Analysis on the influence of rainfall and mine water ratio against pH in East pit 3 West Banko coal mine

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Abstract. In the coal mining area, the pH of mine water is found tend to low and acids. In order to increase the pH, it is important to consider the treatment of acid mine drainage using lime, due the indicators of pollution. This work is focused on the influence of rainfall volume on the pH of acid mine drainage. This research conducted using a ratio of mine water and rainfall water that varies in the 9 (nine) conditions, respectively: 1: 1, 1: 2, 1: 3, 1: 4 and 1: 5 and 5: 4, 5: 3 , 5: 2 and 5: 1. The results were then measured and tested with statistical analysis. The ratio of rainfall and mine water showed a significant effect on the pH. The higher of the rainfall lead to increase pH. This condition will affect the water neutralization process using lime where there are some possible differences on dose of lime needed to neutralized the acid mine drainage in the rainy season and dry season.

1. Introduction

The main problem faced in the coal industry is a pollution due to the presence of acid mine drainage (AMD). It is commonly formed by the oxidation of sulfide minerals, mainly pyrite that produces sulfuric acid [1]. With a high acidity level, coal mine water can dissolve other minerals and releasing cations such as Fe, Mn, Al, Cu, Zn, Cd, Ni and Hg. When the coal mine water flow into water sources, it can reduce biological productivity that was existed in the water system. In severe conditions, the water becomes dangerous for consumption and for other purposes [2].

Acid mine drainage become major concern, where the volume of this water was cames from rainfall and the water which produces from exploration and mining activities at the mine front [3]. The Accumulation of mine water may produce pollution caused by the mining activities that bring pollutants material.

The input factor on producing mine water is the climate, especially the wind that brought mine material, dust, catchment areas, slopes and basin that will be a carry out the water to settling ponds that directly or indirectly will bring mine materials. In addition, the water from the front mines that are the result of excavation and exploration activities will be accumulated with rain water which in certain conditions will produce acid mine drainage.

Mine water management system in the mining area of West Banko using a pumping series system, which means that there are several pumps are placed in certain spots to remove water from the surface / mine. This is because the mining area that has been excavated is located at a depth of ± 100 m, thus allowing a puddles which if not removed would disrupt mining activities[4].

The mine water was pumped from the mine front to the drainage system which located on the surface of mine and then flow into the settling pond. In many cases, mining companies generally use lime to neutralize mine water before the water flows into the settling ponds. This is intended to allow the pH of the water that goes into the pool increases. According to Hakim [5], lime is material that containing calcium which can be given to raise the pH. The increase in pH can occur because the hydrogen ions (H +) in solution disabled.

According to Setyamidjaja [6] calcification, in general is supplying materials for the purpose of increasing the pH. Lime reacts with acids to produce a near-neutral pH value of about 6-7. The degree of neutralization and the end result of this reaction is not known with certainty. When lime is given to the water, probably it will react with water containing CO 2 and soil colloids. The reaction is as follows:

$$CaO + H_2O \longrightarrow Ca(OH)_2$$
$$CaCO_3 + H_2O \longrightarrow Ca_2^{+} + HCO_3^{-} + OH^{-}$$

The reaction with H_2CO_3 is as follows:

$$CaCO_3 + H_2CO_3 \longrightarrow Ca(HCO_3)_2$$
$$Ca(OH)_2 + 2H_2CO_3 \longrightarrow Ca(HCO_3)_2 + 2H_2O$$

Lime generally used because the conditions of water are too acid. Therefore, The pH of the water should be increased so that the nutrients can be absorbed by plants

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and Al toxicity can be avoided. Usefulness of granting lime is to increase the pH, Mg and Ca. Adding lime could increase the availability of P and Mo, eliminating the element content of Al, Fe and Mn, and improve the life of the organism. [7].

The existence of acid mine drainage can reduce the acidity (pH) and the content of total suspended solids (TSS), Fe and Mn, TSS in relatively high amounts. It will reduce the penetration of light / sunlight into the water thus affecting the regeneration of oxygen in photosynthesis. Fe content that exceeds quality standards could endanger aquatic organisms and may cause corrosion to the equipment that metal made, while Mn at high concentrations are toxic. The pH value outside normal range may affect to the organisms in the water such as fish and other animals.

The experimental results in previous studies of acid mine drainage in the sump without rainfall water known that the optimum dose of lime that effectively increasing the pH of acid mine water is at a dose of 0.8 g / liter with operating time of 50 minutes, the pH obtained is 7,32. based on the results of these measurements , it can be known that to raise the pH of 1, the dose of lime needed of 0.24 g / l [8].

Lime requirements to conduct the treatment of acid mine drainage needed a valid data, where lime treatment performed in the third pond. Therefore, precise data is required on the ratio of precipitation and acid mine water or needed to know acid mine drainage debit and rain water discharge then the amount of lime dose required can be known [9].

2. Method

2.1. Laboratory Studies

Laboratory experiment conducted to determine the effect of the ratio of the rainfall volume and mine water to pH. mainly analysis on the use of lime to increase the pH on various conditions (ratio of rainfall volume and mine water).

2.2. Variable Research

1.Mine water
2.Rainfall water

2.3. Effect of rainfall valume and mine water on pH

Measurement on the effect of the ratio of the volume of rainfall and mine water on pH is based on optimum conditions obtained in the analysis of the effect of the operating time and lime dose on pH, . The Variations of ratio on rainfall volume and mine water and its effect on pH was : 1: 5, 2: 5, 3: 5, 4: 5 and 5: 5.

The effect of the ratio of rainfall volume and mine water on pH to be analyzed using ANOVA test and further tests such as real difference test and Tukey method to determine whether a significant effect between variables.

3 Result And Discussion

1. The Influence of Rainfall Volume on the pH

One of the factors that generate acid mine drainage is rainfall. In order to determine whether there is influence of rainfall on the pH of acid mine water, further testing conduct in the laboratory using a variety of volume of rainfall and acid mine water from Settling pond on East pit 3 West Banko Coal mine againts the pH.

From the laboratory test results, it can be seen that the pH levels will be increase if the volume of rain water also increasing, it can be concluded that the volume of rain water would give effect to the pH levels, thisis due to the concentration of acid mine water mixed with rain water will reduce the acidity of the water and then, on the high level of rainfall volume, the higher of the pH levels generated. To test and analyze the effect of rainfall, then the testing on hypothesis as the basic for this research in order to obtain valid results in the conclusion of this experiment. Tests conducted to determine whether there is singnificant effect between the volume of rainfall on pH and whether there is any real difference between each treatment in this trial.

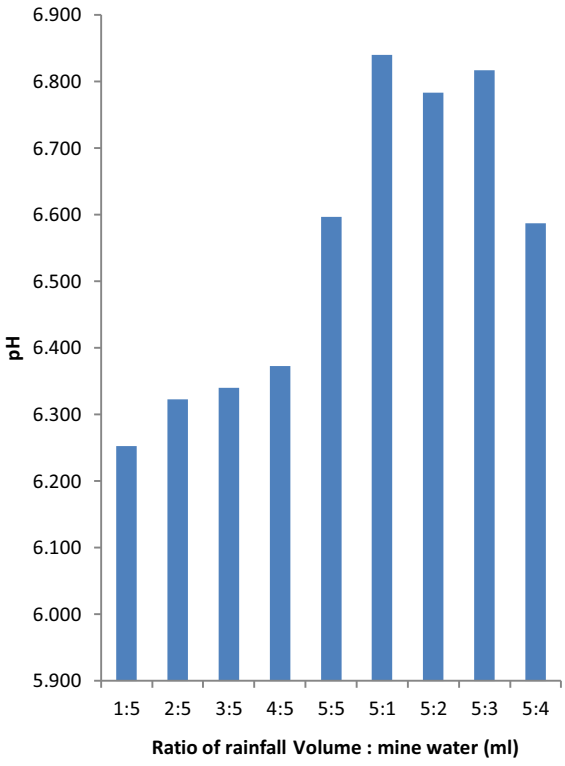

Fig 1. The Influence Of Rainfall Volume and mine Water on pH

As a base of test, then using a hypothesis to the effect of rainfall volume on the pH is as follows.
Ho: $\alpha_1 = \alpha_2 = \alpha_3 = 0$, meaning that there is no difference between the mean treatment of rainfall volume on the pH
H_1:at least there is one $\alpha_i \neq 0$, i = 1, 2, 3

For the above hypothesis, the decision-making that reject Ho if $t_{count} > t_{ref,}$ or otherwise accept Ho if $t_{count} < t_{Ref}$ [10].The test results influence the volume of rainfall volume on the pH of acid mine drainage as shown in Figure 1. From the calculation and analysis show that there was a significant difference between the volume of rainfall water and pH, because the value of significant level is less than 0.01.

Table.1. Variance Analysis

Source	Sum	df	Average Squares	F	Sig.
Rainfall Volume	610 259	5	122. 052	43486.39 9	.000
Error	.028	10	.003		
Total	287	15			

Statistical result

The changes in the pH of acid mine drainage caused by the volume of rainfall. The magnitude coefficient of determination or the closeness of the variable volume of rainfall effect on the pH of acid mine water, known is 0,99 or 99%, which shows the significant level on influencing the pH of acid mine drainage.

The test results further by using the Tukey method is known that the volume of rainfall water affect with a significant level on pH.Variations in rainfall volume shows that in ratio 5: 5 is the most significant level on increasing the pH. This is shown in the table where the condition of five (5: 5) until the condition 9 (5: 4) were significantly different from the conditions 1, 2, 3, and 4. It can be concluded that the higher volume of rain water will increase the pH.

Table 2 .. Comparisons of rainfall volume

(I) rainfall	(J) rainfall	Mean Difference (IJ)	Std .Error	Sig.	95% Confidence Interval	
					LowerBound	Upper Bound
1:00	2:00	-.0700	.04514	.562	-.2260	.0860
	3:00	-.0867	.04514	.379	-.2426	.0693
	4:00	-.1200	.04514	.148	-.2760	.0360
	5:00	-.3433 *	.04514	.000	-.4993	-.1874
2:00	1:00	.0700	.04514	.562	-.0860	.2260
	3:00	-.0167	.04514	.995	-.1726	.1393
	4:00	-.0500	.04514	.799	-.2060	.1060
	5:00	-.2733 *	.04514	.002	-.4293	-.1174
3:00	1:00	.0867	.04514	.379	-.0693	.2426
	2:00	.0167	.04514	.995	-.1393	.1726
	4:00	-.0333	.04514	.941	-.1893	.1226
	5:00	-.2567 *	.04514	.003	-.4126	-.1007
4:00	1:00	.1200	.04514	.148	-.0360	.2760
	2:00	.0500	.04514	.799	-.1060	.2060
	3:00	.0333	.04514	.941	-.1226	.1893
	5:00	-.2233 *	.04514	.007	-.3793	-.0674
5:00	1:00	.3433 *	.04514	.000	.1874	.4993
	2:00	.2733 *	.04514	.002	.1174	.4293
	3:00	.2567 *	.04514	.003	.1007	.4126
	4:00	.2233 *	.04514	.007	.0674	.3793

Statistical Result

The analysis results also concludes that acid mine drainage conditions will be different during the rainy and dry seasons, in which the pH during high rain water tends to be higher and closer to the environmental quality standard, while in the dry season the water will contain lower pH.

Along with it also the amount of lime dose that is given there will be a difference on dose, in the rainy season, the lower dose of lime due to the pH of acid mine water is already approaching the environmental quality standard, while the dry season when rainfall is low, then the dose of lime will be the higher to increase the pH due to acid mine drainage is low.

2. Effect of Rainfall on the use of lime Dose

The estimation amount of precipitation plan that occurred in the region of East Pit 3 West Banko coal mine must be supported by their maximum daily rainfall data over the last few years were obtained from the Civilian Planning and Hydrology on PT. Bukit Asam. This analysis was conducted for the last 10 years ranging from 2005 to 2015. Based on data obtained and analyzed by the Planning and Hydrology section of PT Bukit Asam gained the highest maximum daily rainfall of 165 mm / day and the lowest was 76.4 mm / day.

In Figure 2, note the pattern of rainfall monthly average in the region of West Banko where conditions are the highest in December amounted to 366.09 mm / month and the lowest in August amounted to 97.76 mm / month. Based on the pattern of rainfall monthly averages also showed that the monthly rainfall of high intensity occurs from November to April, while the monthly rainfall at low intensity occurred in the month of May to October. It can be concluded that the rainfall will always be different on each month in one year, it is certainly going to affect the condition of acid mine water, where there will be mixing with rain water levels will be different in each month

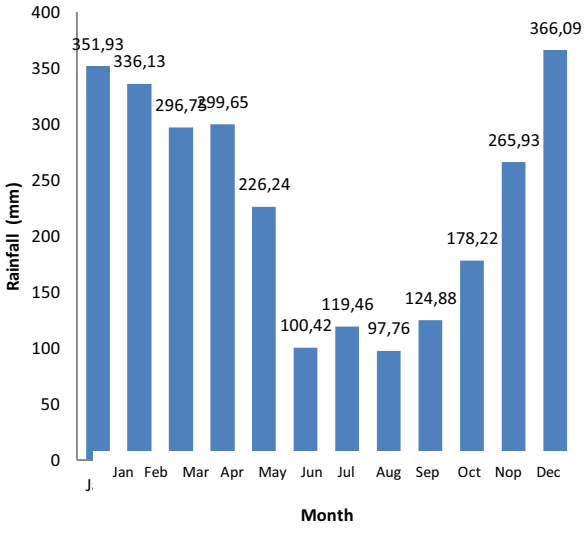

Fig 2.1. Average monthly rainfall on West Banko

Based on the data and the measurement result, it is known that the volume of acid mine drainage is equal to

1.75176 million liters / day. While the volume of rainfall for the east pit 3 West Banko coal mine area as following table.

Table 3. Rainfall Volume

Month	The volume of rainfall for Period					
	2 years	5 years	10 years	25 years	50 years	100 Years
Jan	203,244,064.97	261 636 728	301 704 783	352 323 156	365 021 297	399 869 120
Feb	197,450,329.86	259 587 125	299 339 987	349 562 516	386 821 449	423 750 474
March	188,946,816.62	244 355 895	281 777 086	329 052 432	364 125 242	398 887 460
April	189,887,913.60	252 968 904	291 708 303	340 650 521	376 959 477	412 947 021
May	165,666,191.35	209 066 965	241 092 481	281 542 150	311 550 958	341 294 078
June	120,997,411.20	155 473 820	179 283 763	209 363 178	231 678 606	253 796 477
July	109,149,597.92	143 786 194	165 805 503	193 623 765	214 261 578	234 716 533
Aug	141,075,597.74	190 669 748	219 868 882	256 757 458	290 709 597	311 249 377
Sept	98,656,779.37	129 962 584	149 865 124	175 008 915	193 662 766	212 151 340
Oct	159,444,721.66	210 655 636	242 920 459	283 670 628	313 906 802	343 874 789
nop	174,220,115.36	228 109 732	262 987 688	307 751 591	340 554 085	373 066 081
Der	199,282,486.48	264 529 275	305 039 224	356 217 800	394 186 016	431 818 127

PT. Bukit Asam (2015)

According to table 4 it is known that the volume of acid mine drainage and rain water volume will be different in each month, so the use of lime for acid mine water management differently.

Relating with the use of lime dos , the ratio of the rainfall volume and acid mine drainage is important to know to obtained effectiveness lime treatment monthly pattern on acid mine drainage. The effect of the ratio of rainfall volume and acid mine drainage on the pH of water known based on the trial and interpolation data as follows.

Table 4.1 Effect of Ratio Rainfall and Acid Mine on the pH

RV / AMD	**pH**	**RV / AMD**	**pH**
1.0: 1	5.6	2.7: 1	6.11
1.1: 1	5.64	3.0: 1	6.2
1.2: 1	5.66	3.3: 1	6.29
1.3: 1	5.69	3.4: 1	6.32
1.4: 1	5.72	3.9: 1	6.47
2.0: 1	5.9	4.0: 1	6.5
2.3: 1	5.99	4.1: 1	6.53
2,5: 1	6.05	5.0: 1	6.83

Description: RV: Rainfall Volume, AMD: Acid Mine Drainage

For monthly lime dose, using the data in Table 3 and 4, it can be seen that the monthly dose of lime used is as follows.

Application of lime doses were conducted to determine the effectiveness treatment in order to achieve

Table 4.2 Lime Dose Monthly

Month	**ratio RV: AMD**	**pH**	**pH ENV**	**pH Needs**	**Dose/ 1 pH**	**Lime dose**
January	3.9: 1	6.47	7	0.53	0.24	0.1
February	4.1: 1	6.53	7	0.47	0.24	0.1
March	3.3: 1	6.29	7	0,71	0.24	0.2
April	3.4: 1	6.32	7	0.68	0.24	0.2
May	2,5: 1	6.05	7	0.95	0.24	0.2
June	1.1: 1	5.64	7	1.36	0.24	0.3
July	1.3: 1	5.69	7	1.31	0.24	0.3
August	1.1: 1	5.64	7	1.36	0.24	0.3
boss	1.4: 1	5.72	7	1.28	0.24	0.3
October	2.0: 1	5.9	7	1.1	0.24	0.3
nop	3.0: 1	6.2	7	0.8	0.24	0.2
December	4.1: 1	6.53	7	0.47	0.24	0.1

Description: RV: Rainfall Volume; AMD = Acid Mine Drainage

the environmental quality standards, in which the use of lime will be less in the rainy season and more during the dry season.

Based on precipitation data for the area East Pit 3 West Banko, it is known that the conditions of high rainfall during the period from 2005 to 2015 is from November to April so that the use of doses of lime was low, while in the low rainfall that on May to October the use of lime doses will be much more.

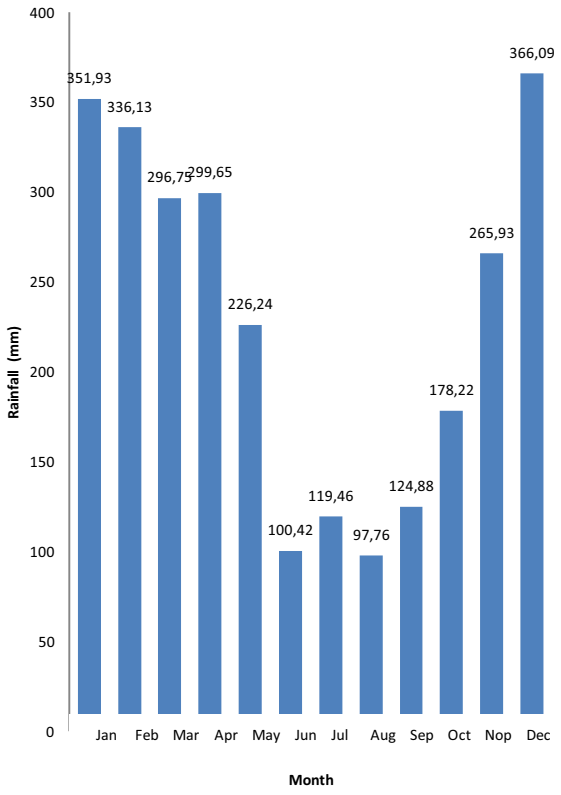

Fig 2.2 Rainfall Volume on East Pit 3 West Banko

4 Conclusion

Based on the analysis and discussion in the previous section, it can be concluded as follows:

a. Laboratory test results shows that the pH levels will be higher if the volume of rain water high, it can be concluded that the volume of rain water effect to the pH levels where the concentration of acid mine water is mixed with rain water and it will reduce the acidity. then, then, the higher the volume of rainfall, the higher the pH.

b. The rainfall volume affect to thepH water due to the process of dilution by rainfall water. It will decreasing H^+ there by increasingt he pH of the mine water.

c. The difference in the volume of rainfall as a result of different seasons will affect the dose of lime that given to raise the pH. Then ,there will be differences in the dose of lime to the dry season and the rainy season.

Acknowledgments

This research was made possible through a permission from the management of PT. Bukit Asam coal mine that would give us an opportunity to research [10].KA. Gomez, *Statistical Procedures for Agricultural Research* .(2010). and work in coal mine field at the west Banko. And special thanks to all of the employees on coal mine field that providing support and helping us every equipment that we all needs.

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