibility and ownership. Therefore, the approach proposed by the OESG is to provide the EEG, and subsequently the COP, the best information possible within the limited time and resources available and to outline how the scientific basis of effectiveness evaluation could be improved in future evaluation cycles.

Figure 1: A draft schedule for completion of OESG tasks by COP-6.



2.2. The Roles of Emissions and Releases Data in the Effectiveness Evaluation

Available emissions and releases data will support the effectiveness evaluation in multiple ways through two sets of tasks that will proceed mostly in parallel. One set of tasks will focus on addressing question (ii) of the four policy questions identified for the effectiveness evaluation: *"Have the actions taken [to implement the Minamata Convention] resulted in changes in mercury supply, use, emissions and releases to the environment?"* To address this policy question, the OESG intends to compile and compare available emissions and releases data for the period beginning prior to the Convention (circa 2010) and extending to as close as possible to the present. The OESG will also compile and compare available projections of future emissions. The compiled data will be used to address a number of analysis questions, which may include:

- How have mercury emissions and releases addressed by the Convention changed over time? How are they expected to change in the future? How do the measures taken to implement the Minamata Convention affect the emissions and releases?
- How have mercury emissions and releases from human activities that are not addressed by the Convention changed over time? How are they expected to change in the future?
- How have emissions and releases from natural sources changed?
- How do uncertainties, spatial patterns, and temporal trends compare across source categories?
- What improvements in emissions and releases data are most needed to better understand the impact of the Convention?

[1] Pending further consideration by the COP, at its fifth meeting, of the timeline for the first effectiveness evaluation.

This plan is intended primarily to provide a structure and a process on which to build a summary of available emissions and releases data, as well as their drivers, to address these types of questions.

A second set of tasks involves the use of emissions and releases data to help address question (iii) of the four policy questions for the effectiveness evaluation: *"Have the changes in emissions and releases resulted in changes in levels of mercury in the environment, biotic media and vulnerable populations and can these changes be attributed to the Minamata Convention?*" This question can only be answered by using both emissions and releases data and observational data in quantitative models that account for the various physical, chemical, and biological processes involved in the fate, transport, and cycling of mercury in the environment. How emissions and releases data will be used in such analyses will be addressed in the separate forthcoming analysis plan and not in this document. However, the current plan includes the collection and compilation of relevant parameters that are needed to use emissions and releases information in such analyses, including source location information (geo-referencing), chemical speciation, emission or release characteristics (e.g., stack heights), where this information is available.

3. Overview of Sources of Emissions and Releases

The Convention addresses emissions of mercury and its compounds to the atmosphere and their releases to land and water. Emissions and releases from relevant point sources are addressed in Articles 8 and 9, respectively, and other articles, such as Articles 4 (mercury-added products), 5 (manufacturing processes) and 7 (artisanal and small-scale gold mining) also mention the control of emissions and releases. Throughout this plan, the terms "emission" and "release" are used accordingly. The first Global Mercury Assessment (UNEP 2002) grouped mercury emissions and releases into several main categories:

- Natural sources associated with the mobilization of naturally occurring mercury from the Earth's crust through natural processes, such as volcanic and geothermal activity and physical and chemical weathering of rocks;
- Current anthropogenic sources due to either
    - the mobilization of mercury impurities in raw materials, such as fossil fuels and other extracted, treated and recycled minerals, or
    - the intentional use of mercury in products and processes, and emitted or released during manufacturing, use (including breakage), and disposal or incineration of spent products;
- Re-mobilization of historic anthropogenic mercury emissions and releases deposited in previous years in soils, sediments, water bodies (including oceans), landfills, waste/tailings piles, and vegetation. These are referred to here as legacy emissions or releases.

Current anthropogenic sources may be divided into more specific sector and process categories, as shown in Table 1. For purposes of the Convention's effectiveness evaluation, these specific sector and process categories can be re-grouped into (a) sources that are specifically addressed by articles of the Convention and (b) sources that are not. Table 1 compares sector and process specific categories used in several available guidance documents and published data sets. Methodologies used to estimate emissions and releases from these anthropogenic source categories, as well as primary data sources, are described further in Annex 2.

Note that anthropogenic releases to land and water include discharge over soil or to a waterbody (including through sewage system), infiltration to underground water and spreading or depositing onto land, and that they are to be distinguished from the disposal of waste in engineered landfill sites. Releases can occur at any stage of the lifecycle of mercury and its compounds, including during supply, trade, application for extraction of metals, storage, or management of landfills and contaminated sites.

The compilation and comparison of available data for emissions and releases from anthropogenic sources is the main focus of this emissions and releases data plan.

Natural emissions and releases from volcanoes and geothermal fields and from the chemical and physical weathering of geological deposits have been estimated in the scientific literature. Legacy emissions and releases of mercury originally mobilized by anthropogenic sources and deposited in previous years may be re-emitted from the ocean, soils, and vegetation, through a variety of processes, including by wildfires. These legacy emissions depend on current conditions as well as the history of deposition and accumulation. They are best estimated through modelling of these physical processes,

informed by observations. It will be necessary to consider trends in natural and legacy emissions and releases to understand trends and spatial patterns in environmental observations and separate the influence of the Convention from the influence of other drivers of environmental change. The OESG will consider the influence of natural and legacy emissions and releases based on available information in the forthcoming analysis plan.

Table 1: Anthropogenic Sources of Mercury Emissions and Releases[2]

Source and Process Categories		Convention provisions[3]
Extraction and use of fuels/energy sources		
	Coal combustion in power plants	Article 8, Annex D
	Coal combustion in coal fired industrial boilers	Article 8, Annex D
	Other coal use	
	Coal mining	
	Mineral oils - extraction, refining and use	
	Natural gas - extraction, refining and use	
	Other fossil fuels - extraction and use	
	Biomass fired power and heat production	
	Geothermal power production	
Primary (virgin) metal production		
	Mercury (primary) extraction and initial processing	
	Gold (and silver) extraction with mercury amalgamation processes	Article 7, Annex C
	Zinc extraction and initial processing	Article 8, Annex D
	Copper extraction and initial processing	Article 8, Annex D
	Lead extraction and initial processing	Article 8, Annex D
	Gold extraction and initial processing by methods other than mercury amalgamation	Article 8, Annex D
	Aluminium extraction and initial processing	
	Other non-ferrous metals - extraction and processing	
	Primary ferrous metal production	
Production of other minerals and materials with mercury impurities		
	Cement clinker production	Article 8, Annex D
	Pulp and paper production	
	Production of lime and light weight aggregates	
Intentional use of mercury in industrial processes		
	Chlor-alkali production with mercury-technology	Article 5, Annex B 5
	Vinyl chloride monomer production with mercury catalyst	Article 5, Annex B
	Acetaldehyde production with mercury catalyst	Article 5, Annex B
	Other production of chemicals and polymers with mercury	Article 5, Annex B
Consumer products with intentional use of mercury		
	Thermometers with mercury	
	Electrical switches and relays with mercury	
	Light sources with mercury	
	Batteries with mercury	
	Polyurethane with mercury catalysts	
	Biocides and pesticides with mercury	
	Paints with mercury	

[2] The description of the source categories is based on the UNEP Toolkit for Identification and quantification of Mercury Releases. A more detailed table including the comparison of source categories is included in Annex 1.

[3] This column refers to the articles that specifically mention the emissions and releases from specific sources. Article 9 does not specify release source categories and therefore is not included in the column. Measures taken under other articles may also address emissions and releases from specific sources.

Source and Process Categories		Convention provisions[3]
	Pharmaceuticals for human and veterinary uses	
	Cosmetics and related products with mercury	
Other intentional product/process use		
	Dental mercury-amalgam fillings	
	Manometers and gauges with mercury	
	Laboratory chemicals and equipment with mercury	
	Mercury metal use in religious rituals and folklore medicine	
	Miscellaneous product uses, mercury metal uses, and other sources	
Production of recycled metals ("secondary" metal production)		
	Production of recycled mercury ("secondary production")	
	Production of recycled ferrous metals (iron and steel)	
	Production of other recycled metals	
Waste incineration		
	Incineration of municipal/general waste	Article 8, Annex D
	Incineration of hazardous waste	Article 8, Annex D
	Incineration of medical waste	Article 8, Annex D
	Sewage sludge incineration	Article 8, Annex D
	Informal waste burning	
Waste deposition/landfilling and waste water treatment		
	Controlled landfills/deposits	
	Diffuse disposal under some control	
	Informal local disposal of industrial production waste	
	Informal dumping of general waste	
	Waste water system/treatment	
Crematoria and cemeteries		
	Crematoria/cremation	
	Cemeteries	
Others		

4. Overview of Data Available for Effectiveness Evaluation

While a number of recommended guidelines exist, the Convention does not yet have an agreed set of guidelines for uniform emissions and releases estimation and reporting covering all the major sources. Therefore, the data to inform the effectiveness evaluation will have to be drawn from a diverse set of data sources. This section will provide an overarching description of the data sources and methodologies that will be used to gather information and compile estimates of emissions and releases.

4.1. Article 21 National Reports

Under the Minamata Convention, Parties have an obligation to develop emissions and releases inventories for sources specifically addressed in Articles 8 and 9 of the Convention and to provide information about the availability of these inventories in their national reports under Article 21. Article 8 addresses mercury emissions to air from five categories of point sources listed in Annex D of the Convention: coal-fired power plants, coal-fired industrial boilers, non-ferrous metals production, cement production, and waste incineration. Article 9 requires Parties to identify significant anthropogenic point sources of release to land and water that are not addressed in other provisions of the Convention. Parties are asked to identify relevant point sources no later than three years after the entry into force of the Convention and to continue to update their point source database on regular basis. Only some Parties have identified relevant point sources under Article 9.

Parties are obligated to establish inventories under Articles 8 and 9 no later than five years after entry into force of the Convention. However, the first full reporting period under Article 21 is for information up to 31 December 2020, before the Convention has been in force for five years. Thus, the

emissions and releases information was provided by a limited number of Parties in the first full reporting cycle, which includes data from:

- Pollutant Release and Transfer Registries (PRTR)
- The UNECE Air Convention emissions database
- Minamata Initial Assessment (MIA) reports
- National Inventories developed for reporting to the Minamata Convention or other national purposes

These different data sources are discussed further in separate sub-sections below.

Article 21 national reports are also expected to contain information that can contribute to the estimation of emissions and releases, including information about

- the supply of mercury (Article 3), including the amount of primary mining and identified stocks;
- mercury-added products (Article 4), including the impact of measures to phase out the manufacture, import, or export of such products;
- manufacturing processes using mercury (Article 5), including the amount of mercury used and abatement measures implemented for production of acetaldehyde, chlor-alkali, vinyl chloride monomer, sodium or potassium methylate or ethylate, and polyurethane production;
- waste management (Article 11), including the mass of waste consisting of mercury or mercury compounds that has been subject to final disposal; and
- contaminated sites (Article 12), including the development of strategies for identifying, assessing, managing, and remediating contaminated sites.

4.2. ASGM National Action Plans

Article 7 addresses artisanal and small-scale gold mining (ASGM), considered to be the largest source of mercury emissions and releases. Parties with more than insignificant ASGM activity are obligated to develop and implement National Action Plans to reduce and where feasible eliminate, the use, emissions, and releases of mercury in ASGM. These National Action Plans are to be updated every three years and contain estimates of the use, emissions, and releases of mercury and the location of ASGM activities.

4.3. Minamata Initial Assessments

As of January 2023, 69 countries have developed and submitted Minamata Initial Assessments (MIAs) to support the ratification and implementation of the Convention. Most MIAs used the "UNEP Toolkit for Identification and quantification of Mercury Releases," which provides guidance on developing quantitative estimates of emissions and releases from all the sectors addressed by the Convention as well as other sectors. The toolkit is based on a mass-flow principle: mercury contained in fuel and material inputs to a process should equal the mercury that is output from the process as a product or as an emission or release to the environment. The toolkit contains recommended factors for initial (level 1) estimates of mercury emissions and releases based on the amount of raw materials and fuels consumed or products produced (activity data), mitigation technologies employed, or more detailed estimates (level 2) incorporating additional information and enabling the use of local estimation factors about the fuel content of mercury or specific process and mitigation technologies employed. MIAs that have been developed provide annual estimates for different years ranging from 2016 to 2021. The activity data underlying these estimates is from the most recent data available for each Party, which may be from years before 2016. UNEP and the Biodiversity Research Institute have conducted an analysis of available MIA inventories.[4]

4.4. Pollutant Release and Transfer Registers

Pollutant Release and Transfer Registers (PRTRs) are databases of emissions, releases, and transfers of pollutants or wastes from large point sources, some of which also cover diffuse sources. Such databases have been created at the national or regional (e.g., European) scale. The databases cover

[4] https://public.tableau.com/app/profile/mark.burton.bri/viz/MIAMercuryInventoryDashboard/Main_Dashboard?publish=yes.

many pollutants, including mercury, and many types of industrial facilities, typically including those identified in Article 8 and Annex D of the Convention. Annual data is typically reported by facilities on an annual or multi-year cycle (e.g., every 3 years). The source categories reported do not necessarily correspond to those used by the Convention or other inventory developers. The size of facilities covered varies by national or regional program. Locations may be reported for the facility itself, or may be reported for a corporate office, depending on the program requirements. Reported data may be estimated under optimal conditions and may underestimate the actual emissions or releases.

4.5. UNECE Air Convention Emissions Reporting

The 1979 Convention on Long-Range Transboundary Air Pollution (LRTAP), also known as the UNECE Air Convention, includes obligations related to mercury air emissions under its 1998 Protocol on Heavy Metals. The Convention is organized under the UN Economic Commission for Europe and involves 51 Parties from Europe, North America, and Central Asia. The Convention requires annual emissions reporting for a variety of pollutants including mercury. Reports are compiled in a database maintained by the Center for Emissions Inventories and Projections hosted by UBA Austria.[5] Emissions are estimated based on tiered guidance in the EMEP-EEA air pollutant emissions inventory guidebook and emission factor database.[6] Estimates are reported in accordance with "Guidelines for reporting emissions and projections data under the Convention." Recent data use the 2014 version of the reporting guidelines, which were recently updated for application starting in 2024.[7]

4.6. National Emissions (and Releases) Inventories

In addition to national PRTRs mentioned earlier, a number of Parties maintain comprehensive national inventories of air emissions that address sources of mercury. Parties may also maintain inventories of mercury releases to land and water, or develop detailed national mass-flow analysis that quantitatively assesses the mercury flow through society and environmental media. These inventories are typically annual estimates that are developed on an annual or multi-year cycle (e.g., every 3-5 years).

4.7. Scientific Assessments and Research Literature

In addition to emissions and releases estimates produced by Parties, there are estimates of mercury emissions and releases in the published scientific literature, including in the periodic Global Mercury Assessments (GMA) produced from 2002-2018 (UNEP 2002, 2008, 2013, 2018).

At the global scale, there are four groups of mercury emissions inventories:

(a) Arctic Monitoring and Assessment Programme/UNEP Global Mercury Assessment (AMAP/GMA) (Pacyna and Pacyna 2002; Pacyna et al. 2006; AMAP/UNEP 2008, 2013, 2019; Steenhuisen and Wilson, 2015, 2019)

(b) Emissions Database for Global Atmospheric Research (EDGAR) (Muntean et al. 2014, 2018)

(c) Streets et al. (2011, 2019a, 2019a, 2019b, 2019c)

(d) WHET (Zhang et al 2016), which evolved from Streets et al. incorporating additional data developed at the national and regional level, particularly for China

In general, the AMAP/GMA inventories were produced to provide the best estimate of annual emissions in a given year. Group (a) includes estimates for annual emissions in five-year increments from 1990 to 2015. However, the estimation methodologies applied to each annual period evolved through different assessment cycles with increasing levels of detail incorporated into more recent inventories. Thus, the estimates from before 2010 are not directly comparable to the estimates after 2010. In contrast, each version of the EDGAR emissions (group (b)) is intended to be a consistent time series going back to 1970. Each new version updates the whole time series. The Streets et al. inventories (group (c)) include estimates for the period 2000-2015, that have been estimated in a manner consistent with estimates at ten-year intervals going back to 1510. However, the estimates are based on activity data and technology assumptions at the regional level, not the country level. The

[5] https://www.ceip.at.

[6] https://www.eea.europa.eu/publications/emep-eea-guidebook-2019.

[7] https://www.ceip.at/reporting-instructions.

WHET inventory (group (d)) includes annual emissions for 1990, 2000, and 2010, driven by a mix of regional and country level data.

Global totals and maps of emissions can be compared across these groups. However, comparing the estimates for individual countries (or regions) by source category is challenging, as the source categories included and their definitions vary between the different families. Within a particular source category, differences in the activity levels, the distribution of different technologies and fuel types within a sector, and the effect of different process and control technologies on mercury emissions assumed in the inventories all can contribute to significant differences in the estimated emissions for particular source category in a single country over a single year.

In addition to these global inventories, there are numerous articles in the literature estimating mercury emissions for a single country or region or for a specific source category.

5. Considerations for Comparing and Compiling Available Emissions and Releases Estimates

The Effectiveness Evaluation of the Convention will require emissions and releases data that is comparable and credible. The following describes some considerations for comparing emissions and release data.

5.1. Data elements

The elements of emissions and releases data to be collected include the following. It should be noted that these elements may not be available for all the data sets. A format for collecting these data in a comparable manner will be developed.

- Quantity of emissions and releases (with units)
- Source Categories
- Methodology
- Activity data
- Emission/release/distribution factors or parameters related to those factors
- Location/Spatial Information
- Temporal Information
- Chemical Speciation of Emitted or Released Mercury

5.2. Transparency

Full transparency regarding the methods, data and assumptions used in generating any given emissions and release estimate is key to ensuring that the estimate can be used in an appropriate way. Therefore, compilations and comparisons should strive to make available as much information as possible about the underlying sources of data, assumptions, and methods applied in the original estimates and in the process of comparison.

5.3. Uncertainties

Ideally, all estimates would be accompanied by an associated measure of their uncertainty. For an individual estimate, this may involve a calculation recognizing, e.g., the range of mercury content in a fuel or raw material, the accuracy of measurements, or assumptions regarding the removal efficiency of applied emission mitigation technologies or representativeness of measurements. For estimates that combine other estimates this may involve statistical methods to address propagation of errors, recognizing that some values will be over-estimated and others under-estimated. Realistically, many of the data that will be made available to the OESG in this process will not include associated quantification of uncertainties. Thus, it will be incumbent upon the OESG to do its best to characterize the scale of uncertainties in the available data and communicate the limitations of the data in addressing the effectiveness evaluation questions.

5.4. Defining the temporal dimension of estimates

Emissions and releases estimates are associated with a given time period, typically a year, for which activity data or observations have been collected. For the purposes of establishing a comprehensive inventory or estimate for a particular year, it is sometimes not possible to gather all of the necessary information for the specific time period. A pragmatic approach is often taken to refer to a nominal target year but use information from a range of years around the target (e.g., plus/minus one year) that is judged to be reasonably representative of the target year (considering the interannual variability of the relevant processes). However, in the process to implement the Convention, a large number of control measures will be taken over a short period, which will lead to rapid changes of parameter values used to estimate the emissions and releases. Therefore, for Convention-related sources, information is recommended to be collected as annual estimates (along with, if relevant, information on underlying parameters) instead of using multi-year average data. For other sources, when such data are used to establish a trend and to ascribe that trend to drivers such as the implementation of the Convention, it is important to document the underlying time period(s) associated with each estimate in the time series and to consider the implications for apparent trends.

5.5. Geospatial distribution and speciation

Most of the data available to quantify emissions and releases pertain to a given facility or a given sector at the national or sometimes sub-national level, in a given year or period. To compare trends in emissions and releases data to trends in observations, it is necessary to account for the intervening environmental processes that might affect the source-receptor relationships, such as through the use models that represent the environmental fate and transport of the emissions and releases. Most such models require emissions and releases information to be geo-spatially distributed, typically at a spatial resolution of some 10's of km, ideally with a seasonal or better temporal resolution (currently most available data are annual), and 'speciated' to represent the chemical form of the mercury emitted. The methods applied to geo-spatially distribute emissions and releases data are complex, benefit considerably if information can be delivered at the facility level (in particular for large point sources), and otherwise rely on 'proxies' for distributing emissions and releases where point sources cannot be defined, which is the case for many of the sources associated with waste. The information required to geospatially distribute emissions and releases is also time dependent – facilities open, close, change their processes or fuels and apply new mitigation technologies over time. Similarly, proxies used to distribute emissions and releases without defined point sources (e.g., population distribution) change over time. No mechanism currently exists for reporting, compiling, or ensuring consistent application of information used in defining geospatial distributions, or updating it at appropriate temporal scales. The OESG will endeavour to compile and compare the geospatial data used in available inventories and consider how needed geospatial data may be compiled or managed in the future.

5.6. FAIR principles for data management and stewardship

The monitoring guidance (UNEP/MC/COP.4/INF/12) notes that, to the extent possible and in accordance with requirements of individual data providers, data used in the effectiveness evaluation should follow the FAIR principles (findable, accessible, interoperable and reusable) for data management and stewardship. This will apply not only to monitoring data but also to emissions and releases data. The Monitoring Guidance also discusses ethical considerations for the use of data, including the need to follow guidance provided by Indigenous Peoples with regards to self-determination of research, research ethics, data considerations, utilization of Indigenous Knowledge, and communication of results as guided by principles such as the "CARE Principles for Indigenous Data Governance".[8] Elements of the FAIR principles that are applicable to the effectiveness evaluation are shown below (Box 1).

Box 1. *Elements of the FAIR principles for data management and stewardship in the context of the effectiveness evaluation*

Findable:

- A searchable and interoperable database acting as a repository of available data;
- Unique identification systems (e.g., "Digital Object Identifiers" or "DOIs") and controlled vocabulary to facilitate searching and retrieval of information;
- Detailed metadata associated with each data record to facilitate the submission, searching, location and retrieval of information;

[8] CARE Principles for Indigenous Data Governance: https://www.gida-global.org/care.

Accessible:

- Free and open access to the data to Governments, Indigenous Peoples, and relevant stakeholders, taking into account the relevant ethical considerations;

Interoperable:

- An interoperability mechanism to facilitate the exchange of information across different programmes and databases;

Reusable:

- Data usage license/agreement identifying the terms and conditions for further use of the data;
- Metadata including enough information describing how the data were collected/produced to enable an assessment of the quality and comparability of the data, reproducibility and further analyses.

6. Data Collection, Management, and Summary

The following describes proposed tasks to develop the emissions and releases data summary.

Task 1 - Identify the available data sources through national reporting, MIA inventory reports and other existing databases, and compare the data elements, source categories and estimation methodologies. This may include sources not initially identified in developing inventories. The information on estimation methodologies will include procedures for collecting activity data and developing emissions/releases factors.

Task 2 - Create a draft format to facilitate the comparison of the data elements identified in section 5.1 from available data sources. This format should be able to a) incorporate currently available information, and b) provide a framework to incorporate new and more detailed information for estimating emissions and releases. This data format and a list of available datasets collected by OESG in Task 1 will be circulated to Parties and other data providers along with an invitation to submit additional datasets for consideration by the OESG.

Task 3 – Compile the information collected in Task 1 and submitted as a result of the invitation in Task 2 into a dataset using the format developed under Task 2. The original sources of all data used by the OESG will be duly acknowledged in the OESG outputs. The dataset will be stored in open-source databases (for example, MySQL) on a data server that will be accessible to the OESG and experts in the roster.

Task 4 – Based on the dataset developed under Task 3, develop an emissions and data summary that describes the following:

(a) Summary of available emissions and releases data for the period circa 2010 to present, with consideration on their comparability

(b) Challenges in obtaining the data

(c) Perceived data gaps within and across data sets

(d) Potential for supplemental data to be added to the existing information, and

(e) Data inconsistencies and the work needed to resolve these for future effectiveness evaluation.

How the compiled dataset will be used to address specific questions to inform the effectiveness evaluation, including considerations for the development of tools that will enable the newly compiled data to be searched, analysed, modelled and visualised, will be included in the forthcoming plan for data analysis and is not the focus of the present document.

The OESG, with input from the roster of experts, will provide overall guidance on the tasks described above.

To help the implementation of this plan, the Secretariat will engage and supervise one or more data management consultants. The data management consultant(s) will be responsible for the day-to-day tasks to collect, organize and store data in accordance with the guidance provided by the OESG.

The cost of consultancy services will be borne by the Convention’s budget, as approved by COP in decision MC-4/13 on the programme of work and budget for 2023.

7. Schedule for the implementation of the Plan for Emissions and Releases Data Summary

The main milestones for the implementation of the plan for emissions and releases data summary is summarized below with associated tentative timelines.

Milestones	*Tentative timeline*
Review by parties of the draft plan, including an invitation to identify relevant available datasets	3 February – 1 March 2023
Revision of the emissions and releases data plan, including a list of initially available data sets, following the face-to-face meeting of the OESG, 27-31 March 2023	April 2023
Development of initial formats for data submission and comparison of data elements from different sources	May-October 2023
Invitation to Parties and other data providers to submit additional relevant data on emissions and releases to support the first effectiveness evaluation	September 2023
Deadline for submission by Parties and other data providers to submit data to support the first effectiveness evaluation	Mid-January 2024
Progress report on the data submitted to support the first effectiveness evaluation	March 2023
Party review of draft report on compilation and summary of available emissions and releases data	April 2024
Submission of the report on available emissions and releases data summary to the Effectiveness Evaluation Group (EEG)	TBD (pending decision at COP-5)

Annex 1

Anthropogenic sources of mercury emissions and releases[1]

Source and Process Categories	UNEP Toolkit Section	GMA 2018 Sector Codes	EDGARv4.tox (IPCC) Sector Codes and Names		Streets et al. Sector Categories	GAINS sector codes
Extraction and use of fuels/energy sources	**5.1**		1.A	Combustion activities		
Coal combustion in power plants	5.1.1	SC-PP-coal	1.A.1.a (coal combustion)	1.A.1.a:Main Activity Electricity and Heat Production	Coal combustion	Subsectors of PP_ In combination with 5 coal types (HC1, HC2, HC3, BC1, BC2)
Coal combustion in coal fired industrial boilers	5.1.2.1	SC-IND-coal	1.A.2 (coal combustion)	1.A.2: Manufacturing Industries and Construction		Subsectors of IN_BO_ IN_OC_ In combination with 5 coal types (HC1, HC2, HC3, BC1, BC2)
Other coal use	5.1.2.2	SC-DR-coal	1.A.4, 1.A.1.bc (coal combustion)	1.A.4: Other sectors including residential 1.A.1.bc: Petroleum Refining Manufacture of Solid Fuels and Other Energy Industries		CON_COMB DOM
Coal mining			1.A.2.i (coal combustion)	Mining		MINE_HC MINE_BC (no associated Hg emissions)
Mineral oils - extraction, refining and use	5.1.3	SC-DR-oil, SC-IND-oil, SC-PP-oil, CO-OR	1.A.1.a , 1.A.2, 1.A.4, 1.A.1.bc (oil combustion)	1.A.1.a:Main Activity Electricity and Heat Production 1.A.2: Manufacturing Industries and Construction 1.A.4: Other sectors including residential	Oil combustion	Extraction, refining: PR_REF Use: Sectors associated with the fuels HF, LPG, MD, GSL (PP, IN, DOM)

[1] This annex is a work in progress. The current table does not imply that the sources listed in the same row are already comparable, or that the blank cells are missing from the inventory. The intention is to further work on dividing the left columns into smaller categories to compare which inventory covers which sources under which categories.

Source and Process Categories	UNEP Toolkit Section	GMA 2018 Sector Codes	EDGARv4.tox (IPCC) Sector Codes and Names		Streets et al. Sector Categories	GAINS sector codes
				1.A.1.bc: Petroleum Refining Manufacture of Solid Fuels and Other Energy Industries		
Natural gas - extraction, refining and use	5.1.4	SC-DR-gas, SC-IND-gas, SC-PP-gas	1.A.1.a , 1.A.2, 1.A.4, 1.A.1.bc (gas combustion)	1.A.1.a:Main Activity Electricity and Heat Production 1.A.2: Manufacturing Industries and Construction 1.A.4: Other sectors including residential 1.A.1.bc: Petroleum Refining Manufacture of Solid Fuels and Other Energy Industries		Sectors associated with the fuel GAS (PP, IN, DOM)
Other fossil fuels - extraction and use	5.1.5		1.A.5	Non-Specified		
Biomass fired power and heat production	5.1.6	BIO	1.A.1.a (biomass combustion)	1.A.1.a: Main Activity Electricity and Heat Production		Sectors associated with the fuel OS1
Geothermal power production	5.1.7					Sectors associated with activity GTH (no Hg emissions associated)
Primary (virgin) metal production	**5.2**		2.C	Metal Industry		
Mercury (primary) extraction and initial processing	5.2.1	NFMP-HG	2.C.7	Mercury extraction	Mercury production	OTHER_HG
Gold (and silver) extraction with mercury amalgamation processes	5.2.2	ASGM	2.C.7	Other (ASGM)	Gold artisanal production, Silver production	AU_SGP
Zinc extraction and initial processing	5.2.3	NFMP-ZN-P, NFMP-ZN-T	2.C.6	Zinc production	Zinc smelting	PR_OT_NFME
Copper extraction and initial processing	5.2.4	NFMP-CU-P, NFMP-CU-T	2.C.7	Other (Copper production)	Copper smelting	PR_OT_NFME
Lead extraction and initial processing	5.2.5	NFMP-PB-P, NFMP-PB-T	2.C.5	Lead production	Lead smelting	PR_OT_NFME
Gold extraction and initial processing by methods other than mercury amalgamation	5.2.6	NFMP-AU	2.C.7	Other (Gold large scale production)	Gold large scale production	AU_LGP
Aluminium extraction and initial processing	5.2.7	NFMP-AL-P				PR_ALPRIM

Source and Process Categories	UNEP Toolkit Section	GMA 2018 Sector Codes	EDGARv4.tox (IPCC) Sector Codes and Names		Streets et al. Sector Categories	GAINS sector codes
Other non-ferrous metals - extraction and processing	5.2.8		2.C.7	Other		PR_OT_NFME PR_ALSEC
Primary ferrous metal production	5.2.9	PISP	2.C.1	Iron and Steel production	Ironmaking, Steelmaking	PR_BAOX PR_PIGI PR_EARC
Production of other minerals and materials with mercury impurities	**5.3**					
Cement clinker production	5.3.1	CEM	2.A.1	Cement production	Cement production	PR_CEM
Glass production			2.A.3	Glass production		PR_GLASS
Pulp and paper production	5.3.2					PR_PULP
Production of lime and light weight aggregates	5.3.3				Caustic soda production	PR_LIME
Intentional use of mercury in industrial processes	**5.4**					
Chlor-alkali production with mercury-technology	5.4.1	CSP	2.B.8	Chemical Industry		PR_CSP
VCM production with mercury catalyst	5.4.2	VCM				OTHER_HG
Acetaldehyde production with mercury catalyst	5.4.3					
Other production of chemicals and polymers with mercury	5.4.4					
Consumer products with intentional use of mercury	**5.5**					
Thermometers with mercury	5.5.1					
Electrical switches and relays with mercury	5.5.2				Electrical and measuring equipment	
Light sources with mercury	5.5.3					
Batteries with mercury	5.5.4					
Polyurethane with mercury catalysts	5.5.5				Chemicals' manufacturing	
Biocides and pesticides with mercury	5.5.6					
Paints with mercury	5.5.7					

Source and Process Categories	UNEP Toolkit Section	GMA 2018 Sector Codes	EDGARv4.tox (IPCC) Sector Codes and Names		Streets et al. Sector Categories	GAINS sector codes
Pharmaceuticals for human and veterinary uses	5.5.6					
Cosmetics and related products with mercury	5.5.9					
Other intentional product/process use	**5.6**					
Dental mercury-amalgam fillings	5.6.1				Dental	
Manometers and gauges with mercury	5.6.2					
Laboratory chemicals and equipment with mercury	5.6.3					
Mercury metal use in religious rituals and folklore medicine	5.6.4					
Miscellaneous product uses, mercury metal uses, and other sources	5.6.5					
Production of recycled metals ("secondary" metal production)	**5.7**					
Production of recycled mercury ("secondary production")	5.7.1					
Production of recycled ferrous metals (iron and steel)	5.7.2	SSC				
Production of other recycled metals	5.7.3					
Waste incineration	**5.8**		4.C	Incineration and Open Burning of Waste		Waste incineration with energy recovery: PP_EX_OTH, Fuel = OS2; Waste sectors: MSW_RUR_OTH, MSW_URB_OTH INW_OTH Waste treatment options are treated as pollution reduction technologies.
Incineration of municipal/general waste	5.8.1	WI	4.C.1	Waste incineration	Municipal waste incineration	Waste sectors associated with combustion: Technology = TREAT_INC_ENE,

Source and Process Categories	UNEP Toolkit Section	GMA 2018 Sector Codes	EDGARv4.tox (IPCC) Sector Codes and Names		Streets et al. Sector Categories	GAINS sector codes
						TREAT_INC, TREAT_BURN, SWD_FLA
Incineration of hazardous waste	5.8.2	WASOTH	4.C.1	Waste incineration	Other waste burning	
Incineration of medical waste	5.8.3		4.C.1	Waste incineration		
Sewage sludge incineration	5.8.4		4.C.1	Waste incineration		
Informal waste burning	5.8.5					Technology: UNC_BURN SWD_FLARE
Waste deposition/landfilling and waste water treatment	**5.9**					Waste sectors: MSW_RUR_OTH, MSW_URB_OTH INW_OTH; these sectors are combined with different control technologies (see sub-sectors)
Controlled landfills/deposits	5.9.1					Technology: SWD_COMP SWD_COVER
Diffuse disposal under some control	5.9.2					Technology: SWD_COVER SWD_UNM_HIGH, SWD_UNM_LOW,
Informal local disposal of industrial production waste	5.9.3					Technology: NOC, UNC_BURN
Informal dumping of general waste	5.9.4					Technology: NOC, UNC_BURN
Waste water system/treatment	5.9.5					WW_ sectors IND_sectors DOM_CC sectors (currently no Hg associated)
Crematoria and cemeteries	**5.10**					
Crematoria/cremation	5.10.1	CREM				RES_CREM
Cemeteries	5.10.2					
Others			1.A.3.b	Road Transportation no resuspension		TRA_RD

Source and Process Categories	UNEP Toolkit Section	GMA 2018 Sector Codes	EDGARv4.tox (IPCC) Sector Codes and Names		Streets et al. Sector Categories	GAINS sector codes
			1.A.3.d	Water-borne Navigation		TRA_INW, TRA_OTS (inland and coastal navigation)
			3.C.1	Emissions from biomass burning (Agricultural waste burning)		

Annex 2

Emission estimation methodologies and primary data sources[1]

1. Introduction

This annex provides an overview of methodologies employed in existing emission and release inventories at the global, regional or national levels, together with primary sources of data used for the estimation of emissions and releases.

Section 2 describes estimation methodologies for point sources, including the sources covered by Articles 8 and 9 of the Convention, as well as manufacturing processes using mercury and manufacturing of mercury-added products. Section 3 addresses artisanal and small-scale gold-mining (ASGM), which is known to be the largest source of anthropogenic mercury emissions and releases. Section 4 covers mercury emissions and releases from waste management, including those associated with the end-of-life mercury-added products. Section 5 discusses methodologies for other sources.

2. Point sources

2.1. General context

Different definitions of 'point sources' exist. Article 8 of the Minamata Convention controls emissions from coal-fired power plants, coal-fired industrial boilers, non-ferrous metals smelting and roasting, waste incineration and cement-clinker production. Article 9 addresses point sources of mercury releases to land and water not addressed in other provisions of the Convention, but the Convention does not define "point sources". This section covers emissions and releases from stationary locations or fixed facilities, including point sources addressed in Articles 8 and 9 and also facilities manufacturing mercury-added products and using mercury in industrial processes. Some jurisdictions may regard artisanal and small-scale mining and waste landfills as point source, but there are discussed in other sections.

2.2. Approaches for estimating point source emissions and releases

Mass-balance / material-flow approaches:

- Use information on the amount of fuels and raw materials utilised in a given activity and/or amounts of energy produced or product of the activity (**'activity data'**), together with information on mercury content of fuels, raw materials or products (**"input factors"**), as well as information on emission control measures in place (to establish **"output distribution factors", ODF's**), to estimate mercury inputs and emissions/releases to relevant media at different points in the process.
- Information on mercury content of fuel and raw materials and consideration of the processes involved is used to define **emission factors** (EFs) that quantify the amount of mercury emitted per unit of activity. Emission factors can be **'unabated'**, i.e., reflecting emissions in the absence of control measures, or **'abated',** reflecting emissions following application of abatement measures such as air pollution control (APC) technologies. Approaches employing activity data and EFs to calculate emissions are widely used in all inventory methods described below.
- Releases to water are estimated using similar approaches for emissions to air as described above. For some sources, it is assumed that major releases originate from the wet gas cleaning technologies used, and therefore estimated in conjunction with the emissions. For other sources, releases are estimated using the estimated flow rate of wastewater and the estimated mercury concentration in wastewater.
- Accuracy of emission estimates is dependent on the availability and accuracy of both activity data and EFs or output distribution factors employed, and all related assumptions. Important in this regard is whether the factors defined for a specific type of fuel or ore, industrial process, or location/region can be applied in other circumstances (e.g., other ore belts, countries or regions). Similarly, whether assumptions regarding effectiveness of abatement technologies can be

[1] This annex is still a work in progress.

extrapolated beyond the situations where they were originally estimated adds uncertainty to estimates. Some methods recommend using site-specific factors, when available.

- The factors used in estimating mercury emissions are a key part of documentation that is made available to individuals responsible for preparing national inventories or facility reporting to PRTRs. This documentation exists in national guidance documents (e.g., specifying requirements for national PRTR reporting), international guidance documents (e.g., EMEP/EEA air pollutant emission inventory guidebook used in connection with CLRTAP reporting) and in documentation compiled in connection with national or global inventory activities (e.g., UNEP Toolkit, AMAP/GMA, BAT/BEP guidance documents, UNEP Process Optimization Guidance).

- Transparent and adequate information on the activity data, estimation factors and any related assumptions applied in estimating emissions is essential for the validity of the estimate to be evaluated, as well as determining associated uncertainties and *post hoc* adjustments that may be required in connection with establishing time trends in emissions or ensuring comparability between estimates.

- The mass-flow approach can be applied at all scales from individual facility to national or global inventory estimates. They are the basis of work employing the UNEP-Toolkit (including most MIAs), global inventories (e.g., GMA, EDGAR), national emissions inventories (NEIs, CLRTAP reporting) and many facility estimates reported in PRTRs.

- In global inventory work, in particular, the approach relies on availability of activity data for all sectors and countries included; and in this respect data compiled (annually) by IEA (on amounts of different fuels used in energy and industry) or e.g., UNEP, USGS or industry bodies (e.g., on production of cement, ferrous and non-ferrous metals) are extremely useful if not essential. It is reasonable to assume that more appropriate (specific) information on activity levels, amounts and characteristics of fuels and raw materials used, and details of abatement technology applied would be available to inventories developed at the national or facility level; however, this is not always the case.

- One advantage of estimating emissions based on a general mass-flow approach is that quantification of amounts the difference between the amounts of mercury entering the flow, and the emissions to air, provides (quantitative) insight into amounts of mercury that may be released to land or water or accumulated in waste; this is reflected by ‘output distribution factors’ defined in the UNEP Toolkit methodology. The fate of mercury not emitted to air can be highly variable (by country, facility, etc.), leading to large real variability and associated uncertainties in the distribution to other environmental compartments. This is attempted reflected in the UNEP Toolkit methodology, with decreasing uncertainty when ensuring use of locally relevant output distribution factors.

- The chemical speciation of mercury emissions to air, whether assumed or measured, has large impacts on the extent to which emissions will be deposited locally versus transported in the atmosphere, with implications for linking emission changes to changes in environmental media as will be required in effectiveness evaluation. Inventories differ as to whether they report speciated emissions (in contrast to total mercury emissions only) and, if so, whether they report the speciation assumptions used and the source of those assumptions. As for estimation factors and abatement, the speciation is among the aspects that influence on whether measurements and assumptions can be widely extrapolated, and transparent reporting of speciation assumptions is therefore valuable. The inadequacy of the currently applied speciation schemes was one of the major needs for improvement noted during the GMA work. Considerable new relevant information has become available for specific types of sources in a few countries; however, this information may not be widely applicable at the global scale, and building out the data base on speciation is therefore a priority.

Measurement-based approaches.

- Most on-site emissions measurement are carried out at larger facilities with high emissions, often to ensure compliance with limit values; however, measurements are also conducted for research purposes including, e.g., evaluating the effectiveness of installed air pollution control devices (APCDs) or technologies, developing EFs and other estimation factors, or validating estimates based on indirect methods.

- Mercury concentrations are typically measured at the point of emission (e.g., combustion exhaust stacks), or in outlets from industrial units where mercury processes are concentrated (e.g., chlor-alkali plants). Concentration measurements alone do not quantify emissions; they need to be

combined with further measurements or estimates of the exhaust flow rate, or assumptions regarding the latter. It should be noted that emission estimates based on measurement also have associated uncertainty. Therefore, information on the amount of mercury in 'inputs' relevant for a given plant or sector may provide a useful means of validating measurement-based estimates. Indeed, such 'triangulation' should be applied wherever possible to any emission estimate to narrow down the associated uncertainty

- Reliability of measured emissions depends on a number of factors, particularly whether the measurements are made under representative conditions. This includes the frequency and duration of the measurements and whether measurements are made under all relevant operating conditions (in consideration of all pollution control systems) and cycles (many plants vary their fuels, sources of raw materials, operating parameters, etc.). Measurements made only under optimal (low emission) situations will underestimate plant emissions, and vice versa.
- Measurements can produce valuable information on emitted species that are important for characterizing emissions for purposes of determining air transport and fate, etc. However, accurately quantifying reactive forms of mercury remains difficult, with some common techniques having limited sensitivity to certain forms of reactive mercury. These measurements are valuable but should be treated with caution.
- Measurement data (and associated details of emission calculations) may be commercially sensitive, considered proprietary in nature and therefore unavailable for independent evaluation unless commissioned by public authorities or published in the scientific literature.
- *Further information is needed for measurement of mercury in wastewater being conducted.*

2.3. Available activity resources for estimating/documenting point source emissions

In the absence of national statistics on activity levels, resources (preferably compiled on the basis of globally consistent, documented and transparent methods) can be used to fill gaps; these include:

Worldwide data compilations

- International Energy Agency (IEA) (https://www.iea.org/data-and-statistics/data-sets)
- USGS (https://www.usgs.gov/centers/national-minerals-information-center/minerals-yearbook-metals-and-minerals)
- UN Comtrade (https://comtrade.un.org/data/)
- The UNEP Toolkit Reference Report's data base (https://www.unep.org/explore-topics/chemicals-waste/what-we-do/mercury/mercury-inventory-toolkit, Section 5; compilation of available relevant technology data and examples of mercury input and output data)
- *other?*

Sector focused data compilation

- OSPAR
    - Chlor-alkali (in cooperation with Eurochlor) (https://www.ospar.org/work-areas/hasec/hazardous-substances/discharges-emissions-and-losses)
- UNEP mercury partnership reports:
    - Chlor-alkali (in cooperations with World Chlorine Council)
    - Oil and gas
    - NFM smelting and mining
- World Resource Institute - Global Power Plant Database (https://datasets.wri.org/dataset/globalpowerplantdatabase)(https://resourcewatch.org/data/explore/Powerwatch)
- Wikipedia – power plants in …
- Harvard/MIT - World Electric Power Plants Database, March 2017 (https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/OKEZ8A)
- *other?*

Industry compiled data

- World Steel Association (e.g., https://worldsteel.org/steel-topics/statistics/steel-data-viewer/)
- World Chlorine Council
- CEMNET (https://www.cemnet.com/global-cement-report/)
- IPIECA
- *other?*

3. Artisanal and small-scale gold mining

Mercury emissions to air, and releases to water and land from ASGM are estimated to be over 2000 tonnes each year (UNEP Global Mercury Assessment 2018). It is the sector demanding the largest quantity of mercury, with virtually all of the mercury used released to the environment. The sector produces about 12 to 15% of the world's gold. An estimated 10 to 15 million miners, including 4 to 5 million women and children, are involved in the sector.

The Global Mercury Assessment 2018 estimated the emissions and releases of mercury based on the estimates of the amount of mercury used in ASGM and gold production methods, assuming distribution factors for different gold production methods. Such information was collected from literature and field evidence including projects to develop national action plans (NAPs), addressing the following key questions.

1. What are the practices in use? (whole ore amalgamation; concentrate amalgamation; Hg recycling - retorts)

1. How much Hg is used per unit gold produced? (the Hg:Au ratio; grams of Hg lost per gram of gold produced); Do miners discard used Hg or recycle Hg?

2. How much gold do miners produce per year? It is important to evaluate the value of the gold and consider whether that value makes sense.

3. What is the total number of miners involved in this production?

NAPs are an important data source for the relevant countries. There is also potential of incorporating a temporal dimension, when countries submit a review of their NAP (as requested by Art 7 , paraph 3 (c)) – if the same methodologies are used to obtain mercury use estimates as in the original NAP.

Regarding data uncertainties, it should be made clear that due to various challenges surrounding ASGM sector, the uncertainties might be relativity high. It should be noted that e.g. in NAPs quantitative uncertainties are not always reported – they might be expressed in narrative/qualitative manner. Further consideration is needed on how to deal with this kind of challenges while collecting/analyzing/comparing ASGM data on emissions and release.

4. Waste management

Mercury is emitted and released to the environment at various stages of the waste stream. Emissions from the controlled incineration of waste is covered in Article 8 of the Convention and included in the estimated emission from point sources. Existing inventories estimate emissions and releases including other stages, such as re-emission from landfill sites. Open burning of waste is also important since it is widely practiced in developing countries.

The Global Mercury Assessment 2018 estimates emissions from wastes associated with mercury-added products. Mercury consumed in mercury-added products is distributed on different pathways using distribution factors with emission factors applied to estimate emissions.

GMA estimates for mercury emission from the waste sector do not currently include emissions due to incineration of industrial waste and sewage sludge, or (in most cases) hazardous waste. This is because it is not currently possible to obtain reliable information on the amounts of such wastes incinerated, and more importantly the Hg content of such wastes, which can be highly variable.[2]

The UNEP Mercury Toolkit used in MIA inventories includes emissions from all common waste handling methodologies. Again, however, these estimates are based on calculation factors that can

[2] An OESG member submitted a paper on methodologies to estimate emissions from open burning of domestic waste and reemission from landfill.

locally vary significantly, and in many cases national inventory developers have not had such local data available and have instead used default input factors - Hg concentrations in waste - not specific to local conditions. In the newest Inventory Level 3, available only from 2023, the emissions and releases estimates are fully mass-flow linked to inputs with products and materials, meaning that local Hg concentrations in waste are not needed. However, this method is dependent on a thorough inventory being made for mercury-added products and materials.

5. Mercury-added products except for emissions and releases associated with their manufacturing and waste management

While most emissions and releases from mercury-added products are associated with their waste management and their manufacture, emissions and releases may occur from the use phase for some products. Most such releases and emissions however relate to breakage (for example thermometers and lamps) or diffuse littering, and these can be defined as being accounted for as (incomplete) waste management. There is little focus on emissions and releases in methodologies and data that does not in some way related to waste management or the lack thereof.

Releases and emissions from diffuse littering of waste are accounted under open waste dumping or open waste burning, as the national case may be, in the UNEP Mercury Inventory Toolkit.

Most emissions and releases from the use of dental amalgam are associated with

- Placing amalgam filling in the dental clinics (mostly from new waste amalgam, drilling particles from older filings and extracted teeth);
- Lost teeth with amalgam fillings to diffuse waste littering or to collected municipal waste; and
- Cremation (air emissions and filter waste) and burial (direct releases to land).

Releases to water (or land) are documented to occur while the amalgam fillings are in the mouth, but in the lifecycle of dental amalgam, these are usually relatively minor fractions (see the UNEP Mercury Inventory Toolkit Reference Report for details).

Emissions and releases from all these lifecycle phases are covered in the Toolkit, and therefore in the MIAs, but with varying associated uncertainty, as explained below.

The Toolkit (in levels 2 and 3) allows and recommends the use of national data on number (and weight) of fillings made. As such detailed data are lacking in many developing countries, default estimation of mercury inputs to the dental amalgam lifecycle based on national population combined with WHO data on dental personnel in the country are however used in many MIA inventories. From review of MIA inventories, a few examples have been seen where countries used both the default methodology and had access to data on number of amalgam fillings made nationally. These have indicated that the default methodology results in reasonable estimates, but they are associated with quite some uncertainty. As regards distribution of outputs, similarly, Toolkit default output distribution factors were used in most countries. The Toolkit default factors are based on available data as reviewed in the Toolkit Reference Report.

The outputs from dental clinics are highly associated with the mercury control equipment and procedures used at the clinics. Chair strainers only retail larger amalgam particles from drilling, while dedicated amalgam separators can retain up to about 95% of the mercury drilled out. Amalgam separators are in turn very dependent on correct mounting and maintenance to have high retention rates. The use of amalgam separators is only gradually increasing, and so far mostly in developed countries. Another important factor influencing the emissions and releases is the clinic’s handling of waste with dental amalgam, including extracted teeth with amalgam fillings. If this waste is incinerated or burned in the open, it will contribute to mercury emissions. Dental amalgam (large chunks) may still in some countries be recycled for recovery of the silver (and mercury) and in cases where such operations are not managed carefully to retain mercury, it may lead to emissions during the recovery operations. Treating waste with dental amalgam as hazardous waste that is disposed of environmentally soundly will result in the lowest emissions and releases.

Mercury in amalgam fillings present in deceased persons cremated are considered primarily emitted to air, unless crematoria are equipped with air pollution controls (filters) that can retain most (~95%) of the mercury. Crematoria equipped with relevant filters are most prevalent in developed countries, and also there, filter use is only gradually increasing. Most MIA inventories are developed for developing countries where filters on crematoria are rare or absent. For most such countries, outside major cities, burial is more common than cremation. The general distribution between cremation and burial in a country is primarily dependent on the religions and traditions prevailing in the countries.

6. Other sources

Further work is needed on sources not covered in the sections above, including the following:

- Coal mining
- Mercury production
- Mobile sources

Annex III*

Plan for data analysis consistent with the Monitoring Guidance[1]

(draft of 20 September 2023)

Executive summary

[to be added]

Acknowledgements

[to be added]

1. Introduction

As per its terms of reference adopted in decision MC-4/11, the Open-ended Scientific Group (OESG) shall perform a data analysis addressing the guiding questions outlined in the "Guidance on monitoring of mercury and mercury compounds to support evaluation of the effectiveness of the Minamata Convention".[2]

An overview of the adopted framework for the first effectiveness evaluation of the Minamata Convention, as contained in annex I to decision MC-4/11, and key points from the Monitoring Guidance, including its six monitoring objectives and associated guiding questions are available in the "Plan for Monitoring Data Compilation and Summary" and "Plan for the summary of available emissions and releases data".[3]

2. Objective

The objective of the present "Plan for data analysis consistent with the Monitoring Guidance" (hereafter "Plan for data analysis") is to structure and guide the OESG's analysis of available information on mercury emissions and releases and monitoring data on mercury levels in humans and the environment.

In the context of this document, "monitoring data" includes: (a) mercury observations which have associated parameters including units, time, location, etc.; (b) ancillary observations, which are observations of environmental parameters other than mercury that are needed to interpret the mercury observations, and (c) metadata, which includes information that describes the observational datasets, including the data provider, data formats, number of sites, frequency of observations, time period covered, operating procedures and quality assurance methods employed, etc.

The output of the data analysis will be a data analysis report addressing the guiding questions outlined in the Monitoring Guidance to inform the first effectiveness evaluation of the Minamata Convention. The data analysis report will be submitted to the Effectiveness Evaluation Group (EEG).

3. Planning for the analysis of data

(a) Mapping questions from monitoring to data analysis

The first step in the development of the data analysis plan was to break down the monitoring objectives and associated guiding questions of the Monitoring Guidance into themes to support the data analysis. For each data analysis theme, the OESG co-Chairs and small groups developed operational questions for each of the monitoring matrices and for emissions and releases.

* This present annex has not been formally edited.

[1] This draft plan has yet to be reviewed by Parties.

[2] Available as document UNEP/MC/COP.4/INF/12.

[3] Presented as annex 1 and 2 to the present document, respectively.

A detailed matrix of operational questions was organized according to the type of data by having one spreadsheet for each monitoring matrix, one spreadsheet for emissions and releases data and an additional spreadsheet for integrated analysis across emissions, releases and monitoring data. By alternating work under the small groups with discussions among the entire group, the OESG populated and cross-referenced the operational questions in an iterative manner.

The resulting matrix of operational questions is available as a spreadsheet the OESG document folder. It is expected that the matrix of operational questions may need to be reviewed and adapted as progress is made and experience is gained through the data analysis, as well as to account for feedback provided by the EEG.

Because the matrix of operational questions for the data analysis does not lend itself easily for presentation as a single document, Table 1 presents summary-level operational questions which capture the scope of the individual questions under each theme.

Table 1
Mapping of the data analysis themes and summary-level operational questions to guide the analysis of data by the OESG in relation to the monitoring objectives in the Monitoring Guidance.

Monitoring objectives (from the Monitoring Guidance)	Data analysis themes	Summary-level operational questions
1. Estimation of mercury concentrations for areas without (i.e., background sites) or with (i.e., affected sites) local anthropogenic sources	A. Current Levels	A.1. What are current levels of Hg emissions and releases and current levels of Hg observed in air, biota, humans, and other media?
2. Identification of temporal trends	B. Temporal Trends	B.1. How have levels of Hg emissions and releases and Hg observed in air, biota, humans, and other media changed over the available record? B.2. How do those changes compare to the timeline of the Minamata Convention? B.3. What specific mitigation measures have contributed to changes in emissions and releases? B.4. How are levels of Hg emissions and releases and Hg observed in air, biota, humans and other media expected to change in the future?
3. Characterization of spatial patterns	C. Spatial Patterns	C.1. How do current levels and temporal trends vary geographically at the global scale?
4. Estimation of source attribution of anthropogenic mercury	D. Source or Process Attribution	D.1. What is the fractional contribution of contemporary anthropogenic emissions and releases to current Hg levels observed in air, biota, humans, and other media? D.2. How have these contribution levels changed over the timeline of the Minamata Convention? D.3. How do the contribution levels and their trends vary geographically at the global scale? D.4. How have drivers other than changes in emissions and releases contributed to the trend in observed Hg levels?
5. Estimation of exposure and adverse impacts	E. Health and Ecosystem Impacts	E.1. How do current levels of Hg observed in air, biota, humans, and other media compare to levels in established guidelines, as well as to observed and projected thresholds for effects to humans, other living organisms and biodiversity based on recent research and knowledge? E.2. How do changes in Hg levels over the timeline of the Minamata Convention compare to those guideline levels and effect thresholds?
6. Quantification of key environmental processes to improve understanding of cause-effect relationships	F. Process Understanding	F.1. How consistent are current levels, temporal trends, and spatial patterns of Hg emissions and releases and Hg levels in air, biota, humans, and other media with estimates from current mechanistic models?

(b) Associated information to the operational questions

To further support the data analysis and help assess the extent to which the operational questions can be answered, a set of ten categories of information was added for each question in the matrix. The information categories are:

(a) *Relevant versus available data* – to determine the type of "relevant and applicable" data that might be used to answer the operational questions, whether the data is accessible in a usable form, and the sources and formats of data readily accessible to the Open-ended Scientific Group;

(b) *Methodological approach* – to identify an appropriate methodological approach for answering the operational question, taking into account the relevant data that are readily accessible to the Open-ended Scientific Group and whether the approach involves statistical modelling or mechanistic modelling;

(c) *Form of the answer/output* – to identify how the answer to the operational question might be expressed (for example, as a map, a time series, a figure, a table of quantitative metrics or a narrative);

(d) *Anticipated result* – to describe, based on published literature, what the answers to the operational questions might look like;

(e) *Confidence* – to assess, based on the identified methodological approach, the level of confidence in the answer (qualitative or quantitative) to the operational question; to identify quality assurance measures applicable to the data and the analysis method; and to identify the most important sources of uncertainty and potential sources of bias;

(f) *Lead responsibility* – to identify who, within the Open-ended Scientific Group or roster of experts, could take primary responsibility for performing the analysis to arrive at an answer to the operational question;

(g) *Contributors* – to identify who, within the Open-ended Scientific Group or roster of experts, could contribute to performing the analysis to arrive at an answer to the operational question;

(h) *Identified gaps* – to identify gaps in the existing data, knowledge and tools that might prevent analysis of the operational question;

(i) *Capacity needs* – to determine the capacity needs to fill the identified gaps;

(j) *Indigenous knowledge or traditional knowledge* – to identify Indigenous knowledge and traditional knowledge that might be used in the analysis.

4. Preliminary indicators related to the work of the OESG

Document UNEP/MC/COP.5/16/Add.1 lists a set of proposed indicators for consideration by the COP at its fifth meeting. Among the proposed indicators, two indicators are related to the work of the OESG. These are indicators 1 "*Levels and trends of mercury and mercury compounds in the environment and in humans due to anthropogenic emissions and releases*" and indicator 29 "*Mercury levels in vulnerable human populations*". The document notes that as the analysis of monitoring data progresses, the Open-ended Scientific Group may further elaborate on those indicators, for example, by proposing sub-indicators.

Based on the summary level questions above, the OESG organized its tentative information outputs under each analysis theme. As the OESG progresses in the analysis of data, the tentative information outputs may be used to derive a set of draft sub-indicators to support the EEG. However, owing to gaps in information and limited resources, it is important to note that not all tentative information outputs are likely to be achievable during the first effectiveness evaluation.

Table 2
Tentative information outputs from the data analysis in relation to the analysis themes.

Analysis themes	*Information outputs*
A. Current levels	Current levels of mercury emissions and releases and current levels of mercury observed in air, biota, humans and other media
B. Temporal trends	Changes over the timeline of the Minamata Convention in the levels of mercury emissions and releases and mercury observed in air, biota, humans and other media
	Specific mitigation measures that have contributed to changes in emissions and releases

Analysis themes	*Information outputs*
	Expected changes in the levels of mercury emissions and releases and mercury observed in air, biota, humans and other media
C. Spatial patterns	Geographic variation at the global scale of current mercury levels and temporal trends
D. Source or process attribution	Changes over the timeline of the Minamata Convention in the fractional contribution of contemporary anthropogenic emissions and releases to current mercury levels observed in air, biota, humans and other media
	Geographic variation at the global scale of contribution levels and their trends
	Contribution of drivers other than changes in emissions and releases to the trend in observed mercury levels
E. Health and environmental impacts	Changes over the timeline of the Minamata Convention between current observed levels of mercury in air, biota, humans and other media in relation to (i) the levels established in health guidelines and (ii) observed and expected impacts on humans, other living organisms and biodiversity based on recent research and knowledge
F. Process understanding	Consistency in the observed levels, temporal trends and spatial patterns of mercury emissions and releases and mercury levels in air, biota, humans and other media in relation to estimates from current mechanistic models

5. Implementation of the Plan for Data Analysis consistent with the Monitoring Guidance

The main milestones for the implementation of the plan data analysis are summarized below with associated tentative timelines. For several milestones, the tentative deliverable timelines depend upon further consideration by the COP, at its fifth meeting, of the overall timeline for the first effectiveness evaluation.

It is noted that the OESG has a very ambitious timeline for its deliverables, particularly because a significant amount of time will be needed to collect existing data from multiple data providers, through a process which may require the secretariat to establish data use agreements with various data providers before data analysis can begin. Furthermore, the time available to harmonize and analyse the available scientific information is very limited, especially given that this is the first effectiveness evaluation for the Convention; the necessary data management infrastructure does not yet exist; there are limited financial resources available from the Convention to fund the work, which is almost entirely reliant on in-kind contributions of the OESG and its rostered experts; and multiple opportunities for review by parties have been built into the process to improve transparency, credibility and ownership.

Table 3
Milestones and tentative timelines for the analysis of data by the OESG.

Milestones	*Tentative timeline*
Party review of draft plan for data analysis (this document)	November 2023
Hiring of consultancy services to assist the OESG in the data collection and analysis	November 2023
Invitation to Parties and other data providers to submit data to support the first effectiveness evaluation	October – November 2023
Deadline for submission by Parties and other data providers to submit data to support the first effectiveness evaluation	January 2024
Preliminary analysis of the data submitted to support the first effectiveness evaluation	TBD (pending decision at COP-5)
Completion of the analysis of the data submitted to support the first effectiveness evaluation	TBD (pending decision at COP-5)
Party review of report on the analysis of data	TBD (pending decision at COP-5)
Submission of the report on the analysis of data to address the guiding questions in the Monitoring Guidance to the Effectiveness Evaluation Group (EEG)	TBD (pending decision at COP-5)