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Study of water quality for post-mining extermination, Banjarbaru City

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ABSTRACT

Banjarbaru City is one of the regencies/cities in South Kalimantan Province which continues to develop in various sectors, one of which is mining. Among the mining areas that left traces of voids in Banjarbaru include the Lake Seran quarry which was once a sand mining site, as well as the Pumpung quarry which was a diamond mining location. Remains of former mining excavations that are left for a long time will be filled with water which accumulates various substances remaining at the excavation site, especially heavy metals which in general are important parameters and affect water quality. This study aims to examine the quality of ex-mine water in Banjarbaru by focusing on analysis through the Pollution Index (IP) of heavy metal parameters in the waters of the research location. The results obtained are that the ex-mine pits in Lake Seran and Pumpung, Banjarbaru City, have quite good water quality, where most of them are at class 2 quality standards. However, further management is needed to improve water quality at some points that are still not meets class 2 quality standards so that it is included in the category of lightly polluted.

Introduction

Mining activities have a very important function in supporting economic activities in Indonesia, including South Kalimantan. Apart from contributing a sizable amount of foreign exchange, mining activities are also able to absorb a large number of workers and create centers of economic growth and new settlements.

In addition to providing great benefits, mining activities also cause problems in environmental management. Some of these problems include the occurrence of water pollution, land degradation, decreased biodiversity (Goswami, 2015; Salomons, 1995; Setiawan *et al.*, 2018; Younger, 2004; Akbar *et al.*, 2023), land conflict (Dutu, 2016; Hudayana *et al.*, 2020), and in certain cases there has been a breakdown of settling ponds and the drowning of several victims (people) in inactive post-mining pits filled with water called coal mine pit lakes or post-mining pits. (Yunus and Prabowo, 2023)

Mining activities have a great impact on the ecosystem around the mining site, one of which is the aquatic ecosystem (artificial lakes). Changes in water quality will definitely occur due to changes in the landscape, which means it will affect the life of living things in it (McCullough and van Etten, 2011; Sofarini, 2011)

In general, post-mining pits will fill with water and accumulate various parameters of heavy metals such as Pb, Hg, Cd, Fe and others (Wahlberg, 2002; Xu *et al.*, 2021; Akbar and Rahayu, 2023). The presence of these heavy metals will disrupt the stability of the ecosystem if not taken seriously. According to Dinora and Purnomo (2013), Fe is a type of heavy metal that can be found in almost all of the earth's surface in all geological layers and waters. In natural water systems and also in water treatment systems, iron compounds can vary depending on the pH of the water.

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Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Volume 12, Number 3, Page 409-414

Post-mining land that has been damaged in its management must prioritize improving its biophysical or ecological conditions, with the results of the analysis in this study being post-mining land management based on sustainable development (Haridjaja *et al.*, 2011; Kodir *et al.*, 2017). The presence of post-mining pits that have not been closed or not closed indicates problems both from the aspect of scenarios for exploitation and operational activities for closing post-mining pits, weak instruments in mining environmental management, and the resulting environmental impacts (Adibi *et al.*, 2015; Asr *et al.*, 2019; Jaelani *et al.*, 2022).

These various problems are an increasing challenge, considering the need for better environmental management while the number of post-mining is increasing (Absori *et al.*, 2021). This study seeks to photograph the problems of post-mining pits and see opportunities for the utilization of post-mining pits from various aspects of utilization and regulatory needs. The results of this study are expected to be useful as a reference for formulating operational policies in the utilization of post-mining pits in mining activities in South Kalimantan

Materials and Methods

Location and time of research

This research was carried out for 4 months from June to October 2022. The research was carried out in ex-mining pits in Lake Seran and Pumpung which are located in Banjarbaru City, South Kalimantan Province (Figure 1 and Figure 2). Determining the location of water sampling was carried out by purposive sampling. The method used is explorative quantitative

Data collection procedure

Analysis of water quality parameters refers to the Indonesian national standard (SNI) according to SNI 6989.59:2008 and 6989.57:2008 as much as 5 liters using a water sampler and sampling container. Then the samples were brought to the laboratory for analysis of the physical and chemical parameters of the water. The instrument used has previously been tested for calibration

Data analysis

The data obtained was then analyzed using the Pollution Index (PI) method according to the Decree of the State Minister for the Environment Number 115 of 2003 concerning Guidelines for Determining Water Quality Status with class 2 quality standard criteria. The PI calculation is carried out based on the following equation:

$$PI_j = \sqrt{\frac{(C_i/L_{ij})_M^2 + (C_i/L_{ij})_R^2}{2}}$$

Information :
PIj = Pollution Index for designation (j)
Ci = Concentration of water quality parameters (j) obtained from the analysis results water sample at a location taking
Lij = Concentration of water quality parameters listed in the Quality Standards Water Designation (j)

$(Ci/Lij)_M$ = maxium value of Ci/Lij
$(Ci/Lij)_R$ = average value of Ci/Lij

The results of the calculations obtained will be interpreted with the following evaluation:

$0 \leq PIj \leq 1.0$ → meets the quality standard (good condition)
$1.0 < PIj \leq 5.0$ → lightly polluted
$5.0 < PIj \leq 10$ → moderately polluted
$PIj > 10$ → heavily polluted

Figure 1. The location of Danau Seran Post-Mining

Figure 2. The location of Pumpung Post-Mining

Results

The concentrations of heavy metals measured at each observation station diverse, some are varied and some are not so much different concentrations.

Table 1. Data results of water sample measurements at Danau Seran

Parameters	Unit	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6
Fe	Mg/L	0.3	0.3	0.40	0.3	0.3	0.3
Mn	Mg/L	0.34	0.23	0.41	0.25	0.25	0.26
Zn	Mg/L	0.688	0.165	0.162	0.148	0.082	0.071
Pb	Mg/L	0.03	0.03	0.03	0.03	0.03	0.03
As	Mg/L	0.001	0.001	0.001	0.001	0.001	0.001
Co	Mg/L	0.001	0.001	0.001	0.001	0.001	0.001
Se	Mg/L	0.001	0.001	0.001	0.001	0.001	0.001
Cd	Mg/L	0.004	0.004	0.004	0.004	0.004	0.004
Cu	Mg/L	0.008	0.008	0.008	0.008	0.008	0.008
Hg	Mg/L	0.075	0.075	0.075	0.075	0.075	0.075
Ni	Mg/L	0.044	0.044	0.044	0.044	0.044	0.044
B	Mg/L	0.001	0.001	0.001	0.001	0.001	0.001
Cr Total	Mg/L	0.015	0.015	0.015	0.015	0.015	0.015

Source : Primary Data, 2022

Table 2. Data results of water sample measurements at Pumpung

Parameter	Unit	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6
Fe	Mg/L	0.86	0.63	0.42	0.3	0.43	0.33
Mn	Mg/L	0.16	0.16	0.19	0.1	0,1	0.11
Zn	Mg/L	0.111	0.075	0.090	0,05	0.051	0.05
Pb	Mg/L	0.03	0.03	0.03	0.03	0.03	0.03
As	Mg/L	0.001	0.001	0.001	0.001	0.001	0.001
Co	Mg/L	0.001	0.001	0.001	0.001	0.001	0.001
Se	Mg/L	0.001	0.001	0.001	0.001	0.001	0.001
Cd	Mg/L	0.004	0.004	0.004	0.004	0.004	0.004
Cu	Mg/L	0.013	0.010	0.010	0.010	0.010	0.010
Hg	Mg/L	0.075	0.075	0.075	0.075	0.075	0.075
Ni	Mg/L	0.044	0.044	0.044	0.044	0.044	0.044
B	Mg/L	0.001	0.001	0.001	0.001	0.001	0.001
Cr Total	Mg/L	0.018	0.015	0.015	0.015	0.015	0.015

Source : Primary Data, 2022

After performing calculations with the PI equation, the following results are obtained:

Table 3. Pollution Index Calculation Results at Danau Seran

Danau Seran	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6
(Ci/Lij)R	1.62	0.91	1.10	0.96	0.96	1.00
(Ci/Lij)M	8.87	1.00	2.26	1.00	1.00	1.09
Pi	4.508	0.676	1.255	0.693	0.694	0.736
Quality Status	Lightly Pollution	Meet Quality Standards	Lightly Pollution	Meet Quality Standards	Meet Quality Standards	Meet Quality Standards

Source : Processed primary data

Table 4. Pollution Index Calculation Results at Pumpung

Pumpung	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6
(Ci/Lij)R	1.28	0.94	1.06	0.92	1.00	1.02
(Ci/Lij)M	8.87	1.00	1.40	1.00	1.04	1.21
Pi	4.481	0.686	0.878	0.681	0.724	0.789
Quality Status	Lightly Pollution	Meet Quality Standards	Meet Quality Standards	Meet Quality Standards	Meet Quality Standards	Meet Quality Standards

Source : Processed primary data

Discussion

Based on the results of the data above, it can be seen that the post-mining pit Danau Seran, Banjarbaru City, generally meets the Quality Standards for class 2 designation. This means that these waters could be used for water recreation infrastructure/facilities, freshwater fish farming, animal husbandry, water to irrigate crops and for other uses that require the same quality of water as those uses. However, at station 1 and station 3, the Pollution Index (PI) results were obtained at 4.508 and 1.255, which means that these locations were indicated to be lightly polluted, so further management of the measured parameters was needed so that the water quality at that point could be appropriate. with the need for predetermined water quality standards (Widiatmaka, *et al.*, 2010; Wikurendra, *et al.*, 2022).

Several specific actions can be taken to overcome light pollution conditions at Stations 1 and 3 (Table 1). The application of the phytoremediation concept can be one of the treatment solutions. Phytoremediation is one method with an environmentally friendly concept. This technique can be applied to overcome light pollution through the biological process of breaking down pollutants. This technology has disadvantages in terms of a slow process and the need to select the right type of plant to reduce the types of heavy metals that pollute waters. The phytoextraction process is one of the important processes in the phytoremediation concept in reducing heavy metals and other pollutants from water (Bhat, *et al.*, 2019; Mangkoedihardjo 2007; Milić *et al.*, 2012)

The development of Danau Seran tourism was originally intended to develop the region and create new growth in the area. Utilization of post-diamond mining land PT. Galuh Cempaka, among other things, was to create new public spaces, encourage the growth of small and medium enterprises, create new jobs, develop tourism objects, and open up regional sources of income. From various aspects of

Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Volume 12, Number 3, Page 409-414

the utilization of Danau Seran, no review was carried out from the side of water quality. The problem of changing the landscape will further impact on the water quality of Seran Lake (Munir and Setyowati, 2017; Novianti *et al.*, 2017).

Numbers of rivers around Seran Lake were experiencing a lot of siltation caused by silt sedimentation from mining activities. This clearly causes the potential for flooding which can occur at any time, but from a micro perspective this can be overcome by improving the quality and performance of the inlet and outlet handles in the Galuh Cempaka Site, where Danau Seran was located on peat soil.

In the post-mining waters in Pumpung, Banjarbaru City, it can be seen that these waters generally meet the Quality Standards for class 2 designations. This is stated in the data in Table 2, where all heavy metals in post-mining waters of Pumpung (Fe, Mn, Zn, Pb, As, Co, Se, Cd, Cu, Hg, Ni, B and Cr Total) do not exceed the required values PP No. 22 of 2021 water quality standards for lake waters. Quality Standards for class 2 designation state that these waters can be used for water recreation infrastructure/facilities, freshwater fish farming, animal husbandry, water for irrigating crops and for other uses that require the same quality of water as those uses (Peraturan Pemerintah RI, 2021). However, at station 1, the results of the Pollution Index (PI) figure were 4.481, which means that the location was indicated to be lightly polluted, so further management of the measured parameters was needed so that the water quality at that point coud meet the needs of water quality standards established (Kirschke *et al.*, 2020) (Table 3).

In contrast to the Danau Seran post-mining, the Pumpung area is a community's traditional post-diamond mining. Pumpung Village is famous for finding a diamond for the size of a chicken egg weighing 166.7 pieces, in the 30s years ago which was known as the Trisakti.

The diamond mining system in Pumpung Village uses a dumping system, namely a method of mining by stripping the surface soil and then continuing with excavation, but after mining was complete, the top soil layer was not returned to its original place. Physically, the condition of the former mining site was very bad, from large holes like lakes and surrounded by heaps of excavated earth like small irregular hills. Under these conditions, the utilization of the post-mining area as agricultural land was very difficult to manage. Returning the quality of former mining areas as agricultural land requires a very large investment, which was actually the responsibility of the miners (Barkatullah and Abdullah, 2016)

Mining activities that do not pay attention to environmental aspects from erosion and landslide hazards as loss of ground cover vegetation. Land clearing on a large scale causes a landscape (morphology and topography), namely a change in the shape of the slope. Stripping, stockpiling of overburden from diamond mining activities causes changes in drainage, river water discharge and surface quality when it rains (Andriawan, *et al.*, 2021).

Based on water quality data for Danau Seran and Pumpung, several heavy metals such as Fe, Zn, and Hg had values that exceed the required water quality standards. Heavy metal pollution from mining activities can cause changes in the quality of the aquatic environment, one of which is post-mining land (Islam, *et al.*, 2015) and affects the life of the biota in it (Barbieri *et al.*, 2020; Fuoco and Giannarelli 2019; Kurz *et al.*, 2013) . Continuous pollution can have an impact on biota and even cause death to impact the population (Kadim *et al.*, 2022).

The heavy metal parameters that had the most influence on the Pollution Index results obtained include Fe, Zn and Hg, which can disturb the environment (Table 4). Even though Fe and Zn are essential heavy metal groups, if they are present in excessive amounts they are toxic to living things (Febrina and Ayuna, 2015; Kamarati *et al.*, 2018; Said and Yudo, 2021).

The presence of iron can be affected by acidic water conditions. Mining land of diamonds in Danau Seran and Pumpung were pyrite (FeS_2). The mineral pyrite (FeS_2), in post-coal mining land, is oxidized to sulfuric acid and can drastically reduce soil pH. Meanwhile carbonate ($Ca/MgCO_3$) which coats minerals and rocks tends to increase soil pH due to weathering and dissolving. In post-mining land where the carbonate is not weathered it causes a greater accumulation of pyrite, so that the pH can fall quickly (Erfandi, 2017; Hirfan, 2016; Supriyatna *et al.*, 2013)

Pyrite oxidation occurs due to the pyrite layer being exposed to oxygen caused by falling groundwater levels or drought. Falling groundwater levels can cause cracks to appear on the soil surface due to dryness, root scars or excessive drainage so that oxygen can enter the soil and can cause the pyrite layer to oxidize (Ratmini, 2018). Pyrite oxidation caused by oxygen as an oxidizing agent is less dangerous compared to oxidation caused by Fe3+. This is in accordance with the pyrite oxidation reaction where the oxidation caused by oxygen only produces 2 mol of H+ ions, while the oxidation of pyrite caused by Fe3+ produces 16 mol of H+ ions. In soil that has undergone pyrite oxidation, pale

Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Volume 12, Number 3, Page 409-414

yellow jarosite rust will be found in the cross-section of the soil and is often referred to as clay paint or in standing water which is toxic (Sandrawati *et al.*, 2019). Pyrite oxidation occurs when pyrite comes into contact with oxidizing agents, namely oxygen (O2), Fe3+, and oxidizing organisms which can accelerate the pyrite oxidation process (Lee *et al.*, 2011).

While the main role of zinc in waters is as a cofactor for two important enzymes for the development of phytoplankton, namely carbonic anhydrase and alkaline phosphatase. Apart from being essential, zinc can also be toxic and generally zinc is toxic when it is in the dissolved phase (Ali *et al.*, 2018)

The presence of Hg as part of non-essential heavy metals will be toxic to organisms in the waters. High Hg levels, both in Danau Seran and Pumpung, would be toxic and the benefits for the aquatic organisms that live in them were not yet known. Metabolic processes in living bodies will be interrupted due to toxic forces that will work as a barrier to the work of enzymes in the body (Kadim *et al.*, 2022; Said and Yudo, 2021; Sofarini *et al.*, 2022).

Based on data on several heavy metals which were quite high in Danau Seran and Pumpung, it will have a further impact on the Pollution Index which was classified as lightly polluted at Stations 1 and 3. However, despite the problems found, Danau Seran and Pumpung still have considerable potential for developed. This of course has to go through several processes and stages, especially post-mining land reclamation.

Reclamation activities are the end of mining activities which are expected to return land to its original state, even if possible, to be better than conditions before mining. The ultimate goal of reclamation is to restore post-mining land to be safe, stable and not easily eroded so that, it can be utilized back (Hirfan, 2016). In general, the outline of the reclamation stages are top soil conservation, land management, sediment management and erosion control, planting cover crops, planting pioneer plants, and controlling heavy metals through the concepts of phytoremediation or bioremediation (Hendrychov´a *et al.*, 2020; Hirfan, 2016) .

Conclusion

The post-mining pits in Danau Seran and Pumpung, Banjarbaru City, have quite good water quality, most of which were at class 2 quality standards. These waters could be used for water recreation infrastructure/facilities, freshwater fish farming, animal husbandry, water for irrigation. plantations and for other uses that require the same quality of water as that use. However, further management was needed to improve water quality at some points which still did not meet class 2 quality standards so that they were included in the lightly polluted category.

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