The effect of amalgamation process to the community water wells: a case study in Pelangan Village, Sekotong, West Lombok

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Abstract. One of the artisanal mining locations in West Nusa Tenggara Province is Pelangan Village, Sekotong Sub-district, West Lombok District. There are two main activities in the artisanal mine site, namely mining operations and material processing, that commonly use logs and mercury (Hg). This study aims to determine the effect of differences in log spacing from mercury content in well water at Pelangan Village, Sekotong Sub-district. This study uses the Cross-Sectional research method to obtain an overview of mercury levels in the Pelangan Village of Sekotong Sub-district based on distance and to determine the differences in variables using Chi-Square statistical test. The results showed that 46 water wells had mercury levels less than 0.001 mg/l and 8 water wells had mercury levels more than 0.001 mg/l. From the results of chi-square analysis, the Pearson Chi-Square value was 6.541 with df = 1 and a significant value less than 0.05. The Chi-Square value concluded that there is an effect between the distance of the log and the mercury content of the community water well. To avoid the mercury pollution, three strategies should be applied including distance of water well from the pollution source should bigger than 95 meters, the best distance, and replacing mercury with something that more environmentally friendly.

1. Introduction

West Nusa Tenggara (NTB) Province has large natural resources. One of the potential natural resources owned by NTB is mineral mining. Therefore many people do mining activities, both metallic minerals and non-metallic minerals and rocks. One of the artisanal mining locations in NTB is in Pelangan Village, Sekotong Sub-district, West Lombok Sub-district with gold mining material [1].

Sekotong Sub-district is an administrative area of West Lombok Sub-district. The artisanal mining activities in Sekotong have been carried out since 2008 and most of the gold mining activities do not have a license (PETI). The artisanal mining is done by using techniques and simple tools. The mining activities carried out are high risk because they do not pay attention to occupational safety and health. The local community does not carry out excavation activities but also processing of mine products using dangerous chemicals (mercury). Therefore, the overall mining activities carried out by the community not only fail to comply with occupational safety and health but also fail to pay attention to environmental aspects. As result, environmental damage and pollution occur.

Mine material processing is done by using amalgamation techniques, i.e. mixing mining material which has already mixed by using mercury (Hg) in the water as media, using log tools to form amalgamation (Au-Hg alloy metal) [1] [2]. The amalgamation process is used widely by local
community miners because the method is very cheap, the cost is very low, it does not require complicated and expensive equipment and the recovery of gold is relatively high. At present, the number of logs in the Sekotong area is 832 units and 321 units of them are in Pelangan Village [3]. The amalgamation process produces the remaining of the processing (tailings). This tailings will cause pollution if it is directly disposed of to the environment or water without prior treatment. In the gold amalgamation process, mercury can be released into the environment in the stages of washing and burning/panning. In the washing process, the waste which generally still contains mercury is disposed of directly into the water. This causes mercury to be mixed/split into fine grains that are difficult to separate in the grinding process, which is done together with amalgamation process. That is why the washing process of mercury in the pulp is carried into the river [4]. Tailings that are disposed of to the environment will be deposited on the surface causing the absorption of mercury pollution into the soil and to the groundwater through crevices brought by rain into the ground. The distribution of chemicals groundwater will follow the pattern and direction of groundwater flow. The pattern of chemicals distribution in water pollution will spread to 25 meters and will then have a narrowing of the distribution starting at 26 meters to a total distance of 85 meters [6].

The level of mercury pollution is assessed based on the concentration of mercury around the well. Heavy metal mercury (Hg) is very dangerous for aquatic ecosystems. Heavy metals that enter the aquatic environment will experience precipitation, dilution and dispersion, then absorbed by organisms that live in these waters [5]. Mercury in the waters will be converted into methyl mercury by certain bacteria. This process is call biomethylation.

The purpose of this study was to determine the effect of spacing toward mercury (Hg) levels of water in the wells in Pelangan Village, Sekotong District, West Lombok Sub-district.

2. Method
This type of research is an observational analytic study, namely a study conducted to determine whether there is an influence of spacing distance toward mercury levels in the water. This research was conducted using cross-sectional method and using the chi-square statistical test. The cross-sectional method was used to obtain a description of mercury levels in well water based on the distance in Pelangan Village, Sekotong Sub-district. While the chi-square statistical test is used to determine the difference in variables. The dependent variable is the mercury content from the pollutant source, while independent variable is the distance of the well location from the pollution source.

The population is the total number of analysis units whose characteristics will be predicted. The population in this study was water from people’s water wells in Pelangan Village. The number of water wells is 54 water wells. The sample is a portion of the population whose characteristics are investigated or measured. The object of this research is the water wells, which includes the height of the well wall, the height of the well’s opening, the condition of the well floor, the distance of the well from the source of pollutants and the nitrite contained in the water wells.

To determine the content of nutrients in water wells, sampling and testing should be done. A water wells water samples are taken with grab sample water, i.e. samples that are selected directly from the water source understudy and only describe the characteristics of the water at the time of sampling process [6]. All of the data obtained will be tested by using a computer application. The data obtained based on laboratory tests were then analyzed using univariate analysis, which aimed to describe the characteristics of each variable studied.

The pattern of distribution of chemicals in the pollution toward the water spread at a distance of 25 meters and will then experience a narrowing of the distribution starting from 26 meters to a total distance of 95 meters. The distance of the log with the well is grouped into two, i.e. the distance < 95 meters is the distance that meets the requirements and the distance > 95 meters is the distance that does not meet the requirements. As for the levels of mercury in well water is classified into two, namely < 0.001 mg/l that meets the quality standard and > 0.001 mg/l that does not meet the quality standard [7]. The standard quality for mercury levels is based on the Minister of Health Regulation Number
492/Menkes/Per/IV/2010 concerning Drinking Water Quality Requirements. From the data obtained is then performed data analysis with computerized techniques using the SPSS program.

3. Result and Discussion
In Pelangan Village, Sekotong Sub-district, West Nusa Tenggara Sub-district, there are 54 water wells and 321 units of logs. From this data, samples were taken from 54 existing water wells and laboratory testing was conducted to determine the level of mercury in each well. In the first stage data, as many as 54 water wells were tested for data validation. Data validation is shown in Table 1.

| Description    | Cases      |          |          |          |
|----------------|------------|----------|----------|----------|
|                | N          | Percentage (%) | N          | Percentage (%) |
| Distance * level | 54        | 100%     | 0        | 0%       |

Based on the result, it is known that the number of samples was 54 (100% and no data was lost, or there was no data. This means that no data is missing when the data was collected. From the results of laboratory testing, it was found that the concentration of mercury in the water of each well was different. The test result can be seen in the following table 2;

| Parameter | Mercury Level < 0.001 mg/l | Mercury Level > 0.001 mg/l |
|-----------|----------------------------|---------------------------|
| Total     | %                          | %                         |
| Mercury (Hg) | 46                  | 85.19                   |
|           |                           | 8                        |
|           |                           | 14.81                    |

Table 2. Mercury testing result

Total of 54 wells indicated that the mercury levels in 48 water wells < 0.001 mg/l and 8 water wells mercury levels > 0.001 mg/l. This means that the mercury in 8 water wells exceeds the quality standard. From the test results, cross-test with water wells and log spacing wan concluded. The result of the cross tests are shown in the following table 3;

| Description | Level         | Cases |
|------------|---------------|-------|
|            | Mercury Level |       |
|            | < 0.001 mg/l  | 0.001 mg/l |
| Total      |               |       |
| Distance   | Distance > 95 meters | 37 | 3 | 40 |
| Distance   | Distance > 95 meters | 9 | 5 | 14 |
| Total      |                | 46 | 8 | 54 |

Table 3. Cross-test between Log Spacing and Mercury Levels

From the cross table between the distance and mercury level in table 3, it is known that the distance of the log with water wells > 95 meters is 40 water wells and the distance of log with water wells < 95 meters is 14 wells. From 40 wells that are > 95 meters away, there are 3 wells that have mercury levels exceeding the quality standard. While from 14 wells < 95 meters apart, there are 5 wells that have mercury levels exceeding the quality standard.

From this cross-test it was found that only 37 wells were eligible, namely the distance to the log location > 95 meters and the mercury content < 0.001 mg/l from 54 existing wells. This means that 17 wells do not qualify to increase from s distance or from mercury levels. In the next stage, an analysis
was performed using chi-square. The result of the chi-square analysis can be seen in the following Table 4.

Table 4. Chi-Square Tests

| Description                | Value   | df | Asymp. Sig. (2-sided) |
|---------------------------|---------|----|-----------------------|
| Pearson chi-square        | 6.541*  | 1  | .011                  |
| Continuity correction     | 4.497   | 1  | .034                  |
| Likelihood ratio          | 5.744   | 1  | .017                  |
| Fisher’s exact test       |         |    |                       |
| Linier-by-linier association | 6.420  | 1  | .011                  |
| N of valid cases          | 54      |    |                       |

Based on the chi-square test results, it is obtained that the Pearson chi-square value was 6.541 with a value of df = 1 and a significant value < 0.05. The Pearson chi-square value (calculate chi-square value) is then compared with the chi-square value in the table. From the comparison result obtained, the Pearson chi-square value is greater than the value of the chi-square table, which means that there is an influence between the distance of log and the mercury (Hg) levels in the water wells of Pelangan Village, Sekotong Sub-district, West Lombok Sub-district.

The closer the water wells is to the log location, the more it is to cause pollution. Wells provide water that comes from the ground that is relatively close to the surface of the soil so that it is easily contaminated through seepage from pollutant sources. Water in a river that is polluted by wastewater will result of leakage and infiltration at the bottom of the river, the waste flows into the soil and pollutes areas in the soil, so this certainly creates a risk of causing groundwater pollution in water wells [6].

Based on the result of field observations, there are several log locations right next to villages' houses and the distance from the water wells is quite close. It can also contribute to mercury levels in water wells water. If the location of the water wells is at the bottom of the location, the mercury along with the groundwater will flow to reach the water wells underneath. So when placing the position of the log location must also pay attention to the pattern and direction of groundwater flow. In addition to the pattern and direction of groundwater flow, the construction of water wells can also affect the levels of mercury in water wells water. Because of the construction of a water well, it is difficult for pollutants carried by water to seep into the water well.

Pollution caused by chemical substances can reach a distance of 95 meters. Thus the water source in the community should be more than 95 meters from the chemical disposal site. The closer to the source of pollutants, the more risk of pollution in water wells water [8] [9]. From the result of research conducted, it is necessary to make efforts to prevent more and more water wells water contaminated by mercury. Some of the efforts that can do are the placement of the logs must be far from the community water wells with a distance of > 95 meters and also to pay attention to groundwater flow patterns, to replace dangerous chemicals (mercury) with environmentally friendly chemicals and provide guidance and technical assistance related to managing gold processing and dangers of mercury to the environment and public health.

Mercury is a chemical element that is difficult to experience weathering processes either physically, chemically or biologically (resistant to breaking down). Mercury is toxic to all living things and is difficult to decompose. Mercury cannot be destroyed by the digestive system or blood vessels, even though the amount is very small. If accumulated in the body, it will have a serious impact on health. The impact on each person will be different depending on age, the amount of mercury that enters the body, the part of the body which is exposed to it and how long the mercury has been exposed to the body.

Knowing the nature of mercury which is very dangerous for the environment, humans and other living things, it is necessary to make an effort to improve the environment so that no damage can occur.
which can worsen the condition. To overcome this condition, it requires the cooperation of various parties and government assertiveness related to the use of mercury, especially in the amalgamation process carried out by the community in Pelangan Village, Sekotong Sub-district, West Lombok Sub-district.

4. Conclusion
The study concludes that the mercury level ranged between < 0.001 mg/l (46 water wells) to > 0.001 mg/l (8 water wells). The statistical analysis showed that there was a correlation between the distance of community water wells from the amalgamation process and the level of Mercury. The presence of Mercury in the community water wells should be taken as an early warning of the amalgamation impact. This impact should be managed shortly to prevent the environmental risks that might affect humans and environment. The proper strategy is also required by involving all relevant stakeholders in provincial and national levels.

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