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Determination of optimum dose of using Cao (quick lime) for acid mine water management on pH parameters in *settling pond* 81W pt. Antareja Mahada Makmur *Site* Perkasa Inakakerta Bengalon district, East Kutai Regency, East Kalimantan

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Abstract

Background: Efforts to manage AAT can be done in several ways, namely by using active and passive methods. For active management is by adding certain chemicals such as lime or alum so that a reaction occurs to control pH and TSS levels. This is related to the actual problems of the research area due to the pH that does not meet the quality standards for coal mining wastewater. The low pH parameters in the research area are a problem in the mining environment, if the content of mining wastewater that has an acidic pH is not neutralized and then directly discharged into the river body causes environmental pollution such as, disruption of aquatic biota that cannot live with an acidic pH and also has an impact on river water which will later be used by the local community for daily activities.

Method: The research methodology is divided into 3 stages, namely: pre-field stage, field stage, and studio or post-field stage**.** Titration testing on each water sample with quicklime Titration testing to determine the optimum dose using initial measurement data obtained from the field. The dose used starts from 0.1 gr/L to neutral pH according to Environmental Quality Standards. Dosage determination is carried out in the Laboratory owned by PT Antareja Mahada Makmur site Perkasa Inakakerta using a jar test tool. Furthermore, the first data analysis carried out was to analyze rainfall data. From the results of actual flow rate measurements carried out at the inlet of the sedimentation pond and pH measurements in each compartment, the process of determining the amount of efficient quicklime dose for water quality management in the sedimentation pond was carried out.

Results: The initial pH test results averaged 3.86. After the titration test, the final pH averaged 7.45. The results of testing several dose ranges obtained for the initial pH of 3.86 were 0.05 gr/L. Why did the researchers only use one initial pH value because it was the average result of daily measurements carried out for 10 days. To change the optimum dose from a laboratory scale to a field scale is to multiply the optimum dose by the hourly discharge entering the *settling pond* 81W.

Conclusion : Several efforts have been made by PT Antareja Mahada Makmur, one of which is stabilization using the lime addition method on coal mining wastewater.

Keywords: Acid Mine Drainage; Coal; Mining; Wastewater

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1. Introduction

Wastewater produced by coal mining activities is water that comes from coal mining activities that include the process of excavation, transportation, stockpiling, coal washing and stockpiling both in open pits and underground mines. One of the wastes that is often produced by industry is liquid waste, including in the mining sector. Liquid waste is the most dangerous waste for the aquatic environment, especially in river areas because indirectly if the management carried out by the company is not right, it will pollute the quality of river water. (Ganjar, 2010).

Suparwartono 2024 stated, *Acid Mine* Drainage is waste that pollutes the environment that is formed due to mining activities, and is water that has a high level of acidity, namely with a pH value below 6, Acid mine drainage is also a term to describe the condition of chemical changes in water in the mining area to become more acidic, due to the effects of mining industry activities. When this acid mine drainage seeps, flows and/or is channeled, it will cause pollution to water sources and the surrounding land. Acid mine drainage containing heavy metals that flows into rivers or other water bodies will damage the ecosystem conditions in the river. This causes a decrease in water quality (Hidayat, 2017).

Optimization of environmental management and occupational safety and health in coal mining is very important (Amirudin et al, 2024). The implementation of the improvement plan strategy carried out at PT. AMM Site MHU went well and showed maximum results. This can be seen from the positive changes for all elements targeted for improvement (man/workers, machines and methods) which generally have an impact on reducing environmental pollution (Amirudin et al, 2024). Environmental quality standards are standards set by the government to ensure that the environment remains secure. These quality standards cover various aspects of the environment such as air, water, soil, noise, waste, and radiation. Environmental quality standards have several roles, one of which is to protect the environment and pollution and to provide guidelines for industry and other human activities to operate in an environmentally friendly manner. The parameters used for environmental quality standards regarding water quality include pH value, COD levels, BOD levels and dissolved oxygen. Standards quality for mining wastewater used as a reference by the Company to discharge wastewater into water bodies so as not to pollute the environment based on the Decree of the Minister of Environment Number 113 of 2003. The parameters listed include pH, Suspended Residue, Fe and Mn. The quality standards for the management of acid mine wastewater in the East Kalimantan region refer to the East Kalimantan Regional Regulation Number 02 of 2011, the parameters listed are TSS, pH, Fe and Mn levels.

pH or the abbreviation of *Potential of Hydrogen* is a degree of acidity used to express the level of alkalinity or acidity of a solution. pH is defined as *the cologarithm of the activity* of dissolved hydrogen ions (H+). The activity coefficient of hydrogen ions cannot be measured experimentally, so its value is based on theoretical calculations. The pH scale is not an absolute scale. The pH scale is relative to a set of standard solutions whose pH is determined based on international agreement. Pure water is neutral, with its pH value at a temperature of 25°C set at 7.0. Solutions with values less than seven are acidic, and solutions with values greater than seven are categorized as basic or alkaline.

According to the Decree of the Minister of Environment Number 113 of 2003 concerning Wastewater Quality Standards for coal mining businesses and/or activities, it states that wastewater from mining and management/washing activities must be managed by sedimentation before being discharged into water bodies. Acid mine water itself can be managed in two ways, namely (Metboke and Lake, 2018):

Active *treatment* Acid mine water treatment generally uses active treatment. *Active treatment* is a treatment that requires operation, maintenance, and monitoring from humans. The active mining waste treatment process is a treatment that works according to chemical reactions depending on the pollutants that pollute the mining waste water. Active treatment can be done by applying the process of coagulation, flocculation, neutralization, chemical precipitation, removal of heavy metal content and also sulfate content.

Acid mine drainage is neutralized by active treatment by continuously adding chemicals. The addition of basic or alkali elements to the sedimentation pond can increase pH and TSS levels. In addition to alkaline chemicals, flocculants, oxidants and coagulants can be used in certain cases to neutralize acid mine drainage.

Quicklime is a white amorphous material with the chemical formula CaO. Quicklime is the most widely used material in the processing of acid mine water using the *active treatment method* . Quicklime is widely used because quicklime is one of the chemicals that can increase pH practically, efficiently, easily found and cheaply and can reduce the content of heavy metals contained in acid mine water (Meinarni, 2017).

The increase in pH value is related to the dosage of quicklime and the duration of stirring. Quicklime (CaO) can increase the pH value because it has alkaline properties, so it can be concluded that the more quantity of material used for neutralization, the more Hydroxide ions (OH^-) will be produced by quicklime, then it will react with hydrogen ions (H^+) which are acidic substances contained in wastewater. This reaction will produce ions (H_2O) and form neutral salts which result in a higher pH value.

The length of contact time between quicklime and acid mine water also affects the increase in pH value. Acid mine water in contact with quicklime will cause a reaction between hydroxide ions (OH^-) from quicklime and Hydrogen ions (H^+) in water which can increase the concentration of hydroxide ions and will reduce the concentration of hydrogen ions in water. Furthermore, if the contact time between quicklime and quicklime is extended, the reaction will continue. So it can be concluded that the longer the contact time, the more hydroxide ions are formed and can cause a significant increase in pH in water based on previous research evaluations (Budianto, 2024).

2. Materials and Methods

The research methodology is divided into 3 stages, namely: pre-field stage, field stage, and studio or post-field stage.

Pre-Field Stage This stage is the initial stage before carrying out a direct inspection of the field. At this stage what is carried out is literature study, preparation of tools and materials and analysis of secondary data that will be used.

Field Stage In the field stage, there are two data taken, namely secondary data and also primary data. Primary data includes actual pump discharge data and acid mine water quality data) The flow discharge data was taken directly in the field, using the float method, namely using tools that can float such as ping pong balls and sand floats. The location of water sampling is adjusted to the purpose of sampling. Researchers determined several points for sampling as follows: inlet *settling pond* 81W, 6 Compartments and 1 *Outlet* or compliance point.

Secondary data includes rainfall data, quicklime requirement data, pump discharge data from *sumps* This rainfall data was obtained from the Company. The data taken is *historical* rainfall data for 10 years owned by the Company. This data is used as a consideration in determining the time of sampling. Lime requirement data was obtained from the Company. This data will be used by researchers as a consideration in determining the comparison of pure lime with the calculation of the Company's optimum and actual doses.

Post-Field Stage In the post-field stage, several things are done, namely: Titration testing on each water sample with quicklime Titration testing to determine the optimum dose using initial measurement data obtained from the field. The dose used starts from 0.1 gr/L to neutral pH according to Environmental Quality Standards. Dosage determination is carried out in the Laboratory owned by PT Antareja Mahada Makmur *site Perkasa Inakakerta using a jar test* tool

Data processing and analysis The first data analysis was carried out, namely analyzing rainfall data. From the results of the actual flow rate measurements carried out at the inlet of the settling pond and pH measurements in each compartment, the process of determining the efficient dose of quicklime for managing water quality in the settling pond was carried out. From the determination of the actual dose and discharge, an efficient composition can be determined. This determination is processed using Microsoft Excel 2021. The calculation of the need for quicklime in the settling pond was carried out. The calculation in question is multiplying the laboratory dose by the *settling* pond inlet discharge and the laboratory water volume. After that, it is multiplied by the time it is used (day/month/year). A comparison is made between the company's quicklime needs and the actual calculation.

3. Results

Settling pond *81W* is one of the work areas at PT Antareja Mahada Makmur *site* Perkasa Inakakerta located in Sekerat Village, Bengalon District, East Kutai Regency, East Kalimantan. *Settling Pond* 81W is one of the settling ponds used to accommodate acid mine water from *sump pit* 81. There are 2 settling ponds at PT Antareja Mahada Makmur *site* Perkasa Inakakerta, namely *settling pond* 81W and *settling pond* 71N. This study only discusses *settling pond* 81W. *Settling pond* 81W has 6 compartments with different lengths, widths and depths. Calculation of *settling pond dimensions* is based on field measurement results and also studio analysis using the *minescape application* with contour analysis of the settling pond.

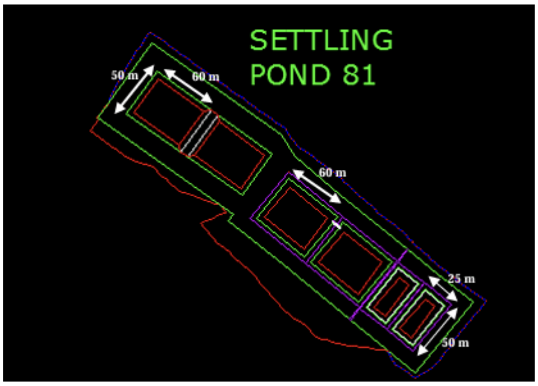

Figure 1 Sketch of *Settling Pond* 81W PT Antareja Mahada Makmur PIK *site* .

The dimensions of the compartments and the total volume of *the settling pond* 81W PT Antareja Mahada Makmur *site* Perkasa Inakarta are rectangular in shape as a whole. In compartment 1, it is rectangular with a length of 50 meters and a width of 60 meters, valid until compartment 4, then for pools 5 and 6, the length is 50 meters and the width is 25 meters. Next, the volume of each compartment and the total volume are calculated as follows

Table 1 Sedimentation Pond Dimensions

Compartment Size	**Sedimentation Compartment Length**	**Sedimentation Compartment Width**	**Depth**	**Number of Compartments**	**Pool Volume**
3.000,00	50	60	3	4,00	28.552,08
1.250,00	50	25	3,5	2,00	5.867,40
Total Volume				6,00	34.419,49

(Source: PT Antareja Mahada Makmur *site* Perkasa Inakakerta)

Actual Flow Rate The flow rate measurement affects the speed or slowness of the sedimentation process that occurs in *the settling pond* 81W. The flow rate measurement is carried out at *the inlet* of the first compartment in *the settling pond* 81W. The faster the flow rate in the tray, the faster the sedimentation rate that occurs. This water flow rate measurement is also used to support the process of calculating the optimum dose amount that will be used to neutralize acid mine water. The results of the actual flow rate measurement are as follows:

Table 2 Actual Flow Discharge at *settling pond* 81W

Sample (*sump* 81)	**Water Flow Rate (m3 / h)**	**Pump Time**	**Water Flow Rate (m3 / day)**
1	284.86	7	1994.02
2	284.86	8	2278.88
3	284.86	3	854.58
4	0	0	0
5	0	0	0
6	0	0	0
7	284.86	16	4557.76
8	284.86	10	2848.6
9	284.86	6	1709.16
10	284.86	9	2563.74
Average	199,402		1680,674

(Source: PT Antareja Mahada Makmur *site* Perkasa Inakakerta

Table 3 Actual Flow Discharge at *settling pond 76* W

Sample (*sump 76*)	Water Flow Rate (m3 / h)	Pump Time	Water Flow Rate (m3 / day)
1	534.96	23	12304.08
2	534.96	22.6	12090.96
3	534.96	23	12304.08
4	534.96	21.3	11394.48
5	534.96	22	11769.12
6	534.96	17.2	9201.12
7	534.96	16.5	8826.84
8	534.96	21.5	11501.64
9	557.52	23	12822.96
10	557.52	23.2	12934.64
Average	537.46	21.33	115,149

(Source: PT Antareja Mahada Makmur *site* Perkasa Inakakerta

From table 2, the results of the actual flow rate measurements above can be seen that every time a measurement is carried out, the results are... relatively the same. The lowest debit of measurement results from *inlet sump* 81 is 0 when the pump is not *running* while the highest debit from *inlet sump* 81 is 284.86 m3 / hour. Then for the lowest debit from *inlet sump* 76 is 534.96 and the highest debit is 557.52 m3 / hour. The resulting debit is quite high because at the time of the research the weather was the rainy season. When 2 pumps *are running* the debit is added between the 2 *sumps* . The debit itself affects how quickly or not the quicklime dissolves in *the settling pond* 81W .

Titration testing is a test used to neutralize pH and reduce metal levels by adding quicklime until the results are in accordance with the quality standards that have been set with reference to the Regulation of the Minister of Environment No. 5 of 2022 and the Regional Regulation of East Kalimantan No. 2 of 2011. The test was carried out in the Laboratory of PT Antareja Mahada Makmurn *site* Perkasa Inakakerta. The dosage used varies according to the initial levels that have been obtained in the field previously. The range of doses used to neutralize the pH of the *inlet acid mine water sample* was 0.01gr/L., 0.02gr/L., 0.03gr/L., 0.04gr/L., 0.05gr/L or making a dose range with an increase of every 10 mg/L. The optimum dose obtained from the titration test results is 0.05gr/L or 50mg/L. With an average initial pH of 3.86, it is used as a comparison to determine which dose is closest to the average pH and the initial pH of each sample. So pH 3.86 was taken with a dose of 0.05gr/L as the most optimal dose.

Table 4 pH Titration Test Results with Quicklime**.**

Sample	initial pH	Lime Dosage	Water Sample Concentration	pH Titration Results
1	3.86	0.01	1000	4.60
2	3.86	0.02	1000	5.09
3	3.86	0.03	1000	5.86
4	3.86	0.04	1000	7.15
5	3.86	0.05	1000	7.64
6	3.86	0.06	1000	8.12
7	3.86	0.07	1000	8.70
8	3.86	0.08	1000	9.20

(Source: PT Antareja Mahada Makmur *site* Perkasa Inakakerta)

Titration Result Testing After the titration test was carried out, a comparison of the initial and final levels was obtained. The following table and graph of the results of the pH level test.

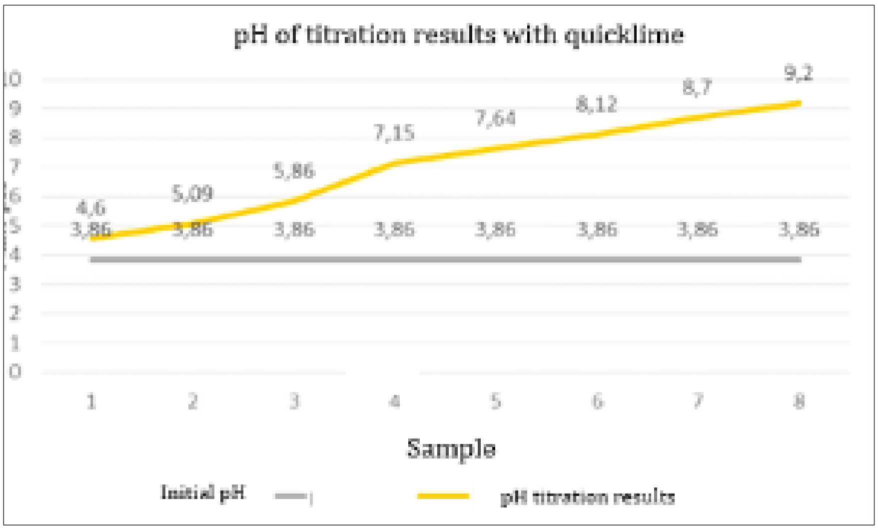

Figure 2 pH graph of titration test results with quicklime.

4. Conclusion

After conducting testing and processing data in this study, the following conclusions were obtained:

- The initial pH test results averaged 3.86. After the titration test was carried out, the final pH averaged 7.45.
- The results of testing several dose ranges obtained for the initial pH of 3.86 are 0.05 gr/L. Why researchers only use one initial pH value is because it is the average result of daily measurements carried out for 10 days. To change the optimum dose from the laboratory scale to the field scale is to multiply the optimum dose by the hourly discharge entering the *settling pond* 81W

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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