Liquid waste pollution model and characterization levels from small-scale gold mining activities

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Abstract. Small scale mining system carried out by local residents in Bunikasih, Sukaluyu Village, Pangalengan District, Bandung Regency causes environmental pollution and long-term ecosystem damage. This is because the mining method does not follow the rules set by the government. To find out the amount of pollution that has occurred, this study was conducted. The research methodology used starts from taking field data samples, then analyzes the chemistry for clean water and waste chemicals. From this study it was found that the presence of heavy metal mercury (Hg) due to mining activities and processing of gold ore using amalgamation with values in the upper reaches of Ciwiwi River = 0.085 mg / kg, in the area of amalgamation gold ore processing = 0.11 mg / kg, and in the lower reaches of Ciwiwi River = 0.097 mg / kg.

1. Introduction
As a unified geological system of the Pacific Ocean basin, the Indonesian archipelago is surrounded by a ring of fire that stretches from Nusa Tenggara, Bali, Java, Sumatra, and continues to the Himalayas, the Mediterranean and ends in the Atlantic Ocean. This condition is since the Indonesian archipelago is located in the extension of the Eurasian plate in the southeast which is bordered to the south and west by the Indo-Australian plate and from the east bounded by the Philippine sea and the Pacific plate forming a horseshoe covering 40,000 km [1]. Tectonic conditions and geological systems have led Indonesia to become rich in natural resources, making it one of the largest producing countries for gold, copper, nickel and tin metal minerals. Specifically, gold mineral potential is found in several regions, including West Java, Cikotok, Pongkor, Jampong, Rejang Lebong (Bengkulu), Batu Hijau (Sumbawa-NTB) and others, which is part of the western segment of Sunda-Banda arc basin. transition, which extends from Sumatra to the north across Java and continues to Maluku to the east [2]. Under these conditions, gold mining is now being actively carried out in these areas by companies or communities on a large-scale mining or small-scale gold mining activities.

Regarding Small Scale Mining which is identical with the activities of the People's Mining, it cannot be classified as a People's Mining activity as referred to in the prevailing laws and regulations. This is due to not fulfilling the provisions, both legal aspects and technical aspects that refer to the concept of good mining practice [3]. People's mining has caused many problems and losses, including environmental damage and pollution that cause ecosystem losses for the long term. This, as can be seen in the field, the community conducts mining and processing of gold ore using the "amalgamation" method. Liquid waste from processing (extraction) of gold ore in this way still contains heavy metals that are quite high and directly discharged into the receiving water body without being treated in...
advance, thus polluting the surrounding aquatic environment [4]. According to Mahesh Mohan, et al., presumably after the launch of the industrial revolution in the 1900s, heavy metal mercury (Hg) is a global contaminant because of its strength and nature that can pollute the environment across borders and potentially polluting the bio-accumulated environment. Besides heavy metals Hg in the environment can spread widely through air, water, snow/glaciers, soil and sediments [5,6]. With the conditions described above, it is necessary to conduct research aimed at determining the model and characterization of the level of liquid waste pollution from community gold mining activities in Bunikasih Village, Sukaluyu Village, Pangalengan District, Bandung Regency, West Java. The intended model is in the form of a pollution level map, while the intended characterization is a water analysis of pollution, so that the level of river water pollution that can occur is modeled and how solutions can be produced.

2. Methods

The research methodology carried out is divided into two stages, namely the first stage is the compilation and analysis of secondary data consisting of literature studies such as reading reference books, journals, seminar results papers or previous research results, especially those related to the topic of this research. Next is primary data collection, which is obtained by conducting research directly in the field and in the laboratory. This is needed to add and complete existing data so that it can support problem solving when discussing and determining conclusions.

3. Results and discussion

3.1. Procurement of samples of rock, water and river mud

This research was conducted to determine the level of pollution of the area where the people's mining activities are located, to obtain a description of the level of pollution, samples were taken, namely the rock or gold ore itself, water and sediments (mud) of river sediments both upstream or downstream and near the people's gold mining activities are located. Observations on bedrock and mineralized rocks exposed on the surface by observing and describing outcrops in the field or in mineralogy laboratories. Taking bedrock samples is done to find out the source of the presence of minerals containing metal mercury and other heavy minerals that can become liquid waste due to geological activity [7].

Samples were taken using channel sampling in the zone of mineralization (vein). Extraction of sediment (sludge) originating from sedimentary rocks and tailings found in rivers in the zone of weak flow of water. Sediment sampling is carried out in each zone of weak flow of river water by sampling at a thickness above 5 cm. Sediment sludge samples were taken for the purpose of analysis to find out the presence of metal minerals found in the river that affected the results of processing activities or from bedrock. While the river water itself can be an indication of its contamination, it is necessary to analyze the existing liquid waste and enter the river. The object that is the target of this research is in river water where the river water can carry and dissolve metal minerals and bring it downstream so that the river is said to be polluted [8]. So that in zoning the sampling area can be divided into three zoning. The first zoning is upstream, the second zoning is the zone where the people's mining activities are located and the third zoning is downstream of the river. Sampling is carried out on bedrock around the river and against the rock or gold ore itself, this is done in addition to knowing the gold content also to determine the presence of heavy metals, especially Hg which allows association with gold metal which can increase the level of water pollution.

The choice of sampling method and taking a number of samples to be taken depends on several factors, among others: Deposition type, dispersion pattern, and sediment size. Stages of work and evaluation procedures. Location of sampling (in the zone of mineralization, alteration). The depth of sampling is related to the location and condition of the host rock, and the budget for sampling and the value of ore.

With the acquisition of the example above, it can be carried out studies and analysis so that the model of pollution from liquid waste can be determined based on the level of pollution, namely by comparing the quality standards in accordance with the applicable legislation, especially heavy metals Hg that
exceed the threshold value in the body designation River water. Figure 1 is photos of activities during sampling conducted in April 2018.

3.2. Results of sample analysis

The mining location and processing process are located around the Ciwiwi River, considering that in the amalgamation process many require water medium both as a mixture of grinding processes.

![Figure 1. Research activities in April 2018.](image)

Taking rock samples, carried out on the river wall and slightly upstream from the river and upstream from amalgamation processing activities. In addition, rock samples are taken from mining openings in the form of tunnels and / or shafts measuring 1.8 meters wide by 1.8 - 2 meters high and mining depths of 150 meters from the ground. Examples taken from the mining section are bedrock. Whereas the sampling of sludge from weathered rock and tailings from the deposited amalgamation process is carried out in a location close to the presence of ore processing activities, with a distance of ± 50 meters downstream.

Examples of mud taken at the upstream location of the amalgamation treatment process are obtained by using stream sediment sampling method, with sampling locations being in the weak current river water zone so that it is expected that sludge deposits can represent other sludge / rock. The results of the mud samples taken were then tested in the Laboratory, Faculty of Civil and Environmental Engineering, ITB with the results of the analysis containing heavy metals mercury of 0.085 mg / kg.

Examples of river water in the upstream are media that can be an early indication of whether or not there is contamination by wastewater from gold ore processing activities with amalgamation methods. Against the river water at the headwaters of the Ciwiwi river, it was taken in the weak current section which was then analyzed at the Water Quality Laboratory, Faculty of Civil and Environmental Engineering, ITB with the results containing 0.07 ppb of Hg heavy metals. While the results of the physical and chemical analysis of water on the water samples at the headwaters of the Ciwiwi river were carried out in the Water Physics and Chemistry Laboratory, the Geological Agency.

Examples of mud (soil sludge) taken 100 meters downstream from the location of the amalgamation treatment process were obtained using the stream sediment sampling method, with sampling locations being in the weak current river water zone so that it is expected that deposits will be truly representative. The results of the samples taken were then tested in the Laboratory, Faculty of Civil and Environmental Engineering, ITB with the results of the analysis containing heavy metals mercury of 0.097 mg / kg.

In the figure 2 can be seen the location of the sampling point of rock bedrock, rocks on the side wall of the river, gold ore, examples of water and mud from the Ciwiwi River. In the picture, it can also be
seen also the points of distribution of amalgamation of gold ore processing sites carried out by the community.

3.3. Model of Hg pollution in research areas
From some of the data obtained from samples taken both upstream, in the area where the processing of gold (amalgamation) ore and downstream, the distribution of contaminants of heavy metal mercury (Hg) contaminants around the Ciwiwi River can be seen from upstream to downstream including in areas where miners spread gold ore by using amalgamation methods using mercury (mercury / Hg). In Table 1, we can see the distribution data of mercury heavy metal contaminants (Hg) in the upstream area, the area where the processing of gold (amalgamation) ore and in the downstream area both from water and sediment sludge. Whereas in figure 3 can be seen a map of the pattern of distribution of heavy metal contaminants Hg.

Table 1. Distribution of Mercury (Hg) heavy metal contaminants.

| No. | Sampling location          | Hg Content In Mud Deposition (mg / kg) | Threshold value (*** | Lab Analysis Results (*) | Hg Content In Water River (ppm) | Threshold value (** | Lab Analysis Results (*) |
|-----|---------------------------|---------------------------------------|----------------------|--------------------------|---------------------------------|----------------------|--------------------------|
| 1   | Up Stream River (Point 1) | 0,045                                 | 0,005                | 0,00007                  |
| 2   | Up Stream River (Point 1) | 0,085                                 | 0,005                | 0,00007                  |
| 3   | Gold Ore Processing Area  | 0,11                                  | 0,005                | <0,00007                 |
| 3   | Down stream River         | 0,097                                 | 0,005                | <0,00007                 |
Figure 3. Map of the pattern of metal contaminant spread of Hg.

4. Conclusion
From the results of observations, tests and analyses of collected data, this study concluded that the presence of heavy metal mercury (Hg) due to mining activities and processing of gold ore by using amalgamation in research objects was quite significant in polluting the environment, as evidenced by several water and sediment samples soil sludge taken in Ciwiwi River, especially soil sludge containing heavy metal mercury (Hg) with a value above the threshold, namely in the upper reaches of the Ciwiwi River = 0.085 mg / kg, around the amalgamation gold ore processing area = 0.11 mg / kg, in the lower reaches of Ciwiwi River = 0.097 mg / kg. For examples of upstream water containing heavy metal mercury (Hg) = 0.07 ppb, around the gold ore processing area <0.07 ppb and downstream <0.07 ppb. With regard to the conditions as described above, therefore by considering numbers or data and after comparing with the quality standard, the Ciwiwi River has been categorized as mercury-heavy metal contaminated so that it is not suitable for any activity.

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