Mercury-Assisted Small-Scale Gold Mining in Mongolia

Macaulay Honors Students: Vijay Singh and Patrick Blake
Instructor: Dr. Angelo Lampousis, Department of Earth and Atmospheric Sciences, City College of New York, City University of New York

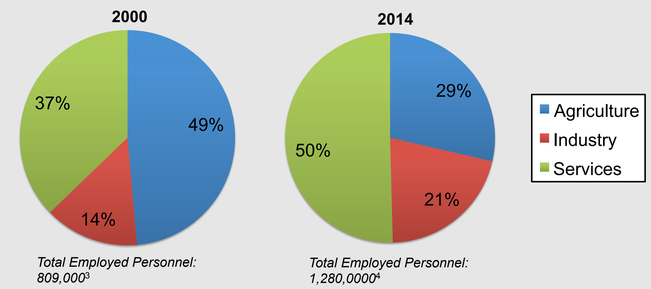
Introduction: Mongolia's History and Mining Detail

Mongolia, located in Central Asia, is a low-income industrial country of 2.9 million. Mongolia transitioned into a market-based economy in the early 1990s[1]. The country's strong ties to the Union of Soviet Socialist Republics (USSR) led to its economic downfall at that time. The economy rebounded steadily ever after, not least through an exploding mining industry. By 2012, the annual economic growth rate had reached a record 17.5% and it is projected to continue to grow[1].

Mining practices in Mongolia have contributed disproportionally in both the unprecedented economic growth and the adverse environmental and public health impacts. Twenty percent of the entire rural Mongolian workforce participates in Artisanal Small-scale Gold Mining (ASGM)[6]. Mercury is the key component in the ASGM method. Mercury is highly available and inexpensive making it ideal for small-scale mining operations. The business of ASGM is triggered by informal individuals in the absence of restrictive regulations or enforcement imposed by the Mongolian government. Labeled as Gold "Ninjas," the ASGM miners consist of former farmers who transitioned into gold miners[6]. A series of droughts and harsh winters have wiped out most of the livestock since 1999 and with it a major source of income for much of the rural population. These events combined with a surge in gold prices in 2007, enticed more than 100,000 Mongolians to switch to ASGM[6]. We present here our current understanding of the underlying causes that adversely affect the environment and the public health due to the adoption of ASGM in Mongolia. We also attempt to explore provisional and long-term solutions to this problem based on our understanding of the challenges involved in performing international environmental assessments in general, and in Mongolia in particular.

Figure 1:: Location Map of Mongolia *image©InTourTradeCo.LTD*

Change in Labor



Total Employed Personnel: 809,000[3] *Total Employed Personnel: 1,280,0000*[4]

* Industry encompasses industrial manufacturing, production of goods, and mining[4]. From 2000 to 2014, the industrial workforce has increased as the agricultural workforce has dropped. It should also be noted that the total number of employed workers have also increased throughout the years.

Challenges

- No regulations regarding controlled use of mercury
- No regulations regarding disposal of mercury waste
- Low awareness of health risks among workers
- Lack of national mercury emission monitoring
- Lack of hazardous waste treatment facilities

Mercury Usage and Detriments

One of the widespread gold extraction methods used by miners is mercury amalgamation. After gold ore, which contains gold particles and other miscellaneous substance, is mined, it is crushed and transferred into a metal drum to be mixed with water and mercury[5]. This creates an alloy mixture called an amalgam, that is milled and drained of excess mercury and water[5]. The leftover mercury in the amalgam is heated, leaving only gold as the product. This method is ideal for the ASGM community because it is inexpensive and can be used by one person independently.

Figure 2: Sample of milled gold ore amalgamated with mercury flour. image©BlacksmithInstituteJHP

"On a global basis, ASGM is responsible for approximately 37% of mercury emissions and is the largest source of air and water mercury pollution."
- World Health Organization (*Mercury Exposure and Health Impacts among Individuals in the ASGM Community)*

In spite of the cost effective nature of amalgamation, the process emits tremendous amounts of mercury vapor in the air[7]. The vaporized mercury not only affects the miners and the encompassing populations around ASGM sites by direct inhalation, but also through indirect exposure via food contamination. Mercury vapor settles in soil near water bodies and is transformed by anaerobic organisms into methylmercury[7]. The methylmercury infects all of the inhabiting organisms thereby contaminating the food chain–including predatory organisms such as the Mongolians consuming fish and other marine life[7].

Mercury is a lethal neurotoxin that when absorbed, can easily pass through the blood system and permanently damage the central nervous system[7]. Some neurological symptoms include reduction in motor function, sleep disorder, vision loss and even death[7]. If inhaled by a pregnant woman, her fetus has an increased risk of being born mentally and/or physically disabled[5]. Studies have also shown that mercury poisoning can lead to potential autoimmune dysfunction and organ failure[7].

Ultimate Goals

Establish guidelines for waste management
- Nationally observed standards regarding collection, transportation, treatment, storage and disposal

Remediation and stabilization at mercury hot spots
- Containment in an effort to minimize damage
- Recovery and possible stabilization of used Mercury

Raising awareness and disseminating information
- Comprehensive health education programs
- Pilot demonstrations of proper methods

Nationally funded implementation of mining alternatives
- Borax Method

Remediation: Implementation of the Borax Method

One of the main alternatives to the standard small-scale gold mining process using mercury is the Borax Method. This method uses no mercury whatsoever, instead using sodium borate, or borax, a common ingredient in many laundry detergents. This method originates from the Benguet Province of the Philippines and in recent years has spread to nearly 15,000 small-scale gold mines in the small area of Luzon, the main island in the northern portion of the Philippines[5].

The Borax Method begins with the same steps as the regular Mercury amalgamation method: the mined gold ore is placed into a drum and milled with long metal rods. After the ore has been reduced to walnut sizes, it is flushed into a sluice. The material in the sluice runs down a chute over a carpet, often made of felt. When the carpet is full of heavy minerals, it is rinsed in a bucket. Panning these minerals produces a gold concentrate. The concentrate is then placed in a small piece of plastic with equal parts borax and a few drops of water. The plastic is next placed into a clay bowl with several pieces of charcoal, which are then ignited. The bowl is heated, melting the heavy minerals and letting the gold flow to the bottom. The borax method is so effective because it lowers the melting point of gold, normally 1,063ºC, to a temperature that is easier to handle[2].

The Borax Method has three major advantages to the common Mercury Amalgamation Method. The first is that it contains no mercury, meaning it is environmentally benign. The second is that it is affordable for small-scale artisanal miners. Most miners do not possess the proper equipment used in mercury amalgamation. The final, and most impressive advantage of the Borax Method is that it has a higher gold yield percentage than the amalgamation method[2].

image©BlacksmithInstituteJHP

Figure 3: Loaded felt is "washed" to get gold and other captured minerals in the bucked

image©BlacksmithInstituteJHP

Figure 4: Proper panning isolates most of the gold and forms a concentrate.

image©BlacksmithInstituteJHP

Figure 5: Gold concentrate mixed with borax and water ready for smelting.

References and Acknowledgements

[1] A Short History of Mongolia. (n.d.). Retrieved November 1, 2015, from https://www.csrm.uq.edu.au/mongolia/history
[2] Appel, P., & Na-Oy, L. (2012). The Borax Method of Gold Extraction for Small-Scale Miners. *Blacksmith Institute Journal of Health and Pollution, 2*(1), 5-10. Retrieved November 1, 2015, from http://journalhealthpollution.org/doi/pdf/10.5696/2156-9614-2.3.5
[3] IT Landscape of Mongolia - IT Workforce. (n.d.). Retrieved November 25, 2015, from http://www1.american.edu/initeb/dp6120a/html/it_landscape_of_mongolia_-_i1.html
[4] (n.d.). Retrieved November 27, 2015, from https://www.cia.gov/library/publications/the-world-factbook/geos/mg.html
[5]Appel, P., & Na-Oy, L. (2014). Mercury-Free Gold Extraction Using Borax for Small-Scale Gold Miners. *Journal of Environmental Protection JEP,* 493-499.
[6] ASGM Borax Training and NGO Capacity Building - Mongolia. (n.d.). Retrieved November 1, 2015, from http://www.pureearth.org/project/asgm-borax-training-and-ngo-capacity-building
[7] Mercury Exposure and Health Impacts among Individuals in the Artisanal and Small-Scale Gold Mining (ASGM) Community. (n.d.). Retrieved November 27, 2015, from http://www.who.int/ipcs/assessment/public_health/mercury_asgm.pdf

We would like to thank our professor, Angelo Lampousis, and our fellow classmates for helping us along the way in developing a true method for change that one day may actually be a reality.