Neutralization Acid Mine Drainage (AMD) using NaOH at PT. Jorong Barutama Grestone, Tanah Laut, South Borneo

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ABSTRACT

Acid mine drainage (AMD) is mine water with a low pH derived from the oxidation of pyrite containing sulfide with water and air to produce sulfide acid (H_2SO_4) containing free sulfate. Acid mine drainage treatment carried out at PT Jorong Barutama Grestone Tanah Laut uses limestone at a cost of Rp.220. - per cubic meter of water. This study was conducted to determine the use of technical NaOH for changes in mine acid quality (pH. Fe and Mn). The method carried out by active handling is by adding technical NaOH into mine acid water. The results showed that neutralization of acid mine drainage using technical NaOH 10% to pH 8. was able to reduce Fe by 18.60 - 25.42% and Mn by 31.95 - 39.27%. at a cost of Rp.327.- per meter cubic of water

1. INTRODUCTION

Coal mining activities in Indonesia continue to increase. Indonesia's coal production has reached 178.8 million metric tons per year. with domestic consumption of 38.8 million metric tons and exports of 140 million tons. In addition to bringing benefits. it turns out that mining activities also have a negative impact. especially on the environment around the mining area. Acid mine water is the main waste generated from coal mining activities both at the extraction stage and also at the processing stage. This waste is a liquid waste formed by the exposure of sulfide minerals (generally pyrite) to water and air which results in oxidation of sulfur and produces high acidity and increased concentrations of sulfur. iron and other metals [1][2].

In general the process of neutralizing acid mine drainage uses quicklime. There are several kinds of lime that can be used namely agricultural lime (CaCO3), lime tohor (CaO), wall lime ($Ca(OH)_2$), dolomite ($CaMg(CO_3)_2$), and silica lime ($CaSiO_3$). Each type has a different level of penetration. The higher the penetration value of a lime. the higher the pH increase power and means the less amount of lime used to increase the pH in one unit [3]. For research on coal mine acid water handling which has been carried out. among others. is that passive treatment systems are almost always used as a permanent solution for various types of acid mine drainage (AMD) with much lower costs compared to active treatment processes. and are very suitable for water treatment acid mine with low flow rate and acidity [4]. Active methods with chemicals to neutralize and reduce heavy metals with active treatment are the addition of chemicals $CaCO_3$, CaO, $Ca(OH)_2$, NaOH, and Na_2CO_3 and passive treatment namely aerobic and anaerobic wetland; limestone ponds. open limestone channels (OLC). vertical flow reactors. sedimentation ponds. limestone diversion wells. and anoxic limestone drains (ALD) [5]. Research on the effective dose of limestone to neutralize acid mine drainage on a laboratory scale is 0.4 gr /L for water pH between 2.4 to 3.2 and 0.3 gr /L for water pH between 3.3 to 4. 0 [6]. the active use of quicklime in the inlet channel saves more than Rp. 93.750 / hour compared to using it on an outlet channel [3]. AMD treatment by limestone in which 40 g limestone is able to absorb 95% and 82% Fe and Mn in 200 ml of acid mine drainage samples [7]. Processing with bentonite and limestone results in that the activated bentonite (1%) is mixed with 1% limestone. the final pH obtained is around 7 and the metal removal efficiency is greater than 60% for most metals [8]. The settling agents, which are coagulant PAC (Poly aluminium chloride) and flocculant PAM (Polyacrylamide), are used to increase particle settling efficiency.

Concentrations of PAM and PAC added in the mine drainage are about 0.2–1 mg/l and 25–-45 mg/l and the treated effluents appear clear and get runoff concentrations of 0.03–0.49 mg/L Fe, 0.07–0.47 mg/L Mn, 13–27 mg/L total suspended solids (TSS) and pH range about 7–9 [9]. The combination of Acid B Extra™ and biochar achieved optimal near term results with >95% removal of Cd, Cu, Fe, Mn, and Zn, and >60% removal of Al, while not clogging [10].

Coal mine acid water treatment conducted at PT. Jorong Barutama Grenstone (JBG) using phytoremediation of purun tikus (Eleocharis dulcis) has the ability to absorb Fe in the range of 26.92 mg/g sample - 91.76 mg/g Mn sample ranging from 0.0596 mg/g sample - 0.2364 mg /g within 12 weeks contact time [11]. Biological treatment using anaerobic processes can reduce sulfate by about 87% and iron [12]. The electrochemical method for processing AMD is the reduction of metals achieved in particular. Zn and Mn which reach 95-97% [13]. Handling of Fe and Mn liquid waste has been carried out. by electrocoagulation process [14]. Research on the adsorption of Fe (III) by kayu apu (*Pistia stratiotes l.*) Charcoal modified chitosan-glutaraldehyde modification in which the optimum pH and time of Fe^{3+} adsorption occurred at pH 4 and 45 minutes with an adsorption capacity of 1.011 mg/g and% recovery of 96. 25% [15]. Mn (II) optimum pH occurs at pH 5 with an adsorption value of 13.27%. the optimum time occurs at 45 minutes that is equal to 1.03 mg/g. The percent recovery yield was 95.72% [16].

At present the handling of coal mine acid water in PT Jorong Batutama Grestone (JBG) is using lime tohor at a cost of Rp. 220 per cubic meter. The use of lime tohor turned out to have another impact. namely the accumulation of lime mud. so that it disturbs the view. For this reason. research into the use of other reagents is needed to overcome the problem of acid mine drainage. One of which is up to 100% efficiency is the use of NaOH. For this reason. neutralization of coal mine acid water will be studied using technical NaOH and its effects on metal content. especially Fe and Mn.

2. METHOD

Research methods to analysis parameters in acid mine drainage such as pH. Fe. Mn and Cd following Table 1.

TABLE I. Parameters and methods for analysis acid mine drainage

No.	Paremeter	Metode
1.	pH	SNI 06-6989 11: 2004 [17]
2.	Cd	SNI 6989.16:2004 [18]
3.	Mn	SNI 6989.5:2009 [19]
4.	Fe	SNI 6989.4:2004 [20]

pH analysis

The pH meter was calibrated at pH 4, 7 and 10. Then, the electrodes is dried with a tissue, and rinse with aquadest, rinse the electrode with sample water, and dip the electrode into the sample water until the pH meter shows a constant reading

Cd analysis

Preparation of standard solution and sample

100 mL of the homogeneous test sample is placed into the glass Trophy and was added 5 mL of nitric acid. Then, the test sample solution was dried and added 50 mL of distilled water. Then, the solution was transferred and added the distilled water until 100 mL. For, the 100 mg/L of cadmium standard solution, 10 mL cadmium metal mother liquor, Cd 1000 mg/L was pipetted into a 100 mL volumetric flask, and matched with the diluent solution to the mark. While for the 10 mg/L of cadmium standard solution, 50 mL cadmium standard solution, Cd 100 mg/L was pipetted into a 500 mL volumetric flask and matched with the diluent solution to the mark. Then, the solution was diluted to make the standard concentration between 0.0 mg/L – 0.2 mg/L. After that, the solution was measured by Atomic Absorption Spectrophotometer at wavelength of 228.8 nm. For heavy metal of Mn and Fe, the preparation standard has same procedures; however, the solution was measured at wavelength 279.5 nm and 248.3 nm, respectively. The concentration of heavy metal was calculated using Eq. 1.

$$Cd\ (mg / L) = C \times FP \quad (1)$$

Where, C is the concentration obtained by the measurement results (mg / L); and FP is the dilution factor.

3. RESULTS AND DISCUSSION

The results of the neutralization of acid mine drainage using NaOH are shown in Table 2 and 3. Table 2 shows that the pH value of acid mine drainage is less than 6. The pH value in acid mine drainage before the 3.92 and 4.18 treatment process shows that acid mine drainage is very acidic and far from the waste quality standard set by the Decree of the Governor of South Kalimantan number 36 of 2008 is 6-9. Acid mine drainage (AMD) in Indonesia is generally caused by high rainfall and the remaining excavated mineral material composed of sulfidic minerals. Acid mine water is characterized by a very low pH, high sulfate concentrations and accumulation of heavy metals [21].

TABLE II. pH acid mine drainage (AMD) and sediments

Code Sample	pH AMD	pH sediment
M23E	3.92	4.29
M4E	4.18	4.20
M54C	7.20	9.00

The acidity that occurs in acid mine drainage is caused by sulfuric acid which can reduce the pH of the water and cause dissolution of metal ions. This pH value greatly affects the metal content in wastewater. At M3E d M4E is acid mine drainage before treatment with limestone, and M54 is after treatment with limestone its settling pond location at PT. Jorong Batutama Grestone, Tanah Laut, South Borneo.

TABLE III. Concentration of Mn. Cd and Fe metals in acid mine drainage (AMD) and sediments

Sample AMD	Mn (mg/l)	Fe (mg/l)	Cd (mg/l)
M23-E	21.75	41.97	0.013
M4-E	8.30	10.32	0.005
M45-C	47.80	2.76	0.003
Sediment	**Mn (mg/l)**	**Fe (mg/l)**	**Cd (mg/l)**
M23-E	22.40	29.15	0.013
M4-E	12.20	39.75	0.012
M45-C	16.37	23.18	0.098

Tables 2 and 3 show that acid mine drainage (AMD) for pH. Fe and Mn parameters shows that it is not in accordance with the threshold set by the Government of South Kalimantan based on the Decree of the Governor of South Kalimantan number 36 of 2008 concerning the standard quality of waste water mining activities coal processing/washing. AMD has a very low pH and causes macro nutrients to become unavailable because it is bound by metal ions. On the other hand the micro nutrients which consist of solubility metals become very high, this is also shown from the results of the analysis of Mn which are 8.3 mg/L and 21.75 is exceed standard 4 mg/L, Fe are 41.97 and 10.32 mg/L is exceed standard 7 mg/L. For this reason, it was tried to be neutralized using 10% NaOH and seen changes in pH and levels of Fe and Mn metals in the acid mine drainage. Results of acid mine drainage treatment by neutralization using 10% NaOH shows the following results shown in Table 4.

TABLE IV. Concentration of Mn. and Fe before and after neutralization using 10% NaOH

Sample AMD		**pH**	**Mn (mg/l)**	**% reduce**	**Fe (mg/l)**	**% reduce**
M23-E[a]	before	3.92	21.75		41.97	
	after	8.00	14.80	31.95	31.30	25.42
M4-E[b]	before	4.18	8.30		10.32	
	after	8.00	5.04	39.27	8.40	18.60

Note:
[a]To make pH 8,1 liter of M23-E acid mine water requires 2.74 mL of 10% NaOH.
[b]To make pH 8,1 liter of M4-E acid mine water requires 2.36 mL of 10% NaOH.

Data in Table 4 shows that the process of increasing the pH was able to reduce levels of metals in acid mine drainage. The results showed that the addition of 10% NaOH was able to reduce Mn by 31.95 to 39.27% and Fe by 18.60 to 25.42%. This research results are smaller when compared with research that has been done by Sweeti 2013 [12] which with anaerobic process can reduce sulfate by about 87% and iron. with an electrochemical process for AMD processing there is a reduction in Zn and Mn which reaches 95-97%. [13] as well as the electrocoagulation process can reduce Fe and Mn [14]. To calculate the cost needed to increase 1 liter of water from a pH of around 4 to 8 it turns out that 10% NaOH is needed as much as 2.56 ml at a cost of 327 rupiah. The calculation of the costs is shown in Table 5. From Table 5. it can be seen that the cost for acid mine drainage treatment per cubic reaches 327 rupiah. which is more expensive than using lime which is 220 rupiah. which produces sludge in ponds. This is a consideration for the treatment of acid mine drainage in the mining industry

TABLE V. Calculation of NaOH cost per m^3 of acid mine drainage

Description	**unit**	**Total**
Volume NaOH 10%	ml/l	2.56
Volume NaOH 10%	l/m^3	2.56
Weight NaOH 10%	g/m^3	256.00
Price 1 kg NaOH 98%	Rp	12.500.00
NaOH 98% needed per m^3	g	26.12
Cost per m^3 of acid mine drainage	**Rp**	**326.53**

4. CONCLUSION

The conclusions that neutralization of acid mine drainage using technical NaOH 10% to pH 8. was able to reduce Fe by 18.60 - 25.42% and Mn by 31.95 - 39.27%. at a cost of Rp.327.- permeter cubic of water.

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