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Environmental Consequences Related to Poor Adherence to Standard Mining Practices by Artisanal and Small Scale Miners: The Case of Ashiraq Mines, Tanzania

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Abstract

This study assesses the contribution of small scale mining towards environmental degradation. Field observation, insitu measurements and laboratory analysis were conducted to determine environmental consequences caused by poor adherence to standard mining practices by artisanal and small scale miners in Ashiraq Mines in Tanzania. Field observation revealed significant land and soil disturbance in the study area such as the existence of abandoned old workings. Direct measurements of pH values for water samples from the nearby river revealed higher acidity on the downstream than the upstream side of the river. Estimates of Mercury concentrations in the atmosphere showed a significant addition of Mercury due to amalgam burning. Also laboratory analysis of water samples from the nearby river was done using the Atomic Absorption Spectroscopy (AAS) to determine Mercury contents in surface water. The analysis revealed high levels of Mercury concentrations in downstream water above recommended values. Mercury contents for the upstream samples were relatively lower than the upstream values but also lower than the recommended values. The study also recommends different measures to be undertaken by regulatory authorities to improve awareness and adherence to standard mining practices for artisanal and small scale miners, to reduce environmental consequences related to small scale mining.

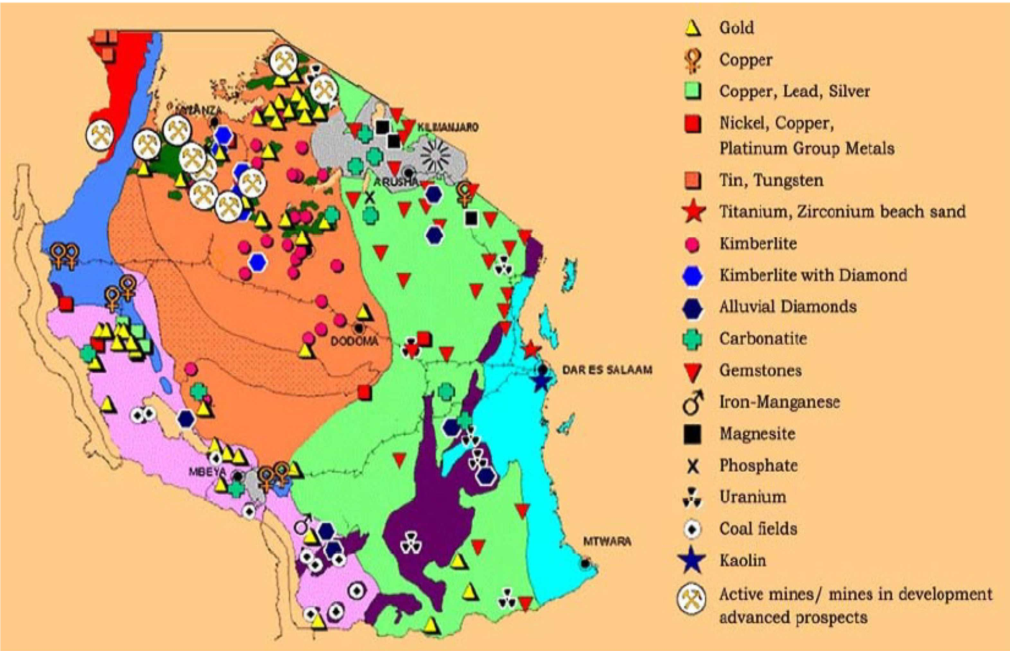
Keywords

Mining Regulations, Standard Mining Practices, Artisanal, Small Scale Mining

1. Introduction

Tanzania is one of Africa's most mineral-rich countries [1]. It is among few countries of the world endowed with mineral deposits of high economic potential, almost, all over the country (Figure 1). The country is ranked fourth (in terms of mineral resources) after South Africa, Democratic Republic of Congo and Ghana [2]. Such valuable minerals include metallic minerals (Gold, Iron, Silver, Copper, Platinum, Nickel and Tin), Gemstones (Diamonds, Tanzanite, Ruby, Garnet, Emerald, Alexandrite and Sapphire), industrial minerals (Kaolin, Phosphate, Lime, Gypsum, Diatomite, Bentonite, Vermiculite, Salt and Beach sand), building materials (stone aggregates and sand), and energy minerals such as Coal and Uranium [3]. Luckily, a significant portion of these valuable minerals is found near surface, making it attractive for small scale mining (SSM) [4]. In Tanzania, SSM activities are said to have started back in the 1940's, and the number of Artisanal and Small Scale Miners (ASSM) has increased rapidly, from 150,000 in 1987 to over 700,000 in 2012 [3]. Rough proportions of ASSM's engagement in SSM are; 60% Gold, 25% building materials, 10% Gemstones and 5% others (Copper ore, salt, industrial minerals) [4].

SSM is usually associated with several challenges including the use of inappropriate and poor technology and practices during mining and mineral processing, low recovery and low level of productivity [1-4], which altogether makes it difficult for ASSMs to abide to standard mining practices. This scenario usually, not only hinders ASSMs' as well as society's economic growth but also results into negative consequences to the indigenous environment. Some of these consequences may include (but not limited to) Acid Mine Drainage (AMD), land disturbance and degradation (due to random pitting and subsidence), air/water/noise pollution, unnecessary vibrations, siltation, deforestation, destruction of natural habitats, influx of people and deviation of rivers and streams [2], [5]. Environmental impacts related to SSM are categorized into two groups; primary and secondary impacts [5]. Primary impacts are such as the destruction of natural habitats (flora and fauna), which is a direct result of mining activities. Secondary impacts are those resulting from spin-offs of the mining activities; littering, sewage and these are said to be more difficult to deal with.



Source: [3]

Fig. 1. *Tanzania's mineral endowment.*

In Tanzania, standard mining practices for SSM are stipulated in the Mining (Environmental Protection for Small Scale Mining) Regulations of 2010. According to these regulations; small scale mining refers to mining operations conducted under primary mining licenses. People who undertake mining activities in such areas are known as Artisanals or small scale miners. The Tanzanian mining environmental regulations are unique from those found in most developing countries in the sense that they recognize the existence and challenges pertaining to SSM [6]. Part II-V of these regulations consist of guidance on environmental protection plan, environmental standards, reclamation and other requirements, as well as monitoring of compliance, that are easy for ASSM to implement and are enforceable [7]. Among other requirements of these regulations are; requirements for constructing washing ponds, restricting vegetation clearance near rivers and streams, using retorts (for those using mercury during mineral beneficiation), the acquisition of a written approval from the Chief Inspector for cyanide leaching, backfilling of old workings, reporting old environmental disturbances prior to mining, prohibiting the employment of children under sixteen years of age, constructing pit latrines in every license, and the provision of protective gear to miners. The regulations also empower relevant authorities to issues fines to any person(s) contravening these regulations.

2. Methodology

2.1. Aims and Objectives

This study investigates environmental consequences related to poor adherence to standard mining practices by ASSM in Ashiraq Mines, Tanzania. The study objective is to uncover improper mining practices performed at Ashiraq mine (as a sample SSM site) and provide recommendations to relevant regulatory organs to devise special mechanisms that will reinforce compliance to proper mining practices in order to avoid negative environmental impacts caused by ASSM's activities.

2.2. Description of the Study Area

Ashiraq mines are located in Ashiraq village, Nzega District, Tabora Region, Tanzania (Figure 2). Ashiraq small scale mining sites are located next to an old famous large scale Gold mine; Resolute Tanzania Limited (Golden Pride

Mine). ASSM at Ashiraq Mines are mining Gold.

Source: [8]

Fig. 2. *Location of Ashiraq Mines in Nzega, Tabora.*

2.3. Data Collection and Analysis

2.3.1. Data Collection

Data for this research were gathered from both primary and secondary sources. Primary data included direct field observation and water samples collection. Direct field observation was done on mining practices (i.e. ore extraction activities, mineral processing activities, wastes and tailing disposal activities) and their consequences to the environment, in relation to the Mining (Environmental Protection for Small Scale Mining) Regulations, 2010. Water samples were collected from Mwanashina River which is the only river crossing the mining area. Water samples were meant for the analysis of pH and Mercury content in surface water as a result of pollution from SSM activities. Secondary data included data for the approximate amount of mercury that was used during amalgamation.

2.3.2. Water Sampling Procedures and Techniques

A total of 8 water samples were taken from Mwanashina River; three (3) samples from downstream and three (3) samples from upstream. pH of each water samples was measured onsite using pH Meter. Samples were taken from both upstream and downstream sections of the river for comparison purposes. Upstream samples were taken at about 2 km upstream of the mining area to avoid any possible contamination by SSM and the downstream samples were taken 2 km downstream of the mining area to measure the impact of SSM activities to surface water pollution. At each sampling point, about 250 ml of water were taken from the center of the stream at about 10 cm to 25 cm deep [9].

2.3.3. Water Samples Preparation

At each sample collection point, all samples were kept in a pre-labelled clean Teflon bottle that has been rinsed in 10% HNO_3. Approximately 3 cm^3 of concentrated HN was added to each sample before sealing the bottles for stabilization of dissolved mercury as it becomes progressively unstable with a pH decrease [10].

2.3.4. Analysis of Water Samples

All water samples were analyzed for Mercury content using cold vapour Atomic Absorption Spectroscopy (AAS) at the Geological Survey of Tanzania (GST) laboratories, in Dodoma. The method of analysis was based on [9-10]. Water samples were further treated with dilute Hydrochloric acid before analysis to prevent further reaction to take place. About 100 cm^3 from each water sample was poured into a 125 cm^3 individual conical flask. Approximately 4 cm^3 of concentrated HN was added and heated in a water bath up to a temperature of 90 degrees of Celsius for 40 minutes. It was then filtered, cooled and transferred into a volumetric flask and diluted to the mark. A solution of 0.1 mg/l was prepared from a commercially prepared solution of 10 mg/l. A calibration standard solution of 2.0, 4.0 and 6 mg/l was prepared from the working solution in 50 cm^3 volume with the addition of 1 cm^3 each of concentrated HNO_3 and 1.0 g of NaCl. Each sample was prepared using the same methodology. A 50 volume of blank and the calibration standards were transferred into flasks and 1.0 cm^3 of 50% stannous chloride was then added. The absorbance signal was noted at both 20s and 40s for the blank and each calibration solution. A graph of absorbance against concentration was generated from each individual sample testing and shown on AAS machine display to give mercury concentration values.

3. Results and Discussion

3.1. Land Disturbance and Soil Contamination

Significant land disturbance was observed at Ashiraq Mines due to SSM activities. This was associated with poor adherence to standard mining practices by ASSM. For instance, indiscriminate dumping of various types of wastes (including waste rocks, metallic and non-metallic used items i.e. plastic bags) within the mining concessions was observed (Figure 3). Infact, there were 20 different locations in which uncontrolled waste dumping was taking place, contrary to the standard mining practices stipulated under part II of the Mining (Environmental Protection for Small Scale Mining) Regulations, 2010.

Furthermore, 6 non-backfilled abandoned shafts and 10 shallow abandoned openings were found in the licensed area. The existence of non-backfilled abandoned shaft (Figure 4) is an indication of lack of adherence to standard mining practices as stipulated under regulation 13, part IV of the Mining (Environmental Protection for Small Scale Mining) Regulations, 2010 that requires backfilling and re-vegetating or fencing of the abandoned previous workings before commencing development of a new working. Shallow abandoned openings are caused by poor or guesswork approach during mineral exploration activities by ASSM.

Fig. 3. *Improper dumping of waste materials at Ashiraq SSM.*

Fig. 4. *Abandoned opening at Ashiraq SSM.*

Not only that, but also 8 improperly constructed tailings dumps were observed in the license area. Figure 5 shows one of the existing tailings dam which is poorly constructed without proper linings, causing a threat towards leaching of waste water and other dangerous contaminants that may cause detrimental effect to the surrounding environment. This is against standard mining practices, stipulated under regulation 14 of the Mining (Environmental Protection for Small Scale Mining) Regulations, 2010 under part IV, that requires a holder of a primary mining license to ensure that tailings are disposed of at a proper place in a manner approved by the inspector.

Fig. 5. *Poorly constructed tailings dam at Ashiraq SSM.*

3.2. Air Pollution

The main and most dangerous air pollution activity observed at Ashiraq mines is amalgam burning, whereby about 26.6 kg of mercury are used annually for amalgamation activities and that 70% of the amalgam burning is performed without the use of retorts. This is to say, approximately 18.62 kg of mercury are burnt each year without using retorts, posing a potential threat of 95% mercury exposure to the atmosphere [11-12], which is equivalent to 17.70 kg of mercury released to the atmosphere on annual basis. This amount is equivalent to a mercury exposure of 1.5 Kg per month, 48.5 grams per day and 2 grams per hour to the atmosphere. This is against the global efforts to reduce Mercury contents in the atmosphere [11-15]. Burning of amalgams without using retorts is lack of adherence to standard mining practices as stipulated under regulation 12, part IV of Mining (Environmental protection for small scale mining) Regulations, 2010 which prohibits heating a mixture of gold and mercury (amalgam) to recover gold without using a retort.

3.3. Water Pollution

Laboratory results have revealed a significant difference between Mercury contents in the upstream water samples and that from downstream water samples. The average Mercury content for downstream water samples is 1.2 µg/l, which is greater than the World Health Organization (WHO) permissible limit [16], which is 1.0 µg/l. On the other hand, all samples collected from the upstream side of the river have Mercury content values below the maximum allowed concentration. The average Mercury content for the upstream samples is 0.34 µg/l. From these results, it can therefore be deduced that, high values of Mercury concentrations in water samples from the downstream side of the river were caused by SSM activities. Figure 6 gives a clear description of the comparison of Mercury content in both upstream and downstream water samples in relation to the standard allowable limits.

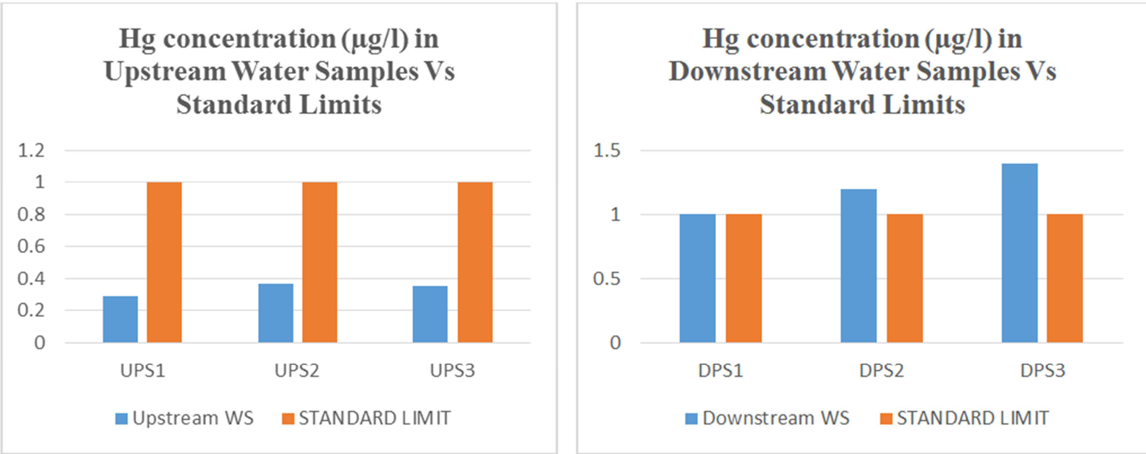


Fig. 6. *Mercury concentration in water samples in comparison to WHO standard values.*

Whereby;
UPS: Upstream water sample and
DPS: Downstream water sample

Figure 6 therefore implies that there's a significant violation of standard mining practices stipulated under regulation 6, part III of the Mining (Environmental Protection of Small Scale Mining) Regulations, 2010 which states that "No Licensee, or Manager or agent of the licensee, shall cause or knowingly permit any discharge, deposit or emission of liquid, solid, gaseous or particulate material, or noise or vibration, from a mine".

Also, the pH for water samples were found to range between 6.8 and 6.9 for upstream samples and between 5.4 and 5.8 for downstream samples as shown in Table 1. All water samples from upstream were within permissible limits of 6.5 to 9.2 for drinking water quality [17]. On the contrary, all downstream water samples had pH values below standard limits. This means that water in the downstream side of the river had higher acidity than that needed for the survival of aquatic animals and plants. This study believes that higher acidity in downstream water samples was caused by SSM activities.

Table 1. *pH values for Upstream and Downstream Water Samples.*

Sample name	pH
DPS1	5.8
DPS2	5.6
DPS3	5.4
UPS1	6.9
UPS2	6.8
UPS3	6.8
Permissible limits	6.5-9.2

4. Conclusion and Recommendations

In a nutshell, this study has revealed that small scale mining activities have a significant contribution towards environmental degradation due to poor adherence to standard mining practices by ASSM. In Tanzania, just like elsewhere in the world, although there exists a proper guidance (Mining (Environmental Protection for Small Scale Mining) Regulations, 2010) for these miners to follow, there still exists a significant violation of standard mining practices that leads to serious destruction of the natural environment. ASSM at Ashiraq mines have failed to abide to proper waste disposal methods, proper discharge of mine effluents, proper construction of tailing dams, the use of retorts during amalgam burning as well as backfilling and revegetation of old workings. This study therefore recommends regulatory authorities to do the following in order to improve adherence to standard mining practices;

a) Provide regular insitu environmental trainings for all artisanal and small scale miners,
b) Pay regular visits to all small scale mining sites to provide required assistance in terms of technical advice and support,
c) To regularly update artisanal and small scale miners on new regulations related to environmental protection in terms of standard mining practices, and
d) Distribute copies of relevant regulations for artisanal and small scale miner to be aware of what they are required to abide to, from time to time.

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