

How Mercury is Poisoning a Nation

And gross mismanagement is aggravating the problem

By Mohamed Salah Abdelrahman



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Cover photo: shows the methods of washing using mercury in the basins. South Kordofan State, Picture taken By M. Salah 2020.



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1 List of Acronyms

ASGM	Artisanal and Small-Scale Gold Mining
HCENR	The Higher Council for the Environment and Natural Resources
MoM	The Ministry of Minerals
PPM	Parts per million
RSF	Rapid Support Forces
SECS	The Sudanese Environment Conservation Society
SMRC	The Sudanese Mineral Resources Company
SSMO	The Sudanese Standards and Metrology Organization
US EPA	United States Environmental Protection Agency
UAE	United Arab Emirates

2 Summary

In the first week of August 2022, flash floods swept through more than 25 villages north of Atbara in River Nile State. Floods swept thousands of metric tons of mercury-contaminated mining residues into the Nile in a disaster that echoes the health and environmental threats that haunt communities in traditional gold mining areas across Sudan. Years of indiscriminate use of dangerous chemicals such as mercury, cyanide, and thiourea without protective measures for miners or local populations has exposed millions of citizens across Sudan to lethal risks. Successive governments have failed to compel private companies importing these materials to comply with required industrial and professional safety precautions. They have also failed to educate citizens on the necessary precautions to avoid harming themselves and their families. Much damage has already occurred, and the practices that expose citizens to such toxins must be remedied and corrected.

Sudan's gold rush began around 2008-09 and saw the country's declared gold production increase steeply from 10 tons in 2008 to 32 tons by 2010, to a peak of 107.3 tons by 2017.¹ Based on the Ministry of Minerals' statistics, an average of 80% of Sudan gold production during this growth period is delivered by the Artisanal and Small-Scale Gold Mining (ASGM) sector which uses mercury for gold extraction through panning and amalgamation.² Global trade statistics of imports and exports of mercury captured in the United Nations' Comtrade database identified Sudan as the largest importer of mercury in sub-Saharan Africa, with the country importing 38% of all sub-Saharan African imports during the period 2010-2015.³

The government of Sudan has failed to tightly control the operations of importing, transporting, storing, using, and disposing of mercury due to its failure to exercise control and enforce minimum standards to safeguard the health of its citizens and the environment, with tragic consequences for both. This failure is a result of conflicts of interest within government structures and entities. International initiatives to promote alternatives for the use of mercury in the ASGM sector to reduce health and environmental risks, such as the one led by the United Nations Industrial Development Organization (UNIDO) in the Blue Nile state in 2007, haven't generated the desired sustainable momentum, due largely to lack of follow up by the Ministry of Minerals to promote the technologies piloted during the project.

Using a ratio of 1.3:1 and the volume of gold produced, the World Bank (WB) estimated mercury consumption in Sudan during the eight-year period 2008-2015 to be 346 tons. During the same period, Sudan imported 336 tons of mercury.⁴ While the amount of Sudan's officially declared imports roughly matches that of the WB at 36 tons per year from 2014 to 2020, other sources arrive at higher estimates of mercury use. Based on direct observation of the ASGM production cycle in Al-Ebeidiya and other mining areas, we and other researchers estimate the ratio of mercury used to be 10-12:1, which indicates that as much as 626 tons per year might be consumed, calculated on the basis of Sudan's declared production volumes. The gap between the official imports and this could be coming from smuggling and undeclared imports from countries that do not declare their exports of mercury to the UN's Comtrade.

¹ See Ibrahim, M.S "Artisanal Mining in Sudan - Opportunities, Challenges and Impacts," UNCTAD 17th Africa OILGASMINE, Khartoum, 23-26 November 2015. Extractive Industries and Sustainable Job Creation. Ibrahim, M.S, Ministry of Minerals, Republic of Sudan.

² The annual reports of the Ministry of Minerals' Sudanese Mineral Resources Company (SMRC) registered 541 tons of total gold production between 2014 and 2020 of which the ASGM sector produced 434.4 tons, or 80%. See SMRC annual reports for 2018 to 2020.

³ World Bank, "Mercury Trade and Use for Artisanal and Small-Scale Gold Mining in Sub-Saharan Africa," 2016, p. 25, available at: <http://cegem.com/wp-content/uploads/2016/02/Mercury-Sub-Saharan-Africa-Trade-Report-12-December.pdf>

⁴ World Bank, "Mercury Trade and Use for Artisanal and Small-Scale Gold Mining in Sub-Saharan Africa," 2016, p. 26, Ibid.

Recent facilitation procedures by Sudamin, namely giving private import companies licenses to import mercury using its name, has led to a troubling surge in the amounts of mercury entering Sudan legally. In fact, official records examined for this brief show that authorities authorized the importation by Sudan more than 4000 tons of mercury between the second half of 2021 and 2022. This is roughly 450% of international formal trade figures in mercury for the year 2020 at 891 tons.⁵

ASGM miners are able to extract about 30% of the gold from the ore they process with mercury and leave behind an estimated 5 to 10 million tons of waste (called tailings or “*karta*”) in open heaps with high mercury content.⁶ Sudan’s Ministry of Minerals has encouraged the development of tailings processing companies to extract the remaining 70% of gold from the tailings using cyanide. Government controls over the use of cyanide and its by-products of processing, including mercuric cyanide, which is even more toxic than either of other two substances, are loose to non-existent.

Sudan's failure to ratify the Minamata Convention, a global agreement intended to address the negative effects of mercury, reflects the absence of political will of successive governments to fulfill their obligations to human health and safety. In addition to the weakness of laws and oversight policies, the state has a monopoly on the import of mercury and other pollutants used in the mining industry which makes it an accomplice in these violations.

A range of measures by Sudanese authorities and the international community actors are needed to address the situation. This should begin with reducing the use of mercury and adoption of more environmentally friendly alternatives, including through awareness raising, restrictions, to reduce and eventually ban of the use of mercury. Sudan should also ratify the Minamata Convention, which requires concerted effort to pressure the Sudanese government to adopt integrated national policies and engage stakeholders to deal with the environmental disaster resulting from the use of mercury in mining.

3 Introduction

Health and environmental risks threaten local communities in artisanal gold mining areas across Sudan. Prolonged use of dangerous chemicals such as mercury, cyanide, and thiourea without adequate protection has exposed millions of gold miners and members of local communities all over Sudan to deadly risks. Successive governments have failed to fulfill their responsibility to compel those using these materials to apply necessary industrial safety measures. They have also failed to educate citizens to take the necessary precautions to avoid harming themselves and their families. Much damage has occurred so far, and urgent action is needed to prevent future damage.

This paper addresses the risks of using mercury for mining workers, their families, communities, and the environment. A forthcoming paper will address the harmful effects of both cyanide and thiourea, and what is required to minimize their dangers to humans and the environment.

Mining has been practiced in Sudan since ancient times. Gold was traditionally extracted through physical separation processes using water. Mining was often carried out at the surface in valleys and natural water courses. However, in the first decade of the twenty-first century, mercury was gradually adopted to extract gold in both surface and digging wells and trenches extending to tens of meters horizontally and at times tens of meters deep. The digging is either done manually or using light

⁵ U.N. Human Rights Council, “Mercury, small-scale gold mining and human rights,” September 2022, A/HRC/51/35 (E), available at: <https://documents-dds-ny.un.org/doc/UNDOC/GEN/G22/403/63/PDF/G2240363.pdf?OpenElement>

⁶ See Dr. Izzeldeen Yousif, “Revisiting the traditional gold mining in Sudan: the challenges of domesticating clean technologies,” an article in Arabic, published in the Khartoum daily *al-Jareeda*, 9 September 2020.

excavators. Over time, first and foremost due to the use of mercury, mining has turned into the greatest environmental threat in Sudan.⁷

After examining where artisanal mining is practiced in the country, this paper discusses the legal and regulatory frameworks governing the use of mercury. The paper then identifies the linkages between artisanal and industrial mining, including the processing of artisanal tailings by franchise companies, and how mercury is used in each. The paper discusses examples of the impact of the use of mercury on humans and the environment in detail. It concludes with a set of recommendations both to national authorities and international actors from a wide swath of interests, such as mass poisoning and transnational crimes, and involvements in the gold industry.

3.1 Mercury and its properties

Mercury is found in nature in various forms. It is a heavy metal and is the only metal that exists in liquid form at room temperature. Mercury is highly toxic and represents significant threats to human health, affecting the nervous system, lungs, digestive system, kidneys, skin, and eyes. It may cause death with sufficient exposure.⁸ It also severely affects fetal development and child health. Mercury pollution can affect soil, water, air, fisheries, and various components of the natural environment causing health and environmental risks as it enters the food chain.

Miners use mercury in extracting gold for its ease of use, availability, low cost, and ability to combine with gold in the ore (with other metals) to form a mercury amalgam that separates from the rest of the solution due to differences in density. It is then separated from gold by exposing it to heat, which causes methylmercury to separate while the gold remains (with some impurities).⁹ It is easy to separate gold from mercury as the first evaporates at 356° C, while gold melts at more than 1000° C. However, the mercury vapor can then generally condense again in the nearest humid surface, including parts of the human body, nearby water, such as air coolers or drinking water pottery containers. This increases human exposure to mercury and pollutes the natural environment. Furthermore, inhalation of even small amounts of mercury can have adverse health effects, although the vapor has no odor and is not irritating, making it difficult to detect and avoid.

3.2 Areas in Sudan where Mercury is Used

According to official estimates, mining is practiced in 15 out of 18 states of Sudan. It is practiced illegally in the other three states.¹⁰ Mining operations are spread out over large areas of Sudan in hundreds of mines. River Nile, Northern, Red Sea and West Kordofan states are considered the highest gold producing states in Sudan.

At the end of 2014, Sudan began to reorganize mining operations. It established central markets in which taxes and fees are collected and in which processing operations that use mercury at a large scale, such as wet roller mills, are concentrated. Although this arrangement should help in

⁷ UNEP, "Sudan First State of Environment and Outlook Report," 2020 available at <https://www.bing.com/ck/a?!&p=3ad625e3dc2b7949JmItDHM9MTY2MjUwODgwMCZpZ3VpZD0yMmM3Y2VjZS00NDRiLTZiNictMiM4MC1jMThiNDU2MzZkY2EmaW5zaWQ9NTE2NA&ptn=3&hsh=3&fclid=22c7cece-444b-6c67-2380-c18b45636dca&u=a1aHR0cHM6Ly93d3cudW5lcC5vcmcvcvcmVz3VvYyY2VzL3JlcG9ydC9zdWRhbi1maXJzdC1zdGF0ZS1lbnZpcm9ubWVudC1vdXRsb29rLXJlcG9ydC0yMDIw&ntb=1>

⁸ EPA, "Health Effects of Exposure to Mercury," last updated April 14, 2022, available at <https://www.epa.gov/mercury/health-effects-exposures-mercury>

⁹ To get an idea about the process, please watch the video available at: <https://web.facebook.com/Albayati.gold/videos/543209953270677/>

¹⁰ Abdelrahman, M. Salah, "Gold Fever: The Social and Environmental Cost of Mining," Gazirat Alward: Cairo, 2018 (In Arabic).

implementing controls, these are almost completely absent and mercury is intensively used without precautions in both formal and informal markets, leading to significant pollution.

There is no accurate count of the number of workers in the mining sector, in particular artisanal miners, available but it is estimated at more than two million workers. This figure rises to five million if workers in associated processing operations are included.¹¹ Therefore, mining is one of the industries employing the largest number of Sudanese, which underlines the importance of this sector and the consequences of its enormous expansion in a country characterized by environmental fragility and



Source: Map from NordNordWest under: Creative Commons licence

extreme climates.

3.3 The Murky Waters of Trading in Mercury and its distribution in Sudan

Despite the global trend towards reducing the use of mercury, authorities in Sudan have, since 2012, monopolized the import of mercury through a government company, Sudamin Company Ltd., in which the Ministry of Finance holds 99% of shares, and the Central Bank of Sudan the remaining 1%, according to the official list of government owned companies published by the Ministry of Finance in April 2021.¹² The same list indicates that Sudamin was a shareholder of several private and public sector mining companies involved in the processing of gold tailings and gold prospecting until 2014.

¹¹ Ibid.

¹² Sudan Ministry of Finance, "Preliminary Listing of the Government's Public Companies," April 5, 2021, available at: <https://tinyurl.com/yfdc9dx>

Since then, all shares have been transferred to the Sudanese Mineral Resources Company (SMRC), a public company of which the Ministry of Finance owns 70% of the shares, and each of the Ministry of Minerals and the Central Bank of Sudan own 15% of the shares, according to the official list of government companies cited above. Sudamin holds a state monopoly to import mercury, cyanide, and other chemicals and materials used in the gold mining sector. This appears to have turned Sudamin into a broker, subcontracting their monopoly rights for the importation of mercury to other private sector companies that import mercury in the name of Sudamin, mostly via the UAE. As explained in a media interview with a former Sudamin Director, Kamal Hassan al-Mahi, Sudamin collects half of the profits from the sale of mercury after the importing companies deduct their capital, administrative, and logistical expenses from the revenue.¹³ The company reportedly distributes mercury imported by its subcontractors to the main sale points in Khartoum and in the main gold markets under its name as court papers studied for this brief and interviews with industry insiders revealed.¹⁴ There is no environmental or health control or supervision by specialists built into this trading and distribution system.

In addition, companies subcontracted by Sudamin in recent months also import other chemicals, including sodium cyanide and active carbon. This has increased the supply in the market, while at the same time controls over distribution have decreased, as the industry is dominated by the private sector companies importing these chemicals on behalf of Sudamin with nominal state oversight despite the risks inherent to the uncontrolled use of these substances. In fact, the involvement of a state-owned company in the distribution and use of these substances creates obstacles to oversight and environmental monitoring even by independent monitors, such as environmental associations. This situation calls for immediate action from Sudamin, the Ministry of Minerals, and the Higher Council for the Environment and Natural Resources to improve the transparency on imports and uses of the toxic materials used in the artisanal and small gold mining sector.

On the other hand, Sudamin is responsible for gold production on behalf of the state and runs two factories processing tailings rich in mercury content produced by artisanal miners.¹⁵ Its roles as an importer and producer give Sudamin an interest in increasing the consumption of mercury, which conflicts with the state responsibility to protect citizens from its deleterious effects. In this context, official statements regarding the fight against the use of mercury have proven time and time again to be only lip service.

Documents of more recent transactions reviewed for this brief indicated that in addition to issuing open tenders for the award of contracts for the importation of mercury as described in a 2016 interview with the former Sudamin director Kamal Hassan El-Mahi, Sudamin has in recent years taken to directly contract companies it considers operational partners for the importation of mining supplies.

For instance, in a letter dated 26 April 2022 reviewed for this paper, Sudamin requested the Ministry of Finance's approval to directly contract five private companies to import a total of 80 tons of mercury, 600 tons of cyanide, and 400 tons of carbon.¹⁶

¹³ Alnilin News Website, "Sudamin: The story of embezzlements by two employees uncovered by the director," August 11, 2016, in Arabic, available at: https://www.alnilin.com/12802400.htm#google_vignette

¹⁴ Sudamin has had an exclusive monopoly to import and trade in mercury since 2012, sources told STPT. During arbitration proceedings in 2018 and 2019, the private company Zazi for Multi Activities Ltd. claimed that Sudamin failed to honor the terms of a 2014 contract, wherein Zazi was required to finance, import, and distribute mercury, before depositing sale proceeds with Sudamin. In turn, Sudamin's role was to conduct monthly reviews of the partnership's accounts and split profits equally with the importer, after reimbursing the company's capital and logistical expenses for each consignment received. The company alleged that Sudamin withheld its share of the profits. Sudamin ultimately won the case.

¹⁵ See: Alnilin News Website, "Sudamin: The story of embezzlements by two employees uncovered by the director," August 11, 2016, in Arabic, available at: https://www.alnilin.com/12802400.htm#google_vignette

¹⁶ According to a copy of the letter reviewed for this brief.

There are other risks that both Sudamin and SMRC could engage in grand corruption practices that have become too familiar to the public in Sudan. While owned by the government, both Sudamin and SMRC are incorporated as private companies, a common practice during the Bashir three decade era which deliberately transformed the government's revenue generating bodies into autonomous entities, freed from government bureaucracy and controls over public monies, and thus easier for the ruling party and its barons to control in order to direct these resources to the service of the political and ideological agendas of the regime and the sustenance of the regime's vast patronage system. In reality, the deliberate suppression of government oversight over the substantial financial flows generated by both companies was a facilitating factor for grand corruption by the former regime's government and ruling party senior officials, enabling them to enrich themselves, their relatives, and their business associates.

Both Sudamin and SMRC continued to enjoy the autonomous status of private sector companies following the fall of Bashir in 2019. Attempts by the relevant ministers during the first civilian-led phase of the transition to bring the resources of both companies back under government control were not entirely successful. Worse, in October 2020, a group of associations of professionals, including from the Ministry of Minerals and the Initiative of Khartoum University for the reform of the mining sector, denounced the unjustified give away by the Ministry of Finance of 34% of Sudamin's shares to a private company owned by the operational commander of Sudan's Rapid Support Forces. The Finance and Mineral ministries said at the time that the shares and monetary compensation of USD 50 m. were in exchange for the company's restitution to the government of its exploration rights in Jebel Amer area in North Darfur and a treatment factory it had been running for several years in the block.¹⁷ However, the Under Secretary of the Ministry of Minerals at the time, Dr. Mohamed Yahia, described the transaction as a "political deal."¹⁸ Matters appear to have fully reverted to Bashir era practices following the October 2021 military coup due to the collapse of any semblance of government authority and controls across the board that followed the coup.

As a publicly owned company revenue generating from the sale of its gold and mining supplies, Sudamin could become a tool for accumulating capital and circumventing controls that it has the mandate to impose. These risks are not just hypothetical. Documents reviewed for this paper showed that Sudamin subcontracted a private company linked to a politically exposed person involved in the gold mining industry to import a staggering 2000 tons of mercury in mid-2021 of which some 400 tons were actually imported according to our latest findings.

3.4 Quantities of Mercury Entering the Country

According to the World Bank, Sudan was already one of the largest importers of mercury in sub-Saharan Africa, with an estimated 346 tons imported from 2008 to 2015, indicating an average of 43.25 tons of annual imports.¹⁹ However, official records examined for this paper indicated that between 2014 and 2020, Sudan officially imported an average of 36 tons of mercury.

These figures should be examined against more recent figures of quantities of mercury that were approved for importation into Sudan by Sudamin through its sub-contractors. Official records reviewed

¹⁷ Ultra Sudan, "Mining entities accuse the Ministry of Finance of easily ceding the shares of Sudamin to Aljunied Company," 19 October 2020, in Arabic, 2020, available at: <https://tinyurl.com/2s245uz3>

¹⁸ Alrakoba, "Mining Under Secretary Mohamed Yahya: The transfer of Jabal Amer to the government is a political deal," 8 November 2020, in Arabic, available at: <https://tinyurl.com/2p994c9b>

¹⁹ World Bank, "Mercury Trade and Use for Artisanal and Small-Scale Gold Mining in Sub-Saharan Africa," December 2016, p. 26, available at: <http://cegem.com/wp-content/uploads/2016/02/Mercury-Sub-Saharan-Africa-Trade-Report-12-December.pdf>

for this brief indicate that from the October 2021 coup to the time of writing, Sudamin approved licenses for the importation of more than 4,000 tons of mercury, including the 2,000 tons approved for the company linked to a politically connected person.

The only plausible explanation of the skyrocketing of licensed imports, according to insiders interviewed for this paper, would be the rush of many newly politically connected companies to exploit the chaotic governance environment that followed the 2021 coup to turn a quick profit. Whether newly approved companies would have the capacity and financial resources to import quantities they were cleared for remained an open question at this writing. Sudamin might also be tapping into this influx of applicants to improve its cash flow from fees and shares in anticipated profits of the trade in mercury and other ASGM mining supplies, including of cyanide. Other plausible explanations relate to the interest of some of the larger traders in mercury to position themselves to provide mercury for the remote and unregulated ASGM mining areas in South Kordofan and South Darfur states and further afield in the Sahel region.²⁰

Based on information from industry insiders, there are also unknown quantities of mercury that are imported into Sudan by private processing companies without the prior approval of, or contractual agreement with, Sudamin. In some cases, Sudamin allows these importers to clear the consignments from customs' custody in Port Sudan upon agreement that Sudamin would collect a percentage of the mercury in kind.²¹

In addition to the official imports of mercury through Sudamin, there are unknown quantities of the substance that are smuggled into Sudan through the western and northern borders with Chad and Libya. Officials recognize that smuggling is a challenge that they face on a daily basis.²² Further, news stories about authorities' operations against smugglers of mercury in Central Darfur, South Darfur and Khartoum are widely circulated on Sudanese media.²³

3.5 Legal Framework Related to Mercury

Many laws in Sudan tackle pollution in general. For example, the Environmental Protection Act 2001, amended 2020, sets a clear framework by requiring environmental impact studies for each project or activity, an element that is lacking in most mining operations in Sudan, especially artisanal ones. The Ministry of Minerals adopted a bill for the Regulation, Use, and Handling of Mercury in 2011, however, there is no evidence of consistency in enforcing the requirements for the storage, handling, and use of the toxic substance.

Increased awareness of the risks of mercury to human health and the environment led to the escalation of popular resistance to the destructive environmental effects of mining. In response to this resistance, the transitional Council of Ministers led by Prime Minister Hamdok early in the civilian-led transitional period (September 2019 – October 2021) issued a decree banning the use of mercury and cyanide in mining operations.²⁴ However, this decision was not implemented due to continued pressure from mining groups and factions of the old regime who controlled the tailing industry. The Hamdok government's rhetorical banning of mercury was also destined to fail as it did not offer the ASGM sector

²⁰ STPT interviews with industry insiders for this paper, Khartoum, October 2022.

²¹ Interview for this paper, Khartoum, August 2022.

²² Mohammed Bashir Abdalla, Minister of Minerals admitted in a statement to Sudan Tribune on September 8, 2021 that mercury is smuggled and used in mining in farms and factories. See <https://sudantribune.net/article249987/>.

²³ See for example TV channel, Sudania 24: <https://sudan4news.net/3341/>.

²⁴ Skynews, "Sudan decides to stop using mercury and cyanide in mining," October 10, 2019, available at <https://bit.ly/3qc3qSI>

a comprehensive approach accompanying the phasing out of mercury with the promotion and adoption of alternate and clean technologies for gold extraction.

The Sudanese Standards and Metrology Organization (SSMO) also developed protocols for the use of mercury, but these have not been implemented. Despite its supervisory mandate over gold exports, the SSMO did not require the implementation of its own protocols as a precondition for export approvals, rendering them ineffective.

The SMRC has set up environmental, health and occupational safety requirements. It has further set limits on permissible pollution rates, including for mercury. For example, the maximum permissible limit of mercury in drinking water is set at 0.004 ppm. Nevertheless, its responsibility for the collection of fees and royalties, as well as supervision and regulation of the mining sector, pushes SMRC to prioritize increased production over environmental conservation and safety, especially in the context of Sudan's economic crisis. In practice, lack of training of supervisory staff, equipment, and the company's presence in the market being limited to tax and royalty collections limits SMRC's ability to perform its inspection role due to its interest in increasing production and revenue.

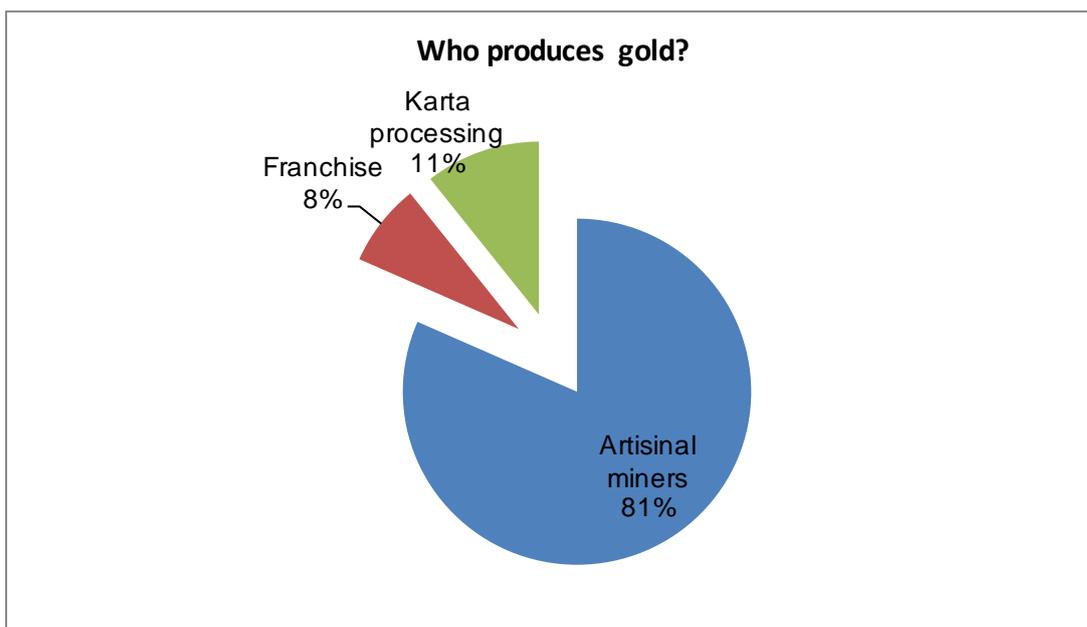
The Minamata Convention on Mercury was opened for signature in October 2013 and entered into force in August 2017. It is concerned with the protection of human health and the environment from mercury. The government of Sudan signed the convention in 2014 but has not yet ratified it. Ratification would represent an important step towards developing an integrated plan to limit the use of mercury. Such a plan would facilitate international support to the government of Sudan in this field. However, the lack of ratification reflects the absence of political will by successive governments since 2013 as they have prioritized increasing the quantity of gold production over safety. Intensified pressure and advocacy are needed to urge the government to ratify the agreement.

In addition, there are other international instruments that relate to pollution control which include mercury pollution. These instruments include the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, 1998; the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel Convention), 1989; the International Convention for the Prevention of Pollution from Ships (MARPOL), 1973; the Aarhus Protocol on Heavy Metals, 1998; and the Stockholm Convention on Persistent Organic Pollutants, 2001. Tightened control is needed to ensure the implementation of Sudan's international commitments through effective oversight by all concerned national agencies to guarantee the containment of mercury pollution. The Sudan Higher Council for the Environment and Natural Resources (HCENR) must lead this effort as it is responsible for environmental protection and sustainable development of the country's natural resources.

4 Use of Mercury in Different Forms of Mining

Since the explosion of the gold boom in Sudan around 2008/2009 artisanal and small-scale gold mining (ASGM) has dominated the production with percentages that dwarf the share of franchise and processing companies. The latter have contended themselves with developing production models that are reliant on the tailings left behind by the ASGM sector.

1. Artisanal mining is the most common type of mining in Sudan. According to the reports of the Ministry of Minerals and the SMRC, artisanal miners produced an annual average of 81.6% of



the total gold production in the country between 2014 - 2020, while the reprocessing of tailings accounted for an average of between 10.69% and 7.7% for tailing and franchise companies respectively.

2. Tailings reprocessing companies process gold-bearing tailings produced by artisanal miners. While artisanal miners extract about 30% of the gold in the ore using mercury, processing companies, using cyanide, can extract up to 95% of the 70% of gold remaining.
3. Production companies, consisting of franchise companies contracted by the government of Sudan to produce gold by and launching industrial production following general research and exploration in areas with viable deposits. However, currently a majority of the nine operating franchise companies depend entirely on the ore supplied by artisanal miners who operate within their concession blocks according to tripartite contracts between the state, the company, and the artisanal miners.

Reprocessing tailings left by artisanal mining began in 2012.²⁵ Regionally known as the 'Sudanese model,' this practice has spread to several neighboring countries.²⁶ The state supports this processing model under the pretext of disposing of the mercury permeating the tailings. In fact, reprocessing the tailings contaminated with mercury using cyanide redoubles the environmental consequences and complicates their treatment. Cyanide extracts metals, including mercury, and combines with the latter in the form of mercuric cyanide, which is extremely dangerous. A study released by the Consultancy Corporation of the University of Khartoum warned, however, that the danger is not fully understood.²⁷ In addition cyanide forms compounds with cadmium, cobalt, lead and other heavy metals found naturally in the ore which are all hazardous and poisonous heavy metals.²⁸

²⁵ Abdelrahman. M. Salah Op. Cit.

²⁶ Abdelrahman. M. Salah. III. E, "How Sudan's gold boom is changing labour relations in Blue Nile state," March 2020, Rift Valley Institute, available at <https://bit.ly/3ALeCL2>

²⁷ Environmental and Social Impact Assessment study for gold mining activity in block 52 in North Sudan. University of Khartoum consultancy corporation (Feb2017). Unpublished.

²⁸ Abdelrahman, Mohammed Salah, "The impact of gold mining on the environment in Sawarda and its surroundings," November 2018. The Six Member Committee against Gold Mining in Sawarda.



Watermills in Northern State, 2018

In short, artisanal miners use mercury indiscriminately while the state promotes processing by franchise companies who only increase the risk, in large part under the influence of its elites. Treatment of one gram of mercuric cyanide costs 360 US dollars, more than the value of the gold produced in the creation of this waste.²⁹ This makes appropriate processing economically unfeasible. The consequences are not adequately studied as official efforts focus only on meeting

the state's need for foreign currency secured through the export of gold. Further, mining revenues are increasingly concentrated among privileged groups of business, political, and security elites who leverage their economic and political influence to obtain licenses for reprocessing tailings.

4.1 Methods of Using Mercury

Traditional miners use mercury to extract gold across mining sites in Sudan. It is used in many ways depending on a number of factors, including the type of gold and the method of extraction. The main methods of using mercury are:

1. Washing in basins is the most common method.

After obtaining the ore from wells or surface mining, stones are ground using windmills to transform the ore into a powder that is washed using mercury. Workers are directly exposed to mercury (which they can inhale as mercury evaporates at room temperature). Mercury also leaks through the soil of the washing basins, contaminating soil, as well as remaining in the tailings (see photo above).

Miners wash the ore in metallic pans that they submerge in a small pond of water mixed with mercury. During this process, the workers sit on the edge of the basin containing the water mixed with mercury and work manually, panning the gold without any sort of protection. Women and children are widely involved in the industry in South Kordofan and Blue Nile, therefore, both are affected by mercury and other contaminants associated with gold. Mercury is particularly harmful to unborn children with implications for women who may be exposed during pregnancy.



Abundant quantities of mercury used in watermills and subsequent manual washing, River Nile State, 2022.

²⁹ Coles, A. C, Cochrane, K. "Mercury Cyanide contamination of groundwater from gold mining and prospects for removal," Sea to Sky Geotechnique, 2006.

2. Watermills (wet grinders)

Watermills are considered a relatively modern method for gold extraction. They are used to mechanically grind and wash the ore in a controlled volume of water running through a basin in which the water mixes with a fixed amount of mercury for each cycle. The process produces a mercury amalgam, then the product is washed manually in panning basins to get the gold as outlined above. Watermills are increasingly used due to their high efficiency in extracting the gold; however, they use larger amounts of mercury and water.



Widespread use of sieves, razing surface soil layers, forming heaps of dredging spoil and polluting large areas, Northern State, 2022

3. Sieves

Sieves are often used in surface mining to obtain gold precipitate. They are set up on the beds of dry rivers and streams that drain their waters during the rainy season, especially in years of exceptionally heavy rains, to the River Nile and Northern states. Machines are used to dredge the soil to obtain ore which is then processed using the sieves. Then the ore is washed using mercury to extract gold.

The sieves are moved from one location to another to carry out dredging and processing operations without any control by the state. Washing operations are carried out across production areas, depending on the location of ore. Therefore, this method of mining has a severe impact on the environment, as excavations can change the terrain and therefore the course of waterways and drainage systems and can spread mercury widely. In areas where seasonal waters flow, these can spread it more widely, which multiplies its effects on the Nile water, agriculture, and humans and animals living downstream.

4.2 A Case Study: Mercury Use in Al-Ebeidiya Market

Al-Ebeidiya is located about 330 kilometers north of Khartoum. It is one of the oldest and largest mining markets in Sudan. Therefore, it is used here as a case study. In the vocabulary of the gold industry in Sudan, "gold market" refers to a gated area in which supplies, and services needed by the artisanal miners in the surrounding areas are concentrated. These include compounds of water mills, gold smiths and traders, groceries, restaurants, and video clubs for entertainment. Most importantly, markets are where the SMRC sets shop to collect royalties, taxes, and fees from gold producers in the area.

Al-Ebeidiya market boasts some 560 compounds of water mills, each one with 10 to 50 mills. As indicated in the previous image, within one complex we find multiple mills arranged in a semi-circle in an estimate area of 200 square meters.

Mercury is used indiscriminately and extensively, although theoretically wet mills reduce its use, in reality the use is very high due to the high level of waste present and larger quantities of ore processed in comparison to hand washing.

In some methods of mercury use, mercury amalgam is burned without any precautions to protect those participating in the burning, mainly artisanal miners, mill owners and workers, or gold smiths and traders. The burning of mercury causes the release of mercury vapors into the atmosphere and surrounding environment, which is the most dangerous production for mercury pollution.



A wet mill complex in Al-Ebeidiya market, River Nile State, 2022

4.3 Other Examples of Mercury Use

Al-Ebeidiya is not an exception. In Sawarda market in Northern State in 2018³⁰ the amount of mercury lost in processing each gram of gold was estimated to be 17.4 grams. In Umm Sareh, located west of Al-Shereik area at the Fifth Cataract on the River Nile a study based on measuring mercury before and after processing during one week of commercial operations found that 38 grams of mercury were dispersed per gram of gold extracted.³¹ When samples of the ore were analyzed, a high percentage of sulfites were found, and this is believed to be the reason for the increased consumption of mercury. The volume of mercury used depends on various factors, including the type of ore, the method of extraction, the quality of processing, and the type and quality of mercury used. However, in all mining areas it was at least 10 to 12 grams of mercury per gram of gold. Using the lower end estimate of 10 grams of mercury per gram of gold, we can estimate the quantities of mercury that may have leaked to the environment. During the period from 2014 to 2020, Sudan produced 438.4 tons of gold according to the official statistics - i.e., not including quantities that were smuggled. This would indicate that an average of 626.2 tons of mercury per year, or 4,384 tons over the seven-year period, may have leached into the environment and atmosphere.

³⁰ Abdelrahman, Mohammed Salah, "The impact of gold mining on the environment in Sawarda and its surroundings," November 2018.

³¹ Interview with a worker in the area, June 2022.

The following are calculations based on extrapolation of direct observations during a June 2022 visit to El-Ebeidiya:

- The capacity of one pan in a water mill is about 10 sacks of ore per day.
- The average number of pans in each complex is 20.
- The total number of mill complexes is 560.
- Each pan requires at least 500 grams of mercury per day for the treatment of 10 sacs of 100 kg of ore.

This would mean that 5.6 metric tons of mercury would be used per day in Al-Ebeidiya market if all the compounds of water mills were operating at full capacity.

From our observations during a recent field visit, each mill loses more than 60 grams of the 500 grams used in the extraction processes for every 10 sacks. This would mean that a total of 672 kg of mercury are leached into the environment per day.

This figure is disastrous.

5 Consequences of Using Mercury: An Ongoing Disaster in the River Nile State

River Nile State is the largest gold producing state in Sudan. It accommodates the largest numbers of mines and workers. In recent years, a new processing method known locally as “mixers” where tailing treatment processes take place has emerged. The operations take place in villages and homes near the Nile, in farms, and along natural water courses. Miners use thiourea, which contain cyanide, a lethal chemical that was used in genocide crimes committed during World War II. It is highly efficient in extracting gold but is highly toxic. Although an official decision by the state governor banned the use of mixers using thiourea in the State³² was issued, it has never been implemented. On the contrary, use of thiourea has increased.



Mixers erected inside farms and near residential areas, Credit TAM

These practices led to large scale mercury contamination in residential areas and near the course of the Nile, increasing the environmental impacts as documented in a recent study conducted by the Sudanese Environment Conservation Society (SECS), High Council for the Environment and Natural Resources (HCENR) and Al-Nilein University.³³

³² Using mixers in residential and agricultural areas was prohibited. See <https://suna-sd.net/read?id=709004>

³³ “Mercury pollution in residential areas and farms in River Nile State,” prepared by researchers from Al-Neelain University, SECS and HCENR, January 2022.

5.1 Raising the Alarm

Many actors have warned of a potential disaster resulting from waste saturated with mercury and expressed fear that frequent floods could even further disperse such hazardous chemical.³⁴



Mixers inside homes, Credit TAM

A joint research team from the Universities of Khartoum, Nilein University, the SECS and the HCENR conducted in the course of 2021 multidisciplinary research in the River Nile State between the towns of Atbara and Barbar. The January 2022 report from the mission indicated alarming rates of contamination of the environment and high percentages of mercury in the blood, urine, hair and skin tissues collected from random samples of

artisanal miners and members of the community in the study area. Analysis of cow and goat milk and agricultural products also showed high rates of mercury contamination in the area.³⁵

The study found out through remote sensing that there were 700 heaps of tailings, or mineral waste, concentrated in the short distance of 64 kilometers between Atbara and El-Ebeidia and estimated the volume of tailings in agricultural and residential sites at 450 thousand tons, with an estimated mercury content of 1.91 tons. Farmers and inhabitants of the small towns and villages in this area have moved the heaps to their own farmlands and yards of their family homes, where they set up a staggering 7,000 treatment mixers using the officially banned thiourea to extract gold. The heaps were right in the passage of seasonal rainwater drainage to the Nile River. The study also documented increased rates of miscarriage among pregnant women. There have also been many press reports of cases of paralysis, blindness and increase of diseases in areas where highly toxic waste is concentrated.³⁶



Waste inside residential sites.

³⁴ A workshop organized by the UNDP on mercury-related risks and ways to deal with mercury, April 26, 2022.

³⁵ Sudanese Environmental Conservation Society, Nilein University, and High Council for the Environment and Natural Resources, "Mercury Contamination in Residential and Farming Areas in River Nile State," a report published in January 2022, in Arabic, available in hard copy from SECS.

³⁶ "Artisanal mining in Sudan, deformations, disease and environmental destruction for the sake of gold," July 2022, <https://bit.ly/3AMVmwI>



Waste inside residential sites.

The disaster feared by locals, specialists and environmental activists happened in August 2022 as flood waters swept piles of waste (*karta*) into the Nile.³⁷ Twenty five villages were affected, including Al-Makaylab, Al-Sadabiya, Al-Nabawiya, Dar Mali, West Berber areas and other villages along the Nile between north of Atbara and south of Al-Ebeidiya.³⁸ Around 25,000 families lost access to shelter.³⁹ This effects of this disaster will not be limited to those villages but will rather extend to the areas near the Nile in the north to varying degrees.

5.2 Mercury Contamination in Human Bodies and the Environment

Previous studies have shown that people are exposed to significantly higher rates of mercury in mining communities than elsewhere. Selected evidence includes:

- A study was conducted in River Nile State and published in 2015. It found that the average concentration of mercury in blood samples collected from miners in the region amounted to 23.6 ± 30.5 mg/liter compared to reference samples which had an average of 1.4 ± 0.6 mg/liter. It also found that mercury concentration in hair samples collected from the miners reached 2.99 ± 1.7 mg/g, significantly higher than reference samples which recorded concentrations of 0.7 ± 0.9 mg/g.⁴⁰



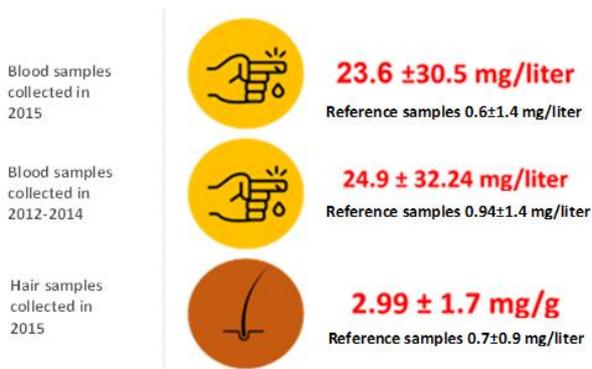
Flood sweeps away waste in a village

³⁷ "The expected has happened" a news story published on the FB page of the Alliance of Demand-based Bodies (TAM) about the mining waste swept by flood into the Nile, <https://m.facebook.com/TAMSudan/?pageid=100311821492063&ftentidentifier=168872044636040&padding=0>

³⁸ Interview with Mamoun Abbashar, one of the leaders of the Al-Obaidiya sit-in, August 13, 2022.

³⁹ "Sudan: Catastrophic expectations after the gold residues mixed with flood waters," SkyNewsArabic, available at <https://bit.ly/3cHjpp2>

⁴⁰ Afran A.M., Edwin P. K., Shin-Ichil O., Kei T., "Mercury Pollution from Artisanal Gold Mining Activities in Sudan," 4th World Conference on Applied Sciences, Engineering & Technology, October 24-26, 2015, Kumamoto University, Japan.

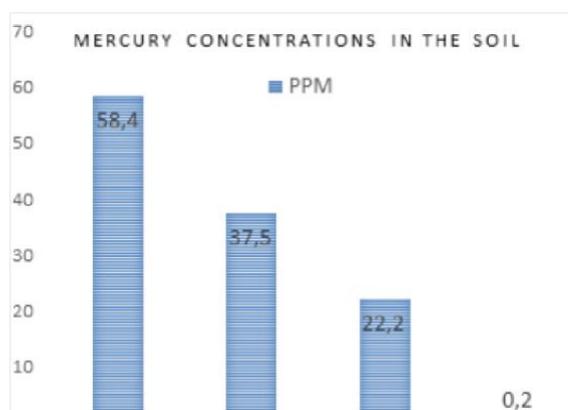


- Another study carried out in Abu Hamad, River Nile State, between 2012 and 2014, found that mercury concentrations in blood samples among mining workers ranged between 24.9 to 32.24 mg/liter, compared to samples collected from other areas, which ranged between 1.4 and 0.94. mg/l.⁴¹

- A study on the Wadi Halfa region including the Nuba Lake area, in

the far north, on the Sudanese-Egyptian border⁴² found that mercury concentrations in the soil in Saras amounted to 58.4ppm (parts per million), in Mak Al Nasir it was 37.5ppm, and in Samna 22.2ppm, compared to the permissible limit of 0.2 ppm set by the US EPA. Other studies have established higher rates of mercury in the soil and water in these areas exceed the limit of 0.001 set by the World Health Organization (WHO):

- The mercury concentrations in water samples collected from Jumi was at 0.0063 ppm, Saras 0.0061 ppm, Okasha 0.0065 ppm, Al-Duwaishat 0.0064, and Samna 0.0064 ppm. Locally, the Sudanese Standards and Metrology Organization (SSMO) (2015) Ministry of Minerals Standards set the maximum permissible limit at 0.004 ppm.⁴³ It is illogical to set a standard that contradicts international standards for drinking water without any justification, and such weak standards legitimize pollution.
- In 2017, a study conducted in Wadi Halfa and its southern surroundings concluded that concentrations of various heavy metals in Lake Nuba, mining markets, the River Nile and mining fields were increasing.⁴⁴
- Another study conducted in 2016 found that the concentrations of mercury in groundwater in wells around mining areas amounted to 0.3981ppm.⁴⁵
- In Sawarda, it was found that the water that reached the village through natural flooding brought many pollutants, including mercury, with a concentration of 0.0022 ppm and 0.0019 ppm⁴⁶ in two different samples.



⁴¹ Tayrab E, Abd Elrahim MA, Ali Elameen ME, Yassin A, Kodi A, "Human Mercury Exposure Associated with Artisanal Gold Miners in Sudan," Int J Earth Environ Sci 1: 118. available at: <http://dx.doi.org/10.15344/ijeess/2016/118> .

⁴² Sief Kierkisawi Mining Enterprise, "Environmental Impact Assessment for Alluvial Gold Placer Mining Project (Lake Nubia, Sudan)," May 2015.

⁴³ SMRC, Ministry of Minerals, "Requirements and Guidelines on Health, Safety and Environment Management System (HSEMS)," 2017.

⁴⁴ Abdelrahman, M. Salah 2018; Ibid.

⁴⁵ University of Khartoum consultancy corporation, "Environmental and Social Impact Assessment study for gold mining activity in block 52 in North Sudan," (Feb 2017), Unpublished.

⁴⁶ Abdelrahman, Mohammed Salah, "The impact of gold mining on the environment in Sawada and surroundings"; Ibid.

- In 2022, the important study conducted by the HCENR, SECS and Al-Nilein University found that 20% of drinking water samples, 2 out of 7 urine samples and 1 out of 14 blood samples collected from River Nile state contained high levels of mercury. Most of the samples were drawn from children between 4 to 11 years old. The study also documented the cases of miscarriage and deaths of birds and animals that drank the polluted water. Further, it showed that polluted waste amount to 450 thousand tons is widespread in 700 locations in River Nile State.⁴⁷
- In 2018, a study showed that the Dar Mali area in the River Nile State suffers from high mercury pollution. The pollution rate in water, for example, was about 29 times higher than the internationally permissible rate.⁴⁸
- Another study published in 2019 in the Al-Ebeidiya similarly demonstrated high pollution rates in soil and water.⁴⁹

In other locations in Sudan, communities inhabiting mining areas complain of increased miscarriages, and similar trends of bird and animal deaths. Also, in various areas, including Al-Tarter locality and Delanj locality⁵⁰ in South Kordofan state, communities complain of the increased malformations of newborns.

6 Recommendations

The current mining operations in Sudan use mercury indiscriminately and without proper controls, representing an environmental disaster by all standards. They have made mining the most serious environmental risk in the country, which requires holistic treatment. To that end, the paper suggests the following recommendations:

To the Government of Sudan:

- Ratify and uphold responsibilities under the Minamata Convention.
- Uphold responsibilities under the Basel and Rotterdam Conventions, both of which Sudan has ratified. These commit Sudan to the responsible trade and use of hazardous materials, including mercury.
- Expand control operations through the development and implementation of Sudanese standards related to the use of mercury and set up a supervisory body led by the HCENR with the participation of concerned authorities as well as civil society to exercise control in mining markets and factories.
- Develop national and adopt international environmentally friendly alternatives to mercury and encourage actors working in this field to adopt them.
- Ensure the government's commitment to related international conventions and national legislation and ensure effective coordination of concerned authorities on the follow up of compliance by all actors in the sector.
- Develop a national policy on land use that defines the sites in which mining can and cannot be carried out, with a view to preserving the ecological balance and achieving sustainability of resources and safeguarding of the rights of future generations.

⁴⁷ Al-Neelain University, HCENR and SECS, "Mercury Pollution in Residential Areas and Farms in River Nile State," January 2022.

⁴⁸ Mushtaha, A. L. I., Elhagwa, A., & Elfaki, J., "An investigation of mercury distribution in the soils around the gold mining area at Dar-Mali locality, River Nile State, Sudan," *Eurasian Journal of Soil Science*, 7(4), 2019, pp.365-372.

⁴⁹ Ahmed, A. M., Purwanto, P., & Sunoko, H. R., "Consequences of Mercury Used by Artisanal and Small-Scale Gold Mining Processes a Case of River Nile State Sudan," *Journal of Ecological Engineering*, 20(2), 2019, pp. 106-115.

⁵⁰ The impacts of mining in Delanj were documented by the Sudan Democracy First Group (SDFG), see the documentary available at: <https://www.facebook.com/100003197051753/videos/3232358970213973/>

To the Parties to, and the Secretariat of, the Basel and Rotterdam Conventions

- Parties to the conventions should report Sudan's non-compliance with the Basel and Rotterdam Conventions to the Compliance Committee.

To the Ministry of Minerals and its Sudamin and Sudan Mineral Resources Company:

- Conduct a detailed study on the use of mercury in mining operations to determine the extent of the resulting damage and clarify who is affected.
- Prohibit indiscriminate use of mercury, limiting its use to closed locations, and enforce policies that reduce the resulting pollution, especially heating mercury/gold amalgam in indoor operations. This should be an initial step towards banning mercury use altogether.
- Encourage waste (tailings processing) companies to gradually shift to become production companies that carry out integrated mining operations as a step towards banning waste companies from working permanently, as they undertake the most dangerous forms of mining in Sudan.

To the Higher Council for Environment and Natural Resources

- Sudan's Secretary General of the Higher Council for Environment and Natural Resources (HCENR), in his role as Basel Convention Competent authority and Basel Convention Focal Point, should report compliance failures with the Basel and Rotterdam Conventions to the Conventions' Compliance Committee.
- HCENR's Secretary General should request assistance from the Compliance Committee of the Basel and Rotterdam Conventions to ameliorate compliance failures.

Sudanese Civil Society Organizations:

- Expand solidarity among Sudanese civil society groups to advocate and pressure the government to ratify Minamata Convention and develop a comprehensive and transparent national plan aiming at reducing the use of mercury, especially in mining.
- Demand that the GoS ratify Minamata Convention.
- Demand that the GoS uphold its responsibilities under the Basel and Rotterdam Conventions.
- Demand that the GoS is reported (either through self-reporting or by another party) for non-compliance with the Basel and Rotterdam Conventions.
- Demand that involved businesses within the EU conform to EU law and strip their mineral supply chains of human and environmental damage.
- Demand that involved businesses outside the EU implement the relevant OECD guidelines relating to mineral supply chains.

The International Community:

➤ To businesses operating in Europe involved in the importation of gold

- Involved businesses should conform to Regulation (EU) 2017/821 of the European Parliament and of the Council of 17 May 2017 regarding due diligence and risk assessments of mineral supply chains.
- Involved businesses should take note of the relevant provisions contained within relating to Conflict Affected and High-Risk Areas (CAHRAs), of which Sudan is one.
- Involved businesses should comply with any other relevant business and human rights guidelines, including the UN Guiding Principles on Business and Human Rights.

➤ To businesses operating elsewhere involved in the importation of gold

- Involved businesses should follow the OECD Due Diligence Guidance for Responsible Business Conduct (RBC) and the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas.
- Companies should implement the use of the OECD Practical Tool on Environmental Due Diligence in Mineral Supply Chains to reduce the presence of harmful activities within their gold supply chains.
- Involved businesses should comply with any other relevant business and human rights guidelines, including the UN Guiding Principles on Business and Human Rights.

Annex I

Gold Production: Official vs. Estimated Consumption

	Gold production from ASGM (t/y)	Official mercury imports figure (t/y)	Estimated mercury consumption based on gold production (t/y)
2014	63.3	10.005	633
2015	67.8	68.6	678
2016	78.2	62.1	782
2017	91.7	31.1	917
2018	77.7	45.5	777
2019	38.4	19.7	384
2020	20.9	18	209
Total	438.4	255.005	4384