Division of Technology, Industry and Economics

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Reducing mercury use in artisanal and small-scale gold mining (ASGM): A practical guide

New UNEP Guidance Document

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A PRACTICAL GUIDE

REDUCING MERCURY USE IN ARTISANAL AND SMALL-SCALE GOLD MINING

Background – Technical Guidance Document on ASGM

- PURPOSE: to help inform policy makers, miners and civil society about technology options to reduce mercury use in ASGM, through conservation or transition away from mercury
- Developed at the request of the Global Mercury Partnership Advisory Group
- Available in English only, but will be translated in the future
- To be formally released at INC 4
- Webinar on 18 June to dialogue (contact pascale.unger@unep.org)


Source: Kevin Telmer

Structure

The Basics

Chapter 1: Mercury use in detail

Chapter 2: Solutions

- 2.1 Identifying appropriate solutions
- 2.2 Mining and concentration
- 2.3 Improving concentration
- 2.4 Processing and refining
- 2.5 Improving processing and refining
- 2.6 Zero-mercury processes
- 2.7 Related topics

Why is mercury used?

- Quick and easy
- Independent- it can be used by one person independently
- Gets gold in most field conditions
- Cheap and accessible
- Facilitates precise transactions and divides profits – between labourers and owners for example; or between concentrates and tailings
- Produces quick capital (money each day or week versus, for example, each season)
- Miners are not aware of the risks, and those that are aware often do not have access to the capacity or capital required for alternatives
- No choice (boss's instructions)
- It is one method that permits custom processing of small individual ore batches - often an important socio-economic structure

Chapter 1: How & when is mercury used?

Chapter 1 - Mercury Use in Detail

There are two main ways that mercury is used in ASGM:

1.1 Whole Ore Amalgamation (WOA)
1.2 Concentrate Amalgamation

Below, an Indonesian miner pours mercury to prepare a WOA process. The Images at right, show concentrate amalgamation: mercury is used on a concentrate to produce amalgam which is later heated to remove the mercury and produce sponge gold.

Chapter 2: Solutions

Mining and Concentration	Processing	Refining
POOR PRACTICE		
Unsafe excavation	Whole ore amalgamation	Lack of fume hoods
Poor crushing and grinding	Chemical leaching after mercury	Poor chemical management
Poor manual sluicing	Open-air amalgam burning	Poor purity assaying
Poor & untargeted power sluicing	No process control	
Poor planning	Little or no waste management	
BETTER		
Excavation planning	No whole ore amalgamation	Use of fume hood
Safe ore extraction	Closed basin amalgamation	Proper chemical management
Efficient crushing and grinding	Use of retorts / fume hoods	Educated purity assaying
Improved and targeted sluicing	Mercury reactivation	
Improved panning	Basic process control	
Established operational protocols	Basic waste management	
BEST		
Excavation planning	Zero mercury methods	Use of fume hoods
Safe ore extraction	Washing and sorting concentrates	Best chemical management
Advanced crushing and grinding	Direct smelting	Formal purity assaying
Efficient sluicing	Chemical leaching	
Enhanced concentration	Advanced process control	
Standardize operational protocols	Advanced waste management	

Identifying solutions – Reducing Mercury

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Retorts

To avoid open burning, the mercury in amalgam can be captured and recycled using a retort or fumehood. Simple and affordable models can reduce mercury emissions by 75 to 95%. Recycling mercury prevents the need for fresh mercury imports. This can lower costs for miners and gold shops by reducing mercury consumption.

Capturing and recycling mercury can be an effective first step in moving towards mercury free processing.

Retorts heat amalgam in one part and cool and condense the mercury vapour back into a liquid in another part of the device. The mercury can then be re-used.

(1) Amalgam is placed in a stainless steel retort; (2) The retort is clamped tight, and placed on a gas burner; (3) Mercury vapor leaves the amalgam, condenses in the steel tube, and drips into the vessel containing cool water. Once the retort has fully cooled after use, it is opened to recover the gold.

Important Precautions

- Once a retort or fumehood is used, it becomes contaminated with mercury and must be treated with care - they should be kept in a secure space and precautions must be taken if they are transported inside cars or in backpacks to prevent exposure.
- Retorts should never be operated by children or by women of child bearing age.
- Retorts should only be used in very well-ventilated areas, preferably outdoors or inside of a fumehood.
- Retorts should not be opened until cool or else mercury gas can escape and cause exposure.

Numerous types of retorts are used in ASGM. An appropriate type can be chosen by users who understand their specific needs. Above right- the three pieces, glass bowl, metal pan and enamel cup, required for a 'kitched bowl' retort', a low cost and simple design (Colombia). Below right- the 'kitchen bowl' retort uses wet sand as a seal around the edges of the overturned glass bowl (CASM, Mozambique meeting). Below left- large retorts fabricated for use with large amounts of amalgam (Indonesia). There are many other retort designs.

Identifying solutions – Reducing Mercury

Mercury Activation

Mercury is less effective for amalgamation when it has become contaminated with other substances through use or has become oxidized- see the photo below. An effective method for cleaning and activating mercury was developed by Dr. Freddy Pantoja. The method uses a solution of table salt and a simple battery to clean and 'activate' the mercury. The resulting 'mirror clean' mercury amalgamates gold more effectively, lowering mercury use, and prevents miners from discarding used mercury into the environment.

The surface of used mercury that has developed a layer of oxides. These inhibit amalgamation causing greater mercury losses and poor gold recovery

Steps

(1) Pour the mercury into a plastic, glass, or ceramic cup. Do not use a metallic cup because the metal will conduct electrical current.

(2) Mix a large spoon of table salt into a glass of water. Once the salt is dissolved, pour salt solution over the mercury. Sodium hydroxide (commonly called lye or caustic soda) also works very well- it produces less toxic by-products such as chlorides and is less corrosive to copper wires.

(3) Connect copper cables. The negative pole of a 9V or 12V battery is connected to the mercury and the positive pole to the solution - a motorbike or car battery works well. The surface of the mercury will become clean in 5 to 10 minutes. Mercury Activation can be done immediately before amalgamation to ensure minimum mercury use and maximum gold recovery.

Copper wires are used to connect the battery to the mercury and the salt-water solution.

Left- 9 volt battery being used for mercury activation. Six common 1.5v batteries connected in series also work well.

Right- after activation the mercury surface is a clean reflective mirror; water is kept on top so that mercury vapor does not escape.

(4) For best results, the activated mercury can be filtered through a pinhole filter. To do this, make a tiny hole (<1mm) in the center of a piece of paper and and carefully pour the mercury through the hole - dirt and oxides will be trapped on the paper. Filtering is helpful to clean mercury even when it has not been activated.

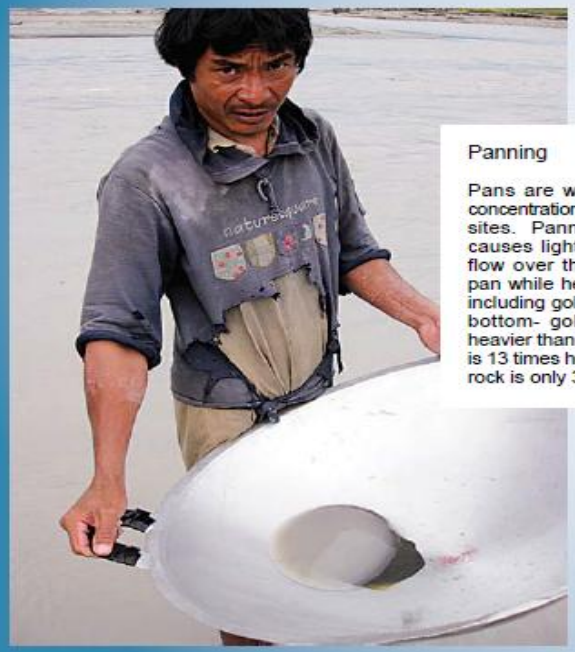
Activated mercury stored securely in a durable glass bottle with water on top, tape around the tightened cap, and properly labelled as mercury and as toxic.

Identifying Solutions – Zero Mercury

2.4 - Eliminating Mercury Use: Zero Mercury Processes

Gravity Only

Gravity methods are the most widely used method of concentrating gold in ASGM. Using gravity is effective because gold is heavy: approximately 7 times heavier than an average rock of the same size. There are a wide variety of approaches to gravity concentration from basic such as panning and sluicing, to more complex such as centrifuges and shaker tables.



Panning

Pans are widely used for concentration in many ASGM sites. Panning with water causes lighter particles to flow over the edge of the pan while heavier particles including gold remain in the bottom- gold is 19 times heavier than water; mercury is 13 times heavier; average rock is only 3 times heavier.

Naturally occuring alluvial gold grains are not pure 24K gold. They contain other metals and typically range from 85 to 95% gold.

The sequence of images above shows miners panning up a sluice box concentrate (1,2), and then drying and heating it (3) to allow magnetic minerals to be removed (4) to produce a high grade gold product (5). This example required about 1.5 hours.

Identifying Solutions – Zero Mercury

Model of a Mercury-Free Processing Plant

With the right equipment and a suitable ore, high gold recoveries can be possible with only gravity methods. The system illustrated on the following pages was installed in Mongolia[1] and recovers around 70% of the total gold - a relatively high percentage for an ASGM operation.

(1) *Gold bearing rocks are extracted from a properly timbered mine shaft*

(2) *Rocks are crushed down to 1-2cm size using a jaw crusher*

[1] The project and plant design was developed by the Sustainable Artisanal Mining Project, (SAM), a collaboration between the Mongolian Governement and the Swiss Development Cooperation (SDC), Mongolia.

(3) *Chilean mills are used to mill the rock- a large portion of the gold stays in the mill; rock powder flows with water from the mill onto a primary sluice, and then a secondary scavenger sluice which captures fine gold.*

Other Available UNEP Guidance on ASGM

(i) Guidance Document - Development of a National ASGM Strategic Plan

- Developed in 2011 based on experiences in Philippines and Cambodia
- Used in Franco-West Africa and Andean Region

(ii) Analysis of Formalization approaches in ASGM

- Also released in June 2012
- Based on experiences in Ecuador, Mongolia, Peru, Tanzania and Uganda

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