United Nations Environment Programme

Global Mercury Assessment 2013

Sources, Emissions, Releases and Environmental Transport

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Cover photo: Tuna fish (Ugo Montaldo / Shutterstock.com). Marine food-webs are an important route of human dietary exposure to mercury.

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Executive Summary

Mercury is a global threat to human and environmental health. This 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.

This 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.

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 includes releases to water because the aquatic environment is the main route of exposure to humans and wildlife. It is in aquatic systems that the inorganic mercury is transformed into the more toxic form, methylmercury, which can accumulate in fish and marine mammals consumed by humans.

This Executive Summary presents an overview of the key findings of the Global Mercury Assessment 2013.

Total anthropogenic emissions of mercury to the atmosphere in 2010 are estimated at 1960 tonnes.[2]

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

Using this approach, the global emissions to air from anthropogenic sources is estimated as 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 vinyl-chloride monomer production; secondary metals production and ferro-alloys; oil and gas extraction and transport; and industrial and some hazardous waste incineration.

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 re-emitted 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

[2] 1 tonne = 1000 kilograms

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.

Artisanal and small-scale gold mining and coal burning are the major sources of anthropogenic mercury emissions to air

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.

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 some 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.

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.

Global anthropogenic mercury emissions from industrial sources may be rising.

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.

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 re-calculation, 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.

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.

Comparing emissions estimates reported under different reporting systems is not straightforward

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.

Asia contributes almost half of global anthropogenic mercury emissions.

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.

Anthropogenic releases of mercury to water total 1000 tonnes at a minimum.

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.

Mercury concentrations in the oceans and in marine animals have risen due to anthropogenic emissions.

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.

Monitoring capability continues to improve, but whether this can be sustained is uncertain.

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.

Anthropogenic emissions and releases over time have increased mercury loads in the environment, so the effects of reductions in emissions will often take time to become apparent.

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 re-cycled 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.

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 peatlands may release globally-significant amounts of long-stored mercury and organic matter into Arctic lakes, rivers and ocean.