

ACID MINE DRAINAGE IDENTIFICATION AT BINUANG AREA, SOUTH KALIMANTAN, AND ITS ALTERNATIVE TREATMENT

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INTISARI

Air asam tambang (AAT) merupakan salah satu dampak negative yang dihasilkan oleh kegiatan pertambangan yang dapat mengancam lingkungan sekitarnya. Oleh karena itu, identifikasi adanya AAT ini sangat penting dilakukan guna melakukan antisipasi meluasnya pembentukan air tambang ini.

Di daerah Binuang, Kalimantan Selatan, penambangan batubara telah menghasilkan banyak kolam-kolam penampungan AAT. Pengetahuan tentang kondisi geologi sangat penting guna melakukan upaya pencegahan maupun penanggulangannya. AAT tersebut tersebar di beberapa tempat dengan pH 2,8-4,4, bertipe kalsium sulfat dan kalsium-magnesium sulfat. Akumulasi AAT ini dipicu oleh kondisi geologi seperti topografi cekungan, proses pelapukan, ketersediaan mineral sulfide (terutama pirit), struktur geologi (berupa kekar maupun sesar-sesar minor) serta iklim yang berupa curah hujan dan temperatur yang cukup panas di daerah ini.

Ada beberapa metode yang dapat dilakukan untuk menanggulangi AAT. Metode pertama adalah active treatment untuk menetralkan sifat keasaman air dengan menggunakan bahan penetral dan mengolahnya agar memenuhi batas baku mutu. Metode kedua adalah passive treatment untuk mengintrodusir lahan basah buatan (artificial wetland). Metode ketiga adalah pengolahan air asam tambang yang dilakukan dengan pembuatan encapsulation in-pit disposal pada waste dump tambang.

Kata kunci : Air asam tambang, identifikasi, penanggulangan.

ABSTRACT

Acid mine drainage (AMD) is one of negative impact resulted by mining operation which might threated its environment. Therefore, Identifying AMD is very important to anticipate spreading of this mining water's production.

At Binuang area, South Kalimantan Province, coal mining produced waste dumps of AMD. Understanding geological condition is very important to consider tasks in order to prohibit and treat this disposal.

AMD at the research area is found in many settlement ponds, have 2.8 – 4.4 in pH, as calcium-sulphate and calcium-magnesium sulphate types. The AMD accumulation in study area was controlled by local geological condition, such as basin topography, weathering, sulfide minerals accurence (pyrites dominantly) and geological structures as joints and minor faults, as well as climate (rainfall and hot temperature).

Those are several methods to tackling AMD. The first method is active treatment for neutralizing the acid water. The second method is passive treatment that usually done by introducing artificial wetland. The last method is building encapsulation in-pit disposal. .

Keywords : Acid mine drainage, identification, treatment.

INTRODUCTION

Background

One of the problems which appears as important impacts of coal mining is acid mine drainage (AMD) phenomena. This fact is showed by some cases of AMD occurrences at several minings in Indonesia. Prevention and remediation are necessary to restricting this AMD formation. The preventive effort requires to understanding chhchemical rock properties of out crop and overburden.

Identifying AMD based on their rocks formation / geological properties is necessary to minimized the worse environmental impacts. At Binuang area, South Kalimantan (Figure 1) there are many pools of AMD which shoud be identification. The study area is belong to 115°11"-115°14" East Longitude and 3°3.5" - 3°7.5" South Latitude.

This study consists of understanding AMD problems related with local geological conditions, and macroscopic and microscopic

analyses. The weathering factors, pools dimensions, spreads of AMD and geological

structures should be noticed to accurating and completing the AMD informations.

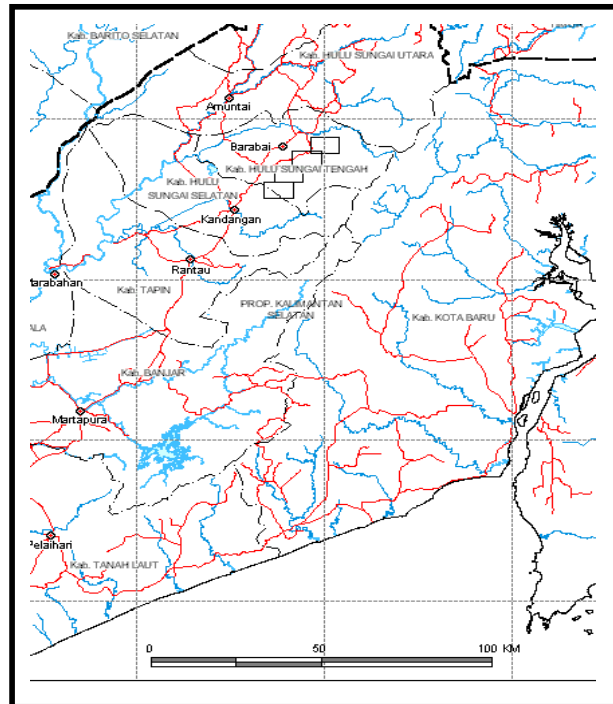


Figure 1. Research area in topographic map of South Kalimantan.

Goal of Research

This research purpose inform the geological field of coal mining areas at Binuang and its vicinities, accompanied with rocks and water sampling. The research goals are to identifying AMD and analyzing geological factors (weathering proces, mineral / rock content, and geological structure) that controlling AMD formation. Then, this paper is also completed by some alternative treatments in restricting AMD formation.

METHODOLOGY

The research has been carried out by field geological mapping including rock and water sampling and inspecting AMD particularly at Tarungin Village. Qualitative physical characteristic of AMD could be known from its pool dimensions, also the color and turbidity of AMD. Whereas, the chemical characteristics of water have been analized from the result of laboratory work of BTKL Yogyakarta laboratory. Geological description and rocks sampling were done in the field. Petrographic analyses were completely performed to describe mineral composition of

rocks for interpreting their relationship between rocks and the AMD formation in the research area.

RESULT AND ANALYSES

Field Description of AMD

At Binuang coal mining area there are some pools of AMD varying in size range meters until hundred meters square. The pools of AMD can be found at Tarungin, Simpangempat and Pakan regions (Figure 2 - 4). Those AMD were formed by mining activities at those places. The mining waste water able to mix with groundwater and surface water/ rain water contaminate to other materials to forming AMD. Minerals and rocks which have been altered at some places, show yellowish to brownish in color and infulence to the color of mine water.

AMD at Tarungin Hill (Figure 2) has been accumulated in the pool approximately as large as 2500 m². Physical appearances of these AMD show clear water on the surface, but orange to yellow in the deep, rather viscous, and no odor. Rocks in its vicinity are

dominantly composed by sandstones and shales with abundant hornblende, quartz and feldspar. Macroscopically, pyrites seem abundant in both *insitu* out crops and overburden surrounding the pool. This mine

water volume is estimated more than 7500 m³ and could be increase if there are heavy rainfalls. The mining activity still have run there, it means acid mine water will be produced much more than today.



Figure 2. The storage pool of AMD at Tarungin Hill, has ± 2500 m² in size.

AMD at Simpangempat pool (Figure 3) shows slightly different appearance. The color of mine water is light to dark green. This water is clear and no odor on the surface. The water storage larger than the pool mentioned before, therefore its environmental impact need to keep under vigilance. AMD at

Simpangempat was accumulated in pool approximately as large as 5000 m². This mine water volume is estimated more than 25000 m³. The mining activities at this site still running, it means that mine water which will be produced much more so this AMD should be overcome.



Figure 3. AMD pool appearance at Simpangempat Village.

The biggest AMD pool can be found at Pakan Hill (Figure 4). Physically, the mine water here is colorless, but has greenis blue sediments. The water shows much volume, indicated as deep water. This water may be infiltrated and transported to other places because of both of vertical and horizontal natural permeability of rocks.

Based on Skousen & Ziemkiewics classification (1996, in Gautama, 2004), the AMD in the research area include in Type 1. This type indicated by low alkalinity and acidity (pH < 4,5) with Fe, Al, Mn and other metal content. This water called mine water drainage (AMD).



Figure 4. The pool of AMD located in Pakan Hill.

Laboratory Testing

Three mine water samples have been taken from coal mining sites, there were Tarungin Hill, Simpangempat Village and Pakan Hill areas. Those mine water have been tested physically and chemically at the laboratorium. Result of the testing summarized at Table 1 and Figure 5 below.

Table 1 shows mine water from coal mining at study area is used to calcium sulphate and calcium-magnesium sulphate

types, with very low pH (2.8 to 4.4). The water quality has been interpreted based on Piper diagram, within type 1, 4 and 6 which characterized by (Suharyadi, 1984) :

- a. Class 1, means that its earth alkali more than alkali content.
- b. Class 4, means that its strong acid more than weak acid content.
- c. Class 6, means that non carbonate hardness more than 50%.

Table 1. Result of laboratory testing of mine water in research area (Simarmata, 2010).

| No. | Parameter | Sample | | | | | |
|-----|-------------------------------|-----------------------------|-------|------------------------------|-------|--------------------------|-------|
| | | A (10120K) Tarungin Hill | | B (10121K) Simpangempat | | C (10122K) Pakan Hill | |
| | | ppm | epm | ppm | epm | ppm | epm |
| 1. | pH | 2.8 | | 3.1 | | 4.4 | |
| 2. | Na ⁺ | 34 | 1.48 | 11 | 0.48 | 21 | 0.91 |
| 3. | K ⁺ | 13 | 0.33 | 4 | 0.10 | 8 | 0.20 |
| 4. | Ca ²⁺ | 557.2 | 27.80 | 115.42 | 5.76 | 226,86 | 11,32 |
| 5. | Mg ²⁺ | 96.71 | 7.96 | 45.94 | 3.78 | 12.09 | 0.99 |
| 6. | Cl ⁻ | <1.7 | 0.04 | <1.7 | 0.04 | <1.7 | 0.04 |
| 7. | HCO ₃ ⁻ | 0 | 0 | 0 | 0 | 0 | 0 |
| 8. | SO ₄ ²⁺ | 2136 | 44.47 | 690 | 14.36 | 716 | 14.91 |
| 9. | Fe | 31.854 | 1.14 | 8.202 | 0.29 | 0.0733 | 0.002 |
| 10. | Mn | 54.23 | | 15.58 | | 9.14 | |
| 11. | Pb | 0.0078 | | 0.0075 | | <0.0041 | |
| 12. | Zn | <0.0041 | | 0.4981 | | <0.0041 | |
| 13. | Ni | 0.0072 | | 0.3453 | | 0.1752 | |
| 14. | Water type | Calcium sulphate | | Calcium – magnesium sulphate | | Calcium sulphate | |

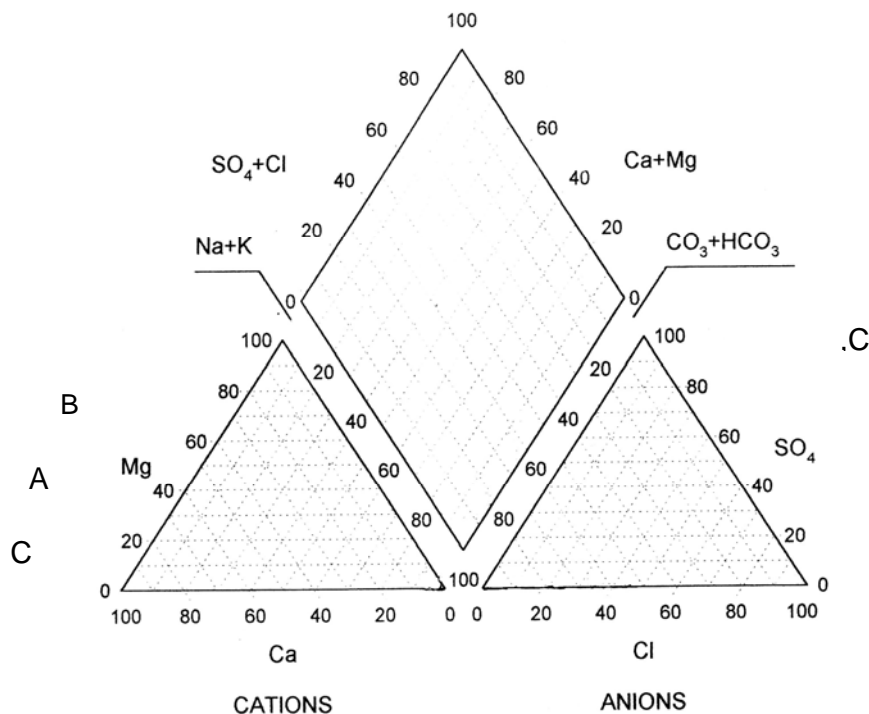


Figure 5. Piper diagram of mine water taken from the research area (Piper, 1944).

Geological Condition

Weathering

AMD in the research area is accumulated in many pools, distributed mainly in Tanjung sandstone unit. The location of pools can be found such as at Tarungin Hill, Simpangempat Village and Pakan Hill. These pools have approximately small until big size, i.e. $\pm 2500 \text{ m}^2$ to 10000 m^2 . The pools located in the mining sites where the mining activities still running or at post mining locations.

The weathering proceed in *insitu* rock layers as well as in overburden. The weathering intensity well running, usually indicated by medium to late weathered rocks. Spheroidal weatherings are found within sandstones intercalated with coal layers. The high weathering intensity would encourage the breaking of minerals in rocks then they became oxydized easily. According to Gautama and Kusuma (2004), the oxidation of sulfide minerals might be naturally affected by contact with free air. In mining area, this process would be accelerated by the increasing volume of sulfide minerals which have contacted directly with free air.

The alteration process was running as long as weathering processes. Some rocks have been altered, that indicated by the appearances of clay minerals. Reddish brown of insitu outcrops and overburden rocks indicate the high oxidation degrees.

The valley morphology push mine water flow and trapped in morphological pool. The hot climate (weather) should fasten oxidation process of sulfide minerals at the study area. Last but not least, the heavy rainfall is also endorsed the formation of AMD. Physical condition such as landform topography and climate of the research area support the formation of AMD.

Mineralogy

Based on geological observation, lithology of study area is composed by sandstones, shales and limestones. Seams of coal are found inserting within those sedimentary rocks. The thickness of the coal seams are approximately 100 m. Pyrite is one of sulfide minerals that could be notice easily by naked eyes. Pyrites are distributed largely in sedimentary rocks especially in sandstones. These pyrites show yellowish spotted color and

shiny. Pyrites usually have angular until medium rounded in shape, mostly in small size (only several millimeters). There are few and

spottly distributed of calcopyrites. The weathered rocks usually show brownish red to reddish brown in color (Figure 6).



Figure 6. The out crop and overburden of mining at Tarungin Hill.

Result of petrographic analysis shows that rocks consisting of mining area are sandstone and shale. Pyrites and another metal minerals are indicated by the presence of opaque minerals, black color, and diameters are as small as 0.02 - 0.5 mm.

Crack / Joint

Cracks formed by joints and minor faults might be triggering rain water to flowing and infiltrating into soil and rocks. Rain water inserting the ground is supported by cracks as seeded in the field. The joints or faults would increase permeability of rocks so that rain water could be infiltrated freely. The availability of water for infiltration / transportation and oxygen for oxidation also supported by many cracks of rocks.

The main bedding planes of joints at Simpangempat show N 250° E/87° and N 310° E/82. There is minor fault with N 240° E/72 bedding plane. At the other places there are some joints with major plane such as 270° E/69°, 275° E/76°, 320° E/81° and N 330° E/82. The intensity of joints are tight enough in some places especially at Simpangempat area. This fact should support the oxidation process of sulfide minerals as affected by their relationship with free air.

ALTERNATIVE TREATMENT

The coal mining with stripping process and removing overburden contain sulfide minerals cause the exposure of sulfide minerals to free air. In opened air condition, the sulfide minerals will be oxydized and if they

soluted in water will form AMD. This AMD potent to have soluble metal then form hazardous and poisonous water which threat the environment. High degree acidity of AMD usually becomes hard problem when it entered into rivers or wells.

There are two principles of AMD management, the prevention and treatment of AMD formation. The preventive effort can be done by isolated the materials (sulfide bearing minerals), avoid the exposure of them, usually for waste disposal from free air. Treatment method should be carried out by *active treatment* to neutralize the water acidity with neutralizing materials or treat them to be standard water. The other method may be passive treatment, usually by introducing artificial wetland. Those treatment methods should be modified together.

Wijaya (2010) gives opinion the manner of mine water treatment by making encapsulation in-pit disposal at waste dump of coal mine. This method may be effective applied at Binuang. Significant isolation of three elements of mine water maker, such as pyrite, oxygen and water applied in this model. Those three elements can be divided by clay soil cover which very low permeability (about $2,3 \cdot 10^{-9}$ m/s), therefore the sulfide minerals oxidation and rain water leaching at waste dump can't be occurred. Clay materials for making encapsulation in-pit disposal model in the research area can be taken from soil of weathered rocks from granite and andesite units which have thickness range 2 to 50 m. Granites are distributed at eastern part of

Simpangempat Village, while andesites have larger distribution especially at Banta and Asamrandah and their surrounding areas.

The most reactive alkali reagent for AMD neutralizing in research area are limestones of Berai and Tanjung Formations. Berai limestones can be found at Suatobaru area, whereas Tanjung limestones distributed at Rampah, south of Simpangempat. These rocks would be reactive matter to neutralizing process and their availability are sufficient enough. According to Gautama dan Kusuma (2004), carbonate minerals can neutralize acidity. Until recent day, carbonate is the only one of alkali mineral which can be controlled AMD and prevented acid water formation effectively. Although silicate minerals like mica and clay minerals also have absorption capacity of acid, but their capability much less than carbonate's one.

CONCLUSION

The AMD can be identified in coal mining at Binuang area and its vicinity, accumulated in many pools. From the laboratory testing known that the AMD has low acidity (pH 2,8-4,4), with calcium sulphate and calcium-magnesium sulphate types. This mine water occurred from mining activities and supported by valley topography and climate that has heavy rainfall and hot temperature.

The geological conditions have influenced AMD formation in the research area such as weathering process, sulfide minerals availability and many geological structures like joints and minor faults. The most influenced sulfide minerals in AMD formation are pyrites. These minerals have angular to medium rounded, small size, and shiny yellow in color. The presence of pyrites and other sulfide minerals in petrographic sections showed by opaque minerals. The AMD formation at Binuang area should be associated with weathering, sulfide minerals, and geological structure in addition to topography and climate.

Some methods that may be done to prevent the abundance of AMD formation are isolation method, avoid the exposure of sulfide bearing materials, usually as disposal, to free air. The treatments of AMD can be done by active treatment for neutralizing acidity with neutralizer or treat the water to be standard one; or passive treatment, by introducing artificial wetland, in addition to encapsulation in-pit disposal on waste dump of coal mining.

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