Global Mercury Program

Proven Strategies To Eliminate Mercury Use In Gold Mining, Remediate Contaminated Sites, And Reduce Health Risks
About Pure Earth

Pure Earth is a US-based, non-profit organization dedicated to reducing public health risks from toxic pollution in low- and middle-income countries. Since 1999, Pure Earth has conducted more than 90 projects around the world to remediate contaminated sites and reduce public exposures to chemicals and heavy metals. Many of Pure Earth’s projects are designed to identify, assess and reduce public and occupational exposures to mercury contamination. Pure Earth has conducted more than 500 field assessments of sites contaminated with mercury.

Mercury Pollution and Health Impacts

Mercury is a toxic heavy metal and one of the top ten chemicals of major public health concern according to the World Health Organization. Exposure to mercury can cause damage to the nervous, digestive and immune systems, as well as the lungs, kidneys, skin and eyes. Mercury is particularly dangerous to young children, babies in utero and pregnant women. The mercury released into the environment knows no borders and contaminates rivers and oceans, fish and other marine animals, and eventually the global food chain.

Artisanal gold mining (ASGM) is the leading source of mercury pollution globally. It is estimated that there are between 10 and 15 million artisanal and small-scale gold miners worldwide, including 4.5 million women and 600,000 children. Many of these miners use liquid metallic mercury during the gold mining process. When mercury is mixed together with ground gold ore, the mercury and gold flakes bind together to form a solid mercury-gold amalgam ball, thus separating the gold from ground rock, dirt and other materials in mined ore or sediment. This amalgam ball is then burned, vaporizing the mercury and leaving behind the gold. The burning results in the discharge of dangerous mercury vapors which can be inhaled by miners and their families and released into the environment. The vapor eventually condenses, settling in soil and waterways where it can transform into methylmercury—one of the most toxic organic compounds and a powerful neurotoxin. According to UNIDO, as much as 95 percent of all mercury used in ASGM mining is released into the environment.
MERCURY POISONING FROM GOLD MINING

Mercury Travels the Globe
Vaporized mercury gas rises into the atmosphere, travels the globe and falls back to earth in rain or snow, spreading the poison far and wide.

Poisoning Our Air
The mercury & gold nugget created by the mining process is burned until the mercury vaporizes and a solid gold nugget is left behind. Children and workers inhale this highly toxic mercury vapor.

Poisoning Our Water
Water and mercury are used to separate tiny particles of gold from tons of ore manually dug out by miners. Mercury-contaminated water drains into waterways and seeps into groundwater. In addition, the mercury and gold nugget created in the mining process is burned, releasing toxic vapors into the air.

Poisoning the Food We Eat
The mercury deposited in lakes and oceans is transformed into methyl mercury, the most dangerous form. This is ingested by fish and ends up in our grocery stores and on our dinner plates.

Harming Infants & Children Most
Pregnant women are advised to avoid certain fish because methylmercury causes birth defects. Children and adults can suffer neurological damage from consuming too much fish like tuna or halibut.

Mercury Travels the Globe
Vaporized mercury gas rises into the atmosphere, travels the globe and falls back to earth in rain or snow, spreading the poison far and wide.
Site Assessment and Remediation Tools

Rapid Environmental And Health Risk Assessments

Over the last 17 years, Pure Earth has conducted more than 3,000 rapid site assessments at contaminated sites around the world through its Toxic Sites Identification Program. Pure Earth has developed a unique rapid site assessment protocol developed in collaboration with experts from the U.S. Environmental Protection Agency, the World Bank, Mt. Sinai School of Medicine, Harvard University and others. Of the sites assessed by Pure Earth, more than 500 are contaminated with mercury.

At sites where mercury and other heavy metal contamination of soil is suspected, Pure Earth measures metal concentrations in soil using a portable, hand-held X-ray fluorescent (XRF) analyzer to collect geospatial data on contaminant concentrations. Conducting in-situ soil screening using a hand-held XRF analyzer has been shown to be an accurate and extremely effective tool for site characterization. Pure Earth also uses a Jerome Mercury Vapor Analyzer to assess mercury concentrations in air and evaluate local inhalation risks.

Pure Earth’s rapid assessment protocol allows site assessors to quickly characterize contamination and related health risks in order to evaluate the need for remediation or other risk-reduction activities and prioritize responses.

Pure Earth created a guidance document with recommendations on how to design and implement a national program to identify and assess sites contaminated with mercury for the Minamata Convention on Mercury.

Site Prioritization And Project Selection

Pure Earth has developed a global contaminated site database that uses an algorithm to analyze data collected during site assessments and evaluate the potential public health risks. The database generates a relative risk score from 0-10 for each site. The database’s algorithm utilizes contaminant concentration data, toxicity data, information about populations living and working around the site, and a variety of other environmental and social data to generate the relative risk score. Pure Earth’s database can be used to compare risks between sites and help governments prioritize their efforts to address sites that pose the greatest risk to human health and the environment.

Detailed Environmental And Health Risk Assessments
Pure Earth’s technical experts conduct detailed assessments of sites that are being considered, or have been selected for remediation. Detailed assessments include extensive soil screening using an XRF analyzer or similar tools to more fully characterize the extent and severity of contamination both laterally and vertically. Duplicate samples are analyzed at a certified lab to ensure accuracy of the XRF readings. If water supply wells or other water bodies are present, Pure Earth typically collects and analyzes representative water samples to evaluate potential impacts to drinking water supplies or surface water bodies as warranted. Detailed assessments also include interviews with community members, health professionals and local leaders.

**Conceptual Site Modeling**

Once Pure Earth completes a detailed assessment, technical experts create a conceptual site model to visually display the relationship between the source of contamination, the pollution’s migration route through the community, and the exposure pathway into the bodies of local residents (ingestion, inhalation or dermal contact). The conceptual site model is used to design the most effective remediation and risk-reduction strategies.

**Alternatives Analysis**

Once Pure Earth has conducted a detailed site assessment and designed a conceptual site model, the organization designs several alternative remediation strategies and analyzes the options to show the costs and benefits of each strategy. This allows governments, donors, community members and other stakeholders to understand how and why a final remediation strategy is selected.

**Remediation And Risk Reduction Strategies**

Pure Earth has developed a global mercury program that aims to reduce public and occupational health risks from mercury exposure among gold miners, their families, local communities and the global population. The program achieves this goal by reducing the unsafe use and release of mercury in artisanal and small-scale gold mining communities, and by developing cost-effective methods of remediating land and waterways contaminated with mercury.

Pure Earth’s multidisciplinary strategy to reduce mercury emissions and exposures includes:

- Environmental monitoring and assessment activities
- Trainings for miners in effective mercury-free mining methods
- Health education on mercury risks among mining communities
• Capacity building for local and national environmental and health agencies
• Remediation of contaminated sites

These activities provide miners with the tools and incentives to convert to mercury-free mining processes, and provide government service providers and regulators the tools to encourage safe mining practices and identify potential health threats.

To achieve the greatest impact, Pure Earth focuses its mercury program on countries that have high rates of mercury use, and where the organization has a sustained presence and strong links with the mining community and government. Sustaining an ongoing presence in select countries provides a number of benefits, including:

• Increased trust and communication between Pure Earth and local miners;
• Reduced costs associated with developing new programs and activities;
• Increased opportunity to develop collaborative relationships with local and national officials; and
• Increased opportunity to scale-up projects and integrate them into existing national programs and services.

In addition to implementing the activities described above, Pure Earth works to integrate its mercury programs into larger national priorities and initiatives. In particular, the mercury program compliments and facilitates national efforts to comply with the Minamata Convention on Mercury. The convention mandates and encourages a number of steps to reduce unsafe mercury use and emissions, including steps to reduce or eliminate mercury use in ASGM, and measures to identify and safely manage contaminated sites. Pure Earth’s mercury program directly advances these goals.
Recent Projects

Peru (2014 – Ongoing)

Artisanal and small-scale gold mining (ASGM) is a traditional livelihood in Peru, as in other parts of South America. It provides much needed income for many impoverished communities. Currently, the prevailing method of ASGM in the country involves using large amounts of mercury to extract gold. These activities result in the release of tons of mercury each year, causing significant air, soil, and water contamination and severe health impacts on local communities.

In 2014, Pure Earth initiated a project to assist the Government of Peru in complying with its own environmental laws that require remediation of contaminated lands, as well as with the Minamata Convention on Mercury, which obligates countries to reduce mercury emissions into the environment. The project is funded by the U.S. Department
of State, and implemented with Pure Earth’s partner, the Center for Research in Environmental Health (CREEH).

The project focuses on reducing the adverse impacts of mercury and ASGM on the environment and local communities, and sustainably restoring affected natural resources. It does so by assisting the government of Peru to assess ASGM sites for contamination and degradation, develop community-driven remediation plans and strategies for alternative livelihoods, train miners in mercury-free ASGM practices, and conduct remediation and rehabilitation of contaminated and environmentally degraded ASGM sites.

In particular, the project has assisted the government to: select three sites in need of remediation—one in the State of Puno and two in the state of Madre de Dios; foster community awareness regarding the human health and environmental detriments of mercury; support development of community-based remediation and rehabilitation plans; promote alternative livelihoods and/or training on mercury-free mining practices; remediate a sector in the site in Puno and rehabilitate three hectares in one of the project sites in Madre de Dios; and expand the capacity of the Peruvian government to replicate similar remediation projects.

Expected Results:
The project will:
• Train at least 20 government officials in environmental and health assessment methodologies, mercury-free ASGM practices, mercury remediation, and rehabilitation of areas degraded by the use of suction pumps that are located in flood-prone areas such as the ones found in the district of Laberinto in Madre de Dios;
• Raise awareness in the communities located at the project sites about the dangers of mercury and mercury use in ASGM;
• Develop 3 community-driven remediation and rehabilitation plans;
• Assist at least 200 miners to convert to mercury-free practices by raising awareness of the risks of mercury exposure and by demonstrating the effectiveness of mercury-free practices and providing training in the same;
• Remediate a sector in the project site in Puno and rehabilitate three hectares in one of the project sites in Madre de Dios;
• And lastly, reduce mercury levels in soil by at least 75% in the remediated sector in the project site in Puno and by this means, reduce human health exposure risk to mercury.

Naiman, Kyrgyzstan (2017-present)
The mercury pollution at Naiman is related not to the use of mercury in mining, but to the actual mining and production of mercury itself.

The town of Naiman was established as a workers’ settlement for the Uluu-Too mercury factory. The factory produced mercury and antimony for many years and is now closed. The irrigation channel running through Naiman village became contaminated with mercury from workers bringing it home to their houses from the factory with the hopes of selling it. When sales failed, the workers dumped the mercury into the channel. The irrigation channel runs along the main road of Naiman Village and the mercury can easily be seen at the bottom of it. The water from the channel is used for irrigation of gardens and for drinking by animals. Water from the irrigation ditch entered vegetable gardens of local residents. Children were observed near the channel and even digging out metallic mercury and playing with it.
A detailed assessment of the site indicated that high levels of mercury in the irrigation channel sediment. Pure Earth designed a remediation plan to clean up 650 meters of the channel and remove approximately 150 tons of contaminated soil. The polluted soil was transported to the tailings of the Uluu-Too mine.

Remediation work was conducted in June 2017. The Administration of Naiman Village was very supportive of the plan to clean up the area, and the project was facilitated further by the Kadamzhay Antimony Factory, which allowed the remediation team to use the tailings of the factory for the disposal of excavated contaminated soil.

Subsequent to the project’s completion, residents of Naiman have identified further sources of contamination in the village. Pure Earth aims to return to Naiman to design and implement further phases of the project and ensure that all significant sources of mercury contamination have been addressed.

**Mongolia (2014-2016)**
From 2014 to 2016, Pure Earth implemented a program to reduce mercury exposures in Mongolia by training more than 1,100 gold miners in mercury-free mining methods and increasing the capacity of our local partner, the Environment and Security Centre of Mongolia (ESCM) to conduct mercury education and influence public policy around mercury and gold mining. The program was funded by the European Union and the Trust for Mutual Understanding.

Over the last 20 years, Mongolia has experienced a surge in the number of people engaging in the practice of small-scale and artisanal gold mining (ASGM). Since 1990, the number of miners increased from zero to an estimated 100,000, and currently represents 20% of the rural workforce. Like independent gold miners around the world, many of these miners use mercury to separate gold from the soil and rock that surrounds it, and as with other ASGM locations, both the environment and public health have suffered.

The purpose of Pure Earth’s three-year project in Mongolia was to educate artisanal gold miners in several regions of Mongolia about the dangers of using mercury in the mining process, and to facilitate switching to a mercury-free method known as the
“enhanced gravimetric method” or “Filipino method” of mining. The Filipino method allows the miners to extract more gold from the ore through more effective sluicing and panning, and decreases environmental pollution by eliminating mercury use from the final stages of the process. In order to promote the safer mercury-free methods, Pure Earth conducted live demonstrations of the Filipino method for local mining communities, NGOs and government officials.

Pure Earth recognized that unless the new gold separation method it was promoting was at least as effective and profitable as the old Mongolian method, the goal of converting 1,000 miners to the mercury-free method would fail. In order to prove the new method’s efficiency and effectiveness at capturing gold, Pure Earth and ESCM conducted side-by-side trials with local miners using common ore that was ground and mixed before being divided into equal weights for each trial team. One team ran the ore through a traditional Mongolian sluice and panned it using Mongolian pans. The other team employed the Filipino equipment and method. The Filipino method resulted in twice as much gold captured, but required more time and more water.

The training actions of the miners were successful in several regions. Many miners were not only taught the Filipino method for their personal use, but were trained to train other miners in their region. The larger yield of gold from the Filipino method was found to be lucrative for many miners. After the completion of the project, between 60-80% of miners trained with the mercury-free Filipino method continued to use it 6-12 months after the end of the project. Miners have been recorded extracting up to 50% more gold with mercury-free method. Currently there’s waiting list of mining communities requesting training, which private funds could support.
Bolivia (2013 - 2014)

In 2013, Pure Earth and its local partner, Plagbol, in Bolivia, began working collaboratively with several organizations including the Geological Survey of Denmark and Greenland (GEUS), Dialogos (Denmark) and Mount Emerald Mining Cooperative (Philippines) to implement demonstrations of mercury-free mining methods and technologies in the communities of Sorata and Guanai in Bolivia.

The purpose of the trainings was to teach a mercury-free methodology developed by miners in The Philippines (knows as the “enhanced gravimetric separation method” or “Filipino method”) and assess its applicability in Bolivia. This method uses specialized sluicing and panning techniques and the addition of borax to gold concentrate as a “flux” to extract gold without the use of mercury.
The specific project objectives and their results included:

1. **Identification and evaluation of sites contaminated with mercury.** Over the course of the project, Pure Earth conducted 19 rapid environmental assessments to identify and characterize environmental health risks at contaminated sites. The results are included in the Toxic Site Identification Program database. This work was developed in coordination with the Central Gold Mining Cooperatives of Yani, Lijuata and Ancoma of the municipality of Sorata and the Central Gold Mining Cooperative of Guanay of the municipality of Guanay.

2. **Mineralogical Research.** A Danish expert from GEUS took samples of rocks and minerals, tailings, sediments and soil to verify if the type of minerals present and to provide more information about the applicability of the Filipino method, which is more effective in some types of ore than in others. The mineralogical investigations show that gold ores from La Suerte and San Mateo in Sorata are not complex and that it is suitable to use the Filipino method for gold extraction.
3. Demonstrate and compare the benefits of the Filipino method against practices using mercury. From 2013 to 2014, Pure Earth brought miners and trainers from the Philippines-based NGO Emerald Mountain to partner with local Bolivian NGO, Fundación Plagbol. Emerald Mountain has years of experience using the enhanced gravimetric method. The program established a south-to-south relationship between groups, allowing miners to learn from each other.

Several demonstration workshops took place. The Filipino method yielded better results than the mercury-intensive method previously used by the miners.

In addition to miner training, local health professionals were trained in identifying and understanding mercury poisoning, occupational risks, and prevention measures when handling mercury. Health professionals committed to disseminating the information learned at health fairs and places where mercury is sold, chiefly drug stores and shops.

Manica, Mozambique (2006-2010)

Manica is a district of Mozambique in the Manica Province with a population of 155,731 people. In the Manica District, more than 10,000 people are directly and indirectly involved in artisanal and small-scale gold mining activities as their main source of income. Most use mercury to extract gold from the mineral ore; the amalgamation process releases most of that mercury, which pollutes the nearby environment. Mercury amalgamation results in the discharge of an estimated 1,000 tons of mercury per annum globally, representing about 30 percent of the world’s anthropogenic mercury releases.

Pure Earth conducted field visits to assess health and technological needs in Manica, with a particular emphasis on the chosen pilot areas for community training. A training protocol was developed in the pilot project area to introduce miners and their families to mercury retort technologies (which capture mercury vapor) and related ways of reducing mercury emissions. Tests performed with homemade retorts showed that mercury emissions can be reduced significantly and cheaply. Following the training sessions, preliminary monitoring of these systems showed that the miners were using the retorts successfully. Adopting a community participatory approach, the implementing organizations devised follow-up plans including the establishment of a Community Amalgamation Centre and other opportunities for future collaboration.

The introduction of bowl- and pipe-shaped retorts to limit mercury vapor release was successful and well-received by the communities in Munhena, Manica District. The miners were also shown how to make their own retorts.
Pure Earth partnered with the Centre for Sustainable Development for Natural Resources, Ministry for the Coordination of Environmental Affairs (MICOA), United Nations Industrial Development Organization (UNIDO), Global Environment Facility (GEF), United Nations Development Programme (UNDP), and the mining community of Chimoio (capital city of Manica Province).

**Senegal (2006-2010)**

Artisanal and small scale gold mining (ASGM) increased in West Africa after gold prices rose and thousands of impoverished citizens were drawn into the industry. Pure Earth supported an outreach program in Senegal which demonstrated alternative techniques to mining villages.
The Senegalese Government led the project team to the Tambacounda Region. The region is internationally renowned for having one of the largest gold deposits in West Africa, known the Sabodala Deposit.

Studies taken before the project started showed that women were most at risk for mercury exposure. Women were typically responsible for milling and pounding the gold ore using a mortar-pestle system in the gold shops. Mercury was added during this process to bond with gold particles, creating an amalgam. Later, a battery powered coal stove, often located in the storefronts, would burn the amalgam to vaporize the mercury and separate the gold. Women wore no protective gear throughout the process and in some cases brought their young children to work.

Awareness raising and technology trainings to introduce retorts took place in 6 villages: Sabodala, Khossanto, Tenkhosto, Tenkoto, Bantanko and Bambaryaya. In collaboration with local miners, the team developed a modified retort that made use of locally available parts and was suitable for the existing conditions. The Project activities spanned from 2006 to 2010.

**Guinea (2006)**

The goal of this project was to reduce occupational health and environmental hazards of artisanal (small-scale) gold mining communities in northern Guinea. The total population of the area covered by the project is estimated at 150,000, of which over 40,000 people are involved every year in gold mining activities. The unregulated burning of mercury amalgam is the primary method for gold separation. It is widely reported that this method yields 1 kg of gold for every 1.3 kg of mercury employed.

In coordination with UNIDO, Professor Marcello Veiga of the University of British Columbia, who is Chief Technical Advisor for the Global Mercury Project, was sent by Pure Earth to Guinea to train miners to use retorts that significantly reduce mercury emissions. This project, which assessed mercury use and mining practices in the region, trained miners and their families in mercury-reduction techniques, monitored usage and developed follow-up/replication plans, was a resounding success, and will be replicated in Northern Guinea in collaboration with Centre d’Appui au Développement (CAD), and the Ministry of the Environment.

Awareness and cleaner-technology trainings took place at the Centre d’Appui au Développement headquarters in Conakry in 2006. The beneficiary communities were the Prefectures of Mandiana and Kouroussa.
Among the greatest challenges in establishing a sustainable program was the lack of support from authorities to institute a long-term educational and financing program for artisanal miners, limiting the possibility of collective solutions. The project team held meetings with the Minister of Environment, Director of Geology of the Ministry of Mines, Director of the Guinean Central Bank and Director of the Ashanti Goldfields – a mining company in Siguiri.

Mercury was not used in the mining process in these communities. Instead, the miners use rudimentary tools, which severely limits their gold yield. Using just a flashlight and locally forged metallic pick, gold miners enter mine depths up to 30 meters. Without any forced ventilation, the activity is risky.

The project team recommended the introduction of more efficient gold processing technologies, such as carpet of magnetic sluices. The establishment of Miners’ Cooperatives or any other type of organization would provide the miners with possibilities to have access to micro-credit in order to establish small processing centers in the area, where appropriate crushing, grinding and concentrating plants could be installed.

Partnerships And Funders

Partnerships

Pure Earth has been working closely with the jewelry industry over the past three years on our mercury reduction efforts. Many independent jewelers, refiners and large jewelry companies are knowledgeable about the issue of mercury pollution from ASGM and are working to find ways to raise awareness of the issue and to prevent mercury pollution from ASGM. We have established relationships with companies, non-profits and industry groups working on this issue. Pure Earth’s annual Benefit features an auction of gold jewelry made with responsibly sourced, mercury-free gold. The auction raises awareness and funds for Pure Earth to continue our work training miners in mercury free mining methods. Some of our partners include the Alliance for Responsible Mining, Ethical Metalsmiths. Hoover and Strong and Brilliant Earth amongst others.

Funders

Pure Earth’s work is funded through grants, contracts and donations from organizations including: the World Bank, the Asian Development Bank, the European Union, USAID, the
U.S. Department of State and other bi-lateral agencies, foundations and individuals. A complete list is available in Pure Earth’s Annual Report.

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