Journal of Cleaner Production 64 (2014) 535–544

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Processing centres in artisanal gold mining

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ARTICLE INFO

Article history:
Received 15 January 2013
Received in revised form
3 August 2013
Accepted 4 August 2013
Available online 19 August 2013

Keywords:
Gold processing
Artisanal mining
Mercury
Cyanide
Processing centres

ABSTRACT

The aim of this paper is to reflect on efforts made worldwide to construct processing centres where artisanal miners can visit to have gold extracted from ore "free" or for a nominal fee. These centres use inefficient grinding and amalgamation processes to extract less than 30% of the gold to give back to the miners. As payment, miners typically leave the tailings (residues) at the centres that are processed by cyanidation to extract at least 90% of the residual gold. The cyanidation of contaminated tailings produces mercury–cyanide complexes that are rarely recovered in the process of activated charcoal or zinc precipitation. As a result, tailings discharged into the local water streams carry mercury either as soluble cyanide complexes or mercury droplets. There are a few processing centres, particularly in southern Ecuador, which use responsible and cleaner gold extraction integrating mining and processing techniques, but the vast majority of the processing centres in developing countries are only creating more pollution. Processing centres from different countries were assessed: Nicaragua, Peru, Colombia, Indonesia and Ecuador and the technical procedures to process ores and extract gold are described. The main environmental issues posed by poor practices are: (1) inappropriate cyanide management, (2) amalgamation of the whole ore, which increases the mercury losses with tailings, (3) usage of cyanide to extract residual gold from Hg-contaminated tailings, (4) dumping tailings with mercury, other heavy metals and cyanide into the local natural drainages, and (5) decomposition of amalgams without any condenser or filter.

1. Introduction

In the developing world, a combined 30 million individuals extract more than 30 different minerals using rudimentary techniques. Gold is the preferred mineral extracted by artisanal operators due to its high unit value and its market price, which has increased almost sevenfold over the last decade. Between 10 and 15 million people are directly involved in this activity, producing 300–400 tonnes of gold annually. This production, however, has caused numerous environmental problems, including high levels of river siltation and mercury pollution (UNEP, 2008). For the purposes of this analysis, artisanal gold mining (AGM) is herein defined as "operations, independently of the size, that use rudimentary techniques to prospect, mine and process gold ore" (Veiga, 1997).

Anthropogenic mercury emissions have been steadily increasing since 1995. In 2010, it was estimated that annually, 1960 tonnes of mercury were emitted into the air from all human activities (UNEP, 2013). The AGM sector is responsible for 37% of these emissions. The increasing dependence on mercury by artisanal miners calls for affirmative action to demonstrate non-mercury technologies (Hilson and Pardie, 2006) or at least methods capable of reducing mercury losses (Metcalf and Veiga, 2012). Unfortunately, there is little will from either host governments or international aid agencies to invest in strategies which can address effectively these harmful practices.

For four decades, AGM activity has intensified in virtually every developing country. The environmental, social and health situation of the sector's operators have deteriorated in the process. The main cause of this has been a lack of an effective and "democratic" distribution network capable of disseminating information to those who most need it. Technical information about more efficient techniques tends to reside with those who hold the greatest financial and intellectual capital. The result has been the installation of well-capitalized toll treatment processing centres which have disproportionate influence and coercive power over the poorer, simpler miners.

This paper describes the performance of processing centres in selected countries visited by the authors between 2003 and 2013 under the auspices of the GEF/UNDP/UNIDO "Global Mercury

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0959-6526/$ – see front matter © 2013 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.jclepro.2013.08.015

Project", the U.S. Dept. of State project of "Reducing Mercury Use and Release in Andean Artisanal and Small-Scale Gold Mining" and the UNIDO Colombia Mercury Project. All data generated from the case studies are based on mass balances and chemical analyses of tailings and effluents as well as in-country interviews with miners and local authorities. Details of the analytical procedures are found in the referred articles.

It is extremely difficult to obtain reliable, accurate information about the use of mercury and cyanide, gold production and methods used to extract gold, largely because the AGM sector is usually informal and often considered illegal. The objective of this paper is to outline and discuss some of the environmental problems created by the rampant growing of these processing centres, and also to highlight an example of more desirable practice of some centres in Ecuador which operate correctly, respecting miners and the environment.

2. "Evolution" of the processing centres

Centralized processing centres for AGM first appeared in the 1990s. The appeal of this model to the miners is that they do not need to invest in expensive pieces of equipment to crush, grind, concentrate and amalgamate the gold; they simply take their ores to facilities where gold is extracted by specialized operators for a fee. One early example of the establishment of processing centres came in 1991, when the Government of Venezuela prohibited all amalgamation activities on board of dredges in the Caroni River (Veiga, 1997). The Government and private investors created three processing centres on the shore of the river. These plants operated to extract gold by amalgamation from gravity concentrates of alluvial ore brought by the miners from their barges. The idea was praised by many experts and during the existence of the centres, substantial reduction of mercury discharges into the river was observed. The centres were closed in 2002 by the Venezuelan Government when two new hydroelectric reservoirs were built. All miners were forcibly removed from the river as they were blamed for river siltation affecting the electricity generator turbines. The Caroni River has less than 0.05% of particles smaller than 0.09 mm and these fine particles settle down within a distance of 140 m from the source (barges). The allegations of turbine damage were absolutely untrue and just a political manoeuvre of the local Government to satisfy local environmentalists who had conflict with the artisanal miners (Veiga, 1996).

The Shamva Centre in Zimbabwe, built in 1989 to process ores from 40 gold mines in the region, was another example of organized processing centres. The centre was created out of an initiative by the National Miners Association of Zimbabwe with the UK Non-Government Organization ITDG (Intermediate Technology Development Group, nowadays known as Practical Action). The Shamva Centre worked to discourage miners from using mercury in their operations and moved tailings disposal away from rivers. The centre was active for many years but the main challenges the miners faced were the distant location from the mines and the lack of an efficient process to extract fine gold (Simpson, 2007). For further examination of the Shamva case see Hilson (2006). The author also highlights the complications in a processing centre implemented by UNIDO and Ghanian Government in Japa. Initially, the miners used the centre to decompose amalgams in retorts. However, like in the Shamva Centre, a high demand for services forced miners to wait for extended periods and the miners preferred to return to the practice of burning their amalgams in open pans in the jungle.

The Shamva Centre model proliferated worldwide. The merit of the idea for the miners was clear: the processing centres provide, for "free" or for a symbolic fee, the whole service to generate, in short time, a bar of gold in the miners' hands. For the governments and funders of projects, the main merit was to avoid discharges of mercury into the rivers. As a payment, miners leave their tailings (waste) in the centres' facilities for further processing to extract residual gold. Many other processing centres have been established in Zimbabwe and in many other developing countries to provide similar services. However, these new centres rarely use clean or efficient techniques in processing the miners' ore. The processing centres use a crude grind to liberate fine gold particles before processing, negatively affecting gold recovery. They use rudimentary methods to concentrate the gold, or they simply amalgamate the whole ore using copper-amalgamating plates (Fig. 1), or they grind the ore with mercury in small ball mills. The amalgamation of the whole ore is the main reason for large mercury losses to the environment. With these inefficient processing techniques, the gold recovery is usually below 30% (Cordy et al., 2011). The centres

Fig. 1. Venezuelan miner amalgamating the whole ore using a hammer mill and a copper-amalgamating plate.