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The Forming of Acid Mine Drainage Based on Characteristics of Coal Mining, East Kalimantan, Indonesia

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ABSTRACT

As one of the world's coal producers, Indonesia continues to increase its coal production. The purpose of this study is to identify and analyze the characteristics of coal that has the potential to produce acid mine drainage. The research method is coal mapping and zoning based on formation, observation, and description of coal characteristics, coal sampling, ultimate and proximate testing, and analysis. The results of the study describe the characteristics of coal related to distribution in the early stages of evaluating the potential for acid mine formation, besides that it can be used as a basis for classifying the potential for acid mine drainage which has a high enough total sulfur based on the results of testing on 15 samples. To prevent the reaction to acid mine drainage, it can be based on the geochemical characteristics of coal by constructing a mine reservoir or making water drainage in a mine that is not close to the stockpile, because there is a possibility that water has the potential to form acid mine drainage (AMD) when it comes in contact with coal potential. So that coal does not have the potential to be a source of acid mine drainage.

Keywords: coal, sulfur, acid mine drainage, NAPP.

INTRODUCTION

Based on the economic growth rate of Asian countries, it is estimated that by 2030, the use of coal to meet electricity needs in Asia will reach 7 billion tons. This large number of requests will continue to increase. One of the problems that occurs when mining is operating is the emergence of acid mine drainage in water channels, namely rainwater or groundwater mixed with rocks containing pyrite sulfide in coal so that the water is very acidic and usually contains high concentrations of iron and manganese. In addition, during mining, groundwater or rainwater collected in mining ponds, apart from being acidic, often contains high concentrations of suspended solids [3, 7]. The Pulaubalang Formation (TMPB) is a formation with alternating rock units between greywacke and quartz sandstones with inserts of limestone, claystone, coal and dacite tuff, greywacke sandstone, greenish-grey, dense, layer thickness between 50–100 cm; while the Balikpapan Formation (Tmbp) is the intersection of sandstone and clay with the insertion of silt, shale, limestone and coal; and for the Kampungbaru Formation (Tpkb) in the form of quartz sandstone with inserts of clay, shale; silt and lignite; generally soft, easy to crush. The sulfide minerals found in coal are pyrite (FeS_2), chalcopyrite ($CuFeS_2$), sphalerite (Zn, Fe) S, and galena (PbS). Based on its characteristics, sulfide minerals can be used as materials for the metallurgical and chemical industries, but in nature they also have the potential to produce acid water which can degrade environmental quality. For comparison, there are also metal sulfides that are commonly found in mining areas, including Fe_xS_x (pyrrhotite), Cu_2S

(chalco-site), CuS (covellite), MoS_2 (molybdenite), NiS (millerite), ZnS (sphalerite), and FeA_2S (arsenopyrite).

Sulfur is one of the components in coal, which is found as organic and inorganic sulfur. In general, the NAPP method static test is a method to determine the formation of AAT through the identification of rock characteristics containing sulfide minerals which emphasizes the analysis of the potential for soil/rock acidity in the mining area, namely in the form of kg H_2SO_4 weight per tonne. The reference parameter to determine the potential of PAF or NAF in the NAPP method is based on the comparison between the value of NAPP and the pH of NAG (Net Acid Generation)

This study was conducted to determine the characteristics of coal at the research site based on the results of ultimate, proximate, ANC, and NAG tests, to determine the characteristics of coal that has the potential to form acid mine drainage at the research site, and to find out how to handle it to prevent the formation of acid water from potential coal mines. This research is not perfect because the study conducted does not involve all factors, but there is a strength in this research that distinguishes it from other studies, namely it involves 3 different rock formations as carriers of coal so that it is hoped that the results can be used as the basis for further research.

RESEARCH AREA BACKGROUND

P.T. GHI

P.T. GHI is a company located in Tenggarong District, Kutai Kartanegara Regency, East Kalimantan Province. This company has been carrying out coal mining activities since 2011. P.T. GHI has an IUP area of 2,459.76 hectares, but the holder of the Second Extended Production Operation Mining Business Permit is allowed to carry out mining in work area 1 with an area of 1,478.15 ha and working area 2 with an area of 953,378 ha with a total working area of 2,431,528 ha.

Climate

According to the Schmidt and Ferguson climate classification, which is based on monthly rainfall data for the 2015–2019 period from the results of the records of the Kutai Kartanegara Meteorological and Geophysical Agency, East Kalimantan Province, the climate type in the study area is included in climate type A (very wet) with a Q value of 0.120 ($0.000 \leq Q < 0.143$). Based on the results of the rainfall recording of the Kutai Kartanegara Agency for Meteorology and Geophysics Station, East Kalimantan Province, it is known that the highest rainfall occurred in December 2011 at 448 mm, while the lowest monthly rainfall occurred in August 2019 at 31 mm and the total number of rainy days as much as 963 days.

Topographical state

The P.T. GHI Production Operation IUP area's topography has a height of 5 meters to 110 meters above sea level. The research area's geomorphology is based on the Indonesian Geomorphology Atlas, Geomorphology IGT, Scale 1: 250,000. The Geospatial Information Agency is included in the folded hill geomorphology unit by occupying 100% of the IUP P.T. GHI area is a sub-dendritic and subparallel flow pattern.

Geological map

Geologically, the P.T. GHI IUP is included in the Geological Map of the Samarinda Sheets, which entirely consists of sedimentary rock units that are rich in hydrocarbon deposits. Two coal carrier formations enter the study area, namely the Balikpapan Formation (Tmbp), the Balang Island Formation (Tmpb), and the Pamaluan Formation (Top) (Fig. 1).

Regional stratigraphy

The stratigraphy of the Kutai Basin area is Tertiary sediment deposits resulting from the transgression cycle and sea regression and is comparable to the Barito Basin and the Tarakan Basin. Transgressive sequences can be found well along the basin's edge without coarse-grained and clastic shale deposits deposited in the shallow sea environment's paralysis. The regressive sequences of the Kutai Basin contain delta to paralyse clastic deposits, which contain many coal and lignite seams.

Lithology

In the P.T. GHI Production Operation IUP area, the type of depositional environment is transition and delta, so that the coal formed has various thicknesses, characteristics, qualities, and structural

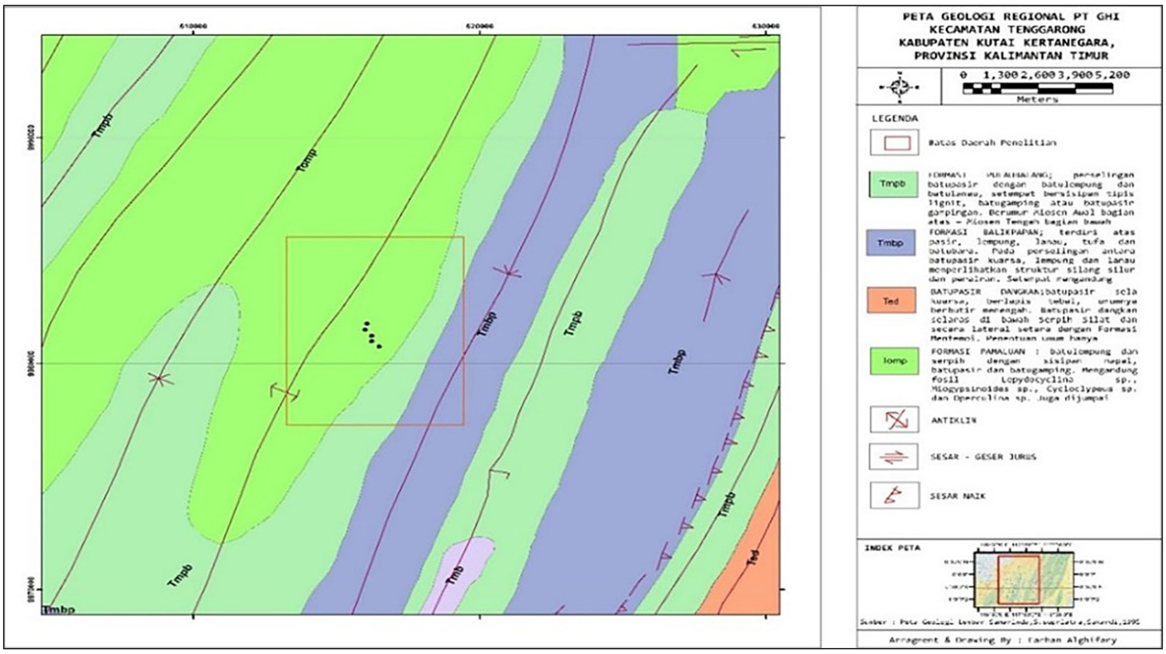

Figure 1. Geological map of East Kalimantan

patterns that affect it, together with coal-bearing formation. In this area, the coal-carrying rock layers are generally clay and coaly shale layers.

The investigated area's lithology consists of looped quartz sandstone with claystone inserts, siltstone, carbonate claystone, shale, and coal. Based on the lithology's variations and characteristics, the investigation area is included in the Balikpapan Formation (Tmbp) and the Kampungbaru Formation (Tpkb) (Fig. 1).

METHODS

Data retrieval technique

The method used in this research is quantitative research with 2 data collection techniques, namely primary data collection and secondary data collection. Primary data was obtained by observing and taking coal samples in the coal seam, data from the ultimate proximate, ANC, and NAG tests on coal. The secondary data taken are drill logs and drill data, some of the results of coal quality tests, climate and weather conditions, geological maps, and topographic maps.

Data processing techniques

The data collected, both primary and secondary, is then processed using the existing formula. In processing the data:

a) Ultimate, proximate, ANC, and NAG test analysis. This analysis is conducted to be able to identify coal that has the potential to form acid mine drainage.
b) Classification of proximate, ultimate, ANC, and NAG test results data to determine coal that can form acid mine drainage.
c) Furthermore, the researcher was also making suggestions for handling coal, which can form acid mine drainage based on coal's potential characteristics.

RESULTS AND DISCUSSIONS

Result

Research area

The determination of the number of sample points and the number of samples taken at each point are adjusted to the needs of the analysis. Prior to sampling, an analysis of the geological

Table 1. Observation point coordinates

Sample's point	X	Y
1	x16073,9	x981770
2	x15997,6	x981508
3	x16225,1	x981232
4	x16225	x980998
5	x16485,6	x980756

Source: P.T. GHI data.

conditions of the research area was carried out as an initial description of the study. The coordinates of sampling can be seen in Table 1.

Sample data

Samples are required for ultimate, proximate, ANC, and NAG testing. So that from this test, it can be classified as coal, which can create acid mine drainage if there is contact between water and coal, which has certain characteristics. The samples tested were 30 samples, accompanied by a description of the sample's thickness, which describes the thickness of the coal seam layer in the field. It can then analyze how much influence the coal seam has on the potential for acid mine drainage if the layer is included in Potential Acid Forming.

Total moisture (T.M.)

T.M. analysis uses two steps of analysis, namely looking for the value of Air-Dried Loss (ADL) and Residual Moisture (R.M.)

Air dried loss (ADL)

The method used in this research is quantitative research with 2 data collection techniques, namely primary data collection and secondary data collection. Primary data was obtained by observing and taking coal samples in the coal seam, data from the ultimate proximate, ANC, and NAG tests on coal. The secondary data taken are drill logs and drill data, some of the results of coal quality tests, climate and weather conditions, geological maps, and topographic maps.

From the gross sample, three trays are taken randomly (weight of sample in each tray is ± 10 kg) then heated at 40 °C, for the first 6 hours weighed then weighed once every hour until the weight is constant/stable and a maximum of 18 hours of ovening.

$$ADL\ formula = \frac{\mathrm{M2} - \mathrm{M3}}{\mathrm{M2} - \mathrm{M1}} \times 100 \quad (1)$$

where: M1 – tray weight;
M2 – tray + sample weight;
M3 – tray + sample weight after the oven.

Residual moisture (R.M.)

After the ADL value was found, the former ADL sample was in a crusher with a size of 4.75 mm, for testing the R.M. sample in an oven at 105 °C for 1 hour with a sample weight of ± 15 grams.

Table 2. Total moisture test results

Number	Sample number	Thick (m)	TM value (%ar)
1	X01/03	0.081	18,091
2	X01/04	3.751	19,671
3	X02/11	1.851	18,051
4	X02/12	0.341	20,401
5	X02/13	2.201	16,511
6	X02/14	0.451	20,061
7	X03/04	1.851	17,941
8	X03/05	0.351	18,421
9	X03/11	0.451	20,551
10	X03/12	0.251	17,661
11	X04/05	0.551	18,491
12	X04/06	0.351	16,851
13	X04/07	0.901	17,661
14	X04/08	4.401	17,381
15	X05/03	2.001	17,661

Source: P.T. GHI sample testing.

$$RM\ formula = \frac{\mathrm{M2} - \mathrm{M3}}{\mathrm{M2} - \mathrm{M1}} \times 100\% \quad (2)$$

where: M1 – weight of the Crucibl;
M2 – crucible + sample weight;
M3 – crucible + sample weight after curing.

After the ADL and R.M. values are found, look for Total Moisture (T.M.) with the formula.

$$TM = RM \times \frac{100 - ADL}{100} + ADL \quad (3)$$

Inherent moisture (I.M.)

This analysis aims to find the water content in coal with an oven process with a temperature of 105 °C and flowing nitrogen gas for 1 hour with a ± 1gram sample weight

$$IM\ formula = \frac{M2 - M3}{M2 - M1} \times 100\% \quad (4)$$

where: M1 – weight of the crucible;
M2 – crucible + sample weight;
M3 – crucible + sample weight after curing.

Carbon value

The purpose of this analysis is to find the value of carbon contained in coal, whose amount is determined by moisture content (I.M.), ash, and flying matter (V.M.).

$$Formula: FC = 100 - (IM + Ash + VM) \quad (5)$$

Table 3. Inherent moisture test results

Number	Sample	Thick (m)	I.M. Value (%ar)
1	X01/03	0.081	14,181
2	X01/04	3.751	14,821
3	X02/11	1.851	12,431
4	X02/12	0.341	16,121
5	X02/13	2.201	16,231
6	X02/14	0.451	14,571
7	X03/04	1.851	14,031
8	X03/05	0.351	15,541
9	X03/11	0.451	14,791
10	X03/12	0.251	13,611
11	X04/05	0.551	13,601
12	X04/06	0.351	13,791
13	X04/07	0.901	13,611
14	X04/08	4.401	13,481
15	X05/03	2.001	13,611

Source: P.T. GHI sample testing.

Table 4. Carbon value testing results

Number	Sample	Thick (m)	Carbon value (%adb)
1	X01/03	0.081	41,051
2	X01/04	3.751	39,541
3	X02/11	1.851	41,801
4	X02/12	0.341	42,241
5	X02/13	2.201	39,001
6	X02/14	0.451	43,611
7	X03/04	1.851	44,621
8	X03/05	0.351	40,141
9	X03/11	0.451	40,491
10	X03/12	0.251	42,971
11	X04/05	0.551	40,391
12	X04/06	0.351	42,201
13	X04/07	0.901	42,971
14	X04/08	4.401	41,041
15	X05/03	2.001	42,971

Source: P.T. GHI sample testing.

Total sulfur

Determining the sample's total sulfur content is done by burning the sample using a furnace tube until it turns green.

Net acid generating (NAG)

The method used in this research is quantitative research with 2 data collection techniques, namely primary data collection and secondary data collection. Primary data was obtained by observing and taking coal samples in the coal seam, data from the ultimate proximate, ANC, and NAG tests on coal. The secondary data taken are drill logs and drill data, some of the results of coal quality tests, climate and weather conditions, geological maps, and topographic maps.

The NAG in the sample is usually determined by the pyrite oxidation reaction to sulfuric acid with the addition of 15% H_2O_2 reagent within one day or a minimum of 12 hours of reaction time.

To predict the production of acid rock drainage (ARD) both during and after the mining activity, the net acid generation (NAG) test was created. It can be utilized both alone as a prediction tool (Miller et al., 1997) and in addition to other static tests like the ABA test (Räisänen et al., 2010, Morin & Hutt 1999).

The NAG test is based on the reaction of a sample with hydrogen peroxide, which has the effect of accelerating the oxidation of the sample's sulphide minerals. The final result of the test is a direct measurement of the net amount of acid generated by the sample. Acid formation and acid neutralization reactions may happen simultaneously during the test. Since the test does not evaluate neutralization potential, the AMIRA guidebook (2002) recommends using the net acid production potential (NAPP) in addition to the neutralization assessment grade (NAG) for a more in-depth classification of acid generation. (Morin & Hutt 1999; Raisänen et al. 2010, [15]).

Table 5. Total sulfur test results

Number	Sample	Thick (m)	Total of sulfur (%adb)
1	X01/03	0.081	0.901
2	X01/04	3.751	0.641
3	X02/11	1.851	0.901
4	X02/12	0.341	1.211
5	X02/13	2.201	1.861
6	X02/14	0.451	1.721
7	X03/04	1.851	1.111
8	X03/05	0.351	1.311
9	X03/11	0.451	0.201
10	X03/12	0.251	0.571
11	X04/05	0.551	2.701
12	X04/06	0.351	1.011
13	X04/07	0.901	1.161
14	X04/08	4.401	0.411
15	X05/03	2.001	2.571

Source: P.T. GHI sample testing.

Table 6. NAG sample testing results

Num.	Sample	Thick (m)	NAG pH	NAG (KgH_2SO_4)	
				pH 4.5	pH7
1	X01/03	0.081	7.851	0	0
2	X01/04	3.751	4.231	0.901	9.311
3	X02/11	1.851	2.281	54.401	92.501
4	X02/12	0.341	3.611	6.201	17.701
5	X02/13	2.201	2.661	24.201	38.801
6	X02/14	0.451	2.921	18.101	27.901
7	X03/04	1.851	3.621	4.101	11.801
8	X03/05	0.351	7.191	0	0
9	X03/11	0.451	6.151	0	1.701
10	X03/12	0.251	7.041	0	0
11	X04/05	0.551	6.211	0	2.801
12	X04/06	0.351	3.191	8.201	16.601
13	X04/07	0.901	3.401	7.401	17.701
14	X04/08	4.401	2.571	142.51	0
15	X05/03	2.001	7.651	0	0

Source: P.T. GHI sample testing.

Acid neutralizing capacity (ANC)

The method used in this research is quantitative research with 2 data collection techniques, namely primary data collection and secondary data collection. Primary data was obtained by observing and taking coal samples in the coal seam, data from the ultimate proximate, ANC, and NAG tests on coal. The secondary data taken are drill logs and drill data, some of the results of coal quality tests, climate and weather conditions, geological maps, and topographic maps.

ANC is a method for determining the amount of neutralizing minerals (usually carbonate, CO_3^{2-}) in a sample that can react with acidic minerals (usually sulfuric minerals, SO_4^{2-}). This method is used to determine the sample's ability to neutralize the acid in the sample as well.

When an acidimetric titration is used to evaluate the acid neutralizing capacity of an aqueous solution, the measured parameter (ANCt) is typically regarded to correspond to the ANC of the sample (ANCi). With ANCe being the ANC of the sample at the titration endpoint, this article shows that ANCt really correlates to ANCi. This association remains true whether the endpoint begins at a constant pH or is selected by a Gran plot. ANCe is typically non-zero when the sample contains organic acids, and ignoring it might result in major mistakes when interpreting the ANC titration data. This study uses a realistic thermodynamic model of the acidities of natural organic acids to show computer simulations of ANC titrations in systems containing both carbonate and organic alkalinity.

Table 7. ANC sample testing results

Number	No. Sample	Thick (m)	ANC (KgH_2SO_4/ton)
1	X01/03	0.081	49.301
2	X01/04	3.751	15.301
3	X02/11	1.851	0
4	X02/12	0.341	1.201
5	X02/13	2.201	0
6	X02/14	0.451	3.701
7	X03/04	1.851	10.801
8	X03/05	0.351	37.301
9	X03/11	0.451	21.801
10	X03/12	0.251	33.801
11	X04/05	0.551	33.901
12	X04/06	0.351	21.901
13	X04/07	0.901	15.301
14	X04/08	4.401	0
15	X05/03	2.001	29.301

Source: P.T. GHI sample testing.

Net acid producing potential (NAPP)

Tests on 15 samples to identify rocks that have the potential to produce acid mine drainage were carried out in the laboratory resulting in data such as:

a) total sulfur (%);
b) clean acid generation (NAG);
c) acid neutralizing capacity (ANC);
d) pH of paste.

Then calculate the NAPP value and find out the NAG value to be classified as PAF or NAF. PAF or NAF classification can be seen in Table 8. In Sample X06/05 the NAG pH value was 1.69, and the NAPP value was 262.7 kg H_2SO_4/ton rock. Can be classified as Acid Formation Potential because NAPP value > 0 and NAG < 4.5

After calculating the NAPP value and knowing the NAG value, it can be classified into PAF or NAF. PAF or NAF classification can be seen in Table 8. In the X02 / 11 sample, the NAG pH value is 2.28, and the NAPP value is 27.6 kg H_2SO_4/ton of rock, which can be classified as Uncertain.

Analysis of coal against AAT characterization

One of the characterizations of coal is the nature of coal to acid mine drainage. Some properties of coal that are associated with acid mine are carbon, inherent moisture, total moisture, and total sulfur. Another element in coal is high sulfur content, which is usually found on the roof and floor of coal seams because sulfur is affected by the coal seam itself and the coal deposition zone. The high and low sulfur content will determine whether the coal has the potential for acid mine drainage or not. As for the carbon element, it affects the neutralization potential of the acid water itself. The higher the carbon element in coal, the higher the acid neutralizing capacity value. For the inherent moisture, and the total moisture value affects the properties of the coal itself to water in the coal environment itself. The height of I.M. and T.M. This value will increase the coal's potential for acid mine drainage because a high IM indicates a high % of the pores in the coal and the easier it is for water to enter the coal seam, while the higher total moisture value indicates that the water is in the seam environment. The coal is very high, and can increase the potential for acid mine drainage.

Based on the result of the test that conducted 30 coal samples, several characteristics of coal can classify the 50% of the samples have potential. The main element that affects the potential of AAT is % the total sulfur. All samples come from 5 observation points with 30 samples. Of all potential samples, each observation point has a sample that has the potential to spawn AAT. Thus, preventive measures are taken for AAT potential to apply to all observation points.

Handling of acid mine water

Swamp creation

Passive acid water treatment systems generally emulate wetland systems and other natural

Table 8. NAPP calculation results

Sample	Thick (m)	pH pasta	NAG pH	NAG (KgH_2SO_4)		ANC	Total sulfur (%)	MPA	NAPP	Classification
				pH 4.5	pH7					
X01/03	0.081	9.721	7.851	0	0	49.301	0.901	27.601	-21.701	NAF
X01/04	3.751	4.811	4.231	0.901	9.311	15.301	0.641	19.601	4.301	PAF
X02/11	1.851	3.261	2.281	54.401	92.501	0	0.901	27.601	27.601	Uncertain
X02/12	0.341	3.401	3.611	6.201	17.701	1.201	1.211	37.101	35.901	PAF
X02/13	2.201	3.171	2.661	24.201	38.801	0	1.861	57.001	57.001	PAF
X02/14	0.451	3.771	2.921	18.101	27.901	3.701	1.721	52.701	49.001	PAF
X03/04	1.851	4.121	3.621	4.101	11.801	10.801	1.111	34.001	23.201	PAF
X03/05	0.351	8.61	7.191	0	0	37.301	1.311	40.101	2.801	Uncertain
X03/11	0.451	6.681	6.151	0	1.701	21.801	0.201	6.101	-15.701	NAF
X03/12	0.251	9.631	7.041	0	0	33.801	0.571	17.501	-16.301	NAF
X04/05	0.551	9.521	6.211	0	2.801	33.901	2.701	82.701	48.801	Uncertain
X04/06	0.351	6.941	3.191	8.201	16.601	21.901	1.011	30.901	9.001	PAF
X04/07	0.901	4.571	3.401	7.401	17.701	15.301	1.161	35.501	20.201	Uncertain
X04/08	4.401	4.661	2.571	142.51	0	0	0.411	12.611	12.601	PAF
X05/03	2.001	9.791	7.651	0	0	29.301	2.571	78.701	49.401	Uncertain
X06/23	1.11	5.981	3.521	5.201	19.301	11.101	0.291	8.901	-2.201	Uncertain

Source: P.T. GHI sample testing.

processes, with modifications geared towards specific treatment purposes. Previous research includes research on *Sphagnum Sp* peat wetlands to treat acid mine drainage [21]. This system can increase the pH and can reduce the iron concentration.

Natural wetland

It was generally planted with *Sphagnum* bogs in Ohio and Virginia. Research conducted by Brooks [24] found the same phenomenon in swamps planted with *Typha*.

Artificial swamp (construted wetland)

After calculating the NAPP value and knowing the NAG value, it can be classified into PAF or NAF. In the X02/11 sample, the NAG pH value is 2.28, and the NAPP value is 27.6 kg H_2SO_4/ton of rock, which can be classified as uncertain.

This swamp system is planted with *Typha* and other swamp plants with a depth of <30 cm, with impermeable sediments consisting of soil, loam, and mine spoil. Aerobic swamps are suitable for net alkaline water conditions because this system provides aeration in pond water, namely by the presence of a root zone of vegetation.

One early design used was a shallow (± 1 foot) wetland runoff, covered with cattails (*Typha sp.*) [24, 25]. The substrate for these wetlands varies from natural soil to organic material (compost). In the "aerobic" wetland system, acid mine drainage to be treated will flow through the vegetation and mix with the air. Thus it is possible to oxidize Fe^{2+} and form a precipitate as FeOOH. Aerobic wetlands are often used to treat acid mine drainage with moderate acidity or alkaline water containing high Fe concentrations.

The published aerobic wetland design criteria for iron (Fe) removals are 310 mg/day per ft^2 of wetland area, designed to meet compliance standards, and 620 mg/day per ft^2 if compliance standards are not at issue [30]. The use of aerobic wetlands to remove Fe generally causes a decrease in pH due to the formation of protons by hydrolysis of Fe following the reaction equation Fe^{3+} + 3 H O <==> Fe (OH) + 3 H^+ [30, 31]. A simple cross-section of the aerobic wetland system and its application can be seen in the figure below.

The hoarding location used is the output dump (overburdened material outside the pit location), namely in disposal area 1 ane disposal area 2. The method used to handle PDF material is the PAF capsulation method, which places PAF material in the disposal and coats it with NAF material. The determination of the thickness of the NAF material for capsulation is 10–20 m.

Making Sumps More Effective

Water that has entered or is at the excavation site (mining site) is removed by making a sump and then pumping it out of the mine area. The research company has made sumps, but the pump is not adjusted to the amount of water that enters. It causes the water to stagnate for too long. The method is mainly used for handling rainwater and groundwater. The marrow functions as a reservoir for water before it is pumped out of the mine.

DISCUSSION

The possibility of acid mine drainage is closely related to coal mining activities. Acid mine drainage will arise as a result of the interaction between coal, surface water, and groundwater. It is well recognized that groundwater resources in coal mining regions are susceptible to pollution and can have a negative impact on the ecosystem. Coal mining operations bring on the global issue of groundwater contamination is brought on by coal mining operations. Indonesia's mining region is not an exception. The outflow of acidic

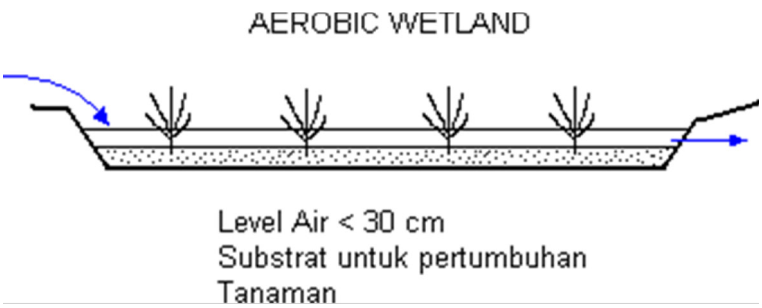

Figure 2. Example of a wetland image

wastewater from coal seam mining, known as acid mine drainage in coal mines, is a matter of concern on a global scale.

After underground coal mining, acid mine drainage typically takes up a portion of the pore space in coal seams. This significantly weakens the coal pillars and creates a serious risk to the stability of the mine. Due to the complex composition of coal, acid mine water will interact with it. The increase or decrease of functional groups containing oxygen, such as carboxy and hydroxyl, is a sign that the chemical breakdown of submerged coal is accelerated by the interaction between the coal and water. Certain metal ions are oxidized as a result of interactions between dissolved metal ions and functional groups in submerged coal that contain oxygen. Finally, this reduces the possibility of coal spontaneously combusting by lowering the oxygen level of these functional groups.

Due to the exploration of coal, huge excess load disposal, and subsequent mixing with coal mine drainage areas, the research on groundwater quality in coal mining areas is crucial. The main goal of this study was to examine the potential impact of acid mine drainage on major ions, trace elements, and hydrogeochemical properties of groundwater.

CONCLUSION

Based on the results and discussion above, it can be concluded that; (1) the characteristics of the coal found in the research area in general have various relatively complex characteristics, both from the ultimate analysis and proximate analysis, (2) through these two results, several characteristics have the potential to form acid mine drainage, including total sulfur content, ash content, elemental carbon, as well as NAG and ANC, and (3) through testing all samples where 50% of the sample is potential, several treatment suggestions can be selected to prevent acid mine drainage from forming.

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