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Analysis of pH, Temperature and Color in Coal Mine Acidic Water in West Aceh

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Abstract

Acid coal mine drainage from the coal mining industry contains a number of heavy metal ions and dissolved organic matter. An important step in wastewater treatment so that the waste treatment process runs effectively is to know the characteristics of coal mine acidic water. This study aims to determine the characteristics of coal mine acidic water originating from mine pond water by taking samples from a holding pond located in West Aceh. The method used in this research consists of field research and laboratory research. Measurement of acid coal mine water parameters including pH, temperature, and color. Data obtained from the measurement results were analyzed descriptively. The measurement results include pH, temperature, and color contained in coal mine acid water are also compared with the quality standards of liquid waste. The results showed that coal mine acid water in the former coal mine pond has the following pH, temperature, and color; water pH in void 1 is 4.0, void 2 is 4.50, and void 3 is 4.75. The water temperature in void 1 is 25 oC, in void 2 is 33.9 oC and in void 3 is 32 oC. The color in void 1, void 2 and void 3 is rather light and bright. All parameters of coal mine acid water measurement analysis results are still above the quality standards of coal mine acid water based on the Decree of the Minister of Environment No. 113 of 2003 concerning Quality Standards for Coal Mining Liquid Waste.

Keywords: Color; pH; Quality Standard; Temperature

Introduction

All regions of Aceh have abundant mineral resources. West Aceh district, in particular, has coal reserves of 1.7 billion tons, with known coal reserves of 600 million tons and total coal reserves of 400 million tons, according to data from the Ministry of Energy and Mineral Resources (2012)(Afin & Kiono, 2021). Coal mining practiced in West Aceh still uses open pit mining (Kiswanto et al., 2020)

PT Mifa Bersaudara was established on January 14, 2002 based on the Deed of Establishment of Limited Liability Company No. 69 and has been authorized by the Decree of the Minister of Law and Human Rights of the Republic of Indonesia No.C-03647.HT.01.01.TH.2002(Ninla Elmawati Falabiba et al., 2014).One of PT Media Djaya Bersama's subsidiaries is located in West Aceh, Aceh Province. The company works in coal mining. PT Mifa Bersaudara has a production operation mining business license (IUP-OP) No.117b/2011. Their concession area is 4,629 ha (Ha) in the West Aceh region, which has received a Clean

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and Clear (CnC) certificate No. 234/Bb/03/2014. A report on JORC standard coal reserves and resources released by PT Runge Indonesia in July 2011 showed that the company has potential coal reserves of 383 million cubic meters (Ninla Elmawati Falabiba et al., 2014;Kiswanto, 2023)

Since January 2012, the company has been conducting trial mining, also known as pilot mining. Since October 2012, the company has been shipping coal to Lhok Nga, Aceh Besar. With its first barge shipment, PT MifaBersaudara became a pioneer in the Aceh coal industry. The company received registered exporter (ET Coal) recognition Number 03.ET-04.14.0072 and began exporting since January 2015. The company has built infrastructure, including mine operational facilities, a coal crushing plant, a dedicated coal haul road, and a system for loading bulk coal onto barges at Peunaga Beach, West Aceh, better known as the PT MifaBersaudara coal terminal(Ninla Elmawati Falabiba et al., 2014;Fachlevi, 2015).

It is undeniable that the negative impacts of mining are increasing as the foreign exchange economy grows. This is especially true for environmental damage and the decline of public health. (Kiswanto&Wintah, et al., 2020). Communities around PT Mifa Bersaudara's concession complain about environmental pollution and river water pollution, which has recently become worse (Said & Yudo, 2021). It is clear that coal mining directly pollutes water due to coal washing waste that separates coal with sulfur. This waste pollutes river water, making the water cloudy and acidic, and coal washing deposits are scattered throughout the river, causing siltation of the river (Suroso et al., 2017).

Acid mine drainage is acidic water originating from mine drainage that has the potential to pollute natural water bodies both in the form of acid mine drainage and non-acid mine drainage if not properly managed and controlled(Gautama, 2014;Kiswanto et al., 2018).Coal mining activities have created giant ponds that are expected to put pressure on the surrounding environmental ecosystem, due to changes in rock structure followed by changes in physical and chemical quality. (Komarawidjaja, 2011;Kiswanto et al., 2021).Coal mine ponds will form when the rainy season arrives. During the rainy season, soil stripping and remnants of former coal mining will be dissolved in it. As a result, the water in this ex-coal pond will become acidic(Wijaya, 2010)

The former coal mining pond at PT MIFA Bersaudara is not far from the coal stockpile which has the potential to affect the quality of the surrounding environment. During the rainy season, liquid waste from the coal stockpile dissolves and enters the ex-coal mine pond and a number of dissolved substances in it. Coal Mining Activities at PT Mifa Bersaudara (Kiswanto & Wintah, 2024). PT Mifa Bersaudara uses an open pit mining system with the open cast method. The drainage system used is mine drainage and mine dewatering(Kiswanto et al., 2022;Madaniah, 2016). The source of water comes from rainwater and runoff water is allowed to flow into the pond, then removed by pumping. During the rainy season, puddles and overflows often occur on the mine floor because the volume of rainwater and runoff water entering the mine site is quite large but the volume of the well is not sufficient to accommodate the incoming water(Nugraha et al., 2020).

In order not to pollute the surrounding environment, the acidic water must be treated first before being discharged on the surface of the river. an important step in wastewater treatment is to know the characteristics of wastewater. (Kiswanto et al., 2020;Nugraha et al., 2020;Meyzilia, 2018). The characteristics of coal mine acidic water need to be treated effectively so as not to pollute the environment. So it is very important and necessary to do this research to find out the characterization of acidic water in the coal mine pond carried out by PT Mifa Brothers on the impact of the surrounding environment.To analyze the quality of acid mine drainage, it is necessary to analyze the parameters of pH, temperature and color. This is important as an indicator of the quality of acid mine drainage before it is discharged into river waterways.

Methods

The research method used is in situ. Field surveys were carried out by taking acidic water from ex-coal mining ponds and then taking field measurements. The parameters measured are pH, temperature, and color.

Tools and Materials

The tools used include pH meter, thermometer, sample bottle, cool box, label paper, oven, desiccator, analytical balance, measuring cup, beaker, and filter paper. The materials used are sulfuric acid reagent, buffer solution 10, distilled water, and blank solution.

Research Procedure

Coal acid water samples were taken from several former coal mine ponds using grab samples. Measurement of wastewater parameters includes pH, temperature, and color.

Data Analysis

Data obtained from the measurement of coal acid water parameters were analyzed descriptively. The measurement results of pH, temperature, and color parameters contained in the liquid waste were also compared with the quality standards of liquid waste based on the Decree of the Minister of Environment No. 113 of 2003 concerning Quality Standards for Coal Mining Liquid Waste.

Results

Testing the quality of coal mine acid water carried out at the location of void 1, void 2 and void 3 at the coal mine in West Aceh to determine the characteristics of water originating from the coal mine whether the existing water treatment has been able to carry out its function properly or not.

Testing the quality of coal mine acid water in void 1, void 2 and void 3 of the former coal mine is carried out to determine the characterization of pH, temperature, and color that play a role in coal acid water in the storage pond. Acid mine drainage is produced from rainwater runoff that carries fine particles of coal. These fine particles then dissolve and mix with organic matter in void 1, void 2 and void 3 of the former coal mine. The characterization test of coal acid water in ex-mining ponds is carried out in three ex-coal mining

ponds, namely void 1, void 2 and void 3. The characterization analysis activities in the three ex-coal mining pits will be seen in the parameters of pH, temperature, and color.

Acidity (pH).

The pH value in acid coal water is caused by stripping overburden, coal excavation, and waste materials that cause the exposure of soil/rock containing sulfide minerals, including Pyrite and Marcasite. The sulfide minerals then react with oxidants and water to form acid mine drainage.:

$2FeS + 7O2 + 2H2O \rightarrow 2Fe2+ + SO42- + 4H+$

Thus, in addition to being characterized by a low pH, acid mine drainage will also contain high concentrations of metals. This is in line with the results of the analysis of metals at the inlet in much greater concentrations than the outlet, so that it can have adverse effects on environmental and human health (Marganingrumdan Noviardi, 2010).

Temperature

Water temperature is influenced by water depth and seasonal changes. Temperature is one of the most important factors that can affect the physical and chemical properties of a body of water. Temperature can affect oxygen in water. The temperature in coal mining ponds in western aceh is on average higher than the quality odor. especially for voids 2 and 3 which reach above 32 ^{o}C. An increase in temperature can reduce the oxygen content in a body of water(Astuti et al., 2021;Dewi *et al.*, 2016).

Color

Color is one of the physical parameters of wastewater that can be observed directly, but is not a priority. The color of acid coal mine drainage in voids 1, 2 and 3 is influenced by the very high heavy metal content. Color arises due to the presence of a dissolved or suspended material in the water, in addition to certain coloring materials that contain heavy metals(Kiswanto et al., 2018b;Kiswanto et al., 2018a).

Discussion

pH (Acidity)

The pH value or degree of acidity indicates the level of acid or base in a solution. pH is a term to express the intensity of the alkaline or acidic state of something through the level of hydrogen ions or (H^{+}). Hydrogen ions are the main factor to determine chemical reactions. H+ ions are always in dynamic equilibrium with water (H_2O), which forms the atmosphere for all chemical reactions related to water pollution issues, although the source of hydrogen ions is inexhaustible. The normal pH value is around neutral between pH 6-8. The degree of acidity (pH) of waste water varies depending on the type of waste, the pH value is one of the main limiting factors for the survival of aquatic biota. (Kristanto, 2004). In wastewater treatment, pH also has an important role, namely in reducing the pollutants in it(Effendi, 2003). Changes in acidity in waste water either towards alkali (pH rises), ortowards acid (pH) decreases will greatly interfere with aquatic life and the surrounding environment. Decreasing the pH value will increase corrosiveness. High acidity will also dissolve

heavy metals, increasing the solubility of metals. (Connel, and Miller, 1995).

From the results of the analysis of acidic water quality in the pit of the former coal mine pond, it was found that the pH value in void 1 was 4.01, void 2 was 4.5 and void 3 was 4.75. In general, the pH value in these three voids is at an acidic pH value, thus exceeding the quality standard threshold limit. Acid mine drainage waste occurs due to the oxidation of pyrite (FeS_2) and sulfide mineral materials that are exposed in the process of extracting mine mineral materials. These mineral materials produce sulfate with a high acidity level(Geomine et al., 2018).Sulfide minerals affect the formation of acid mine drainage(Azis et al., 2016).

The dynamic position of water will affect the condition of the degree of acidity (pH) of water, pH conditions can change at any time depending on the content of substances contained in water bodies (Dewi *et al*., 2016).The physiological characteristics of mining water bodies can be identified by analyzing environmental factors, one of which is pH(Perala *et al.,* 2022)

The degree of acidity (pH) 6-8 is the maximum level of coal mining and processing activities. This is based on the Decree of the Minister of Environment No.113 of 2003 concerning the quality standards of wastewater from mining and coal activities.

Temperature

The former coal mine pond at the research location has a water temperature in void 1 of 25 ^oC, void 2 of 33.9 ^oC, and in void 3 of 32 ^oC. The temperature in void 1 still meets the required quality standards for wastewater quality standards from mining and coal activities (Kiswanto et al., 2022)

Of the three voids, the highest acid water temperature in void 2 is 33.9 ^oC. Because in void 2 there are many waste discharges that affect temperature changes in acidic water. High temperatures will directly affect the physiological processes of several types of fish and reduce their abundance in the waters(Maidie et al., 2010). At high temperatures, decomposition occurs and additional levels of oxidation of organic matter occur.Temperature is a very important parameter due to its effect on chemical reactions, reaction rates, the life of aquatic organisms and the use of water for various daily activities.

Color

The color in the former coal mine in void 1, void 2 and void 3 is rather light and bright. This is because the bioremediation process in the three voids is running well. turbidity occurs during the rainy season. Turbidity is strongly influenced by the presence of suspended materials such as sand, mud, organic and inorganic materials, plankton and other microscopic organisms. This can disrupt the ecological balance of a habitat because it can reduce the penetration of sunlight entering the habitat.(Alghifary& Widayati, 2020)

The measurement results of the turbidity value on the color value in void 1 are 3.01, void 2 is 0.00 and void 3 is 0.23. This shows that the color of acid mine water is very bright even in void 2 shows very good brightness, this occurs precipitation and the presence of several plants in the former coal mine pond helps in the bioremediation and phytoremediation process.(Wróbel et al., 2023)

Lottermoser (2010) states that one of the indicators of water exposed to acid mine drainage is color.

Turbid water color with variations of tosca, red, yellow, and brown indicates the presence of heavy metals dissolved in water. A low pH value can dissolve heavy metals. High heavy metals cause a low pH value and can be used as a physical indicator of water by looking at the color changes in water bodies..

Quality Standard for Liquid Waste

Coal liquid acid waste located in voids 1, 2 and 3 is a former coal mining industry at PT MifaBersaudara West Aceh. Decree of the Minister of Environment No. 113 of 2003 concerning the quality standards of coal mining liquid waste. Table 1. Comparison of effluent Quality Standards and characteristics no parameter quality standards unit void 1, void 2, and void 3.

Table 1. Comparison of effluent quality standards and characteristics

No	Parameters	Unit	Quality Standards	Void 1	Void 2	Void 3
1	pH	-	6-8	4,0	4,53	4,75
2	Temperature	^{0}C	25-30	25	33,9	32
3	Color	mg/	1	3,0	0,0	0,23

Description: EQS = Environmental Quality Standard

In the table above, it can be seen the comparison of Liquid Waste Quality Standards stipulated in the Decree of the Minister of Environment No. 113 of 2003 concerning the quality standards of coal mining liquid waste.The table shows that the characteristics of liquid acid waste entering void 1, void 2, and void 3, for the pH parameter, are in accordance with the quality standards of coal mining liquid waste. Temperature in void 1 is in accordance with the quality standards of coal mining liquid waste while in voids 2 and 3 it exceeds the quality standard threshold. Color in voids 1 and 2 is in accordance with the quality standards of coal mining while void 1 is above the quality standard

Conclusion

Coal mine acid water in the coal mine void has the highest pH value of 4.01, the highest temperature of 33.9, the highest color of 3.01. This proves that coal mine acidic water is not in accordance with quality standards. This has an impact on pollution that affects the surrounding aquatic environment.

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