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Environmental damage and pollution from artisanal and small-scale gold mining in Gumelar Subdistrict, Banyumas Regency, Indonesia

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Abstract

Artisanal and small-scale gold mining (ASGM) is recently expanding the area on a hill around Gumelar Subdistrict, Banyumas Regency, Indonesia. The mining practice is unique in that they recover gold from pyrite concentrate. The existence of ASGM in Gumelar as well as other areas has caused problems such as safety, public health, and geo-hazard. This note describes the author's survey result as an environment officer at Banyumas Regency in the years 2012, 2014 and 2016.

Keyword : artisanal and small-scale gold mining, environment, pyrite, ASGM, Gumelar, Banyumas, Indonesia

Introduction

Artisanal and small-scale gold mining (ASGM) is recently expanding in size and dimension on a hill around Gumelar Subdistrict, Banyumas Regency, Indonesia (Fig. 1). Especially it is rampant near Babakan Hamlet in Paningkaban Village, and in Cihonje Village. There are 63 holes in Paningkaban Village and 46 holes in Cihonje Village. In each hole about five to ten workers are digging. However, they have no permission, and thus they are considered illegal and it is unable for the competent agencies to apply normal business management.

Hundreds of miners conduct their daily mining in these holes despite of the heavy rain and threat of local landslide. In addition, other threats come from mining wastes. Since the wastes contain mercury that was used in the ore processing the environmental impact is significant; and in the long term the waste will narrow the width of the river because of the sedimentation.

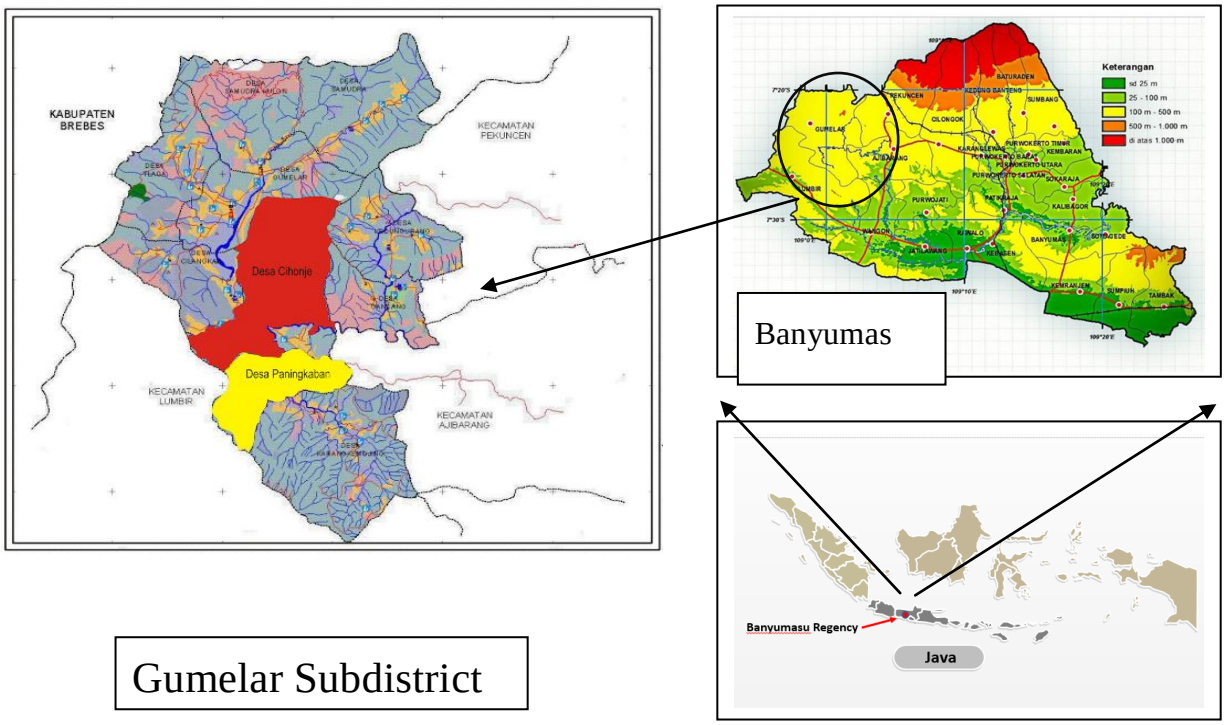

Fig. 1 A map showing the location of Paningkaban and Cihonje Villages, Gumelar Subdistrct, Banyumas Regency, Indonesia (lower right picture was depicted based on Your Free Templates, https://yourfreetemplates.com/free-indonesia-map-template/).

Fig. 2 Gold panning at Penaruban River.

Fig. 3 Mining waste dumped in a residential area.

Fig. 4 Miners crushing gold ore and jamming the product to sacks at a milling station.

Fig. 5 Rod-mills locally called "Glondong".

Condition of mining site and management

ASGM in Gumelar Subdistrict

Gumelar Subdistrict is a hilly countryside; consequently, most of Gumelar's indigenous residents live on the hillsides. The subdistrict itself is prone to natural disasters, especially landslides, and disaster occurred several times from a small scale to a big one with a lot of casualties.

Here, there is a flow of a large river which is the upstream of the longest river in the Western part of Banyumas, namely Tajum River. Originated from Samudra Village, this river goes through Gumelar Village, Cihonje Village and enters Ajibarang Subdistrict. Tajum River flowing through those regions is then joined by several lesser tributaries; one of them is Penaruban River that passes Paningkaban Village.

Apparently, the areas around Tajum River have various potentials of community ASGM. It is gold that becomes the mostly explored material in both Paningkaban and Cihonje Villages. The existence of ASGM (Fig. 2) in those two villages as well as other areas has created problems such as environmental degradation, safety, public health, and geo-haza1rd.

Landslide threat is due to the existence of waste heap from illegal gold mining around the mining site. As for the existence of piles of excavated soil that is placed on a steep location, has the potential collapse of the soil pile. The initial excavation is done in vertical direction, then at a certain depth (± 15-25 meters) workers conduct horizontal drifting. The waste is dumped to make large heaps with steep slope in the location of mining site and settlement areas.

This condition has made the local inhabitants restless. Those whose houses are below the mining site are very anxious since the waste heap may collapse at any time (Fig. 3). Besides, the gold disposal waste flowing into the river also causes health problems and water quality degradation due to the accumulation of heavy metal like mercury that enters the natural environment through the river flow used by the inhabitants for daily purposes.

Engineering and processing

The mining techniques include some (not necessarily all) of the following stages (Figs. 4 and 5).

- Gold-bearing quartz vein is dug underground, or placer gold is panned in streams.
- Hard ore from the vein is manually split into smaller pieces with hammer.
- Milling of crushed hard ore is done for approximately two hours. The obtained slime is then mixed with mercury to separate gangue mineral and gold-containing pyrite. This process is repeated three times.

- After milling the ore, mercury is then added to extract the pure form of pyrite concentrate.
- The obtained amalgam is then burned by using a burner to get pure gold in which its content is to be calculated next.

Observation

The vegetation

Vegetation at certain area around the ASGM has experienced significant deforestation. According to some secondary information, it is indicated that the mining area is a permanent production forest area.

Unfortunately, there is lack of attention on mitigation and reclamation aspects since on certain deforestation areas cassava plants are the only planted vegetable. As a result, the plants have less function as soil movement retardation; therefore, the potential of land movement on that area still remains.

Sedimentation

Based on a field observation, there is a lot of sedimentation along Penaruban River that crosses the mining site. The remaining gold sludge is flowed through trenches into Penaruban River. Besides, the volume and weight of sludge are also much greater than the water volume, so in some certain points along the river, there is significant sedimentation.

Water pollution

Pollutants that occurs in aquatic environment is grouped as follows: (1) organic waste materials and (2) inorganic materials. Organic waste generally can be decomposed or degraded by microorganisms, so this can lead to the development of microorganisms and pathogenic microbes which breed easily and result in various diseases. Inorganic waste is material that microorganisms cannot decompose and degrade easily.

Change in hydrogen concentration is another problem. The measurement by the Indonesian Government showed pH of ± 8,5 for Penaruban River. According to a field observation water contamination in this area is caused by the residual mining materials, either sludge from the grinding process or mercury as the separating compound of gold from rocks. This happens because there are no efforts to gather the pollutants in a particular area; moreover, what the miners have done is throwing garbage into the river directly through man-made trenches (Fig. 8).

A function of the river is not as grave of waste disposal but as cradle of life resources. If polluted rivers can have impacts on the community and the surrounding environment, these impacts can spread to a wider region, especially along the Penaruban River. Even, it becomes more extensive because Penaruban River will flow to Tajum River which has a vast flow area.River. Even, it becomes more extensive because Penaruban River will flow to Tajum River which has a vast flow area.

Dissemination of pollution

Based on the information from several local inhabitants and field observation, the activities of gold processing and dried sludge collection are widely spreading from hill side towards residential areas and even outside of village. Since the sludge contains a lot of mercury, it should be concerned about the negative impacts.

Workers usually pile up dried sludge which is wrapped in plastic bags around the houses where they live. The dried sludge is the residual materials from the first process and even from the third process; therefore, mercury in the sludge has been accumulated from the previous processes. Because the plastic bags are piled up in open place, the pollutants are carried away during the rainy season.

In addition, sometimes, non-miners in the mining community add mercury to the residual sludge which is already contaminated with mercury. This is the practice in order to recover residual gold and they double the mercury concentration. After the processing, the rinse water and the sludge will be discharged into the environment through channels to rivers, gardens, or rice fields around the people's residence.

Monitoring results

Environmental inspection in 2012

One of the results of laboratory testing of the waste water of gold processing entering several points of environmental waters located in Penaruban River on Paningkaban Village showed the mercury level of 6.15 ppb (6.15 mg/ton or 0.00615 mg/l), in 2012. According to the decree of Environment Minister Number 22 Year 2004 about the standard quality of waste water for business or activities in gold and copper ore mining, the maximum threshold level of mercury (Hg) is 0.005 mg/l. Clearly the concentration in Penaruban River has exceeded the threshold.

Environmental inspection in 2014

1) Mercury in River

- The upstream part indicates mercury content of 0.0016 - 0.0018 mg/l
- The middle part shows mercury content of 0.0014 - 0.0029 mg/l
- The downstream section indicates a mercury level of 0.0016 - 0.0018 mg/l

2) Mercury in Clean Water*

- Paningkaban Village has mercury level of 0.0005 - 0.0006 mg/l
- Cihonje Village has mercury level of 0.0005 mg/l

Fig. 6 Atmospheric monitoring focusing on mercury.

Fig. 7 Amalgam on a miner's unprotected hand.

Fig. 8 Polluted stream in a residential area with garbage.

Fig. 9 Hair sampling by a research team from the Ministry of Health.

* Clean water is water in a reservoir originating from a water source and is usually used for bathing, washing cutlery and clothing. The criteria of clean water quality is specified in Regulation of the Minister of Health No. 416 of 1990 (Attachment II).

3) Mercury in Benthos

- The upstream section shows a mercury level of 0.08 - 0.09 mg/kg
- The middle part indicates mercury level of 0.09 - 0.22 mg/kg
- The downstream section shows a mercury level of 0.06 - 0.11 mg/kg

4) Mercury in Sediment

- The upstream section, showing mercury levels of 0.12 - 0.18 mg/kg
- The middle portion shows a mercury level of 0.12 - 0.28 mg/kg
- The downstream section shows a mercury level of 0.10 - 0.13 mg/kg

5) Mercury in Sludge

- Paningkaban Village has mercury level of 0.13 - 0.18 mg/kg
- Cihonje Village has a mercury level of 0.10 to 0.11 mg/kg.

6) Mercury in Soil

- Paningkaban Village has mercury level of 0.06 - 0.10 mg/kg
- Cihonje village has mercury level of 0.05 - 0.11 mg/kg

7) Mercury in Ambient Air

- Paningkaban Village, showed mercury level of 0.06 μg/m^3

First examination of people

Urine and hair are good indicators of mercury poisoning and the authors tested the specimen from local residents. For the comparison nail was also donated by the subjects.

The author's teal employed a criterion of respondents that they should be over 17 years old and work in the ASGM. The examination was conducted on 50 respondents with the results shown on Table 1.

Second examination of people

Being perturbed with the health situation in the Regencey, the Ministry of Health is collaborating with the Environmental Office of Banyumas Regency for the health issues arising from ASGM (Figs. 7 to 9).

The examination of mercury concentration on blood was done on 30 respondents from Cihonje Village and 30 respondents from Paningkaban Village after getting the consent of the subjects. Plants were also analyzed for the future consideration. The results (both in 2016) are indicated in Table 2.

Table 1 Result of medical examination for people in ASGM.

Urine Examination Result	Total (%)
≤ 30 μg/g	32 (64) %
31 – 50 μg/g	11 (22) %
≥ 50 μg/g	7 (14) %
Hair Examination Result	**Total (%)**
≤ 5 μg/g	49 (98) %
≥ 5 μg/g	1 (2) %
Nail Examination Result	**Total (%)**
≤ 2 μg/g	10 (20) %
≥ 2 μg/g	40 (80) %

Table 2 Mercury concentration in blood of local residents.

	Mercury concentration (μg/l = ppb)	
	CIHONJE	PANINGKABAN
Number of respondents	30	30
Maximum	52.005	117.847
Minimum	2.386	12.270
Average	19.675	36.577

Table 3 Mercury content for some important

	Mercury content (mg/kg)	
	CIHONJE	PANINGKABAN
Banana heart	0.246	–
Banana	–	1.426
Papaya	0.238	4.361
Cacao	0.184	1.527 – 2.448
Pandanus leaves	0.426	–
Chilli	0.126	–
Arrowroot	0.431	8.562
Cassava	0.627	6.384
Katuk leaves	–	1.255
Winged beans	–	2.692

Conclusion and recommendations

Conclusion

The ASGM in the Gumelar Subdistrict has negative impact on the environment and society although it is expected to spur local economy if managed properly.

- Environmental degradation due to deforestation,
- Collapse of waste heap
- Sedimentation caused by the milling process.
- Increase in environmental pollution (soil, yard, rice field), water pollution (Penaruban river flow around the mining site) due to the existence of pollutants such as mercury that is used in the ASGM

Especially the mercury pollution is of great concern in terms of people's health as well as ecosystem conservation. Banyumas Regency is well known for the biodiversity and beautiful nature, and if any, alternative livelihood such as eco-tourism should be offered to the ASGM communities in this subdistrict.

Recommendations

To minimize the negative impacts of mining activities, the following measures can be taken into account:

- Rehabilitation of ex-mining land or excavated shaft/hole with vegetation of proper characteristics such as teakwood.
- Providing clear information related to the cost-benefit balance associated with the ASGM in the region.
- Delineating exclusive area for waste disposal and tailings.
- Making rules to control mercury flow into/out of ASGM sites and villages.
- Providing alternatives such as reasonable and practical technology for mercury-free gold production.
- Finding alternative livelihood to eliminate poverty in the region

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