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Characterization of Acidic Water from the Former Coal Mine of PT Mifa Bersaudara in West Aceh

Kiswanto[1,2]*, Wintah[1,3]

[1]Faculty of Science Health, Teuku Umar University, Indonesia, Postal Code: 23615

[2]Faculty of Engineering, Civil Engineering Study Program, Teuku Umar University Indonesia, Postal Code: 23615

[3]Faculty of Fisheries and Marine Science, Master of Fisheries Science Study Program, Teuku Umar University, Indonesian, Postal Code: 23615

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*Corresponding author:
Kiswanto
Teuku Umar University
E-mail: kiswanto@utu.ac.id

Abstract

Acid coal mine drainage from the coal mining industry contains a number of heavy metal ions and dissolved organic substances. 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 former coal mine ponds by taking samples from a holding pond located in West Aceh. The method used in this research consists of field work and laboratory work. Samples of coal mine acidic water were taken from the former coal mine pond using grab samples. Furthermore, measurements of acid coal mine water parameters were measured including pH, TSS, COD, Color, Fe and Mn conducted at the integrated laboratory of Diponegoro University. Data obtained from the measurement of acid coal mine water parameters were analyzed descriptively. The measurement results include pH, TSS, COD, Color, Fe and Mn ions 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 contained pH, TSS, COD, Color, Fe ions, and Mn with an average value of (5.5); (260mg/l); (162.82mg/l); (57mg/l); (4.7mg/l); (0.2mg/l). All parameters of coal mine acid water measurement analysis results are still above the quality standards of coal mining based on the Decree of the Minister of Environment No.113 of 2003 concerning Quality Standards for Coal Mining Liquid Waste.

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INTRODUCTION

The Aceh region has abundant mineral resources, one of which is West Aceh Regency which has large coal reserves. According to data from the Ministry of Energy and Mineral Resources (2012), West Aceh Regency has potential coal resource reserves of 1.7 billion tons with known coal resources of 600 million tons and total reserves of 400 million tons (Fachlevi 2015).

PT Mifa Bersaudara, established based on Deed of Establishment of Limited Liability Company No. 69 dated January 14, 2002 and has been ratified by Decree of the Minister of Law and Human Rights of the Republic of Indonesia No.C-03647.HT.01.01.TH.2002 concerning Ratification of Deed of Establishment of Limited Liability Company (Ninla Elmawati Falabiba et al, 2014). PT Mifa Bersaudara is a subsidiary company of PT Media Djaya Bersama, which operates in West Aceh Regency, Aceh Province which is engaged in coal mining. Production Operation Mining Business License (IUP-OP) No.117b/2011 on behalf of PT Mifa Bersaudara has a concession area of 4,629 Hectares (Ha) in the West Aceh area which has received a Clean and Clear (CnC) Certificate Number: 234/Bb/03/2014. Based on the coal reserves and resources report in accordance with the JORC standard issued by PT Runge Indonesia in July 2011, the Company has potential coal reserves of 383 million (Fachlevi, 2015; Ninla Elmawati Falabiba et al., 2014).

The company has been conducting pilot mining since January 2012 and has been shipping coal to Lhok Nga, Aceh Besar since October 2012. Thus, PT Mifa Bersaudara is a pioneer of the coal industry in Aceh with its first barge shipment. The company has obtained Registered Exporter (ET Coal) recognition No.03.ET-04.14.0072 and has started exports since January 2015. The company has built infrastructure from mining operational facilities, coal crushing plants, special coal haul roads, to a bulk coal loading system to barges at Peunaga Beach, West Aceh, better known as the PT Mifa Bersaudara coal terminal, as well as other supporting facilities. Lately, things have gotten murkier. Clearly, coal mining directly causes water pollution, namely from the coal washing waste, which separates coal from sulfur. The washing waste pollutes river water, so that the color of the water becomes cloudy, acidic, and causes siltation of the river due to the coal washing sediment (Setiawan et al., 2018;Kiswanto et al., 2020).

Acid mine drainage is acidic water originating from mine drainage that has the potential to pollute natural water bodies in the form of both acid mine drainage and non-acid mine drainage if not properly managed and controlled (Gautama, 2014; Alghifary and Widayati, 2020). 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 the physical and chemical quality of soil and water in ex-coal mine ponds. (Komarawidjaja, 2011;Madaniah, 2016). 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 (Nurcahyani, 2011; Meyzilia, 2018; Said & Yudo, 2021).

The former coal mine pond 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 use an open mining system with the open cast method. The drainage system used is mine drainage and mine dewatering. 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 at PT Mifa Bersaudara there are often puddles and overflows of water on the ground floor of the mine because the volume of rainwater and runoff water entering the mine site is quite large but the volume of the pits is not enough to accommodate the incoming water (Meyzilia & Darsiharjo, 2017; Kamarullah et al., 2022).

In order not to pollute the surrounding environment, the acidic water must be treated first before being discharged into the environment. An important step in liquid waste treatment is to know the characteristics of liquid waste (Kiswanto 2024; Setiawan et al., 2018).

To find out the characteristics of acidic water to be treated, the waste treatment process will run effectively. So it is very important and necessary to do this research to find out the characterization of acidic water in the mine pond of the former coal mine carried out by PT Mifa brothers on the impact on the surrounding environment. This study aims to determine the characteristics of coal mine acid water originating from the former coal mine pond by taking samples from the storage pond located in the village of Pucok Reudep Meureubo District, West Aceh Regency.

METHOD

The research method used consisted of field surveys and laboratory work. Field surveys were carried out by taking acidic water from the former coal mine pond. Sampling research taken three (3) void with coordinate points 4 0 12'23,86''N 96 0 15'2, 14''E, 4 0 12'42,25''N 96 0 14'56, 93''E 4 0 12'51,37''N 96 0 14'59, 77''E. Each void taken 3 stations. So the total sampling is 9 stations. Measured pH, Temperature, Color, COD, BOD, DHL, TSS, Fe, Mn and Cd pH was carried out in the Environmental Tenik laboratory Diponegoro University. The research location can be seen in the following figure;

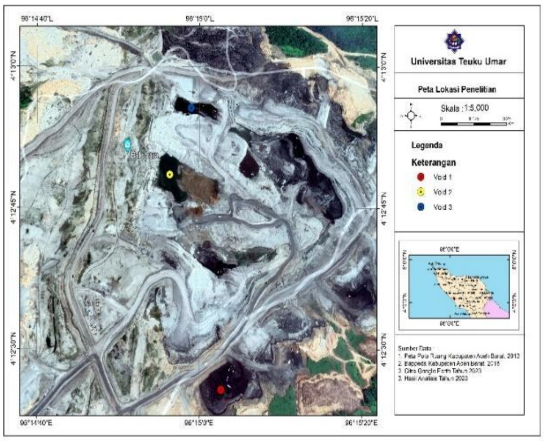

Figure 1. Research Sampling Location

Tools and materials

The tools used include pH meter, sample bottle, cool box, label paper, oven, desiccator, analytical balance, measuring cup, beaker, filter paper, and Atomic Absorption Spectrophotometer (SSA). The materials used are buffer solution 3, Digestion solution, 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 liquid waste parameters includes pH, Temperature, Color, COD, BOD, DHL, TSS, Fe, Mn and Cd.

Data Analysis

Data obtained from the measurement of coal acid water parameters were analyzed descriptively. The measurement results of pH, Temperature, Color, COD, BOD, Electrical Conductivity, TSS, Fe, Mn and Cd parameters contained in 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.

RESULT AND DISCUSSION

Testing the quality of acidic coal mine 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. Quality testing of coal mine acid water in void 1, void 2 and void 3 of the former coal mine was carried out to determine the characterization of pH, Temperature, Color, COD, BOD, DHL, TSS, Fe, Mn and Cd that play a role in coal acid water in the storage pond. Acid mine drainage is generated 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 the former mine pond was carried out in three former coal mine ponds, namely void 1, void 2 and void 3. The characterization analysis activities in the three former coal mine pits will be seen in the parameters of pH, Temperature, Color, COD, BOD, EC, TSS, Fe, Mn and Cd.

pH.

The pH of the water in the former coal mine pond water has a low value due to the rock stripping process in open pit mining. (Pertiwi, 2011;Said & Yudo, 2021). Coal excavation, as well as waste materials that cause the exposure of soil/rocks containing sulfide minerals (Kamarullah et al., 2022; F. Z. Ijazah, D. Rohmat, 2016; Said et al., 2021). Pyrite and Marcasite. The sulfide minerals then react with oxidants and water. Excavation forms 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 (Marganingrum and Noviardi, 2010).

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^+) (Said and Yudo, 2021). Hydrogen ions are the main factor to determine chemical reactions. H+ ions are always in dynamic equilibrium with water (H2O), which forms the atmosphere for all chemical reactions related to water pollution problems, although the source of hydrogen ions is never exhausted. The normal pH value is around neutral between pH 6-8. The 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 (Dlamini et al,2013;Nurcahyani, 2011; Hafids & Pagoray, 2015).

In wastewater treatment, pH also has an important role, namely in reducing the contaminants in it (Ilahi et al., 2018; Wijaya, 2010). Changes in acidity in waste water either towards alkali (pH rises), or towards 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 (Geomine et al., 2018). 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 4.010, 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.

Temperature

The temperature of coal mine acid water will affect the receiving body if there is a large enough temperature difference. Temperature can also affect the speed of chemical reactions and the organization of life in water. Changes in temperature reveal the chemical and biological activity of solids and gases in water. (Ira Triswiyana et al., 2019).

It 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. At high temperatures there is decay and an increase in the degree of oxidation of organic matter. (Setiawan et al., 2018). There is a former coal mine pit pond that has a water temperature in void 1 of 25 oC, void 2 of 33.9 oC and in void 3 of 32 oC. Of the three voids, the highest acidic water temperature is in void 2 at 33.9 oC. Because in void 2 there are many waste discharges that affect temperature changes in acid water.

Color

Color is one of the physical parameters of wastewater that can be observed directly, but is not a priority. 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 (Marsay, 2018).

The color in the pit of the former coal mine pond in void 1, void 2 and void 3 is rather light and bright. This is because the remediation process in the three voids is running well. turbidity 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 (Dlamini et al., 2013; Matsumoto et al., 2016).

This can disrupt the ecological balance of a habitat because it can reduce the penetration of incoming sunlight. The results of measuring the turbidity value on the color value in void 1 of 3.01, void 2; 0.00 and void 3; 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.

COD

COD is the amount of oxygen needed in water for the chemical reaction process to decompose existing pollutants. Measuring the strength of waste with COD is another form of measuring oxygen demand in wastewater. This measurement emphasizes the oxygen demand for chemistry where the compounds measured are materials that cannot be broken down biochemically (Santoso, 2018). COD values in unpolluted waters are usually less than 20 mg/l. If this is allowed to continue and increase, it can cause water biota to die. Fat and oil samples showed no increase or decrease in COD (Ismail and Moustafa, 2016).

The COD number is a measure for water pollution by inorganic substances. In the laboratory, COD measurement is carried out momentarily by making K2Cr2O7 oxidizer which is used as an oxygen source. Based on the analysis of laboratory testing, the COD results were obtained in void 1 with a value of 56.50 mg/l, void 2 with a value of 15.69 mg/l, and in void 3 with a value of 3.93 mg/l. The lowest COD in void 3, this is because in void 3 the bioremediation and phytoremediation processes have been carried out so that there is a decrease in COD values during the deposition process.

BOD

BOD is a measure of organic matter content in liquid waste. BOD is determined by measuring the amount of oxygen absorbed by the effluent sample due to the presence of microorganisms over a period of time (Yadav and Jamal 2018). High BOD values indicate poor water quality. BOD is acceptable when the amount of oxygen that would be consumed within five days by aerobic decomposing organisms in a volume of effluent at 20 ^{0}C (Suroso., 2017) Karathanasis et al,, 2003). The results are expressed in ppm the amount of dissolved oxygen needed by living organisms to decompose or oxidize waste materials in the water. So the BOD value does not show the actual amount of organic matter, but only measures relatively the amount of oxygen needed to oxidize these waste materials. If oxygen consumption is high, which is indicated by the smaller amount of dissolved oxygen remaining in the water, it means that the content of waste materials that require oxygen is high.

The increased BOD value of coal mine acid water in West Aceh causes mobilization of organic particles and reduces retention time, resulting in fluctuating BOD values (Karathanasis, A. D., Potter, C. L. & Coyne 2003). The results of BOD testing in void 1 amounted to 20.34 mg/l void 2 amounted to 5.49 mg/l and void 3 amounted to 1.37 mg/l. This also shows that Void 1 has the highest BOD value, so the process of degrading organic matter has not taken place to the maximum.

Electrical Conductivity

Electrical conductivity is the ability of water to conduct electric current, which is reflected in the total solids content in water and temperature at the time of measurement. The conductivity of wastewater in conducting electric current depends on the mobility of ions and levels dissolved in the waste (inorganic compounds > organic compounds conductor) (Kiswanto et al., 2018;Noor et al., 2019).

Electrical conductivity (DHL) is the ability of a liquid to conduct electricity (also called conductivity). DHL in water is a numerical expression that indicates the ability of a solution to conduct electricity. Therefore, the more dissolved salts that can be ionized, the higher the DHL value. The amount of DHL depends on the presence of inorganic ions, their valence, temperature, and total and relative concentrations.

Water with too high a DHL often has an unpleasant taste and/or high hardness and can also have a laxative effect. Other effects of high DHL concentrations also affect water clarity, decrease photosynthesis, incorporation of toxic compounds and heavy metals leading to increased water temperature (Hafids and Pagoray 2015). DHL measurements in void 1 amounted to 1 us, void 2 amounted to 1 us and void 3 amounted to 1 us. This shows that the DHL in the three voids has the same value and is still below the quality standard threshold (Nurcahyani, 2011).

TSS (Total Suspended Solid)

Total Suspended Solid (TSS) or suspended solids are solids that cause water turbidity, are not dissolved, and cannot settle. Suspended solids consist of particles that are smaller in size and weight than sediment, such as certain organic materials, clay and others. In laboratory examinations TSS is a solid that is retained on a filter consisting of parts that can settle and parts that cannot settle. TSS is a solid that causes turbidity, is not dissolved and does not settle directly.

The fact that suspended matter has a negative impact on water quality because it reduces the penetration of the sun into the water body, the turbidity of the water increases which causes growth disturbances for producer organisms due to a decrease in the photosynthesis process(Riyanda Agustira et al., 2019).

The results obtained from the TSS analysis are for acidic water samples of ex-coal mine ponds in voids 1, 2 and 3 that do not meet the quality requirements. For coal mine acid water samples, the results obtained in void 1, void 2 and void 3 are 42 mg/l, 320 mg/l, 652.67 mg/L respectively. The test of characterization results exceeds the allowed quality requirement of 200 mg/L.

Table 1. Quality Test Results of Coal Acid Liquid Waste

No	Parameter	Satuan	Void 1	Void 2	Void 3
1.	pH	-	4,01	4,50	4,75
2.	Suhu	^{0}C	25	33,9	32
3.	Warna	mg/l	3,01	0,00	0,23
4.	COD	mg/l	56,50	15,69	3,92
5.	BOD	mg/l	20,34	5,49	1,37
6.	DHL	us	1	1	1
7.	TSS	mg/l	62	320	652,67
8.	Fe	mg/l	5,408	8,05	9,46
9.	Mn	mg/l	1,172	1,25	1,24
10.	Cd	mg/l	< 0,01	< 0,01	< 0,01

Description: EQS = Environmental Quality Standard

Suspended solids in water generally consist of phytoplankton, zooplankton, human waste, animal waste, mud, plant and animal residues and industrial waste. If solids have a high value in the water, it can reduce the penetration of sunlight into the water so that the photosynthesis process of biota will be disrupted (Agustira et al., 2019 ;Dlamini et al., 2013).

Laboratory examination results with three sampling times showed the TSS content in void 1 was 62 mg/l, void 2 was 320 mg/l, and in void 3 was 652.67 mg/l. Based on visual conditions, the effluent in void 1 does look quite clear. The low TSS content in void 1, if seen from the conditions in the field, this occurs because void 1 does not receive runoff from the stacking area.

Receives runoff from the coal stacking area. While void 1 is the oulet pool of the WWTP treatment, where around it there are plants that function as bioremediation and also phytoremediation that can degrade suspended solutions and purify liquid waste in the former coal mining pond. However, the scattered coal is only in small quantities, so the TSS levels contained in the wastewater from void 1 are very low. For void 2 and void 3, in both ponds, the TSS parameter has very high levels, ranging from 320 mgl - 652.67 mgl. according to Plaffin et all, (2006) that suspended solids originating from coal stockpile run-off are at levels above 2000 mgl-1 even reaching 10,000 mgl-1. The high levels of TSS in void 2 and void 3 occur because both Ponds receive runoff water from the coal stockpile. Rainwater that falls in the coal stockpile area carries fine particles of coal to void 2 and void 3. The large amount of coal debris and particles carried by rainwater causes the TSS content in both Ponds to be very high.

Iron (Fe)

Iron is a metal that may be present in waters and sediments in high concentrations. Iron is the fourth largest element found in the earth's crust and is an essential element for living things (Kamarullah et al., 2022). Iron is required by plants and animals at significant concentrations. In animals, iron is essential in oxidative metabolism and is a key component in hemoglobin. In plants, iron is an essential element in the synthesis of chlorophyll, cytochromes, and in the enzyme nitrogenase (Kadlec et all., 2009). In plants, iron also plays a role in enzyme systems and electron transfer in photosynthesis. However, excessive iron levels can inhibit the fixation of other elements (Thisani et al., 2020).

The results of the analysis of acidic waste water in coal mine voids show iron content in void 1 has a value of 5.408 mg/l, void 2 has an iron content of 8.05 mg/l and iron content in voids of 9.46 mg/l. High iron content can endanger the life of aquatic microorganisms. Moore in (Effendi, 2003) menyatakan bahwa kadar besi 1,0 mgl-1 dianggap membahayakan kehidupan mikroorganisme akuatik.

Manganese (Mn)

Manganese is a micro-nutrient that is essential for plants and animals. Manganese plays a role in growth and is an important component of the enzyme system. Manganese deficiency can result in stunted growth, as well as impaired nervous system and reproductive processes (Mačingová et al., 2016) In plants, Manganese is an essential element in metabolic processes. Effendi (2003), stated that although manganese is not toxic, it can control toxic elements in waters, such as heavy metals. In natural waters, manganese content is found between 0.1 and 1 mg/l. Higher concentrations of manganese can be found in waters with low pH levels (Mačingová et al., 2016). The results of the analysis of coal acid liquid waste in the former coal mine pond show that the manganese content in void 1 has a value of 1.72 mg/l, void 2 is 1.25 mg/l and the manganese content of void 3 is 1.24 mg/l. From the test results it is still dangerous to the environment and health, so it is necessary to carry out continuous management and monitoring.

Cadmium

The results of the analysis of coal acid liquid waste in coal mine voids show that the Cadmium content in void 1 has a value of 0.011 mg/l, void 2 has a content of 0.0101 mg/l and the content in void 3 is 0.01006 mg/l. The results of the analysis of Cd content in voids 1, 2 and 3 show that it does not exceed the quality standard value that has been Decree of the Minister of Environment No. 113 of 2003 which is 0.1 mg / L. The results of the analysis of Cd content in all voids of Cd content did not exceed the quality standard value determined by the Decree of the Minister of Environment No. 51 of 1995 which is 0.1 mg/L. Cd contamination does not exceed the limit because the contaminant has been given dolomite lime ranging from 0.0750-0.0966 mg/kg (Susana, 2011;Kiswanto et al., 2020).

Quality Standard

Coal liquid acid waste located in voids 1, 2 and 3 is a former coal mining industry in South Kalimantan. Decree of the Minister of Environment No. 113 of 2003 concerning the quality standards of coal mining liquid waste. Comparison of Liquid Waste Quality Standards and Characteristics No Parameter Unit BML void 1, void 2, and void 3 can be seen in comparison to the 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. Table 1 shows that the characteristics of liquid acid waste entering void 1,void 2 dan void 3, for the parameters of pH, Temperature, Color, COD, BOD, DHL, TSS, Fe, Mn are still above the quality standard. As for the Cd content, it is still below the quality standard in accordance with the environmental quality standards set in the Decree of the Minister of Environment No. 113 of 2003 concerning the Quality Standards for Coal Mining Liquid Waste regarding the quality standards for liquid waste for coal mining activities. However, the government should review the quality standard of Fe content which is 9.46 mg/l and is far above 1.0 mg/l. according to Effendi, (2003) that iron levels of 1.0 mg/l are considered harmful to the life of aquatic microorganisms.

Another heavy metal is Mn must also be managed properly even though it is still not dangerous, but when accumulation occurs it will endanger the surrounding environment. TSS contained in acidic water waste from former coal mines is above the established quality standards. The TSS content reaches a value of 652.67 mg/l while the environmental quality standard sets the TSS content at 200 mg/l. Thus, the TSS content in the acidic water waste of the former coal pond is above the established quality standards.

CONCLUSION

Acidic coal mine water in coal mine voids has the highest pH value of 4.01, the highest temperature of 33.9, the highest color of 3.01, the highest COD of 56.50, the highest BOD of 20.34, the highest DHL of 1, the highest TSS of 652.67, the highest Fe of 9.46, the highest Mn of 1.72 and the Cd content is still below the quality standards set less than 0.01. The processing of acidic liquid waste in the former coal mining ponds in West Aceh needs to be processed again, especially for the parameters of pH, heavy metals Iron (Fe) and Manganese (Mn). Currently, the processing method using dolomite as an absorbent is not optimal so that more efficient and environmentally friendly processing needs to be done.

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