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Mercury contamination in groundwater from artisanal and small scale gold mining activities: a case study of Southern Lombok Coast, West Nusa Tenggara Province

Mercury contamination in groundwater from artisanal and small scale gold mining activities: a case study of Southern Lombok Coast, West Nusa Tenggara Province

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Abstract. Artisanal and small scale gold mining (ASGM) activities usually use the amalgamation process with mercury to extract the gold. The waste of amalgamation is disposed of in a pond or discharged directly into the river. Most of the tailing ponds are located close to the community wells due to water supply purposes for the amalgamation activity. The amalgamation activity could cause mercury pollution to the community well. This study is aimed to determine the mercury concentration in the groundwater in Southern Lombok Coast. The method used during the study were observation and laboratory testing for mercury concentration. An observation activity had been completed at three villages, namely West Sekotong, Pelangan, and Batu Putih, to identify the process of amalgamation and tailings disposal. Ten community wells associated with the amalgamation process were taken as the sample locations for mercury laboratory testing. It was found that the mercury concentration at the nine location samples was below 0.06 µg/l, and only one location sample (sample code P2) was detected with mercury concentration more than 0.06 µg/l. The results indicated that most of the community wells water met with the government standard (Hg = 0.005 mg/L) as stipulated in government regulation No. 82 of 2001.

1. Introduction

Gold mining activities in the coastal areas of South West Lombok have attracted many people for a couple of years now. The community drills and digs rocks in the hills. The rock processing is conducted in various locations by using an amalgamation with mercury to extract the gold. This amalgamation activity is carried out traditionally. The residue of amalgamation is disposed of in the ponds or dumped directly into the river. The location of tailings pond is very close to the community clean water sources (wells). This condition might cause the mercury pollutants to infiltrate the groundwater. Based on the results of the previous studies,one amalgamation process requires 7.5 kg of rocks, ± 20 liters of water (for processing and washing), and 0.5-1 kg of mercury, which is processed for ± 3-4 hours. The mercury concentration was accumulated in tailings and varies depending on the roller accuracy in washing stage, but on average, it has a high level of up to thousands ppm [1]. In the handling of amalgamation residue, there are several ways commonly practiced by the community: 1) Using a simple sediment pond without cement; 2) Construct a sediment pond with cement, and 3) Discharged directly into the backyard and/or

river. Improper disposal of tailings and waste collection might affect the quality of groundwater with mercury pollution.

Therefore, good tailings management is required to minimize the impact of mining activities [2]. Some of tailings management practices were explored by [3] [4] [5], however, the current artisanal mining practices were less consideration to the good tailings management. This study is critical for assessing the impact of artisanal mining activity (amalgamation stage) to the community groundwater quality particularly mercury parameter.

The artisanal mining activities in the southern part of West Lombok is one of the main community incomes [6] for their daily life. On the other hand, the artisanal mining activities left some high-risk impact including mercury contamination. The high risk might occur due to mercury application for the amalgamation process. Therefore, the mercury distribution study is required in the southern part of West Lombok to identify the mercury concentration in the community groundwater.

2. Method

Two methods were applied, namely observation and laboratory testing. The water samples from ten community water wells were delivered to the accredited laboratory for being analyzed. Tools and materials used during the study are presented in Table 1.

Table 1. Tools and materials

No.	Tools and materials	Purpose
1	Sample bottle	Sample storage
2	HNO_3	Preservation of water samples
3	Coolbox	Water samples storage
4	GPS	Location coordinate
5	Camera	documentation
6	Water sampler	Grab water samples
7	Water quality tester	Water physical parameters testing
8	The meter	Groundwater level (depth) and distance
9	Landsat ETM 7+ images	Location of the settlement

The sampling and analyzing method were carried out according to the Indonesian National Standard (SNI) Number: 6989.58. Some parameters were considered during the groundwater sampling including groundwater conditions (level and depth), and distance from amalgamation location. Water sampling is carried out according to the Indonesian National Standards (SNI). Water samples were taken using a water sampler and then dripped with HNO_3 to create a range of pH between 2 - 3. The samples were kept in the cooler box with the temperature at ± 4° C. Analysis of mercury concentration was using mercury analyzer (AAS). The quality standard for mercury concentration in well water referred to Government Regulation No. 82 of 2001 regarding the surface water quality.

Ten samples were taken from the community water wells near to the amalgamation process as shown in Figure 1.

Figure 1. Location of study

3. Result and Discussion

Mining activities bring various impacts that can be categorized as irreversible and reversible impacts including climate change, land and water contamination, and land-use change [7] [8]. One of the artisanal mining activities that created an impact is the amalgamation stage. The amalgamation stage is carried out by the Sekotong community at their homes. The amalgamation process requires almost 7.5-10 liters of water supplied from a community well. Meanwhile, the amalgamation process residue (tailings) consisting of water, rock powder, and mercury is disposed of either in the backyard or river.

The process stage as shown in Figure 2 is started from crushing and grinding activities to generate the smaller size of rock ore. The mercury liquid is injected in a small volume into the grinding process and the gold will be absorbed within mercury. Two main products were generated from the grinding activities, namely mercury with gold, and residue (tailings). The gold extraction using amalgamation method produced two common products: gold as the final product, and mercury vapor as the by-product (residue).

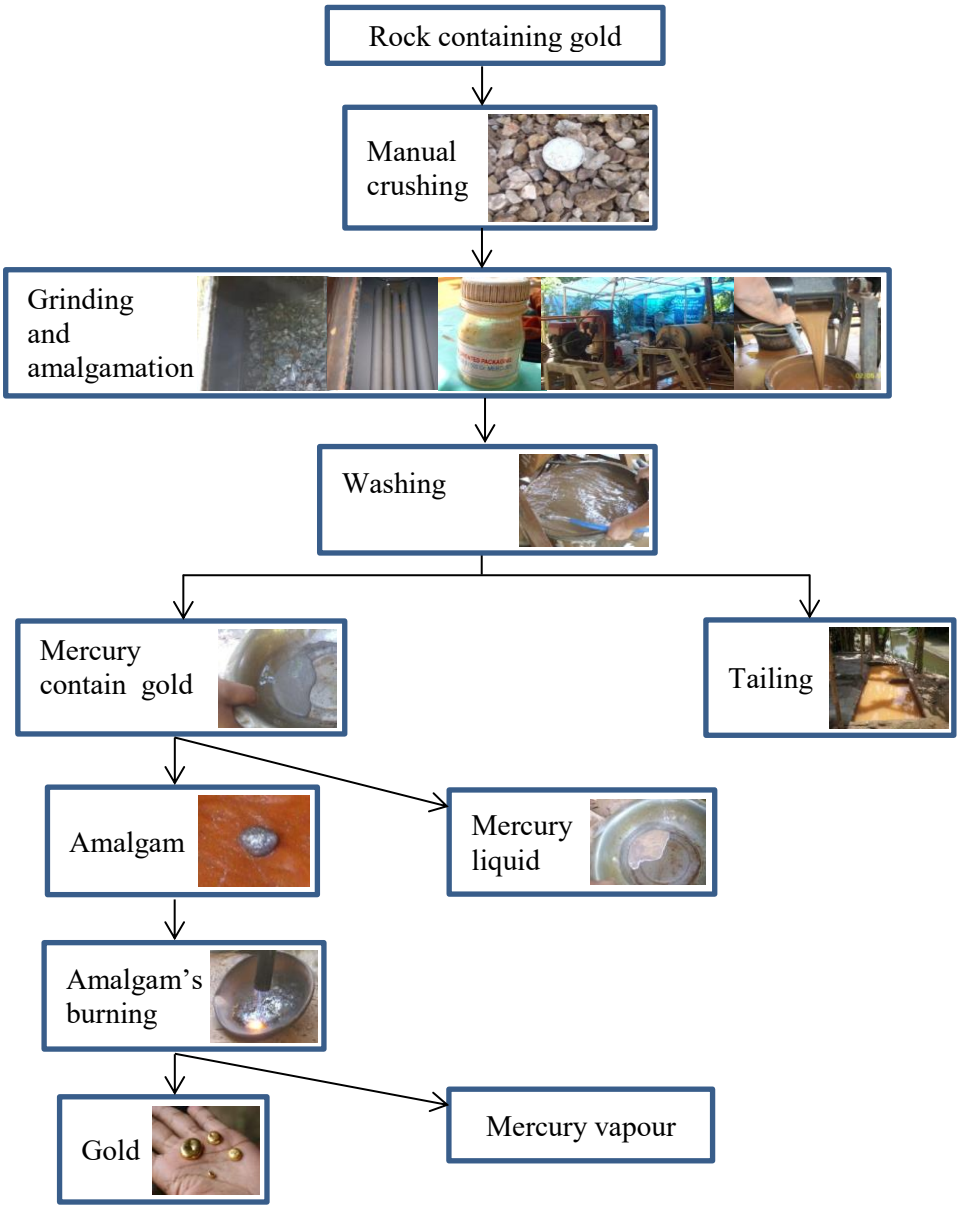

Figure 2. Stages of the amalgamation process

Seventeen samples from three villages (Sekotong Barat, Pelangan, Batu Putih) were taken to determine the mercury concentration in well water. The laboratory result analyzes are presented in Table 2.

Table 2. Mercury concentration in the water wells

Sampling location	Sample code	coordinate X	coordinate Y	Mercury concentration (µg/L)
Sekotong Barat	P1	-8.76231	115.94242	<0.06
	P2	-8.75565	115.94290	0.085
	P3	-8.73627	115.98121	<0.06
	P4	-8.74383	116.02115	<0.06
	P5	-8.74486	116.03246	<0.06
	P6	-8.74273	116.02940	<0.06
	P7	-8.76001	116.03776	<0.06
	P8	-8.76920	116.05309	<0.06
Pelangan	P1A	-8.77419	115.91129	<0.06
	P2A	-8.77560	115.91287	<0.06
	P1B	-8.77597	115.91483	<0.06
	P2B	-8.77815	115.92821	<0.06
	P1C	-8.77555	115.92870	<0.06
	P2C	-8.78059	115.93027	<0.06
Batu Putih	P1	-8.76493	115.88221	<0.06
	P2	-8.76871	115.88348	<0.06
	P3	-8.77102	115.89046	<0.06

Table 2 indicated that 94% of samples have mercury concentration less than 0.06 µg/L (0.06 is the lowest concentration that can be detect by the AAS), only one data with sample code P2 has mercury concentration higher than 0.06 µg/L. However, all mercury concentrations in well water are still below the threshold limit (PP Number: 82 Year 2001) which mean that the groundwater is not polluted by mercury. This result can be caused by some potential reasons such as 1) the direction of groundwater flow is not in the same direction as the well and the location of amalgamation, or if it is in the same direction, the water well location is behind the amalgamation so that when the tailing flows to the ground, it will not pollute the well water, 2) the amalgamation location and the tailing pond has been cemented so the seepage into the soil can be minimized.

The laboratory analyzes provide an early warning that there is an opportunity of mercury contamination from the amalgamation process with 6% possibility. In addition, due to the importance of water well as the community clean water sources then it is necessary to be aware of mercury bioaccumulation. Therefore, the good tailings management generated by the amalgamation process is importantly required to reduce and minimize the risks to human and the environment.

4. Conclusion

Artisanal mining contributes not only to the community incomes but also to environmental degradation. The community income of Sekotong village increased significantly due to the artisanal mining activities. However, the environmental risks of artisanal mining activities have increased noticeceably. One of the risks is associated with the community water well quality.

Mercury concentration in the ten community's well water indicated that mercury level was mainly below the Government threshold limit. However, the potential risks for mercury contamination are widely open due to poor tailings management. Further study is required to assess the mercury content in the river sediment.

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