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Policy issues: state of the environment

Global Mercury Assessment 2013: Sources, Emissions, Releases and Environmental Transport

Note by the Executive Director¹

Summary

In response to Governing Council decision 25/5, paragraph 36, the present note provides background information and key findings on worldwide atmospheric mercury emissions, releases to the aquatic environment and the transport and fate of mercury in the global environment. The summary report, *Global Mercury Assessment 2013: Sources, Emissions, Releases and Environmental Transport*, which emphasizes emissions to air from human (anthropogenic) activities but also includes, for the first time, information on mercury releases to water, is available at http://www.unep.org/publications/contents/pub_details_search.asp?ID=6282.

* UNEP/GC.27/1.

¹ Issued without formal editing.

1. Introduction

Mercury is a global threat to human and environmental health. The Global Mercury Assessment 2013 report, focusing on anthropogenic emissions of mercury and their transport and transformation in the environment, is a contribution to international efforts to reduce mercury pollution.

1. The Summary Report and the accompanying Technical Background Report for the Global Mercury Assessment 2013 are developed in response to Decision 25/5, paragraph 36 of the Governing Council of the United Nations Environment Programme (UNEP), that:

“Requests the Executive Director, in consultation with Governments, to update the 2008 report entitled “Global Atmospheric Mercury Assessment: Sources, Emissions and Transport,” for consideration by the Governing Council/Global Ministerial Environment Forum at its twenty-seventh session.”

2. The report provides the most recent information available on worldwide atmospheric mercury emissions, releases to the aquatic environment, and the transport and fate of mercury in the global environment. The report emphasizes emissions to air from human (anthropogenic) activities, but also includes new information on mercury releases to water.

3. This note presents an overview of the background, the scope and the key findings of the Global Mercury Assessment 2013. The summary report can be found at http://www.unep.org/publications/contents/pub_details_search.asp?ID=6282

2. Background and mandate

4. Global inventories for mercury emissions to air from human sources have been produced at approximately 5-year intervals since 1990 by scientific groups. UNEP produced its first Global Mercury Assessment in 2002. In 2007, the Governing Council of UNEP through its decision 24/3 requested the Executive Director of UNEP:

“to prepare a report, drawing on, among other things, ongoing work in other forums, addressing:

Best available data on mercury atmospheric emissions and trends including where possible an analysis by country, region and sector, including a consideration of factors driving such trends and applicable regulatory mechanisms;

Current results from modelling on a global scale and from other information sources on the contribution of regional emissions to deposition which may result in adverse effects and the potential benefits from reducing such emissions, taking into account the efforts of the Fate and Transport partnership established under the United Nations Environment Programme mercury programme.”

5. The results of this request were presented as a summary report entitled “The Global Atmospheric Mercury Assessment: Sources, Emissions and Transport”, released in December 2008, and an accompanying “Technical Background Report to the Global Atmospheric Mercury Assessment”.

6. The Technical Background Report, which formed the basis for statements made in the summary report and was prepared in cooperation with the Arctic Monitoring and Assessment Programme (AMAP) Secretariat, included an updated inventory of anthropogenic emissions of mercury to the atmosphere. The inventory was based on national emissions data for the year 2005 submitted by governments, as well as estimates, based on a consistent methodology, prepared for countries that did not provide data.

7. In 2009, the Governing Council of UNEP, through its Decision 25/5, paragraph 36, requested the Executive Director of UNEP:

“... in consultation with Governments, to update the 2008 report entitled Global Atmospheric Mercury Assessment: Sources, Emissions and Transport for consideration by the Governing Council/Global Ministerial Environment Forum at its twenty-seventh session.”

8. The updated Global Mercury Assessment 2013 and its accompanying and updated Technical Background Report are the response to that Governing Council request.

3. Developing the 2013 Report

9. As in 2008, the *Technical Background Report for the Global Mercury Assessment 2013* forms the basis for the statements made in the Summary Report and is fully referenced according to standard scientific practice. As such, it is the single reference for the Summary Report. It has again been prepared in co-operation with the Arctic Monitoring and Assessment Programme (AMAP) and uses national data and information submitted by several governments, as well as information and data from the published scientific literature. Contributions have also been incorporated from the UNEP Global Mercury Partnership, in particular its partnership areas on mercury control from coal combustion, reducing mercury in artisanal and small-scale gold mining (ASGM), and mercury air transport and fate. Additionally, information was provided by the AMAP mercury expert group; UN Economic Commission for Europe (UN ECE) Long-range Transboundary Air Pollution (LRTAP) Convention groups; industry; and non-governmental organizations. Each section was prepared by a team of experts and then reviewed to ensure its scientific accuracy. The evaluation of information of mercury released into the aquatic environment benefits from contributions from the Group of Experts on Scientific Aspects of Marine Environmental Protection (GESAMP).

4. Scope and coverage

10. The update to the Global Mercury Assessment provides the most recent information available for the worldwide emissions, releases, and transport of mercury in atmospheric and aquatic environments. Since the Global Mercury Assessment is intended as a basis for decision making, emphasis is given to anthropogenic emissions (mercury going into the atmosphere) and releases (mercury going into water and land), that is, those associated with human activities.

11. The Technical Background Report includes a detailed inventory of global mercury emissions to air based on data for 2010. "Inventory" in this context means a compilation of the estimated emissions and releases from various sectors and sources. While it attempts to catalogue all major sources of mercury emissions worldwide, it should not be regarded as complete and exhaustive.

12. In addition, for the first time, this Global Mercury Assessment includes an evaluation of information of mercury released into the aquatic environment and its associated pathways and fate. The information available for this evaluation is less complete than that for emissions to air and is based on data from recent years. The inclusion of this new element of the Global Mercury Assessment is as a response to the requests from many governments for more information on releases to land and water.

13. The Technical Background Report includes chapters on:

- *Global Emissions of Mercury to the Atmosphere*, describing sources, anthropogenic emissions, and trends in emissions;
- *Atmospheric Pathways, Transport and Fate*, examining pathways, levels and trends in air and deposition, and modelling of pathways and deposition;
- *Global Releases of Mercury to Aquatic Environments*, containing global estimates of releases to water; and
- *Aquatic Pathways, Transport and Fate*, examining mercury pathways in aquatic systems that result in important routes of human exposure.

14. Technical Background Report chapters were prepared by teams of experts and then reviewed to ensure their scientific validity. The summary report is then based on the content of the Technical Background Report and has been reviewed by the authors of the Technical Background Report. It was also circulated for national review and comment.

5. What's new in the Global Mercury Assessment 2013

15. Global mercury emissions inventories continue to improve as new and better data become available concerning some sources. The method for compiling the inventory of anthropogenic emissions to the atmosphere has also been revised and improved. Differences in air pollution control technologies and differences in the mercury content of raw materials and fuels in different countries and regions have been factored into emissions calculations to better reflect actual conditions in each country.

16. In the Global Mercury Assessment 2013, a new updated inventory, based on data from 2010, is presented in which some new sources (including emissions from combustion of natural gas and primary aluminium production and emissions associated with oil refining) have been quantified for the first time. A more detailed analysis has also been made of some of the major mercury emission sectors, including the break-down of emissions from coal burning in power plants, industrial and other uses. In addition, new information acquired through the UNEP Global Mercury Partnership area on Reducing Mercury in Artisanal and Small-scale Gold Mining, in particular from the Artisanal Gold Council, has resulted in a significant re-evaluation of emissions from the ASGM sector.

17. New observational data and new modelling results provide fresh insight into atmospheric mercury transport and fate.

18. One of the objectives of the updated assessment has been to provide transparent documentation and comprehensive compilations of the data that form the basis for all of the estimates presented. This approach will allow a more consistent and replicable method for compiling the global mercury emission inventory, so that valid comparisons can be made in the future. In addition, a wider range of experts from around the world have been involved in preparing the Technical Background Report on which this summary is based.

19. The inclusion of an assessment of releases of mercury to the aquatic environment and its subsequent pathways and fate is a further significant development as these topics were not addressed in the 2008 UNEP Global Atmospheric Mercury Assessment. The aquatic environment is critical for the following reasons:

- Hundreds of tonnes of mercury are estimated to be released directly into water, so an inventory limited to mercury emissions to air provides an incomplete assessment of anthropogenic impacts on the mercury cycle.
- Mercury in aquatic environments can be transformed into methylmercury, which is far more toxic to humans and animals and can enter and biomagnify in food webs more readily than other forms of mercury.

6. Key findings and conclusions of the 2013 assessment

20. The 2010 emissions inventory has several improvements over the previous inventory for 2005, including:

- A more detailed analysis of emissions from some major source sectors.
- A more detailed consideration of the mercury content of fuels and raw materials used in different countries/regions.
- New and updated information on artisanal and small-scale gold mining.
- The use of different pollution control technologies in different countries and regions have been factored into the emissions estimates.
- Emission estimates for sectors not previously included, such as aluminium production, oil refining, and contaminated sites.
- More and better information on location of major point sources such as individual power plants, smelters and cement kilns.
- Better documentation and greater transparency with respect to the data and information behind the estimates

21. Using this approach, the global emissions to air from anthropogenic sources is estimated at 1960 tonnes in 2010. Despite recent progress in improving the available knowledge base, the emissions estimate still has large associated uncertainties, giving a range of 1010-4070 tonnes. The work also identifies potentially important sectors that are not yet quantified, including use of mercury in vinylchloride monomer production; secondary metals production and ferro-alloys; oil and gas extraction and transport; and industrial and some hazardous waste incineration.

22. Present day anthropogenic emissions contribute to both current and future emissions to the air. Current anthropogenic sources are responsible for about 30% of annual emissions of mercury to air. Another 10% comes from natural geological sources, and the rest (60%) is from 're-emissions' of previously released mercury that has built up over decades and centuries in surface soils and oceans. Although the original source of this reemitted mercury cannot be determined with certainty, the fact that anthropogenic emissions have been larger than natural emissions since the start of the industrial

age about 200 years ago implies that most re-emitted mercury was originally from anthropogenic sources. Reducing current anthropogenic sources is therefore vital to reduce the amount of mercury that is cycling in the environment.

23. The inventory confirms the role of artisanal and small-scale gold mining (ASGM) and coal burning as the largest components of anthropogenic emissions, followed by the production of ferrous and non-ferrous metals, and cement production.

24. Annual emissions from ASGM are estimated at 727 tonnes, making this the largest sector accounting for more than 35% of total anthropogenic emissions. This is more than twice the figure from this sector in 2005; however, most of the increase is attributed to new and better information. For example, West Africa was thought in 2005 to have minimal ASGM activity, but is now recognized as an important source region. It is thus difficult to determine whether actual emissions from this sector have changed because their estimation involves a great deal of uncertainty. Much of the activity is unregulated or even illegal, and thus reliable official data are still hard to obtain. More work is needed to confirm the emissions estimates from this sector, including field measurements around ASGM sites to better establish the amounts and fate of the mercury used.

25. A large amount of coal is burned around the world to generate electricity, to run industrial plants, and for in-home heating and cooking. Coal burning emitted some 475 tonnes of mercury in 2010, the majority of which is from power generation and industrial use. The estimate of emissions from other coal burning (including domestic and residential burning) is lower than that reported in the previous global assessment, due to differences in estimates of the amounts and mercury content of coal burned in these uses. Use of coal for power generation and industry is increasing, especially in Asia. However, wider use of air pollution controls and more stringent regulations in several countries, together with improved combustion efficiency, have reduced emissions from coal-burning power plants, helping to offset most of the increase arising from higher coal consumption.

26. Emissions to air are thought to have peaked in the 1970s, declined over the following two decades, and have been relatively stable between 1990 and 2005. There were some indications of slight increases in emissions between 2000 and 2005.

27. Any evaluation of trends needs to take into account changes in reporting and methods used to produce inventory estimates, including the introduction of additional sectors. Thus, a direct comparison of the results of global inventories produced over the past 25 years is not possible. A preliminary recalculation, using the improved methodology, of global anthropogenic emissions in 2005 indicates that emissions from fossil fuel combustion, metal and cement production increased between 2005 and 2010, but continue to decline in other sectors such as the chlor-alkali industry. Overall, indications are that emissions from industrial sectors have increased again since 2005.

28. Future emission trends have been examined using scenarios and models. Without improved pollution controls or other actions to reduce mercury emissions, mercury emissions are likely to be substantially higher in 2050 than they are today.

29. The 2010 global inventory results were generally consistent with nationally reported emissions estimates for 2010, providing a degree of confidence in the methods used. However, comparing estimates for individual countries and sectors is complicated by differences in reporting methods, in particular the specification and categorisation of sectors used in different national and international reporting systems. National emissions estimates based on individual facility reporting and site measurements should be more accurate than those based on the global inventory methodology. However, this is difficult to evaluate as most nationally reported inventories lack estimation of associated uncertainties. It is also important to recognize that many measurement based estimates are based on relatively few measurements covering short periods that are then extrapolated to produce annual emissions. It is important that all reporting is subject to validation and that associated uncertainties are quantified. If different reporting systems are to be compared, they need to be better aligned in terms of the emission sources that are identified and used.

30. Increasing industrialization has made Asia the main source region of mercury emissions to air, with East and Southeast Asia accounting for about 40% of the global total, and South Asia for a further 8%. The new data on ASGM and the related increase in emission estimates from this sector have increased South America and sub-Saharan Africa's share of global emissions. However, modelling results continue to indicate that East Asia is the dominant source region for long-range airborne mercury transport worldwide.

31. Previous UNEP global mercury assessments considered only atmospheric emissions. The 2013 report is thus the first attempt to compile a global inventory of aquatic releases. Three types of sources were considered. Point sources are industrial sites such as power plants or factories, and they release

an estimated 185 tonnes of mercury per year. Contaminated sites, including old mines, landfills, and waste disposal locations, release 8 - 33 tonnes per year. Artisanal and small-scale gold mining was evaluated separately, with total releases to water and land totalling more than 800 tonnes per year. Deforestation mobilizes another 260 tonnes of mercury into rivers and lakes. Other sources remain to be quantified, and so these estimates comprise only a partial total. Thus, anthropogenic releases to waters are likely to be at least 1000 tonnes per year.

32. Anthropogenic emissions and releases have doubled the amount of mercury in the top 100 meters of the world's oceans in the last 100 years. Concentrations in deeper waters have increased by only 10-25%, because of the slow transfer of mercury from surface waters into the deep oceans. In some species of Arctic marine animals, mercury content has increased by 12 times on average since the pre-industrial period. This increase implies that, on average, over 90% of the mercury in these marine animals today comes from anthropogenic sources. The timing of the initial stage of the increase, which started in the mid-19th century and accelerated in the early 20th century before the rise of Asian industrialization, indicates emissions from Europe, Russia and North America were probably responsible. Studies from the South China Sea suggest a similar pattern occurring there more recently, likely as a result of Asian industrialization.

33. Existing mercury monitoring networks such as the European Monitoring and Evaluation Programme (EMEP), the Arctic Monitoring and Assessment Programme (AMAP), the North American Mercury Deposition Network (NAMDN), and others in the northern hemisphere have been complemented by new monitoring sites in the southern hemisphere, in particular, some sites established under the Global Mercury Observing System (GMOS) initiative. The longer-term status of many of the newly established sites however depends on availability of sustained funding to continue operations.

34. Large amounts of mainly inorganic mercury have accumulated in the environment, in particular in surface soils and in the oceans, as a result of past emissions and releases. Owing to their larger volumes, intermediate and deep ocean waters below 100 metres actually store much larger tonnages of anthropogenic mercury than surface waters. There are also relatively large tonnages of natural mercury circulating in the intermediate and deep waters. A significant fraction of the mercury in intermediate waters is recycled back to the surface each year by upwellings. Today's anthropogenic emissions continue to load the oceans, and the catchments and sediments of lakes and rivers, with inorganic mercury. This mercury, which is the "feed-stock" for toxic methylmercury production, is stored and recycled in the bioavailable part of the environment for decades or centuries before it eventually is removed by natural processes. One consequence is that there will likely be a time-lag of years or decades, depending on the part of the water column, before emissions reductions begin to have a demonstrable effect on mercury levels throughout the environment and in the fish and marine mammals which are part of the human food-chain. At the same time, mercury levels in parts of the Atlantic Ocean are decreasing, likely due to reduced emissions in past decades in North America and Europe, indicating that emissions reductions can eventually lead to decreases in mercury levels in surface oceans. This reinforces the need to continue and strengthen international efforts to reduce current mercury emissions and releases, as delays in action now will inevitably lead to slower recovery of the world's ecosystems in future from mercury contamination.

35. Global climate change may also complicate the response of global ecosystems to mercury emission reductions, through its profound effects on many aspects of the movement and chemical transformations of mercury in the environment. For example, warmer temperatures may increase rates of organic productivity in freshwater and marine ecosystems, and rates of bacterial activity, possibly leading to faster conversion of inorganic mercury to methylmercury. Thawing of the enormous areas of northern frozen peat lands may release globally significant amounts of long-stored mercury and organic matter into Arctic lakes, rivers and ocean.
