

**DEVELOPMENT OF THE
MERCURY MATERIAL FLOW (MMF)
IN THE PHILIPPINES (2021)
Draft Report**

April 2025
(Final Draft)

EXECUTIVE SUMMARY

The Minamata Convention on Mercury is a global treaty that aims “*to protect human health and the environment from the anthropogenic emissions and releases of mercury and mercury compounds*”. The Philippines ratified the Convention on July 8, 2020. Prior to ratification, the government has conducted several inventories using the UNEP Level-1 and Level-2 Toolkit for Identification and Quantification of Mercury Release. This is crucial for the government to take effective action to prevent, minimize and manage mercury along its life cycle.

The “Development of the Mercury Material Flow in the Philippines” aimed to assist the country to manage mercury in an environmentally sound manner. While the mercury inventory developed using the UNEP Toolkit is a good initial step, Japan’s MMF analysis visually presents the life cycle flow of mercury in the country by integrating relevant information and provides more accurate estimate of mercury flow based on actual country-specific information. The development of the MMF strengthened the capability of government agencies to fulfill its reportorial duties to the Convention. If updated and upgraded periodically, the MMF could serve as a tool to assess the impact and effectiveness of domestic policy and regulatory measures aimed at reducing mercury pollution.

This MMF in the Philippines benefited from the technical support of the Ministry of Environment-Japan, which shared its experience and expertise in developing both sector-specific and nationwide MMFs. The framework covered national-level mercury flows, with sectoral analysis focused on artisanal and small-scale gold mining, mercury-added products, and coal combustion—sectors identified through previous inventories as major contributors to mercury pollution.

To facilitate MMF development, data gaps with reference to the 2018 inventory have been identified. These included lack of updated trade data, use of default input and output factors, and other information relevant to assessing the flows of mercury across environmental media and sectors/ source categories. To address these, a combination of data collection activities were undertaken, including desk research, key informant interviews, field data collection and investigative research (specifically for ASGM).

The project could have benefited from a fully established Project Steering Committee and Inter-Agency Technical Working Group, both of which were not set up in a timely manner. Aside from the actual data collection activities and analysis, stakeholder engagement activities (e.g. consultations) were held to get the commitment of relevant stakeholders and to collect their inputs to the project process and methods, key findings and outputs.

The MOEJ's support is limited in both duration and resources; hence, some data may not be fully accurate and certain gaps may remain. It is expected that the data will be updated and improved regularly through other projects in the future. Accordingly, this report should be regarded as a living document that will require further refinement. Users of this report are advised to take these limitations into full consideration.

The MMF development process has led to the following key findings and outputs:

- **Primary (virgin) metal production** is the largest source of mercury inputs and emissions in the country. Within this, **gold and silver production using mercury amalgamation** is the main anthropogenic source, driven by uncontrolled practices that lack mercury recovery technologies such as retorts. Estimates indicate that **14.14 to 22.42 metric tons** of elemental mercury are consumed annually in the ASGM sector, most of which is likely **imported informally**. Additionally, **mercury impurities from copper extraction** and **non-amalgamation-based large-scale gold and silver mining** contribute approximately **62.5 metric tons** of mercury input per year.
- A further concern is the use of **cyano-mercury**, where mercury continues to be used alongside cyanide in processing plants, particularly during the **cyanidation of mercury-contaminated gold tailings**.
- Copper extraction and concentrate production account for 18% of total air emissions from primary metal production, while gold and silver production without mercury amalgamation contribute 23%, based on the MIA 2018 data for gold processing. Given their substantial contributions, both industries should be prioritized in mercury reduction efforts.
- Coal-combustion industries are significant sources of mercury air emissions, with emissions increasing compared to MIA 2019. Large power plants contribute the majority of mercury emissions, with an input of **2.123 metric tons of mercury** per year and **air emissions of 1.274 metric tons** per year. In the production of other minerals and

materials with mercury impurities, **cement production is the primary contributor**, with **1.3 metric tons of mercury input** per year and **air emissions of 0.8 metric ton** per year.

- Mercury-added products, specifically skin lightening creams and, to a lesser extent, mercury amalgam, traded and sold illegally, present a significant challenge alongside ASGM in terms of mercury pollution, posing risks to the health of vulnerable populations.
- The country has seen a reduction in the use of mercury-added lamps following its phase-out measures. However, the management of waste from these products, in light of the 2022 phase-out date, has yet to be fully addressed.
- While most regulatory test emission results of industries indicate compliance, the lack of separate mercury analytical procedures and analyses to determine mercury content in raw materials and fuels used in regulated industries may be insufficient. Existing regulatory actions and policies aimed at controlling mercury emissions from coal-fired power plants and cement clinker production facilities may be remiss in effectively managing releases into the environment and to support evaluation, recommendations and environmentally-sound waste management. The Minamata Initial Assessment 2018 also highlighted challenges in verifying data sets obtained through self-monitoring mechanisms in regulated industries.

Based on these, the following recommendations were identified:

To effectively address mercury pollution, regulatory frameworks must be strengthened to close gaps in emission controls, while monitoring and verification mechanisms should be developed through the implementation of separate mercury-specific analytical procedures. Targeted strategies are needed to manage mercury waste, particularly from ASGM and phased-out mercury-added products.

- Conduct a nationwide ASGM mercury use assessment to validate the identification of elemental mercury stock sourced from traders who illegally import, buy and sell, and implement measures to address the challenge. A comprehensive review of mercury import and export data and monitoring of illegal traders and online sellers may be conducted.
- Pursuant to Article 8 of the Minamata Convention, regulatory policies must require BAT/BEP in relevant point sources for a stronger mercury standard taking into

consideration economic, technical, and social viability. This could include alternative testing procedures to promote representative and accurate quantification of mercury pollution risk. This will principally entail the updating of existing related policies and regulations.

- Improve monitoring and reporting mechanisms from facilities and plants to national data systems under DENR, including the conduct of on-site surveys to establish a mercury stock and emission inventory for relevant sources.
- Based on these, appropriate strategies for identifying and assessing sites contaminated by mercury and mercury compounds, as well as for future management, may be effectively developed, initially focusing on the sectors with the highest documented emissions.
- Prioritize key areas of activity on mercury added products, especially skin-lightening products, by focusing on coordinated compliance mechanisms before they are sold to consumers.
- Conduct further assessments on the prevalence and risks of other MAPs, including mercury-laced toy products being sold in the market, especially in sectors or locations suspected and reported to be widely present. The emergence of mercury-laced toy products being sold on the market based on market monitoring and screening requires further research to assess their prevalence and risks.
- Enhance regular monitoring in tracking the demand for and sale of mercury-added products and regulatory mechanisms such as inspections, sanctions, penalties, voluntary agreements and screening tools for customs. including effective engagement with e-commerce platforms.
- Improve the identification of stock inventory and the collection of phased-out mercury containing consumer products for final disposal, including uncollected stocks of fluorescent lamps and medical-measuring devices at the household, barangay and hospital levels, to reduce the risk of mercury release to the environment when breakage occurs.

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LIST OF ACRONYMS AND ABBREVIATIONS

ASEAN	Association of Southeast Asian Nations
ASGM	Artisanal and Small-scale Gold Mining
BAT/BEP	Best Available Technologies / Best Environmental Practices
BOC	Bureau of Customs
BSP	Bangko Sentral ng Pilipinas
CIP	Carbon-in-Leach
CCO	Chemical Control Order
CFFP	Coal-Fired Power Plant
COP	Conference of the Parties
DA	Department of Agriculture
DAO	Department Administrative Order
DENR – EMB	Environmental Management Bureau
DENR – MGB	Mines and Geosciences Bureau
DOE	Department of Energy
DOH	Department of Health
DTI	Department of Trade and Industry
ESM	Environmentally Sound Management
FDA	Food and Drug Administration
ILO	International Labor Organization
MOEJ	Ministry of the Environment – Japan
MAP	Mercury-added Product
MCMMD	Mercury-Containing Medical Measuring Device
MIA	Minamata Initial Assessment
MMF	Mercury Material Flow
MT	Metric Ton
NAP	National Action Plan
NCSSMPI	National Coalition of Small-Scale Mining of the Philippines
PCO	Pollution Control Officer
RA	Republic Act
SLP	Skin Lightening Product

SMR	Self-Monitoring Report
TCLP	Toxicity Characteristic Leaching Procedure
TSD	Treatment, Storage and Disposal
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
WHO	World Health Organization

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CHAPTER 1. INTRODUCTION

1.1 BACKGROUND

Mercury and mercury compounds are highly toxic substances with adverse effects on humans^[1], ecosystems^[2], and wildlife^[3]. Initially seen as an acute, localized hazard, mercury pollution is now recognized as a global problem, threatening populations and ecosystems distant from the point source of emissions at risk from its toxic effects. As of 2019, it is ranked third in the substance priority list of the US Agency for Toxic Substances and Diseases Registry (ATSDR), just below arsenic and lead, and has been in the list of substances for “virtual elimination” since 1997 (US EPA, 2021).^[4]

Mercury Management in the Philippines

The Minamata Convention on Mercury (“Convention”) is a global treaty that aims *“to protect human health and the environment from the anthropogenic emissions and releases of mercury and mercury compounds”*.^[5] It was agreed at the fifth session of the Intergovernmental Negotiating Committee (INC) on January 19, 2013, and entered into force on August 16, 2017, 90 days since the date of deposit of the 50th instrument of ratification, acceptance or approval of accession. The Preamble of the Minamata Convention recognizes that mercury is a chemical of global concern owing to its long-range atmospheric transport, its persistence in the environment once released, its ability to bioaccumulate in ecosystems, and its significant negative effects on human health and the environment. The Convention provides a wide range of control over the whole life cycle of mercury—from mercury supply sources and trade, to mercury use in products and processes, to the environmentally sound management (ESM) of its wastes.^[6] With these controls, the Convention aims to, among others:

- Contribute towards the reduction and, if possible, the elimination of mercury use in the ASGM sector;
- Regulate mercury emissions from industries such as coal-fired power plants and industrial boilers, metals and cement production, and waste incineration (among others);

- Contribute to the reduction and, if possible, the elimination of mercury use in manufacturing processes such as chlor-alkali production, vinyl chloride monomer production, and acetaldehyde production; and
- Contribute to the phase-out or reduction of mercury use in products such as batteries, switches, lights, cosmetics, pesticides, and measuring devices as well as the reduction of mercury used in dental amalgam.

The Philippines was among the 128 countries which signed the Convention at a Diplomatic Conference held in Kumamoto, Japan in 2013. On July 8, 2020, the country ratified the Convention, serving as the 123rd country to do so.^[7]

Before ratifying the treaty, the Philippines already had in place several regulatory policies on mercury. These include Republic Act (RA) No. 6969, or the Toxic Substances and Hazardous and Nuclear Waste Control Act of 1990, RA 9003 or the Ecological Solid Waste Management Act, the Chemical Control Order (CCO) for Mercury and Mercury Compounds, among others. Legislations regulating sectors involved in the life cycle of mercury are also available, such as RA 7076 or the Peoples' Small-scale Mining Act of 1991, Presidential Decree (PD) 1586 or the Environmental Impact Statement (EIS) System of 1978, and the Department of Health (DOH) AO 2008-21 or the Gradual Phaseout of Mercury in all Philippine Healthcare Facilities and Institutions. Amendments have been made in some of these legislations to reflect the country's commitment to the Convention, such as in the case of Department Administrative Order (DAO) 2019-20, which updated DAO 1997-38 or the CCO for Mercury and Mercury Compounds to set phase-out dates for products listed under Annex A of the Convention.

Developing Mercury Inventories in the Philippines

Aside from the development of policies, the Environmental Management Bureau (EMB) of the Philippine Department of Environment and Natural Resources (DENR) has undertaken several projects to address mercury and its impacts to the environment. These include preparation an inventory using the Toolkit for Identification and Quantification of Mercury Releases ("Toolkit"), developed by the United Nations Environment Programme (UNEP). The Toolkit is intended to assist countries to *"identify and quantify the sources of mercury releases"*, *"set priorities and reduction targets"* and *"enhance international cooperation, knowledge sharing and enable*

targeted technical assistance".^[8] The Toolkit has three levels to meet the different needs of countries:

- Level 1 is a simple and easy-to-use tool that requires less data and effort, although the estimated values (outputs) are more uncertain. The Philippines conducted its first Minamata Initial Assessment (MIA) activity in 2008.
- Level 2 is more detailed and comprehensive, where all underlying factors can be tailored according to national information. The country embarked in its second MIA activity using the Level 2 Toolkit in 2018-2019.
- Level 3 integrates all mercury sources into a comprehensive mass flow through society and into the environment. This allows for a clearer understanding of the links between different mercury sources, as well as the potential for greater accuracy and better reflection of local conditions. The Philippines has not yet applied Level 3.

The development of a mercury inventory is crucial for governments to take effective action to prevent, minimize, and manage mercury along its life cycle. Mercury inventories may be used to establish a baseline for quantities of mercury and mercury-added products produced, circulated/ traded or in use, and commodity mercury and wastes consisting of elemental mercury and wastes containing or contaminated with mercury. In addition, mercury inventories can be used to establish an information registry to assist with safety and regulatory inspections; obtain the accurate information needed to draw up plans for lifecycle management of mercury; and assist with the preparation of emergency response plans; and track progress towards reducing and phasing out mercury.

More so, specific Convention provisions require Parties to:

... establish, as soon as practicable and no later than five years after the date of entry into force of the Convention for it, and maintain thereafter, an inventory of emissions from relevant sources. (Article 8 section 7);

... establish, as soon as practicable and no later than five years after the date of entry into force of the Convention for it, and maintain thereafter, an inventory of releases from relevant sources. (Article 9 section 6)

Article 21 (Reporting) of the Convention also requires Parties to report the measures it has taken to implement the provisions of the Convention, on the effectiveness of such measures, and on the possible challenges in meeting the objective of the Convention. The report also includes the information as called for in Articles 3, 5, 7, 8 and 9 of the Convention, some of which are enumerated in Table 1.^[9] By ~~conducting~~ preparing inventories, the country can supply the needed information for the national reporting requirements of the Minamata Convention.

Table 2. Required information for National Reporting pursuant to Article 21 of the Minamata Convention on Mercury

Articles of the Convention	Information needed for the National Reporting
Article 3. Mercury supply sources and trade	Primary mercury mines in operation
	Individual stocks of mercury or mercury compounds exceeding 50 metric tons
	Sources of mercury supply generating stocks exceeding 10 metric tons per year that are located within its territory
	Excess mercury available from the decommissioning of chlor-alkali facilities
	Import and export of mercury
Article 4. Mercury-added products	Manufacture, import or export of mercury-added products listed in Part I of Annex A of the Convention
	Mercury-added products listed in Part II of Annex A
	Manufacture and the distribution in commerce of mercury-added products not covered by any known use
Article 5. Manufacturing processes in which mercury or mercury compounds are used	Facilities within the territory of the party that use mercury or mercury compounds for the processes listed in Annex B of the Minamata Convention
	Facility that has been developed using any other manufacturing process in which mercury or mercury compounds are intentionally used that did not exist prior to the date of entry into force of the Convention

Article 7. Artisanal and small-scale gold mining	Steps been taken to reduce, and where feasible, eliminate the use of mercury and mercury compounds in, and the emissions and releases to the environment of mercury from, artisanal and small-scale gold mining and processing
Article 8. Emissions	Any Annex D source categories for which there are new sources of emissions of mercury or mercury compounds
	Any Annex D source categories for which there are existing sources of emissions of mercury or mercury compounds
	Inventory of emissions from relevant sources within 5 years of entry into force of the Convention
Article 9. Releases	Relevant sources of releases as defined in paragraph 2 (b) of article 9
	Inventory of releases from relevant sources within 5 years of entry into force of the convention
Article 10. Environmentally sound interim storage of mercury, other than waste mercury	Measures to ensure that the interim storage of non-waste mercury and mercury compounds intended for a use allowed to a party under the Convention is undertaken in an environmentally sound manner
Article 11. Mercury wastes	Measures outlined in article 11, paragraph 3, implemented for the party's mercury waste
	Facilities for final disposal of waste consisting of mercury or mercury compounds in the party's territory
Article 12. Contaminated sites	Strategies for identifying and assessing sites contaminated by mercury or mercury compounds

Meanwhile, the “Development of the Mercury Material Flow (MMF) in the Philippines” project stems from the long-standing commitment of the Government of Japan to assist developing countries to manage mercury in an environmentally sound manner. In 2014, the Ministry of the Environment of Japan (MOEJ) launched the MINAS (MOYAI Initiative for Networking, Assessment and Strengthening) program to support developing countries in ratifying and

implementing the Minamata Convention on Mercury. The Philippines was selected as one of the target countries to conduct a survey to determine the technical needs for mercury management. One of the priority technical needs identified and presented during a workshop held in March 2015 was the development of an inventory and material flow for understanding the status of mercury use and emissions in the country. Consequently, MOEJ invited technical experts from the Philippine office of the United Nations Industrial Development Organization (UNIDO) to Tokyo, Japan in 2020 for a training course to share experiences and know-how related to the preparation of Japan's mercury emissions inventory and material flow. This was followed in 2023 by another training course in Tokyo, which included representatives from the Department of Environment and Natural Resources and implementing partner BAN Toxics.

While the mercury inventory developed using the UNEP Toolkit is a good initial step for countries to understand the current situation of their mercury emissions, Japan's MMF analysis covers other aspects not initially included in the Toolkit. It visually presents the life cycle flow of mercury in the country by integrating relevant information and provides a more accurate estimate of mercury flow based on actual country-specific information. The method used for developing the MMF assists policymakers and other stakeholders to obtain a clear and accurate understanding of the overall picture of the mercury flow and to identify the key sectors and mercury emission hotspots where mercury management must be improved on a priority basis. Moreover, the development of the MMF may strengthen the capability of government agencies to fulfill its reportorial duties to the Convention, as the MMF contains almost all the information required to report to the COP. If updated and upgraded periodically, the MMF could be used to examine the impact and effectiveness of domestic policy measures.

Data collection and analysis activities and stakeholder engagement activities (e.g. consultations) were held to collect inputs to the project process and methods, key findings and outputs. A detailed implementation plan was developed at the start of the project (see Annex A). Progress reports containing details of data collection activities and consultations are also provided in Annex B.

The technical support provided by MOEJ in developing sector-specific and nationwide MMFs in the Philippines draws from Japan's experience and technical expertise. However, this support is limited in both duration and resources, which means that some data may not be fully accurate and certain gaps may remain. It is anticipated that the data will be updated and improved

regularly through future projects. As such, this report should be regarded as a living document that will require further refinement, and its limitations should be fully noted when using the data.

1.2 OBJECTIVES OF THE DEVELOPMENT OF THE MERCURY MATERIAL FLOW (MMF) IN THE PHILIPPINES PROJECT

The overall objective for the development of the MMF is to enhance the capacity of government agencies and other stakeholders (e.g., industry, non-government organizations, academia, and the general public) to characterize the mercury flows within the country's territory. Specifically, the MMF aimed to:

1. Obtain the overall picture of the domestic flow of mercury and update our present knowledge of the use, consumption and dispersal of mercury, by complementing the national mercury emissions inventory developed using the UNEP Level 2 Toolkit;
2. Identify the priority areas where mercury management should be strengthened, including developing strategies for risk communication, awareness and outreach to keep relevant stakeholders informed;
3. Identify key stakeholders and responsible entities relevant to mercury emissions/releases and disposal;
4. Identify gaps in national programs by providing necessary information and insights to assess the effectiveness of existing policy measures; and
5. Support the country's reportorial duties under Article 21 of the Minamata Convention.

1.3 TARGET USERS AND OUTLINE OF THE MERCURY MATERIAL FLOW IN THE PHILIPPINES (2021) REPORT

1.3.1 Target Users

The main target audience of this Mercury Material Flow in the Philippines (2021) Report are the technical staff, line officers, and managers of the government agencies involved in the ESM of mercury in the Philippines. The document can also be used by relevant stakeholders including, but not limited to artisanal and small-scale gold miners, waste generators (e.g., healthcare facilities), treatment, storage and disposal (TSD) facility operators, civil society, and international organizations concerned in the full life cycle management of mercury.

1.3.2 Outline of this Document

Chapter 1 provides an introduction of the project, its objectives and the outline of the document. Chapter 2 delves into the overview of the methodologies undertaken in the development of the MMF at the national- and sectoral-levels, including the scope and limitation of the data collection and analysis. This is followed by the discussion of the results (Chapter 3) and how it can be used by relevant government agencies in their reportorial duties to the Minamata Convention as well as in developing and amending policies that will lead to the environmentally sound management of mercury and mercury compounds. The last chapter of this document is dedicated to enumerating the challenges and opportunities in MMF development and potential action points that can be taken.

1.3.3 Entry Method of Numerical Values

All the numerical values are corresponding values in metric tons of mercury (t-Hg). The notation “t,” means metric tons (also called “tonnes” in UK terminology).

CHAPTER 2. METHODOLOGY

2.1 SCOPE AND LIMITATION OF THE MMF (2021) REPORT ANALYSIS

This mercury material flow report considers all known sources and use of mercury within the territory of the country and has been developed using data from calendar year 2021. It provides

a visual representation of the flow of mercury including import, use and releases. However, the calculated or estimated values, derived from the best available statistics, literature, and interview surveys may not fully account for all instances of mercury usage, emissions, or transfers. Wherever possible, raw data from the year 2021 has been utilized but in cases where such data is unavailable, average values over several years have been used for calculations or estimations.

It uses source-specific data for certain sources and sub-categories, specifically the coal-combustion industry, ASGM, and mercury-added cosmetics, particularly skin-lightening creams. The calculations are derived from limited point-source data based on documented information reported to the DENR and field data. These values were then extrapolated to the national scale.

The calculations carried out during the preparation of the MMF is primarily based on the UNEP Level-2 Toolkit to supplement this study's design by accounting for source categories and subcategories that were not originally prioritized, thereby contributing to a more comprehensive national mercury inventory. The Philippine 2019 MIA included a mercury inventory, which estimated the relative and absolute contributions of different sectors (i.e., source categories) to mercury emissions and releases to air, land and water. However, the precision and accuracy of inventory results rely on the certainty of the data used. High certainty is achieved when activity data is based on national, industry-specific or comprehensive data and specific input and output estimates for each source are available. Meanwhile, there is low certainty when data is not available and is based on subjected assessment.

Given that the baseline year of the MIA is 2018, the MMF updated this information through various data collection activities that will be discussed in this chapter. Annex C summarizes the activity rate, input and output factors used in the 2018 mercury inventory, as well as:

- Data/ approach used to estimate/ quantify activity data for each source category/ sub-category;
- Data/ approach used to estimate/ quantify mercury flows (input and output factors) for each source category/ sub-category;
- Data collection activity and analysis undertaken to complete the update; and
- Assessment on whether MMF data collection activities were able to address, partially address, or retained the data gaps/ limitations of the 2018 inventory.

Identification of the data gaps/ limitations of the 2018 mercury inventory played a key role in the prioritization of resources for the development of the MMF. Some of the data gaps identified in the MMF implementation plan (Annex A) stem from the actual lack of information collected (hence the need to substitute for alternative data parameters for activity data or default input/output factor values), others are due to the use of older data which needs to be updated. While effort is made to address these limitations, limited resources require prioritization of key source categories/ sub-categories which have more significant impacts on the mercury flows in the country. In particular, consultations conducted in line with the development of the MMF highlighted ASGM, MAPs, and combustion of coal as key sectors (Figure 1). In addition, the characterization of the final life cycle stage (i.e., disposal pathways) of mercury, mercury compounds and MAPs was considered important to fully understand how mercury impacts the environment and human health.

Despite the prioritization of key source categories and sub-categories under this MMF (2021) Report, data collection faced significant methodological limitations. For artisanal and small-scale gold mining (ASGM), coverage was restricted to a limited number of sites, and no direct sampling or quantitative field measurements were undertaken. For coal-fired power plants and the cement industry, data were derived from incomplete individual industry reports on environmental compliance, as no on-site observations or emission monitoring were conducted. With regard to mercury-added products (MAPs), particularly skin-lightening creams, the illicit nature of their production and distribution in both physical and online markets precluded systematic data collection, thereby preventing the generation of robust estimates of mercury inputs.

These limitations introduce uncertainties into the dataset and highlight the need for future studies incorporating comprehensive field surveys, direct monitoring, and enhanced regulatory data capture. Therefore, the findings presented should be interpreted with caution, as data gaps and the absence of direct field measurements introduce uncertainties into the estimates.

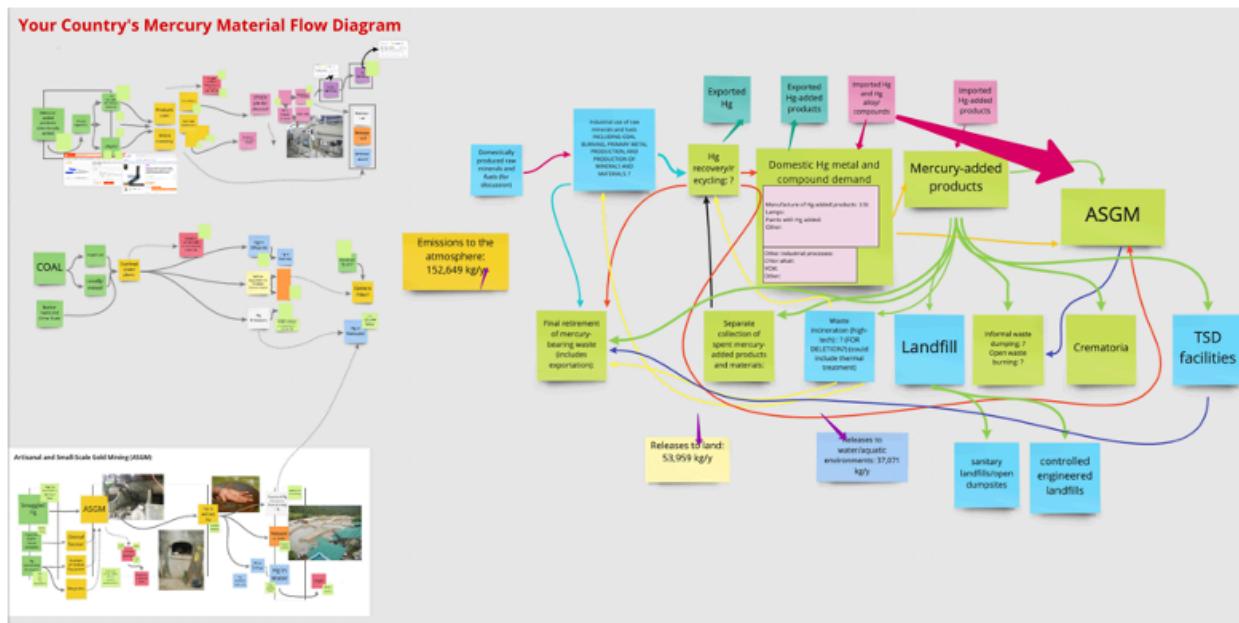


Figure 1. Initial MMF for the Philippines developed during the MOEJ-UNEP workshop (January-February 2022)

2.2 DATA COLLECTION ACTIVITIES FOR MMF DEVELOPMENT^[C1]

Due to the data gaps and information required for MMF development, several data collection activities were undertaken (Table 2). These include:

- Desk research and coordination with relevant government agencies – This enabled the updating of data (i.e., availability of most current data). Government agencies have databases of Self-Monitoring Reports (SMRs) and other compliance documents that were reviewed to gain deeper understanding on the flows of mercury across source categories.
- Key informant interviews and questionnaires – Key informant interviews using structured questionnaires are key to understanding the operations at the facility level. Key informants included mining financiers, operators, and workers familiar with the origin and characteristics of mercury used in the operation, the processes being undertaken and technologies used, as well as the potential pathways for mercury to different environmental media. For mercury-containing products, key informants were traders and users who provided a picture on the consumption and disposal trends in the country; interviews with distributors and manufacturers of illegal products were not held due to

the character of their activities and/or their hesitance to divulge confidential information, which rendered them inaccessible.

- Field data collection and investigative research (for ASGM) – Given the significant contribution of Artisanal and Small-Scale Gold Mining (ASGM) to mercury pollution in the country, an in-depth investigation of the sector is necessary. This involves updating data on mercury consumption and emissions/releases from the sector, using mass balance measurements conducted at ASGM facilities. Due to resource limitations, direct measurements were not carried out for this report; instead, previous studies were referenced. A more comprehensive investigative study is required to identify illicit mercury flows within the sector, primarily through key informant interviews. Interview questionnaires used to collect data are provided in Annex C^[C2].
- UNEP Toolkit Levels 2 and 3– Due to the lack of data for emissions and releases for most source categories, default distribution factors from the UNEP Toolkit were applied.

Table 3. Data collection activities for MMF development, based on order of priority

Source category	Data collection activities		
	High Level	Mid Level	Low Level
Extraction and use of fuels/ energy sources	- Desk research and coordination with relevant government agencies for data (e.g. trade data, list of facilities, SMRs)	- Key informant interviews and questionnaires for relevant facilities (e.g. Pollution Control Officers)	- Sampling and laboratory analysis of raw materials and/or effluents and by-products
Primary (virgin) metal production	- Desk research and coordination with relevant government agencies for data (e.g. trade data, list of facilities, SMRs) - Key informant interviews and questionnaires for relevant facilities - Investigative research (key informant interviews) on the illicit flows of		- Field data collection (i.e., mass balance measurements of mercury use in ASGM operations) - Sampling and laboratory analysis of raw materials and/or effluents and by-products

	mercury in the ASGM sector		
Production of other minerals and materials with mercury impurities	- Desk research and coordination with relevant government agencies for data (e.g. trade data, list of facilities, SMRs)		- Key informant interviews and questionnaires for relevant facilities - Sampling and laboratory analysis of raw materials and/or effluents and by-products
Intentional use of mercury in industrial processes	- Desk research and coordination with relevant government agencies for information		
Consumer products with intentional use of mercury	- Desk research and coordination with relevant government agencies for data (e.g. trade data, list of facilities, SMRs)	- Key informant interviews and questionnaires for relevant facilities	- Household consumption survey - Sampling and laboratory analysis of raw materials and/or effluents and by-products (for lighting sources, pesticides and cosmetic products)
Other intentional product/ process use	- Desk research and coordination with relevant government agencies for data (e.g. trade data, list of facilities, SMRs)	- Key informant interviews and questionnaires for relevant facilities	
Production of recycled metals	- Desk research and coordination with relevant government agencies for data (e.g. trade data)		- Sampling and laboratory analysis of raw materials
Waste deposition/ landfilling and wastewater treatment	- Desk research and coordination with relevant government agencies for data (e.g. trade data, list of facilities, SMRs)		- Key informant interviews and questionnaires for relevant facilities (e.g. Pollution Control Officers) - Sampling and laboratory analysis of raw materials and/or effluents and by-products

Crematoria and cemeteries	- Desk research and coordination with relevant government agencies for data (e.g. trade data, list of facilities, SMRs)		
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2.3. Further Development of this MMF

As with any methodology, the MMF requires live testing, validation, and regular updates. It is designed as a dynamic and evolving collection of tools, which will be refined and revised as needed and practical, incorporating new information and insights gained from experience.

Developing industry- or sector-specific emission factors can help achieve more accurate values. This could be realized through enhanced reporting and monitoring by further developing existing regulations.

The more challenging aspect of addressing unregulated and informal sectors, which have been found as major and emerging significant contributors to mercury pollution in the country, deserves greater attention and a comprehensive approach. Subsequent updating of the MMF will necessitate participatory approaches, engaging indigenous and local communities, local traders, and stakeholders, in data collection and assessment. This may include community surveys, focus group discussions, and participatory mapping, to identify usage and distribution patterns.

Contextual information, such as country of origin for imported mercury or mercury-added products, the destination country for exported mercury or MAPs, and trade codes, can help identify any significant discrepancies. This may highlight previously unknown sources of mercury or mercury compounds, as well as mercury-added products, validate current information, or indicate the existence of other supply sources.

CHAPTER 3. RESULTS AND DISCUSSION

3.1 NATIONAL LEVEL MMF

3.1.1 Overview of the 2008 and 2018 Mercury Inventories

Mercury pollution is a long-standing issue in the Philippines. In 2008, DENR EMB conducted a mercury assessment for the country, following the UNEP Level 1 Toolkit. The report revealed a staggering annual release of 133.589 t-Hg into various environmental media.^[10] The most significant source of anthropogenic mercury is primary virgin metal production (i.e., ASGM), producing over 49% of the total emissions with 65.928 t-Hg per year. This was followed by the extraction and use of fuels and energy sources at 31.94 t-Hg per year (24%) and other intentional use of mercury in products and processes at 27.431 t-Hg per year (20%) (Figure 2). The report further noted that atmospheric emission bears the brunt of mercury emissions among all environmental media. More than 80,000 kilograms of mercury are released to the air annually. Releases to land is a far second with 16.784 t-Hg per year, followed by releases to water with 15,695 kilograms per year.

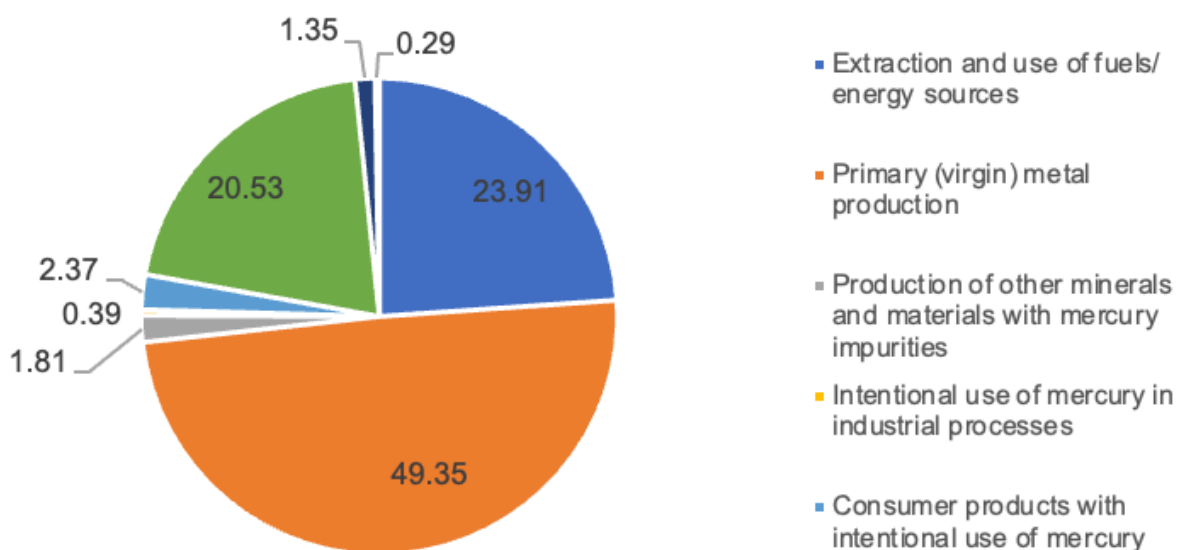


Figure 2. Summary of the mercury inventory in the Philippines using the UNEP Level 1 Toolkit (2008)[11]

A follow-up mercury assessment using the UNEP Level 2 Toolkit in 2018 found higher levels of mercury output per year, reaching a total of 273.264 t-Hg from nine source categories.^[12] The report further highlighted the significant contribution of ASGM in mercury pollution, contributing as much as 78% (or 212.972 t-Hg per year) of mercury output per year. This was followed by

intentional use of mercury in consumer products (13% or 35.905 t-Hg per year) and waste deposition/ landfilling and wastewater treatment (3% or 0.008057 t-Hg per year). Similar to the 2008 report, mercury emissions to air is highest, at 153.94 t-Hg per year, followed by land (53.959 t-Hg per year) and water (37.135 t-Hg per year).

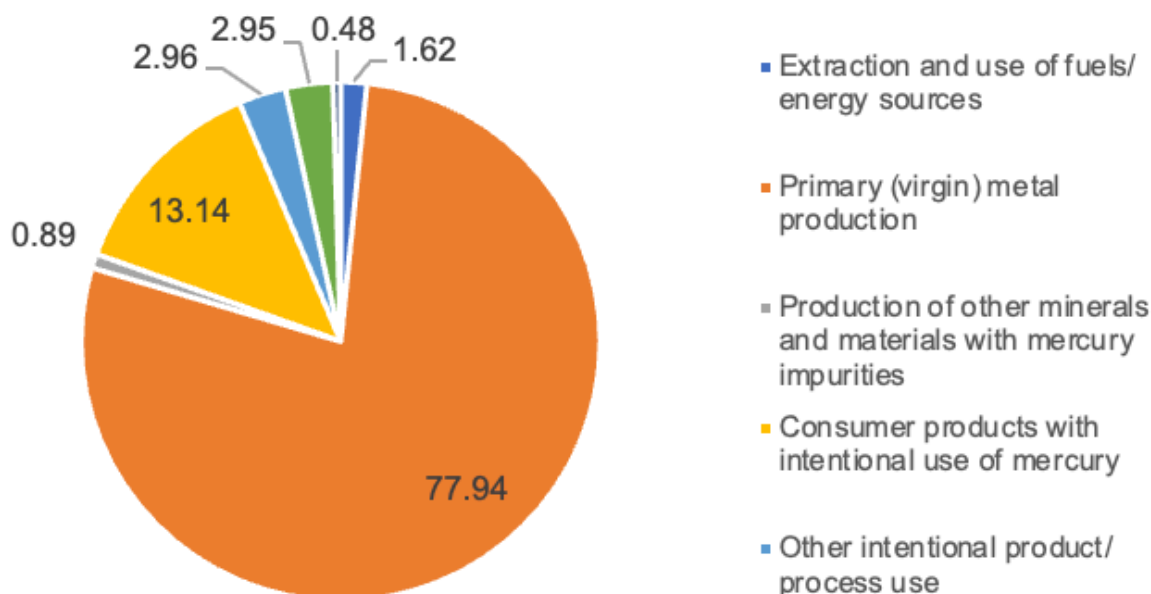


Figure 3. Summary of the mercury inventory in the Philippines using the UNEP Level 2 Toolkit (2018)[13]

The discrepancy between the 2008 and 2018 results can be attributed to differences in the Toolkit versions and data inputs used. The 2008 assessment applied Level 1 of the Toolkit, which relies on generalized default values, whereas the 2018 assessment employed Toolkit Level 2.0 ver. 1.4, using updated input and output factors from local and regional mercury studies and incorporating country-specific data for the Philippines.

3.1.2 National Level MMF Diagram

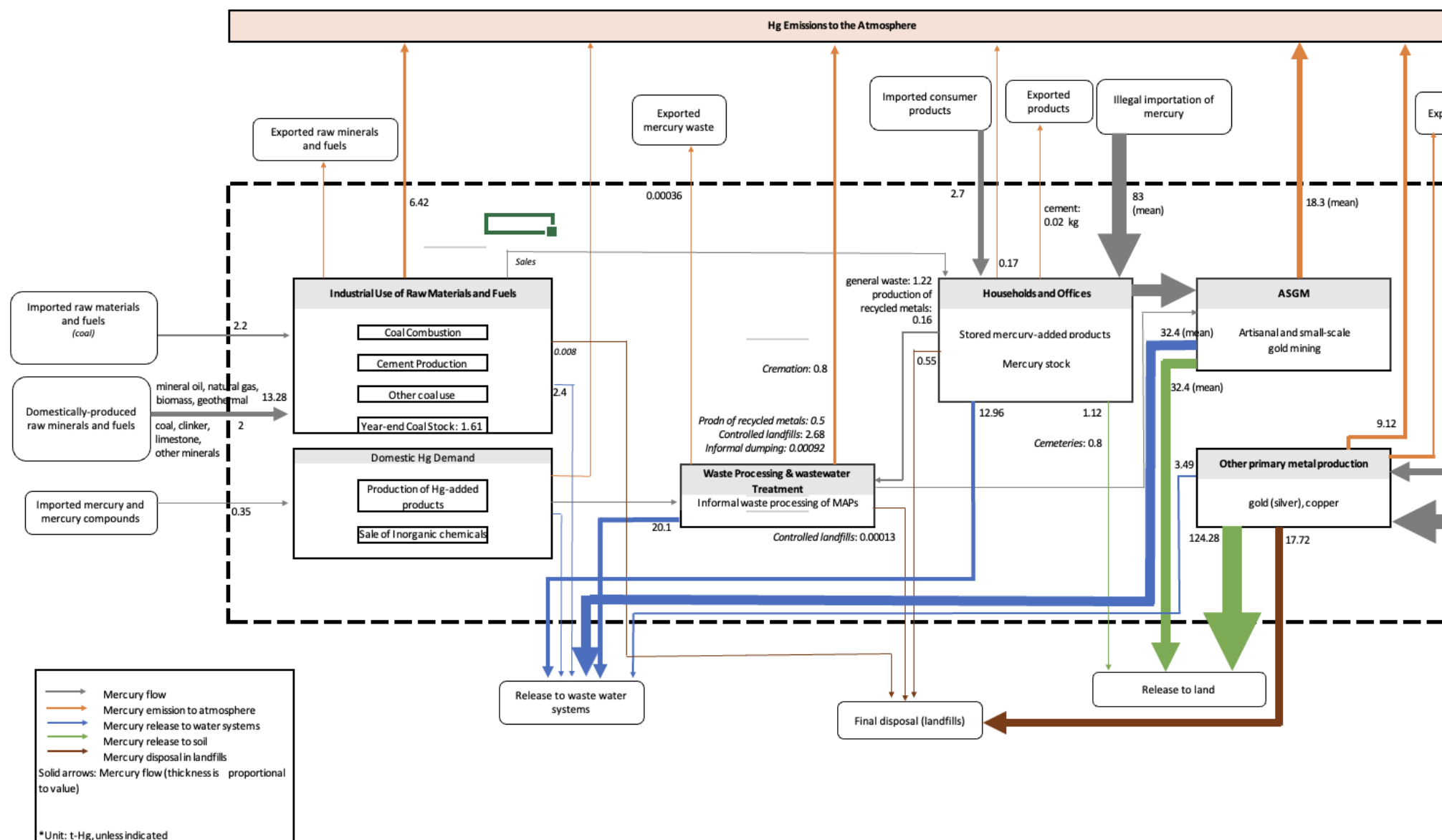


Figure 4. Detailed Philippine mercury material flow (2021)

This Mercury Material Flow (2021) Report confirms **higher mercury outputs, including emissions and releases** when compared to the mercury inventory in 2018, except for (a) consumer products with intentional use of mercury and (b) other intentional product or process use categories, for various reasons. The ASGM sector remains the largest source of mercury emissions due to unabated practices, while illegally traded mercury-added products, such as skin lightening creams and amalgam, pose additional challenges. Mercury inputs in coal-combustion industries indicate higher mercury inputs due to the quantification of raw materials and by-products with mercury impurities, implying current measures in controlling mercury emissions from these industries may be insufficient to manage releases into the environment.

Table 3 outlines the progress of updates for specific source categories, enumerating improvements in quantification relative to the previous mercury inventory. It also provides recommendations for achieving higher accuracy in future updates.

Table 4. Progress and Recommendations for Updating Mercury Source Category Quantification

Source category	Progress	Recommendations for updating
Extraction and use of fuels/ energy sources	-Coal combustion industries, coal-fired power plants and cement sector mercury material flows developed - Quantities of coal combustion by-products, specifically coal ash, that are recycled for use in the cement sector have been considered in the estimations	-Conduct on-site survey or obtain plant-level data for higher accuracy of quantification for industry -Obtain mercury concentration for Coal Fired Power Plants (CFFP) by-products -Include quantification of alternative raw materials and/or fuels (co-processing) in the cement industry mercury material flow -Develop the mercury material flows for mineral oil, natural gas, biomass-fired power and heat production, and geothermal power production

Primary (virgin) metal production	- ASGM sector mercury material flow developed using data from literatures, interviews and surveys with the national coalition of small-scale miners and MGB - Copper extraction and initial processing distinguished between 2 processes: mining and concentrating, and production of copper concentrates	- Conduct mining-site direct measurements for higher accuracy of estimates for gold production, mercury use, and emissions and releases - Develop large-scale gold/silver mining production mercury material flow for gold and silver production not using mercury amalgamation
Production of other minerals and materials with mercury impurities	- Quantities of raw materials containing mercury impurities and coal-combustion by-products used in the cement industry, have been included	- Collect data from Continuous Emissions Monitoring Systems (CEMS) to enable real-time monitoring systems that measure mercury concentrations directly in flue gases emitted from coal combustion processes - Conduct coal and coal ash analyses at the plant level to measure mercury content
Consumer products with intentional use of mercury	-Current MMF covers a snapshot of unregulated mercury-added skin-lightening creams -Data in skin lightening products limited to mercury concentration; using MIA 2018 estimate activity rate gives overestimated figures	- Estimate total mercury content by developing methodology to estimate total quantification of creams in the market at a given time - Obtain data on domestic production of mercury-added skin-lightening creams - Quantify unregulated medical-measuring devices on sale -Investigate trade flows of unregistered and quantify mercury in mercury-laced cosmetics and toys
Other intentional product/ process use	-Current MMF findings include a major reduction in the use of dental mercury amalgam fillings based on survey conducted by dental association and environment department	- Conduct on-site survey on dental amalgam use in dentistry training - Obtain data on legacy stock and waste from dental amalgam - Investigate the prevalence of unregulated dental amalgam on sale

Other source categories	Either baseline year used is 2021 or the MIA 2018	-Update quantification from baseline year (2021) to succeeding year and obtain on-site/facility-level data -Obtain information on source categories that are subjected to continued illegal manufacture and/or trade, including investigating their trade flows
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3.2 SECTORAL LEVEL MMF

This section focuses on the results of sectoral MMFs and analyses for significant source categories/sub-categories identified.

3.2.1 Artisanal and small-scale gold mining

The use of mercury in ASGM communities in the Philippines is prevalent and can be traced back to the late 80s and 90s when mercury amalgamation was widely practiced at the height of the gold rush.^[14] Widespread poverty in the rural areas, the growing demand for gold, and the inability to formalize due to legal and technical hurdles have all contributed to push small-scale miners to produce more gold within the fastest time possible, thereby making mercury amalgamation an attractive option especially for those engaged in subsistence mining. Furthermore, many of the miners handling the chemical do so with lack of knowledge of the substances and basic protective equipment.

RA 7076 defines small-scale mining as *“mining activities which rely heavily on manual labor using simple implements and methods and do not use explosives or heavy mining equipment”*. It involves mining operations that have an annual production of not more than 50,000 metric tons of ores. Around 500,000 individuals and their families in more than 30 different provinces in the Philippines rely on ASGM as a main source of livelihood.^[15] However, a substantial portion of these operations are considered informal due to the failure to acquire the appropriate licenses and permits. Despite this status, the sector’s contribution to the total gold production in the country is substantial. Available data from the Mines and Geosciences Bureau (MGB) show that total gold production from 2005 to 2014 averaged 30.733 metric tons annually, of which 63% came from ASGM.^[16]

3.2.1.1 Overview

Figure 5 outlines the typical gold production process in the Philippines. For most operations in the country, mercury is used at rod mill processing facilities.^[17] Depending on the method employed by miners, mercury may also be used at different stages in the process. In Camarines Norte, for example, a number of miners have stated that mercury may be used as early as during initial extraction of ores, where these ores are panned in nearby rivers or water bodies to separate gold from other materials.

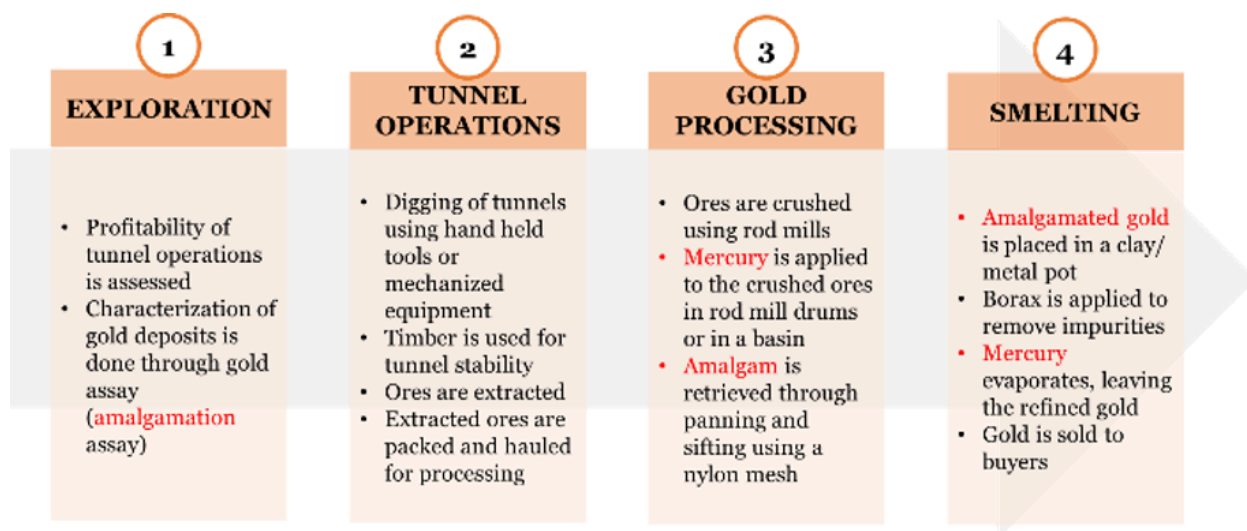


Figure 5. Gold production process in the Philippines

The first stage of the mining process is the excavation stage. In this stage, miners prospect for gold by testing soil and rock samples for their gold content. Once the gold deposit in the area is deemed economically-viable, the area is cleared to pave way for the construction of mining stations. Extraction activities will then commence through the use of handheld tools, machines and/or explosives. While explosives provide efficient extraction of gold ores, it is prohibited in small-scale mining operations.

The extracted ores are brought to a gold processing facility, where they undergo a series of steps to extract the gold. Processing plants may vary depending on the scale or the kind of ore available in the area. In some parts of the country, cyanidation is done through carbon-in-leach (CIP), and heap leach systems. In many instances, rod mills are used to process ores in small

batches. The latter enables miners to earn a living on a daily basis, providing for the daily needs of their families.

Amalgamation is a concentrating process in which metallic gold is mixed with mercury to form an amalgam. Ores brought to a rod mill facility are subjected to continuous grinding for a defined period of time. Typically, a drum may contain 1 sack of ore, weighing 0.04 to 0.05 metric tons. Once the ore is reduced to fine particles, mercury is added to the drum and milled for another 15 to 30 minutes. Gold particles bind with the mercury, forming an amalgam. The amalgam is then retrieved and smelted, leaving behind the “sponge gold”. The gold is sold to gold buyers, who may refine the gold through further smelting. Some gold-buying facilities may collect the condensed mercury vapors in their chimneys and resell them to gold processors at a lower price.

The excess mercury recovered after amalgamation are often re-used by miners, until the amount of mercury is fully exhausted. Since mercury can also end up in the tailings, some abandoned milling facilities were reported to recover mercury from their tailings ponds. These are subsequently sold or reused by processors.

Mercury is widely used in gold extraction because it is inexpensive and is easily accessible to miners.^[18] Most miners believe that only mercury can effectively capture the gold from crushed ores, although several studies have suggested that the chemical can only capture 50 percent of gold particles contained in ores.^[19] Moreover, the health and environmental impacts of mercury have been documented across the world, and international and national policies have been established to regulate and/or prohibit its use.

A study conducted by BAN Toxics in 2016 in 3 ASGM communities in the Philippines found that miners use an average of 19.2 g-Hg to process a gram of gold.^[20] However, the amount used may range from 1.4 to 149.0 g per extraction process. Still, this average is 6 times higher than the default factor prescribed in the UNEP Level-1 Toolkit.

A similar methodology for mercury inventory was conducted in three ASGM areas in 2017 (Table 4).^[21] The study found varying levels of mercury use in each locality. Operations in

Barangay New Leyte had the least mercury consumption, using 5.04 g of mercury to process a gram of gold. On the other hand, gold processing in Barangay Bayugan 3 used 10.61 g of mercury per gram of gold. The difference between the volume of mercury used may be attributed to the differing techniques employed in the operations—from the application of mercury in the drums or basins, manual scrubbing of the crushed ore, application of detergent and plant extracts, as well as the quality of mercury used. While these values are relatively lower than those computed in other ASGM sites, this can still be considered as high volume utilization of mercury and calls for immediate interventions through the introduction and adoption of mercury-free technologies, among others.

Table 5. Inventory of Mercury Use, Emissions and Releases in ASGM Communities in the Philippines

	<i>New Leyte</i>	<i>Panora on</i>	<i>Bayuga n 3</i>	<i>Camarin es Norte</i>	<i>Mt. Diwata</i>	<i>T'boli</i>
Number of operations surveyed	6	4	3	18	27	7
Hg:Au						
Average, g	5.04	9.62	10.61	34.3	10.7	12.6
Maximum, g	7.84	18.57	22.35	149.0	33.8	97.2
Minimum, g	2.65	2.93	3.87	1.5	2.9	1.8
Emissions and releases						
Air, %	36.3	69.9	15.4	3.5	26.8	11.7
Land and water, %	63.7	31.1	84.6	96.5	73.2	88.3
Ambient Hg levels, 35.8 µg/m ³	16.0	10.0	35.9			
Hg in tailings, ppm	96.5	28.5	38.0			

In this 2016 study, the bulk of mercury that enters the environment is in the form of releases to land and water—as much as 96 percent goes to the tailings. A similar pattern was observed in Barangay New Leyte and Bayugan 3, while operations in Barangay Panoraon have more mercury emissions than releases. Most of the mine wastes from these ASGM sites overflow to

identified bodies of water and watershed areas, thereby spreading the contamination to downstream communities.

Analysis of tailings collected from the facilities also found varying amounts of mercury, ranging from 28.49 to 95.62 ppm across all sites. This can cause further issues as most tailings are brought to CIP plants for further processing. In this scenario, cyanide reacts with mercury to produce soluble chemical compounds that are easily transported with water, thereby spreading mercury contamination to large areas. It also converts the mercury to a form which makes it easier to enter the food chain and bioaccumulate. Mercury-cyano compounds contaminating groundwater and drinking water are dangerous, and removal to an acceptable level can only be achieved at an exorbitant cost.

Ambient mercury levels were measured using a portable Lumex RA-915+ mercury vapor analyzer in rod mill facilities with characteristics ranging from ventilated and open spaces (Camarines Norte), enclosed facilities (T'boli), and even makeshift facilities like within the miners' homes and in informal gold buying stalls (Bayugan). Measurement of ambient mercury levels during the smelting stage showed alarming concentrations of mercury in the air. Average mercury levels detected in Barangays New Leyte and Panoraon, and Rosario were 15.98, 9.98 and 35.8 $\mu\text{g}/\text{m}^3$, respectively. The high levels of mercury in ASGM operations in Rosario, Agusan del Sur may be attributed to the location of smelting areas, as most smelting activities are done inside the house or gold-buying stalls. In comparison, the acceptable levels of mercury in indoor air is at 1.0 $\mu\text{g}/\text{m}^3$, based on standards set by the World Health Organization (WHO).^[22] The lack of ventilation and air circulation within these areas exposes household members, including children, to mercury vapors. Moreover, existing gender roles in this community assign women, usually the wife of the rod mill facility owner, the task of smelting the amalgam. However, the methodology used in these studies warrants a review to ensure that a representative air sampling has been carried out, and that residual mercury in already contaminated sites has not been overlooked in the quantification, as this could lead to overestimation.

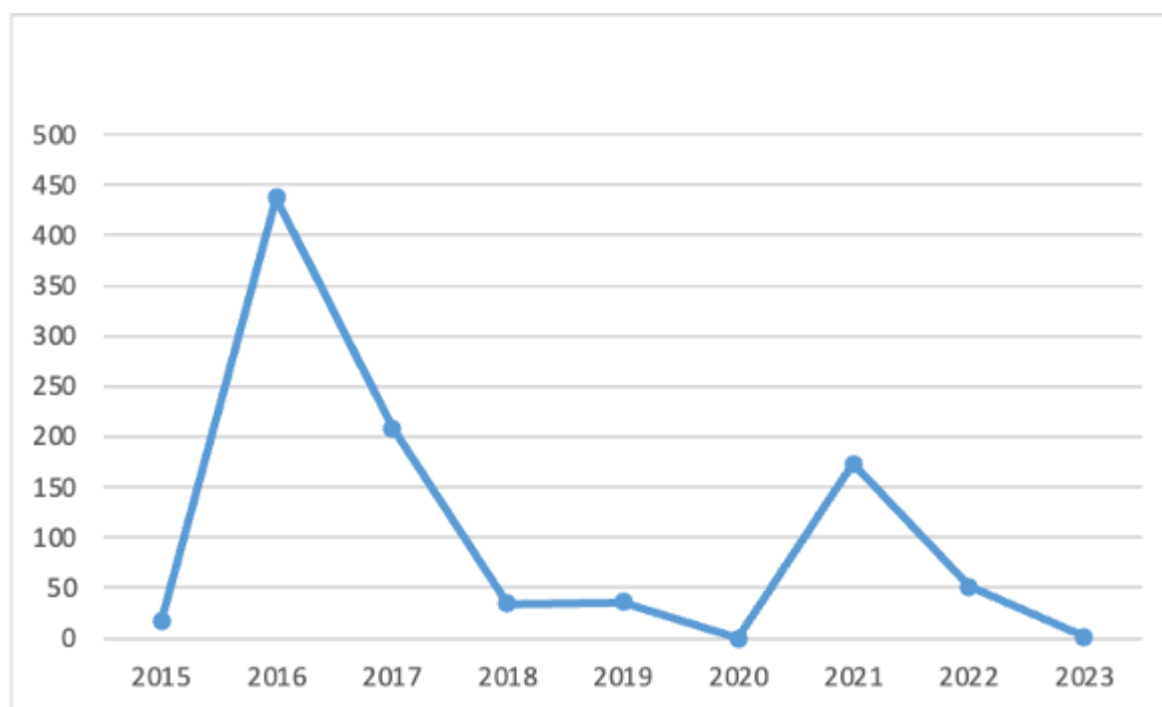
As a final process, contaminated tailings are often deposited in landfills with inadequate environmental management practices in place. Current tailings waste management practices in the ASGM often include the disposal of tailings in ponds or pools, while the abandonment of

tailings remains a common issue. Approximately 33 million metric tons of metal mine tailings are produced annually in the country. [XX]

3.2.1.2 Mercury trade in ASGM

The illicit trade of mercury persists and remains a significant challenge in the Philippines, particularly in the ASGM sector, which remains the largest source of mercury emissions in the country. Despite having no domestic mercury or cinnabar mining and only small amounts of legally imported mercury, the country continues to grapple with the illegal importation and distribution of mercury, as evidenced by the continued under-the-table sale of mercury in hardware stores and by suppliers, as well as open advertisements for sale on e-commerce and online platforms.

Estimates of mercury use in the ASGM sector vary widely, ranging from 30 to 95 t-Hg annually, according to UNEP's Global Mercury Assessment 2018, to 170 t-Hg, as reported in the Philippines' first national inventory in 2019. This discrepancy highlights the challenges in accurately quantifying mercury use, particularly given the prevalence of illicit trade and informal mining practices. These figures far exceed official mercury import data, suggesting that a significant portion of mercury enters the country illegally. Figure 8 presents an overview of elemental mercury imports from 2015 to 2023.



Source: Philippine Statistics Authority, UN COMTRADE

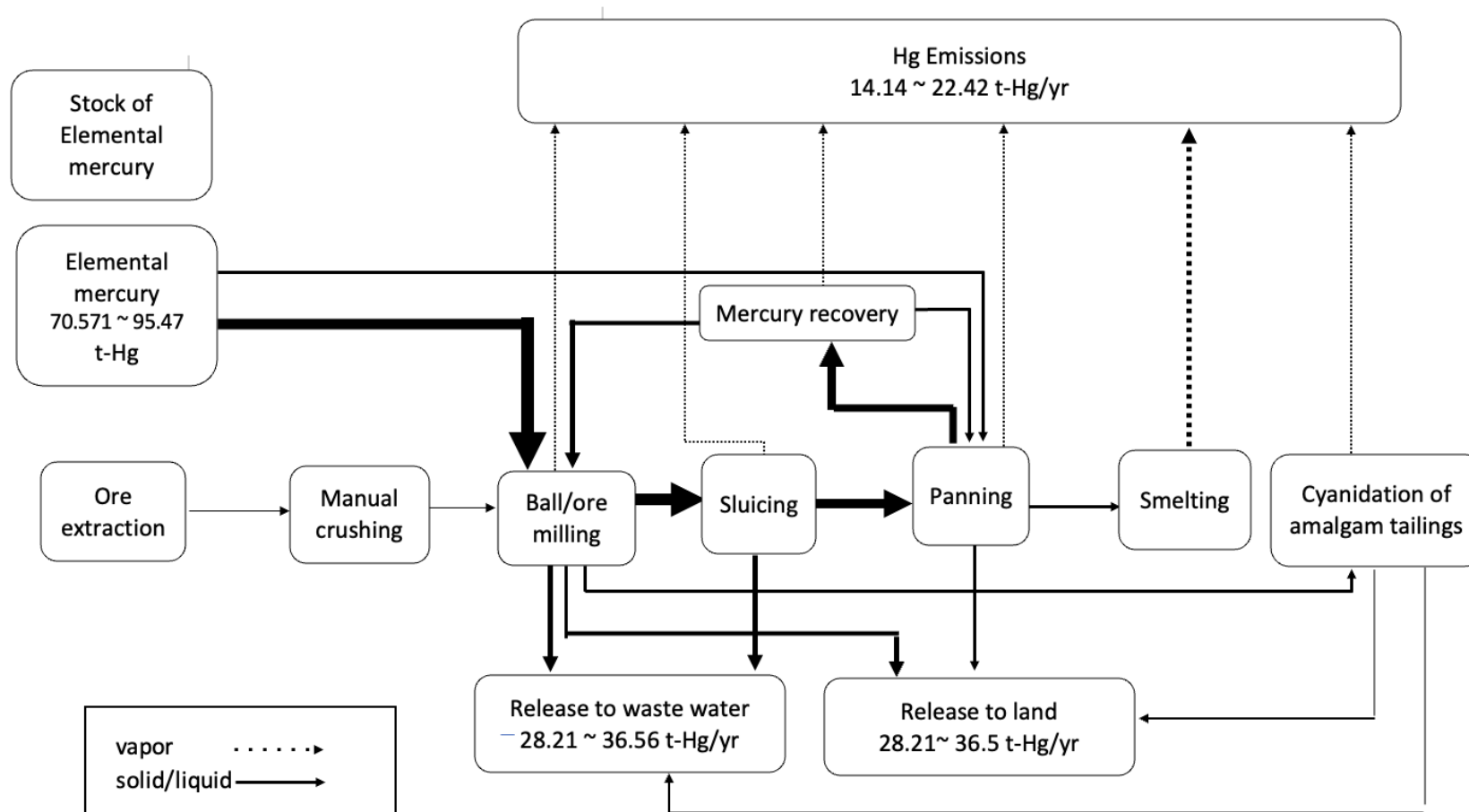
Figure 6. Philippine elemental mercury imports, 2015-2023 (in gross kg/yr)

Since the Philippines signed the Minamata Convention in 2017 and ratified it in 2020, reported formal imports of mercury have declined. However, Article 3 of the Convention, which prohibits the export and import of mercury except under specific conditions, has not fully curbed illicit trade. Domestic regulations under DAO 2019-20 restrict mercury use to specific applications, such as laboratory research, certain industrial processes, and mercury-added products. Yet, these measures have not stopped the illegal importation and distribution of mercury, which continues to fuel the ASGM sector.

Previous studies by BAN Toxics indicate that the majority of smuggled mercury enters through Mindanao, often via informal ports. Labelling on seized mercury suggests origins in Indonesia, Malaysia, and China, with Indonesia being a significant source due to its historical cinnabar mining activities. Mercury is sold by primary importers and smugglers and is easily purchased in hardware stores in cities where active gold extraction occurs. Surveys conducted in 2024 among the national coalition of miners reveal that gold buyers and financiers also supply mercury to small-scale miners. In Camarines Norte, mercury is said to be transported by bus and delivered to local distributors via motorcycle. A quick online search reveals that elemental mercury is also being illegally advertised for sale on e-commerce platforms.

Border control and monitoring of illegal shipments are regulated by the Bureau of Customs (BOC) under Memorandum Order No. 38-2019. Through the Environmental Protection and Compliance Division (EPCD), the BOC monitors shipments of hazardous substances, including mercury. However, key informant interviews in 2024 revealed that no new data on intercepted mercury shipments have been reported, highlighting gaps in enforcement and monitoring.

3.2.1.3. MMF in ASGM



Flow: Based on interviews with small-scale mining operators and miners.

Values in the flow: Estimated result based on on-site measurement in three mining sites conducted (2023-2024) and extrapolated to approximate national figures. The values show the range of mercury use and emissions.

Figure 7. Mercury material flow in the ASGM sector

Gold production in ASGM

As mandated by law, small-scale mining may only be carried out in Minahang Bayan under the People's Small-Scale Program. Small-scale mining contracts within the Minahang Bayan are then issued to cooperatives and associations of small-scale miners. There are 63 declared total Minahang Bayan across the country, while 209 are ongoing application process as of 2024.^[23] However, many small-scale gold mining operations remain largely unregistered.

To approximate the number of small-scale mining operations using mercury, Information gathered from site surveys, data from National Coalition of Small-Scale Mining of the Philippines (NCSSMPI), and from the MGB are utilized. Specifically, for the number of active operations, data from sites, NCSSMPI information, and pending MGB Minahang Bayan applications are considered in this report. Heavy mercury use is assumed to be existent in ASGM across seven regions: Region 5 in Luzon, Region 8 in the Visayas, and Regions 9, 10, 11, 12, and 13 in Mindanao.

To estimate mercury use, two approaches were used to quantifying gold production:

- a) gold sold to the central bank (Banco Sentral ng Pilipinas or BSP) as declared to be sourced from small-scale miners, along with an estimation of black market leakages; and
- b) gold production based on extraction estimates.

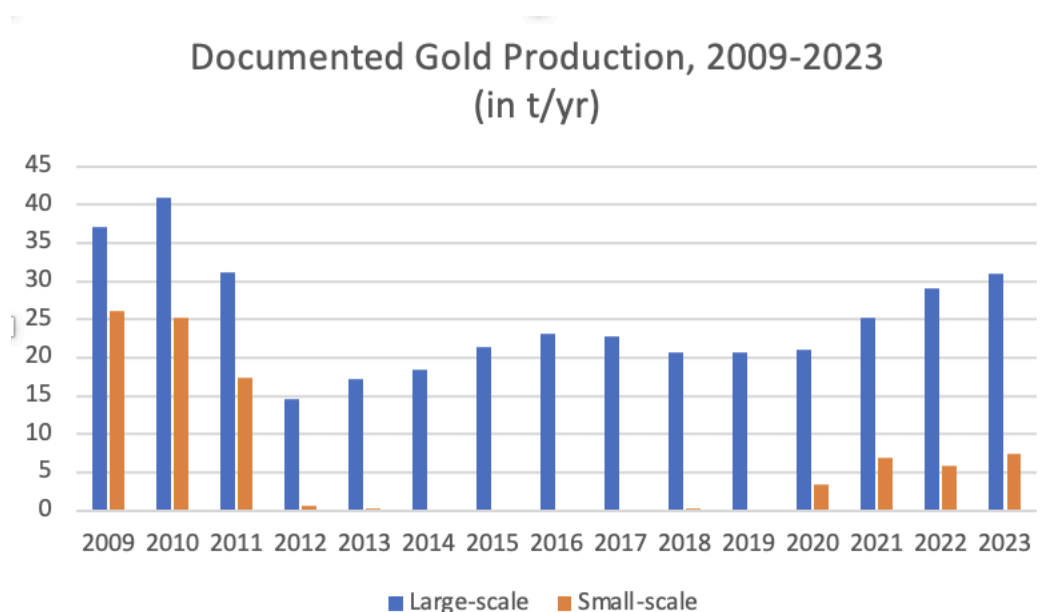
The results are compared to gold production estimates from the literature to determine the differences in gold produced using the specified estimation methods.

For accurate estimations, plant site visits are recommended and small-scale mining contract applications to Provincial Mining Regulatory Boards (PMRBs) may be considered.

Gold sold to the market

The officially reported gold production (excluding black market sales), is shown in Fig. 8. However, these figures underrepresent actual small-scale gold mining output, due to a large percentage of gold entering the black market. This is estimated to be over four times the gold

output of all large-scale primary gold mining companies,^[24] or 90 to 95 % goes to the black market,^[25] ¹



Source: Data from MGB

Figure 8. Declared gold production in the Philippines, 2009-2023

A review of the literature indicates a range of estimates on the proportion of gold production diverted to the black market, with 70% taken as the conservative figure. This estimate will be used in this report as a working basis, corresponding to a 3:7 ratio of BSP purchases to black market sales.²

BSP data for the years 2021 to 2023 are considered and averaged in the estimation, excluding purchases from the Cordillera Administrative Region, which are assumed to be mercury-clean, and gold dorés sourced from large-scale mining. Using the ratio of 3:7 for BSP purchases to black market sales, the average annual production of gold from ASGM used for mercury input is

¹ World Bank. 2020. 2020 State of the Artisanal and Small-Scale Mining Sector . Washington, D.C.: World Bank. Retrieved from: https://documents1.worldbank.org/curated/en/884541630559615834/pdf/Delve-2020-State-of-the-Artisanal-and-Small-Scale-Mining-Sector.pdf?utm_source=chatgpt.com

² UNEP, 2019. Towards a mercury-free future in Mongolia and the Philippines. Retrieved from: <https://www.unep.org/news-and-stories/press-release/towards-mercury-free-future-mongolia-and-philippines?>

estimated at 22.41 metric tons, shown in Table 5. Recent field monitoring in three mining areas in the Cordillera region, however, revealed active mercury use as of writing of this report.

Table 6. Gold production estimate based on gold purchases

Year	BSP purchases (metric tons)	Estimated black market purchases (using 3:7 ratio)	Gold production estimate (metric tons)	3-year average (metric tons)	As referenced in the published MIA 2019 (metric ton/year)	PIDS' estimate of total gold sourced from SSM, averaged for 2012-2018 (t)
2021	6.93	16.17	23.11	22.41	~25	48.5
2022	5.84	13.63	19.48			
2023	7.40	17.27	24.68			

Notes: Data from Cordillera Administrative Region (CAR) and gold dores purchases were excluded in the figures, except for PIDS estimate, which includes all ASGM areas regardless of mercury use.

Extraction-based calculation

Another approach to estimating gold production is through extraction-based calculations (UNEP, 2017)^[26], with Camarines Norte calculation provided in Table 6, using the formula: Au Production = $\sum_i$ Ore Grade X Gold Purity X Days Worked per Year X Daily Ore Throughput_i X Number of Units_i.

Table 7. Extraction-based calculation in J. Panganiban to estimate gold production

Extraction type	Ore grade, g/t	Gold purity, % (lowest grade)	Average No. of miners	Days worked, per year (d/yr)	Daily ore throughput (t/d/unit)	No. of active operations	Gold produced (in t/yr)	Gold produced per operation/year (t/yr)
Big tunnel operations	7.36	0.75	69	325	31	26	1.446	0.0556 t
Small to medium tunnel operations	7.36	0.75	30	261	2.5	16	0.05763	0.036
Compressor mining/alluvial panning	7.36	0.75	6	120	0.6	10	0.00397 (0.26% of total Au)	0.0004

Notes: Data obtained from field visits in ASGM sites in the mining municipality of Jose Panganiban in Camarines Norte.

Because of limited site-level data available, the estimations based on Table 6 have been utilized to extrapolate the national data based on estimated active small-scale mining operations obtained from surveys and reports from the NCSSMPI and triangulated with the IETI report from surveys conducted among local government units and the MGB in 2015.^[27]

These calculations assume the following:

- a) A total of 542 active operations, shown in Table 6;
- b) The ratio of tunnel extraction to alluvial/panning types is assumed at 4:1 for sites without specific information; and
- c) For type 1: whole ore amalgamation, the average gold produced per operation for big and small to medium operations in J. Pangasinan, or 29.6 t/operation/year, is assumed to approximate gold production in whole ore amalgamation mining operations other than Camarines Norte.

Table 8. No. of active operations and estimate of gold production per year

Region	Approximate no. of active operations	Type 1: Whole Ore Amalgamation	Type 2: Concentrated amalgamation	Estimate of gold produced (t/yr)
Region 5	142	114	28	3.646
Region 8	16	13	3	0.380
Region 9	11	9	2	0.261
Region 10	12	2	10	0.047
Region 11	336	269	67	7.983
Region 12	33	26	7	0.784
Region 13	44	35	9	1.045
Total	542	426	116	14.152

Notes: Estimated values are based on available statistics, literature, and interview surveys with small-scale mining operators and miners and do not necessarily cover all the active operations using mercury.

For estimating mercury use based on gold production data, the extraction-based quantification (14 t/yr) will serve as the lower range, while the market-based quantification (22.41 t/yr) will represent the upper range.

Mercury use in ASGM

To determine mercury consumption, mercury to gold ratio (Hg:Au) is used in combination with gold production estimates above. In determining the ratio, this report differentiates between two types of gold processing using mercury amalgamation: whole ore amalgamation without the use of retorts, categorized as Type 1, and concentrate amalgamation without retorts, categorized as Type 2. Whole ore amalgamation is used in tunnel mining, while concentrate amalgamation is employed in compressor mining and alluvial panning.

Actual Hg:Au ratios vary widely across the country due to the metallurgy, type of amalgamation process, and practices of miners, such as measuring mercury instinctively without using precise measurements. While no retorts are used in the ASGM in the country, miners practice the re-use of excess mercury recovered after amalgamation until it is fully exhausted. In whole ore amalgamation processing, the input factor ranges from 0.35 to as high as 34.3, while concentrate amalgamation uses smaller amounts of mercury, typically ranging from 1 to 3 parts of mercury to gold.

In a previous study by BAN Toxics (2016), which used direct measurements, the mercury-to-gold ratio ranged from 1.5:1 to as high as 149:1, with an average of 19.2:1 (i.e. 19.2 grams of mercury used to extract 1.0 gram of gold). [28] Meanwhile, an ILO study (2020)^[29] reported an average mercury-to-gold ratio of 20.16:1 across 74 operations inventoried in 2015 and 2017, with values ranging from as low as 1.3 g of mercury per gram of gold to as high as 207.7 g mercury per gram of gold. For the purposes of mercury quantification in this report, however, the UNEP Toolkit Level 2 (version 1.7) input factors are applied, as shown in Table 7, which are lower than the figures reported in the aforementioned studies.

Table 9. Range of mercury use estimates using UNEP Toolkit input factors

	Gold Production (extraction-based), low (t/y)	Gold Production (market-based), high (t/y)	Total Mercury Use estimate (t/y)
Type 1: Whole Ore amalgamation	14.10	17.928	70,505 ~ 89.64
Type 2: Concentrate amalgamation	0.051	4.482	0.0663 ~ 5.8266

Total		70.571 ~ 95.467
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Notes: Gold production estimate based on market sales assumes the same ratio of 4:1 (ratio of tunnel extraction to alluvial/panning type).

These calculations assume the following:

- a) Gold production uses the same ratio of 4:1, as the ratio of tunnel extraction to alluvial/panning type; and
- b) Input factors used are from UNEP Level 2 (ver. 1.7) according to type of amalgamation, which is **5 for whole ore amalgamation** and **1.3 for concentrate amalgamation**.

When compared to the MIA 2019 report of 170 t-Hg per year mercury input in the ASGM that used the same input factor of 5 (i.e., a 5:1 mercury-to-gold ratio), the mercury use estimates in this report are lower by 44% to 58%. This discrepancy can be attributed to differences in the estimated activity rates, arising from the distinct methodologies employed to calculate gold production. The MIA (2019) report used the USGS 2016 data, adjusted to reflect an estimated 70-80% ASGM production share and the average annual growth rate of the mining industry in the country.

Emissions and releases in ASGM

Using the estimated low and high ranges of mercury use presented above, emissions and releases are quantified in this section using the UNEP Toolkit Level 2 (ver. 1.7) emissions and releases distribution factors. Quantification was undertaken using the following equation: mercury use estimates X distribution factors, as shown in Table 8.

Table 10. Range of emissions and releases in ASGM

	Air (t-Hg)	Water (t-Hg)	Land (t-Hg)
Extraction-based gold production estimate (Type 1), low range	14.1	28.2	28.2
Extraction-based gold production estimate (Type 2), low range	0.039	0.008	0.008
Total (low range)	14.14	28.21	28.21
Market-based gold production estimate (Type 1), high range	17.93	35.86	35.86

Market-based gold production estimate (Type 2), high range	4.49	0.7	0.64
Total (high range)	22.42	36.56	36.5
Mean	18.28	32.38	32.36
MIA 2018	141.44	0.36	28.63

Notes: According to the UNEP distribution factors for Type 1, mercury releases are allocated as follows: 0.2 to air, 0.4 to water, and 0.4 to land (expressed in t-Hg), while the UNEP distribution factors for Type 2 allocate 0.77 to air, 0.12 to water, and 0.11 to land. Figures in the table are rounded.

The estimated average air emissions are quantified at 18.28 t-Hg, while the mean releases to land and water are quantified at 32.38 and 32.36 t-Hg, respectively. In comparison, the MIA (2019) report estimated 141.44 t-Hg for air emissions, 0.36 t-Hg for water releases, and 28.63 t-Hg for land releases.

One reason for the differences in emissions and releases compared to the MIA 2019 report, aside from the over-all differences in activity rates estimates, is the use of updated emission factors in the current version (1.7) of the UNEP Toolkit versus those applied in MIA (2019). The UNEP Toolkit version adopted in this MMF (2021) report provides more detailed guidance on estimating mercury releases from ASGM, including consideration of the methods and equipment used in gold production through mercury amalgamation.^[31] In contrast, the MIA (2019) applied emissions factors of 16.8% land, 0.21% water, 82.99% air, based on a 2018 published study.

In the same study of BAN Toxics (2016) using direct measurement, air emissions are estimated to account for approximately 4 to 27% of the total mercury input in the operation released directly into the atmosphere during the smelting process.^[30] An average of 0.14 for air and 0.86 for both water and land are used as output distribution factors.

These findings underscore the need to revisit policy formulation and interventions on mercury pollution control in informal gold mining, as emission pathways indicate higher releases to water than previously estimated, aside from air pollution controls and regulations. The results highlight data and methodological gaps, suggesting that current monitoring and control measures may be inadequate for accurately capturing and mitigating mercury discharges into aquatic environments.

3.2.2 Mercury-added products

Mercury-added products (MAPs) is defined as any product that contains mercury, a mercury compound, or a component containing mercury, when the mercury is intentionally added to the product (or component) for any reason. The intentional use of mercury in products is further divided into two subcategories, representing Part I and II of Annex A of the Minamata Convention. Table 9 lists the MAPs under these categories, and compares the phase-out dates prescribed by the Convention and Philippine legislations.

Table 11. Mercury-added products listed in Annex A of the Minamata Convention

Mercury-Added Products	Phase-out Date	
	Convention	DAO 2019-20
Part I		
Batteries, except for button zinc silver oxide batteries with a mercury content < 2% and button zinc air batteries with a mercury content < 2%	2020	2022
Switches and relays, except very high accuracy capacitance and loss measurement bridges and high frequency radio frequency switches and relays in monitoring and control instruments with a maximum mercury content of 20 mg per bridge, switch or relay	2020	2022
Compact fluorescent lamps (CFLs) for general lighting purposes that are ≤ 30 watts with a mercury content exceeding 5 mg per lamp burner	2020	2022
Linear fluorescent lamps (LFLs) for general lighting purposes: (a) Triband phosphor < 60 watts with a mercury content exceeding 5 mg per lamp; (b) Halophosphate phosphor ≤ 40 watts with a mercury content exceeding 10 mg per lamp	2020	2022
High pressure mercury vapour lamps (HPMV) for general lighting purposes	2020	2022

Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for electronic displays: (a) short length (≤ 500 mm) with mercury content exceeding 3.5 mg per lamp (b) medium length (> 500 mm and $\leq 1\,500$ mm) with mercury content exceeding 5 mg per lamp (c) long length ($> 1\,500$ mm) with mercury content exceeding 13 mg per lamp	2020	2022
Cosmetics (with mercury content above 1ppm), including skin lightening soaps and creams, and not including eye area cosmetics where mercury is used as a preservative and no effective and safe substitute preservatives are available	2020	2022
Pesticides, biocides and topical antiseptics	2020	2022
The following non-electronic measuring devices except non-electronic measuring devices installed in large-scale equipment or those used for high precision measurement, where no suitable mercury-free alternative is available: (a) barometers; (b) hygrometers; (c) manometers; (d) thermometers; (e) sphygmomanometers.	2020	2022
Part II		
Mercury-Added Products	Convention	DOH AO 2020-20
Dental amalgam	Phase down	2023

MAPs are primarily regulated by DAO Order 2019-0020 otherwise known as the “Revised Chemical Control Order (CCO) for Mercury and Mercury Compounds” which updates DAO 1997-38, otherwise known as the CCO for Mercury and Mercury Compounds. The revised CCO is consistent with the provisions outlined in the Minamata Convention on Mercury and sets a phase-out date of 2022 for the products listed in Annex A of the Convention text, instead of the 2020 originally targeted in the Minamata Convention text. The 2022 phase-out was identified due to a number of reasons, including the late ratification of the Convention in the Philippines and to give ample time for distributors to adjust before the phase-out is officially implemented.

The CCO also outlines various requirements and protocols for importers and manufacturers of MAPs before the phase-out is implemented. A summary of these requirements includes:

- Any person or entity importing, manufacturing, distributing, storing, or allowed user of mercury, mercury compounds, and MAPs must register with the DENR EMB;
- Any person importing MAPs are required to secure a clearance from appropriate government agencies such as the Department of Trade and Industry’s Bureau of Philippine Standards (BPS-DTI) for lamps and batteries and the Department of Health (DOH) for cosmetic products; and
- Importers, manufacturers, distributors, and industrial users of mercury, mercury compounds, and MAPs including treaters and disposers of mercury-bearing and/or mercury-contaminated wastes are required to submit quarterly reports to the EMB with information including (1) the quantity of products supplied, (2) the names and addresses of the importer, manufacturer, distributor and purchasers, and (3) the quantity of mercury-bearing and/or mercury-contaminated wastes generated, among others.

In addition to the CCO, there are a number of policies that have impacted the availability of MAPs and alternatives and contributed towards shaping trader and consumer behavior. Department Order 2008-0021 outlines guidelines for the elimination of mercury-containing devices in healthcare facilities in the Philippines.^[33] Key provisions of the DAO include requirements for registered healthcare facilities to implement within 2 years the following:

- The switch to mercury-free alternatives with specific focus on thermometers and, if possible, sphygmomanometers;
- The implementation of a mercury-minimization program; and

- The development and implementation of a mercury management module in accordance with the guidelines set in the DAO.

The enactment of the DAO significantly impacted the trade of mercury-containing thermometers and sphygmomanometers, as its primary users were prohibited from using them. The study conducted by BAN Toxics in 2021 showed that users of Mercury-Containing Medical Measuring Devices (MCMMDs) in the Philippines were reduced from 5% of total Healthcare Facilities (HCFs) in 2010 to just 1% in 2020 for thermometers and from 4% to just 0.7% during the same period for sphygmomanometers.^[34]

As for dental amalgam, DOH promulgated Administrative Order No. 2020-0020 titled “Guidelines on the Phase-Out of Mercury Use in Dental Restorative Procedures”. Under this groundbreaking policy, the use of dental amalgam will no longer be allowed after the phase-out period of three years from the effectivity of the said order. The directive bans the importation of liquid mercury and dental amalgam for dental restorative procedures, and further bans the use of dental amalgam for children 14 years old and below, pregnant women and breastfeeding mothers.

On June 10, 2022, the Food and Drug Administration (FDA) enacted FDA Circular No. 2022-003: Banning of all Mercury-Added Thermometers, Sphygmomanometers, Dental Amalgam Capsules and Liquid Mercury for Use in Dental Restorative Purposes.^[35] This circular imposes a total prohibition on the importation, distribution, sale or offer for sale of liquid mercury and dental amalgam capsules for use in dental restorative purposes.

The Department of Trade and Industry’s Bureau – Bureau of Philippine Standards (DTI-BPS) also started developing the DAO titled “The new technical regulation concerning the mandatory certification of mercury-added products.”^[36] The new DAO aims to impose a certification scheme which requires manufacturers and traders to meet mercury limits in their products before they are allowed to operate. The proposed limits for mercury content in these are consistent with the limits set by the revised CCO on mercury and mercury compounds, which in turn are consistent with the limits identified by the Minamata Convention on Mercury.

With these policies, DENR, in partnership with UNIDO, developed the National Action Plan (NAP), which aims to detail the 5-year implementation plan for the ESM of mercury-containing products in accordance with the provisions of the Minamata and Basel Conventions.^[37] It outlines the responsibilities of government agencies involved in the inter-agency technical working group (IATWG) on five key intervention areas, namely: (1) policy, (2) strengthening capacities, (3) quality data and evidence, (4) innovation and implementation, and (5) partnerships advocacy. One of the key activities identified in the NAP is the establishment of an inventory of MAPs, which will support the achievement of policy targets and the monitoring and evaluation of NAP activities.

3.2.2.2 Skin lightening creams

The Philippines signed the Agreement on the ASEAN Harmonized Cosmetic Regulatory Scheme in 2003 and fully implements the directive since 2008. Member States are obliged to prohibit the marketing of cosmetic products, including those containing mercury and its compounds. From 2013 to 2023, the FDA has issued a total of 35 advisories against the sale and purchase of 164 cosmetic products. A total of 27 ASEAN Post-Marketing Alert System (PMAS) advisories were likewise issued for 103 products.

As of October 2024, the PMAS Report for the year identified 96 cosmetic products adulterated with 16 different banned pharmaceutical ingredients. Of these, 63 products (approximately 66%) contained mercury as a whitening agent. Twenty-five of these products used mercury in facial preparation.

While mercury-added skin lightening products (SLPs) are produced in the country according to the European Union Rapid Alert System (RAPEX),^[38] empirical data indicate that most SLPs in the market are primarily sourced from imports. Bastiansz et al.'s (2022) systematic review of mercury exposures from SLPs identifies known sources as Pakistan, Malaysia, and Thailand.^[39]

In terms of trade, Thailand is the leading exporter of skin creams or lotions to the Philippines, with an annual average of 4,700 metric tons between 2021 and 2023, as reported by the PSA. China's average annual export during the same period was 804 metric tons, Indonesia exported

an average of 940 MT over three years, and Malaysia exported 1,185 metric tons. Pakistan exported a very minimal amount to the country in 2021, with only 0.303 metric tons.

In 2021, Thailand reported 3,316 metric tons (net weight) under the nomenclature 'beauty or make-up preparations and preparations for the care of the skin (other than medicaments)' or HS Code 330499, while the Philippines reported 3,543 metric tons (gross weight) of imports of the same commodities.

Estimation of illegal sales

The Regulatory Enforcement Unit-Southern Luzon Cluster (REU-SLC) of the FDA seized a total amount of 245,015 mercury-contaminated cosmetic products for years 2018 to 2023, shown in table below. Excluding soap products, the total quantity of these confiscated skin-lightening creams is 109,190 units.

Table 12. FDA's Regulatory Enforcement Unit-Southern Luzon Cluster (REU-SLC) seizure of mercury-contaminated cosmetic products

Year	Product Name	No. of seizures conducted	Estimated amount
2023	Goree Whitening Soap with Lycopene and Avocado & Aloe vera	4	135,825
2022	Goree Beauty Cream with Lycopene	2	2,030
2021	Goree Beauty Cream with Lycopene w/ SPF 30	1	450
2020	Goree Beauty Cream with lycopene	2	10,750
2018	Goree Beauty Cream with Lycopene Avocado and Aloe Vera, and Goree Day and Night Whitening Cream Oil Free	5	95,960

Using **seizure data from the REU-SLC**, the average annual seizure volume from 2018 to 2022 was 27,297.5 units, equivalent to approximately 0.464 t (each Goree cream approximately weighs 0.000017 t). By extrapolating this amount across the four other REU clusters nationwide (assuming comparable activity levels), the projected national seizure estimate totals approximately **2.32 t** of mercury-added facial creams per year.

Applying the formula:

$$\text{Estimated illicit volume (t)} = \text{seized volume (t)} \div \text{Seizure rate}$$

and assuming a 1% seizure rate, the estimated total volume of mercury-added SLPs in the market would be **232.028 t**, as shown below:

$$\text{Estimated illicit volume (t)} = \text{seized volume (t)} \div \text{Seizure rate}$$

$$2.32 \text{ t} \div 0.01 = 232.028 \text{ t}$$

This assumption is supported by field interviews with sellers and stall owners, many of whom report selling these products for several months or years—suggesting limited enforcement coverage and a low interception rate. It is also corroborated by the widespread availability of prohibited SLPs online, where products remain easily accessible with little to no disruption from authorities.

Estimating mercury concentration in skin-lightening products

A sample of 50 imported skin-lightening creams (n=50) using availability sampling was collected from beauty stores in secondary malls across various cities in Metro Manila and from major online platforms in the country. The manufacturing locations listed on the labels, based on frequency, were as follows: China (f=25), Thailand (f=12), Pakistan (f=6), India (f=4), and Vietnam (f=1).

The products were tested for mercury using an Olympus Vanta C Series HH XRF Analyzer. Figure 4 visualizes the range of mercury concentration in SLP samples. Out of all the 50 products, seven samples returned below the limit of detection, while the Hg concentration in the rest ranged from 7 to 67,400 ppm. The total mercury content in the samples is estimated at 23.39 grams.

Mercury Concentration in sampled 50 SLPs distributed by country of origin

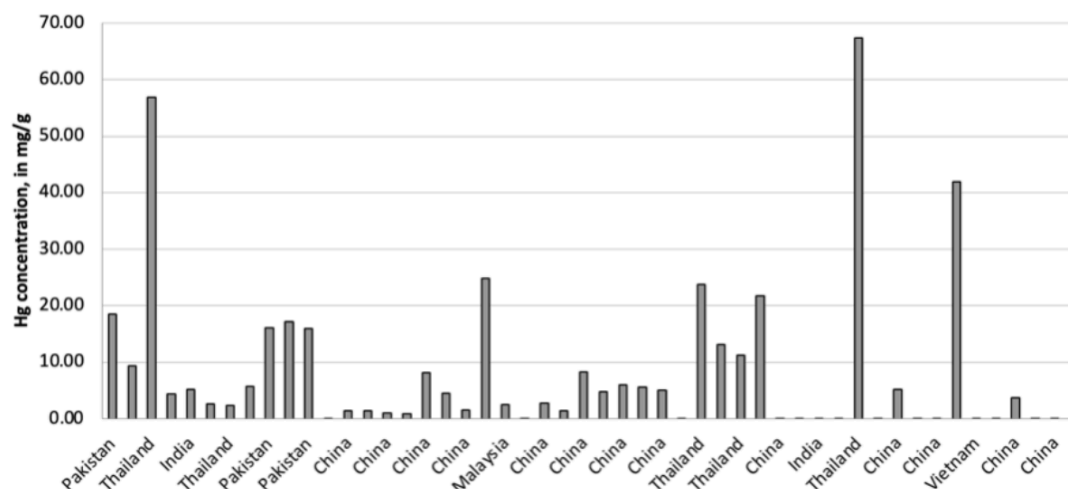


Figure 9. Mercury concentration levels in SLP samples distributed by country of origin

Table 13. Mercury concentration levels in SLP samples

Brand name	Manufacturer/ Distributor	Country of Origin	Weight (g)	Hg concentration (mg/g)
Aneeza Gold Beauty Cream with Avocado & Aloe Vera	Pakistan	Pakistan	<u>20</u>	18.50
Meiyong Seaweed Whitening Cream Set	Meiyong RA	<u>Thailand</u>	<u>60</u>	9.40
Meiyong Super Extra Whitening Cream	Meiyong RA	<u>Thailand</u>	<u>20</u>	56.94
C Collagen Plus Vit E Day and Night Cream		India	<u>40</u>	4.36
Faiza Beauty Cream	Poonia Brothers (Pvt.) Ltd.	India	<u>30</u>	5.20
88 Underarm Whitening Cream		Thailand	<u>35</u>	2.58
88 Whitening Night Cream		Thailand	<u>5</u>	2.39
Golden Pearl Beauty Cream		Pakistan	<u>28</u>	5.70
Goree Beauty Cream with Lycopene		Pakistan	<u>17</u>	16.10
Goree Day and Night Whitening Cream		Pakistan	<u>17</u>	17.20
Goree Gold 24K Beauty Cream		Pakistan	<u>17</u>	16.00

4k PLUS 5x WHITENING NIGHT CREAM	Nantawat Cosmic Company Limited	Thailand	<u>20</u>	0.00
JiaoLi HuiChuSu Face Cream 7 Day Specific Eliminating Freckle		China	<u>20</u>	1.41
JiaoLi HuiChuSu Miraculous Cream		China	<u>20</u>	1.40
Szitang 7-days Whitening Cream		China	<u>20</u>	1.06
Szitang 10-day Whitening and Spot Day & Night Set		China	<u>40</u>	0.93
Feique 2 in 1 Papaya Whitening & Freckle-Eliminating Set	(Feique) Beauty Cosmetic Co., Ltd	China	<u>40</u>	8.19
Feique 3 in 1 Papaya Whitening Cream Set	(Feique) Beauty Cosmetic Co., Ltd	China	<u>40</u>	4.46
Feique 25g papaya freckle removing face cream	(Feique) Beauty Cosmetic Co., Ltd	China	<u>25</u>	1.57
Parley Goldie Beauty Cream	Khyber Chemical (Pvt.) Ltd.	Pakistan	<u>20</u>	24.90
Temulawak Day & Night Cream		Malaysia	<u>50</u>	2.54
Feique Snail Liquid Whitening Anti-Freckle Set	GZ CaiLi Daily Chemical Co., Ltd	China	<u>40</u>	0.06
Feique Cucumber Whitening & Freckle Eliminating Night Cream	GZ CaiLi Daily Chemical Co., Ltd	China	<u>40</u>	2.71
Feique Lemon Whitening Anti-Wrinkle Face Cream Set		China	<u>40</u>	1.40
Feique Green Tea Face Cream Set		China	<u>40</u>	8.31
Feique Herbal Extract Whitening Freckle-Removing Cream 2in1	(Feique) Beauty Cosmetic Co., Ltd	China	<u>40</u>	4.84
Feique Ginseng whitening freckle day cream and night cream		China	<u>40</u>	6.06
Feique Rose Essence Anti-freckle Whitening Day and Night Cream		China	<u>30</u>	5.54
Feique 25g Herbal Extract whitening freckle-removing cream	GZ CaiLi Daily Chemical Co., Ltd	China	<u>25</u>	5.01
Eelhoe 24K Gold Face Cream	Shantou Cross-border Premium Products E-commerce Co., Ltd	China	<u>50</u>	0.00
Dr Yanhee Facial Cream Set (Blue)		Thailand	<u>200</u>	23.80
Dr Yanhee Facial Cream Set (Red)		Thailand	<u>200</u>	13.10
Dr Yanhee Facial Cream Set (Green)		Thailand	<u>200</u>	11.30
Dr Yanhee Facial Cream Set (Pink)		Thailand	<u>200</u>	21.80
Kinang Whitening Day Cream	Guangzhou Tata biotechnology Co., Ltd	China	<u>50</u>	0.00
Pyary Turmeric Beauty Cream		India	<u>80</u>	0.00

Japanese Girl's Day and Night Whitening Cream	Korea Century Ya Skin Cosmetics International Co., Ltd.	Korea	<u>20</u>	1.50
Day and Night Whitening Anti Freckle Melasma (Green)	China (Shenzhen) IMEI Cosmetics Co., Ltd.	China	<u>36</u>	0.12
Lady Gold Super Whitening Cream		Thailand	<u>50</u>	67.41
Sujialih Facial Cream		Taiwan	<u>5</u>	0.00
BL Vterly Day and Night Cream	Shenzhen Shiyi Cosmetics Co., Ltd.	China	<u>50</u>	5.15
SADOER Snail Face Cream Anti Aging	GUANGZHOU AILIAN COSMETIC CO., LTD.	China	<u>140</u>	0.00
White Gold Anti Marks Cream Extra Whitening		China	<u>30</u>	1.80
Best Beauty Cream (Blue Container)		Thailand	<u>5</u>	42.00
LIFE LINH CHI Whole Body Whitening Cream	Bao Xinh cosmetics Joint Stock company	Vietnam	<u>80</u>	0.01
Alada Gluta X Extra Whitening Cream	ALADA (THAILAND) CO., LTD.	Thailand	<u>5</u>	0.01
PEARL NATURAL Whitening & Anti-Aging Cream	GLDJB (Harbin) Cosmetics Co., Ltd.	China	<u>40</u>	3.72
Baihua Fang EELHOE BRIGHTENING AND MOISTURING SPOT REMOVIING CREAM	Shantou Cross-border Premium Products E-commerce Co., Ltd	China	<u>30</u>	0.05
HOUMAI Skin Whitening and Freckle Removing Cream		China	<u>20</u>	0.02
DEVNEN KOJIC ACID AND COLLAGEN Whitening Cream		China	<u>50</u>	0.02

The top three manufacturing countries, based on labeling, with the highest mercury concentrations in the samples exceeding the allowable limit are Thailand, China, and Pakistan, with Thailand showing the highest frequency of high-mercury SLPs.

This study will use the average mercury concentration based on the sampling above, Releases use the UNEP Toolkit Level 2 distribution factors.

Table 14. Mercury in cosmetics and other related products

	Baseline Year	Activity Rate (t/yr)	Hg Concentration (mg/g)	Annual Hg input (t/yr)	Water, t/yr	Land, t/yr.
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Cosmetics: Face or skin creams (regulated)	2021	8,557	0.0000005	0.00428	0.004	0.00021
Cosmetics and other related products - unregulated	2021	232	8.47	1.97	1.87	0.1
Total				1.97	1.87	0.1

Notes: Hg concentration in regulated products uses half of the allowed limit (1ppm) while the Hg concentration for unregulated cosmetics uses the mean mercury concentration in 50 sampled products (8.47 mg/g). Releases use the UNEP distribution factors of 0.95 to water and 0.05 to land.

When compared with the MIA (2018), mercury input for 2021 is higher despite the use of lower activity rates or import data estimates. One key difference is the higher average mercury concentration used in this report, based on direct measurements in samples.

3.2.2.3 Light Sources with Mercury: Lamps

Table 13 shows mercury content in imported and exported mercury-added lamps from 2017 to 2020. The four-year lamp import is estimated to contain 0.41 kg of mercury while exported lamps contain an estimate of 0.082 kg of mercury.

Table 15. Mercury content in imported and exported lamps, 2017-2020

	Average Hg concentration (mg-Hg/unit)	Imported lamp (1,000 unit)	Hg in imported lamp (t-Hg)	Exported lamp (1,000 unit)	Hg in exported lamp (t-Hg)	Net Hg Input (t-Hg)
Fluorescent lamps	8	42,856.24	0.3428	9,118.156	0.0729	0.27
HID metal halide	62	96.079	0.006	2.999	0.0002	0.013
Mercury vapor	40	549.394	0.0220	224.471	0.009	0.002
Neon lamps	425	84.010	0.0357	0	0	0.036
Total		43,585.72	0.4065	9,345.626	0.08211	0.321

Notes: The mercury concentration for neon lamps is sourced from the Interstate Mercury Education and Reduction Clearinghouse (IMERC) Fact Sheet on Mercury Use in Lighting, while the concentrations for the other lamps are derived from the UNEP Toolkit Level 2. The mercury concentrations used for the estimations represent the average range.

Mercury emissions and releases

Table 16 shows the estimated mercury emissions and releases during the use and disposal of mercury-added lamps. The lifespan of lamps before disposal is assumed to be 5.9 years. The mercury output scenario also assumes the separate collection of used lamps from household waste generators by registered TSD facilities, with controlled waste handling. Therefore, there are no releases to land and water, ideally.

Media releases were calculated using UNEP output distribution factors. The net total mercury content in lamps (0.321 t-Hg) was multiplied with 0.005 for air emissions, 0.80 for general waste, and 0.15 for special treatment/disposal, resulting in 0.016 t-Hg to air, 0.257 t-Hg to general waste, and 0.048 t-Hg to treatment and disposal, summarized in Table 14.

Table 16. Mercury emissions and releases from lamps

Mercury input (t-Hg)	Mercury output		
	Air (t-Hg)	General waste (t-Hg)	Sector specific treatment/disposal (t-Hg)
0.321	0.016	0.257	0.048

Notes: Indicated mercury input is the sum of mercury content in lamp imports minus the mercury content in lamp exports for the four-year period. UNEP Toolkit Level 2 distribution factors have been used to estimate the emission and releases. Sector specific treatment/disposal refers to disposal through registered Treatment, Storage, and Disposal (TSD) facilities

It is important to note that hazardous waste generators, treaters, and disposers are required to periodically report and provide data on hazardous waste category D407, or mercury and mercury compounds waste, on a quarterly basis. However, these are not disaggregated by specific types of mercury waste, meaning that disposed lamp data is lumped together with other types of mercury and mercury compounds under the category. Furthermore, air pollution source installations (APSI), such as bulb eaters, are not required to conduct emission testing, meaning emission data for mercury is unavailable. Therefore, further scrutiny is required to arrive at more accurate estimations.

A major concern in this sector is waste management, as empirical data show that some collected bulbs at the barangay and hospital levels remain uncollected, with improper interim storage making air emissions remain a plausible risk.

3.2.2.4 Other Intentional product/process use: Dental mercury-amalgam fillings

The catalytic effect of the phase-down policy of mercury use in dental restorative procedures is demonstrated in the Philippine Dental Association (PDA) and the DENR survey for dental clinics and educational institutions for 2022-2023. This survey, which covers 959 registered dental clinics and the majority of dentists across the country, found that 94.2% of the respondents noted that they used composite fillings, with glass ionomers being the second most popular product in 2023-2024. Only a small portion of respondents continued to use dental amalgam.^[40] The exact number of these dentists was unavailable at the time of writing the report.



Source: Philippine Dental Association

Figure 10. Use of dental restorative procedures in dental clinics and research institutions

Mercury use in Dental Mercury-Amalgam Fillings

This sector estimation uses the UNEP Toolkit Level 3 (February 2023) default mercury input and distribution factors and calculated using population and density of dental personnel. The estimated mercury input was estimated across three phases, based on lifecycle stages.

For mercury consumption in the preparations of fillings, national population of the country in 2015 (101,716,359) was multiplied by dental personnel density (0.1131) and 0.2 g-Hg consumed per inhabitant per year, and divided by the dental personnel capacity of Denmark (reference country).

Table 17. Mercury inputs and outputs for year 2021

Phase in life-cycle	Mercury inputs (t-Hg)	Mercury outputs, share of Hg input ^a					
		Air t-Hg)	Water (t-Hg)	Land (t-Hg)	Products (t-Hg) ^b	General waste (t-Hg) ^e	Sector specific treatment/ Disposal (t-Hg) ^f
Preparations of fillings in the teeth at dentist clinics	1.94	0.04	0.27		1.16	0.23	0.23
Use (while in the mouths) ^c	1.16 ^g		0.02		1.14		
Disposal ^d	1.14 ^g		0.55	0.16	0.12	0.16	0.16
Total	4.24	0.04	0.84	0.16	2.42	0.39	0.39

a. Output scenario assumes the absence of high efficiency amalgam filters or amalgam separators. In some cases, dentists either grind extracted teeth with fillings, allowing residues to enter drainage and waste water systems, or store them separately.

b. Fraction of mercury that remains in the mouth as fillings.

c. From fillings in the mouth (releases from mercury supply for fillings 5-15 years ago)

d. Releases from mercury supply for fillings 10-20 years ago (amalgam fillings typically have a lifetime of 10-20 years). This represents fillings reaching end-of-life, via clinics, households, and death..

e. Mercury remaining in fillings by the time of the person's death, released to cemeteries or via cremation.

f. Separate collection for treatment as hazardous/medical waste or for recycling.

g. These are not considered 'inputs' and are not added to the total mercury input as these represent amalgam fillings already in the mouth and in lost

One challenge in the phaseout of dental amalgam is the illicit flow of this type of mercury-added product as market monitoring by BAN Toxics reveals that dental amalgam supplies are sold in dental supply stores and online e-commerce platforms. A survey on popular online platforms shows the availability of these supplies from both domestic sellers and China-based sellers,^[41] although the available data for estimation is insufficient as of this report. The FDA has verified this information through its post-marketing surveillance and has recently issued an advisory to warn consumers against specified banned products^[42].

While available stocks of dental amalgam for sale in the market may be legacy stocks following the phase-down date in 2022, this situation calls for further monitoring and research to enable targeted interventions, may be including trade regulation, determining and addressing legacy stocks, and managing associated mercury-containing waste.

3.2.3 Use of coal as energy source

3.2.3.1 Overview

There are six identified subcategories in the extraction and use of the different energy sources, namely: (1) coal combustion in large power plants, (2) other coal use, (3) extraction, refining and use of mineral oils, (4) extraction of natural gas, (5) geothermal power production, and (6) biomass fired power and heat production. This study focuses on the two main industrial users of coal as energy fuel, namely, coal-fired power plants and the cement industry.

Coal production, consumption and trade overview

The Philippines relies heavily on coal as its primary energy source, remaining the largest contributor to the power generation mix. This fossil fuel accounted for 61.92% of all electricity generated in 2023, marking a continuous rise over the past 15 years.^[43]

In 2021, the majority of coal consumption was attributed to the power industry (88.57%), followed by cement production (4.74%), and all other non-energy use industries such as food, paper, and beverage (6.12%).

Coal deposits are scattered across the Philippines with 349.61 million metric tons in stock of Class A coal reserves in 2022^[44]. The largest deposit is located in Brgy. Semirara, Caluya, Antique,^[45] designated as a coal mining reservation by Proclamation 649 of 1940 and has been developed since 1977. The mining operations on the island are managed exclusively by a private corporation with a combined annual production capacity of 16 million metric tons using the open-pit mining method with operation covering an area of 3,369.25 ha. Other coal deposits with active mining operations are located in Albay, Bataan Island, Cebu, Negros. Small-scale coal mining is also registered in CARAGA, Cebu, Zamboanga, and Albay, providing 77,101.21 metric tons in run-of-mine in 2021.

During the oil crisis in the mid-80s, the Philippines' energy policy has been to reduce dependence on imported oil intending to enhance the development of domestic energy resources, with a particular focus on expanding domestic coal resources. The Aquino

administration set the targets to raise the share of coal-fired generation within nationwide power generation from 7% in 1986 to 13.3% by 1992^[46].

To date, the country is a net importer of coal having imports constantly rising over the past decade in order to meet its growing energy demand. Based on official trade statistics data from the Philippine Statistics Agency (PSA), the country imported a total of 31,422,818 metric tons of coal, primarily from Indonesia, in 2021^[47]. The pattern is shown in Figure 13 below. The coal roadmap of the country seeks to further increase coal production to 282 million metric tons in the long-term in 2023 to 2040^[48]. Domestically-produced coal for the same year accounted for 14,378,268 t, while the country exported 9,333,445 t, primarily to China.

The country's production, trade, and consumption overview for 2014-2023 is shown in fig. 13 below.

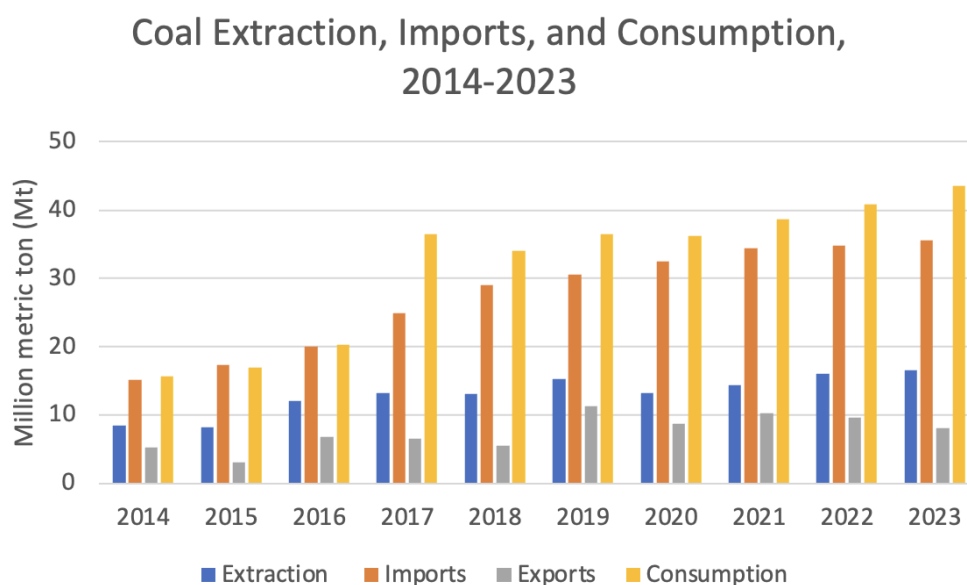


Figure 11. Pattern of coal extraction, trade, and consumption, 2014-2023

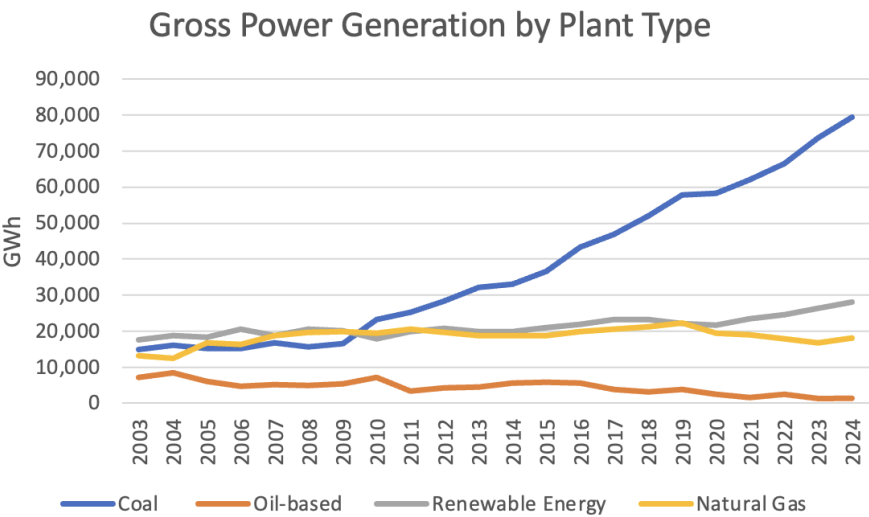
Note: Data from the Dept. of Energy were taken from Coal End-Users' Reports and may show discrepancies when compared to PSA trade data used in the estimations in this report.

Coal-Fired Power Plants

As of June 2025, the Philippines has an installed coal power plant capacity of 13.006 GW, according to DoE statistics.

In 2020, a moratorium on new coal-fired power projects was implemented, halting the processing of new applications. Aiming to accelerate the transition to renewable energy, the country introduced a policy change in 2023 that allows full foreign ownership of renewable energy projects.

Despite these seeming shifts, nine coal-fired power projects—announced in 2024—with a combined installed capacity of 2,255 MW are expected to strengthen the country’s main power grids. Figure 14 illustrates the pattern in the energy mix over the past 20 years.



Source: DoE 2024 Power Statistics

Figure 12. Shares of energy consumption, 2003-2024

Pulverized coal combustion is the most commonly used technology for coal power generation. Existing CFPPs in the Philippines utilize either Pulverized Subcritical Technology (54%) or Circulating Fluidized Bed (CFB) technology (46%). Additionally, a few supercritical coal-fired power plants, which offer higher efficiency and consequently lower emissions compared to subcritical plants, are currently in operation.

Coal combustion produces coal combustion by-products, mostly ashes. The coarser fraction, known as bottom ash or slag, is removed from the bottom of the boiler, while the finer particles, called fly ash, are captured from the flue gas stream by the particulate controls. Emissions

control technology are installed in CFFPs, usually Electrostatic Precipitators (ESP), Atmospheric Circulating-Fluidized-bed (ACFB), and flue gas desulfurization (FGD). Despite the high efficiency of ESPs and Fabric Filters (FFs), a small fraction of fly ash by-pass these controls and reach the Flue Gas Desulfurization (FGD) system.

Cement Production

The cement industry, the second-largest consumer of coal, is likewise expected to expand, with robust demand being driven by ongoing construction activities. Coal is the primary energy source in cement production, which uses raw materials like limestone, silica, shale, and by-products from coal combustion, such as fly ash and bottom ash, containing traces of mercury. Both the fuel and feedstock used in cement manufacturing contribute to mercury releases and emissions into the environment.

There are 19 integrated cement plants and four grinding plants in the country.^[49] The total annual cement production capacity in 2021 is estimated at approximately 36.39 million metric tons. This figure is based on plant-level capacities from published documents of cement companies, including the Environmental Compliance Certificates (ECCs) issued by the DENR-EMB, Environmental Impact Assessment (EIAs), Environmental Performance Reports, and Management Plans of cement manufacturers. The estimate covers ten cement manufacturers, excluding cement manufacturers that operate grinding plants only. The country has consistently imported Portland cement, averaging 5.12 million metric tons annually for years 2018 to 2023, with the majority coming from Vietnam.

Limestone, the most abundant non-metallic resource in the country, plays a key role in cement production, with over 4.55 billion metric tons in resources and 0.90 billion metric tons in reserves. The country has 59 operating non-metallic mines, including 28 limestone quarries, as well as shale and silica sources, as of July 2023.^[50]

3.2.3.2 MMF for Coal Use

3.2.3.2.1 Coal-fired Power Plants

The mercury flow in coal-fired power plants is shown in Fig. 13.

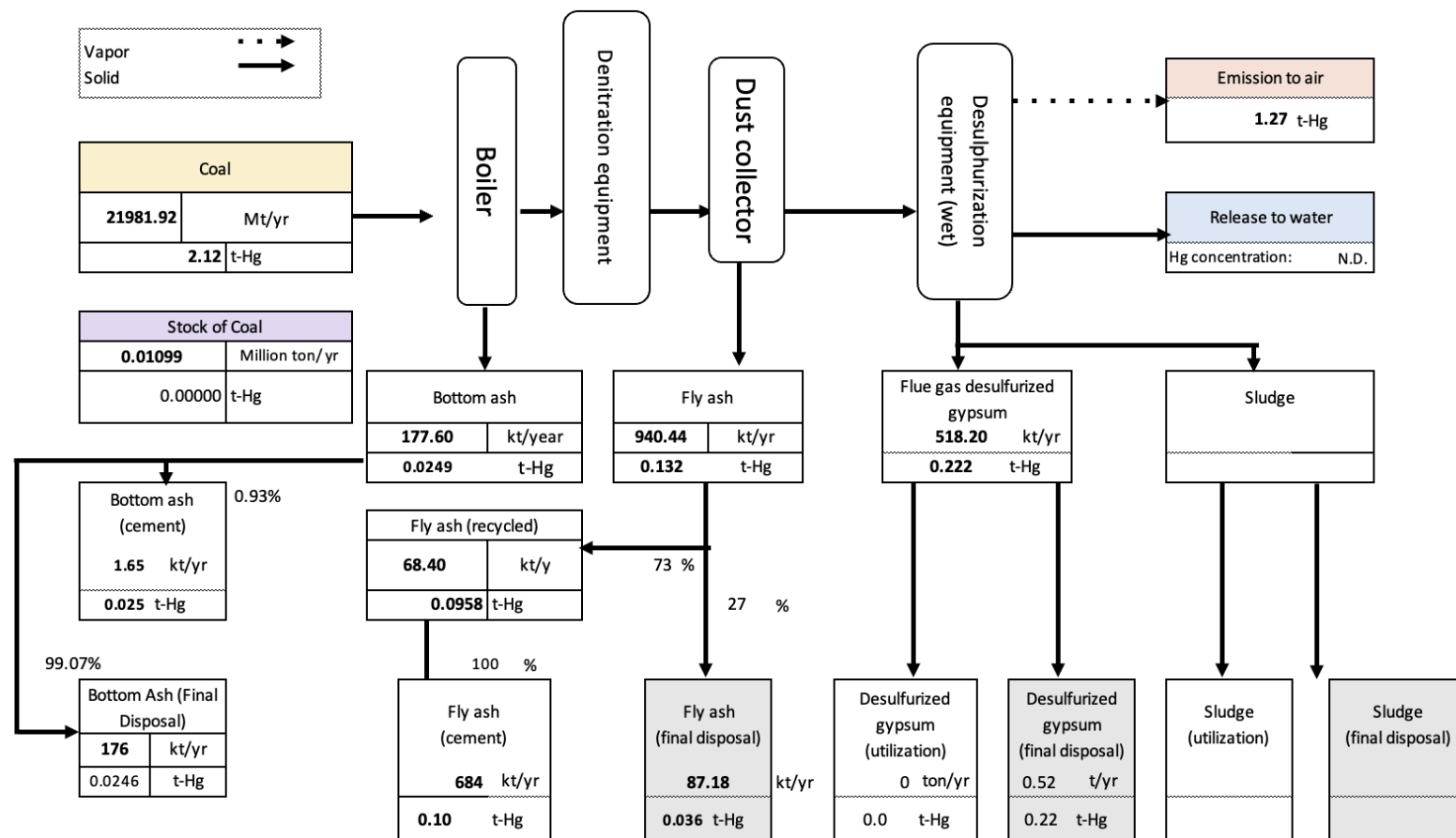


Figure 13. Mercury material flow of coal-fired power generation industry (2021)

Mercury content in coal consumption

In 2021, approximately 21.98 million metric tons of coal were consumed for power generation, according to data from the DOE, with most of it sourced from imports. About 97% of imported coal came from Indonesia and is classified as subbituminous, with an average mercury concentration of 0.11 g/t, whereas domestically-produced coal has a mercury concentration of 0.04 g/t. The total mercury content in coal is estimated by multiplying the quantities of imported coal and domestic coal production by their respective mercury concentrations.

For the year 2021, the amount of mercury in imported coal is estimated at **3.45 t-Hg**, when calculated based on the mercury concentration for each source country. The amount of mercury in domestically produced coal is estimated at **0.58 t-Hg**, making the **total mercury content in coal for the year at 4.03 t-Hg**, summarized in Table 17.

Table 18. Mercury content in imported and domestically-produced coal (2021)

Country Source	Import amount (metric tons or t)	Hg concentration (g/t)	Hg input (t-Hg)
Australia	222,238.81	0.068	0.0107
China	51	0.2	0.102
India	167,2	0.14	0.00005
Japan	15,016.1	0.04	0.00059
Republic of Korea	92.31	0.082	0.00003
Russian Federation	168,849.95	0.063	0.02702
USA	.249.48	0.1	0.00004
Vietnam	283,823.79	0.1	0.02338
Indonesia	30,678,227.28	0.11	3.37461
Taiwan	2.2	0.1	0
South Africa	54,100	0.2	0.01082
Sub-total			3.45
Domestically-produced coal (Run-of-mine)	14,378,268.46	0.04	0.58

	TOTAL	4.03
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Source: Trade data from PSA

Notes: The Hg concentration for Australia, India, Republic of Korea, Russian Federation, and USA are from UNEP GMA 2018, for Indonesia from UNEP 2017, and for China and Taiwan from literature. Numbers are rounded.

Meanwhile, the mercury content in exported coal, with the majority going to China, followed by South Korea and smaller amounts to other countries, is **0.37 t-Hg**, shown in Table 18.

Table 19. Mercury content in exported coal (2021)

Destination	Export amount (MT)	Hg concentration (g/t)	Hg content (t-Hg)
China	8,809		
S. Korea	379	0.04	
Others	110		
Total	9,298		0.37

Source: Data from DOE

Note: Hg concentration uses the UNEP GMA 2018 default factor for the Philippines.

Mercury in by-products from coal combustion

Coal combustion in power plants generated an estimated 1.11 million metric tons of by-products, primarily fly ash, bottom ash, and FGD gypsum. Of these, approximately 73% of generated fly ash and 4% of bottom ash were recycled for use in cement production. Initial data for these estimates were obtained from SMRs submitted to DENR-EMB regional offices, representing 34% of total CFFPs generating capacity. These data were then extrapolated to estimate national figures. For FGD gypsum, data on generation, recycling, and disposal from the largest plant were extrapolated to approximate national figures.

The mercury content of each by-product was calculated by multiplying the quantity by the mercury concentration, using UNEP Hg content intermediate value of 0.14 g/t. Table 19 summarizes the mercury content in the generation, utilization, and disposed coal combustion by-products.

Table 20. Content of mercury in generation, utilization, and disposed waste by-products (2021)

	Amount (metric tons)			Hg concentration (g/t)	Hg content (kg-Hg)		
	Generated	Recycled for cement	Final disposal	UNEP 2018 default value	Generated	Recycled for cement	Final disposal
Fly ash	940,442	684,016	248,797	0.14	0.132	0.096	0.035
Bottom ash	172,606	1,650	7,453	0.14	0.024	0.00023	0.001
FGD gypsum	518,203	0	518,203	0.428	0.222	0	0.222

Source: Amount of generation, utilization, and final disposal from EMB data in 2021.

Notes: The ratio of installed generating capacity of CFFPs with available EMB fly ash data and nationwide generating capacity according to the DoE (CFFPs with EMB data:DOE nationwide CFFPs = 5,527.5:11,220.5 =100:202)) is used for extrapolation. Hg content figures are rounded.

Mercury emissions and releases

During coal combustion, the mercury present in coal is vaporized and transformed into elemental mercury vapor in the high-temperature areas of coal-fired boilers.^[51] Mercury emissions are controlled through existing pollution control equipment used to remove particulate matter (PM), sulfur dioxide (SO₂), and nitrogen oxides (NO_x). Mercury is trapped by particulate matter control equipment, while soluble mercury compounds are captured in wet flue gas desulfurization (FGD) systems. Evidence also indicates that the application of selective catalytic reactor (SCR) to control NO_x emissions boosts the oxidation of mercury in flue gas, leading to greater mercury removal in wet FGD systems. Continuous Emissions Monitoring System (CEMS) devices are also installed at the smokestack to monitor emissions and particles conformity with international and DENR standards.

This study uses the UNEP Toolkit Level 3 distribution factor of 0.6 (60%) of mercury input to air to estimate emissions in the absence of point source data. The calculation assumes the combustion of sub-bituminous coal coal with efficient air pollution control (APC) system in place, such as particulate matter (PM) control combined with spray dry absorbers (SDA) and flue gas desulfurization (FGD). Other mercury pathways—particularly by-products and disposal—were estimated using extrapolated point source data. The total estimated mercury emission is **1.783 t-Hg**, as shown in Table 20.

Table 21. Mercury emissions and releases in CFFPs

	Mercury output (t-Hg)
Air Emission	1.274
Releases to water	Negligible
Total Hg in by-products generated	0.156
Total Hg in by-products recycled for cement	0.096
Final disposal	0.257

When compared to MIA (2018) findings, the following observations can be made, primarily due to the methodological differences outlined below:

- A 41% increase in mercury input from coal combustion in large power plants in 2021 is estimated in this report compared to the levels reported in the MIA, despite a lower activity rate in 2021 than in the MIA reference year of 2018. This discrepancy is primarily due to the difference in mercury concentration values used for coal by source country—for example, the MIA used 0.03 g/t for Indonesian coal, while this report uses 0.11 g/t.
- There was also a significant increase in air emissions in 2021 compared to the 2018 level, with an approximate increase of 180% due to the different mercury input estimates notwithstanding the higher air emission factor (90% mercury input to air) used in MIA.

In summary, the application of the MMF methodology, along with the updated UNEP Toolkit Level 3 and the use of extrapolated point source data, accounted for the major differences—despite only a minor decrease in activity rate.

3.2.3.2 Cement Production

The country's estimated production of cement clinker in 2021 was 36.39 million metric tons, while exports, according to UN Comtrade, amounted to 4.9 metric tons. Imported clinkers have not been included in the calculations of mercury releases estimations.

This mercury flow considers significant raw materials with mercury impurities, recycled by-products (i.e. coal ash), and coal used as fuel, in estimating mercury inputs. It does not include waste used as fuel due to the lack of obtained data, nor does it account for the potential

recycling of flue gas desulfurized gypsum by other cement plants during the finishing process. The detailed flow is shown below.

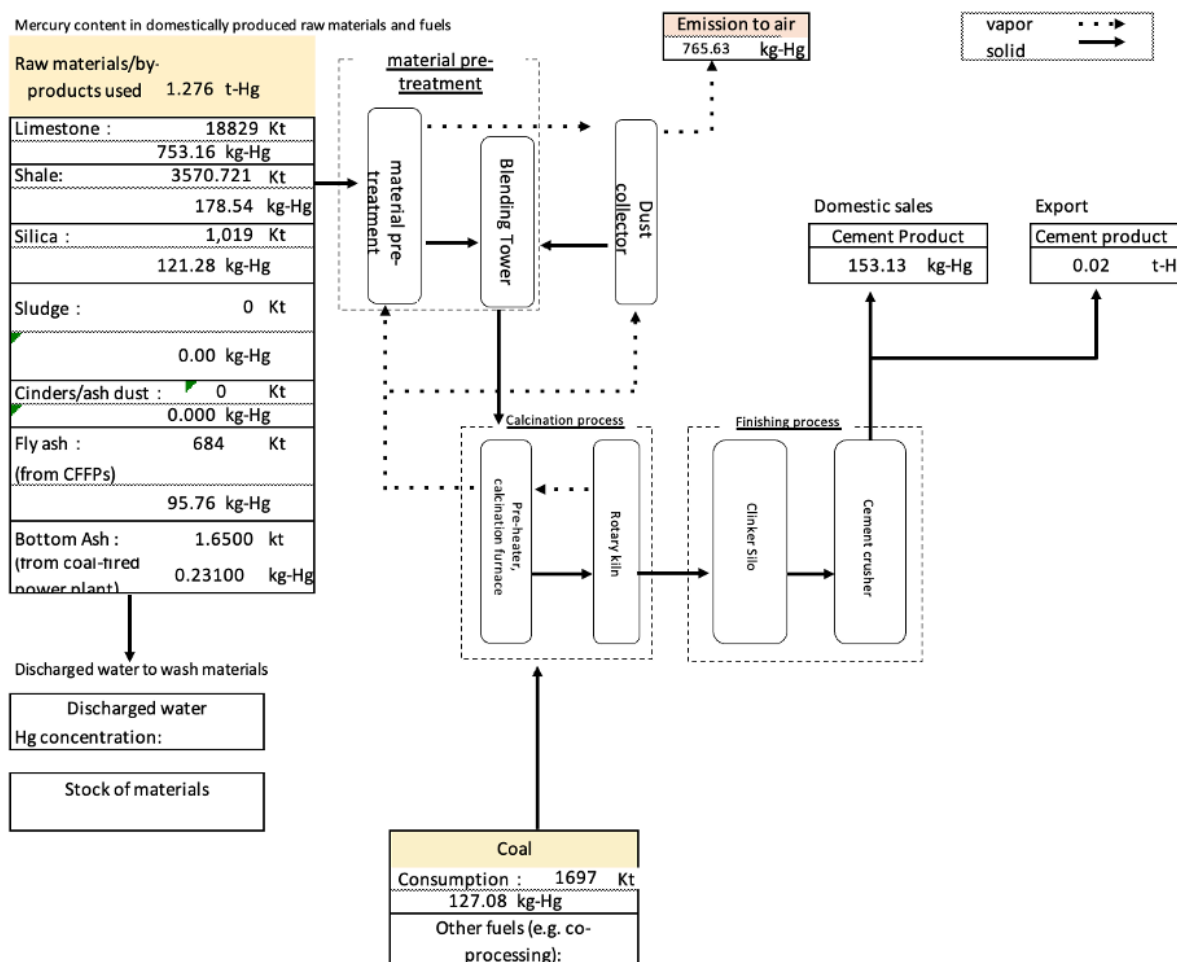


Figure 14. Mercury material flow in cement industry (2021)

Mercury Input in Cement Production

The cement production in the country primarily uses coal as fuel, though co-incineration of waste is being practiced. In 2021, the industry utilized 4.47% to up to 6.66% of the country's coal supply based on DoE data. This study does not yet account for the use of waste materials and fuels in cement kilns that may contribute to mercury emissions and releases.

Aside from the use of fuel, raw materials and by-products used in cement production contribute to emissions and releases of mercury into the environment. The estimated mercury content in raw and recovered materials, and fuel is 1.28 metric tons, as shown in Table 21.

Table 22. Mercury content in raw materials and fuel (2021)

Raw/recovered material and fuel		Ph-sourced		Imported		Hg content (t-Hg)
Raw materials and fuel		Consumption (t)	Hg Concentration (g/t)	Consumption (t)	Hg Concentration (g/t)	
	Coal	850,741.27	0.04	845,873.81	0.11	0.127
	Limestone	18,829,061	0.04	-	-	0.75
	Silica	1,019,156	0.119	-	-	0.12
	Shale	3,570.721	0.05	-	-	0.18
Recycled matter	Fly ash (from CFFPs)	684,016	0.14	-	-	0.10
	Bottom ash (from CFFPs)	2,665	0.14	-	-	.00023
Total						1.28

Notes: Hg concentrations were sourced from different literature, including UNEP documents. Figures are rounded.

The major pathway for mercury releases in the cement industry is through emissions to the atmosphere during the milling or resizing of cement raw materials, the homogenization of milled materials, kiln-feeding and operations, all of which fall under the clinker burning and grinding stages. These air pollution sources have corresponding control facilities as mandated under the law. Cement producers are also required to collect and re-use dust in the kiln gases to the production process to improve operation efficiency and reduce atmospheric emissions, thereby also reducing the input of raw materials.

Dust collectors and electrostatic precipitators (ESPs) are used for air pollution control. Cement manufacturers are also required to install ambient air quality and environmental monitoring equipment as part of their environment compliance, with quarterly self-reporting to the DENR EMB. As generators of hazardous waste, they must comply with regulations governing the proper storage, treatment, and disposal of such wastes.

The processes for cement production in the country are primarily dry, and wastewater generation is limited to domestic wastewater, wastewater from maintenance activities, and run-off from surfaces, which is mitigated by siltation or settling ponds in the cement plants that are regularly desilted to abate water pollution. Data obtained from TCLP results from cement plants indicate levels below the set regulation limit, ranging from <0.0002 to <0.0004 mg/L, demonstrating that effluent from the siltation ponds are compliant to DENR General Effluent Standards (GES). Data obtained from emission test results submitted by cement manufacturers indicate that all are compliant with the applicable mercury emission standards, with reported figures falling within the allowable limits for air emissions.

To estimate mercury emissions on a national scale, activity rate data – quantity of cement produced from nationally produced clinker per year -- was used, applying UNEP Toolkit Level 2 (ver. 1.17) distribution factors of 60% to air, 20% to products, and 20% to sector-specific treatment/disposal. This estimation assumes the use of simple particle control technologies, such as electrostatic precipitators (ESP), particulate scrubbers (PS), or fabric filters (FF), as air pollution control measures, along with the recycling of filter dust.

The annual mercury emission is estimated to be 0.766 t-Hg, while approximately 0.153 t-Hg is estimated to migrate into finished products, as shown in Table 22.

Table 23. Mercury releases in cement clinker production facilities

Cement clinker production	Mercury output (t-Hg)
Air Emission	0.766
Products	0.153
Sector Specific treatment/disposal ^a	0.255

a. Sector specific treatment/disposal refers to disposal through registered Treatment, Storage, and Disposal (TSD) facilities

When compared to MIA (2018 reference), changes observed are as follows:

- Notwithstanding a higher activity rate of approximately 37% in 2021, the mercury input in this report is lower than that reported in the MIA, likely due to differences in the estimation method used; and

- Mercury output across all media is also lower in this report, likely due to the lower mercury input and differences in the distribution factors used.

3.2.4 Other primary (virgin) metal production

3.2.4.1 Copper extraction and initial processing

Estimates for the copper production as a source sub-category are distinguished between two processes: mining and concentrating, and the production of copper from concentrates. In 2021, copper extraction recorded **214,684 metric tons**, reflecting local production across seven processing plants.³ The country's sole copper smelter facility reports processing 1.2 million metric tons of copper annually. This volume of copper concentrates, sourced globally, is processed, smelted, and treated at this facility. Extraction and concentration of copper and the smelting process are estimated to contribute an **annual mercury input of 42.44 t-Hg**.

Mercury output is estimated using UNEP Level 3 distribution factors for each process. For the extraction phase, 0.062% is released to water, 82% to products, and 17.938% to sector-specific treatment/disposal, assuming the use of BAT/BEP (best available technique/best environmental practice), including wastewater treatment. For the initial production of copper, emissions are distributed as follows: 2% to air, 2% to water, 1.3% to products, and 94.7% to sector-specific treatment/disposal, assuming the presence of an existing gas purification system at the acid plant. Summary of estimates is given in Table 23.

Table 24. Summary of Estimates for Copper Extraction and Initial Processing

Subcategory	Activity Rate, ton/year	Mercury concentration (g/t)	Annual mercury input (t-Hg)	Annual Mercury Output, t-Hg/yr				Sector Specific disposal
				Air	Water	Land	Products	
Mining and concentrating of copper	214,684 ^a	30	6.44		0.004		5.28	1.16
Production of copper from concentrates	1,200,000 ^b	30	36	0.72	0.72		0.47	34.09
Total			42.44	0.72	0.724		5.75	35.25

Notes: Figures are rounded.

a. Concentrate produced

b. Concentrate used

When compared to MIA using 2016 data for copper extraction and initial processing, changes observed are as follows:

³ MGB (2020). Metallic production - value stays upbeat. Retrieved on 15 March 2025. Found in <https://mgb.gov.ph/attachments/article/1374/Metallic-Production-Value-Stays-Upbeat-16-Feb-2023.pdf>

- This MMF report reflects a **higher mercury input** due to a significant increase in the activity rate of local production of copper from concentrates, as shown in the summary given in Table 25.
- In terms of emissions and releases, the MIA reports higher air emissions due to the use of different distribution factors, which stem from the application of different versions of the UNEP Toolkit.

Table 25. Comparison between MMF (2021) and MIA (2019) input and releases

Source Category	Updated in 2025 (data for year 2021)		MIA (2019) Estimates	
	Activity rate, ton/year	Calculated Hg	Activity rate, ton/year	Calculated Hg
		Hg input (t-Hg)		Hg input (t-Hg)
Mining and concentrating of copper	214,684	6.44	317,536.80	9.53
Production of copper from concentrates	1,200,000	36	317,536.80	9.53

These estimations could benefit from validation at the plant level and waste disposal data of TSDs to investigate further.

3.2.4.2 Gold extraction and initial processing by methods other than mercury amalgamation

This MMF report uses the gold ore extraction data from the MIA (2018) report as the activity rate, due to the unavailability of updated national data. The same mercury output values are also referenced in this report.

3.3. SUMMARY OF EMISSIONS AND RELEASES OF MERCURY

Primary (virgin) metal production remains the major source of total emissions and releases in the country, accounting for approximately 71% of all source categories. Excluding waste deposition/landfilling and waste water treatment (which are outside the specific scope of this MMF report), the next significant source category is the extraction and use of fuels/energy sources, contributing approximately 9% of total releases, followed by releases from consumer products at approximately 7%.

Tables below show the summary estimated results of atmospheric mercury releases to the environment in Mercury Material Flow (2021).

Table 26. Mercury atmospheric emission inventory (2021), specific sectors

Source category	Emission source	Emission (ton-Hg/year)
Extraction and use of fuels/energy sources and raw materials	Coal-fired power plants	1.274
	Cement clinker production	0.766
Primary (virgin) metal production	ASGM	18.28 ^a
	Copper extraction and initial processing	0.72
Consumer products with intentional use of mercury	Light sources with mercury	0.016
	Skin lightening creams	1.97
Other intentional product/process use	Dental mercury-amalgam fillings	0.04

a. Average of the high and low values

Table 27. Mercury releases to water (2021), specific sectors

Release source	Mercury release (t-Hg/year)
ASGM	32.38 ^a
Copper production and initial processing	0.724
Consumer products with intentional use of mercury (light sources with mercury)	0.84

Consumer products with intentional use of mercury (skin lightening creams)	1.87
Dental mercury-amalgam fillings	0.84

a. Average of the high and low values

Table 28. Mercury releases to land (2021), specific sectors

Release source	Mercury release (t-Hg/year)
ASGM	32.38 ^a
Consumer products with intentional use of mercury (skin lightening creams)	0.1
Dental mercury-amalgam fillings	0.16

a. Average of the high and low values

CHAPTER 4. APPLICATION

4.1 MMF INFORMATION FOR MINAMATA CONVENTION REPORTING

The information presented in this MMF report may be used to support the country's reporting obligations under the Minamata Convention, as follows:

Table 29. Application to Minamata Convention reporting obligations

Relevant sections	Application
Part B: Information on measures taken to implement the relevant provisions and on the effectiveness of such measures in meeting the objectives of the Convention	
Article 3: Stocks and sources of mercury and mercury compounds	
Question 3.3/3.4. Endeavour to identify stocks and sources of mercury	The MMF (2021) report serves as a measure to identify significant stocks and sources of mercury supply. It provides update to the Minamata Initial Assessment (2018) and may support the identification of mercury stocks and sources as outlined below: • Gold and silver production using mercury amalgamation may constitute an individual stock of mercury. This observation is supported by both online and on-site market monitoring, which indicate the unregulated import and sale of liquid mercury into the country. Further investigation may be undertaken to confirm and substantiate this finding; • This also applies to the illegal import and sale of mercury-added products, particularly skin-lightening creams. When considered alongside unregulated imports of liquid mercury,

	illegally sold mercury-added products may also constitute an individual stock or source of mercury and mercury compounds; and • Further investigation and control measures may be needed to obtain more accurate estimates and substantiate these findings, given the unregulated nature of these source subcategories.
Article 4: Mercury-added products	
Questions 4. Appropriate measures to not allow the manufacture, import or export of mercury-added products	• Findings on cosmetics and dental amalgams in this report indicate the continued import of mercury-added products. Relevant measures or strategies undertaken may be reported in this section.
Article 5: Manufacturing processes in which mercury or mercury compounds are used	
Question 5.1. and 5.5 Facilities that use mercury or mercury compounds for the processes listed in Annex B to the Minamata Convention	• The domestic manufacture of mercury-added cosmetics may warrant further investigation, as empirical data gathered during the preparation of this report suggest such activity. Furthermore, the European Union Rapid Alert System (RAPEX) has identified mercury-added skin lightening products reportedly manufactured in the country.
Article 7: Artisanal and small-scale gold mining	
Questions 7. Reduction, elimination of the use of mercury and mercury compounds in, and the emissions and releases to	• This report suggests that the continued use of mercury in the ASGM remains the leading anthropogenic source of mercury emissions. Furthermore, the calculations on emissions and releases indicate higher discharges to waterways compared to previous estimates, highlighting the need for measures, including alternative mechanisms, to control mercury pollution.

the environment of mercury from ASGM	• The findings in this report may be further investigated and verified to support the development and implementation of a national action plan, and the country's three-year review of its progress in meeting its obligations under article 7. • Include in the Minamata reporting the development of MMF (2021), which was undertaken in cooperation with the Ministry of Environment-Japan.
Article 8: Emissions	
Question 8.2. Existing sources of emissions	• The following source subcategories covered in this MMF report show higher emissions compared to those reported in the MIA, warranting further verification and the implementation of control measures: • Gold and silver production using mercury; • Copper extraction and initial processing; and • Consumer products with intentional use of mercury: a) skin-lightening creams, b) dental mercury amalgam fillings, and c) light sources. • The following source subcategories covered in this report continue to show significant emissions, but current monitoring mechanisms may be insufficient to accurately estimate mercury content/concentration or to ensure compliance with BAT/BEP control standards: • Coal combustion in coal-fired power plants; • Production of other minerals and materials with mercury impurities (cement clinker production)/
Article 9: Releases	
Question 9.1./9.2. Relevant sources of releases	• The following are existing sources of releases, but with higher estimated values compared to the baseline from MIA (2018): • Gold and silver production using mercury amalgamation without the use of retorts or alternative reduction measures; and

	• Consumer products with intentional use of mercury, specifically cosmetics.
Article 11: Mercury wastes	
Question 11. Measures implemented for mercury waste	Findings in this report provide the following insights for question 11: • For consumer products, specifically cosmetics, measures are in place to control the illegal sale of mercury-added cosmetics through the issuance of FDA public advisories and the seizure of prohibited items; and • Explanations for measures not yet taken for certain sources of mercury waste may include challenges in meeting the objectives of the Convention.
Article 12: Contaminated sites	
Question 12.1. Measures to develop strategies for identifying and assessing contaminated sites	• Findings in this report indicate the following insights relevant to the question: • There is a clear evidence of contaminated sites resulting from the continued use of mercury amalgamation in ASGM; and • Progress on the ASGM National Action Plan and other related information may be explained.
Article 19: Research, development and monitoring	
Question 19.1. Undertaken research, development and monitoring	• The development of the MMF (2021), in cooperation with the Japan government, through the Ministry of Environment-Japan, may be cited, among other relevant initiatives, if applicable.
Part C: Comments regarding possible challenges in meeting the objectives of the Convention	• This MMF (2021) report may be referenced to support responses to this section of the Minamata Reporting, as it contains relevant challenges and explanations related to the questions in part B.

4.2 MMF INFORMATION FOR POLICY DEVELOPMENT, MONITORING AND EVALUATION

This study provides insights for policy development, monitoring and evaluation for the elimination or reduction of mercury pollution in the country. It emphasizes the need to resolve persisting gaps and challenges in meeting the Minamata Convention objectives.

Primary (virgin) metal production

For gold and silver production using mercury amalgamation, following measures may be undertaken:

Reassess source attribution in order to come up with strategies to curb supply availability and accessibility. Further investigation into mercury use in ASGM is strongly recommended, as empirical data challenges the information—reported in the Philippines' Short National Report [52] – that dental practitioners are the primary source of mercury. Interviews with small-scale miners indicate that mercury is primarily purchased illegally from hardware stores, with supplies provided by mining financiers and gold traders. Field observations corroborate this, noting substantial quantities of mercury used in ore processing, with one mining operator reporting up to 40 kg. of mercury consumed per month. While dental amalgam remains available on the market, further research is needed to determine whether these are legacy stocks or have been smuggled into the country post-phasedown and diverted to ASGM. However, the volume of mercury sourced from hardware stores and mining financiers far exceeds what could plausibly originate from dental practitioners.

The ASGM National Action Plan may be expanded to include provisions for tracking mercury flows, as well as for investigating the scope and impact of mercury-cyanide complexes, which are highly-toxic and water-soluble. Engagement with local government units and affected communities will be essential to support effective data collection and monitoring. In the interim, the adoption of retorts is recommended to reduce mercury emissions, while continuing to promote the transition to alternative, mercury-free technologies and practices.

For gold and silver production where mercury is not intentionally used, data reporting requirements may be undertaken. Estimating mercury input from the extraction of gold and silver—where mercury is not intentionally used—requires the development or updating of mechanisms for reporting and monitoring gold ore extraction data by the large-scale gold and silver mining industry, as this source subcategory may still contain significant mercury content. Environmental compliance may incorporate BAT/BEP-based monitoring and mercury pollution control measures, as substantial amounts of mercury impurities can be mobilized during smelting stage.

Copper extraction and initial processing represent a significant source of mercury input and air emissions, with future increases expected due to the growing demand for copper as essential components in clean energy technologies. The application of BAT/BEP technologies and enhanced monitoring is necessary to mitigate associated mercury releases.

Consumer products

Information from this report further strengthens current proposals of Philippine regulatory agencies pertaining to mercury-added products, particularly cosmetics. Findings on continued sale of mercury-contaminated skin-lightening products entering the market illegally from other countries and likely manufactured in the country strengthens current measures deemed important as inherent part of the implementation and enforcement of a ban on mercury-added cosmetics. The Philippines has expressed its inquiry as to the necessity to be specified in Part II of Annex A containing measures for the phase-down of mercury-added products, specifically dental amalgams.

Furthermore, the proposed deletion of the 1 ppm mercury threshold in the ban on cosmetics under Part I of Annex A is intended to improve the efficiency of marketing surveillance by eliminating the threshold limit, thereby allowing the use of XRF analyzers for heavy metal detection. Estimating the mercury content in illegal and unregistered, imported mercury-added skin lightening products from other countries warrants further research as well as empirical data on local manufacture. Sample testing using XRF provided valuable insights, revealing the continued entry of high-mercury SLPs into the country—some exceeding the maximum allowable limit by as much as 42,000%. Although the XRF method is not included in the ASEAN

Harmonized Cosmetics Regulatory Scheme,^[53] regulatory bodies should investigate these findings, as they have been consistently observed over a significant period.

For dental amalgams, investigate dental amalgam supply to determine whether currently available dental amalgam is legacy stock or part of an illicit import stream.

The reporting and monitoring of mercury-added products, as well as BAT/BEP compliant emission testing for air pollution source installations, may be integrated into the permitting and reporting responsibilities of regulated facilities.

Extraction and Use of fuels and production of other minerals and materials with mercury impurities

For coal-fired power generation and the cement facilities, efficient testing methods for determining mercury concentration can lead to improvements in quantifying mercury input, thus supporting more environmentally-sound management of mercury waste and by-products. These facilities comply with hazardous waste management regulations based on the emission tests and maintain current standards. However, the quantification of mercury input in these industries reveals discrepancies not captured by current testing methods. Implementing better mercury monitoring controls, reporting, and testing could improve the detection and management of emissions and releases.

Mercury waste

Current efforts to amend hazardous waste category reporting requirements should prioritize the disaggregation of mercury waste into specific subcategories. Waste generators and treaters can be required to specify the type, source, and quantity of mercury waste in their quarterly submissions to DENR-EMB. In support of this, existing monitoring systems can be updated to enable more detailed categorization and digital tracking of mercury waste streams.

To complement regulatory reporting, surveys and consultations with stakeholders may be conducted to determine the types and volumes of mercury-containing products and wastes being generated, stored, treated and disposed. These measures will directly contribute to the

development of a national mercury waste profile or inventory, aligned with the country's obligations under the Minamata Convention.

In addition, specific measures and strategies can be developed to address the informal dismantling and disposal of e-waste, which may include mercury-containing components. This includes community engagement, capacity-building, and enforcement mechanisms to reduce environmental and health risks associated with unregulated mercury releases.

CHAPTER 5. WAYS FORWARD

5.1 CHALLENGES AND OPPORTUNITIES

Obtaining facility-level information at the national level will improve the accuracy of estimations and enable more targeted regulatory reforms and interventions. To determine the exact input and output values for mercury across relevant source categories, sampling and laboratory analyses may be conducted. This will allow for the updating of the mercury inventory by reducing reliance on default input and output factors from the UNEP Toolkit. Enhancing current regulations on reporting and monitoring of facilities and industries could be beneficial in collating information for subsequent updating of inventory. Coordination with government agencies and facilities is crucial for the successful implementation of this activity.

On regulatory issues, despite the existence of comprehensive regulations, there is a need to implement a robust enforcement and post market surveillance program to efficiently control and remove products with undesirable effects from the market. This applies to all consumer products including the smuggling of illegal mercury that flows into the ASGM sector.

The growth of e-commerce in the sale of unregulated mercury-added products poses significant challenges and opportunities, as already presented in the latest National Report of the Philippines to the Minamata Convention on Mercury. There is a need for reforms to strengthen the capacity of customs authorities to target suspect imports, including small consignments sold through digital platforms. These efforts should complement ongoing initiatives by regulatory

bodies to develop new e-commerce regulations and adopt appropriate technologies and equipment to enhance border and regulatory controls.

Engaging with local communities and employing participatory approaches to data collection and analysis, to arrive at more accurate estimations, present an opportunity to address the complexities and uncertainties in unregulated and informal sectors significantly contributing to mercury use and releases.

5.2 NEXT STEP AND ACTIONS

The development of the Mercury Material Flow primarily aims to support the Philippines' efforts to manage mercury in an environmentally sound manner and the government's reportorial duties as a Party to the Minamata Convention on Mercury. To maximize the MMF's capacity to examine the impact and effectiveness of domestic policy and measures, the MMF report will be updated and upgraded periodically.

The results of the MMF will be used as the basis for updating the country's mercury inventory, including the identification of significant stocks and sources of mercury supply. Succeeding MMF studies can aim to obtain facility-level information at the national level with an emphasis on more accurate quantification of point sources and other additional sources highlighted in this report.

The information presented in updated MMF and inventory will play a significant role in the country's mercury management agenda. Currently, the Environmental Management Bureau of the Department of Environment and Natural Resources is implementing the five-year project titled "Reduction of unintentionally-produced persistent organic pollutants and mercury through an environmentally-sound approach on health care wastes management in the Philippines with a special focus on the pandemic," with funding from the Global Environment Facility (GEF) and support from the UN Industrial Development Organization (UNIDO). Under the project, the MMF and the MIA will serve as the basis for a) updating the National Action Plan for Mercury Added Products, b) the development of relevant policy and program recommendations, and c) developing and implementing final disposal plans for MAPs in the healthcare sector.

ANNEXES

Annex A. MMF FINAL IMPLEMENTATION PLAN

Annex B. PROGRESS REPORTS (*hyperlink drive containing reports*)

Annex C. Comparison of the activity rate, input and output factors used in the 2018 mercury inventory and updates undertaken for MMF development

Source category	Subcategory	2018 Inventory (Level 2)			Updated Inventory for MMF Development			
		Hg Output per year	Activity rate and input and output factors used	Data Gaps/ Limitations	Quantification of mercury per source	Quantification of mercury flows	Methodology Used	Status of Data Gaps/ Limitations
Extraction and use of fuels/ energy sources	Coal combustion in large powerplants	1,522.61 kg/y	*National/ overview approach - Amount/ proportion of imported and locally mined coal (per coal type) used for electricity generation - Defined input factor (per coal type) - Defined air pollution device - Default output factor	- Output estimate based on toolkit	- <i>Point source data</i>	- <i>Same approach as 2018 inventory for input factor (UNEP Toolkit 2 version Jan. 2023)</i>	- Self-Monitoring Reports (SMRs) submitted to EMB-DENR - Desk research	Partially Addressed as submitted SMRs are not complete

	Other coal use	358.636 kg/y	*National/ overview approach - Amount/ proportion of imported and locally mined coal (per coal type) used in industrial processes - Defined input factor (per coal type) - Defined air pollution device - Default output factor	- Output estimate based on toolkit	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	Retained
	Extraction, refining and use of mineral oil	567.39 kg/y	*National/ overview approach; point source approach - Amount/ proportion of imported and locally extracted oil - Activity data (production, refining and use) - Default input factor - Default output factor	- Input and output factors are based on toolkit	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	Retained
	Natural gas - extraction	397.33 kg/y	*Point source approach - Annual consumption data - Input factor based on geographically comparable data	- Input and output factors are based on toolkit	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	Retained

			- Default output factor					
	Extraction and use of other fossil fuels	--	--	--	--	--	--	--
	Biomass fired power and heat production	835.08 kg/y	*National/ overview approach - Annual consumption data - Default input factor - Default output factor	- Annual consumption data is based on aggregated data - Input and output factors are based on toolkit	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	Retained
	Geothermal power production	549.29 kg/y	*National/ overview approach - Annual production data - Default input factor - Default output factor	- Input and output factors are based on toolkit	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	Retained
Primary (virgin) metal production	Mercury extraction	--	*National/ overview approach	--	--	--	--	--

	Gold and silver production	170, 427.48 kg/y	*National/ overview approach; point-source approach - Literature-based activity factor (annual gold and silver production) - Defined input factor - Defined output factor	- Need to update production data, input and output factors	- Updated point source data - Updated input and output factor based on UNEP Toolkit Level 2 (version January 2023) - Amount of elemental mercury [illegally] imported per year - Amount (or proportion) of mercury emitted to the atmosphere - Amount (or proportion) of mercury released to soils (via tailings) - Amount (or proportion) of mercury released to water (via tailings) - Amount (or proportion) of tailings exported	- Desk research - Field research - Key informant interviews - Surveys	Partially addressed since only a few mining sites using mercury have been covered
	Zinc extraction and initial processing	--	*National/ overview approach	--	--	--	--
	Copper extraction and initial processing	19,052.2 kg/y	*National/ overview approach - Annual production data - Default input factor - Default output factor	- Input and output factors are based on toolkit	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research - Retained

	Lead extraction and initial processing	--	*National/ overview approach	- Mercury output was estimated in the 2008 inventory using production data (literature-based)	--	--	--	--
	Gold and silver, not using mercury	20,086.10 kg/y	*National/ overview approach - Literature-based activity factor (annual gold and silver production) - Default input and output factors	- Production data is based on literature - Input and output factors are based on toolkit	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	- Retained
	Aluminum	--	*National/ overview approach	--	--	--	--	--
	Other non-ferrous metals	--	*National/ overview approach	--	--	--	--	--
	Ferrous metals (iron and steel)	218.75 kg/y	*National/ overview approach - Annual production data - Default input and output factors	- Input and output factors are based on toolkit	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	Retained

Production of other minerals and materials with mercury impurities	Cement production	239.77 kg/y	*National/ overview approach; point-source approach - Annual production data - Defined input factor - Default output factor	- Activity data considers cement locally produced and not imports (which may have mercury) - Input factor based on one point source only - Output factors are based on toolkit	- Activity data using point source approach and added additional point sources (clinkers imports, raw materials) - Same approach as 2018 inventory; updated data when available.	- Same approach as 2018 inventory for input factor (UNEP Toolkit 2 version Jan. 2023)	- Self-Monitoring Reports (SMRs) submitted to EMB-DENR - Desk research	Partially Addressed as submitted SMRs are not complete
	Pulp and paper production	--	*National/ overview approach	- Incorporated in other estimates	- Same approach as 2018 inventory; updated data when available.	- Same approach as 2018 inventory; updated data when available.	- Desk research	Retained

	Lime production	0.50 kg/y	*National/ overview approach - Annual production data - Literature-based input factor - Default output factor	- Input factor based on one point source only - Output factors are based on toolkit	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	Retained
	Other materials and minerals: volcanic cinder and tuff	381.68 kg/y	*National/ overview approach - Annual production data - Default input factor - Default output factor	- Input and output factors are based on toolkit	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	Retained
Intentional use of mercury in industrial processes	Chlor-alkali production	---	--	-	--	--	--	--
Consumer products with intentional use of mercury	Thermometers with mercury	251.46 kg/y	*National/ overview approach - Based on previous inventory data - Literature-based input factor - Default output factor	- Data need to be updated based on more recent inventory (both stock and import)	- Activity data using point source approach	- Trade data	- Desk research	Addressed

	Electrical switches	1,817.87 kg/y	*National/ overview approach - Default input factor vis-à-vis projected population - Default output factor	- Input and output factors are based on toolkit	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	Retained
	Light sources with mercury	973.50 kg/y	*National/ overview approach - Activity data based on 2010 disposal rate corrected by projected population - Default input factor - Default output factor	- Activity data is based on older disposal rate data instead of actual consumption rate - Activity rate and input factors for different lighting sub-types needed	- <i>Same approach as 2018 inventory; updated data when available</i> - Trade data used as additional data source	- <i>Same approach as 2018 inventory; updated data when available.</i> - Input factors updated based on variation in mercury content of light sources (even those belonging in the same model) ^[55]	- Desk research - Key informant interviews	Partially addressed

	Batteries containing mercury	347.27 kg/y	*National/ overview approach - Import data - Default input factor - Default output factor		- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	Addressed
	Polyurethane with mercury catalyst	--	*National/ overview approach	--	--	--	--	--
	Biocides and pesticides	88.45 kg/y	*National/ overview approach - Total annual consumption rate vis-à-vis % mercury in formulation - Default output factor	- Input factor is based on conservative estimate as per regulations	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	- Retained
	Paints	--	*National/ overview approach	--	--	--	--	--
	Pharmaceuticals for human and veterinary use	--	*National/ overview approach	--	--	--	--	--

	Cosmetics and other related products	32,472.5 1 kg/y	*National/ overview approach - Annual trade data - Defined input factor - Default output factor		- <i>Same approach as 2018 inventory; updated data when available</i> - Trade data used as additional data source	- <i>Revised input and output factors based on collected data</i>	- Desk research - Surveys	Partially addressed
Other intentional product/ process use	Dental mercury amalgam fillings	3,585.47 kg/y	*National/ overview approach - Activity data based on population and correction factor - Default input factor - Default output factor	- Activity data is based on population estimates; does not consider stocks - Input and output factors are based on toolkit	- <i>Same approach as 2018 inventory; updated data when available</i> - Trade data used as additional data source	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research - Surveys - Key informant interviews	Partially addressed

	Manometers and gauges with mercury	877.36 kg/y	*National/ overview approach - Based on previous inventory data (sphygmomanometer) and population-based calculations (other gauges) - Default input factor - Default output factor	- Data need to be updated based on more recent inventory (both stock and import) - Output factor considered for stock items only	- <i>Point source data</i> - <i>Trade data</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research - Key informant interviews	Addressed
	Laboratory chemicals and equipment with mercury	3,635.33 kg/y	*National/ overview approach - Activity data based on population and correction factor - Default input factor - Default output factor	- Activity data is based on population estimates - Input and output factors are based on toolkit	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	Retained
	Mercury use in religious rituals and folklore	--	*National/ overview approach	--	--	--	--	--
	Miscellaneous product uses, mercury metal uses, and other sources	--	*National/ overview approach	--	--	--	--	--

Production of recycled metals	Recycled mercury	--	*National/ overview approach	--	--	--	--	--
	Ferrous metals	15.57 kg/y	*National/ overview approach - Import data - Default input factor - Default output factor	- Input factor based on toolkit	- Same approach as 2018 inventory; updated data when available.	- Same approach as 2018 inventory; updated data when available.	- Desk research	Retained
	Other recycled	0.22 kg/y	*National/ overview approach - Import data - Default input factor - Default output factor	- Input factor based on toolkit	- Same approach as 2018 inventory; updated data when available.	- Same approach as 2018 inventory; updated data when available.	- Desk research	Retained
Waste incineration	--	--	--	--	--	--	--	--
Waste deposition/ landfilling and wastewater treatment	Controlled landfills and deposits	378.36 kg/y	*National/ overview approach - Annual disposal rate - Default input factors - Default output factors	- Need to characterize the composition of the municipal waste stream	- Same approach as 2018 inventory with additional inputs/ factors (e.g. composition of waste, collection rate, etc.); updated data	- Same approach as 2018 inventory; updated data when available.	- Desk research	Addressed

					<i>when available</i>			
	Diffuse deposition with some control	--	*National/ overview approach	--	--	--	--	--
	Informal local disposal of industrial waste	--	*National/ overview approach	--	--	--	--	--
	Informal dumping of general waste	85.70 kg/y	*National/ overview approach - Estimated uncollected municipal waste - Default input factors	- Default output factors - Need to characterize the composition of the municipal waste stream. Some waste (e.g. electronic wastes) are collected by informal recyclers and used domestically or exported	- <i>Same approach as 2018 inventory with additional inputs/ factors (e.g. composition of waste, collection rate, etc.); updated data when available</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	Addressed

	Wastewater systems	7,593.40 kg/y	*National/ overview approach - Annual volume of wastewater - Default input factors - Default output factors	- Input and output factor based on toolkit	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	- Retained
Crematoria and cemeteries	Crematoria	1,323.87 kg/y	*National/ overview approach - Average dental restoration per individual - Proportion of population cremated/ buried - Default input factors - Default output factors	- Input and output factor based on toolkit	- <i>Same approach as 2018 inventory; updated data when available.</i>	- <i>Same approach as 2018 inventory; updated data when available.</i>	- Desk research	- Retained
	Cemeteries							

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[C1]This will be revised depending on the agreed data collection activities on a yearly basis.

[C2] [C2]This will be revised/ updated depending on the agreed data collection activities on a yearly basis.