Mercury Trade and Supply, Use, and Impacts in the Artisanal and Small-scale Gold Mining Sector in Kenya Status Report

By

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Executive Summary

Mercury is among the top ten chemicals of public health concern, according to the World Health Organization (WHO). Mercury exposure can lead to serious health problems, including neurological disorders, kidney damage, and brain injuries, among others. The persistence of mercury and its ability to bioaccumulate in the aquatic food chain can lead to long term ecological risks.

The Minamata Convention on Mercury was adopted in 2013 to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds. Kenya became a Party to the convention in 2023. Mercury use in artisanal and small-scale gold mining (ASGM) is addressed in Article 7 of the Convention. This article requires Parties with ASGM activities to take steps to reduce and, where feasible, eliminate the use of mercury and mercury compounds in mining and processing, as well as reduce the emissions and releases to the environment.

The objective of the study was to establish the status of the mercury trade and supply, its use in the ASGM sector, and its impacts on health and the environment. Information used in this report was gathered through a desktop study.

The ASGM is a key source of livelihood for many communities in Kenya, employing at least 40,000 people and another 800,000 indirectly. Women play a vital role in ASGM, comprising 40% of the workforce. ASGM activities are dominant in at least 7 counties, namely Migori, Siaya, Kakamega, Narok, Vihiga, Nandi, and Turkana counties. According to Kenya's National Action Plan for the ASGM sector, an estimated 8,236.5 kg of mercury is used every year to produce 6.864 tons of gold in the sector. Mercury used in Kenya is formally imported through Mombasa and Nairobi ports as the country does not mine mercury. This mercury is usually imported for industrial use. However, some of it is diverted for use in the ASGM sector through various actors, demonstrating a clear link between formal imports and their illicit use in ASGM.

According to the United Nations International Trade Statistics Database (UN Comtrade), an average of 9033 Kilograms (Kg) of Mercury were imported into the country from 2018 to 2023 from countries such as Mexico, India, and Kyrgyzstan, among others, with Mexico being the largest importing partner. Kenya also exported an average of 697 kg of mercury between 2018 and 2023, mainly to the Democratic Republic of the Congo (DRC), Rwanda, and Oman.

Mercury is imported in 54.5kg metallic cans. Once imported into the country, mercury is illegally distributed to the ASGM sector through several actors, including mercury dealers, shaft owners, jewelry shop owners, gold dealers, transporters, and ASGM miners. These dealers, both local and foreign, import mercury and act as intermediaries in supplying ASGM miners and other interested parties.

In terms of storage, mercury is primarily stored in plastic bottles of various sizes, with the largest being 1kg plastic bottles that resemble syrup medicine containers, which are then distributed into bags or caps to accommodate those purchasing in smaller quantities. It was further noted that there are no specialized facilities for the treatment and recovery of mercury; as a result, mercury waste is frequently combined with ordinary waste and sent to municipal dumpsites where it is openly burned.

The study also noted that the import of Mercury for industrial use is allowed (licensing system is provided for in the chemicals regulation) however its use in ASGM is prohibited. Mercury is regulated by various sectoral laws governing the environment, mining, public health, and water sectors, among others. The trade and use of mercury and mercury compounds is controlled by the EMCA (Management of Toxic and Hazardous chemicals and wastes) regulations 2024. On the other hand, the mining act of 2016 prohibits the use mercury in ASGM.

It was further established that up-to-date information on the health and environmental effects of mercury is not available in Kenya due to a lack of health and environmental monitoring programs. Ad hoc studies conducted in Kenya show that ASGM workers are exposed to elevated levels of mercury beyond recommended limits. Likewise, studies conducted to establish the level of mercury contamination in the environment (soil, sediment, water, and fish) have reported levels exceeding the recommended limits. This is a concern for communities living near ASGM operations. Information on the impacts of mercury on air was not available at the time of the study.

To reduce mercury use in the ASGM sector and its impacts to health and the environment, this study recommends the need to end the global mercury trade and the end of mercury use in ASGM by 2032 to achieve the Minamata Convention's ultimate goal of protecting human health and the environment from mercury pollution.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACEMP	Africa Centre for Energy and Mineral Policy
ASGM	Artisanal and Small-Scale Gold Mining
CEJAD	Centre for Environmental Justice and Development
EMCA	Environmental Management and Coordination Act
FAO	Food and Agriculture Organization
Hg	Mercury
IPEN	International Pollutant Elimination Network
IUCN	International Union for Conservation of Nature and Natural Resources
KEBS	Kenya Bureau of Standards
Kg	Kilogram
KRA	Kenya Revenue Authority
NAP	National Action Plan
NEMA	National Environmental Management Authority
WHO	World Health Organization
USEPA	United States Environmental Protection Agency
T-Hg	Total Mercury

1 Introduction

1.1 Background

Mercury (Hg) is a toxic element known for its mobility, persistence, and severe impact on human health and the environment. Recognized by the World Health Organization (WHO) as one of the top ten chemicals of major public health concern, mercury exists in various forms: elemental, inorganic, and organic. It is widely found in fossil fuels, metal ores, and other minerals. Human activities, such as mining and refining of metals like copper, zinc, gold, and lead, often release mercury into the environment, where it bioaccumulates in the aquatic food chain and becomes trapped in soil, posing long-term ecological risks (WHO, 2013).

Consequently, mercury exposure to humans can cause serious health problems, the severity depends on how much one is exposed to it. Even small amounts can damage the nervous system, leading to issues like muscle tremors. Higher exposure levels can cause a range of neurological disorders, kidney damage, mental health problems, and irreversible brain injuries. Pregnant women are especially at risk because their fetuses can accumulate mercury at levels up to ten times that of the mother, which may lead to severe poisoning at birth (ibid).

The Minamata Convention on Mercury is a legally binding international treaty adopted in 2013 to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds. Kenya became a party to the convention in 2023. Article 7 of the convention obliges parties with ASGM activities to take steps to reduce and, where feasible, eliminate the use of mercury and mercury compounds in mining and processing, as well as reduce the emissions and releases to the environment. Article 3 prohibits parties from exporting mercury without written consent. In addition, parties can only export mercury for uses allowed under the convention or for environmentally sound interim storage (UNEP, 2013).

Despite the convention being in force since 2017, mercury is still widely used in artisanal and small-scale gold mining (ASGM). The ASGM sector remains the largest contributor to anthropogenic mercury emissions globally, accounting for 37% of total mercury consumption and 38% of emissions in 2015. Annually, ASGM releases approximately 640 to 1,350 tons of mercury into the environment, resulting in widespread contamination of ecosystems and severe health risks for miners, particularly women, children, and nearby communities (UNEP, 2019). This is mainly attributed to the global illegal trade of mercury and a lack of a defined timeline for the phasedown or phase-out of mercury use in the ASGM.

This report provides an overview of the mercury trade and use in Kenya, examining the regulatory landscape, sources of mercury supply, and its impact on human health and the environment to highlight the urgent need to eliminate mercury from the ASGM sector by introducing a mercury phase-out date, addressing illegal mercury trade, and supporting the transition to mercury-free gold mining technologies.

1.2 Objectives of the study

The objective of this study was to establish the status of mercury trade and supply, its use in the ASGM sector and its impacts on health and the environment.

1.3 Methodology

The information on mercury trade and supply, its use in the ASGM sector, and its impacts on health and the environment was gathered through desktop research. Some of the secondary data sources reviewed included government reports and policy documents, international reports and agreements, academic and scientific research, and trade data, among others.

2 Overview of ASGM in Kenya

2.1 Gold Mining in Kenya

Kenya's history of gold mining traces back to the early 1920s, particularly in regions such as Macalder, Kilimapesa, and Rosterman. Gold in Kenya occurs along the Archean Nyanzian Craton belt, which spans numerous counties, including Migori, Siaya, Kakamega, Vihiga, Narok, and Nandi, among others. In recent years, there has been a rise in the number of individuals entering the gold mining sector, diversifying their livelihoods beyond agriculture.

Large-scale, small-scale, and artisanal mining is practiced in Kenya. According to the 2024 economic survey report, the mining sector in Kenya contributed less than 1% (0.7%) to the national Gross Domestic Product (GDP). This contribution is mainly by the large-scale mining sector since the artisanal and small-scale sectors have been informal. The contribution of gold mining to the GDP remains unknown since it is lacking in publicly available reports. Table 1 below provides information on gold production from the large-scale mining sector in Kenya.

2.2 The Size of ASGM in Kenya

Artisanal and Small-Scale Gold Mining (ASGM) is prominent throughout Kenya in regions historically associated with large-scale mining activities but most predominantly in 7 counties namely Migori, Siaya, Kakamega, Narok, Vihiga, Nandi, and Turkana counties as shown in Table 1 below (GoK, 2022).

Table 1: ***Distribution of ASGM activities across Kenya***

S/No	Counties	Areas of operation
1	Migori	Masara, Macalder, Osiri and Mikei, Masaba, Kitere, Kamwango (Rongo), Kehancha and at the Kuria- Transmara border
2	Siaya	Wagusu, Ligega, Nyamasare and Bar Kalare villages
3	Kakamega	Ikolomani, Lurambi (Rosterman area), Shinyalu and Khwisero.
4	Narok	Lolgorian Town; Got Kabongo, Kilimapesa, Nyatigile, Masurura, Blure and Teng Teng
5	Vihiga	Vyalo, Shaviringa and Mbale

6	Nandi	Kapsaos and Chemase areas
7	Turkana	Naduat, Namoruputh, Nakalale and Lapur wards. Gold deposits are also found in Lomaguro, Atereka and Nakareareka, Karusuk, Nakalale, Kaputir, Loima and Sasame

Source: NAP, 2022

Other counties with ASGM activities include Kisumu, Elgeyo Marakwet, West Pokot, Homa Bay, and Marsabit (Gok, 2022). The spread of ASGM is largely influenced by the geological characteristics of the Archean Nyanzian Craton belt (ibid**).**

The official up-to-date statistics of the number of people employed directly or indirectly in the sector are missing. In 2017, it was estimated that 40,000 people were directly dependent on the sector, resulting in 800,000 indirect dependents (ARM, 2017). The number of people directly dependent on the sector has been reported by other sources to be 250,000[1]. The number of people dependent on the sector is higher compared to the reported statistics given the increasing occurrence of the gold rush in Kenya. It is also estimated that 40% of the ASGM workforce are women (Gok, 2022).

2.3 Legislative Frameworks

2.3.1 Laws and regulations on mercury import, trade, and transport

The use of mercury for gold extraction in ASGM is prohibited in section 140 of the Act. Regulation of mercury is addressed in different laws in various sectors, including environment, mining, public health and water, among others. Some of these laws directly address mercury while others address it indirectly. Mercury is regulated by the Mining Act 2016, EMCA (Waste Management Regulations 2024), and EMCA (Management of Toxic and Hazardous Chemicals and Materials) Regulations 2024. The details of laws that govern the use of mercury and its compounds in Kenya are provided in Table 2 below.

Table 2: ***Legislative frameworks governing ASGM sector in Kenya***

Regulatory Frameworks	Sections
The Kenya Constitution 2010	The Constitution has far-reaching implications for national, regional, and county-level environmental management, including chemicals. It shapes the laws, policies, institutions, and processes that guide environmental governance in practice. ● Article 42 provides for the right to a clean and healthy environment for all emphasizing the need to protect the environment for human and environmental benefits. ● Article 69 provides for the obligation of the state and citizens to uphold the right to a clean and healthy environment. Article 69 (1g) obliges the state to eliminate processes and activities that are likely to endanger the environment. ● Article 2(6) further states that any treaty or convention ratified by Kenya is considered part of the laws of Kenya including the Minamata Convention.

[1] Gold and governance provide hope for Kenya’s artisanal miners | ISS Africa

Environmental Management and Coordination (Amendment) Act 2015	This is an environmental legislation promulgated to establish an appropriate legal and institutional framework for the management of the environment. ● Section 6 (j) of the second schedule highlights that mining projects, including quarrying and open-cast extraction of alluvial gold with mercury, require the submission of an assessment study report.
Mining Act (2016)	This is the principal Act governing Kenya's mining sector. It includes provisions for ASGM and prohibits the use of mercury in gold recovery. ● The use of mercury for gold extraction in ASGM is prohibited in section 140 of the Act.
The Occupational Health and Safety Act, No. 15 of 2007.	This is an Act of parliament that provides for the safety, health, and welfare of workers and all persons lawfully present at workplaces. ● Section 83 provides measures for the safe handling, transportation, and disposal of hazardous substances and materials within a workplace.
Pharmacy and Poisons Act CAP 244 R.E, 2012.	This Act controls the trade in drugs and poisons. The poisons list confirmation order lists mercury as a poisonous substance under the Act. ● Section 28 of the Act provides licensing for mercury use in mining.
The Fishery Management and Development Act (2016)	This Act provides for the conservation of fisheries and other aquatic resources to enhance the livelihood of communities dependent on fishing. ● Section 49(1) of the Act forbids pollution of Kenya's fishery waterways. It prohibits anyone from introducing or attempting to introduce any deleterious article or substance into Kenyan fishery waters, directly, indirectly, or deliberately, including those with toxic, hazardous, or other harmful properties or effects on fish, the marine environment, or those that may harm the fish's habitat or health.
EMCA (Waste Management Regulations 2024)	This regulation governs the handling, storage, transportation, and segregation guidance of waste. ● Section 16 (1) requires that every container for storing hazardous waste should be labeled in eligible characters written in English and Kiswahili. 16(2) further specifies the information to be included in the label. ● Section 17(1) requires every person who generates hazardous waste to treat them using the classes of incinerators specified within the Act or by the use of other appropriate technologies approved by the authority. ● 18(1) prohibits any person from exporting hazardous wastes without a valid permit issued by the authority and a valid prior informed consent document issued by the designated competent authority of the receiving country ● 19(1) prohibits the transportation of hazardous wastes belonging to another country through the territory of Kenya without a valid permit and a valid prior informed consent form from the receiving country.

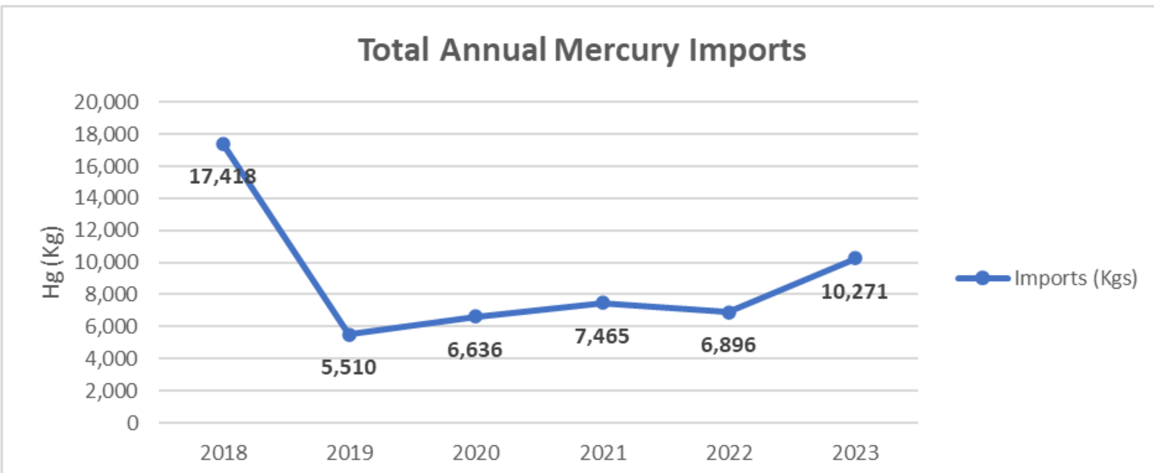
EMCA (Management of Toxic and Hazardous Chemicals and Materials) Regulations 2024.	This regulation aims to ensure the protection of human health and the environment from adverse effects of toxic and hazardous industrial chemicals and materials. It applies to the manufacture, export, import, transport, distribution, storage, handling, and disposal of toxic and hazardous industrial chemicals and materials including mercury and mercury compounds. ● Part 1 of the Sixth Schedule lists mercury, mercury compounds, mercury-added products (MAPs), and manufacturing processes using mercury or mercury compounds as restricted chemicals. ● Section 4 requires all manufacturers and importers to classify chemicals and mixtures before placing them on the market. Sections 7&8 further provide for the registration of all hazardous chemicals and materials, including mercury, before they can be manufactured, exported, imported, distributed, or supplied. ● Part iv section 20(1) requires licensing before engaging in the manufacture, import, or export of toxic and hazardous industrial chemicals or materials. ● Section 29(9) requires the owner or operator of an extractive facility or process to ensure that the use of mercury or mercury compounds is reduced and, where feasible, eliminated. ● Section 36(1) requires a manufacturer, importer, exporter, storage facility operator, user, or any person handling toxic and hazardous industrial chemicals and materials to establish safe handling procedures to prevent risks to human health and the environment. ● Section 40(4) requires the owner, operator or an agent licensed to manufacture, distribute, store, transport, handle, import, export or use toxic and hazardous chemicals and materials in an industrial, extractive or any other activity to undertake a hazard and risk assessment. ● Section 44 (2) prohibits the manufacture, importation, exportation, distribution, storage, or handling of restricted chemical or material, including mercury, without a valid license. ● Section 33 requires that the use, emissions, releases, and discharges of toxic and hazardous chemicals and materials into the environment should minimized and eliminated in the oil and gas, geothermal, mining, dredging, and other extractive processes.
EMCA (Water Quality Regulations of 2024)	The regulation provides for the prevention of land and water pollution by establishing standards for wastewater management to ensure clean and healthy water resources as well as the provision of standards for water for different uses. The third and fifth schedules provide limits for the release of hazardous chemicals and other pollutants into the aquatic environment, establishing a maximum allowed limit of 0.05 mg/l Hg for discharge into public sewers and 0.005 mg/l Hg for discharge into the environment.

3 Mercury use in the ASGM sector in Kenya

This section provides information about mercury import, export, supply, use and storage in the ASGM sector.

3.1 Mercury Imports and Exports

All the mercury used in Kenya is imported since mercury is not mined in the country (CEJAD and ACEMP, 2020). There are no official government statistics on mercury imports and exports therefore this report relied on statistics from the UN Comtrade database[2] to assess the imports and exports of mercury in the country. An analysis of the UN Comtrade database revealed that various countries have exported mercury to Kenya. Between 2018 and 2023, Kenya imported a total of 54,196 kg of mercury with an average of 9,033 Kg annually. The graph below shows the trade pattern of mercury importation over the last six years.



Source: Data based on the UN Comtrade

The imports were the highest in 2018, followed by a sharp decline in 2019. Imports also steadily increased from 2020 to 2021, and a considerable jump is seen in 2023. The decline could be attributed to the implementation of the Minamata Convention in different countries affecting the trade patterns.

The top five exporters of mercury to Kenya over the last six years were Mexico (22,609 kg), India (7,853 kg), the Russian Federation (7,346kg), Türkiye (6,354kg), and Kyrgyzstan (4,170kg). The other notable exporters were Vietnam, Tajikistan, and Panama. See Table 3 below.

Table 3: ***Import data to Kenya (Kgs)***

[2] The United Nations Comtrade database aggregates detailed global annual and monthly trade statistics by product and trading partner for use by governments, academia, research institutes, and enterprises.

Countries/Year	2018	2019	2020	2021	2022	2023	Total
Mexico	**10,708**	**1464**	**863**	**2415**	**5071**	**2088**	**22,609**
India	**1193**	**2665**	**2495**	**1500**	**-**	**-**	**7859**
Russian Federation	**-**	**-**	**-**	**3550**	**1825**	**1971**	**7346**
Turkey	**4313**	**-**	**-**	**-**	**-**	**2041**	**6354**
Kyrgyzstan	**4170**	**-**	**-**	**-**	**-**		**4170**
Vietnam	**862**	**863**	**2415**	**-**	**-**	**-**	**4140**
Tajikistan	**-**	**-**	**863**	**-**	**-**	**-**	**863**
UAE	**-**	**518**	**-**	**-**	**-**	**-**	**518**
Panama	**342**	**-**	**-**	**-**	**-**	**-**	**342**
Total	**17, 418**	**5510**	**6636**	**7465**	**6896**	**6100**	**54,195**

Source: UN Comtrade

Table 4*: Export data from Kenya to other countries (Kgs)*

Kenya has also exported an average of 697 kg of mercury from 2018 to 2023. From 2018 to 2020 Kenya exported mercury to the Democratic Republic of the Congo (DRC). No exports were recorded for 2021 to 2023 for DRC; however, an insignificant amount of mercury was exported to Rwanda (in 2021) and Oman (in 2023) see table 5 below.

Year	Countries	Total (kgs)
2018	DRC	1869
2019	DRC	657
2020	DRC	1688
2021	Rwanda	1
2023	Oman	12
TOTAL		4227

Source: UN Comtrade

3.2 Trade and supply in the ASGM sector

Mercury used in Kenya is sourced from legal imports and smuggled supplies through informal networks. A significant quantity is believed to be diverted for ASGM in Kenya and neighboring countries. It may also go as far as the DRC, which is supported by a diverse group of actors and established distribution networks within the mining communities. Due to the mercury trade's connection to the gold value chain, the trade exhibits a complex, multidirectional flow, complicating the identification of its supply network. The trade is predominantly managed by gold dealers and mercury suppliers with established financial resources and connections, while local dealers and operation owners exert control at lower levels. The informal cross-border routes and supply networks have complicated the efforts to gather accurate trade data (ACEMP and CEJAD, 2020).

The supply chain has two levels: upstream and downstream. The upstream level contains licensed and informal importers of mercury, largely centered in Nairobi. The downstream level includes local merchants who buy mercury from upstream sources and maintain relationships with ASGM miners and gold brokers in Nairobi (ibid).

The mercury supply chain primarily involves various actors, including mercury dealers, mining pit owners, jewelry shop owners, gold dealers, transporters, and artisanal small-scale gold mining (ASGM) miners. Mercury dealers, both local and foreign, import mercury and serve as intermediaries, supplying ASGM miners and other interested parties. Mining pit owners leverage their capital and equipment, such as elusion plants and gold refineries, to establish a trade network that benefits ASGM miners. Jewelry shop owners also contribute by supplying mercury directly to these miners. Goldsmiths and dealers play a crucial role in the mercury trade as key importers, supplying both local retailers and ASGM miners. Transporters, often young males familiar with remote mining sites, deliver mercury, occasionally utilizing individuals with disabilities to navigate customs checkpoints. Additional cases of police/customs officers engaging in trade of confiscated mercury have been documented (ACEMP and CEJAD, 2020).

Mercury is supplied to the owners of sluices by dealers, who in turn provide it to their workers employed at the sluices for amalgamation (CEJAD and IPEN, 2018). ASGM miners typically do not prioritize mercury procurement; they sometimes trade or lend mercury among themselves. It is often sold in small, discrete packages of 1 kg (often packaged in 75 ml plastic bottles meant for medicinal syrup) to avoid detection (ACEMP and CEJAD, 2020). According to a report done by CEJAD in 2018, mercury wholesale prices fluctuate between USD 113 and USD 148 per kg, while retail prices range from USD 150 to USD 180 per Kg. The distance from ASGM sites, seasonal changes, and supply chain stages influence the prices. Prices generally fall during the rainy season due to decreased mining activity and rise during the dry season.

3.3 Online sales of mercury in Kenya

There is insufficient data on the sale of mercury via online platforms in Kenya, primarily due to the informal nature of the artisanal and small-scale mining (ASGM) sector and the existing regulatory challenges. While mercury can be sourced through international e-commerce platforms and shipped to Kenya, specific documented cases of such transactions are lacking. Consequently, it is concluded that mercury is mainly obtained through traditional channels within the country.

3.4 Baseline estimates of the amount of Mercury used in ASGM

According to the National Action Plan (2022), 6.864 tons of gold are produced using mercury each year based on production from six Kenyan counties (Kakamega, Migori, Siaya, Nandi, Narok, and Vihiga). Based on a mercury-to-gold ratio of 1.2:1, 8.237 tons of mercury are used to extract the gold. Table 5 indicates the amount of mercury used in Kenya's ASGM sector.

Table 5: ***Amount of mercury used in the ASGM sector in Kenya***

County	Annual ASGM Gold Production (Kgs)	Amount of mercury (Kgs)
Migori	1,947.78	2,337.34
Siaya	523.98	628.78
Kakamega	1,406.46	1,687.75
Narok	1,520.40	1,824.48
Vihiga	1,385.04	1,662.05
Nandi	80.10	96.12
Total	**6,863.76**	**8,236.51**

Source: NAP, 2022

3.5 Storage of Mercury and Management of Mercury-Related Waste

Mercury is formally imported in 54.5kg metallic cans and stored in plastic bottles of various sizes. Distribution is done in 1kg plastic bottles that resemble syrup medicine containers that are further distributed into bags or caps. In Kenya, there are no specialized facilities for the treatment and recovery of mercury; consequently, mercury waste is often mixed with general waste, which typically goes to municipal dumpsites where open burning occurs. The lack of comprehensive data on mercury waste generation and disposal presents significant challenges for potential investments in effective mercury waste management solutions (Gok, 2022).

4 Impacts of Mercury on the Health and Environment in Kenya

4.1 Impacts on Human Health

Up-to-date information on the health impacts of mercury in Kenya is not available due to a lack of mercury health monitoring programs among the population and workers.

Ad hoc studies conducted in Kenya have reported mercury exposure among ASGM workers. A study conducted by Ondayo et al., (2024) in Kakamega County, Kenya, among ASGM workers and non-ASGM workers within a 100 m radius living from ASGM activities found mercury levels ranging between 11.1 and 178 $\mu g\, L^{-1}$ in the urine of 12% of the ASGM workers. According to Ye et.al., (2016), typical urinary Hg concentrations in unexposed individuals are less than 10 $\mu g\, L^{-1}$. Urinary Hg concentrations ranging from 30 to 100 μg L-^{1} have been linked with subclinical neuropsychiatric symptoms and tremors, while those greater than 100 $\mu g\, L^{-1}$ can be associated with overt neuropsychiatric disturbances and tremors.

The study also found elevated hair Hg concentrations that exceeded the USEPA 1 mg kg^{-1} threshold in 21 % of ASGM workers who mainly participated in ore washing, sluicing, amalgamation, and amalgam burning (range, 1.1–13 mg kg^{-1}; median 2.6 mg kg^{-1}), which exceeded Hg concentrations found in the Migori gold belt in Kenya (0.12–0.32 mg kg^{-1}) (Ngure et. al.,2017). Women in Kenya are often involved in the amalgamation and burning of Hg, which is of concern for future generations, as Hg in maternal scalp hair is a proxy of fetal Hg exposure.

Nails sampled from the ASGM workers in the same study area also contained similarly significant Hg concentrations. Mercury in human toenails reflects long-term exposure via food consumption, especially fish. Toenails from 46 % of the ASGM workers had Hg concentrations (0.4–3.3 mg kg^{-1}; median, 0.87 mg kg^{-1}; mean 0.98 mg kg^{-1}) that exceeded a published reference range of 0.03–0.31 mg kg^{-1} up to 11 times (Coelho et al., 2013). These ASGM workers were involved in multiple ASGM processes across seven villages but significantly higher than reported from the Migori gold belt in Kenya (0.24–0.5 mg kg^{-1}) (Ngure et. al., 2017). The hair and nail findings provide significant evidence indicating that most ASGM workers and their residents in the Kakamega gold belt are exposed to mercury levels above reference values. However, the levels in external tissues could also arise from environmental contamination by dust and dirt.

Another study conducted by CEJAD and IPEN (2017) in Migori County revealed that 71% of women from three gold mining sites in Kenya (Masara, Osiri, Mikei) had elevated mercury levels above 0.58 ppm in hair samples, with 44% exceeding the 1 ppm threshold. Additionally, the study also found that women of childbearing age had elevated mercury levels, with some beginning to show symptoms such as hand tremors, posing serious and substantial threats to their health and to babies in utero, especially when pregnant.

In addition, a study conducted by Aduwo (2012), among 196 miners in Lolgorien Kenya, found that 56% of the miners exhibited symptoms of central nervous disease, 21% exhibited renal toxicity, 17% had dermal infections, and 7% gastrointestinal complications based on the duration of exposure and concentration levels of mercury. These are complications common among patients suffering from mercury poisoning.

4.2 Impact on Environment

4.2.1 Mercury concentrations in soil

Mercury contamination in the soil can suppress crop growth or kill plants, eventually affecting human health through bioaccumulation. A study conducted by Odumo et al (2014) to determine the environmental impact of gold mining activity in the Migori-Transmara area in Kenya, revealed that mercury is released to the environment from the mining process, thus contributing to the degradation of soil and water bodies. This is a result of the technology used to extract gold throughout amalgamation processes thus causing high mercury pollution. The study quantified high mercury content in soil (140 µg kg (-1), sediment (430 µg kg (-1), and tailings (8,900 µg kg(-1) within the mining area which is attributed to wet and dry depositions from the mechanism used to transport mercury to the terrestrial ecosystem. The study also found that the further the distance from mining areas, the lower the mercury levels.

Another study by Ondayo et. al (2023) in Kakamega and Vihiga counties found elevated Hg concentrations in soils in ASGM villages. Concentrations of Hg in 49% of the samples were up to 144 times greater than the US EPA 1 mg kg^{-1} limit for residential soils. All sediment samples (100%) from washing ponds, fishponds, streams, rivers, exhausted mine wastes, and springs had Hg concentrations above the 0.15 mg kg^{-1} European Union standard. Ore processors introduce Hg into the mining environment during the amalgamation process for recovering gold and dumping mine tailings. The study also noted that through the gastrointestinal tract ingestion of soil in ore mining and processing areas, agricultural farms, schools, playgrounds and residential areas in Kakamega and Vihiga counties, the uptake is likely to damage the health of ASGM workers and local communities.

4.2.2 Mercury concentration in water

ASGM activities also contribute to mercury depositions in natural and human water sources. A study conducted by Omondi et al (2023) to establish mercury concentration in groundwater from boreholes, soil tailings, and pan-pond water near ASGM sites in Migori county (Masara, Osiri Matanda, Macalder, Kitere, and Kehancha) established a significant difference in the levels of mercury in groundwater between wet and dry seasons at a 95% confidence level.

Out of the 15 boreholes and 20 pan-ponds sampled, all the boreholes had groundwater mercury levels higher than the recommended limit by KEBS of 0.001 mg/L during the dry season with the highest being 0.76mg/l in Macalder making it a public health concern when used for drinking. All the mercury concentration values obtained from soil tailings during the dry season were above the recommended NEMA effluent discharge value (0.05 mg/Kg). The highest value was 9.08 mg/kg found in the Osiri Matanda mine. Mercury values determined in pan pond water during the dry season were all above the recommended NEMA effluent discharge value (0.05 mg/L). The highest level of mercury measured was 2.08 mg/L (Osiri Mine), while the lowest value was 0.16 mg/L (Masara Mine). During the wet season, all the waters achieved the recommended mercury level of NEMA effluent discharge limits, while the soil tailings had mercury levels above the recommended limit.

4.2.3 Mercury Concentrations in Plants

Gaining insight into mercury absorption in plants is crucial for safeguarding food crops from contamination. A study conducted by (Ondayo et. al 2024) to investigate the public health risk associated with Potentially Harmful Elements (PHEs) dispersed into the environment by ASGM activities in Kakamega and Vihiga counties found appreciable amounts of mercury in stable food crops which confirmed the transfer of mercury from soil and natural waters to locally grown crops. The study reported elevated concentrations of mercury in cowpeas leaves (0.002–0.97 mg kg^{-1}), which indicated processing-related contamination, possibly from airborne mercury, and food crops storage in rooms where mercury is stored and amalgam burning is done. The mercury concentrations in the studied ASGM villages were higher than the Food and Agriculture Organization (FAO) and WHO maximum allowable limits found in community drinking water sources and locally grown staple food crops.

4.2.4 Mercury concentration in fish

Understanding mercury levels in gold mining areas where locals consume fish is important in evaluating the risk to the population. A study by Kola et al., (2019) determined the total mercury (T-Hg) levels in Nile tilapia, water, and sediment in the Migori gold mining belt and the potential risk to human health. Water, sediment, and fish were sampled from 10 sites in Rongo and Nyatike and analyzed for T-Hg using cold vapour atomic absorption spectroscopy.

The study found that Sediment from 6 sites was moderately polluted with T-Hg, while 2 sites were strongly polluted. Water from all the sites had T-Hg levels higher than the FAO-recommended level for surface water. About 78% (38/49) of all tissues sampled had T-Hg levels above the 0.5 µg/g limit for consumption by the general human population. About 31% (15/49) of muscle tissues had T-Hg levels above the 0.5 µg/g limit, while 88% (43/49) of brain, 69% (34/49) of liver, and 69% (34/49) of muscle tissues had T-Hg levels above the 0.2 µg/g limit for consumption by at-risk groups. There were positive correlations between T-Hg levels in the brain, muscle, and pond sediment; T-Hg levels in the brain and water pH and temperature; and negative correlations between T-Hg levels in the brain and levels in the water, T-Hg levels in the brain and weight of fish.

Given that mercury vapour is released during gold processing activities, there are no notable studies specifically measuring mercury levels in the air within the mining communities in Kenya, hence a critical gap that needs to be filled. It can be concluded that mercury can transfer to the food chain in both aquatic and terrestrial environments. Therefore, the effluent from improperly treated wastewater can be detrimental to marine life, plants, and people who consume seafood and food grown around ASGM areas.

5 Conclusion

Mercury is still widely used in the ASGM sector in Kenya despite being prohibited by the Mining Act. The continued use of mercury in the ASGM sector is acerbated by lack of a dedicated law that regulate the trade and use of mercury in ASGM. Mercury is regulated by different sectoral laws that does not adequate control the trade and diversion of mercury for use in the ASGM sector. Although programs for monitoring mercury impacts on health and the environment are lacking in Kenya, available information points to risk of exposure to mercury, particularly for the venerable populations. To reduce the use and exposure of mercury in the ASGM, concreate strategies are urgently needed to control the trade and supply of mercury at national, regional and global levels.

6 Recommendations

To reduce exposure to mercury and achieve the Convention's goal of protecting human health and the environment from mercury pollution:

1. Kenya should prohibit import and export of mercury
2. Kenya should advocate for elimination of global trade of mercury in regional and international forums on Minamata Convention
3. Kenya should eliminate mercury use in ASGM by 2032.

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