Analysis of water pollution index around gold mining in the downstream of Krueng Kluet sub-watershed

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Abstract. Water is one of the primary needs of every living creature. With the increase in population, the need for water continues to increase. The declining water quality caused by human activities is one of the world's concerns. This study examines river water quality status in the gold mining area in the downstream of Krueng Kluet sub-watershed. The method used to determine the level of river water pollution is based on the Decree of Minister of Environment Number 115 the Year 2003, which uses class 1 water quality standards according to Government Regulation of The Republic of Indonesia Number 82 the Year 2001. The results show that river water in the study area is in the category that is not polluted or fulfills water quality standards for drinking water and daily needs.

1. Introduction

Water is an essential resource for human life, and water has great benefits for humans, such as household needs, agricultural irrigation needs, and others. Along with the increased population in the world, the water demand is increasing. On the other hand, the presence of water tends to decrease. Therefore, effective and efficient water use is needed to fulfill the level of water demand [1]. Mining activity is one of the industrial projects with a very profitable business; on the other side, this activity can affect their environment [2]. Gold mining also has a negative impact on water sedimentation, land cover degradation, deforestation, soil degradation, and contamination of heavy metals such as mercury, iron, and zinc [3].

In gold mining activity, one of the extraction processes is breaking crystallographic bonds within each mineral to improve the element or compound required [4]. Some heavy waste with large quantity produced by gold mining in the world, minerals extracting process in gold mining is released to the environment around mining area as waste, reach over 99% [5]. Heavy metals are one of the wastes that have been implicating in around mining area; one of the negative impacts of the mining sector is heavy waste which attracts the attention of researchers to observe it because them effect are hazardous to plants, animals, and humans [6].

The river is one of the irrigation water sources commonly used by the community to fulfill plants needed for water. Heavy metal contamination such as mercury (Hg) in irrigation water can negatively impact, such as a decrease in the quality of crop production. Water contaminated by heavy metals and then used for irrigation purposes can contaminate plants so that it can harm humans who consume the crop [7].
The downstream of Krueng Kluet sub-watershed is part of the Krueng Kluet watershed in the Baru – Kluet River Basin. In this sub-watershed, some gold mining activities are carried out by the community and the mining industry. Some of these mining activities are carried out in Kluet Tengah District, South Aceh Regency. Exploitation activities have been started since 2009. Mining activities often do not follow mining procedures determined by the government. Many miners violate the area or land permitted for mining so that many exceed or exceed the area determined by the government [8]. Mining activities are carried out on the outskirts of river bodies so that waste and minerals that are no longer used are disposed of directly into water bodies. This can reduce the quality of river water in the area and can affect the status of river water quality for various purposes such as household use and irrigation

2. Materials and methods

The tools and materials used include the Global Positioning System (GPS), sample bottles, stationery, camera, tools needed for analysis in the laboratory, ice boxes, maps of sampling points, water samples, and materials used for sample analysis. In the laboratory. This research uses a descriptive method by collecting samples at several predetermined points. Water sample points are shown in Figure 1.

![Figure 1. Map of sample point at research area.](image)

River water samples were taken using the SNI 6989.57:2008 method regarding the surface water sampling method. Analysis of water samples was carried out at the Laboratory of Research and Industrial Standardization of Banda Aceh. The indicators analyzed include Electrical Conductivity, Turbidity, pH, Sodium Adsorption Ratio, Salinity, Total Fe, Total Ca, Total Mg, Total Na, Mercury, Lead, and Copper. Determination of the river water quality status can be done using the pollution index method as stated in the Decree Minister of the Environment Num. 115 the Year 2003. The formula used to determine the level of river water pollution is as follows:
\[ Plj = \sqrt{\frac{(Ci_{ij})^2 + (Li_{ij})^2}{2}} R \]  

(1)

Where,
- \( Plj \) = Pollution index
- \( Ci \) = Concentration of water quality parameters based on laboratory test results
- \( Li_{ij} \) = Concentration of water quality parameters based on the designation quality standard j
- \( M \) = Maximum
- \( R \) = Average

### Table 1. Pollution Index Criteria (PI).

| No | Pollution Index Criteria (PI) | Explanation |
|----|-----------------------------|-------------|
| 1  | \( 0 \leq PI \leq 1.0 \)     | Fulfilled quality standard |
| 2  | \( 1.0 < PI \leq 5.0 \)     | Slightly polluted |
| 3  | \( 5.0 < PI \leq 10 \)     | Fairly polluted |
| 4  | \( PI > 10 \)              | Heavily polluted |

Source: Minister of Environment Decree No. 115/2003

The standard of each parameter is used from Government Regulation of the Republic of Indonesia No. 82 of 2001 concerning Water Quality Management and Water Pollution Control in class I for household water purposes (Table 2). The geographical coordinate point of the research location is shown in Table 3.

### Table 2. Water Quality Standard GR No. 82/2001.

| Parameter       | Unit | Class |
|-----------------|------|-------|
| pH              | -    | 6 - 9 |
| Fe Total        | mg/L | 0.3   |
| Merkuri (Hg)    | mg/L | 0.001 |
| Timbal (Pb)     | mg/L | 0.03  |
| Tembaga (Cu)    | mg/L | 0.02  |

Source: Government Regulation Number 82/2001

### Table 3. The geographical coordinate point of research location.

| No | Sample Points | Coordinate                     | Villages    |
|----|---------------|--------------------------------|-------------|
| 1  | T1            | 3° 11’ 2.4” N and 97° 20’ 27.6” E | Simpang Dua |
| 2  | T2            | 3° 11’ 24” N and 97° 20’ 42” E    | Simpang Dua |
| 3  | T3            | 3° 11’ 37” N and 97° 20’ 42.8”E   | Simpang Dua |
| 4  | T4            | 3° 11’ 52.6” N and 97° 21’ 1.9” E | Simpang Dua |
| 5  | T5            | 3° 12’ 36.2” N and 97° 21’ 3.3” E | Mersak      |
| 6  | T6            | 3° 12’ 38” N and 97° 21’ 23.1” E  | Mersak      |
| 7  | T7            | 3° 12’ 0.4” N and 97° 20’ 59.2” E | Mersak      |
| 8  | T8            | 3° 13’ 4.2” N and 97° 20’ 59.5” E | Mersak      |
| 9  | T9            | 3° 12’ 20” N and 97° 22’ 24.8” E  | Malaka      |
3. Results and discussion

Kluet Tengah is one of the sub-districts in South Aceh Regency, which is the capital city of Kluet Tengah in Menggamat. This sub-district has 286.7 km² with an average altitude of 50-200 m above mean level and is located at coordinates 3°19'12.1" N and 97° 37'12.1" E. This research was carried out along the Lawe Menggamat river in several villages in Kluet Tengah, including the Simpang Dua, Mersak and Malaka villages. The results of the analysis of several parameters in the laboratory can be seen in Table 4.

Table 4. The results of the analysis of several parameters in the laboratory.

| No. | Sample points | pH     | Fe (mg/L) | Hg (mg/L) | Pb (mg/L) | Cu (mg/L) |
|-----|---------------|--------|-----------|-----------|-----------|-----------|
| 1.  | T1            | 8.06   | 0.031     | 0.001     | 0.0003    | 0.0001    |
| 2.  | T2            | 7.75   | 0.031     | 0.001     | 0.0003    | 0.0001    |
| 3.  | T3            | 7.71   | 0.031     | 0.001     | 0.0003    | 0.0001    |
| 4.  | T4            | 7.89   | 0.031     | 0.001     | 0.0003    | 0.0001    |
| 5.  | T5            | 8.14   | 0.031     | 0.001     | 0.0003    | 0.0001    |
| 6.  | T6            | 7.78   | 0.031     | 0.001     | 0.0003    | 0.0001    |
| 7.  | T7            | 8.17   | 0.031     | 0.001     | 0.0003    | 0.0001    |
| 8.  | T8            | 8.21   | 0.031     | 0.001     | 0.0003    | 0.0001    |
| 9.  | T9            | 7.86   | 0.031     | 0.001     | 0.0003    | 0.0001    |

It was found that the degree of acidity (pH) of the river water studied had a range of 7.71 – 8.21. The highest pH value of river water is at point T8, and the lowest is at point T3. In the research study area, the pH of river water is still below the maximum limit of class I water quality standards in Government Regulation Num. 82 /2001, of which the value is 9. According to WHO [9] the value of the degree of acidity (pH) is a crucial indicator in determining the corrosivity of water; the lower the pH value, the higher the corrosion rate. Irritation to eyes, skin, and mucous membranes may result from exposure to extreme water pH values [10]. Although the pH value does not directly impact consumers, it is a vital indicator of water quality. The occurrence of fluctuations in the pH value for each observation point is caused by the riverbanks' disposal of organic and inorganic waste [11]. Furthermore, the occurrence of fluctuations in water pH at T1 to T3 can be caused by the company's iron and gold mining activities.

The heavy metals for Mercury (Hg), Lead (Pb), and Copper (Cu) were found very low below the tolerance limit of the testing method used. This causes the values of Fe, Hg, Pb, and Cu to be the same for all observation points of 0.031 mg/L, 0.001 mg/L, 0.0003 mg/L, and 0.0001 mg/L, respectively. Heavy metals can enter the aquatic environment through human activities and natural processes. Industrial processes such as electroplating, metal smelting, and industrial waste are also sources of heavy metals. Heavy metal contamination in drinking water can have severe effects on humans[12]. Known fatal impacts of heavy metal poisoning in drinking water include impaired or decreased mental and central nervous function and decreased energy levels [13,14]. They can also cause irregular blood composition and affect vital organs such as the kidneys and liver [15].

Table 5 shows river water in the area around gold mining in the downstream of Krueng Kluet subwatershed is in a condition that fulfills quality standards for use in drinking water purposes. This can make river water a source for class I water needs based on Government Regulation No. 82/2001. There are no indications of pollution in the study area; this may be because mining waste treated according to sewage treatment standards can maintain river water quality in the mining area. The Terms of Reference for Environmental Impact Analysis for Iron Ore Mining and its Companion Minerals [16] states that the biosorption method processes heavy metal waste. Other factors do not cause pollution of the rivers around the mining area; according to [17], the Aceh Government and South Aceh District Government closed and stopped community gold mines that had been in the study area, which had caused casualties. In addition, there is a possibility that the occurrence of heavy metal
waste sediments on the riverbed causes heavy metals to be undetectable in the waters, accordance with a study where [8] detected an accumulation of heavy metals in river sediments where the value of each heavy metal content was higher compared to the levels of heavy metals found in river water.

| No. | Sample Points | Pi   | Category                  |
|-----|---------------|------|---------------------------|
| 1   | T1            | 0.737| Fulfilled Standard Quality |
| 2   | T2            | 0.730| Fulfilled Standard Quality |
| 3   | T3            | 0.729| Fulfilled Standard Quality |
| 4   | T4            | 0.733| Fulfilled Standard Quality |
| 5   | T5            | 0.740| Fulfilled Standard Quality |
| 6   | T6            | 0.730| Fulfilled Standard Quality |
| 7   | T7            | 0.740| Fulfilled Standard Quality |
| 8   | T8            | 0.742| Fulfilled Standard Quality |
| 9   | T9            | 0.732| Fulfilled Standard Quality |

4. Conclusions
River water in the gold mining areas in the downstream of Krueng Kluet sub-watershed is unpolluted and meets quality standards for drinking water and daily necessities.

References
[1] Sosrodarsono S and Takeda K 2003 *Hidrologi Untuk Pengairan* (Jakarta: PT Pradaya Paramita)
[2] Badan Pengendalian Lingkungan Hidup Provinsi Jawa Barat 1977 *Rencana Strategis BPLHD Provinsi Jawa Barat 2013-2018* vol 13
[3] Gafur N A, Sakakibara M, Sano S and Sera K 2018 A case study of heavy metal pollution in water of Bone River by Artisanal Small-Scale Gold Mine Activities in Eastern Part of Gorontalo, Indonesia *Water (Switzerland)* 10
[4] Lottermoser B 2010 *Mine Wastes: Characterization, Treatment and Environmental Impacts*
[5] Ramontja T, Coetzee H, Hobbs P, Burgess J, Thomas A, Keet M, Yibas B, van Tonder D, Netili F, Rust U, Wade P and Maree J 2011 *Mine Water Management in the Witwatersrand Gold Fields With Special Emphasis on Acid Mine Drainage*
[6] Almiqrhi A 2018 Determination of Heavy Metals (Pb, Zn, Cd, Cu) in Coastal Sediments and Fish Urban Area of Semarang, Indonesia *J. Environ. Anal. Toxicol.* 08
[7] Jeliazkova E and Craker L 2008 Seed Germination of Some Medicinal and Aromatic Plants in Heavy Metal Environment *J. Herbs. Spices Med. Plants* 10 105–12
[8] Ramli I, S and Lestari M R 2020 Water and Sediment Quality Index Due To Gold Mining in The Krueng Kluet Hilir Watershed, Aceh Selatan Regency *Ach Int. J. Sci. Technol.* 9 29–39
[9] World Health Organization 2012 *Guidelines for water quality SECOND EDITION Addendum to Volume 2* vol 155
[10] Helmi H, Munawar A A, Bakhtiar B and Zulfahmi Z 2021 Comparisons among soil tillage system and their impacts to the tested rice varieties on lowland rainfed alluvial in aceh jaya *Food Res.* 5 173–8
[11] Yuliastuti E 2011 kajian kualitas air sungai ngringo karanganyar dalam upaya pengendalian pencemaran air
[12] World Health Organization 2011 Guidelines for drinking-water quality - 4° ed. Geneva. *Who* 314–652
[13] Abubakar A, Yusuf H, Syukri M, Nasution R, Karma T, Munawar A A and Idroes R 2021 Chemometric classification of geothermal and non-geothermal ethanol leaf extract of seurapoh
(Chromolaena odorata Linn) using infrared spectroscopy *IOP Conf. Ser. Earth Environ. Sci.* **667**

[14] Ramli I, Rusdiana S, Basri H, Munawar A A and Zelia V A 2019 Predicted Rainfall and discharge Using Vector Autoregressive Models in Water Resources Management in the High Hill Takengon *IOP Conference Series: Earth and Environmental Science* vol 273 (Institute of Physics Publishing)

[15] Khan S, Uddin Z and Zubair A 2011 Levels of selected heavy metals in drinking water of Peshawar city *Int. J. Sci. Nat.* **6** 648–52

[16] Koperasi Serba Usaha Tiega Manggis 2020 Penambangan, Rencana Pemurnian, Pengolahan dan Besi, Bijih Mineral dan Mineral Pengikutnya

[17] Aceh Tribunnews 2021 Lokasi Tambang Emas Menggamat Akhirnya Ditutup, Ekses 8 Penambang Tradisional Tertimbun Longsor