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The 6th International Symposium on Sustainable Urban Development (The 6th ISoSUD) 2023

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The 6th INTERNATIONAL SYMPOSIUM ON SUSTAINABLE URBAN DEVELOPMENT (The 6th ISoSUD) 2023

The International Symposium on Sustainable Urban Development (ISoSUD) is a series of international activities organized by the Faculty of Landscape Architecture and Environmental Technology, Universitas Trisakti, Jakarta. The event is held once every 3 (three) years with themes related to current issues regarding sustainable urban development, in particular related to urban environmental management and environmental technologies. The activity aims to facilitate academics to publish their research results in order to enhance their scientific expertise as researchers.

The 6th ISoSUD in 2023 carried the theme **"From Recovery To Resilience: Building A Sustainable Future For A Better Life"** which means this symposium will focus on how we can recover from the difficult times caused by the COVID-19 pandemic and build a better future and sustainable. This theme also shows the importance of building resilience in facing future challenges, whether related to climate change, economic policies, or other social problems.

The COVID-19 pandemic that swept the world in the last four years has had a significant impact on human health, the global economy, and the daily lives of people around the world. It will take the concerted efforts of all countries and peoples to overcome this pandemic and rebuild the world after it. This pandemic underscores the need for global efforts to strengthen health systems, enhance societal resilience, strengthen international cooperation, and accelerate action to achieve sustainable development goals and combat climate change. This crisis provides an opportunity to make significant changes in the way we view and manage our economic and social activities and to create a world that is more sustainable and fairer for all people and our planet. Now is the time to make a difference, to make a profound systemic shift towards a more sustainable economy for the benefit of our people and our planet. In other words, now is the right time to undertake significant transformations in existing economic and social systems, which can help sustainably achieve the SDGs and fight climate change to ensure a better future for people and our planet. Overall, post-pandemic recovery must be based on the principles of sustainable development contained in the SDGs. By integrating the SDG goals into our recovery policies and actions, we can create a more sustainable, inclusive, and resilient future for our people and the world.

The 6th ISoSUD was held in the hybrid conference:

a. Day 1, on Wednesday, August 2nd, 2023, at Building M, 12th floor, Universitas Trisakti, Jakarta, Indonesia. There were 130 participants offline and 170 participants on the Zoom platform in the plenary session.

b. On day 2, on Thursday, August 3rd, 2023, using the Zoom meeting facility, 270 participants attended virtually on Day 2.

In this two-day International Symposium, experts, researchers, and academician shared their valuable insights and research findings. These esteemed presenters hail from 58 universities and institutions in Filipina, India, Indonesia, Iraq, Japan, Malaysia, Netherlands, Singapura, and Taiwan, reflecting the symposium's diverse and inclusive nature. The call paper system that has been used since the first ISoSUD in 2008 succeeded in inviting 165 manuscripts (more than 400 authors) that were presented offline and virtually. Then, 136 from 165 papers were selected further to be published in IOP Proceedings Indexed by Scopus. After another review process, 106 manuscripts were published in IOP EES. To improve the quality of the manuscripts, the organizing committee held a Coaching Clinic for Scientific Paper Writing on June 24th, 2023. Prof. Mohamad Ali Fulazzaky, Ph.D, delivered the coaching clinic.

The 6th ISoSUD 2023 involved co-host universities consisting of five from within the country and four from abroad: Universitas Jember (UNEJ), Jember, Indonesia; Universitas Islam Indonesia (UII), Yogyakarta, Indonesia; Universitas Pasundan (UNPAS), Bandung, Indonesia; Institut Teknologi Sepuluh November (ITS), Surabaya, Indonesia; Universitas Indonesia (UI), Jakarta, Indonesia; Universiti Teknologi Malaysia (UTM), Malaysia; Universiti Tun Hussein Onn Malaysia (UTHM), Malaysia; The University of Kitakyushu, Japan; Chung Yuan Christian University (CYCU), Taiwan. During the class presentation session, a presentation from the participants representing the 6th ISoSUD co-host was carried out. Besides that, The 6th ISoSUD 2023 was supported as well by the Indonesian Society of Sanitary and Environment Engineers (IATPI), which has continuously supported our symposium since 2008. And sponsored by PT Enviro Cipta Lestari.

In the plenary session, some main speakers delivered more focused seminar themes; they were:

Welcoming Speech:

Prof. Dr. Kadarsah Suryadi DEA – Rector of Universitas Trisakti

Opening Speech:

Ir. Diana Kusumastuti, MT. - Director General of Human Settlements, Ministry of Public Works and Public Housing Indonesia

Plenary Speakers:

Day-1

1. Prof. Lin Chi Wang - Chung Yuan Christian University (CYCU), Taiwan
2. Prof. Ir. Joni Hermana M.Sc.ES., Ph.D – Institut Teknologi Sepuluh November (ITS), Indonesia

Day 2

3. Prof. Ts. Dr. Azmi Bin Aris - Universiti Teknologi Malaysia (UTM), Malaysia
4. Prof. Dr. Eng. Toru Matsumoto - University of Kitakyushu, Japan
5. Associate Prof. Victor R Savage – Nanyang Technological University (NTU), Singapore

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We believe that this event will be able to facilitate good networking among researchers, scientists, engineers, and practitioners with common interests, especially in sharing the latest research results, ideas, development, and applications in Sustainable Urban Development. Hopefully, all participants enjoyed the seminar and found this experience inspiring and helpful in their professional field. Thank you for choosing the 6th ISoSUD as your symposium reference. Let us embrace the spirit of collaboration and innovation as we strive towards a sustainable future for a better life. We hope to have your pleasant support and participation in the next three years on The 7th ISoSUD 2026.

Sincerely,
Assoc. Prof. Ariani Dwi Astuti, ST., MT., PhD
Chairperson of The 6th International Symposium on Sustainable Urban Development (ISoSUD) 2023

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A preliminary study on the formation of acid mine drainage through rock geochemical test in the coal mining areas

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Abstract. Acid mine drainage (AMD) is the biggest issue occurring in every mining industry. Therefore, it is necessary to check the rock, particularly its potency to form acid mine drainage. PT X in Lahat, South Sumatra does not yet own a distribution model for the PAF and NAF rocks. Thus, this research was conducted to determine the distribution of PAF and NAF rocks as an initial potency for the formation of acid mine drainage. Six samples in the field were taken from the pit walls, in which these sample codes were A, B, C, D, E, and F, respectively. These samples were subjected to the static and kinetic tests in the laboratory. The static test showed that a sample with a potency to form acid was sample E, while the other five samples did not have any potency to form acid. Afterwards, kinetic tests were conducted with a daily cycle for 25 days. The result showed that the sample F had lower pH value, compared with the other five samples. Thus, based on this study, it can be concluded that the only sample having the potency to form acid was sample F, while the other samples, namely A, B, C, D, and E, respectively, did not have any potency to form acids.

1. Introduction

The mining system in the Indonesian territory is dominated by an open mining system, which will leave a large number of the ex-mining holes in the future and has a potency to form a void [1]. Quality of the water in these abandoned voids will vary, ranging from poor to higher quality that meets environmental standards. The water quality that is poor or has a low pH value, also known as the acid mine drainage, becomes an issue for the mining business activities. The Indonesian government, through Decree of the Minister of Energy and Mineral Resources No. 1827 K/30/MEM/2018 concerning the Good Mining, has required all of the mining businesses to have a Rock Geochemical model to be used for the management of acid mine drainage during the mining operation.

The mine acid water is characterized by a low pH value below 5 [2], due to the oxidation of sulfide minerals which comes with water to leach it [3]. The acid mine water formed in the mining operation area will negatively affect the surrounding environment or waters when it is drained into the surrounding waters [4,5]. The formation of acid mine drainage can be managed properly, provided that the company has information, as conveyed through the rock geochemical models in the mining industry, about the distribution of rocks having a potentially acid forming (PAF) as well as rocks non-acid forming (NAF). Based on the existing geochemical model, the Company can perform a strategy in managing the formation of acid mine drainage [6].

Rock geochemical characterization should be carried out from the exploration stage, which can be validated during the ongoing mining operation. When companies have not carried out the rock geochemical characterization at the exploration stage, it can be performed during the mining operations by sampling the exposed rock walls. In Indonesia, research on the geochemical characterization of rocks for the potential for the formation of acid mine drainage has been carried out [7], which can serve as a guide for doing the same in other locations. The study area was Lahat area of South Sumatra, a coal mining company without any rock geochemical characterization to date. Thus, this study on the rock geochemical characterization was conducted to determine the distribution of PAF and NAF rocks as an initial potential study on the formation of acid mine drainage.

2. Methods

2.1. Location

This research was conducted at one of the PT X coal mining companies in Lahat Regency, South Sumatra Province. This coal mining area was in the Muara Enim Formation and the Kasai Formation, while the research location was in the Kasai Formation in which the mining operation was carried out on two coal seams as the main seam. The mining business license covers an area at the width of 519.80 Ha, while the mining activities in this location are still active to date. The company has produced two coal products, namely Medium Range Coal (MRC) with a calorific value of 4750 GAR and Lower Calorific Value (LCV) with a calorific value of 3800 GAR.

2.2. Sampling

The sampling location on a rock wall was taken into account because of its ease of access. Rock samples were taken from the rock lithology in the study area, in which the samples were overburden and interburden rocks. The sampling was conducted through a grab-sampling method (Figure 1), in which the sample surface was cleaned first to obtain an area that was fresh and not oxidized. The rock samples taken were 6 samples having codes A, B, C, D, E, and F, respectively. Samples A and B were shale stone, samples C, D, E were clay stone, while sample F was soil.

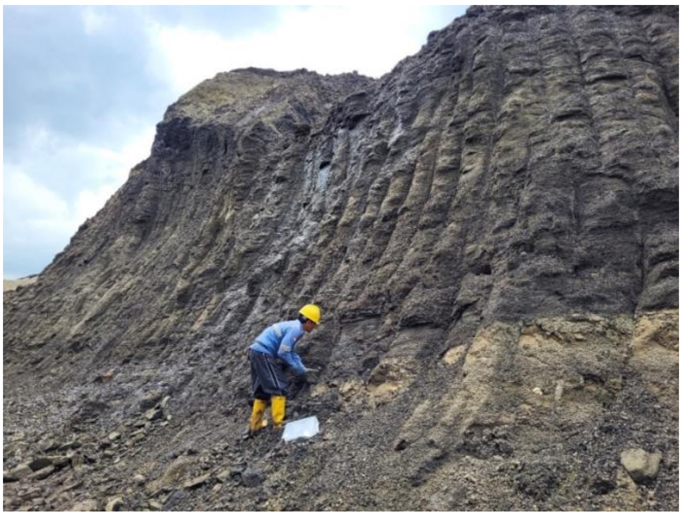

Figure 1. Sampling

2.3. Laboratory testing

The tests conducted in this study were static and kinetic tests in the Coal Quality Analysis Quality Laboratory and the Rock Mechanics Laboratory, Mining Engineering Study Program, Faculty of Earth Technology and Energy, Universitas Trisakti. Static test was conducted to calculate the balance between acid components, namely sulfide mineral and acid consumption components, which were mainly carbonate minerals in the sample. This test aimed to determine the potency of acid formation. This test was conducted based on the Indonesian National Standard (SNI) 6957: 2021 and AMIRA 2002 [8]. The stages of this static test included are described below.

1. Paste pH test was conducted to investigate the similarity indication in the sample by mixing a 200 mesh sample with 50 ml of deionized water, leaving it overnight, and checking its pH to categorize the sample into the PAF (Potential Acid Forming) or NAF (Non acid Forming) category.
2. Total sulfur to determine the percentage of sulfur content in the sample was obtained using the ESCHA method, by burning the sample at a temperature of 800 ºC in the muffle furnace for 1 hour 30 minutes, filtering the sample by mixing the burning sample in the heated distilled water, and filtering it again using ash filter paper. Afterwards, ± 150 mL of filtrate was collected into an erlenmeyer, while the filtrate was mixed with some reagents to observe the color change, in which the reagent used was the indicator SM, 10% KOH, HCL 1: 1, HCL 1: 9. The next step was to heat the filtrate and to add 10 mL of $BaCL_2$ for checking the precipitate in the filtrate, in which the filtrate was filtered using filter (no ash) no.42. Afterwards, the container was weighed to identify its empty weight, while the filter paper was folded, put into the container, and burned again for 1 hour 30 minutes. After the burning process, the container was weighed again as the value of the weight content. Therefore, based on these results, value of the sulfur content can be identified in the sample with the formula listed in ASTM D2662.
3. NAG (Net Acid Generating) test was conducted adding H_2O_2 to a sample at 2.5 grams and a size of 200 mesh. In this test, the solution containing the sample was distilled overnight to see the reaction in the sample. Afterwards, the solution was heated for 2 hours to check its pH, called NAG pH. The next step was to titrate the solution to reach pH at 4.5 and 7.0 with different NaOH concentrations.
4. ANC (Acid Neutralizing Capacity) test was conducted by adding hydrochloric acid (HCl) to the sample and determining the fizz rating of each sample to identify the volume of HCl added to the sample. The sample that has been added with HCl and 20 mL of deionized water was heated for 2 hours until the reaction was complete or considered complete. After the heating process, the pH was checked to see whether or not the sample can continue with the titration at pH between 0.8 and 1.5. Meanwhile, the results of the titration were used to calculate the value of the ANC acid neutralizing capacity.

The kinetic test was conducted to determine the reaction kinetics of acid formation in the sample by simulating oxidation reactions in rocks. Furthermore, this test was a characterization of the long-term weathering. In this study, the test used the Free Draining Column Leach Test (FDCLT) method, a column loach test in which 2-2.5 kg of rock samples was put into a buchner funnel with filter paper [9]. The sample was designed with two cycles, namely the wet-dry cycle daily for 25 days.

3. Results and Discussions

3.1. Static test

The static test, as presented in Table 1 showed the result that the lowest pH value of the paste was sample F at 4.9, while the other samples were in the range from 6.9 to 8.5. Based on the results of pH of this paste, the pH value was close to a neutral pH. The net acid generation (NAG) test showed the result that there were three samples with low pH values, namely sample C at 3.2, sample E at 3.7 and sample F at 4.8, while the other samples were in the range from 6.5 to 7. This result of NAG shows that there was a tendency for the three samples to generate the acid. Acid Neutral Capacity (ANC) showed the result that two samples without any neutralizing capacity were sample D with a value of -109.00 kg H_2SO_4/ton and sample E with a value of -184.37 kg H_2SO_4/ton. Meanwhile, samples A, B, C and F had the neutralizing capacity with values ranging from 3.71 to 35 kg H_2SO_4/ton. The total sulfur test showed the result that all samples had low values ranging from 0.07 to 0.21. The result of Maximum Potential Acidity (MPA) was in the range from 2.10 to 6.31 kg H_2SO_4/ton, while the sample having the highest MPA value was sample F at 6.31 kg H_2SO_4/ton. The result of Net Acid Production Potential (NAPP) showed that the sample with the highest value was samples D and E, while samples A, B, C, and F showed negative NAPP values. Therefore, based on this NAPP value, samples D and E had the potency to produce acid.

Table 1. Results of the static test

No	Sample ID	pH Pasta	NAG			ANC*	Total Sulphur (%)	MPA*	NAPP*
			NAG pH	NAG pH = 4.5*	NAG pH = 7*				
1	A	8.5	7	0	0	3.71	0.07	2.10	-1.61
2	B	7.8	6.6	0	0.39	8.29	0.07	2.10	-6.19
3	C	6.9	3.2	10.98	15.68	35	0.14	4.20	-30.80
4	D	7.1	6.5	10.00	1.37	-109.00	0.07	2.10	111.10
5	E	7.2	3.7	5.88	17.64	-184.37	0.14	4.20	188.57
6	F	4.9	4.8	0	2.35	22.27	0.21	6.31	-15.96

Note: *unit in kg H_2SO_4/t

Based on the results of the static tests that have been conducted, the geochemical characterization of rock can be interpreted through a comparison chart of NAPP and NAG pH values as shown in Figure 1. The results of the geochemical characterization in Figure 2 showed that sample E was categorized as the Potential Acid Forming (PAF) having NAG pH value < 4.5 and NAPP value > 0. Meanwhile, the other three samples, namely samples A, B, and F, were categorized as the Non Acid Forming (NAF) with NAPP values > 4.5, and NAPP < 0. The other two samples, namely samples C and D, were categorized as the Uncertain (UC) since the pH values of NAG and NAPP were not in accordance with the stipulation set in PAF and NAF categories.

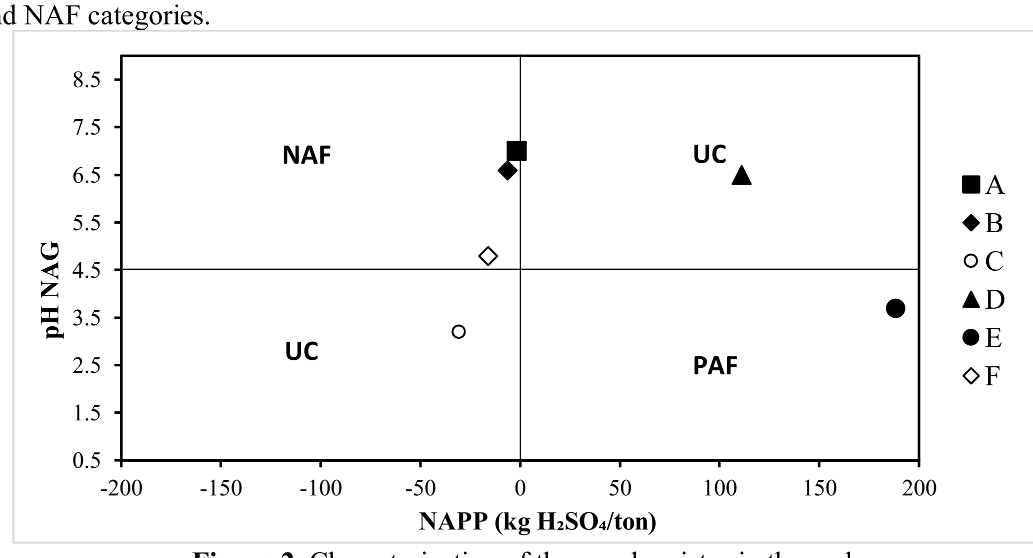

Figure 2. Characterization of the geochemistry in the rock

3.2. *Kinetic test*

The results of kinetic test were used to confirm the geochemical characterization of rock based on the results of the static test. The leachate taken from each sample was measured for its pH value. As shown in Figure 3, concerning the pH value of each sample the sample with a low pH value ranging from 5.2 to 6.2 was sample F. The sample with the highest pH value was sample A with a range of pH value from 8.1 to 8.6. The other samples, namely samples B, C, D, and E, had pH values in the range from 6 to 8.5. Based on this pH value, it shows that all samples were categorized as rocks having no potency to form acid, while only sample F had low pH value.

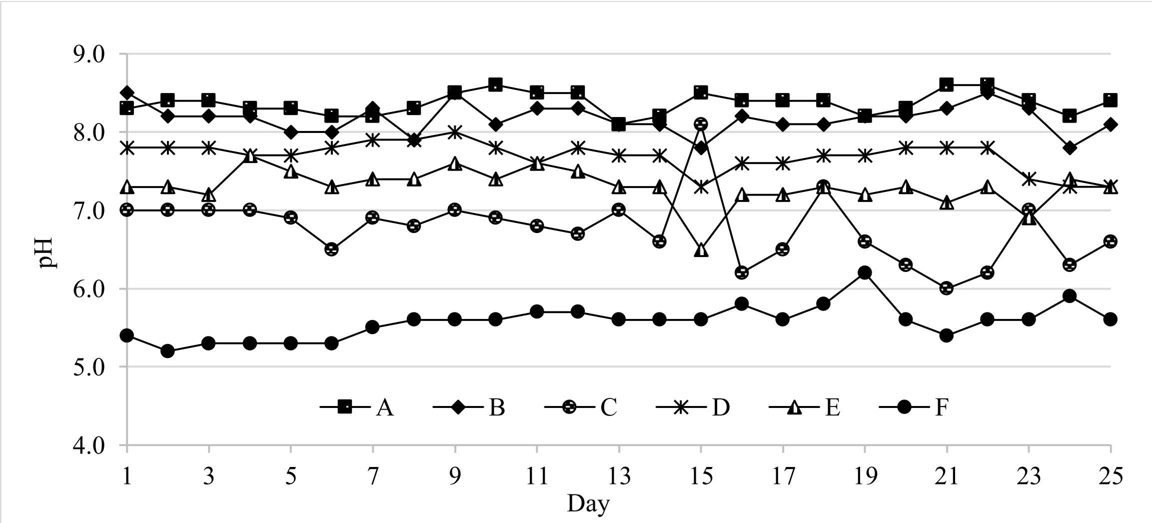

Figure 3. pH value

Total Dissolved Solid (TDS) parameter visualized amount of the dissolved solids (solids) in the leachate. TDS value for each sample is shown in Figure 3. TDS refers to the solubility value of a substance in leachate, while the TDS value is directly proportional to the pH, in which high pH also means high TDS value. In Figure 4, almost all samples at the beginning of the daily cycle, except for sample E, showed a significant increase, decrease, and fluctuation. Sample C apparently had a fairly high average TDS value compared to the other five samples, having TDS values ranging from 137 to 890 mg/L. Besides, sample C underwent fluctuation in the process of the test period. Samples showing low TDS values were sample F with TDS values ranging from 4 to 58 mg/L. Thus, TDS value of all samples showed that all samples were below 800 gr/mL.

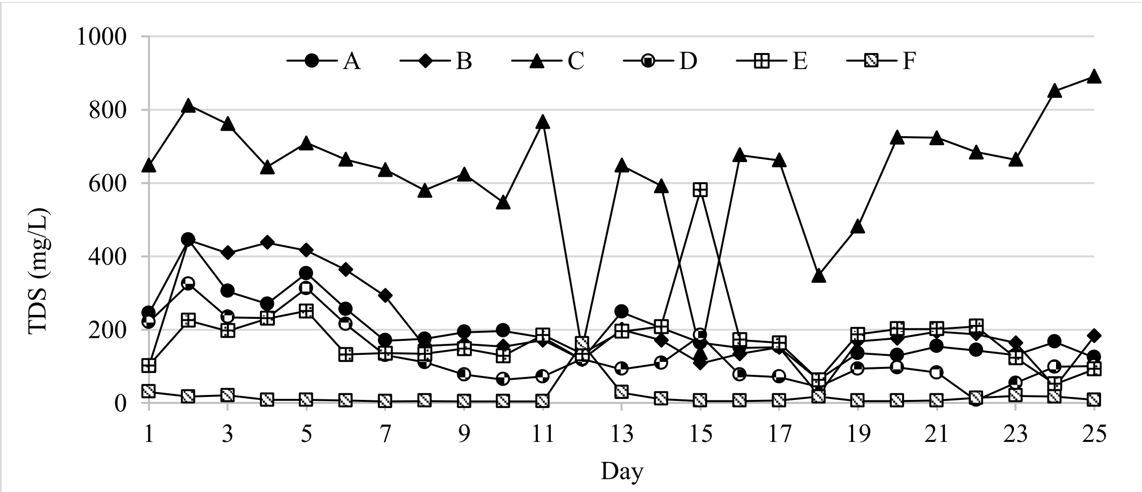

Figure 4. TDS value

3.3. Overall geochemical characteristics of the samples

Based on the results of static and kinetic tests, the rock geochemical characterization of all samples was rock without any potency to form acid. The static test, in which sample E was categorized as PAF, showed the result that the sample was NAF rock with a pH value ranging from 6.5 to 7.7. For other samples categorized as Uncertain, namely samples C and D, the kinetic tests showed the result that pH values were from 6 to 8.1 for sample C and from 7.3 to 8 for sample D. Thus, these two samples were confirmed as NAF rocks. Based on the static test results, samples A, B, and F were categorized as NAF rocks confirmed by kinetic testing in which sample A had pH value ranging from 8.1 to 8.6, sample B had pH value from 7.8 to 8.5, and sample F had pH value from 5.2 to 6.2. Thus, it can be said that sample F indicated a tendency of a low pH value.

4. Conclusion

A conclusion that can be drawn from the results of this study is that all rock samples undergoing the geochemical characterization did not have any potency to form acid. However, in sample F, the kinetic test showed the result that there is a tendency to have a potency to form acid because of having the lowest pH value of all samples. This research is expected to give suggestion to the company for managing its acid mine drainage. Further methods which can be performed by the company to confirm whether or not the rock has a potency to be acidic are mineralogical tests on each rock sample.

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A Preliminary Study on the Formation of Acid Mine Drainage through Rock Geochemical Test in the Coal Mining Areas

by Edy Jamal Tuheteru

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A Preliminary Study on the Formation of Acid Mine Drainage through Rock Geochemical Test in the Coal Mining Areas

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Abstract: Acid mine drainage (AMD) is the biggest issue occurring in every mining industry. Therefore, it is necessary to check the rock, particularly its potency to form acid mine drainage. PT X in Lahat, South Sumatra does not yet own a distribution model for the PAF and NAF rocks. Thus, this research was conducted to determine the distribution of PAF and NAF rocks as an initial potency for the formation of acid mine drainage. Six samples in the field were taken from the pit walls, in which these sample codes were A, B, C, D, E, and F, respectively. These samples were subjected to the static and kinetic tests in the laboratory. The static test showed that a sample with a potency to form acid was sample E, while the other five samples did not have any potency to form acid. Afterwards, kinetic tests were conducted with a daily cycle for 25 days. The result showed that the sample F had lower pH value, compared with the other five samples. Thus, based on this study, it can be concluded that the only sample having the potency to form acid was sample F, while the other samples, namely A, B, C, D, and E, respectively, did not have any potency to form acids.

1. Introduction

The mining system in the Indonesian territory is dominated by an open mining system, which will leave a large number of the ex-mining holes in the future and has a potency to form a void [1]. Quality of the water in these abandoned voids will vary, ranging from poor to higher quality that meets environmental standards. The water quality that is poor or has a low pH value, also known as the acid mine drainage, becomes an issue for the mining business activities. The Indonesian government, through Decree of the Minister of Energy and Mineral Resources No. 1827 K/30/MEM/2018 concerning the Good Mining, has required all of the mining businesses to have a Rock Geochemical model to be used for the management of acid mine drainage during the mining operation.

The mine acid water is characterized by a low pH value below 5 [2], due to the oxidation of sulfide minerals which comes with water to leach it [3]. The acid mine water formed in the mining operation area will negatively affect the surrounding environment or waters when it is drained into the surrounding waters [4], [5]. The formation of acid mine drainage can be managed properly, provided that the company has information, as conveyed through the rock geochemical models in the mining industry, about the distribution of rocks having a potentially acid forming (PAF) as well as rocks non-acid forming (NAF). Based on the existing geochemical model, the Company can perform a strategy in managing the formation of acid mine drainage [6].

Rock geochemical characterization should be carried out from the exploration stage, which can be validated during the ongoing mining operation. When companies have not carried out the rock geochemical characterization at the exploration stage, it can be performed during the mining operations by sampling the exposed rock walls. In Indonesia, research on the geochemical characterization of rocks for the potential for the formation of acid mine drainage has been carried out [7] [8] [9] [10], which can serve as a guide for doing the same in other locations. The study area was Lahat area of South Sumatra, a coal mining company without any rock geochemical characterization to date. Thus, this study on the rock geochemical characterization was conducted to determine the distribution of PAF and NAF rocks as an initial potential study on the formation of acid mine drainage.

2. Method

2.1. Location

This research was conducted at one of the PT X coal mining companies in Lahat Regency, South Sumatra Province. This coal mining area was in the Muara Enim Formation and the Kasai Formation, while the research location was in the Kasai Formation in which the mining operation was carried out on two coal seams as the main seam. The mining business license covers an area at the width of 519.80 Ha, while the mining activities in this location are still active to date. The company has produced two coal products, namely MRC with a calorific value of 4750 GAR and LCV with a calorific value of 3800 GAR.

2.2. Sampling

The sampling location on a rock wall was taken into account because of its ease of access. Rock samples were taken from the rock lithology in the study area, in which the samples were overburden and interburden rocks. The sampling was conducted through a grab-sampling method (**Figure 1**), in which the sample surface was cleaned first to obtain an area that was fresh and not oxidized. The rock samples taken were 6 samples having codes A, B, C, D, E, and F, respectively. Samples A and B were shale stone, samples C, D, E were clay stone, while sample F was soil.

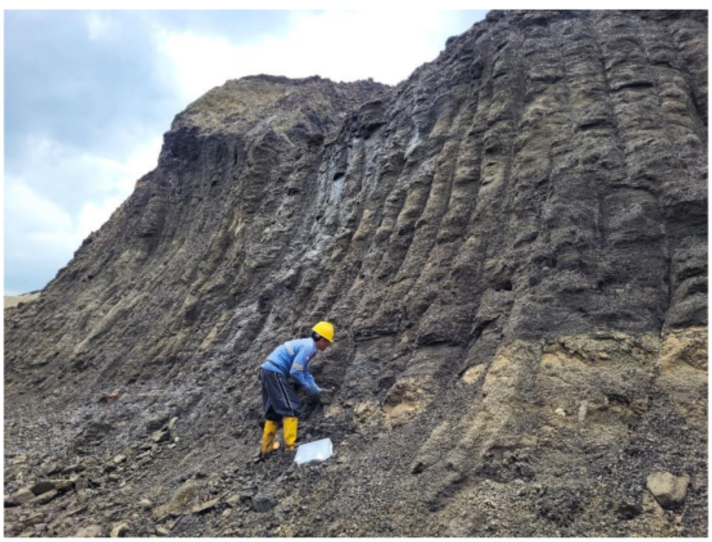

Figure 1. Sampling

2.3. Laboratory Testing

The tests conducted in this study were static and kinetic tests in the Coal Quality Analysis Quality Laboratory and the Rock Mechanics Laboratory, Mining Engineering Study Program, Faculty of Earth Technology and Energy, Trisakti University. Static test was conducted to calculate the balance between acid components, namely sulfide mineral and acid consumption components, which were mainly carbonate minerals in the sample. This test aimed to determine the potency of acid formation. This test was conducted based on the Indonesian National Standard (SNI) 6957: 2021 and AMIRA 2002 [11]. The stages of this static test included are described below.

- Paste pH test was conducted to investigate the similarity indication in the sample by mixing a 200 mesh sample with 50 ml of deionized water, leaving it overnight, and checking its pH to categorize the sample into the PAF (Potential Acid Forming) or NAF (Non acid Forming) category.
- Total sulfur to determine the percentage of sulfur content in the sample was obtained using the ESCHA method, by burning the sample at a temperature of 800 ^{o}C in the Muffle Furnace for 1 hour 30 minutes, filtering the sample by mixing the burning sample in the heated distilled water, and filtering it again using Ash Filter paper. Afterwards, ± 150 ml of filtrate was collected into an Erlenmeyer, while the filtrate was mixed with some reagents to observe the color change, in which the reagent used was the indicator SM, 10% KOH, HCL 1: 1, HCL 1: 9. The next step was to heat the filtrate and to add 10 ml of $BaCL_2$ for checking the precipitate in the filtrate, in which the filtrate was filtered using filter (no ash) no.42. Afterwards, the container was weighed to identify its empty weight, while the filter paperwas folded, put into the container, and burned again for 1 hour 30 minutes. After the burning process, the container was weighed again as the value of the weight content. Therefore, based on these results, value of the sulfur content can be identified in the sample with the formula listed in ASTM D2662.
- NAG (Net Acid Generating) test was conducted adding H_2O_2 to a sample at 2.5 grams and a size of 200 mesh. In this test, the solution containing the sample was distilled overnight to see the reaction in the sample. Afterwards, the solution was heated for 2 hours to check its pH, called NAG pH. The next step was to titrate the solution to reach pH at 4.5 and 7.0 with different NaOH concentrations.
- ANC (Acid Neutralizing Capacity) test was conducted by adding hydrochloric acid (HCl) to the sample and determining the fizz rating of each sample to identify the volume of HCl added to the sample. The sample that has been added with HCl and 20 ml of deionized water was heated for 2 hours until the reaction was complete or considered complete. After the heating process, the pH was checked to see whether or not the sample can continue with the titration at pH between 0.8 and 1.5. Meanwhile, the results of the titration were used to calculate the value of the ANC acid neutralizing capacity.

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The kinetic test was conducted to determine the reaction kinetics of acid formation in the sample by simulating oxidation reactions in rocks. Furthermore, this test was a characterization of the long-term weathering. In this study, the test used the Free Draining Column Leach Test (FDCLT) method, a column loach test in which 2-2.5 kg of rock samples was put into a Buchner funnel with filter paper [12]. The sample was designed with two cycles, namely the wet-dry cycle. daily for 25 days.

3. Results and Discussion

3.1. Static Test

The static test, as presented in **Table 1** showed the result that the lowest pH value of the paste was sample F at 4.9, while the other samples were in the range from 6.9 to 8.5. Based on the results of pH of this paste, the pH value was close to a neutral pH. The net acid generation (NAG) test showed the result that there were three samples with low pH values, namely sample C at 3.2, sample E at 3.7 and sample F at 4.8, while the other samples were in the range from 6.5 to 7. This result of NAG shows that there was a tendency for the three samples to generate the acid. ANC showed the result that two samples without any neutralizing capacity were sample D with a value of -109.00 Kg H2SO4/Ton and sample E with a value of -184.37 Kg H2SO4/Ton. Meanwhile, samples A, B, C and F had the neutralizing capacity with values ranging from 3.71 to 35 Kg H2SO4/Ton. The total sulfur test showed the result that all samples had low values ranging from 0.07 to 0.21. The result of Maximum Potential Acidity (MPA) was in the range from 2.10 to 6.31 Kg H2SO4/Ton, while the sample having the highest MPA value was sample F at 6.31 Kg H2SO4/ton. The result of Net Acid Production Potential (NAPP) showed that the sample with the highest value was samples D and E, while samples A, B, C, and F showed negative NAPP values. Therefore based on this NAPP value, samples D and E had the potency to produce acid.

Table 1. Results of the Static Test

No	Sample ID	pH Pasta	NAG			ANC*	Total Sulphur (%)	MPA*	NAPP*
			NAG pH	NAG pH = 4.5*	NAG pH = 7*				
1	A	8.5	7	0	0	3.71	0.07	2.10	-1.61
2	B	7.8	6.6	0	0.39	8.29	0.07	2.10	-6.19
3	C	6.9	3.2	10.98	15.68	35	0.14	4.20	-30.80
4	D	7.1	6.5	10.00	1.37	-109.00	0.07	2.10	111.10
5	E	7.2	3.7	5.88	17.64	-184.37	0.14	4.20	188.57
6	F	4.9	4.8	0	2.35	22.27	0.21	6.31	-15.96

Note: *unit in kg H_2SO_4/t, ANC: acid-neutral capacity; NAG: Net Acid Generation; MPA: Maximum Potentially Acidity; NAPP: net acid production potential.

Based on the results of the static tests that have been conducted, the geochemical characterization of rock can be interpreted through a comparison chart of NAPP and NAG pH values as shown in Figure 1. The results of the geochemical characterization in **Figure 2** showed that sample E was categorized as the Potential Acid Forming (PAF) having NAG pH value < 4.5 and NAPP value > 0. Meanwhile, the other three samples, namely samples A, B, and F, were categorized as the Non Acid Forming (NAF) with NAPP values > 4.5, and NAPP < 0. The other two samples, namely samples C and D, were categorized as the Uncertain (UC) since the pH values of NAG and NAPP were not in accordance with the stipulation set in PAF and NAF categories.

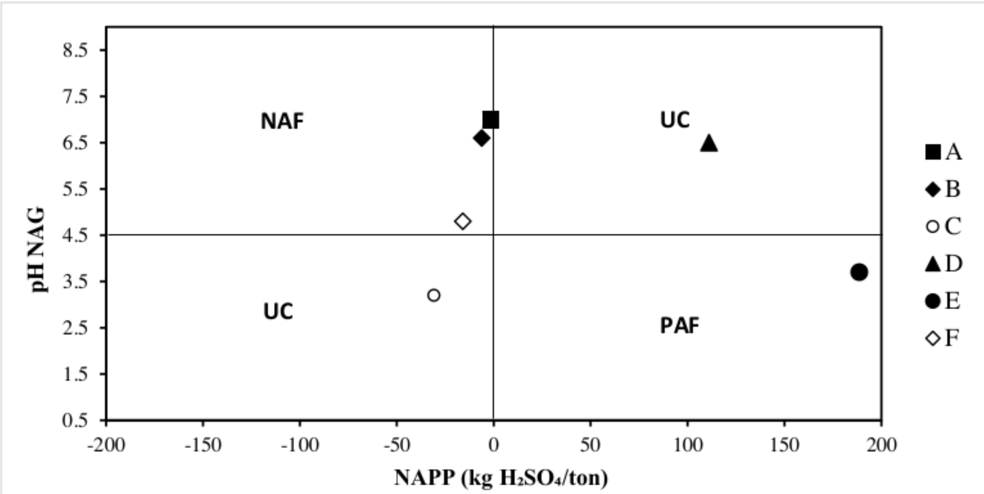

Figure 2. Characterization of the Geochemistry in the Rock

3.2. Kinetic Test

The results of kinetic test were used to confirm the geochemical characterization of rock based on the results of the static test. The leachate taken from each sample was measured for its pH value. As shown in **Figure 3**, concerning the pH value of each sample the sample with a low pH value ranging from 5.2 to 6.2 was sample F. The sample with the highest pH value was sample A with a range of pH value from 8.1 to 8.6. The other samples, namely samples B, C, D, and E, had pH values in the range from 6 to 8.5. Based on this pH value, it shows that all samples were categorized as rocks having no potency to form acid, while only sample F had low pH value.

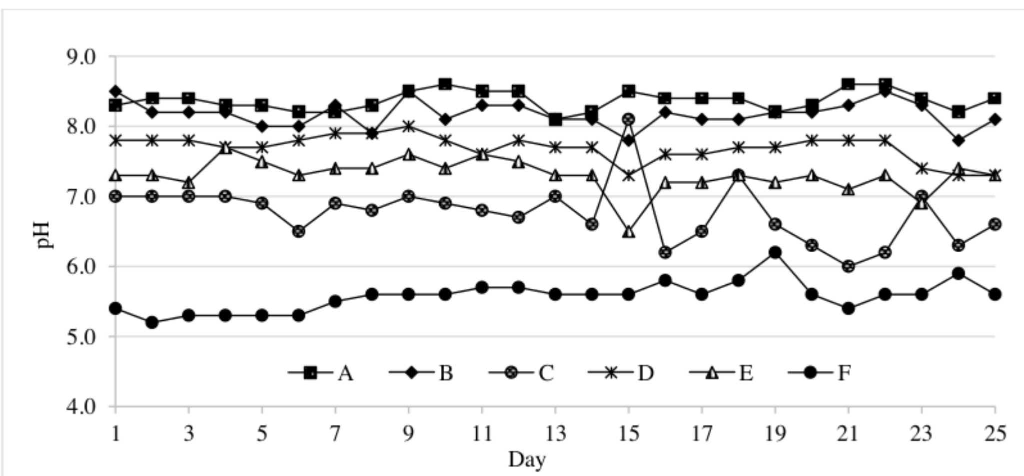

Figure 3. pH Value

Total dissolved solid (TDS) parameter visualized amount of the dissolved solids (solids) in the leachate. TDS value for each sample is shown in Figure 3. TDS refers to the solubility value of a substance in leachate, while the TDS value is directly proportional to the pH, in which high pH also means high TDS value. In **Figure 4**, almost all samples at the beginning of the daily cycle, except for sample E, showed a significant increase, decrease, and fluctuation. Sample C apparently had a fairly high average TDS value compared to the other five samples, having TDS values ranging from 137 to 890 mg/l. Besides, sample C underwent fluctuation in the process of the test period. Samples showing low TDS values were sample F with TDS values ranging from 4 to 58 mg/l. Thus, TDS value of all samples showed that all samples were below 800 gr/ml.

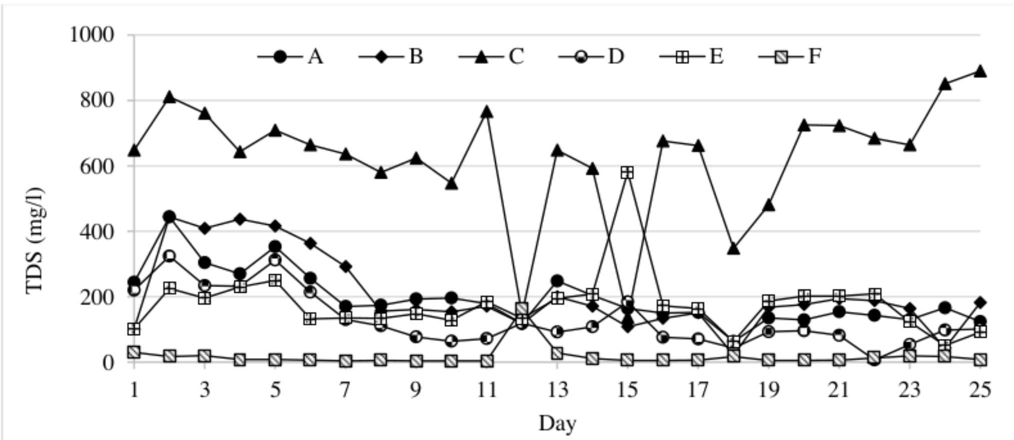

Figure 4. TDS Value

3.3. Overall Geochemical Characteristics of the Samples

Based on the results of static and kinetic tests, the rock geochemical characterization of all samples was rock without any potency to form acid. The static test, in which sample E was categorized as PAF, showed the result that the sample was NAF rock with a pH value ranging from 6.5 to 7.7. For other samples categorized as Uncertain, namely samples C and D, the kinetic tests showed the result that pH values were from 6 to 8.1 for sample C and from 7.3 to 8 for sample D. Thus, these two samples were confirmed as NAF rocks. Based on the static test results, samples A, B, and F were categorized as NAF rocks confirmed by kinetic testing in which sample A had pH value ranging from 8.1 to 8.6,sample B had pH value from 7.8 to 8.5, and sample F had pH value from 5.2 to 6.2. Thus, it can be said that sample F indicated a tendency of a low pH value.

4. Conclusion

A conclusion that can be drawn from the results of this study is that all rock samples undergoing the geochemical characterization did not have any potency to form acid. However, in sample F, the kinetic test showed the result that there is a tendency to have a potency to form acid because of having the lowest pH value of all samples. This research is expected to give suggestion to the Company for managing its acid mine drainage. Further methods which can be performed by the company to confirm whether or not the rock has a potency to be acidic are mineralogical tests on each rock sample.

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