Artisanal mining: "An island of prosperity in a sea of poverty" UNIDO, 2003

The term 'artisanal mining' describes an informal and unregulated system of small-scale mining prevalent in many of the world's poorest countries and communities. Artisanal miners do not make large profits; they strive to make sufficient money to support their immediate family. Many metals and minerals are mined using artisanal methods, but high value commodities such as precious metals and gemstones provide the greatest return.

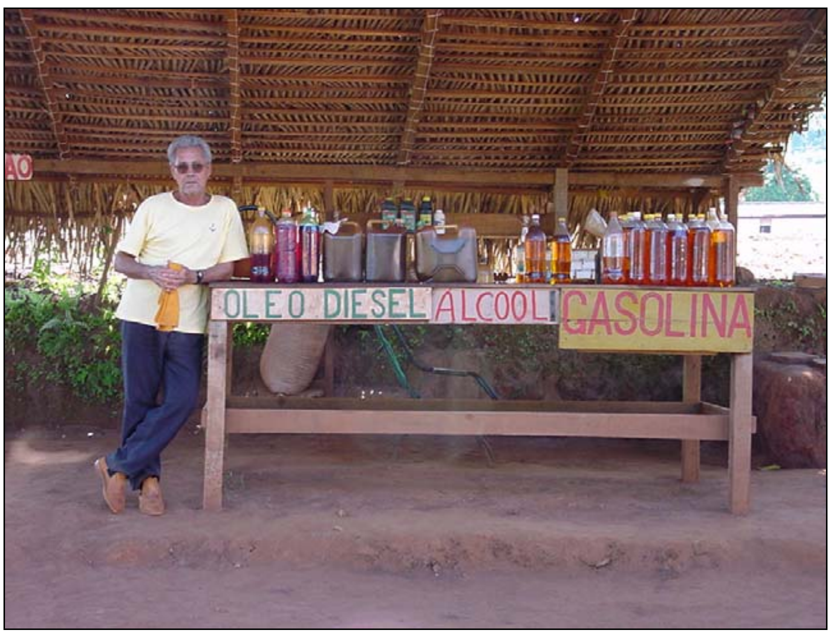
Artisanal mining is practiced in the developing nations of Africa, Asia and South and Central America. An estimated 20 to 30 million artisanal-small scale miners operate in 55 countries. Each miner is thought to generate income for a further 10 people. Artisanal operations are often illegal and poorly regulated. Miners have no title to the land they are working and thus there is no incentive for sustainable land management. Environmental destruction is the most visible outcome of artisanal mining. Problems include acid mine drainage, deforestation, soil erosion, river silting and the pollution of soil and water with toxic compounds.

Artisanal miners re-working tailings and waste rock at the Serra Pelada mine, Amazonia, Brazil.
Photo credit C. Anderson June 2003

Abhorrent health and social problems are typical of many artisanal communities. Primitive and low-cost technologies lead to high levels of work-place hazard; fatal accidents are common. Workers migrate from mine-site to mine-site, creating friction, resentment and social instability. Gambling and prostitution increase the prevalence of HIV infection in mining areas. In some areas in Africa the incidence of HIV affects 50% of the artisanal mining communities. Poor infrastructure for water, sanitation, education and law and order are all manifestations of the illegal industry.

Artisanal mining is characterised by a vicious poverty cycle: discovery, migration, and relative economic prosperity are followed by resource depletion, out-migration and economic destitution. After depletion of easily exploitable gold reserves, sites are abandoned, and the miners who remain contend with a legacy of environmental devastation and extreme poverty. These people have little opportunity to escape their circumstances (Veiga and Hinton, 2002).

Despite the negativity, artisanal mining plays an essential role in developing societies. Small mines can be a major source of revenue for rural communities, and can provide income for investment. Artisanal miners can exploit a mineral deposit considered uneconomic by modern industry. Every $1 generated through artisanal mining generates about $3 in non-mining jobs. In the words of Sir Mark Moody Stewart, the President of the Geological Society of London during a November 2003 conference on sustainable mining, “Artisanal mining should be encouraged; however, the associated poor health, safety and environmental conditions must be improved.”



Local enterprise in Serra Pelada. This is one of town’s ‘gas stations’
Photo credit C. Anderson June 2003

Artisanal gold mining

Artisanal gold mining accounts for around 50% of the world’s artisanal and small-scale mining. Mercury amalgamation is the preferred gold extraction method used by artisanal miners worldwide. Amalgamation is simple and cheap, leading to quick profits, but is inefficient and will discharge mercury and gold into the environment. A common legacy of artisanal gold mining is mercury pollution.

There are approximately 2000 artisanal mines in the Amazon region of Brazil alone, producing around 20 tonnes of gold per year. About 2 million people owe their jobs to these mines (Veiga et al., 1995). One tonne of mercury is typically released to the environment for every tonne of gold produced. When the cumulative calculations are made, the level of mercury discharge is staggering. Anywhere between 3000 and 4000 tonnes of metallic mercury have been released into the Amazon region since the beginning of the gold rush in the 1980's. A high proportion of this mercury finds its way into the atmosphere, but 20% commonly ends up in the waste soil and rock of a mining operation (tailings).

Mercury in tailings can transform into methylmercury, and accumulate in the food chain. Methylmercury is the sixth most toxic of six million compounds known to mankind (Malm, 2001). Plants and animals, in particular fish, a major food source, are contaminated by methylmercury. Many mine workers and their families show elevated mercury concentrations in their blood and urine, and neurological disorders have been linked to these high mercury concentrations. Although technology is available to manage mercury pollution, it is expensive, and therefore unattractive to artisanal communities.

Banana palms covered by gold tailings / artisanal miner panning with mercury
Photo credit C. Anderson June and April 2003

New technology to clean-up mercury is essential for the ongoing prosperity of the miners. This must be easily implemented, have a low requirement for capital and infrastructure investment, and must be financially rewarding. A simple plant-based technology, phyto-reclamation, could satisfy this need.

Phyto-reclamation: a new technology for artisanal communities

Phyto-reclamation is an application of phytoextraction; a developing technology that uses fast-growing plants to remove metals from the soil (Chaney, 1983). Once harvested, the metals can be recovered and safely disposed of, sold, or recycled. The secret to phytoextraction is choosing plants and treatments that will target metals in the soil. Some plants naturally accumulate very high metal concentrations as they grow. Other plants will accumulate metals if the soil is amended to increase their solubility. This is called induced accumulation, and is the technology used to make plants accumulate insoluble metals such as lead, mercury and gold.

The idea of farming mercury and gold

This new environmental idea is to empower artisanal communities with phyto-reclamation, a technology that will allow them to clean-up toxic metals such as mercury and compounds such as cyanide from polluted land. The system has three key steps. Land is first planted with a fast-growing and high-biomass plant species. Once the crop has reached maturity, an amendment is applied to the soil that will make some of the gold as well as mercury and other toxic metals soluble. The crop will absorb soluble metals and store them in roots, shoots and leaves as the plants continue to grow. Non-metallic compounds such as cyanide may be broken down in the soil. Finally, after one-to-two weeks of metal accumulation, the crop is harvested and processed to recover gold, mercury and other metals.

The key aim of this system is to clean-up polluted land, but there is a crucial advantage; the value of gold in the harvested crop. The United Nations Development Programme Sustainable Livelihoods Project has recognized that miners will show little interest in environmental initiatives if there is no quantifiable and immediate payback. Phyto-reclamation could address this critical issue. The gold value of the crop should provide a cash incentive to artisanal farmers who clean up their land.


The author (C. Anderson) surveying a spent cyanide heap leach pad with an eye to potential phyto-reclamation operations, Carajas, Brazil / doctoral student Fabio Moreno assessing plant growth at an active phyto-reclamation test site, in Bahia, Brazil watched over by Cerqueira da Silva of the Fazenda Brasiliero gold mine. Photo credit C Anderson April and June 2003

Artisanal mining can clearly benefit communities while resources are rich. What is needed is a livelihood for these communities when resources are poor or depleted: a livelihood that will break the poverty cycle. Phyto-reclamation could rehabilitate polluted soil releasing land for the development of productive farming. Education and training paid for by gold revenues could empower communities to farm their land efficiently. Farming might then be seen as a more attractive alternative livelihood for migrant workers. Gold could be a catalyst to bring about sustainable agriculture.

Working scenario……… 'Local co-operatives' train artisanal farmers with the agronomic skills necessary to farm metals. Co-operatives then employ and subsidise farmers to carry out the metal recovery operation, and purchase the metal-rich biomass upon harvesting. Environmentally sound processing would recover the mercury for disposal or recycling. Recovery and sale of the gold would make the operation economically viable. A newly empowered farming community would eventually utilise the clean soil and their new skills for agricultural production.

Mercury removal and productive land use: environmental sustainability...
Gold removal and agricultural development: economic sustainability...
Employment and education for the artisanal community: social sustainability

Discussion point: areas of potential concern associated with phyto-reclamation

Toxins in the plant... Phyto-reclamation uses plants to absorb toxins from the soil. Although the plants will not accumulate significant levels of metal while they are growing, there is potential for toxins to enter the food chain during the final stage of the system; in the one-to-two weeks prior to harvesting after treatment has been administered. As soon as the treatment is applied to the soil, plants will begin accumulating anything made soluble (gold but also silver, mercury and copper for example). If animals, insects or humans were to ingest such metal-rich plant material, there is the potential for risk. Solutions to this issue include: treatment prior to plants setting flower; use of non-food plants; education and security.

Chemicals used for the process... The technology still requires the use of a chemical to make gold soluble. Plants will not accumulate metals unless solubility is promoted. The conventional mining industry uses large amounts of cyanide to dissolve gold. For example, in Australia, cyanide may be irrigated onto rock 24 hours a day for months and sometimes years. Cyanide can be used for phyto-reclamation (cyanide is not toxic to plants) but other naturally occurring and man-made chemicals are also available (e.g. thiocyanate and thiosulphate, as well as proprietary lixiviants). The choice of chemical depends on the geochemical environment. For example, it would seem logical to use cyanide on an old cyanide 'heap-leach pad' or as part of artisanal operations where cyanide was already being used. The key difference between phyto-reclamation and conventional technology is that a small amount of chemical once only, over several hours, to mature plants. There is a risk that farmers employing the technology could use chemicals improperly. Such risk would need to be carefully managed in all operations. It is possible to use chemicals safely; the aim is to have a crop of plants absorb all irrigated solution. However, a system to ensure that artisanal farmers followed set protocols is potentially one difficult area for regulation.

For details of a decision support system that is used to plan and manage lixiviant irrigation, see the manuscript entitled 'Gold phytomining. Novel developments in a plant-based mining system'.
http://www.gold.org/discover/sci_indu/gold2003/pdf/s36a1355p976.pdf

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