Education and Remediation Efforts to Reduce Mercury Use and Contamination in the ASGM sector of Puno and Madre de Dios

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Artisanal and Small-Scale Gold Mining in Peru

- ASGM releases up to 1,000 tones of mercury per year, over half of which originates from South America.
- In recent decades, Peru has experienced an explosion in ASGM, with about 40,000 illegal miners operating in the Madre de Dios Region alone.
- In Madre de Dios, authorities declared a state of emergency in eleven districts in 2016 due to mercury poisoning in local populations.
- ASGM has caused the removal of almost 100,000 ha of rainforest in Madre de Dios since 1985, with about 65,000 ha deforested from 2010 to 2017.

Figure 1 An ASGM mining operation in Madre de Dios

Figure 2 Previously lush rainforest scattered with barren craters dure to ASGM in Madre de Dios

Project Background

This poster describes a four-and-a-half-year intervention, implemented by the environmental health not-for-profit organization *Pure Earth* and funded by the United States Department of State, to reduce mercury contamination and use in ASGM communities in Puno and Madre de Dios, Peru.

To accomplish this objective, Pure Earth and stakeholders implemented the following activities:

✓ Select three contaminated sites in need of remediation; foster community awareness of the human health and environmental impacts of mercury;
✓ Support development of community-based remediation plans;
✓ Promote alternative livelihoods and profitable mercury-free mining practices;
✓ Remediate and restore three demonstration sites; and
✓ Expanded the capacity of the Peruvian government to replicate similar remediation projects.

Figure 3 A miner holds pieces of gold ore in Ollachea, Peru

Phase 1: Site Selection and Environmental Assessment

Site Selection Criteria

The project team selected and assessed mercury-contaminated and/or degraded informal ASGM sites using the following criteria:

✓ Active ASGM operations
✓ Evidence of environmental and health impact by ASGM activities
✓ Miner investment and support in the project via signed agreement
✓ Miners are formalized (legal) or in-route to formalization

Figure 4 A miner rocks quimbalates to refine gold; an investigator measures Hg with an XRF near Qumbalates

Site 1: Ollachea, Puno

- Ollachea contains 5,000 inhabitants, 800 of whom are registered members of the local mining group.
- Miners in Ollachea extract gold by mixing the ore with water and mercury using crushing stones. (quimbaletes) and melting a mercury amalgam.
- Each mining sector contained concentrations significantly above the Peruvian standard of 24 ppm Hg in industrial areas, typically nearby mining tailings and the quimbaletes.
- Of 15 laboratory readings, eight violated the Peruvian standard while six did not.

Site 2: Gold Shops & Mining Concessions, MDD

- Pure Earth identified two site types in the Madre de Dios Region: rainforest mining concessions and gold shops.
- In concessions, miners clear rainforest to form a mining pit, suction soil from the pit, and pump soil over a carpet, which is mixed with Hg to form an amalgam.
- The mercury-gold amalgam is purchased and re-burned in gold shops, exposing employees and the surrounding population to mercury vapors.
- Mining Concessions: all soil samples < Industrial Standard.
- Laberinto Gold Shops: 3 soil samples > Residential Standard, with one sample reaching 109.2 ppm

Figure 5 A mining camp in Madre de Dios; investigator takes an XRF measurement in a Laberinto gold shop

Phase 2: Health Improvement

Health Trainings

During the project, Pure Earth fostered awareness regarding the dangers of mercury pollution in 168 community members.

In general, the mercury risk workshops and miner health trainings emphasized the following points:

✓ General overview of heavy metals and their toxic nature
✓ The use, migration and exposure pathways of Hg
✓ Health risks for miners and their communities
✓ Strategies to safely handle Hg and avoid spills
✓ Alternatives livelihoods and mercury-free techniques

Figure 6 A study participant provides information and receives health recommendations

Urine Sampling in Affected Populations

- In March 2016, Pure Earth conducted a preliminary urine sampling in 205 individuals Puno and Madre Dios to evaluate human mercury exposure.
- Both populations reported moderate-to-high mercury poisoning in both communities, with values as high as 209.4 ug/l in Madre de Dios and 477.2 ug/l in Puno.
- In February 2019, a follow-up urine evaluation in 120 miners was conducted in Ollachea
- While exposure was still evident, mean urinary levels decreased from 32.8 ug/L in 2016 to 15.8 ug/L in 2019.

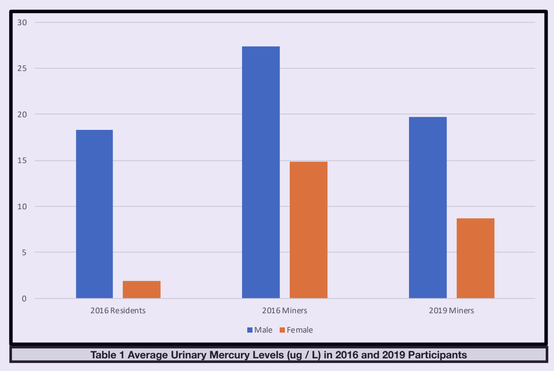

Table 1 Average Urinary Mercury Levels (ug / L) in 2016 and 2019 Participants

Phase 3: Miner Development

Gravimetric Mining

Gravimetric methods can eliminate or greatly reduce mercury use by using the high density of gold to remove lighter particles and increase gold concentration in the ore.

- **Filipino Method**: the primary mercury-free method introduced by Pure Earth was the Filipino Method, a gravimetric technique which uses sluicing and borax to smelt the concentrated ore.
- **Shaking Tables:** Pure Earth found gravimetric shaking tables effective, which uses shaking to facilitate particle separation.

Figure 7 Miners in Ollachea watch gold smelted using non-toxic borax

Mercury-Free Trainings, Ollachea

- 40 miners in Ollachea adopted a mercury-free technique and reduced mercury use by 80% or more.
- A miner who reduced mercury usage from 4 kg/month to 0.8 kg/month, reported saving about $682 monthly
- Female miners were particularly receptive to change
- Male miners were reluctant to adopt “panning”
- The train-the-trainer method was one of the most effective means for changing extraction techniques.

Figure 8 Female miners in Ollachea, Puno learning the non-toxic Filipino Method during a mercury-free training

Mercury-Free Trainings, Madre de Dios

- Miners in Madre de Dios were reluctant to adopt the Filipino Method due to concerns of efficiency and scale.
- As a result, Pure Earth adapted its approach, developing an altered method that incorporates shaking tables rather than mercury to concentrate gold.
- One mining concession owners (pictured at left) adopted gravimetric methods and responsibly closed 2.5 ha of his mining concession using a reforestation methodology.

Figure 9 Concession Owner Ynfantes recovers gold after it is processed by a shaking table

Phase 4: Environmental Remediation and Restoration

Soil Remediation in Ollachea, Puno

The objective of the Ollachea Environmental Remediation Plan was to improve soil by decreasing mercury concentrations. The following measures were taken:

✓ Close tailing ponds and quimbaletes in proximity to the Oscocachi River
✓ Using the assessment measurements as a guide, excavated and safely remove eight tons of contaminated soil
✓ Improve 11 tailings ponds for mercury-free mine owners using using bricks and roof repair to prevent rainwater entrance
✓ To aid with disposal, provide miners with five new platforms for storing discarded tailing sacks
✓ Install new pipes and water channels to improve drainage and reduce runoff

Figure 10 One of the platforms for storing discarded tailings bags and one of the improved tailing ponds for handling mining waste.

Restoration in Paolita II and FORTUMIL Mining Concessions

- Pure Earth conducted two restoration plantations in the Paolita II and FORTUMIL mining concessions, restoring 3.5 ha of degraded land and planting 5,866 seedlings.
- Species selection and methodology was based on longstanding research with experimental plots by project CINCIA (Amazon Center of Scientific Innovation).

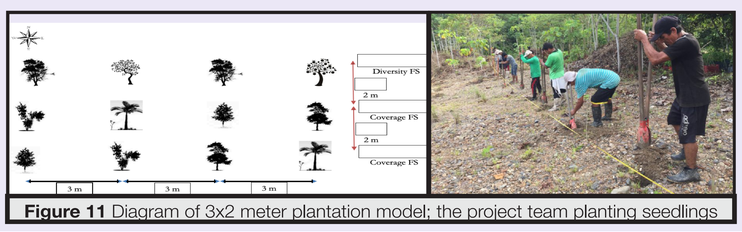

Figure 11 Diagram of 3x2 meter plantation model; the project team planting seedlings

- The restorations served as a pilot plan for future use by miners and stakeholders.

Conclusion

The outcomes of the project demonstrated that transforming mining practices requires substantial research of site conditions, including an understanding of the local mineralogical characteristics and the cultural and technical strategies employed in the respective ASGM community. Illegality is a key obstacle in working with the Peruvian ASGM sector and finding a community that is committed to the project and pursuing formalization is challenging. Regarding mercury-free techniques, future projects should consider the use of shaking tables, centrifuges and other gravimetric alternatives. Peter Plates, a technology previously tested in the Philippines to treat tailings and recover mercury with successful results, proved unsuitable for the project’s objectives, as it was inefficient and ultimately recirculates elemental mercury. Finally, given patterns of mercury contamination and the significant environmental impact of ASGM in Madre de Dios, the project team found that implementing restoration plantations in this region is more effective than soil-based remediation.

Overall, the project experience suggests that growing economic, legal and moral pressures are causing an increasing number of ASGM miners to learn and adopt responsible mining practices, provided that appropriate resources and knowledge are made available.

Figure 12 Ollachea miners during an Hg-free training