EnviroInfo 2007 (Warschau)
Environmental Informatics and Systems Research
 ISBN: 978-3-8322-6397-3

Merging Old and New: Framing Technology Transfer to Improve Mercury Risk Management for Artisans and Communities

Marianne Bailey[1], Luis Fernandez[1], Loren Habegger[2], Margaret MacDonell[2], Leo Newland[3]

Abstract

Millions of people worldwide are involved in artisanal mining and the crafting of precious metals. Mercury is a common additive for extracting gold from ore, and potential health impacts are substantial. A number of initiatives are under way to reduce mercury releases and exposures, and a recent pilot demonstration of a retort installation shop has demonstrated a 20-fold reduction in airborne levels within a small Brazilian gold shop. Information technology and educational outreach are key to increasing local awareness of the mercury threat and options for mitigating exposure, including via trainers. A prototype website is being developed to serve as an information resource for this effort.

1. Artisanal Mining

Artisanal mining for precious metals directly involves an estimated 10-15 million people in more than 55 countries, including nearly 5 million women and 1 million children. In fact, artisanal mining produces 20-30% of the world's gold supply (500-800 tonnes/year), and it provides income directly and indirectly for at least 100 million people. These small- to medium-scale operations use rudimentary processes to extract precious metals from primary and secondary ores. Mercury is typically added as part of this process to form an amalgam that increases gold recovery from the ore. With limited or no controls in place, mercury releases are substantial and many millions of people are being exposed (Telmer, 2006).

Technical solutions are readily available to reduce these environmental releases. In fact, with the money saved by using less mercury and recycling more, those changes could pay for themselves. The main constraint is technology transfer to workers whose technical training is limited. Modern information technologies can be part of the solution, to improve health and environmental conditions for local artisans and communities. The United Nations Industrial Development Organization (UNIDO)-sponsored Global Mercury Project is demonstrating ways of overcoming the barriers to adopting best practices that can limit mercury contamination (UNIDO, 2007), as are collaborative programs being conducted through the U.S. Environmental Protection Agency (EPA) Office of International Affairs.

2. Mercury Use by Artisans

Gold mining involves processing large quantities of ore materials, which range from alluvial deposits to sand, gravel, and hard rock. In alluvial mining, material from a river bottom or shore deposit is poured or pumped down a sluice, which is an inclined trough with ridges or other gravity trapping mechanisms on the bottom. Similar processes are applied for the other ore materials, with water added to support the slu-

[1] U.S. Environmental Protection Agency, Office of International Affairs, Washington, DC, USA; bailey.marianne@epa.gov, fernandez.luis@epa.gov.
[2] Argonne National Laboratory, Environmental Science Division, Argonne, IL, USA; lhabegger@anl.gov, macdonell@anl.gov.
[3] Texas Christian University, Institute of Environmental Studies, Ft. Worth, TX, USA; lnewland@tcu.edu.

icing and gravity separation. Lighter materials are carried away as tailings, while the gold and heavier materials deposit in the bottom pockets of the sluice. Mercury is commonly added to form an amalgam, which typically contains 60% gold and 40% mercury, because this combination is more easily recovered than the gold alone. Two main amalgamation methods are used: one with the whole ore and the other with gravity concentrates. For the first, mercury is mixed with the ore material in a continuous process as it is introduced into the sluice; that which does not form an amalgam with gold in this material is carried away with the tailings. For the second, concentrates are collected from the gravity traps on the sluice and then mixed with mercury in pans, blenders, or drums; this method reduces mercury losses to the environment.

After the amalgam is collected, artisanal miners heat it to drive off the mercury. The torches and stoves being used in the field are typically low temperature, so the remaining "sponge gold" still contains about 5% mercury. This material is taken to gold shops where buyers drive off the remaining mercury and pay the mining company for the gold content. Thus, the main mercury emissions during gold mining and processing are: (1) to waterways and shorelines, with tailings from the sluice; and (2) to air, during heating of the amalgam and sponge gold.

3. Health Concerns for Mercury from Artisanal Mining and Processing

Mercury released to air and water during gold mining and processing can pose health concerns to both the artisans involved and the broader community. When mercury is heated, it enters the atmosphere as a colorless, odorless gas. If metallic mercury vapors are inhaled, about 80% is absorbed into the body. This exposure represents a major concern for the miners and artisans themselves, especially children and pregnant women because children and the developing fetus are more susceptible to neurological damage.

When metallic or inorganic mercury is released to water, microorganisms and natural processes convert it to the organic form, methylmercury, which can bioaccumulate such that concentrations in fish and shellfish are often much higher than in the surrounding water or sediment. Thus, ingestion of fish containing relatively high mercury content (resulting from tailings-associated releases) can pose a real health concern for the local community. The form of the mercury greatly affects how much is absorbed into the bloodstream following ingestion; >95% of organic mercury is absorbed, while only <0.01% of metallic mercury and <10% of inorganic mercury is absorbed via this route.

Once in the bloodstream following either inhalation or ingestion, mercury distributes throughout the body. It tends to stay in the body for weeks or months, accumulating in the kidney where it can cause damage. In the brain, both metallic mercury and methylmercury can be converted to an inorganic form that is trapped in the brain. Exposure to high levels of mercury can cause tremors, memory loss, and changes in personality, vision, and hearing; it can affect a child's behavior and ability to think and learn, and it can also cause neurological damage to a developing fetus.

4. Reducing Mercury Releases and Exposures

In partnership with the UNIDO Global Mercury Project, the EPA is gaining insights on approaches for improving health conditions for artisanal workers and communities through a training program for artisanal miners in Senegal and a technology transfer project for gold shops in Brazil. Simply put, better gold mining and processing techniques can significantly reduce mercury releases and exposures, by modifying traditional practices with additional technologies. A straightforward solution for reducing airborne releases is to add a retort; this device contains released mercury vapor in a confined area so it can cool and condense. Many types of retorts could be used when burning the amalgam in the field. These can be built inexpensively from a variety of materials, ranging from stainless steel to relatively cheap cast iron. Simple retorts have been built from standard plumbing pipes and even kitchen bowls.

Although the basic retort concept has not been applied as extensively in gold shops where the 5% mercury is vaporized from the sponge gold, it can also be used effectively there. A recent Brazil project de-

monstrated a preliminary design that involved installing a retort on the exhaust of a hood. In this design, the mercury vaporized with a high-temperature torch was drawn into an expansion chamber with a baffle. The chamber and baffle allowed the mercury to cool and condense. As a further safety measure, vapor from the expansion chamber was drawn through a filter medium (pebble bed) to capture any further condensation. The concentration measured at the exit of the mercury retort demonstrated a removal efficiency of 95% compared to the hood exhaust levels of about 300 mg/m^3. (As a note, based on standard physical-chemical properties, the equilibrium concentration of metallic mercury in the presence of liquid mercury after condensation is expected to be about 15 mg/m^3 at room temperature.)

This striking 20-fold reduction in airborne mercury levels from the gold shop exhaust would also translate to lower residual concentrations reaching the general community. Within the gold shop, the concentration leaving the retort nevertheless exceeded the upper limit established for U.S. workers by a factor of 150 (the permissible exposure limit ceiling for metallic mercury vapor is 0.1 mg/m^3; for context, concentrations in ambient U.S. air have generally been reported at 0.01 to 0.02 $\mu g/m^3$). Thus, it is important to inform the workers that any direct inhalation of the retort exhaust should be avoided. Mercury levels could be further reduced by passing this exhaust through an additional absorbing medium such as activated carbon.

Both the retort and supporting filter media represent measures that control exposures. Source-control measures can also be considered, for example, mercury could be eliminated from the mining process altogether by using a different processing technique such as cyanide leaching. However, such alternate methods have their own set of health and environmental concerns.

5. Technology Transfer

Information transfer is essential to improving health and environmental conditions for small gold artisans and communities across the world. Studies have shown that emphasizing the gravity concentrate amalgamation method to limit water releases and adding a simple retort to trap airborne releases can vastly reduce mercury exposures and improve public health. In addition, these enhanced systems can save money due to reduced mercury costs. The question is: how to get this information to those who need it?

Information technology is key to the solution. While digital media have not been widely accessible to artisanal miners in non-industrialized regions of the world, access continues to expand – including via wireless telecommunication. If points of contact can be identified within key regions, those individuals could serve as the hubs for local educational outreach. A prototype website is being developed to serve as an information resource for such purposes.

Furthermore, digital media can be effective for trainers, as a focused resource of scientific information that can readily be updated, including with best practices and lessons learned. Computerized training materials could be developed for artisanal miners, geared to the backgrounds of the audience being reached. Existing materials (see Veiga et al., 2006) serve as a valuable resource for this broader dissemination. In addition, these educational training materials could be incorporated into the market process, for example, via the companies responsible for moving the product into the supply system. If they understood the issues and agreed to play a key role in educational outreach, by ensuring that the information reached local workers and communities affected by artisanal mining and processing, both health and environmental protection and overall cost-effectiveness could be substantially improved. Public involvement in industrialized areas where these exposure issues have already been addressed may help encourage companies to shoulder this role.

Acknowledgements

The authors would like to express their appreciation to Marcello Veiga, for sharing extensive program materials, and to Argonne interns Angela Parker and Maggie McKie for their contributions to this project, including organizing and developing educational outreach materials for the prototype website.

Bibliography

Veiga, M.M., Metcalf, S.M., Baker, R.F., Klein, B, Davis, G., Bamber, A., Siegel, S., and Singo, P. (2006): Manual for Training Artisanal and Small-Scale Gold Miners, Global Mercury Project, GEF/UNDP/UNIDO.

Telmer, K. (2006): Mercury and Small Scale Gold Mining – Magnitude and Challenges Worldwide, Powerpoint presentation. International Conference on Managing the International Supply and Demand of Mercury, European Commission in Brussels, October.

UNIDO, 2007, Global Mercury Project – Home, The United Nations Industrial Development Organization, http://www.unido.org/doc/44254.