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Geochemical Behavior of Leachate Water from Column Leaching Test of Dry Cover Simulation with The Application of Fly Ash and Organic Material

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Abstract

Acid mine drainage (AMD) has been considered as a serious water pollution in the mining since several decades ago. Even though its source is a point mine site, AMD capable to heavily pollute its surrounding environment by flowing to both surface and groundwater consequently increase the dissolved metal concentration beyond the threshold. Therefore, it is important to prevent AMD generation rather than conducting treatment method which generally more difficult and expensive. This research aims to investigate the possibility of using fly ash and organic material as a measure to prevent and control the AMD generation. Fly ash is able to neutralize water with alkaline matter content and also cementation properties to bind the material and reduce the AMD reaction. Meanwhile, organic material has a capability in consuming the oxygen during the degradation process, which contribute in diminishing the oxidation process of AMD generation. Column leaching test was conducted to simulate the process of AMD, with the fly ash and organic material applied as a dry cover layer. Several scenarios were conducted to examine the effect of materials in case of high sulfur waste material. Leachate water behavior was observed for the pH, conductivity, major anion-cation, dissolved metal concentration and total organic carbon.

1. Introduction

AMD is generated when sulfide mineral exposed to the air and oxidized by the oxygen in the presence of water. This reaction is also called as weathering reaction. As a result, acidic water is formed which could easily dissolve metals from the other minerals. Increasing concentration of dissolved metals and sulfates within acidic water, hence becomes the general characteristics of AMD.

The dry cover method is a common method to prevent AMD generation at mine site, because its simplicity and effectiveness. Generally, this method utilizes segregation of waste rock material into potentially acid forming (PAF) and non-acid forming (NAF) rock. PAF is placed below the NAF to minimize water infiltration and oxygen percolation therefore cut off the weathering of sulfide mineral.

Several problems could be found during the application of dry cover methods, such as improper techniques in dry cover application, the insufficient amount of NAF material as a cover layer to reduce AMD generation and the abundance amount of sulfide minerals in the PAF with the lack capacity of neutralizing mineral in the NAF. These problems need to be solved in order to be able to construct the dry cover effectively despite the availability of NAF material, which may vary in the nature depend on the environment of deposition or formation.

In this research, utilization of additional cover layer is proposed by using the material which generally available in the coal mine site: fly ash and organic material. Both of the materials are easy to be found in the coal mine site and as combination, these materials able to increase the pH of water and also consume the oxygen. Moreover, cementation

properties of fly ash could be expected for the long term AMD prevention, form a hard span in the upper layer thus decrease infiltration. A laboratory experiment was conducted in a column leaching test for simulation of dry cover in the field with smaller scale. The objective of this experiment is to investigate the effectiveness of material combination as cover layer by observing the leachate water behavior, including the pH, conductivity, major cation-anion, dissolved metals and total organic carbon.

2. Materials and Methods

2.1. Materials

Sample materials were obtained from Asam-asam Coal Mine site, located in South Kalimantan Province in Indonesia. Rock sample was coal-bearing rock that can be categorized as PAF and NAF based on the static test (Sobek, 1978; AMIRA, 2002) result (see Table 1). Fly ash was collected from Asam-asam Coal-steam Power Plant, which belong to the State Electricity Company for Southeast and South Kalimantan Province. The fly ash is categorized as a class C (ASTM C618), contributes to its pozzolanic and cementitious properties. Based from Tabel 1, NAPP value of PAF Mix is ≥10 kg H_2SO_4/ton which means acidic, while the NAF material is near 0, indicates this material will produce almost no acidity and also alkalinity. This result is also supported by NAG pH and pH paste test results. Fly ash, in contrast, has a negative NAPP value that shows its alkalinity capability to buffer acidic water.

The grain size of PAF and NAF is almost similar based on the particle size distribution sieve analysis. For the column experiment, PAF and NAF grain size passed the #20 mm sieve (size opening=19 mm) with the d_{50} equals to 0.80 mm and 0.75 mm, respectively while d20 of both materials equal to 0.20 mm. Meanwhile, the fly ash particle size is finer than the PAF and NAF Mix particle. It has d_{50}=0.21 mm and d_{20}=0.08 mm.

Table 1 Static test results of material for column test

Sample	pH Paste	TS*	MPA**	ANC***	NAPP****	NAG***** pH	NAG pH 4.5	NAG pH 7.0
		(%)	(kg H_2SO_4/ton)				(kg H_2SO_4/ton)	
PAF mix	4.16	1.1	33.78	1.95	31.83	2.33	42.65	9
NAF mix	5.77	0.11	3.32	2.65	0.67	6.04	0	5.87
Fly ash	11.81	0.59	17.97	224.69	-206.72	10	0	0

*TS – Total Sulfur ** MPA – Maximum Potential of Acidity ***ANC – Acid Neutralizing Capacity ****NAPP – Net acid producing potential *****NAG – Net acid generating

2.2. Methods

The simulation in the laboratory was conducted for observing the behavior of leachate water. These columns have 2 different sizes, diameter (d)=100mm and height (h)=300mm and 100mm. The smaller size was used to investigate the behavior of individual material while the bigger column for the layering scenario of dry cover. More details of layering scenario and material could be seen in the Figure 1.

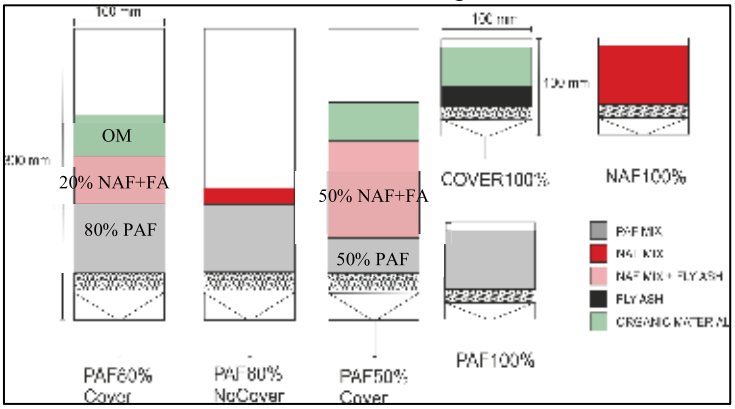

Fig.1 Column configuration

The simulation was carried out for total 56 days, with drying and wetting phases in order to resemble the mining field condition. Drying was performed with natural drying in the room temperature for 12 hours and heating by lamps with measured temperature on the surface of the column for around 35 – 40^{o}C. Then wetting simulation was carried out by spraying the deionized water, 250 ml for each column. Leachate water then collected for further analysis: pH and conductivity (EC) (direct measurement) and major cation-anion, dissolved metals and total organic carbon (after filtering with 0.45µm membrane filter and acidified for storage purpose until measurement day).

3. Result and Discussion

Kinetic test that was used in this experiment showed the behavior of dry cover in modifying the leachate water within specified time. This behavior should be able to inform the possibility of using the material combination in the field. The measurement result of pH and EC of column is presented in the Figure 2.

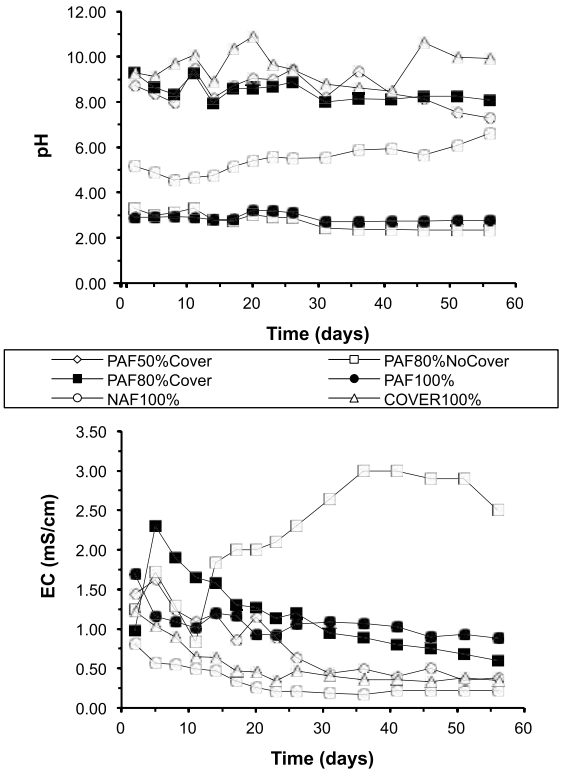

Figure 2. pH and EC measurement result

The result indicates the improvement that can be observed from the column with the additional cover layer of fly ash and organic material combination (PAF-50%Cover and PAF80%Cover). The pH of these columns significantly increased compared to PAF80%NoCover that had similar behavior of column with only PAF material, PAF100%. This suggests the role of fly ash and organic material combination to have a role in buffering the pH of acidic water that should be produced from the reaction of acid mine drainage generation. Moreover, the conductivity measurement result also showed similar behavior of leachate water, where the highest value was seen from PAF80%NoCover column, which imply a higher concentration of dissolved ions in the leachate water compared to other columns.

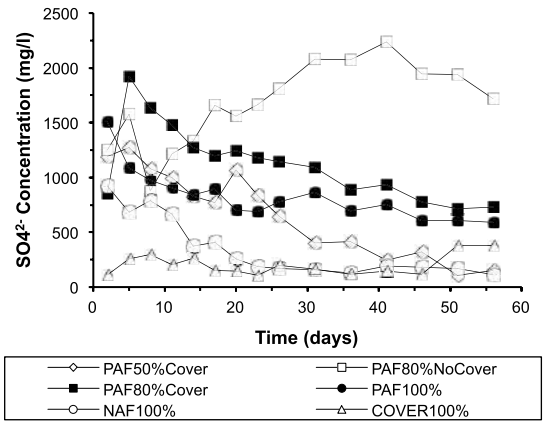

Figure 3. Sulfate measurement result

Sulfate measurement showed interesting results from comparison of PAF80%Cover and PAF80%NoCover. Both columns initially have similar value of dissolved sulfate. With the assumption that mostly sulfate derived from the AMD generation reaction, this implies that in the beginning these columns still have AMD reaction occurred even though the pH values were on the contrary. It suggests the role of additional cover layer to buffer the pH of leachate. Interestingly, as the time passed, sulfate in the column without cover was decreased while with the additional cover was increased until it had considerable gap. It indicates the role of cover layer materials

as a combination which can reduce the AMD generation for a long term application.

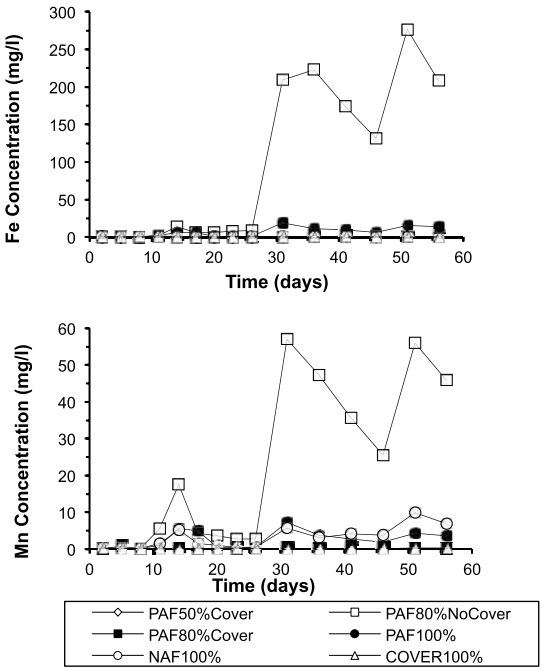

Figure 4. Fe and Mn measurement result

Figure 4 shows the measurement of Fe and Mn as the dissolved metal concentrations in the leachate water of columns whereas the measured were Fe, Mn, Cu, Zn and Al.. Characteristic of each dissolved metal on the time basis generally alike that can be represented by Fe and Mn. These results also supported the previous result of leachate water behavior.

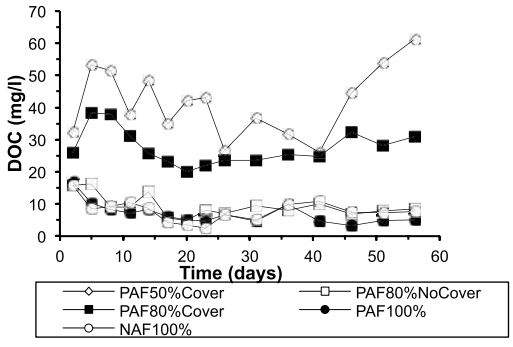

Figure 5. Dissolved organic carbon (DOC) measurement result

The DOC measurement result was shown in the Figure 5. Columns without fly ash and organic material were observed to have a less DOC than the column with the additional cover layer material. This suggests the role of organic material in dissolving organic material. During the degradation process of organic material, oxygen consumption was expected to occur. Moreover, the significant differences between PAF80%Cover and PAF50%Cover indicates the further reaction happened with the dissolved organic material within the column, since these two columns has the same weight of the organic material cover. The reducing reaction between sulfate and DOC was expected, with the product of sulfide metal as a precipitation.

4. Conclusion

Leachate water of column with the additional layer of cover showed positive improvement that can increase the pH, reduce the ions and also dissolved metals. Not only role in the buffering pH, AMD generation is also expected to be reduced based on the observation of the behavior of sulfate and DOC measurement.

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