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To cite this article: M Amiruddin *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **343** 012002

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Environmental impacts due to unlicensed gold mining: Poboya, Central Sulawesi case study

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Abstract. This study aimed to analyze the impact of the mining site on biological, physical-chemical, and social aspects in Poboya. The method used to analyze the impact of mining is quantitative analysis on biology, physical-chemical, and social aspects. The results show that the impact of mining in this study site has changed the biology, physical-chemical, and social community aspects. The results of forest vegetation analysis show that there had been a loss of tree-level plants and poles on the post-mining land. Besides, there had been a loss of *Ficus sp.* plantation on the post-mining land, which was a plant with the highest INP. The result of diversity index analysis of Poboya River plankton showed that in the upstream part falls to a medium polluted category that was in the range of 1.0-1.5, while on the upstream falls in the category of heavy pollution that was in the range 1.0-1.5<1.0. The plankton uniformity index (E) showed upstream and downstream fell in the stable category E>1. The result of dominance index analysis (D) showed that the type of plankton in the upstream area and that was D=1. Physical-chemical changes seen from soil mercury contents indicate that the mercury content of the soil had exceeded the critical limits. In the land, the mercury content was 0.7784 ppm, while the area of mercury mixed plantation content and paddy fields were 0.9916 ppm and 1.1788 ppm, respectively. Moreover, it could be concluded that the social perception of the implementation of people mining policy was in a not good category.

1. Introduction

Poboya is a sub-district area in Palu, Central Sulawesi, Indonesia, with a potential of the natural resource of a gold mine as an asset for the surrounded society. This potential becomes a magnet for the community in that area to exploit it. Base on the Ministry of Energy and Natural Resources data, there are approximately 7000 persons in 2009 explored at the gold mine in Poboya traditionally. The main problem in public mining in Poboya was continuing. It because those activities conducted without any official permission. If this unpermitted exploitation continued in such an extended period, it would cause adverse impacts to the environment. The existence of this unpermitted gold mine caused the problem of how far the sustainable effect of this activity not arranged by the local regulations and affected on biology, physical-chemical, and social aspects in Poboya.



2. Methods

This research measured biology, physical-chemical, and social aspects [1]. The biology aspect measurement was conducted by collecting data of terrestrial such as the primary data of forest vegetation and aquatic from planktons as the sample [2]. The physical-chemical aspect was measured from primary data by collecting samples of mercury (Hg) taken from soil; as well as the indicators of pH, BOD, COD, DO, sanitary, conductivity, and turbidity from a water sample of the river [3]. The social aspect assessed by interviewing the society about their perception of the policies of the local government regarding public mining [4].

3. Result and discussion

3.1. Biological Aspect

The transfer of land functions from the forest into the mining field caused the degradation of vegetation composition on the population, biodiversity, and species of all existed vegetation. The specific amount of seedling, stake, pole, and tree in the undisturbed area were decreasing its function when the area transforms into the mining field. This was also seen in the Poboya mining area when comparing forest vegetation between before and after mining.

According to the result of vegetation analysis, it found several types of plants (seedling, stake, pole) at the pre-mining forest, which very was different with the data collection at the post-mining area where only seedling and stake existed. The degradation of the plants during pre and post-mining activity is presented in table 1.

Table 1. Amount of plant pre and post-mining activity

Location	Individual Amount/Ha				Total/Ha
	Tree	Pole	Stake	Seedling	
Pre-mining	65	180	1,120	13,750	15,115
Post-mining	0	0	880	8,800	9,680

Ficus sp. is a parameter of a plant with the highest role in a community. At the pre-mining forest, it was found a plant with tree level at *Ficus sp.* area with the highest INP up to 84.24%. However, in the post-mining area, *Ficus sp.* was not found anymore. The loss of *Ficus sp.* vegetation was most likely caused by mining activities occurring in that area. Furthermore, *Ficus sp.* had the highest INP index (64,681 %) in the pre-mining forest area while in the post-mining forest area, the type of plant that had the highest INP value was *Leucaena glauca* (93,610%).

Based on the results of laboratory tests, 22 types of plankton were identified in the watershed, consisting of 12 types of phytoplankton and ten types of zooplankton. In the upstream section, 15 types of plankton had been identified while in the downstream areas, there were 16 types have been identified. The Diversity Index (H') is used to determine the biodiversity of the biota under study. In principle, the higher the index value, the more diverse the community in the waters. The results of this study indicated that in the upstream section of the river, the index value of H' ranged between 1.02393-1.18525 with an average value of 1.135126 (table 2). This inferred that the H' index in that section was in the range 1.0-1.5. Base on table 3, this condition is included in the medium polluted category. The H' index in the downstream ranges from 0.4179-1.25199 with an average value of 0.906227 (table 2). This shows that the downstream part of the river is included in the heavily polluted category (table 3).

Table 2. Biodiversity, uniformity, and dominancy index

	Upstream					Downstream				
	US 01	US 02	US 03	US 04	US 05	DS 01	DS 02	DS 03	DS 04	DS 05
H'	1.1374	1.0239	0.9824	1.0414	1.1853	0.4179	0.8788	1.2058	1.0470	1.2520
E	0.3935	0.4908	0.3723	0.3845	0.4377	0.2148	0.4226	0.5488	0.5034	0.6021
D	1.0000	1.0000	1.0000	1.0000	1.0070	1.0000	1.0000	1.0000	1.0000	1.0000

Table 3. Water quality based on the diversity index

Contamination Level	Diversity Index
Not contaminated	> 2,0
Low contaminated	1,6 – 2,0
Medium contaminated	1,0 – 1,5
High contaminated	< 1,0

The uniformity index (E) shows the distribution pattern of plankton that is evenly or not. If the value of the relative uniformity index is high, the existence of each type of biota in the waters is evenly distributed. If the value of E=0, the uniformity structure is low, whereas if E=1 then the uniformity structure is relatively uniform. Table 3 reveals that the E index was still in low condition. In the upper section of the river, the index E ranges from 0.37226 to 0.437677 with an average value of 0.415. While in the downstream, the E index ranges from 0.21476 - 0.602079 with an average value of 0.458. Thus in the downstream uniformity index is in a low category.

Dominance index (D) is used to show information about the type of plankton that dominates in a community. If the value of Index D approaches 0, then there is no type that dominates, and vice versa if the value of Index D approaches 1, then there is a type that dominates. The data in table 3 shows that the D index at all points, both upstream and downstream has an average value of D = 1. This shows that in the upstream and downstream areas, there is one type of plankton that dominates the other types.

3.2. Physical-chemical Aspect

Based on the results of laboratory testing, the lowest mercury (Hg) content was found in residential land (0.7784 ppm) (figure 1). That was because the distance of the settlement was not too far from the Poboya gold processing area. However, the value of the Hg content has exceeded the critical limit. The Hg content that has exceeded the critical limit in residential land needs serious attention. If not, the mercury would be absorbed into the well, which could endanger the health of both humans and animals that consumed water from the contaminated well [5]. Hg content in mixed plantations and rice fields were 0.9916 ppm and 1.1788 ppm, respectively (figure 1). The Hg content in these areas was also relatively high and had exceeded the critical limit. The high content of Hg in the area was caused by the location of rice fields, which was also quite close, which was just below the area of processing of gold Poboya. This needs serious attention. The Hg that was absorbed by plants could endanger people's health when consuming these plants. The highest Hg content was found in the area near processing which was an open area that was overgrown with wild plants in the form of bushes and the residence of some workers (4.06 ppm) (figure 1). The high Hg content in the field was due to the soil sampling done near the Poboya gold processing area [6].

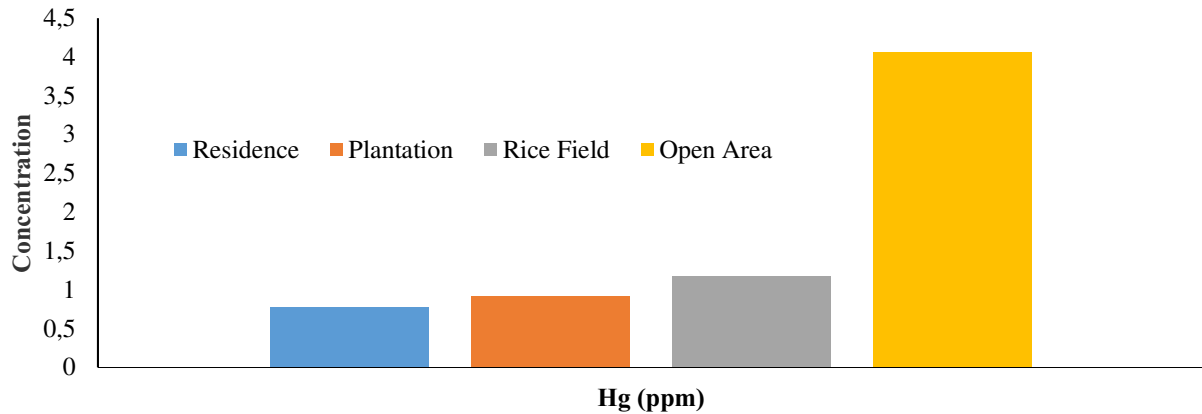


Figure 1. Content of mercury (Hg) in Soil

Figure 2 shows the results of the pollution index analysis between upstream pollution index values ranging from 0.003 to 0.81, with an average value of 0.268 ($0 \leq P_{ij} \leq 1.0$). This shows that the upstream area of the Poboya River was still in good condition. The pollution index in the downstream areas was higher than in the upstream. Values range from 0.92 to 1,447 with an average value of 1.22 ($1.0 < P_{ij} \leq 5.0$). This shows that the downstream area of the Poboya River was in a mild polluted condition, according to Minister of the Environment Decree No. 115 of 2003 concerning Guidelines for Determination of Water Quality Status. The Poboya gold mining processing waste not being discharged directly into the river, but the waste is disposed of in a temporary container, so that river water is not significantly polluted causes this mildly polluted condition.

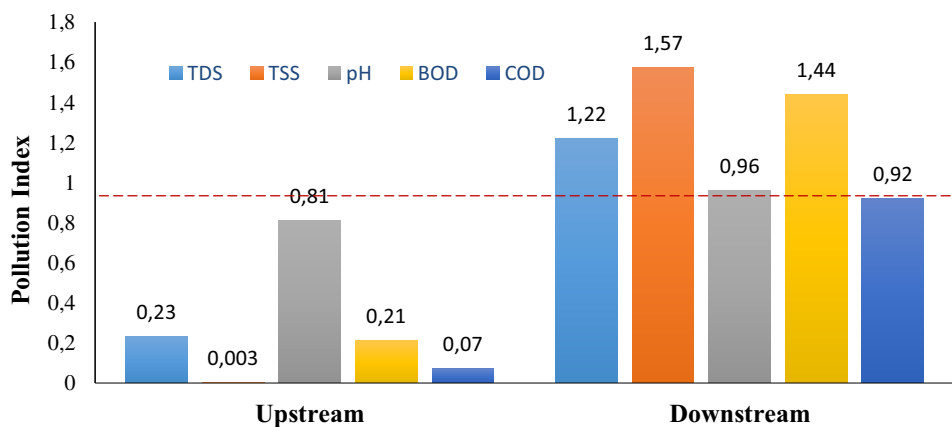


Figure 2. Pollution index of Poboya River

3.3. The Perception of the Inhabitant

In general, community perceptions of the implementation of mining policies in the Tahura Region, the implementation of community mining permit policies, environmental control, and community perceptions of the negative impacts of mining, were in the range of 26-50 (figure 3). It could be said that people's perceptions of the implementation of people's mining policies fall into the bad category. This means that the public had not been able to accept the policy properly. This perception could be an obstacle to the implementation of the policy so that it could have an impact on the effectiveness of the policy itself. This can lead to the implementation of policies running in vain because people are less aware of the contents of the policy. Diana [7] suggested that community participation is so crucial that it is needed because community participation is a tool for obtaining information about the conditions of community needs and attitudes. Without community participation, the development program will fail. Besides, the community will trust the development project or program more if they feel involved, starting from the process of preparation, planning, and implementation.

Based on this explanation, the Palu City Government needs to improve the quality of socialization of the people's mining policies to the mining community both in terms of quality and quantity.

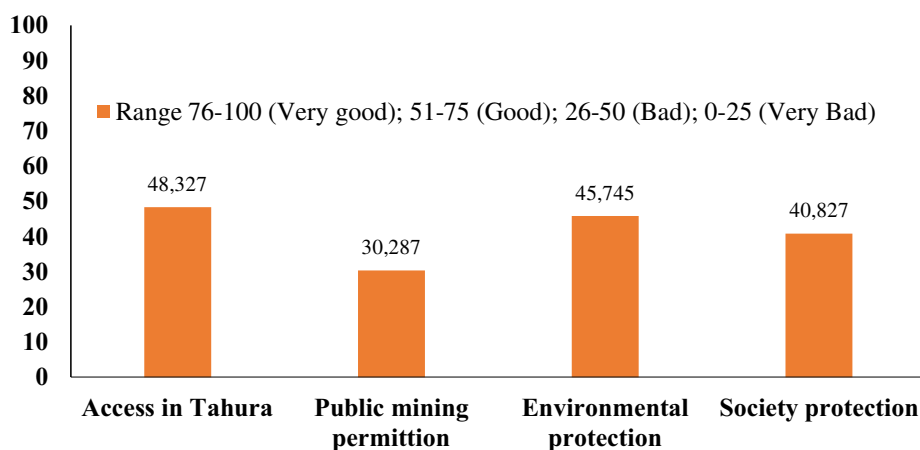


Figure 3. Inhabitant perception about public mining policies

4. Conclusion

Biological aspects show that there had been a decrease in the composition of vegetation, population and species diversity in all vegetation growth and loss of some plant species due to the conversion of land functions that were initially a forest into mining activities. In addition, there had been a change in plankton in the downstream Poboya River, which tends to decrease both in terms of abundance, diversity, uniformity, and dominance compared to the upstream Poboya River. The downstream section of the river was categorized as heavily polluted.

Physical-chemical aspects indicate Hg pollution has occurred in the land in residential areas, plantations, rice fields, and open land in the area around the mining location with Hg contamination above the threshold. There has also been an increase in the river water pollution index downstream (mildly polluted). If there is no serious attention, it can endanger human health.

Public perception of the implementation of community mining policies is in a bad category. This means that the community has not been able to accept the policies decided by the regional government

so that it is necessary to improve the quality of the socialization of the people's mining policy to the mining community.

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