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Study of water quality in ex-mining pits for fish cultivation in Gunung Mas Regency, Central Kalimantan

Studi kualitas air di lubang bekas tambang untuk budidaya ikan di Kabupaten Gunung Mas, Kalimantan Tengah

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ABSTRACT

Ex-mining pit is wide expanse, often becoming an environmental problem for the community. Lack of information about the use of mining pits for aquaculture activities, especially the study of the quality of mining pits to support the growth of cultivated fish. This research was conducted in Tanjung Riu Village, Gunung Mas Regency, Central Kalimantan Province, using two community-owned ex-mining ponds. The results showed that the value of the quality parameters in the water of the two mining pits was dissolved oxygen (DO) with an average value of 6.09 mg/L–7.45 mg/L, pH 2.94–3.54, biological oxygen demand (BOD) 4.78 mg/L, temperature 30-32°C, turbidity 51.7-53.5 NTU, total dissolved solids (TDS) value 3.0×10^{-3}–1.7×10^{-3} gr/L, mercury content (Hg) 2.47×10^{-4}–3.59×10^{-4} mg/L, pool depth 1.70–2.74 m. While the range of plankton abundance values is between 869-1106 cells/L, and benthos abundance is between 264-352 ind/m^2. The range of pond water quality based on the second-class national water quality standard, which is suitable for fish cultivation with moderate plankton abundance.

Keywords: abundance of benthos, abundance of plankton, ex-mining pits, water quality

ABSTRAK

Lubang bekas tambang merupakan hamparan yang luas, sering menjadi masalah, terutama untuk lingkungan. Kurangnya informasi tentang pemanfaatan lubang tambang untuk kegiatan perikanan terutama studi tentang kualitas air lubang tambang untuk mendukung pertumbuhan ikan budidaya. Penelitian ini dilaksanakan di desa Tanjung Riu, Kabupaten Gunung Mas, Propinsi Kalimantan Tengah, dengan menggunakan dua kolam bekas tambang milik masyarakat. Hasil menunjukkan bahwa kualitas air untuk kedua lubang tambang dengan parameter air untuk oksigen terlarut (DO) rata-rata 6,09 mg/L–7,45 mg/L, pH 2,94–3,54, biological oxygen demand (BOD) 4,78 mg/L, suhu 30-32 ^{o}C, kekeruhan 51,7-53,5 NTU, nilai total padatan terlarut (TDS) $3,0\times10^{-3}$–$1,7\times10^{-3}$ gr/L, kandungan merkuri (Hg) sebesar $2,47\times10^{-4}$–$3,59\times10^{-4}$ mg/L, kedalaman kolam 1,70 m–2,74 m. Kelimpahan plankton antara 869-1106 sel/L, dan kelimpahan bentos 264-352 individu/m^2. Kisaran kualitas air kolam berdasarkan baku mutu air nasional kelas dua, layak untuk budidaya ikan dengan kelimpahan plankton tergolong sedang.

Kata kunci: kelimpahan bentos, kelimpahan plankton, kualitas air, lubang bekas tambang

INTRODUCTION

Gunung Mas Regency is one of the regencies located in the province of Central Kalimantan, characterized by numerous former mining pits and vast expanses of land. Until now, much of the post-gold mining land has remained dormant, rendering it highly unproductive, thus limiting the survival of many plant species. Vegetation on such land is predominantly composed of weed species, including grasses, ferns, and shrubs. Furthermore, the aftermath of gold mining results in abandoned pits that gradually fill with water, forming ponds where various organisms thrive, serving as natural fish feed (Gusmaweti *et al*., 2022). Former mining pits, often referred to as voids, often receive negative responses from both the government and the communities around mining locations.

Therefore, mining companies need to seriously consider how to handle and utilize these former mining pits after mining operations cease. Social, economic, and environmental aspects for sustainable development in the areas around mining areas, from the time mining operations cease, should not only become areas that cannot be utilized, but the community is expected to be able to independently participate in sustainable development with the assistance of local governments (Putrawiyanta, 2020). One of the alternatives that can be developed in utilizing gold mining pits is fish farming (Triswiyana *et al*., 2019). Fish farming efforts conducted in former mining ponds require identification of local environmental conditions by considering factors that affect fish farming efforts (Pagoray *et al*., 2014). According to Gusmaweti *et al*. (2022), former gold mining ponds as fish farming media need to be more deeply considered, both in terms of water quality (physical and chemical) and natural feed.

In the process, before being utilized for fish farming areas, mining ponds must be rested or there should be no mining activities around the pond location. The duration varies depending on the size and depth of the former mining pit openings (Kusuma, 2017). For the mining ponds owned by the community in Tanjung Riu village, the mining pits have not been used or activated for seven to eight years. Therefore, a feasibility study is needed for the former gold mining pits in Tanjung Riu village, especially regarding water quality and other biological parameters for fish farming activities. The aim of this research is to analyze the water quality of former gold mining pit and its suitability for fish farming activities.

MATERIAL AND METHOD

This study was conducted in Tanjung Riu Village, Gunung Mas Regency, Central Kalimantan Province, at the former mining pits owned by the community. The materials used in this study were Lugol's solution and formalin. The instrument used to measure water quality *in situ* was the Horiba Quality Checker with parameters including temperature, pH, turbidity, dissolved oxygen (DO), total dissolved solids (TDS), and water depth. Sampling for biological oxygen demand (BOD) and chemical oxygen demand (COD) were done with bottles.

These bottles were labeled and then taken to the DLH Laboratory in Katingan Regency for content analysis. The BOD measurement was conducted using the method by Andika *et al*. (2020). BOD measurement involves measuring the initial dissolved oxygen content (DOi) of the sample immediately after collection, then measuring the dissolved oxygen content in the sample that has been incubated for five days in the dark and at a constant temperature (20°C), often referred to as DO5. The difference between DOi and DO5 (DOi-DO5) represents the BOD value expressed in milligrams of oxygen per liter (mg/L).

The COD measurement method is slightly more complex, involving the use of special reflux equipment, concentrated acid, heating, and titration (Andika *et al*., 2020), while for the measurement of heavy metal Hg in water samples, it was done according to the method used by Hutagalung *et al*. (1997). Samples were taken at a depth of 1 m below the water surface. A total of 2 L of water samples were taken using a water sampler (Nansen). Water samples for heavy metal residue analysis were stored in polyethylene (PE) bottles and preserved with nitric acid (HNO_3) until the pH reached approximately 1.5. The samples were observed at the Baristan Banjarmasin Laboratory to analyze mercury content.

Biological data consisted of plankton and benthos parameters. Plankton samples were taken and preserved with a 4% formalin solution. Plankton samples were observed using a microscope. The observed plankton were counted and identified. The calculation of plankton abundance was performed as follows:

$$n = \frac{a \times c}{l}$$

Note:
n = Plankton abundance (cells/liter)
a = Average number of plankton filtered in 1 L
c = Volume of filtered concentrated plankton water (in bottles)
l = Volume of filtered water (L)

Next, an analysis was conducted on the types of plankton and their abundance using the Shannon-Wiener diversity index (H') and dominance index. The diversity index was calculated based on the observations of plankton using the Shannon-Wiener formula (Odum, 1971) as follows:

$$H' = (-\sum \frac{ni}{N}) \times (ln \frac{ni}{N})$$

Note:
H' = Shannon-Wiener diversity index
ni = Number of individuals of species-i
N = Total number of individuals

Benthic sampling was conducted using an Ekman grab. After obtaining the substrate samples, they were placed in plastic sample containers and then supplemented with five drops of 4% formalin. The samples were then observed and analyzed. Benthic abundance was calculated based on the number of individuals per unit area (ind/m^2) using the following calculation by Odum (1993):

$$K = \frac{10.000 \times b}{a}$$

Note:
K = Species abundance index (ind/m^2)
a = Area of capture or area of the Ekman grab mouth opening (cm^2)
b = Total number of captured benthic individuals (ind)

The Shannon-Wiener diversity index for benthos is calculated as follows:

$$H' = \sum_{i=1,2,3,...}^{x} (pi \log 2\ pi)$$

Note:
H' = Species diversity index
pi = Proportion of individuals of species i to the total number of all species (pi = ni/N), log 2 = 3.321928
ni = Number of species i
N = Total number of individuals of all species

RESULT AND DISCUSSION

Result

The results of water quality measurements in two community-owned former mining ponds in Tanjung Riu village are shown in Table 1. These measurements aim to assess the environmental condition of surface water quality, using several parameters according to the field instruments used. According to Government Regulation PP (2021) on the Implementation of Environmental Protection and Management, in Annex. VI regarding National Water Quality Standards for class two designated for water recreation facilities, freshwater fish farming, livestock farming, irrigation water for crops, and/or other uses that require the same water quality standards.

It states that the water quality in both former mining ponds is still suitable for fish farming, except for the pH level, which is below the standard, but can still be addressed with special treatment. In fisheries cultivation, water quality management is indeed crucial. Some of the most important chemical parameters for fish life are dissolved oxygen, pH, Biological Oxygen Demand (BOD), and physical parameters such as temperature (Pratiwi *et al*., 2021). Plankton are organisms, both plant and animal, generally relatively small in size (microscopic), floating in water. They lack mobility/although some have relatively weak mobility, thus their distribution is greatly influenced by water movement, such as currents and others (Sianipar *et al*., 2022).

Changes or pollution in a water body are closely related to its potential, characterized by changes in the plankton community (Akbarurrasyid, 2021). The plankton analysis results include five types, consisting of 2 phyla for phytoplankton, namely Chlorophyta and Cyanophyta, and one phylum Arthropoda for zooplankton. The plankton analysis results for pond one and pond two can be seen in Table 2. Benthos are animals and plants that live on or below the bottom of bodies of water or in areas known as the benthic zone or the bottom of the shoreline area. The results of the benthos analysis for pond one and pond two of the former mining area can be seen in Table 3.

Discussion

From Table 1, the average dissolved oxygen (DO) at both sampling points range from 6.09–7.45 mg/L, which is sufficiently good for fisheries and agricultural purposes (Class II) according to Government Regulation PP (2021), as the observed

Table 1. Water quality of the community-owned former mining pond in Tanjung Riu Village, Gunung Mas Regency.

No	Parameter	unit	Observation result		Quality standards	Explanation
			Pond 1	Pond 2		
1	Temperature	°C	30.87	32.03	Dev 3	The temperature difference with the air temperature above the water surface
2	pH		3.54*	2.94*	6-9	Not applicable to peat water (Based on its natural condition)
3	Dissolved Oxygen-DO	mg/L	6.09	7.45	4	Minimum limit
4	Total dissolved solid–TDS	gr/L	1.7×10^{-2}	3.0×10^{-3}	10^{3}	
5	Turbidity	NTU	51.7	53.5	400	Maximum limit
6	Oxidation Reduction Potential, ORP	mV	359	328		
7	BOD	mg/L	4.78	4.78	3.00	Minimum limit
8	COD	mg/L	12.2	10.7	25.0	Maximum limit
9	Dissolved mercury (Hg)	mg/L	2.47×10^{-4}	3.59×10^{-4}	2×10^{-3}	Still below the quality standard
10	Water depth	m	1.75	2.74		The depth at the edge of the pond

Note: *Not applicable to peat water (Based on its natural condition).

Figure 1. Former artisanal mining pit in Tanjung Riu Village.

DO exceeds 4 mg/L. DO represents the amount of oxygen dissolved in water from photosynthesis processes and atmospheric absorption. The higher the DO level, the better the water quality. The high DO values are due to the high photosynthesis process by surface phytoplankton, resulting in high dissolved oxygen levels in the water. The increase in oxygen consumption by aquatic organisms is also influenced by increasing water temperature (Said & Yudo, 2021).

According to Sugianti and Astuti (2018), the minimum DO requirement for tropical freshwater fish is approximately 5 mg/L. The pH measurements for the mining pit water for both ponds range from 2.94–3.54, indicating pH values below the water quality standards. According to the water quality standard, the pH range should be 6–9, but this standard does not apply to peat areas or is adjusted based on their natural conditions according to Government Regulation PP (2021).

Table 2. Plankton analysis in the former mining ponds.

No	Plankton type	Sample	
	Fitoplankton	Pond 1	Pond 2
A.	Cholorophyta		
1	*Navicula gracilis*	158	-
2	*Microspora lumidula*	79	158
3	*Scenedesmus abundance*	237	316
B.	Cyanophyta		
1	*Oscillateria curviceps*	237	158
	Zooplankton		
A.	Arthopoda		
1	*Daphnia cucullata*	395	237
Abundant (cell/L)		1106	869
Diversity index (Shannon-Wiener)		1.4944	1.3421
Similarity index		0.9285	0.9681
Dominance index		0.2449	0.2727
Number of taxa		5	4

Source: SNI 06-3963-1995.

Table 3. Benthos analysis in the former mining ponds.

No	Benthos type	Sample	
		Pond 1	Pond 2
A.	Gastropod		
1	*Chysalkuda Sugniudea*	88	132
B.	Polychaeta		
1	*Marphysa sanguinea*	176	220
C.	Arthophod		
1	*Daphnia cucullata*	395	237
Abundant (Ind/m^2)		264	352
Diversity index (Shannon-Wiener)		0.63.65	0.6616
Similarity index		0.9183	0.9544
Dominance index		0.5556	0.5313
Number of taxa		2	2

Source: SNI 06-3963-1995.

Acid mine water can occur in excavation or mining activities, whether in open-pit or underground mines (Perkasayuda, 2020).

Based on the water quality analysis results, if for fish farming activities, special treatments or liming (pond liming) can be carried out. Acidity is also caused by dissolved heavy metal minerals, and the potential of this water can be addressed easily by spreading plants with root absorption capabilities that can bind heavy metals, such as water hyacinth, and applying manure to neutralize acid into base (Meyzilia, 2018). The tolerance limit for aquatic organisms is pH 5–9; if pollutants disturb the water's buffering system, they can cause disturbances to aquatic organisms (Dewi *et al*., 2014). In addition to pH, water quality can also be indicated by its color and turbidity.

Bluish-green and clear water usually indicate high acidity or low pH levels (Suryaningtyas *et al*., 2019). The BOD values from Table 1 for ponds one and two indicate a value of 4.78 mg/L, exceeding the water quality standard limit of 3 mg/L, based on the National Water Quality Standard for class two (PP, 2021). However, according to Supratno (2006), the optimal BOD range for fish life is approximately 3–5 mg/L. Overall, the water temperature for both mining pits is still suitable to support aquatic life, ranging from 30–32°C, suitable for fish farming according to the National Water Quality Standard.

The optimum temperature for aquaculture fish is 28–32 °C (Siegers *et al*., 2019). The turbidity values for the mining pit water for both sampling points range from 51.7–53.5 NTU. The maximum turbidity limit for fish farming is 400 NTU. The turbidity values are still below the maximum value. Water turbidity can be caused by small particles such as dust and other small particles.

Former mining lakes, whether from rocks or overburden materials, can release minerals or compounds dissolved in water, resulting in high concentrations of total dissolved solids (Gautama, 2019). The total suspended solids (TDS) from the test results indicate values ranging from 3.0×10^{-3}–1.7×10^{-2} g/L, still below the maximum water quality standard. TDS refers to solids dissolved in the solution, whether organic or inorganic substances. The heavy metal mercury (Hg) content in the water is 2.47×10^{-4} mg/L in pond 1 and 3.59×10^{-4} mg/L in pond 2, which means the mercury content (according to the test results) is still below the required quality standards for fish farming. The water quality measurement results do not exceed the set water quality criteria.

This condition is also supported by water quality test results for mercury in voids in Gunung Mas Regency conducted by the Fisheries Department with tests conducted at the Industrial Research and Standardization Institute, Banjar Baru in 2019, which showed test results of $<7.5\times10^{-2}$ μg/L with the AAS test method or 7.5×10^{-5} mg/L. Meanwhile, according to PP (2021), for class two, it is 2.0×10^{-3} mg/L with a limit of 5.0×10^{-5} mg/L. Most mercury found in nature is in the form of compounds with other elements rarely found in separate elemental forms. Mercury components are widely distributed in corals, soil, air, water, and other living organisms through complex physical, chemical, and biological processes.

Heavy metals entering the water column can interact with free organic matter or suspended particles and settle to the bottom of the water (Harlyan & Sari, 2015). Mercury can occur naturally in the environment as a result of mineral breakdown in nature through weather/climate processes, from wind and water. Mercury compounds can be found in the air, soil, and water, as well as in dirty places (Mahmud *et al*., 2017). The results of water quality measurements indicate that although the water status in the mining pit environment still contains some compounds or elements that may be harmful to human health, it can still be tolerated for the suitability of aquatic biota life.

However, the effects of these toxic compounds and elements still need to be further studied regarding their influence on the growth and development of fish or on fish organs and their suitability for human consumption. With proper management, mining pits can become a source of water, fish farming ponds, and attractive recreational areas (Munawar, 2017). The data on aquatic biota parameters analyzed from the research location are the abundance of plankton and benthos. According to Pagoray *et al*. (2014), plankton diversity indices, and physical water quality parameters such as turbidity and chemical water quality parameters such as pH, Hydrogen Sulfide (H_2S), and NH_3, are parameters that affect the sustainability index for former mining fish farming.

Environmental support and resources for the development of natural and alternative feed for sustainable fish farming. Additionally, direct observations in the field at the research site, especially in former mining ponds, revealed the presence of water plants such as water lettuce (*Pistia stratiotes*) and floating ferns. Plants like water lettuce (*Pistia stratiotes*) and water ferns (*Salvinia natans*) can be used for wastewater treatment and absorb pollutant metals (Pagoray *et al*., 2017). The biological characteristics of a water body can also be determined from aquatic biota such as plankton, benthos, and fish.

Based on Table 2, it can be seen that the highest abundance and diversity of plankton are found in the first mining pond, namely 1.106 cell/L and 1.4944, respectively. The highest uniformity and dominance indices are found in the second mining pond, namely 0.9681 and 0.2727, respectively. Uniformity index values approaching zero tend to indicate an unstable community, while values approaching one indicate a stable community (Shabrina *et al*., 2020). This condition shows that the uniformity indices of plankton communities are relatively stable for both the first and second mining ponds, as the values approach one.

Organisms living in water bodies certainly have limiting factors, one of which is acidity or pH level. Each organism has a different pH tolerance range. pH in freshwater ranges from 5.0 to 10.0. Aquatic organisms, especially plankton, have a pH tolerance range of 5.0 to 9.0 (Sofarini, 2012). Based on the data from Table 3, it shows that the highest abundance of benthos is found in pond 2, namely 352 ind/m^2.

The uniformity index for both ponds indicates a stable community, while the dominance index indicates the absence of species dominance because it ranges from 0-1. According to Odum (1993), a dominance index value of 0–1, where the smaller the dominance index value, indicates that there is no dominant species among certain species. There are three types of benthos from the benthos analysis, indicating a low number of benthic species. According to Pratami *et al*. (2018), low dominance means that there are no significantly dominant species, environmental conditions are stable, and ecological pressure in the water body is low. Based on benthos analysis, the diversity values range from 0.6365 for pond one to 0.6616 for pond 2, indicating low benthos diversity values, and poor water conditions.

According to Alwi *et al*. (2020), the diversity index (H') consists of several criteria: if (H') is greater than 3.0, it indicates very high diversity, if the value of (H') is 1.0-1.5, it indicates moderate diversity. If H'<2 then the diversity of genera/species is low, the spread of the number of individuals per genus/species is low, community stability is low, and the water body is polluted (Odum, 1993). Gastropod benthos can be used as a bio-indicator of water quality because gastropods have strong adaptation to environmental changes due to their hard shells and more active mobile properties allowing them to survive compared to other classes (Alwi *et al*., 2020). Benthic animals, especially those that are herbivores and detritivores, can break down both living and dead aquatic macrophytes, including fallen litter entering the water, into smaller pieces.

Based on interviews and direct surveys in the field, some communities in Tanjung Riu Village, Gunung Mas District, have already utilized former mining pits for cultivation activities. One type of fish cultivated is tilapia (*Oreochromis niloticus*). According to the test results conducted by the Gunung Mas District Fisheries Service conducted by the Research and Industrial Standardization Institute, Banjar Baru in 2019, the mercury (Hg) content for tilapia was 1.5×10^{-2} mg/kg for liver samples and 1.6×10^{-2} mg/kg for meat samples, with the samples taken from one of the mining pit ponds in Gunung Mas District. In accordance with the Indonesian National Standard (SNI) in 2009 for mercury (Hg) content in fish and its processed products based on Decree of the Director General of POM 1989 is 0.5 ppm. The average mercury content (Hg) in fish from former mining pit ponds is still below the limit.

CONCLUSION

Based on the analysis of water quality in the former mining pits, it is still suitable for fish farming activities, except for the low pH parameter of the water. However, it can still be tolerated by fish, especially local fish and tilapia. Additionally, with the presence of water plants such as water lettuce, and the presence of plankton and benthos, it also supports the utilization of former mining pits for aquaculture activities.

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