WASTE MERCURY PERSPECTIVE

2010 – 2035 | FROM GLOBAL TO REGIONAL

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LIST OF ACRONYMS

ASEAN	Association of Southeast Asian Nations
ASM	Artisanal and Small-Scale Mining
BCRC	Basel Convention Coordination Center
Ca.	per Capita
CEIT	Countries with Economies in Transition
CFLs	Compact Fluorescent Lamps
Comtrade	United Nations International Trade Statistics Database
CoP	Conference of Parties
CPC	Central Product Classification
DC	Developing Country
EAs	Enabling Activities
EEE	Electric and Electronic Equipment
ESM	Environmentally Sound Management
EPR	Extended Producer Responsibility
EU	European Union
FDP	Flat Panel Display
FMEnv	Federal Ministry of Environment (Nigeria)
g	Grams
GC	Governing Council
GEF	Global Environment Facility
Hg	Mercury
HS	Harmonized Commodity Description and Coding System
kt	Thousand metric tonnes
IOMC	nter-Organization Programme for the Sound Management of Chemicals
ISWA	International Solid Waste Association
LFLs	Linear Fluorescent Lamps
MIA	Minamata Initial Assessment
Mt	Million metric tonnes
NAFDAC	National Agency For Food & Drug Administration and Control
NEWMOA	Northeast Waste Management Officials' Association
non-EEEs	non-Electric and Electronic Equipment
OECD	Organisation for Economic Cooperation and Development
PPP	Purchasing Power Parity
RoHS	Restriction of Hazardous Substances
SCYCLE	Sustainable Cycles
SON	Standard Organization of Nigeria
t	tonne
UN Environment	United Nations Environment
UNEP	United Nations Environmental Programme
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
UNITAR	United Nations Institute for Training and Research
UNU	United Nations University
VINACHEMIA	Vietnam Chemicals Agency
WEEE	Waste Electrical and Electronic Equipment
WHO	World Health Organization
ZMWG	Zero Mercury Working Group

*Within the report, the following terminology is adopted.
Waste mercury > refers to the Hg content of the mercury added product
Mercury added product waste > refers total waste generated from Hg added products

EXECUTIVE SUMMARY

The adoption of the Minamata Convention on Mercury represents a milestone for chemical safety, to protect the human health and the environment. It is a demonstration of the important role of a multilateral treaty responding to a threat with global dimension. The Convention, in fact, contains provisions that relate to the entire life cycle of mercury, including controls and reductions across a range of products, processes, and industries in which mercury is used, released, or emitted.

In the hope of supporting the Convention Parties in implementing the provisions in a more coordinated matter, this report provides a forecast of the volume of waste mercury in electronic and electric products, and in a set of other non-electronic product categories, in the next 15-20 years.

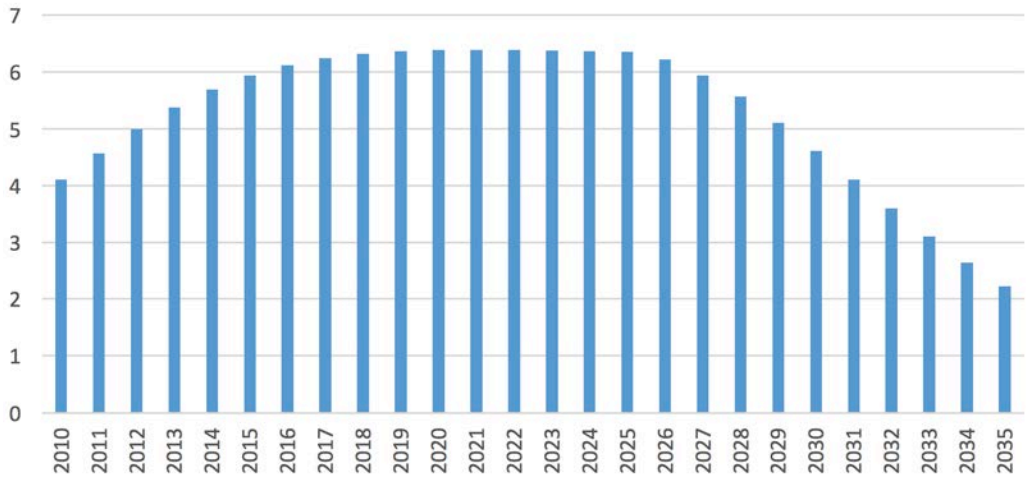
In fact, a better understanding of the volumes of waste mercury, and its distribution worldwide, guides governments and relevant bodies in the development of regional and global policies to adopt measures to manage mercury waste in an environmentally sound manner as required by the Minamata Convention.

The forecasts of the waste mercury generated worldwide were developed based on an internationally recognized methodology and measurement framework to compile e-waste statistics developed by the Sustainable Cycles (SCYCLE) Programme of UNU. In this study 'waste mercury' only refers to mercury-added products, both electric and electronic equipment (EEE) (lamps, screens and small IT) and non-EEE (thermometers, barometers, hygrometers). It does not consider other sources such as waste mercury generated by the chlor-alkali industry, the cement industry, the natural gas extraction, and the Artisanal and Small-Scale Mining (ASM), which are regulated by Article 4 of the Minamata Convention on Mercury. From a methodological point of view, the quantitative estimate of waste mercury, for a range of EEE and non-EEE products for which the data were available, has been integrated with an assessment of legal provisions and data on consumption or trade related to the remaining set of products (batteries, cosmetics, pesticides, biocides, manometers, sphygmomanometers). In order to gain a general outlook on waste mercury, at both the global and regional levels, sales of electric and electronic products and non-electric measuring devices were calculated from the UN-Comtrade database. Weibull functions were then used to calculate waste from mercury-added products and an assessment of the waste mercury embedded in those products was possible, taking into account their composition. The overall analysis thus provides a comprehensive estimate of waste mercury worldwide until 2035.

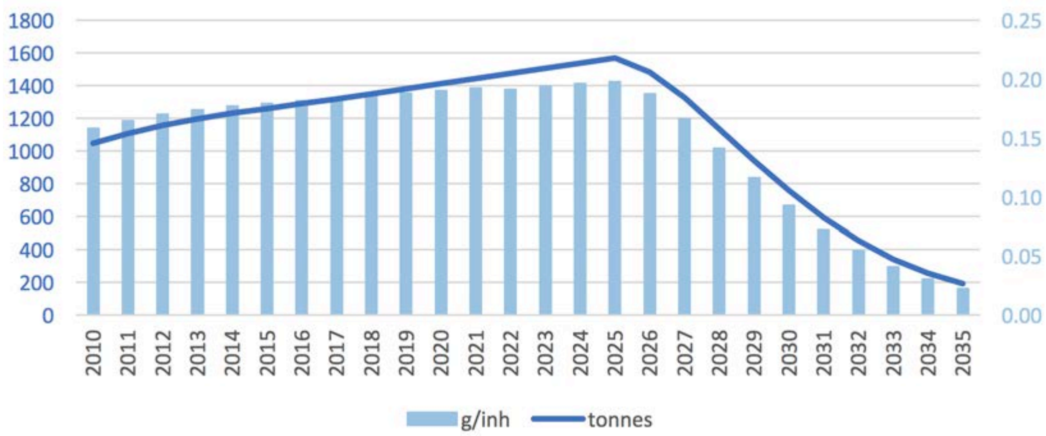
In 2017, 6.2 million metric tonnes (Mt) of mercury-added product waste were generated worldwide, of which around 1,300 tonnes were waste mercury (the mercury content of the mercury-added product waste) – namely approximately 0.18 grams per capita. The global quantity of waste of mercury added EEE plus non-electronic measuring devices was 4.1 Mt in 2010. As a general trend, it gradually increased by an average of 7% per year until 2018, reaching a 2018-2025 plateau of around 6.4 Mt. After 2025, the mercury-added product waste is expected to decrease rapidly, as this is the final phase-out date for all the parties of the Convention. In fact, while the phase-out date for banning the manufacturing, import, or export of mercury-added products has been set at year 2020, certain countries have already asked for an extension, for both part of and for the entire range of relevant products. Thus, for the purpose of this report, 2025 has been considered as the average date in which countries will not be producing/exporting/importing mercury-added products anymore.

Similarly, the amount of mercury contained in waste products is expected to slowly grow until 2025 - up to a maximum of about 1550 t of mercury– and then decrease rapidly in response to the Convention's ban on production, export and import. It is estimated that in 2035 the mercury content of waste products will be around 190 t: that is only 12% of the mercury content of waste products that is expected to be generated in 2025.

Global mercury-added product waste - time series (Mt)



Global mercury content in the mercury-added waste – time series (tonnes mercury and g mercury /ca.)

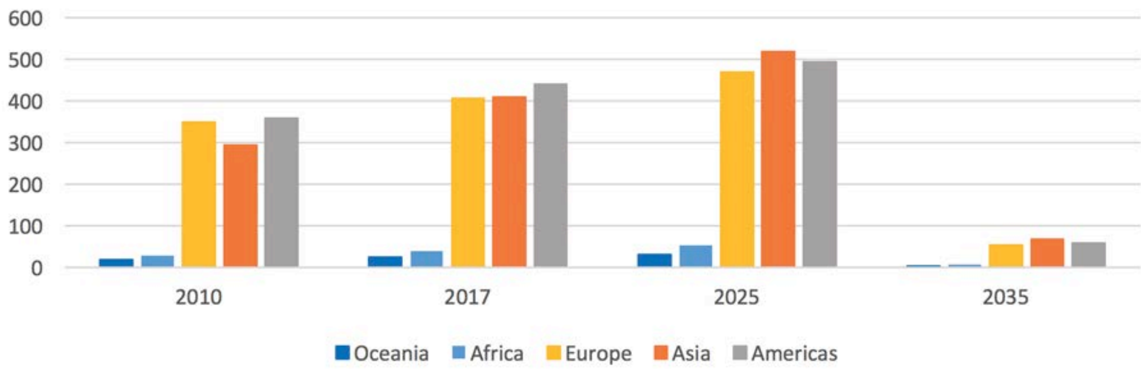


The highest quantities of waste mercury are estimated to derive from non-electric measuring devices, which constitute most of the total waste mercury in terms of total quantities. The analysis also illustrated that the generated waste mercury in thermometers is relatively low, in comparison to that of hygrometers and barometers, and the decrease of waste volume from 2025 will therefore be lower than the decrease of hygrometers and barometers. For lamps, most of the generated waste in 2017 is from straight tube fluorescent lamps (39 tonnes); the generated waste from special lamps is estimated at 19 tonnes. The data shows both a smooth increase until 2025 and then a rapid decrease in the following 10 years.

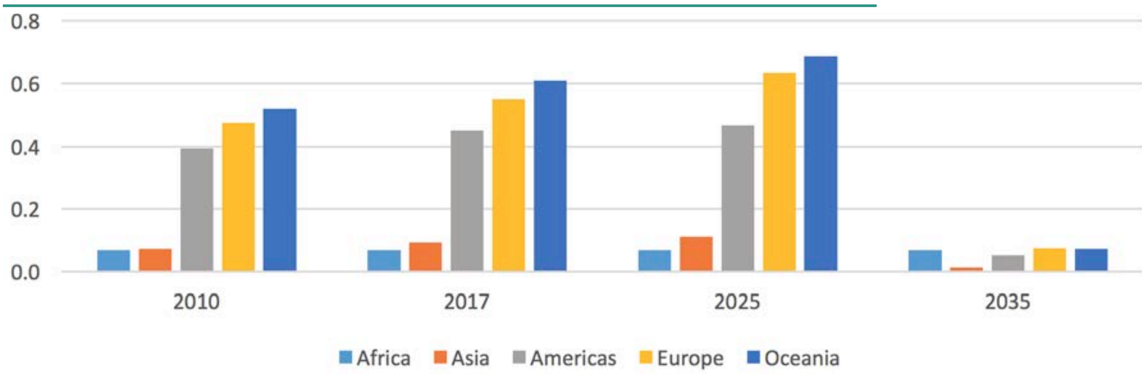
An overview of the amount of waste mercury by geographical region, in g/ca. and tonnes, is illustrated in the graphics below; while the list of countries is further detailed in Annex 3.

The graphics on the next page immediately show that in 2017 Americas is the continent that generate the highest amount of waste mercury in absolute quantity - equivalent to 439 t; and Americas and Europe are just behind Oceania in grams per capita. Oceania is estimated to generate considerable amount of waste mercury per capita (0.6 g/ca., in 2017) due to the relatively high per capita consumption of mercury added products.

Waste mercury generation per continent - time series (tonnes)



Waste mercury generation by geographical region - time series (g/ca.)



In addition to the study of the mercury-added products electric and electronic equipment (EEE) (lamps, screens and small IT) and non-EEE (thermometers, barometers, hygrometers), a literature assessment was made for the mercury-containing product categories 'pesticides, biocides, topical antiseptics', 'manometers, sphygmomanometers' and 'cosmetics'. For these categories there were no matching HS code in the Comtrade database, or the HS codes were too general and not representative of the products containing mercury. The assessment assembles information on the mercury content of the products, relevant regulations and production and consumption estimates from non-governmental organisations, intergovernmental organisations, scientific literature and recycling companies.

The analysis of the mercury content per product showed that the ratio of mercury content varies because there are different product brands and different types of manufacturing of the product. The different indications of mercury per product complicates the quantification of waste mercury, as only an average can be used with analyzing these products. As mentioned, the Minamata Convention prohibits the manufacturing, import, or export of the above product categories from 2020 or 2025. It was found that in many countries the use of these mercury-containing products is already banned and is expected to be phased out in the coming years. This confirms that the trend in consumption is generally decreasing. However, there are countries that are the exception, and where mercury could still be used or in waste stocks. Because the phase out of these categories is only in certain countries and regions, a global analysis based on relevant regulations was not possible. The closest comparable estimate to the generated waste mercury in these products is from UN Environment (2017), who estimated the total consumption of batteries and of mercury compounds (including cosmetics, pesticides, and fungicides) was between 374 t and 796 t in 2015.

1. INTRODUCTION

1.1 Objective of the study

Mercury (Hg) is a heavy, silvery-white metal, which is liquid at room temperature and evaporates easily.[1] Mercury has been used since antiquity, and even nowadays it is commonplace in our daily lives. A number of products, such as electrical and electronic devices, switches, and relays, measure and control equipment, energy-efficient fluorescent light bulbs, batteries, along with cosmetics, pesticides, biocides, and food products - among others - can contain mercury.

At the same time, there are safe and cost-effective replacements for nearly all mercury-added products, including health care applications and pharmaceuticals, [2] and precise goals have been set at the international level – by the Minamata Convention - to phase out many mercury-containing devices altogether. In fact, the negative effects that mercury poses on nature, and its consequences to the human health, have garnered attention in the international agenda in recent years.

A recent report by the United Nations Environment Programme - UNEP (2017) [3] provides an overview of the current state of the worldwide mercury market, which has seen fundamental changes in recent years, including major disruptions, sometimes occurring during relatively short periods of time. One of the influencing factors has certainly been the adoption of the Minamata Convention on Mercury, which includes a number of provisions to control the supply, trade, use of mercury, and management of waste. The text of the Convention was adopted by the Conference of Plenipotentiaries on 10 October 2013 in Japan. [4] Its main objective is to protect both the environment and human health from the anthropogenic emissions and releases of mercury and mercury compounds, by setting out a range of measures to meet that objective. It launched in 2017 and has up to now 98 parties. "The adoption of the Minamata Convention was seen as a milestone for chemical safety and the environment, as a groundbreaking treaty addressing a substance throughout its life cycle, and as proof that multilateralism can work". [5] One of the reasons for its success, in fact, lies in the fact that the threat has a global dimension, and no country argued with the fact that the need for global action was real and urgent.

In this overall process, the United Nations Industrial Development Organization (UNIDO) plays an essential role in assisting member states with the implementation of the main provisions of the Minamata Convention, including in the field of the sound management of waste mercury.

On 10-11 September 2018, a UNIDO Expert Group Meeting on waste mercury management took place in Vienna, involving more than 60 representatives from governments, the waste mercury management sector, civil society, academia and other relevant UN agencies and international bodies.

The Expert Group Meeting provided an opportunity to present the current status of the waste mercury management from different perspectives; to facilitate the exchange of knowledge and transfer of existing or innovative technologies among the different stakeholders; to assess the most interesting elements of a roadmap towards an integrated approach for the sound management of waste mercury, and possibly e-waste.

From this perspective, the present report represented a background document for the UNIDO conference, aimed at estimating the volume of waste mercury in electronic and electric products, as well as in a set of other product categories, in the next 15-20 years. A better understanding of the quantities, differentiated by types of waste, and impacts of mercury-containing waste, both in the present and in the near future, and its distribution worldwide is essential to guide governments in the development of national and regional policies and to monitor the impact of measures to manage waste mercury in an environmentally sound manner. Overall, this study should also help the Parties to implement the provisions of the Minamata Convention in a more organized manner.

More specifically, this research has been conducted by a team of experts from the Sustainable Cycles (SCYCLE) Programme [6] of the United Nations University (UNU), in close collaboration with the UNIDO team dealing with the Minamata Convention. Its main goal is to present a research study on the annual waste mercury volume produced in the different UN regions, including an estimate of the volume up to the year 2035, providing a break-down at the sub-regional level.

It's worth highlighting that for the purpose of this study, 'waste mercury' refers only to mercury-added products, both electric and electronic equipment (EEE) and non-EEE as further specified in the methodology, and it does not consider other possible sources, such as waste mercury generated by the chlor-alkali industry, the cement industry, natural gas extraction, Artisanal and Small-Scale Mining (ASM), etc.

Mercury-added products include both manufactured and formulated products. A manufactured product is a combination of individual components, one or more of which has added mercury, that combine to make a single product. A formulated product comprises a consistent mixture of chemical components that together form a particular function.

The mercury-added products considered in the present study include both manufactured and formulated products, namely: batteries; electric components including switches and relays; compact fluorescent lamps (CFLs) and linear fluorescent lamps (LFLs); displays; pesticides/biocides/ topical antiseptics; cosmetics; non-electronic measuring devices, such as barometers, hygrometers, manometers, thermometers and sphygmomanometers.

While providing the relevant stakeholders with new geo-referenced statistics and estimates on waste mercury volumes, this report also represents an important contribution and reflection on the main limits and gaps of existing data in this field. The report also demonstrates a novel methodology to monitor mercury flows, which can be potentially used to calculate global and regional baselines to help measure the impacts of the Minamata convention.

The preliminary findings of this study were discussed in Vienna, and the different inputs and contributions collected during the event were subsequently integrated in the final version of the report, herewith presented.

1 United Nations Environment Programme (2013b), Mercury time to act, available online at: http://cwm.unitar.org/cwmplatformscms/site/assets/files/1254/mercury_timetoact.pdf

2 Examples include non-mercury thermometers or blood pressure devices.

3 UN Environment (2017a), Global mercury supply, trade and demand. United Nations Environment Programme, Chemicals and Health Branch, available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/21725/global_mercury.pdf?sequence=1&

4 For a more detailed analysis on the negotiation process and the main provisions of the Minamata Convention relevant for this study, see also the next section of this report 1.2

5 Eriksen H.H. and Perrez F.X. (2014), "The Minamata Convention: A Comprehensive Response to a Global Problem", in Review of European, Comparative & International Environmental Law – Special Issue: International and European Chemical Regulation, Vol. 23 – n.2, pp. 195-211.

6 For an overview of the current activities of UNU - SCYCLE, see: https://scycle.vie.unu.edu

1.2. The Minamata Convention on Mercury

1.2.1 The origins of the Convention [7]

Mercury has been used for a long time because of its unique properties, as at normal temperature it is a liquid metal. However, its toxicity has also been known since slaves were sent into Roman mercury mines, and long before, especially the negative effects that direct exposure to mercury vapors can have on human health. On the other hand, the negative effects of organic methylmercury were only identified more recently, during the 1960s - 70s.

The most notable event was the catastrophic pollution in Minamata (Japan), where methylmercury-tainted industrial wastewater poisoned thousands of people, leading to a range of debilitating symptoms of tripping that became known as 'Minamata disease'. Even at a low level of exposure, methylmercury is extremely toxic. Health effects can include damage to the central nervous system, thyroid, kidneys, lungs, immune system, etc. Its damage to the brain cannot be reversed, and newborn babies are amongst the most vulnerable and sensitive to its adverse effects. [8]

Once mercury is released into the environment, it persists in the atmosphere (mercury vapor), soil (ionic mercury) and aquatic phase (methyl-mercury-ion CH_3Hg^+). Some mercury in the environment ends up in the food chain because of bioaccumulation and bio magnification and is eventually ingested by humans.

Risk reduction measures for mercury were increasingly adopted in national legislation in the 90s, including in the EU. At the international level, there were initiatives under the North Sea Conferences and OSPAR Convention for the North-East Atlantic. [9]
Due to the increasing global releases and the potential severe risks to human health and to the environment, in 2001 - at the 21st session of the UNEP Governing Council (GC) - the United States proposed a study on mercury, supported by the EU and Iceland and by a strong call for action from the Arctic Council. There was a proposal from some countries that the assessment should cover other heavy metals as well. Finally, UNEP received the mandate to undertake an assessment only of mercury and its compounds, and to report on the results to the 22nd GC (Decision 21/5 Mercury Assessment (9 February 2001)).

The first Global Mercury Assessment was presented in 2003 and the UNEP GC considered that it contained sufficient evidence on the adverse impacts of mercury and its compounds to warrant further international action to reduce the hazardous effects on human health and the environment.

All the proponents for a legally binding approach to mercury, which included EU-members, Switzerland, Norway, but also support by the African Group and some Latin American countries, argued that in light of the global dimension of the problem, including transboundary externalities and trade implications, voluntary actions alone would not be sufficient to reduce use and emissions. Instead, they argued that a legally binding instrument would be the most robust and most effective framework for concrete action, including international cooperation and support. This approach was opposed by several countries, including the US, Canada, China, India, the latter arguing that a binding instrument could limit economic development during which mercury emissions were unavoidable.

The agreement on launching negotiations on a comprehensive Convention on mercury was only reached at the 25th UNEP GC session, in 2009, and it was considered as an important success. The idea of developing a legally binding instrument on heavy metals, in general, remained under discussion during the process that led to the adoption of the negotiation mandate in 2009. Also during the subsequent negotiation process, the option to focus first on mercury but to leave the door open for other heavy metals of global concern was further discussed. However, it finally did not receive sufficient support for different reasons.

The intergovernmental negotiating committee (INC) met in five sessions. INC 5, in January 2013 in Switzerland, finally agreed on the text of the Minamata Convention on mercury, which was formally adopted and opened for signature at the Diplomatic Conference of Plenipotentiaries in Kumamoto, Japan, on 10 October 2013.

The Minamata Convention, negotiated in less than four years, is thus a comprehensive treaty addressing mercury throughout its life cycle. It benefited strongly from factual and technical input, including from UNEP, WHO, and civil society.

"The main objective of the Minamata Convention is […] to protect the human health and the environment from the anthropogenic emissions and releases of mercury and mercury compounds. It contains, in support of this objective, provisions that relate to the entire life cycle of mercury, including controls and reductions across a range of products, processes and industries where mercury is used, released or emitted". The 35 articles and 5 annexes of the Convention are grouped in 4 categories: operational provisions; support to Parties; information and awareness raising articles; administrative matters.

Moreover, while no country can control transboundary effects of mercury alone, as mercury is transported and traded globally, the Minamata Convention moves in this direction: pushing governments all around the world to take effective measures in dealing with emissions and releases of mercury, and thus reducing the threats posed by this substance to the environment and to the health of millions.

While the Convention addresses a number of aspects related to mercury emissions and releases, this report focuses only on the generation of waste mercury from mercury-added products.

In the next paragraph, the articles concerning the phase-out and phase-down process of mercury both in products and in processes will be further analyzed. The Minamata Convention requires parties to not allow the manufacture, import or export of mercury-added products listed in part I of Annex A after the phase out date specified for those products, except where an exclusion is specified. The phase-out date was set as 2020 for all products in the Annex, such as batteries, light bulbs, switches and relays, cosmetics, pesticides, biocides and non-electronic measuring devices. Countries can request additional time of 5 years to comply with this deadline. Such requests need to be submitted when a country submits its articles of ratification of the Convention.

7 Main source for this paragraph is Eriksen H.H. and Perrez F.X. (2014)

8 For further reference see, among others, AMAP/UNEP (2013), Technical Background Report for the Global Mercury Assessment 2013. Arctic Monitoring and Assessment Programme, Oslo, Norway/UNEP Chemicals Branch, Geneva, Switzerland

9 Convention for the Protection of the Marine Environment of the North-East Atlantic (Paris, 22-09-92, in force 25-03-98). See also: http://www.ospar.org/content/content.asp?menu=00590624000000_000000_000000

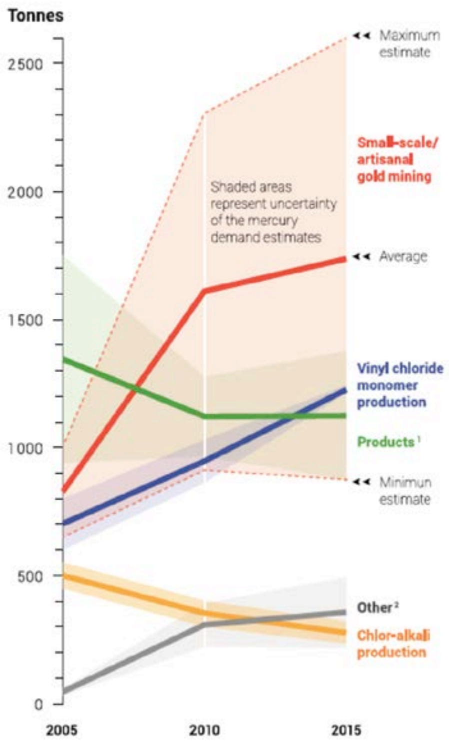
1.2.2 Regulation of phase-out and phase-down of mercury use in products and processes and environmentally sound management of Hg waste

Article 4 of the Minamata Convention focuses on mercury-added products. According to the Convention, parties shall not allow manufacture, import, or export of mercury-added products in Part 1 of Annex A after the phase-out date. The phase-out date has been set at year 2020, however certain countries already asked for an extension, for part or the entire range of relevant products. Thus, for the purpose of this report we consider 2025 an average date in which countries will no longer be producing/exporting/importing mercury-added products anymore (unless allowed for internal use). [10]

Moreover, Parties shall take measures for products listed in Part II of Annex A [11], shall discourage the production or use of new mercury-added products, unless there are environmental or human health benefits. Parties may also propose new products and the Conference of Parties shall review Annex A based on these proposals.

Figure 1 shows that the demand for mercury-added products has been decreasing during the period 2005 to 2015. As reported by UNEP (2017), China remains a major manufacturer of such products like measuring instruments, batteries, and lamps. "Mercury demand for all these products has declined modestly in recent years, although some are subject to competing influences. For example, incentives for reduced energy demand have encouraged the substitution of incandescent lamps (that do not contain mercury) by compact fluorescent lamps (that do indeed contain mercury) in many countries. At the same time, wealthier economies are already witnessing the replacement of compact fluorescent lamps by such energy-efficient and mercury-free alternatives as light-emitting diodes". [12]

Figure 1 – Demand for mercury-added products [13]



Source: UN Environment (2017a)

10 The full text of the Minamata Convention is available online at: http://www.mercuryconvention.org/Portals/11/documents/Booklets/COP1%20version/Minamata-Convention-booklet-eng-full.pdf

11 Products listed in Part II of Annex I include Dental Amalgam.

12 UN Environment (2017a), Global mercury supply, trade and demand. United Nations Environment Programme, Chemicals and Health Branch, available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/21725/global_mercury.pdf?sequence=1&

13 In Figure 1, the category 'Products' include batteries, dental application, measuring and control devices, lamps, electrical and electronic devices.

The Zero Mercury Working Group (ZMWG) developed a dedicated guide to provide a simplified list of steps that governments may use for preparing to undertake the obligations under Article 4 of the Minamata Convention.[14]

It is not easy for governments to conduct inventories of the manufacturing and trade of mercury-added products, especially because, for many of the products, official trade data does not differentiate between mercury and non-mercury units. [15] Other sources of information may include importers, manufacturers, principal users, etc. Box 1 briefly describes existing standard and methodologies to identify and quantify mercury releases, such as the Basel Convention reporting mechanisms.

The availability of Minamata Convention compliant products in the country, before the end of 2020, may influence the need for an extension of time to respect the phase-out requirement as specified in the Convention. "Where the mercury products are produced locally, this assessment may relate to the earliest or optimal time frame for converting to Convention compliant manufacturing processes. For most countries in the developing world, mercury products are largely imported, and thus this evaluation will involve the global or regional availability of Convention compliant products, and the transition time that may be required by users of these products within the country".[16]

According to UNEP (2017b), the assessment conducted on the current waste mercury management practices in almost 30 countries revealed that "the gap between the provisions of the Minamata Convention and the current waste mercury management practices is wide."[17] The fundamental challenge is, in fact, the waste management itself: even though waste mercury is identified in most of the regulatory frameworks of the countries analyzed in the UNEP study, they usually do not have the capacity to implement the mercury provisions.

As further specified in the next paragraph, the options for disposal of waste mercury under the Technical Guidelines of the Basel Convention are the final disposal of stabilized and solidified mercury in a specially engineered landfill or permanent storage in a secure underground storage facility that's specifically designed for that purpose. However, only a few countries have the technology for the solidification and stabilization of mercury, and a limited number of disposal facilities are available all around the globe. The export of waste mercury for environmentally sound disposal is allowed for countries without facilities of their own.

14 Zero Mercury Working Group - ZMWG, Natural Resource Defense Council (2017), Guide and Checklist for Phasing Out Mercury-added Products Under the Minamata Convention on Mercury, available online at: http://www.zeromercury.org/phocadownload/Developments_at_UNEP_level/FAO_project_2014-17/180219_map_checklist_final_en.pdf

15 See in chapter 2 the methodology developed by UNU-SCYCLE to collect and elaborate these sets of data.

16 Zero Mercury Working Group - ZMWG, Natural Resource Defense Council (2017: p6), Guide and Checklist for Phasing Out Mercury-added Products Under the Minamata Convention on Mercury, available online at: http://www.zeromercury.org/phocadownload/Developments_at_UNEP_level/FAO_project_2014-17/180219_map_checklist_final_en.pdf

17 United Nations Environment Programme (2017), Global Mercury Waste Assessment, Review of Current National Measures. Available online at: http://web.unep.org/ietc/sites/unep.org.ietc/files/Global-Mercury-Waste-Assessment-English-web.pdf

1.2.3 The role of the Basel Convention in the regulation of the sound management of waste mercury

Under the Basel Convention, elemental mercury and mercury containing or contaminated waste are categorized as hazardous wastes. The improper handling, collection, transportation, or disposal of waste mercury, as well as some disposal technologies, can lead to emissions or releases of mercury.

A set of technical guidelines have been developed under the Basel Convention for the environmentally sound management of the waste that falls under its scope. These guidelines basically provide a foundation which countries can use to achieve a standard of waste management that is at least as environmentally sound as that required by the Basel Convention.

Article 1 ('Scope of the Convention') defines the waste types covered by the Convention. Subparagraph (a) sets out a two-step process to define when a waste is 'hazardous': the waste must belong to one of the categories listed in Annex I [18] to the Convention, and it must possess at least one of the characteristics listed in Annex III [19] to the Convention. The characteristics listed in Annex III include 'Poisonous (acute)', 'Toxic' (delayed or chronic), and 'Ecotoxic': national tests can help identifying a particular characteristic.

According to Art.1 - para (b), "wastes that are not covered under paragraph (a) but are defined as, or are considered to be, hazardous wastes by the domestic legislation of the Party of export, import or transit are also subject to the Convention".

Table 1 and Table 2 provide a list of those wastes consisting of elemental mercury and wastes containing or contaminated with mercury, as specified in Annexes I and VIII to the Basel Convention.

The technical guidelines thus provide guidance to countries for the Environmentally Sound Management (ESM) of waste mercury, by touching upon the practical steps to be implemented in the following areas: the legislative and regulatory framework; the phases of identification and inventory; the sampling, analysis and monitoring; the waste prevention and minimization; the handling, separation, collection, packaging, labelling, transportation and storage; the environmentally sound disposal; the reduction of mercury releases from thermal treatment and disposal of waste; the remediation of contaminated sites; the respect for health and safety of human beings and, last but not least, the emergency response plan.

With particular regard to the prevention and minimization of mercury-added products and, specifically, those addressed by the present report, the guidelines outline a 'closed system for utilization of mercury', represented in Figure 2.

According to this system, waste containing mercury should be separated and collected, and mercury should then be recovered from the waste and used for production (instead of primary mercury) or disposed of in an environmentally sound manner. In this context, the extended producer responsibility (EPR) should play a role in encouraging the production of mercury-free products, or products containing reduced amounts of mercury, and collection of end-of-life products.

18 Annex I - Categories of wastes to be controlled

19 Annex III - List of hazardous characteristics

Table 1 – Entries with direct reference to mercury

Entries with direct reference to mercury	
Y29	Wastes having as constituents: ***Mercury*; *mercury compounds***
A1010	Metal wastes and waste consisting of alloys of any of the following: … - ***Mercury*** … but excluding such wastes specifically listed on list B.
A1030	Wastes having as constituents or contaminants any of the following: … - ***Mercury; mercury compounds*** …
A1180	Waste electrical and electronic assemblies or scrap[2] containing components such as accumulators and other batteries included on list A, ***mercury-switches***, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or contaminated with Annex I constituents (e.g., cadmium, ***mercury***, lead, polychlorinated biphenyl) to an extent that they possess any of the characteristics contained in Annex III (note the related entry on list B B1110)[3]

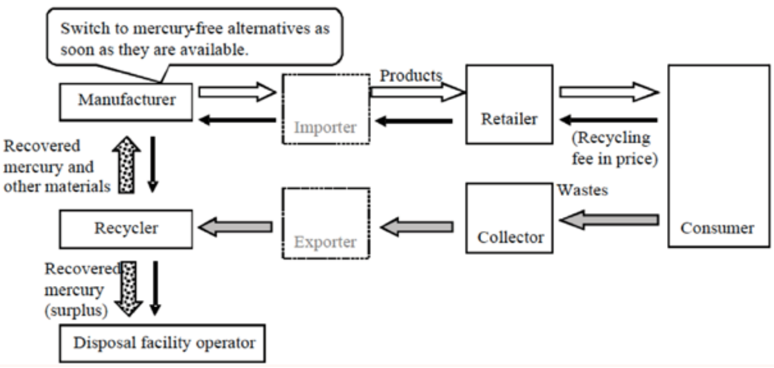
Source: UNEP (2011), p.8

Table 2 – Other entries for wastes that may contain or may be contaminated with mercury

Other entries related to wastes which may contain or be contaminated with mercury	
A1170	Unsorted waste batteries excluding mixtures of only list B batteries. Waste batteries not specified on list B containing Annex I constituents to an extent to render them hazardous
A2030	Waste catalysts but excluding such wastes specified on list B
A2060	Coal-fired power plant fly-ash containing Annex I substances in concentrations sufficient to exhibit Annex III characteristics (note the related entry on list B B2050)
A3170	Wastes arising from the production of aliphatic halogenated hydrocarbons (such as chloromethane, dichloro-ethane, vinyl chloride, vinylidene chloride, allyl chloride and epichlorhydrin)
A4010	Wastes from the production, preparation and use of pharmaceutical products but excluding such wastes specified on list B
A4020	Clinical and related wastes; that is wastes arising from medical, nursing, dental, veterinary, or similar practices, and wastes generated in hospitals or other facilities during the investigation or treatment of patients, or research projects
A4030	Wastes from the production, formulation and use of biocides and phytopharmaceuticals, including waste pesticides and herbicides which are off-specification, outdated, or unfit for their originally intended use
A4080	Wastes of an explosive nature (but excluding such wastes specified on list B)
A4160	Spent activated carbon not included on list B (note the related entry on list B B2060)

Source: UNEP (2011), p.8

Figure 2 – Life cycle of a ‘closed system’ for utilization of mercury



Source: UNEP (2011), p. 26

IN FOCUS

Vietnam

In 2016, the Vietnam Chemicals Agency developed a thematic report on the gaps and legal barriers of existing regulations in the country on mercury management in the country. This assessment was carried out in the framework of the GEF Minamata Initial Assessment project, implemented with UNIDO. In the country, there are 7 management departments participating in mercury (and waste mercury) management. [20]

Examining to what extent the Vietnamese legislation meets the requirements of the Minamata Convention, and in particular Article 4 that focuses on mercury added products, there are currently a number of regulations on the maximum allowed threshold of mercury in certain products containing mercury (Annex I). However, there are no regulations or guidelines requiring the reduction or replacement of mercury-containing dental amalgams, as the Minamata Convention sets less stringent measures for these products. Neither does Vietnam have any legal provision related to applying preventive measure to the merging of products containing mercury with assembly equipment/devices in which their manufacture, import, export is not allowed under Art. 4 of the Convention. Current legislation in Vietnam does not even mention the encouragement of production and commercial distribution of products that do not contain mercury. The table included in Annex 1 provides, in more detail, Vietnam's regulations related to the management of mercury contained in the products mentioned in Appendix A, Part I of the Convention.

Additional provisions in the Vietnamese legislation are specifically related to waste mercury. Circular 36/2015/TT-BTNMT on hazardous waste management has detailed regulations about packaging, storage and warehouse facilities for hazardous waste storage. These requirements may be applied to waste mercury. However, currently there are currently no specific regulations or guidelines on the management of waste containing mercury. This might lead to the risk of environmental contamination and risk for exposure from mercury and mercury compounds to human health.

Circular 36/2015/TT-BTNMT regulates the hazardous waste management, and Decision N. 16/2015/QD-TTg provides regulations on the collection and disposal of waste products, though regulations or specific instructions to prevent exposure to mercury and mercury compounds still have to be improved.

Vietnam started the implementation of the Convention only recently; one of the goals of the impact assessment was to identify gaps and formulate priorities. The absence of regulations on the management of hazardous chemicals, including redundant/unused mercury, mercury compounds made available by the closure of factories using these compounds, as well the absence of warehouse management regulations and inventory/identification of mercury, mercury compounds, and storage requirements, could create sources of pollution and a major risk to the environment and human health. However, the country is working to make improvements in this direction. [21]

The Basel Convention involves the development of further regulations on hazardous waste transported across borders. The transport of waste containing mercury and mercury compounds are now performed according to the provisions of Circular 36/2015/TT-BTNMT, or in accordance with the Basel Convention, if it is a transboundary transport of waste mercury. [22]

Based on the initial assessment concerning Vietnam, the management of chemicals should be linked with a complete lifecycle management. One of the existing barriers, at present, is related to the need for improved coordination and cooperation between the different departments involved. Even though the majority of the current legislation on chemicals management can be applied to mercury and mercury compounds, the legislation has not yet fully met the requirements of the Minamata Convention. Another challenge to be addressed in the coming years relates to the limited capacity in the disposal of waste mercury, as well as further improving awareness of the related dangers surrounding the monitoring and disposal of this material.

According to the information collected by the Chemicals Department in the Country, the total amount of mercury imported in 2014 was approximately 14 kg, including 2.23 kg used for fluorescent lamps and 6 kg used by paint companies. There is no evidence of domestic production of thermometers and switches and relays; according to what was reported by companies, batteries and accumulators do not utilize mercury, while domestic pesticides are produced mainly by reprocessing and re-packaging imported chemicals (so no use of mercury).

Nigeria [23]

In 2017, UNIDO and UNITAR implemented, with the government of Nigeria and the Global Environment Facility (GEF,) the Minamata Initial Assessment (MIA) project. The report provides data on the amount of mercury contained in individual components or products per grams – as reported in the Annex 2 – together with a qualitative description of the products containing mercury. An overview of some relevant characteristics of a selection of products is provided below.

In 2013, based on an inventory undertaken by the Federal Ministry of Environment (FMEnv), a total of 37,765 tonnes (t) of batteries (zinc air, mercuric oxide, silver oxide, and some alkaline manganese batteries) were imported to Nigeria from 22 countries, though China was responsible for 91%. Other African countries were among the main exporters, including Egypt, Congo, and Ghana. However, the general lack of knowledge about mercury concentrations in batteries on the African market, makes it difficult to calculate the actual mercury input.

In Nigeria, switches, relays, lamps, and other electrical equipment represent over 60% of the total mercury-added products imported into the country. [24] Usually, they're comprised of parts of near-end-of-life EEE and second-hand vehicles, often imported without strict controls (See table in Annex 2).

Mercury-containing lamps, both for indoor and outdoor applications, are commonly found in the country, including CFLs and LFLs: more than 51 million lamps were shipped into the country in 2013-2014, 87% coming from China and the rest coming from 45 different countries.

Although mercury use in cosmetics is banned in Nigeria, there are concerns that mercury-added cosmetic products sold as creams, lotions, and soap are still in current use and widely available. Based on UNEP data, Nigeria still has the highest users of skin lightening creams compared to a number of African countries.

In Nigeria there are 3 types of thermometers that contain mercury. They are usually not produced locally, but rather imported from other countries, though mercury-free thermometers are more and more available. Sphygmomanometers, used for blood pressure measurement, are also still in use by many clinics and hospitals, especially in the rural areas, and those manufactured in the EU typically contain 85 to 100 gr of Hg.

Based on the legal assessment conducted in the country under the MIA GEF project, a number of actions still need to be implemented to meet the obligations under the Minamata Convention. With particular regard to Article 4 on mercury-added products, Nigeria "will need to consider what amendments to the NAFDAC act 15 (1993) are necessary to meet the obligation in paragraph 1 of the article with regard to the import and export of mercury-added products listed in Annex A Part I. In preparing such measures, Nigeria will need to consider whether the registration of any exemptions is required. The Standard Organization of Nigeria (SON) will need to develop standards and regulations excluding mercury from such products".

Last but not least, mercury in end-of-life and obsolete EEE is of concern in Nigeria, because the quantity of import of these products being imported is increasing rapidly. One of the main problems concerning e-waste management in Nigeria is related to the dumping of EEE from developed countries. According to Basel Convention Regional Coordination Center – Nigeria imports about 500,000 used computers annually through the port of Lagos; about 75% of the products are actually not usable. Most of the disposed computers and televisions may contain heavy metals, including mercury.

20 Vietnam Chemicals Agency - VCA (2016). Thematic Report – Report on the gaps and legal barriers of existing regulations on mercury management.

21 Ibid, p.32

22 Ibid, p.36

23 The main source for this in-focus on Nigeria is GEF, UNIDO, UNITAR (2017), Minamata Convention on Mercury. Initial Assessment Report for Nigeria.

24 Data from the Nigeria Customs Administration.

BOX 1

Existing standards and methodologies to identify and quantify mercury releases and for the sound management of mercury containing waste

Basel Convention reporting system:

Based on Article 13 of the Basel Convention, Parties are obliged to report information related to different aspects of the Convention itself. This reporting system, in fact, works as a monitoring tool to assess the implementation of the Convention, and the Focal Points are responsible to submit national reports.

The information that should be reported is captured in a questionnaire. In order to assist Parties in the submission of the questionnaires, the Secretariat developed an electronic reporting system that can be accessed online by the webpage of the Convention (see screenshot below). The quality control of the information submitted, performed by the Secretariat, should generate a set of harmonized data to be input into the system.

Additional monitoring tools include the technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with mercury or mercury compounds, [25] adopted by the CoP to the Basel Convention with decision BC-12/4 (see par 1.2.3). The guidelines provide guidance on the environmentally sound management (ESM) of 'waste mercury' – namely that categorized as hazardous waste.

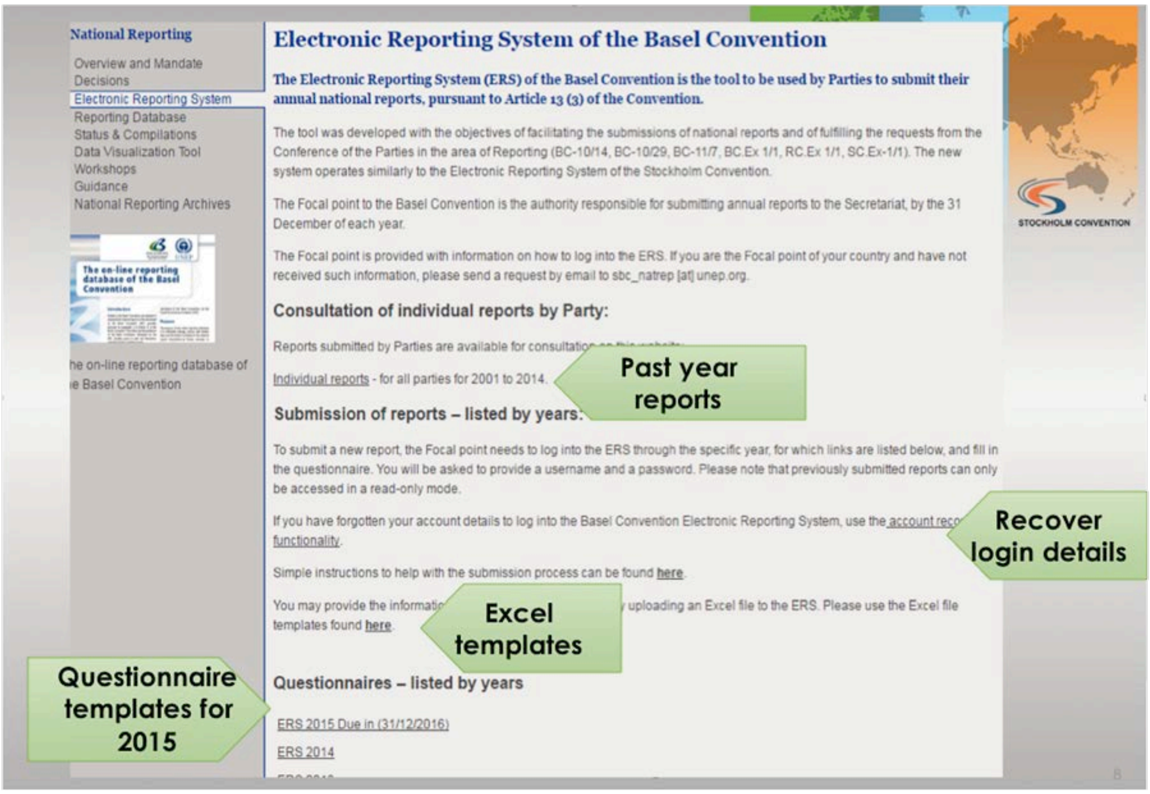
A specific monitoring system is going to be implemented as well, under the Minamata Convention on Mercury. [26] An ad-hoc expert group developed recommendations on arrangements on comparable monitoring data and elements of an effectiveness evaluation framework for consideration of the Second Conference of the Parties. [27] The recommendations formulated in this study provide a set of suggested tasks to encourage joint actions towards the implementation of monitoring and data gathering systems, in a more coordinated manner.

25 United Nations Environment Programme (2013b), Mercury time to act, available online at: http://cwm.unitar.org/cwmplatformscms/site/assets/files/1254/mercury_timetoact.pdf

26 For more specific information, the Secretariat of the Minamata Convention can be contacted.

27 The recommendation can be found in the following meeting document for COP 2: UNEP MC/COP.2/13

Figure 3 – Electronic reporting system of the Basel Convention



Source: Basel Secretariat (2016)

2. METHODOLOGY

The activities covered by the Minamata Convention are summarized in Table 3. The table also provides a summary of the hierarchic relations between the products covered by the Minamata Convention and the scope used in the present study. This report solely focuses on quantifying the mercury content only in final products. The products containing mercury are separated into two main groups: Electric and Electronic (EEE) products and non-EEE products.

The methodology described in this chapter refers to selected mercury-added product categories included in the Minamata Convention, as specified in the Introduction. The electric and electronic equipment (EEE) considered in the quantitative analysis are:

- compact fluorescent lamps (CFLs)
- linear fluorescent lamps (LFLs)
- displays (desktops, laptops, mobile phones, flat display panel monitors, and TVs);
- non-electronic measuring devices, namely barometers, hygrometers, and thermometers.

Other mercury-added products listed in the Minamata Convention, such as batteries, electric components including switches and relays, pesticides/biocides/topical antiseptics, cosmetics, and other non-electric measuring devices (including manometers and sphygmomanometers), were not considered in the quantitative analysis. This is because there was either no matching HS code in the Comtrade database, or the HS codes were too general and not representative of the products containing mercury, or it was not possible with the current information to determine reliable composition data for some of the product categories (such as batteries, switches and relays). However, a qualitative assessment of these products, their mercury contents and possible effects on the environment is described in Chapter 4.

Table 3 – Hierarchic relations between the products covered by the Minamata Convention and the scope of this study

PRODUCTS TYPE	PRODUCT CATEGORIES COVERED BY THE MINAMATA CONVENTION	PRODUCT CATEGORIES CONSIDERED IN THIS STUDY	DESCRIPTION	INCLUDED IN THIS STUDY
Electric and Electronic Equipment (EEE)	Displays	Small IT and telecommunication equipment	Desktop PCs (excl. monitors, accessories)	Yes, quantitative
			Mobile Phones (incl. smartphones, pagers)	
		Screens, monitors, and equipment containing screens (..)	Laptops (incl. tablets)	Yes, quantitative
			Flat Display Panel TVs (LCD, LED, Plasma)	
			Flat Display Panel Monitors (LCD, LED)	
	Electric Components	NA (according to the international classification system, these are electric components and not a stand-alone product category)	Switches and relays	Yes, quantitative
	Lamps	Lamps	Compact Fluorescent Lamps (incl. retrofit & non-retrofit)	Yes, qualitative
			Straight Tube Fluorescent Lamps	
			Special Lamps (e.g. professional mercury, high & low pressure sodium)	
Non Electric and Electronic Equipment (non-EEE)	Non-electric measuring devices	Non-electronic measuring devices	Thermometers and pyrometers; liquid filled, for direct reading, not combined with other instruments	Yes, quantitative
			Hydrometers and similar floating instruments, barometers, hygrometers, psychrometers, thermometers, pyrometers; recording or not, any combination of these instruments, parts and accessories	Yes, qualitative
			Barometers; not combined with other instruments	Yes, qualitative
			Manometers, and sphygmomanometers	Yes, qualitative
		Pesticides, biocides and topical antiseptics		Yes, qualitative
		Cosmetics		Yes, qualitative
		Batteries		Yes, qualitative

2.1 Classification: product categories

The mercury-added products considered in the quantitative analysis were categorized following the principles of the UNU-KEYS classification system.

The UNU-KEYS are constructed so that products are categorized by similar function, comparable material composition, and average weights [28]. The classification system for EEE was developed by UNU [29], it consist of 54 categories. The classification was developed to link the reporting categories of the WEEE directive [30], which came into effect in August 2018. The UNU-KEYS encompass all possible electric and electronic devices that can be found in the harmonized statistical coding of the international trade codes: the Harmonized System (HS)1. There are about 270 HS codes regarded as relevant to EEE (according to their descriptions) and they are clustered into 54 product categories, named UNU-KEYS.

As previously stated, in the present study the quantitative analysis only focuses on a set of selected EEE; therefore, the following UNU-KEYS listed in Table 4 were taken into account. It should be noted that the three other non-electronic measuring devices considered in the quantitative analysis (thermometers, hygrometers, and barometers) were not included in the original UNU-KEYS classification system, therefore three new product codes were created: 0906, 0907, and 0908. They can be identified in the group "non-electronic measuring devices" in Table 4.

Table 4 – Mercury-added product codes (UNU-KEYS) that were analyzed based on sales, material composition and a lifespan approach

UNU-KEYS	DESCRIPTION	GROUP
0302	Desktop PCs (excl. monitors, accessories)	EEE
0303	Laptops (incl. tablets)	EEE
0306	Mobile Phones (incl. smartphones, pagers)	EEE
0309	Flat Display Panel Monitors (LCD, LED)	EEE
0408	Flat Display Panel TVs (LCD, LED, Plasma)	EEE
0502	Compact Fluorescent Lamps (incl. retrofit & non-retrofit)	EEE
0503	Straight Tube Fluorescent Lamps	EEE
0504	Special Lamps (e.g. professional mercury, high & low pressure sodium)	EEE
0906	Thermometers and pyrometers; liquid filled, for direct reading, not combined with other instruments	Non-electronic Measuring devices
0907	Hydrometers and similar floating instruments, barometers, hygrometers, psychrometers, thermometers, pyrometers; recording or not, any combination of these instruments, parts, and accessories	Non-electronic Measuring devices
0908	Barometers; not combined with other instruments	Non-electronic Measuring devices

28 Forti V., Baldé C.P., Kuehr R. (2018). E-waste Statistics: Guidelines on Classifications, Reporting and Indicators, second edition. United Nations University, ViE – SCYCLE, Bonn, Germany.

29 Wang, F., Huisman, J., Baldé, K., Stevels, A. (2012). A systematic and compatible classification of WEEE. In Electronics Goes Green, Berlin, Germany

30 European Commission (2002). WEEE-Directive 2002/96/E. Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32002L0096

2.2 Methodology for the calculation of statistics on mercury-added product waste

UNU developed an internationally recognized methodology and measurement framework to compile statistics on the amount of e-waste generated [31]. A similar method has been applied in this study.

The simple equation Imports – Exports was used to calculate the sales of mercury-added products. This equation is accurate for countries that do not have domestic production. However, countries that have domestically-produced products that are also sold domestically are not considered in this simple equation as they would lead to a too low value. Instead, low outliers in countries with suspected domestic production were imputed with the average values from other countries that do not have domestic production.

After the equipment has been sold, it stays in households or businesses for some time until disposed of. This period is called "life-time" and the equipment in use or stored in households, companies, or institutions is referred to as "stock". After a certain "life-time", which varies from product to product, the good is disposed of and becomes "mercury-containing waste generated". The calculation of the waste generated from mercury-added products is thus based on empirical data from a sales-lifespan model. In this model, lifespan data (a Weibull function) for each product is combined with a time series of sales to calculate the waste generated from mercury-added products [31]. Data on the mercury content in products (g Hg/kilogram product) are added to the year of production/sales of the product. In a later phase, the projected waste generated data can be compared with the actual collected and managed mercury-containing waste amounts to monitor the effectiveness of policies.

The calculation, steps, and statistical routines used to determine the volumes of waste from mercury-added products, and consequently the volumes of waste mercury, are described in detail below:

1. Selecting the relevant codes that describe mercury-added products considered in the present study in the Harmonized Commodity Description and Coding System (HS).

2. Extracting the statistical data on imports and exports from the UN Comtrade database. This was done for 178 countries and 17 HS codes for the time period 1995-2015. Countries have then been classified into five groups according to the Purchasing Power Parity (PPP) [32]. This procedure has been repeated for each year since the Country's PPP changes over the years, especially for developing countries. This was useful to make statistics comparable between countries, and to calculate trends between groups.
A specific number of countries was used for each group:
Group 1: Group 1: (highest PPP (higher than 34000 USD/ca. in 2015): 35 countries
Group 2: (high PPP (34000 – 15280 USD/ca. in 2015): 43 countries
Group 3: (mid PPP (15280 – 6740 USD/ca. in 2015): 43 countries
Group 4: (low PPP (6740 – 1700 USD/ca. in 2015): 44 countries
Group 5: (lowest PPP (lower than 1700 USD/ca. in 2015): 13 countries

31 Forti V., Baldé C.P., Kuehr R. (2018). E-waste Statistics: Guidelines on Classifications, Reporting and Indicators, second edition. United Nations University, ViE – SCYCLE, Bonn, Germany.

32 Purchasing Power Parity: PPPs are the rates of currency conversion that equalize the purchasing power of different currencies by eliminating the differences in price levels between countries. In their simplest form, PPPs are simply price relatives that show the ratio of the prices in national currencies of the same good or service in different countries. (OECD, 2018).

3. Calculating the sales (in tonnes) for the 11 mercury-added product categories (see Table 1, 2) using the following equation: Sales = Import – Export [33].

4. Performing automatic corrections for outliers on the sales data. This was needed to detect values that were too low (due to the lack of domestic production data in some countries, where domestic production is relatively large) or too high (due to misreporting of codes or units). Those detected entries are replaced with more realistic sales values, either from the time series of the origin country or from comparable countries. These statistical routines lead to a harmonized dataset with a similar scope and consistent sales for a country, based on their own trade statistics.

5. Performing manual corrections resulting from the analysis of the automatic corrections. This was needed to correct unreliable data using knowledge of the market.

6. Extending the time series of sales. Past sales were calculated back to 1980, based on the trends of available data and the market entry of the appliance. Future sales were predicted until 2025, using sophisticated extrapolation methods: the principle takes into account the ratio between the sales and the PPP per county, and uses that ratio to estimate the sales with the forecast of the PPP from the World Economic Outlook elaborated by the IMF [34]. The sales of mercury-added products were predicted until 2025 rather than until 2020 (the actual phase out date reported in the Minamata Convention), because many countries asked for an extension.

7. Then, the mercury concentration (g Hg / tonne product) per product code is multiplied by the sold volume (in tonnes) considered to determine the quantity of mercury contained in the sold products. Consequently, the volumes of sales of all mercury-added products obtained from the steps 3, 4, 5 and 6 were transformed into volumes of sales of mercury embedded in these products.

8. To determine the waste mercury generated by country, sales and lifespan distributions were used. Lifespan data was obtained from the 28 EU Member States using the Weibull distribution [35, 36]. The lifespan of each product should ideally be determined empirically per product, per type of country [35]. At this stage, only harmonized European residence times of EEE were available from extensive studies performed at the EU level, and were found to be quite homogeneous across Europe, leading to a ±10% deviation in final outcomes [35]. Due to the general absence of data, it was assumed that the higher lifespan per product in the EU was approximately applicable for non-EU countries as well [36]. The lifespans of the new UNU-KEYS (non-electric and electronic products), made up for the purpose of this study, were assumed to be similar to other electric and electronic products that have a similar function (e.g. household monitoring & control equipment).

9. Determining the quantity of mercury (embedded in mercury-added products) in stock as the difference between the historical sales of mercury (result of Step 7) and the mercury waste generated (result of Step 8) over the years.

10. The total quantities of waste from mercury-added products and stock were also calculated following the same methodological steps described above, except Step 7.

33 Forti V., Baldé C.P., Kuehr R. (2018). E-waste Statistics: Guidelines on Classifications, Reporting and Indicators, second edition. United Nations University, ViE – SCYCLE, Bonn, Germany

34 International Monetary Fund (2017). Available online at: World Economic and Financial Surveys - World Economic Outlook Database: https://www.imf.org/external/pubs/ft/weo/2017/01/weodata/index.aspx

35 Magalini, F., Wang, F., Huisman J., Kuehr, R., Baldé K., v. Straalen, V., Hestin, M., Lecerf L., Sayman, U. and Akpulat, O. (2014). Possible measures to be initiated by the commission as required by article 87 7(4), 7(5), 7(6) and 7(7) of directive 2012/19/eu on waste electrical and electronic equipment (weee).

36 Forti V., Baldé C.P., Kuehr R. (2018). E-waste Statistics: Guidelines on Classifications, Reporting and Indicators, second edition. United Nations University, ViE – SCYCLE, Bonn, Germany.

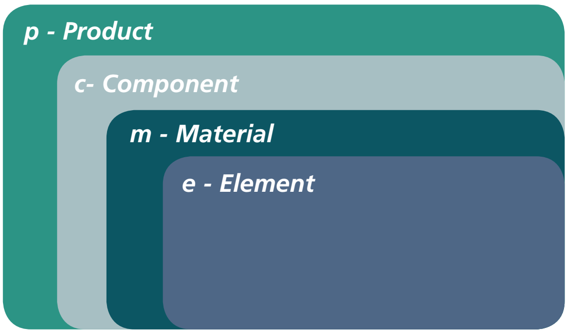
2.3 Analysis of the mercury content in products

2.3.1 Analysis of mercury content in EEE

This project used several data sources to determine the mercury content in the products. They are described in two separate parts, namely the analysis of mercury content in EEE and of the non-electronic measuring devices.

For electronic and electric equipment, the outcomes of the ProSUM project [37] were used as a data source for the quantity of mercury embedded in mercury-added EEE, considered in the quantitative analysis. The ProSUM database represents the most harmonized and consolidated data source currently available for the compositions of EEE, as the project has embodied the current state of knowledge to produce the best possible estimate of the compositions [38]. In the ProSUM database, the products (reported in UNU-KEYS) are represented as the sum of their constituent components, materials, and elements as shown in the figure below.

Figure 4 – Simplified ProSUM calculation sequence



In the present study, only mercury data were extracted and used for the analysis.

In the ProSUM database, the data used for the analysis are expressed as:

- milligrams (mg) of mercury in a kilogram (kg) of component (e-c)
- and mg of component in a kg of product (c-p)

37 ProSUM Project (2018). Available online at: http://www.prosumproject.eu/

38 Huisman J., Leroy P., Tertre F. et al. Prospecting Secondary Raw Materials in the Urban Mine and mining wastes (ProSUM) - Final Report, ISBN: 978-92-808-9060-0 (print), 978-92-808-9061-7 (electronic), December 21, 2017, Brussels, Belgium

Building on these data, the mg of mercury in a kg of product (e-p) were calculated for the 8 UNU-KEYS listed in Table 4 for the period 1980-2025. These composition data were then used in Step 6 of the methodology to determine the quantity of mercury in sold products.

It is worth highlighting that ProSUM data, at the component-product (c-p) level, are time dependent, while at the element-component (e-c) level are not. Therefore, it was assumed that mercury was found in the respective components for the whole timeframe in which the same components were present in the final products. In other words, due to a lack of data, it was assumed that mercury can be found in the components, regardless of the year of production of that specific component. For example, mercury might have been used for the production of some type of display only in a certain period, and its use might have stopped in subsequent years. These changes in the use of mercury, and in the production of various components, are currently not captured in the ProSUM database and therefore could not be considered in the present study, due to a lack of information.

2.3.2 Analysis of mercury content in non-electronic measuring devices

To identify the mercury content in non-electronic measuring devices, a literature review was conducted. Several sources were found, that indicated the mercury content per product. The sources include the Danish Ministry of Environment (2006) [39], the Government of Canada (2018) [40], Newmoa (2010) [41], and UN Environment (2017c) [42]. In some cases, the sources only provided a range of mercury content. Based on the average mercury content, and by taking into consideration the total weight of the product, the amount of mercury content was then selected.

The analysis of the weight of products was based on a review of online marketplaces where the products containing mercury are sold and an indication of the weight was provided. The following table summarized the chosen average weight per product category.

Table 5 – Sources of mercury content in non-electric and electronic measuring devices

MEASURING DEVICE	GRAMS OF MERCURY PER ITEM
Medical Thermometers	• 0.5g -3 g (Government of Canada, 2018)
Industrial and/or laboratory thermometers	• 5 g (Government of Canada, 2018) • 0.5-54 g (Newmoa, 2010) • 2 – 40 g (UN Environment, 2017) • 14 g (Danish Ministry of the Environment, 2006)
Engine control thermometers	• Up to 200 g (UN Environment, 2017) • 5 g to 200 g (Danish Ministry of the Environment, 2006)
Barometers	• 40g -1000 g (Danish Ministry of the Environment, 2006) • 400 g – 620 g (Newmoa, 2010)
Hygrometers	• 3g -7 g (Newmoa, 2015)
Manometers	• 70 g- 140 g (Danish Ministry of the Environment, 2006) • 30 g – 75 g (Newmoa, 2015)
Sphygmomanometers	• medium value 80 g (UN Environment, 2017) • 70 g (Danish Ministry of the Environment , 2006) • 50 g - 140 g (Newmoa, 2010)

These two products could not be considered in the quantitative analysis, as the respective HS codes were not representative of the product containing mercury.

39 Danish Ministry of Environment (2006). Alternatives to mercury-containing measuring devices. Available online at https://www2.mst.dk/Udgiv/publications/2006/87-7052-133-6/pdf/87-7052-134-4.pdf

40 Government of Canada (2018). Products that contain mercury: thermometers and thermostats. Available online at: https://www.canada.ca/en/environment-climate-change/services/pollutants/mercury-environment/products-that-contain/thermometers-thermostats.html

41 Newmoa (2010). IMERC Fact sheet. Mercury use in measuring devices. Available online at: http://www.newmoa.org/prevention/mercury/imerc/factsheets/measuring_devices.cfm

42 UN Environment (2017c). Toolkit for Identification and quantification of mercury releases. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/14777/Hg-Toolkit-Guideline-IL1-January2017.pdf?sequence=1&isAllowed=y

Table 6 – Chosen average weight per product category

MEASURING DEVICE	AVERAGE WEIGHT PER ITEM
Barometers	700 g
Hygrometers	160 g
Thermometers	80 g

Table 7, below, shows the lifetime profiles of the mercury-added products in the Netherlands, France, Belgium, Italy, and non-EU countries. The lifetime profiles reflect the probable obsolescence rate of products in future years and could be modelled using several probability functions. The Weibull distribution function is considered to be the most suitable to describe discard behavior for EEE and non-EEE measuring devices. The Weibull function is defined as a time-varying shape parameter $\alpha(t)$ and $\beta(t)$ a scale parameter.

Table 7 – Life time profiles of mercury-added products

UNU-KEYS	DESCRIPTION	SHAPE PARAMETER	SCALE PARAMETER
0302	Desktop PCs (excl. monitors, accessories	1.8	10.33
0303	Laptops (incl. tablets)	1.94	8.76
0306	Mobile Phones (incl. smartphones, pagers)	1.52	5.62
0309	Flat Display Panel Monitors (LCD, LED)	2.3	12.18
0408	Flat Display Panel TVs (LCD, LED, Plasma)	1.88	10.95
0502	Compact Fluorescent Lamps (incl. retrofit & non-retrofit)	1.6	8.43
0503	Straight Tube Fluorescent Lamps	1.75	5.79
0504	Special Lamps (e.g. professional mercury, high & low pressure sodium)	1.6	6.9
0906	Thermometers and pyrometers; liquid filled, for direct reading, not combined with other instruments	1.55	5.89
0907	Hydrometers and similar floating instruments, barometers, hygrometers, psychrometers, thermometers, pyrometers; recording or not, any combination of these instruments, parts and accessories	1.55	5.89
0908	Barometers; not combined with other instruments	1.55	5.89

2.4 Main gaps and challenges in the existing datasets

2.4.1 Availability of data in the UN Comtrade Database and HS codes limitations

The UN Comtrade database is a useful source for foreign trade statistics. It contains international trade analytical data on imports and exports of products. In this study, Comtrade data were used as a source for the calculation of the volumes of sales of mercury-added products. As explained before, sales were calculated as Imports – Exports.

Ideally, sales of products in a country should be calculated as follows: Sales = Imports – Exports + Domestic Production. However, in this study the lack of "Domestic Production" data was compensated by performing the detection and correction of outliers. However, domestic production data, when available, might be taken into account in future versions of the study.

Products in trade statistics are registered under the Harmonized Commodity Description and Coding System (HS codes) developed by the World Customs Organization. [43] There are about 5,300 HS codes (six digits) describing all commodities per year. Within that group, 17 HS codes were considered to be representative of the mercury-added products analyzed in this study. However, many mercury-added products are difficult to track because the respective HS codes are not mercury-specific, and thus are too general to be representative of the mercury-containing products herewith considered. This applies to some of the measuring devices, such as manometers and sphygmomanometers, to cosmetics (e.g. the skin lightening creams) and to pesticides/biocides and antiseptics. Consequently, these products were not considered in the quantitative analysis; nevertheless, a qualitative assessment of available data is provided in Chapter 4.

Additionally, in some cases it was not possible to know the exact representation of products in the respective HS category. This was the case of barometers: the product description of the respective HS code (902580) is "Barometers; not combined with other instruments". The description does not distinguish between different types of barometers.

The same applies for the other non-electric measuring devices considered in the quantitative analysis (Thermometers and Hygrometers). Experts from UNITAR, UN Environment, and UNIDO were consulted to gather information on the ratio of mercury-added: mercury-free measuring devices; however it was found that there is a current lack of such information. Therefore, in this study it was assumed, in agreement with experts, that a maximum of 50% of measuring devices reported in the trade statistics contain mercury.

2.4.2 Data gaps in the assessment of the products composition

The ProSUM database, used in the present study as a source for the composition data of mercury-added EEE, presents some data gaps. Information was found for the 8 UNU-KEYS listed in Table 4.

However, a consultation with experts and desktop research revealed that mercury can also be present in some electric and electronic components (e.g. switches and relays) not reported in the ProSUM database, and consequently the quantities of these components incorporated in the final EEE products are currently unknown. For example, mercury can be found in the large glass tube of an old CRT TV, however this is not currently tracked in the ProSUM database. For certain UNU-KEYS, the ProSUM database contains data at the component-product level (e.g., mg of batteries in a kg of laptop). However it does not reveal information about the mercury content in batteries. For this reason, mercury batteries in EEE could not be considered in the quantitative analysis. On the contrary, in the case of the Flat Display Panel TVs and Monitors, there is information on the mercury content in two components that are not reported at the component-product level, therefore this information was not relevant for the present study.

In addition, as previously explained, data on the mercury content in components (e-c) are not time dependent. Therefore, the changes in the compositions of components with time could not be taken into account. This would be an interesting analysis to be performed, however it would require additional research.

Lastly, the content of mercury may vary substantially among products grouped in the same product category (UNU_KEY). For example, thermometers can contain different quantities of mercury according to their functionality, or might not contain mercury at all. As previously mentioned, given the current lack of information on the share of measuring devices that contain mercury, experts in the field agreed to consider that a maximum of 50% of the measuring devices sold every year contain mercury.

In conclusion, for some products (e.g. switches and relays, batteries, and pesticides) it was not possible to find reliable data in the literature, therefore they were not considered in the quantitative analysis but a qualitative assessment was conducted in Chapter 4.

2.5 Official (and unofficial) time-frames

As introduced above, it was not possible to collect time dependent data on the mercury content of EEE components in the present study. According to different inputs provided by experts, mercury could be used as a cathode sputtering inhibitor in DC plasma displays until 2010, with content up to 30 mg per display. However, this has been used for a few years and may not be relevant considering the total picture. Older, and mainly larger equipment, also used to have mercury switches.

However, according to what the ZMWG reports on its website, and based on some informal conversations conducted with experts in the field, there might currently still be a number of EEE products containing Hg produced in certain countries. [44]

The EU developed and adopted two pieces of legislation regulating the content and disposition of EEE. Directive 2002/96/EC (WEEE) mainly ensures separate collection and recycling of EEE, while Directive 2002/95/EC (RoHS) bans the use of certain hazardous chemicals, including mercury or any component containing Hg, in new equipment marketed after 1 July 2006.

The RoHS is currently under revision and is expected to cover EEE measuring and control devices, including switches and relays, as well as medical devices. Several countries in the EU have already taken action to ban or restrict the use of some or all products containing mercury, including Sweden, Norway, Denmark, France, and the Netherlands. However, as many other countries have yet to put such measures in place, we can probably assume that Hg was still present in some EEE products even after 2006; also taking into consideration that, according to the Minamata Convention, the phase out date for these product categories is 2020.

43 United Nations (2012). Central Product Classification (CPC) Version 1.1, New York, 2002

44 China, India, the Russian Federation - among others.

2.6 Differences in the products composition and phase out dates among countries

The product composition may differ substantially among the producing countries. Therefore, some countries may produce products that contain mercury while others do not. The country that produces a mercury-added product could use it internally (for domestic consumption) or export it to other countries. As a consequence, the mercury-added product is recorded in the sales of the importing country even if the latter does not use mercury in the manufacture of similar products. Due to a lack of data on the country-specific product composition, it was assumed that the mercury-added product composition was the same in all countries.

In addition, some of the countries that have ratified the Minamata Convention have asked for exemptions from the phase-out dates listed in Part I of Annex A. Since both China and India have asked for exemptions to extend the length of time they can continue to manufacture mercury-added products, and given the fact that these are among the largest producers and exporters of mercury-added products and, furthermore, amongst the most populous countries in the world, the phase out date of 2025 was assumed for all countries.

This is because large quantities of products containing mercury will be expected to be produced, and therefore sold, by the largest countries that produce both in the domestic and in the international market, until the year 2025.

2.7 Summary of the uncertainties in the calculation of the mercury content of product wastes

This paragraph presents a list of existing uncertainties and limitations related to the calculation of the mercury content of product waste:

- Some products have no matching HS code and therefore there was no Comtrade data available for some products (e.g. Sphygmomanometers).
- Existing HS codes are sometimes not representative of the product containing mercury, or there are not specific HS codes to distinguish between mercury-added and not mercury-added products (e.g. for cosmetics).
- Other HS codes might be too general and do not distinguish between products that contain mercury and those that do not (such as Thermometers, Barometers, and Hygrometers). The maximum share of mercury-added products within each product category was estimated but needs to be further researched.
- There was no harmonized domestic production data available for countries other than EU.
- There may be gaps from composition data from existing harmonized sources such as ProSUM (e.g. the composition of switches and relays is missing) or might be inaccurate (e.g the composition by element are not time dependent).
- Data on the average mercury content per product found in the literature has a high level of uncertainty (e.g. for the measuring devices).
- For some product categories there is a current lakc of information on the actual mercury c ontent (e.g. pesticides). In addition, the mercury content may vary per country of production.
- Product lifetimes are estimated from European country studies.
- Need to estimate phase-out dates for different countries and product categories.

Considering these limitations, available harmonized data sources such as Comtrade and ProSUM were used to make a quantitative analysis of the waste mercury in mercury-added products waste. The results of this quantitative analysis are presented in Chapter 3. These preliminary results are a good step towards the quantification of waste mercury embedded in mercury-added products and the limitations listed above can be seen as a starting point for further research on this topic.

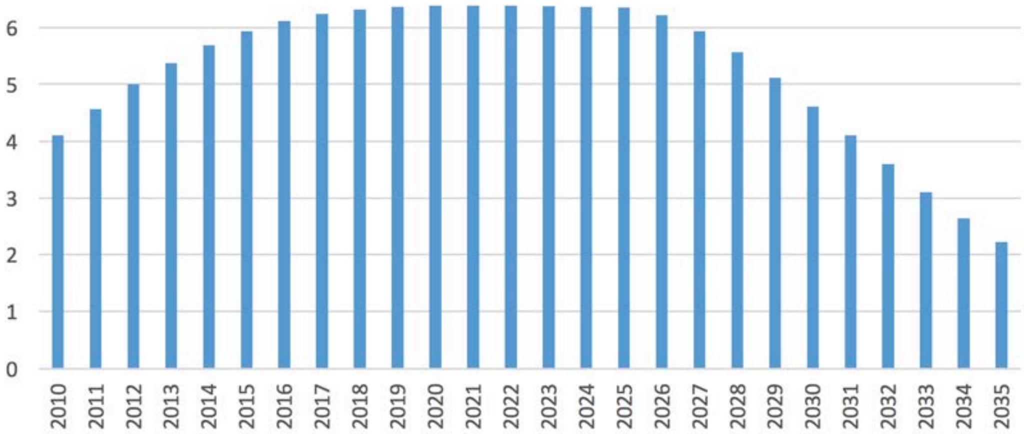
3. GLOBAL WASTE MERCURY QUANTITIES AND TRENDS

3.1 Mercury-added product waste

According to UNU estimates, based on the methodological steps described in Chapter 2, the global quantity of mercury-added waste in EEE plus non-electronic measuring devices was 4.1 million metric tonnes (Mt) in 2010. It gradually increased with an annual average of 7% from 2010 until approximately 2018 (Figure 5), then started to increase at a slower rate until reaching a plateau of around 6.4 Mt in 2018 to 2025. After 2025, the mercury-added product waste is expected to decrease rapidly due to the assumption that, starting in 2025, the sales of mercury-added products will end in all countries. [45]

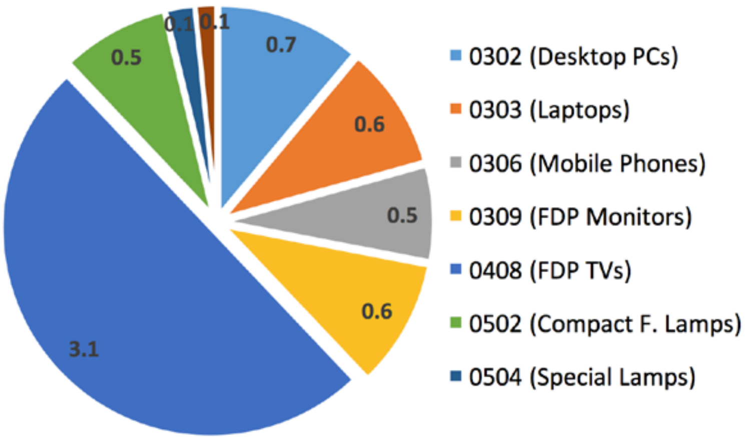
Looking at the estimates for the single product categories in 2017 (Figure 6), the global quantity of mercury-added product waste is mainly comprised of flat display panel TVs (3.1 Mt), desktop PCs (0.7 Mt), laptops and flat display panel monitors (0.6 Mt each), and mobile phones and compact fluorescent lamps (0.5 Mt each).

Figure 5 – Global mercury-added product waste - time series (Mt)



45 It is assumed that sales will be banned, even though the Convention does not require it.

Figure 6 – Estimates of mercury-added products waste – per product – in 2017 (Mt)



3.2 Waste Mercury

The global quantity of mercury in waste generated in 2017 was around 1300 tonnes (t), or 0.18 grams of mercury per capita (g/ca.) **(Figure 7).** The amount of mercury in waste is expected to grow until 2025 [46], which corresponds to the phase-out date for the sale of mercury-added products. It is estimated that in 2025, the mercury content of waste generated globally will exceed 1550t. From 2025, mercury content will decrease rapidly as a consequence of the Minamata Convention ban on the production and sale of mercury-added products in all countries. It is estimated that in 2035 the amount of mercury in waste will be around 190t, which represents only 12% of the total amount of mercury in waste that is expected to be generated in 2025.

Focusing on the trends of waste mercury embedded in the various product categories over the period 2010-2035, one can notice that barometers, hygrometers, and thermometers contribute the most to the generation of waste mercury **(Figure 8).** In 2017, the mercury content of barometer waste was estimated to be 750t, from hygrometer waste 350t, and from thermometer waste 144t. The mercury in waste generated from barometers and hygrometers follows the same trend as the total waste mercury in Figure 7, whereas the thermometer trend is more linear.

It is worth highlighting that the results of the literature review presented in Table 10 show that the content of mercury is much higher in measuring devices than in all other product categories [47]. In addition, these figures represent a high level of uncertainty due to a lack of reliable data on the share of measuring devices containing mercury compared to other liquids (mercury-free). Following discussion with experts from UNITAR, UN Environment, and UNIDO, it was assumed that a maximum of 50% of the measuring devices (thermometers, hydrometers, and barometers) contain mercury. However, the percentage of measuring devices containing mercury may vary per product type or per year of production.

Figure 9 refers to the trends of mercury waste generated from the disposal of straight tube fluorescent lamps and special lamps. In 2017, it is estimated that the waste mercury from straight tube fluorescent lamps was 39t

46 The year 2025 is considered as a benchmark because it was assumed that from 2025 the sales of new mercury-added products will be banned and stopped in all countries

47 Newmoa (2010) suggests that the minimum quantity of mercury in barometers is 400 grams. A literature review revealed that the average weight of barometers (that have different sizes and functionalities) is 1 kilogram. Therefore, the mercury waste resulting from the disposal of a barometer is almost half of the barometer's weight.

(5 mg/ca.) and from Special Lamps 19t (3 mg/ca.). Both trends are comparable to the trend of the total waste mercury in Figure 5. It shows a smooth increase until 2025 and then a rapid decrease in the following 10 years to 13t and 6t, respectively, for straight tube fluorescent lamps and special lamps.

Figure 10 refers to the trends of waste mercury generated from the disposal of all other product categories not listed so far. Unlike before, waste mercury from mobile phones, flat display panel TVs, and monitors is expected to decrease over the entire period of 2010-2035. Possible explanations for this trend are the effect of miniaturization (which mainly affects screens) and the fact that in recent years, certain components that contain mercury (e.g. background lightening) are no longer used in screens and mobile phones. In 2017, it is estimated that the waste mercury from mobile phones was 2.3t, or 0.3mg/ca.; from flat display panel TVs 1.2t (0.02mg/ca.), from compact fluorescent lamps 1t; from laptops 0.6t; from flat display panel monitors 0.2t and ultimately from desktop PCs 0.1t.

Figure 7 – Global mercury content in mercury-added product waste – time series (tonnes mercury and g mercury /ca.)

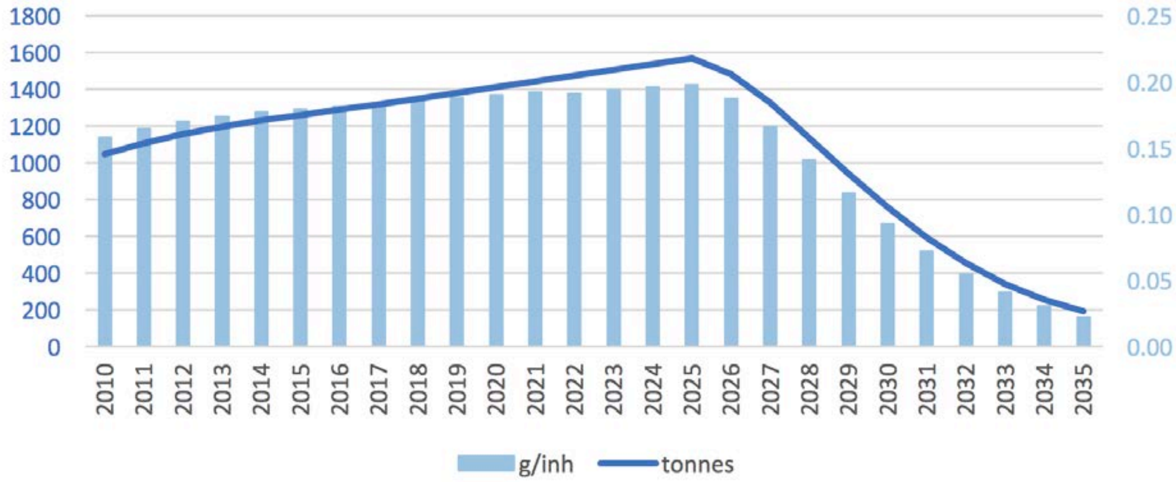


Figure 8 – Mercury waste in Thermometers, Hygrometers, and Barometers – time series (t)

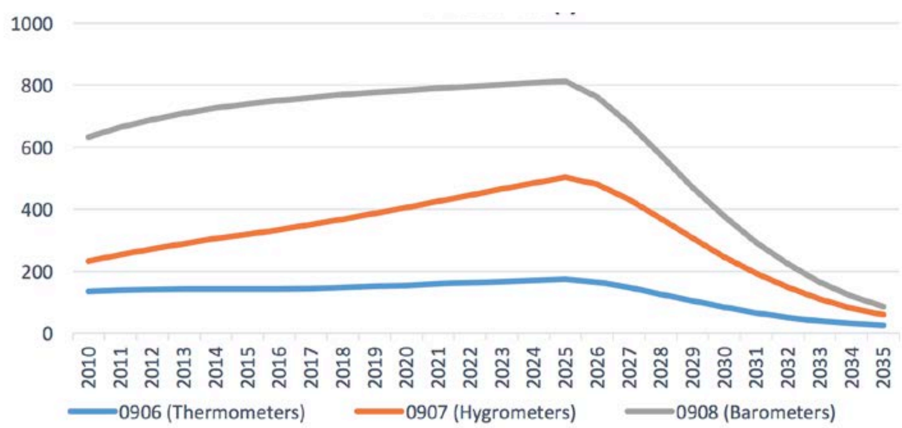


Figure 9 – Waste mercury in Straight Tube Fluorescent Lamps and in Special Lamps – time series (t)

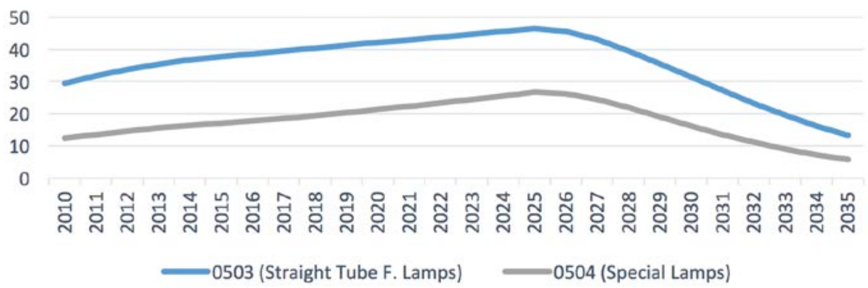
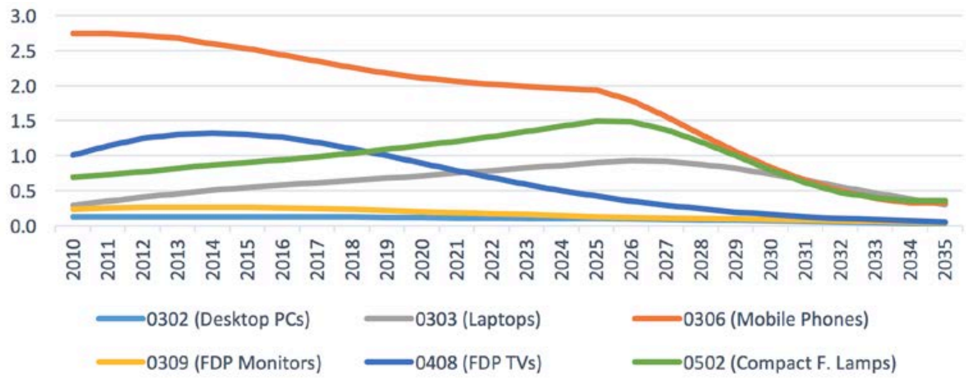


Figure 10 – Waste mercury in other product categories – time series (t)



3.3 Waste mercury per region

In 2017, the highest quantity of waste mercury was generated in the Americas (around 439t), of which 297t was in North America, 95t in South America, 44t in Central America, and 3t in the Caribbean (Table 8). On average, the Americas generated 0.5 grams of mercury per capita in 2017. The European continent, including Russia, generated an amount of waste mercury comparable to the Americas: 406 t or 0.5 in g/ca. Oceania generated the lowest quantity of waste mercury in the world in 2017 with 24t. However, on average, Oceania generated the highest quantity per capita (0.6 g/ca.). The lowest amount of waste mercury per capita was generated in Africa with 0.1g/ca. The whole continent generated in total 40t of waste mercury, while Asia generated 409t, which is only 0.1g/ca.; this is due to the large population in the continent [48]. More detailed data on the waste mercury generated per UN region in 2017 are presented in the Annex 4.

48 Overall the countries with a higher Purchasing Power Parity show a higher mercury waste generation than the ones with a lower PPP.

Table 8 – Waste mercury waste generation in EEE and non-electronic measuring devices per continent in 2017

INDICATOR	AFRICA	AMERICAS	ASIA	EUROPE	OCEANIA	WORLD
Countries in region [49]	49	33	45	39	12	178
Population in region (millions)	1098	972	4343	739	40	7192
Waste mercury (g/ca.)	0.1	0.5	0.1	0.5	0.6	0.2
Waste mercury (t)	40	439	409	406	24	1318

The graphs below indicate the trends in the generation of waste mercury per continent. The graphs show that America and Europe generate the highest amount of waste mercury both in total quantity and in grams per capita. Oceania is also estimated to generate a considerable amount of waste mercury per capita (g/ca.), while Asia generates a large quantity of waste mercury due to its large population.

Figure 11 – Waste mercury generation per continent - time series (g/ca.)

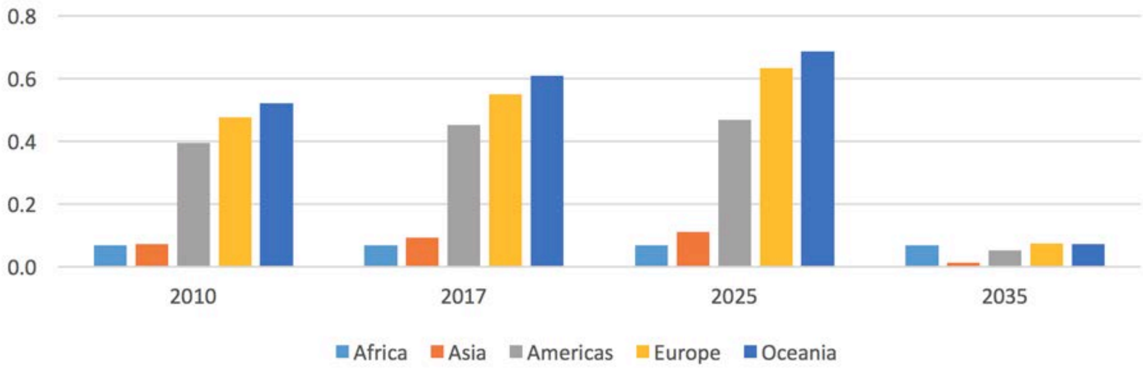
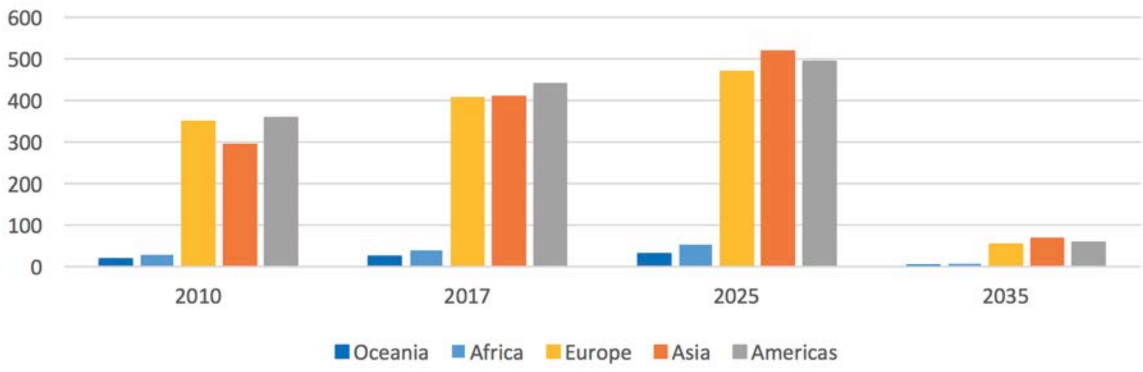


Figure 12 – Waste mercury generation per continent - time series (tonnes)



49 A complete list of the countries considered in the study can be found in the Annex 3

4. ASSESSMENT OF LITERATURE ON REMAINING PRODUCT CATEGORIES

In this chapter, data was compiled on those mercury containing product categories included in the Minamata Convention, for which there was no matching HS code in the Comtrade database or the HS codes were too general and not representative of the products containing mercury.

Thus no quantitative calculation or estimate of the waste volume was possible for the following product categories: pesticides, biocides, topical antiseptics, manometers, sphygmomanometers, cosmetics, and batteries. The objective of this chapter is, therefore, to provide an assessment of available data, mainly from the literature, that could assist in answering the question of how much volume of waste mercury of these products will be generated in the next 10-20 years. For each product category, information is provided on three topics. The first one is on the mercury content per product, which can be matched with the data on consumption or trade of products. However, as the trade data were not available for product categories, the information on mercury content might be useful for future studies. The second topic is related to regional or national regulations concerning the ban on mercury, as this information could be linked to the national decrease in the use of certain mercury-containing products. Finally, where available, total regional and global production and consumption estimates are included. This could give an indication of the waste mercury of product categories that are not included in Chapter 3.

4.1 Pesticides, biocides, and topical antiseptics

Mercury content

Mercury compounds are used in pesticides, biocides, and topical antiseptics. These are also called 'organomercury' and consist of at least one carbon element bonded to a mercury atom, such alkyl mercury compounds that were used as pesticides to treat fruit against diseases. [50] The content of organomercury varies per brand of product. For example, the product Shirtan Liquid Fungicide is still used in Australia by sugarcane growers to control pineapple disease; it contains 120 grams of mercury per liter. [51] Merbromin is also an organomercury compound that is used as a topical antiseptic. Antiseptics based on mercury, and that have small amounts of Hg, posed little threat to human health. Most of these antiseptics were discontinued because they were relatively ineffective. [52]

Regulation

The Rotterdam Convention has considered inorganic mercury compounds such alkyl mercury compounds, alkyl- oxyalkyl compounds, and aryl mercury compounds as pesticides since 2004. The Rotterdam Convention does not apply to these mercury compounds if they are intended for industrial use. Pesticides containing mercury are included in Annex III, which are chemicals subject to the prior informed consent procedure. [53] This ensures that international trade does not take place if an importing Party decides to prohibit use of these compounds as pesticides in the country. The Minamata Convention states that the manufacturing, import, or export of pesticides, biocides, and topical antiseptics containing mercury will not be allowed starting in 2020.

In the United States, by 1995, all U.S. registrations for mercury-containing pesticides had been cancelled. Pesticides manufactured today are mercury-free. [54] The European Union Directive 79/117/EEC from 1978 prohibited both placing on the market and the use of plant protection products that contain mercury. [55] This directive was replaced in 2009 by Regulation No 1107/2009. [56] Following this regulation, the use of mercury compounds (alkyl, alkyloxyl, and aryl mercury compounds and other inorganic mercury) in pesticides was prohibited. [57] Also, other countries have national legislation on the use of mercury in pesticides. For example, mercury has been banned in Thailand since 1992 under the Hazardous Substance Act B.E. 2535. [58]

Production, consumption, and waste

Biocides have been used in the paper industry, in paints, and on seed grain and other agricultural applications. These uses have been discontinued or banned in many countries. [59] UNEP and ISWA (2015) found that biocides and pesticides could still be in obsolete waste stocks. [60] In the European Union, recent monitoring data confirms that residues of mercury compounds occur in several products at levels higher than the limit of determination. As mercury-containing pesticides have been phased out for more than 30 years in the Union, the presence of mercury in food is assumed to be due to environmental contamination. [61]

50 European Commission (2011). Council Directive 79/117/EEC. Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31979L0117

51 Cropcare (2006). Shirtan Liquid Fungicide. Available online at https://www.cropcare.com.au/assets/888/1/ShirtanRLP495720506.pdf

52 Science Encyclopedia (2018). Antisepsis - The search for antiseptics. Available online at: http://science.jrank.org/pages/445/Antisepsis.html

53 Rotterdam Convention (2015). On the prior informed consent procedure for certain hazardous chemicals and pesticides in international trade. Available online at: http://www.pic.int/Procedures/PICProcedure/tabid/1364/language/en-US/Default.aspx

54 Mercury Sourcebook (2018). Mercury use: agriculture. Available online at: http://infohouse.p2ric.org/ref/04/03851/agr.pdf

55 European Commission (2011). Council Directive 79/117/EEC. Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31979L0117

56 European Commission (2009). Regulation (EC) No 1107/2009. Available online at https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32009R1107

57 EU Pesticides Database (2018). Mercury. Available online at: http://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=activesubstance.selection&language=EN

58 UN Environment (2017b). Regional study on mercury waste management in the ASEAN countries. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/21135/reg_study_mercury_waste_mgt_asean.pdf?sequence=1&isAllowed=

59 Zero Mercury (2018). Pesticides. Available online at: http://www.zeromercury.org/index.php?option=com_content&view=article&id=143&Itemid=92

60 UNEP, ISWA (2015). Practical Sourcebook on Mercury Waste Storage and Disposal. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/9839/practical_Sourcebook_on_Mercury_Waste_Storage_and_Disposal-2015Sourcebook_Mercruy_FINAL_web.pdf.pdf?sequence=3&isAllowed=y

61 European Commission (2018). Regulation (EC) No 396/2005. Available online at: https://www.fsai.ie/uploadedFiles/Legislation/Food_Legisation_Links/Veterinary_Medicines,_Animal_Remedies,_Control_of_Illegal_Substances_and_Po/Reg2018_73.pdf

Table 9 gives an overview of the countries where mercury containing pesticides, biocides, paints, and disinfectants (antiseptics) were still used in 2002. [62]

There was no aggregated data found on the consumption of mercury in pesticides, but UN Environment (2017) made an assessment of the consumption of mercury compounds in 2015. This category may contain pesticides and fungicides, as well as laboratory chemicals, catalysts, chemical intermediates, porosimeters, pycnometers, pharmaceuticals, mercury compounds in paints, traditional medicine, cultural and ritual uses, and cosmetics such as eye makeup and skin-lightening creams. [64]

The global mercury consumption of this category was, in 2005, between 30 and 60 tonnes (t), in 2010 between 222t and 389t, and, in 2015, between 215t and 492t. [65] In the report by UN Environment, a regional breakdown of the consumption of mercury compounds in 2015 can be found. [66] According to the study from Concorde for UNEP (2009), the consumption of the category 'other' in 2005 was between 40t and 80t in China, between 30t and 40t in East and Southeast Asia (except for China), and between 20t and 30t in South Asia. [67] The study estimates that there will be a gradual reduction up to 55% of mercury consumption in this category by 2020, and another 50% by 2050.

Table 9 – Indications of use of pesticides, biocides, and disinfectants in 2002 [63]

APPLICATION	INDICATIONS OF USE IN 2002
Pesticides (seed dressing and/or others)	Australia, Belarus, Benin (unspecified), Burkina Faso (unspecified), Côte d'Ivoire, Ghana, Guinea (unspecified), India (unspecified), Ireland
Biocides for different products and processes	Cameroon (unspecified industrial production), Ireland
Paints (latex paints and possibly others)	Australia, Ghana, Guinea, India, Ireland, Samoa, Thailand (substitution ongoing), Trinidad and Tobago (subst. ongoing or completed recently)
Disinfectants, e.g. in hospital	Burkina Faso (unspecified)

62 United Nations Environment Programme (2002). Global Mercury Assessment. Available online at: http://wedocs.unep.org/bitstream/handle/20.500.11822/11718/final-assessment-report-25nov02.pdf?sequence=1&isAllowed=y

62 Ibid.

62 Ibid.

62 Ibid

62 Ibid.

67 Concorde for UNEP (2009: p.9). Assessment of excess mercury in Asia, 2010-2050. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/11589/AsianHgstorage_ZMWGFinal_August2011.pdf?sequence=1&isAllowed=y

4.2 Non-electronic measuring devices (Manometers, Sphygmomanometers)

Mercury content

A manometer is an instrument to measure pressure, for example the pressure of gases or liquids such as steam, water, and air. A sphygmomanometer is a type of manometer that is used to measure blood pressure. In different reports, a different range is provided on the mercury content of manometers and sphygmomanometers. Table 10 presents an overview of different estimates.

Regulation

In North America and in the European Union (EU), legislation has been developed to ban these devices, aside from for very limited exception. In the EU, only the sale of mercury thermometers and other mercury instruments were banned in 2007 to the public. In 2017, the EU Regulation 2017/852 was passed, which prohibits the export, import, and manufacturing of non-electronic measuring devices from the end of 2020. [68] Mercury-free alternatives are available and offered by most international suppliers. In a document released by the Danish Environment (2006), existing alternatives are described for each measuring device. The World Health Organization also initiated a campaign to phase out Hg in thermometers and blood pressure devices by 2020 [69]. Though there are replacements for mercury-containing measuring devices, the replacements for Hg-filled thermometers of comparable accuracy usually cost 10 times the price of Hg-containing devices. [70]

Furthermore, in the UN Environment regional study on waste management in ASEAN countries, and in the UN Environment Global Waste Assessment, some national information is included. For example, Singapore has banned the importation of mercury-containing clinical thermometers since 2009. [71] And in Vietnam, mercury-containing medical measuring devices (thermometer, sphygmomanometer) have been phased-out since 2012. [72]

Production, consumption, and waste

At the global level, UN Environment (2017) [73] calculated the global mercury supply, trade, and demand in different products. In 2015, the global mercury consumption of non-electronic measuring devices was estimated between 267t and 392t. [74] The report by Concorde for UNEP (2009) makes an assessment of the consumption of mercury in non-electronic measuring devices in 2005. [75]

Table 10 – Mercury content in manometers and sphygmomanometers

MEASURING DEVICE	GRAMS OF MERCURY PER ITEM
Manometers	• 70 g- 140 g (Danish Ministry of the Environment, 2006) • 30 g – 75 g (Newmoa, 2015)
Sphygmomanometers	• medium value 80 g (UN Environment, 2017) • 70 g (Danish Ministry of the Environment, 2006) • 50 g - 140 g (Newmoa, 2010)

68 UN Environment (2017a).

69 Ibid.

70 Lin, Y., Wang, S., Wu, Q., Larssen, T. (2016) Material Flow for the Intentional Use of Mercury in China. Environ. Sci. Technol. 2016, 50, 2337–2344, DOI: 10.1021/acs.est.5b04998

71 UN Environment (2017a). Global Mercury Waste Assessment. Review of Current National Measures. Available online at: http://web.unep.org/ietc/sites/unep.org.ietc/files/Global-Mercury-Waste-Assessment-English-web.pdf

72 UN Environment (2017b). Regional study on mercury waste management in the ASEAN countries. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/21135/reg_study_mercury_waste_mgt_asean.pdf?sequence=1&isAllowed=

73 UN Environment (2017a).

74 Ibid.

75 Concorde for UNEP (2009). Assessment of excess mercury in Asia, 2010-2050. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/11589/AsianHgstorage_ZMWGFinal_August2011.pdf?sequence=1&isAllowed=y

Table 11 – Consumption of mercury in non-electronic measuring devices including products for export in 2005 [76]

MERCURY CONSUMPTION (IN TONNES)	CHINA		EAST AND SOUTHEAST ASIA EXCLUDING CHINA		SOUTH ASIA	
	min	max	min	max	min	max
Measuring and control devices	280	310	20	30	40	50

Table 12 – Basic assumptions about future mercury consumption, 2010-2050 Concorde (2009)

MERCURY CONSUMPTION 2010-2050	2015	2020	2025	2030
Measuring and control devices Asia (excluding China)	28	11	0	0

In Asia, in 2009, non-electronic measuring devices were still being manufactured. It is estimated that 80% of the total mercury consumption in this category is represented by thermometers and sphygmomanometers. [77] In 2004, tt was estimated that 80% to 90% of the world production of these two products was represented by Chinese production. According to Lin et al. (2016), in 2011 China produced thermometers containing an estimated 150t of mercury, of which about 50% were exported about. In the same year, China produced sphygmomanometers containing nearly 100t of mercury, of which about 30% were exported. This implies a total production of 250t in China in 2011 [78].

According to UN Environment, the mean production in East and Southeast Asia in 2015 was 208t. By 2015, China had not implemented measures to reduce the use of mercury in this business sector, so it's reasonable to assume that the production there remains stable, with a production mean of 208t in 2015. [79] In Asia (except for China), Concorde for UNEP (2009) estimates the phase out of the mercury fever-thermometer and blood pressure cuff manufacturing by 2017, and the phase out of remaining demand by 2025. [80] The regional consumption of mercury in measuring and control devices in other regions in 2015 can be found in the report by UN Environment [81] .

76 Ibid.

77 Ibid.

78 UN Environment (2017a).

79 Ibid.

80 Concorde for UNEP (2009). Assessment of excess mercury in Asia, 2010-2050. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/11589/AsianHgstorage_ZMWGFinal_August2011.pdf?sequence=1&isAllowed=y

81 UN Environment (2017a: p.81). Global mercury supply, trade and demand. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/21725/global_mercury.pdf?sequence=1&

4.3 Cosmetics

Mercury content
Mercury is still used in cosmetics in certain countries, as reported by a number of studies. Wang and Zhang (2015) evaluated the mercury levels of cosmetics currently marketed in Shijiazhuang in China. In this study, almost all (91.8%) of the 146 samples analyzed contained mercury, but the concentrations were below the legal limit. The skin cosmetics had the highest mean mercury content of 45ng per gram, as reported in Table 13. [82] Also according to UN Environment (2017), the most important use of mercury in cosmetics is for skin-lightening creams. The estimated mercury content in skin-lightening cream or soap is 30 milligram of mercury per kilogram. [83] A study by Hamann et al. (2014) screened 549 products, of which 6% had a mercury content exceeding 1,000 ppm. These were produced in several countries including China, Jamaica, Japan, and Thailand. [84]

Table 13 – Mercury content of cosmetic samples from (Wang and Zhang, 2015). ND, not detectable

	TOTAL QUANTITY	DETECTED CONTAINING-MERCURY QUANTITY (N)	RATIO OF MERCURY DETECTION (%)	RANGE OF MERCURY CONTENT (NG/G)	QUALIFIED RATIO (%)	RSD (%)
Shampoo	32	29	90.6	ND-592	100	0.4
Hairdressing gel	8	7	87.5	ND-423	100	0.4
Hair color	2	2	100.0	4.02-27.0	100	0.4
Body wash	6	5	83.3	ND-12.2	100	0.8
Hair conditioner	8	7	87.5	ND-74.3	100	0.4
Hand lotion	4	4	100.0	7.99-122	100	0.8
Hand washing	1	1	100.0	220	100	0.8
Facial cleanser	17	14	82.4	ND-162	100	0.8
Moisturizers/cream	35	35	100.0	0.03-163	100	0.8
Whitening	17	15	88.2	ND-561	100	0.4
Eye gel	1	1	100.0	87.5	100	0.8
Lip care	3	3	100.0	28.6-230	100	0.5
Toner	5	4	80.0	ND-44.2	100	0.5
Nail savers	3	3	100.0	ND-16.4	100	0.5
Others	4	4	100.0	1.95-22.8	100	0.3

82 Wang, L., Zhang, H. (2015). Mercury content in marketed cosmetics: analytical survey in Shijiazhuang, China, Cutan Ocul Toxicol, Early Online: 1–5 1556-9535

83 UN Environment (2017)c. Toolkit for Identification and Quantification of Mercury Releases. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/14777/Hg-Toolkit-Guideline-IL1-January2017.pdf?sequence=1&isAllowed=y

84 UN Environment (2017a).

Regulation
In the Minamata Convention, cosmetics with a mercury content above 1ppm are included in Annex A: after 2020 the manufacture, import, or export of this product will not be allowed.

Though in the European Union and in many African nations, the distribution of mercury-containing creams and soaps is banned, they are still used in certain areas. [85] In the European Union, mercury and mercury compounds are not allowed as ingredients in cosmetics, except for phenyl mercuric salts in eye-makeup and eye-makeup removal with a maximum concentration of 0.007% by weight. The United States allows mercury compounds in the eye area cosmetics, at a concentration at or below 65 mg/k. In all other cosmetics, the concentration must be less than 1 mg/kg. [86] Countries also have national legislation to decrease or ban mercury in cosmetics. For example, Thailand has required limited mercury content in their overarching cosmetic regulation (Cosmetics Act B.E 2559) since 2016. [87, 88]

Global statistics
Global or regional aggregate production or consumption quantities of mercury estimates in cosmetics were not found in literature. The only estimates available concern the consumption of mercury in a group category of mercury compounds. According to UN Environment (2017), the global mercury consumption of the category 'other' was between 30t and 60t in 2005, between 222t and 389t in 2010, and between 215t and 492t in 2015. [89]

Regional statistics
According to Gerdeman (2017), facial care was a USD1 billion market in India by 2015, of which skin-lighteners represented almost half the market size, and it was expected to double by 2019. According to the WHO, in 2011 mercury was still used in skin-lightening products on a regular basis, by 25% of women Mali, 77% in Nigeria, 27% in Senegal, 35% in South Africa, and 59% Togo. In 2004, nearly 40% of women surveyed in China (Province of Taiwan and Hong Kong Special Administrative Region), Malaysia, the Philippines, and the Republic of Korea reported using skin-lighteners. In India, 61% of the dermatological market consists of skin-lightening products. [91]

The study by Concorde for UNEP (2009) estimates that in Asia in 2005, the consumption of the category 'other' (uses of mercury in pesticides, fungicides, catalysts, paints, chemical intermediates, laboratory and clinical applications, research and testing equipment, pharmaceuticals, cosmetics, traditional medicine, cultural and ritual uses, etc.), was between 40t and 80t in China, between 30t and 40t in East and Southeast Asia (excluding China), and between 20t and 30t in South Asia. [92]

In the study by UN Environment (2017), the regional mean of the consumption of 'mercury compounds and other applications' for East and Southeast Asia is 62t, 59t in South Asia, 84t in the European Union, 37t in CIS and other European countries, 9t in the Middle Eastern States, 5t in North Africa, 15t in Sub-Saharan Africa, 61t in North America, 8t in Central America and the Carribean, 13t in South America, and 1t in Australia, New Zealand, and Oceania. [93]

85 WHO (2011). Mercury in Skin Lightening Products. Available online at: http://www.who.int/ipcs/assessment/public_health/mercury_flyer.pdf

86 Ibid.

87 UN Environment (2017b). Regional study on mercury waste management in the ASEAN countries. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/21135/reg_study_mercury_waste_mgt_asean.pdf?sequence=1&isAllowed=

88 Chemlinked (2016). Thailand Cosmetics Legislation. Available online at: https://cosmetic.chemlinked.com/cosmepedia/thailand-cosmetics-legislation

89 Ibid.

90 UN Environment (2017a). Global mercury supply, trade and demand. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/21725/global_mercury.pdf?sequence=1&

91 WHO (2011). Mercury in Skin Lightening Products. http://www.who.int/ipcs/assessment/public_health/mercury_flyer.pdf

92 Concorde for UNEP (2009: p.9). Assessment of excess mercury in Asia, 2010-2050. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/11589/AsianHgstorage_ZMWGFinal_August2011.pdf?sequence=1&isAllowed=y

93 UN Environment (2017a:81).

4.4 Batteries

Mercury content

Different types of batteries contain mercury, the function of which is to extend the lifetime of the battery. Of the different types, mercury oxide batteries (also called mercury-zinc cells) contain the highest quantity of mercury (329 kg of Hg per tonne of battery). These batteries have been used for many years in, amongst others, military, medical, and maritime applications. The following table illustrates the mercury content in mercury-added batteries. [94]

Table 14 – Mercury content in batteries

MERCURY-ADDED BATTERIES	MERCURY CONTENT (KG HG/TONNE BATTERIES)
Mercury oxide (also called mercury-zinc cells), all sizes	320
Zinc-air button cells	12
Silver oxide button cells	4
Alkaline button cells	5
Alkaline, other than button cell shapes	0.25*

* European Union regulations restrict the mercury content to no more than 0.005 kg of mercury per tonne (t) of batteries. Source: UNEP (2015), p207 [95]

Additionally, a company specialized in responsible recycling services provided UNU with data on the mercury content per battery. The company estimates that their batteries contain between 30 and 50 ppm Hg. This is under the legal limit of 2% Hg per battery. The company collects, on average, 2,800 tonnes (t) of batteries per year, of which 2,200 have an ''average" concentration of 30 ppm Hg and, in addition, around 1.5t of zinc air button cells containing mercury. zinc air button cells may contain higher quantities of mercury, but the volumes of zinc air buttons cells with mercury that are collected are relatively small. [96]

Regulation

Following the Minamata Convention, the manufacturing, import, and export of batteries, except for zinc button silver oxide batteries with a mercury content of less than 2% and zinc air button batteries with a mercury content of less than 2%, will not be allowed from 2020 onward.

Several countries have already placed a limit on the mercury content of batteries. In the European Union, all batteries and accumulators that contain more than 0,0005% of mercury by weight have been prohibited since 2006, except for button cells that can have a mercury content of no more than 2% by weight. [97] However, a study by the Federal Environment Agency from Germany (2011) analyzed 300 samples of batteries from different producers in Germany and the analysis showed that Hg contents above the limit of 20000 mg/kg for button cells were found in 1 of 30 zinc air button cells. Hg contents above the limit of 5 mg/kg for mono-cells and other types were found in 4 of 25 zinc/carbon mono cells and in 1 of 11 9-V-zinc carbon batteries. [98]

94 UN Environment (2017a). Global mercury supply, trade and demand. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/21725/global_mercury.pdf?sequence=1&

95 Ibid.

96 BATREC (Veolia group) (2018). Data provided via email upon request.

97 European Commission (2006). DIRECTIVE 2006/66/EC. Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006L0066&from=En

98 Federal Environment Agency (2011). Survey of Mercury, Cadmium and Lead Content of Batteries. Analysis of Samples of Customary Batteries and Batteries Sold in Appliances. Preparation of a Sampling Plan, Purchase of Samples and Analysis.

Production, consumption, and waste
Globally, the use of mercury in batteries is estimated to continue to decline. The use of mercury has already declined from 270 tonnes (t): 460t in 2005 to 159t-304t in 2015. [99] However, there remains considerable uncertainty about the contribution of mercuric oxide batteries. UN Environment (2017) analyzed trade statistics from 2015 which indicated that there is ongoing international commerce in mercuric oxide batteries. The Comtrade statistics showed that more than 100 countries imported mercuric oxide batteries in 2015, with net world imports of these batteries of about 300t. China was the major producer of alkaline manganese button cells. In 2015, China exported over 200 000t of batteries (of all sizes) identified in Comtrade as manganese dioxide cells and batteries, some of which were alkaline and some not. [100] According to Comtrade, Belgium and Indonesia exported about 60 000t each, and Singapore and the United States exported over 30 000t each. China's objective to shift production to mercury-free alkaline manganese button cells appears to be realistic by 2020.

A study from Concorde for UNEP (2009) estimates a decrease of 75% in mercury consumption in Asia between 2005 and 2015 in batteries, (from 230t - 370t in 2005 to 57,5t - 92,5t in 2015) and estimates the remaining demand for mercury in batteries will be phased out gradually until 2025.

Summary of results

This chapter provided an overview of the regions and countries where the use of mercury in certain products has been banned (sometimes for many years). Though this indicates that consumption has decreased, products are still produced and consumed in other regions. Therefore, based on an analysis of the regional or national mercury regulations, it was not possible to make global estimates of the consumption of mercury.

UN Environment (2017) made estimates of global mercury consumption and production, and the report by Concorde for UNEP (2009) made estimates of mercury consumption in the Asian region. The most recent estimates of mercury production and consumption are for 2015: UN Environment (2017) [101] estimated that the global mercury consumption of non-electronic measuring devices was between 109 tonnes (t) and 185t, and the consumption of batteries between 159t - 304t. Concorde for UNEP (2009) estimates that the mercury consumption of batteries in Asia was 57.5t – 92.5t in 2015 and also estimates the remaining demand for mercury in batteries will be phased out gradually until 2025. The category of cosmetics and pesticides and biocides were included in the overarching category of mercury compounds, so the mercury consumption of these products was not specified. The total consumption of batteries and mercury compounds (including cosmetics, pesticides, and fungicides) is between 374t and 796t for 2015. [102] Finally, estimates were provided on the mercury content per product which show the ratio of mercury content between different products. The content varies per brand and product and therefore different estimates were found.

As outlined in the introduction, no data was found on the trade flows related to the product categories analyzed in this chapter.

99 UN Environment (2017a). Global mercury supply, trade and demand. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/21725/global_mercury.pdf?sequence=1&

100 Ibid.

101 Ibid.

102 Ibid.

Therefore the data related to the mercury content per product could not be used to calculate the global consumption and waste estimates.

However, based on the availability of relevant trade flows information, the matching exercise could be conducted in future studies, similar to what has been done for the products included in Chapter 3, as it will be also specified in the final recommendations.

Finally, the table included in Annex 5 was developed by the authors to provide an overview on i) the sources of mercury listed in the Minamata Convention ii) the data on consumption developed by UN Environment and iii) the specific products analyzed within this report, with an indication on if it was based on the developed methodology in this report or on a literature review along with the relevant waste global estimate (when available). The data included in the table are meant to support the reader in understanding the state of the data available, the elaborations developed in this study, and the existing gaps that could be potentially filled in with further analyses.

RECOMMENDATIONS

Based on this research on the generation of waste mercury from 2010 to 2035, the following recommendations have been developed:

- The projections of waste mercury volumes, developed here, could be further extended to analyse environmental impacts by linking the estimates of waste from mercury-added product to estimates of mercury releases from mining, soil contamination, etc.

- For some of the products listed by the Minamata Convention, there was no matching code in the Harmonized Commodity Description and Coding System (HS), which is used in trade statistics. Many of the codes were too general and did not specify products containing mercury. Further work to develop HS codes, that specifically identifies mercury-added products, would greatly facilitate monitoring of these products and wastes.

- More information on mercury is needed in specific product categories, such as the evolution over time of the average concentration of mercury in non-electronic measuring devices, cosmetics, switches, relays, etc. Such information could be integrated easily with the developed methodology. It should be coordinated with the main international, national, and regional organizations and other groups (e.g., governments, IOs, NGOs, recycling companies, etc.) working in this field.

- For many countries, it might not be easy to conduct inventories of mercury-added product manufacturing and trade, especially because, for many of the products, official trade data will not differentiate between mercury and mercury-unit. According to a number of UN agencies working in this field, there is still a wide gap between the provisions of the Minamata Convention and the current waste mercury management practice. Even though waste mercury is already present in regulatory frameworks worldwide, many developing countries usually do not have the capacity to implement specific provisions: thus the environmentally sound management of hazardous wastes itself remains the main challenge. Within the framework of ongoing work under the Minamata Convention on Mercury and the Basel Convention on hazardous wastes, countries should be supported and encouraged to conduct additional assessments and to develop national and regional statistics on mercury production, consumption, and disposal of waste from mercury-added product. A set of performance indicators should be developed, possibly in line with the methodological approach adopted and presented in this study. For instance, the methodology and outcomes of this study could be adapted into a toolkit to inform policymakers about mercury in their countries, and to allow them to improve the accuracy of their national data.

- A cooperation mechanism on monitoring global mercury trends, such as following the model of the Global E-waste Statistics Partnership (GESP), is encouraged. Such a mechanism could make global and regional data available to the general public and policymakers. It can contribute to the development of a harmonized methodology, provide estimates if national data are lacking, and provide a framework to monitor mercury-added products and waste disposal. It could also develop guidelines and build capacity in specific countries in support of a fact-based policymaking process.

- In addition to improving forecasts, the actual achievements from countries on the management of mercury-containing waste is an essential next step to monitor the effectiveness on the policies, of which the presented methodology provides a good framework to monitor. Developing arrangements on comparable monitoring data and an effective evaluation framework could also complement the ongoing work under the Minamata Convention. Moreover, it might also assist countries in their reporting obligation, both under the Basel and Minamata Convention.

- At the same time, by building upon other monitoring measures utilized in this field by international organizations such as UN Environment, a set of more detailed performance indicators could be established and regularly monitored in an organized manner. The Mercury Inventory Toolkit could improve data in the future, as it provides a standardized methodology and accompanying database for the development of consistent national and regional mercury inventories. When a large number of countries provide data through the toolkit, a global picture of mercury consumption can be achieved.

- Finally, the assessment and prevention of illegal transboundary movement and dumping of mercury waste–similar to what previously occurred in the field of e-waste—should be encouraged. In general, a more comprehensive approach to address the challenges of environmentally sound management of hazardous wastes should be considered.

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ANNEX

Annex 1 – Overview on Vietnam's regulations

	Minamata Convention	Current regulations of Vietnam			
No	**Product containing mercury (Appendix A, part I, MC)**	**Prohibit to produce/ circulate on the market**	**Prohibit to export**	**Prohibit to import**	**Sources cited**
(1)	(2)	(3)	(4)	(5)	(6)
1	Batteries, except zinc oxide–silver button cells with a mercury content of <2%, zinc-air button cells with mercury content <2%	None	None	None	
2	Switches and relays, except for capacitance switches and relays with very high accuracy and high-frequency radio waves in the monitoring and controlling tools with a maximum mercury content to 20 mg per bridge	None	None	None	
3	Compact fluorescent light (CFL) for general lighting purposes, with capacity ≤ 30 watt with a mercury content exceeding 5 mg per lamp burner	There are no regulations on the mercury content of compact fluorescent lamps. However, with the unipolar fluorescent lamps for general lighting purposes, capacity <30W, maximum levels of mercury are not permitted> 2.5 mg / burner	None	As column 3	- Circular No. 30/2011 / TT-BTC dated 11/08/2011, and - Decision 16 / VBHN-BCT dated 04.25.2014 supplementedcircular 30/2011 / TT-BCT
4	Linear fluorescent lamps (LFLs) for general lighting purposes: (a) Phosphorous three-band, capacity <60 watts with a mercury content exceeding 5 mg per bulb; (b) Halophosphate phosphor, capacity ≤ 40 watt with a mercury content exceeding 10 mg per bulb	There is no maximum allowable limit of mercury in three-band fluorescent lamps, capacity <60 watts. However, with dipolar linear fluorescent lamps for general lighting purposes, the maximum allowable value of mercury in fluorescent lamps with three spectral lines, average lifespan, with diameters from 17 mm - 28 mm is not exceeding 3.5 mg / lamp;	None	As column 3	- Circular No. 30/2011 / TT-BTC dated 11/08/2011, and - Decision 16 / VBHN-BCT dated 04.25.2014 supplementedcircular 30/2011 / TT-BCT
5	High pressure mercury vapor lamps (HPMV) for general lighting purposes	No mercury regulations for high-pressure mercury vapor lamps. Prohibit to exceed the maximum value allowed for mercury (i) High pressure sodium vapor lamps for general lighting purposes: 30 mg / burner (P <155W), 40 mg / burner (155 W <P <405W), 40mg / burner (P> 450W); (ii) Other high pressure sodium vapor lamps used for general lighting purposes: 25 mg / burner (P <155 W), 30 mg / burner (155 W <P <405 W), 40 mg / burner (> 405W);	None	As column 3	- Circular No. 30/2011 / TT-BTC dated 11/08/2011, and - Decision 16 / VBHN-BCT dated 25/04/2014 supplemented circular 30/2011 / TT-BCT
6	Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps external electrode (CCFL and EEFL) for electronic screens: (a) short length (≤ 500 mm) with a mercury content above 3.5 mg per bulb (b) average length (> 500 mm and ≤ 1 500 mm) with a mercury content above 5 mg per bulb (c) long length (> 1500mm) with mercury content above 13 mg per lamp	Prohibit cold cathode fluorescent lamps and external electrode fluorescent lamps to have mercury content exceeds the maximum allowed value (for each lamp): (i) Short length (≤500mm): 3.5 mg/lamp; (ii)Average length (> 500mm and <1500mm): 5mg /lamp; (iii) Long length (> 1500 mm): 13 mg / lamp;	None	As column 3	- Circular No. 30/2011 / TT-BTC dated 11/08/2011, and - Decision 16 / VBHN-BCT dated 25/04/2014 supplemented circular 30/2011 / TT-BCT on temporary regulations about some toxic chemicals in electrical, electronic products
7	Cosmetics (with a mercury content above 1 ppm), including soaps and lightening creams , and not including cosmetics for eye area in which mercury is used as a preservative and	Prohibit cosmetics production that exceeds the maximum allowable value of mercury: **1ppm**	None	As column 3	Circular 06/2011 / TT-BYT BYT dated 25/01/2011 regulated on cosmetics management
	currently there is no equally effective and safe alternative preservation [2]				
8	Pesticides, biocides and disinfectants on the spot	- Regulation on production, trade, export, import of pesticides in general - Regulation on management (export, import and circulation ...) of chemicals, insecticides, disinfectants in the field of dosmetic and medical appliances - List of chemicals, insecticides, disinfectants in dosmetic and medical fields	As column 3	As column 3	- Circular 21/2015 / TT-BNN on pesticide management, - Circular 29/2011 / TT-BYT dated 30/06/2011 - Circular 25/2011 / BYT dated 30/06/2011
9	Non-electronic measuring devices following, excluding non-electronic measuring devices installed in large-scale equipment or in devices used for high accuracy measurements, which there is no appropriate mercury-free device available for replacement: (a) barometers; (b) hygrometer; (c) pressure gauge ; (d) thermometer; (e) sphygmomanometer	None Circular 30/2011 / TT-BCT mentioned only limited value for the majority of mercury allowed in automatic measuring instrument: volume 0.1%	None	None	

Source: VCA (2016), pp. 23-37

Annex 2 – Typical values for mercury in manufactured and formulated Hg products (Nigeria)

Manufactured Mercury-added Components and Products

Component or Product	Amountof Mercury in Individual Component or Product (grams)
Measuring devices:	
Barometers	400 – 620
Sphygmomanometers	50 – 140
Manometers	30 – 75
Psychrometers	5 – 6
Thermometers	0.5 – 54
Switches & Relays:	
Flame Sensors	>1
Float Switches	0.1 – 70
Tilt Switches	0.05 – 5
Relays	0.005 - >1
Dental Amalgam	>0.1 – 1
Lamps:	
Fluorescent	<0.10
Compact Fluorescent	<0.01
High Intensity Discharge (metal halide, ceramic metal halide, mercury vapor, high pressure sodium)	<1
Mercury Short Arc	0.1 – 1
Button-cell Batteries	<0.05

Source: GEF, UNIDO, UNITAR (2017), p.15

Annex 3: List of countries considered in quantitative analysis

COUNTRY	REGION
Afghanistan	Asia
Angola	Africa
Albania	Europe
United Arab Emirates	Asia
Argentina	Americas
Armenia	Asia
Antigua and Barbuda	Americas
Australia	Oceania
Austria	Europe
Azerbaijan	Asia
Burundi	Africa
Belgium	Europe
Benin	Africa
Burkina Faso	Africa
Bangladesh	Asia
Bulgaria	Europe
Bahrain	Asia
Bahamas	Americas
Bosnia and Herzegovina	Europe
Belarus	Europe
Belize	Americas
Bolivia (Plurinational State of)	Americas
Brazil	Americas
Barbados	Americas
Brunei Darussalam	Asia
Bhutan	Asia
Botswana	Africa
Central African Republic	Africa
Canada	Americas
Switzerland	Europe
Chile	Americas
China	Asia
Côte d'Ivoire	Africa
Cameroon	Africa
Congo	Africa
Colombia	Americas
Comoros	Africa
Cape Verde	Africa
Costa Rica	Americas
Costa Rica	Americas
Cyprus	Asia
Czech Republic	Europe
Germany	Europe
Djibouti	Africa
Dominica	Americas
Denmark	Europe
Dominican Republic	Americas
Algeria	Africa
Ecuador	Americas
Egypt	Africa
Eritrea	Africa
Spain	Europe
Estonia	Europe
Ethiopia	Africa
Finland	Europe
Fiji	Oceania
France	Europe
Micronesia (Federated States of)	Oceania
Gabon	Africa
United Kingdom of Great Britain and Northern Ireland	Europe
Georgia	Asia
Ghana	Africa
Guinea	Africa
Gambia	Africa
Guinea-Bissau	Africa
Greece	Europe
Grenada	Americas
Guatemala	Americas
Guyana	Americas
China, Hong Kong Special Administrative Region	Asia
Honduras	Americas
Croatia	Europe
Hungary	Europe
Indonesia	Asia
India	Asia
Ireland	Europe
Iran (Islamic Republic of)	Asia
Iraq	Asia

COUNTRY	REGION
Iceland	Europe
Israel	Asia
Italy	Europe
Jamaica	Americas
Jordan	Asia
Japan	Asia
Kazakhstan	Asia
Kenya	Africa
Kyrgyzstan	Asia
Cambodia	Asia
Kiribati	Oceania
Saint Kitts and Nevis	Americas
Republic of Korea	Asia
Kuwait	Asia
Lao People's Democratic Republic	Asia
Lebanon	Asia
Libya	Africa
Saint Lucia	Americas
Sri Lanka	Asia
Lesotho	Africa
Lithuania	Europe
Luxembourg	Europe
Latvia	Europe
China, Macao Special Administrative Region	Asia
Morocco	Africa
Republic of Moldova	Europe
Madagascar	Africa
Maldives	Asia
Mexico	Americas
The former Yugoslav Republic of Macedonia	Europe
Mali	Africa
Malta	Europe
Myanmar	Asia
Montenegro	Europe
Mongolia	Asia
Mozambique	Africa
Mauritania	Africa
Mauritius	Africa
Malawi	Africa

COUNTRY	REGION
Malaysia	Asia
Namibia	Africa
Niger	Africa
Nigeria	Africa
Nicaragua	Americas
Netherlands	Europe
Norway	Europe
Nepal	Asia
New Zealand	Oceania
Oman	Asia
Pakistan	Asia
Panama	Americas
Peru	Americas
Philippines	Asia
Palau	Oceania
Papua New Guinea	Oceania
Poland	Europe
Portugal	Europe
Paraguay	Americas
Qatar	Asia
Romania	Europe
Russian Federation	Europe
Rwanda	Africa
Saudi Arabia	Asia
Sudan	Africa
Senegal	Africa
Singapore	Asia
Solomon Islands	Oceania
Sierra Leone	Africa
El Salvador	Americas
Serbia	Europe
Sao Tome and Principe	Africa
Suriname	Americas
Slovakia	Europe
Slovenia	Europe
Sweden	Europe
Swaziland	Africa
Seychelles	Africa
Chad	Africa

COUNTRY	REGION
Togo	Africa
Thailand	Asia
Turkmenistan	Asia
Timor-Leste	Asia
Tonga	Oceania
Trinidad and Tobago	Americas
Tunisia	Africa
Turkey	Asia
Tuvalu	Oceania
United Republic of Tanzania	Africa
Uganda	Africa
Ukraine	Europe

COUNTRY	REGION
Uruguay	Americas
United States of America	Americas
Saint Vincent and the Grenadines	Americas
Venezuela (Bolivarian Republic of)	Americas
Viet Nam	Asia
Vanuatu	Oceania
Samoa	Oceania
Yemen	Asia
South Africa	Africa
Zambia	Africa
Zimbabwe	Africa

Annex 4: Mercury waste per region in 2017

CONTINENT	REGION	MERCURY WASTE (G/INH.)	MERCURY WASTE (T)
World		0.18	1319
Africa	Eastern Africa	0.01	5
	Middle Africa	0.03	2
	Northern Africa	0.08	19
	Southern Africa	0.16	10
	Western Africa	0.01	5
Americas	Caribbean	0.19	3
	Central America	0.25	44
	Northern America	0.82	297
	South America	0.23	95
Asia	Central Asia	0.24	7
	Eastern Asia	0.14	219
	South-Eastern Asia	0.08	50
	Southern Asia	0.03	49
	Western Asia	0.35	83
Europe	Eastern Europe	0.30	88
	Northern Europe	0.69	72
	Southern Europe	0.59	90
	Western Europe	0.81	157
Oceania	Australia and New Zealand	0.82	24
	Melanesia	0.01	0.1
	Micronesia	0.03	0.01
	Polynesia	0.02	0.01

Annex 5: Comparison between global estimate of mercury consumption from the UN Environment and mercury waste from this report

SECTORS OR PRODUCT CATEGORIES	GLOBAL MERCURY CONSUMPTION [1] (T) SOURCE: UN ENVIRONMENT (2017) [2]	SECTORS OR PRODUCT CATEGORIES INCLUDED IN THIS STUDY	PRODUCT NAME	GLOBAL MERCURY WASTE (T) SOURCE: THIS REPORT[2]
Small scale and artisanal mining	872 - 2 598	Not included in the present study		
Vinyl chloride monomer production	1 210 - 1 241	Not included in the present study		
Chlor-alkali production	233 - 320	Not included in the present study		
Batteries	159 - 304	Qualitative analysis		Global estimates not available
Dental applications	226 - 322	Not included in the present study		
Measuring and control devices [3]	267 - 392	Quantitative analysis	Thermometers [4]	141
			Hygrometers [5]	318
			Barometers	726
		Qualitative analysis	Manometers	Global estimates not available
			Sphygmomanometers	Global estimates not available
Lamps [5]	112 - 173	Quantitative analysis	Compact Fluorescent Lamps	0.9
			Straight Tube Fluorescent Lamps	38
			Special Lamps	17
Electrical and electronic devices	109 - 185	Quantitative analysis	Desktop PCs	0.1
			Laptops (incl. tablets)	0.6
			Mobile Phones (incl. smartphones, pagers)	2.5
			Flat Display Panel Monitors (LCD, LED)	0.3
			Flat Display Panel TVs (LCD, LED, Plasma)	1.3
		Qualitative analysis	Switches and relays	Global estimates not available
	215 - 492	Not included in the present study		
Total	**3 404 - 6 027**			**1246**

1 Note: Rather than "demand," the term "consumption" is used here to indicate the mercury content of all mercury added products used in a given country or region during a given year, as well as the gross mercury inputs of any industrial processes. For example, although most energy-efficient lamps (such as compact fluorescent lamps) are produced in China and therefore represent basic Chinese "demand" for mercury, many of them are exported, used and disposed of in another country, which is the actual place of "consumption." If mercury-added products consumed in a country are also produced in the same country, then all of the mercury that goes into their production (and related production waste) is also included in the calculation of consumption. Likewise, all mercury used in dental practices should be included in the calculation of a country's mercury consumption. If mercury happens to be consumed, recycled and consumed again in the same year, it would be counted two times as consumption, consistent with the overall level of activity. (UN Environment, 2017)

21 The data refer to 2015

3 This category includes: dairy manometers, general-purpose thermometers (laboratory, industrial) and fever thermometers. (UN Environment, 2017)

4 This category includes: thermometers and pyrometers; liquid filled, for direct reading, not combined with other instruments. Source: this report

5 This category includes: hydrometers and similar floating instruments, barometers, hygrometers, psychrometers, thermometers, pyrometers; recording or not, any combination of these instruments, parts and accessories. Source: this report

6 This category includes: discharge lamps, fluorescent, hot cathode, with and without double ended cap, Mercury and sodium vapour lamps and discharge lamps (excl. fluorescent, hot cathode lamps, mercury/sodium vapour lamps, metal halide lamps and ultraviolet lamps). (UN Environment, 2017)

7 This category comprises of mercury-added switches and relays. (UN Environment, 2017

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