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Research Article

A comparison of soil characteristics from four land covers around coal mining concession area in South Kalimantan

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Abstract

Understanding soil characteristics is importantly required to determine the alternative strategies of land management, particularly related to the scheme of soil and water conservation. This study investigated soil characteristics from four land covers around coal mining concession area, located in South Kalimantan. Soil suvey was conducted using a purposive sampling method with three replicates in each land cover. The soil sample was taken at depth of 0−10 cm, 11−20 cm, and 21−30 cm. Then, these sample were composited before brought to the laboratory for quantifying their characteristics such as texture and organic carbon content. Data analysis was processed using non-parametric test with a significant level of 5%. Comparison average of soil characteristics between land covers was evaluated using Kruskal-Wallis test and followed by Nemenyi-test. Results found that soil characteristics from four land covers were significantly different in texture and organic carbon content. The highest sand fraction was noted in shrubs (67.23±0.86%) while the greatest silt fraction was recorded in plantation forests (29.71±2.84%). Compared to other land covers, the clay content in plantation forests and reclamation area was relatively equal by around 53−54%. On another side, The highest soil organic carbon was found in plantation forests with ranging of (4.44±0.14%) and followed by natural forests (4.24±0.62%), shrubs (3.38±0.09%) and reclamation area (1.14±0.09%). These findings indicated there were high variation of soil characteristics from different land covers around coal mining concession area. Therefore, we suggest to the managers to apply adaptive strategies in supporting soil conservation efforts based on the soil characteristics in each site.

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Introduction

Soil is a component of natural resources that plays important roles in maintaining environmental stability. Besides supplying water and nutrients for plants (Sadono et al., 2021), soil also has fundamental contributions to support biogeochemical cycles and energy flow in the ecosystems (Smith et al., 2015). Numerous studies also report that soil characteristics directly correlates to the vulnerability of natural disaster like flood and landslide (Djukem et al., 2020). Considering to these strategic positions, it is important to apply soil conservation efforts for minimizing the risk of degradation. This challenge has become the most essential issue in many commercial sectors, one of them is coal mining industry.

During the last periods, the existence of coal mining business has provided high contribution to increase gross domestic product. This industry also gives a lot of work opportunities for people who live around its concession. In fact, some literatures explain the presence of coal mining industry can accelerate the effort of rural development, particularly from corporate social responsibility programs. However, the activity of coal mining exploration also has negative impacts on the environment, mainly related to the soil degradation (Ma et al., 2019). For example, coal mining industry commonly uses open pit-systems wherein it is conducted by removing vegetation cover (Kuzevic et al., 2022). Consequently, the rate of run-off and erosion will occurs more rapidly. This circumstance can reduce soil fertility because amount of top soil layers have been leached (Lulu et al., 2022). Moreover, the use of chemical compounds can also cause soil contamination (Mourinha et al., 2022). Thus, the effort of reclamation will be more difficult to implement because the soil contamination can stimulate plant stress (Li et al., 2018). It will make plants die or demonstrate detrimental growth (Chibuike and Obiora, 2014). Therefore, the integrated soil management is necessary to minimize the impacts of coal mining activity on soil degradation. This scheme is only possible to formulate if there are comprehensive information about soil characteristics around coal mining concession area.

As one of the mining enterprise, PT Borneo Indobara has received a permit to manage coal mining concession area located in South Kalimantan. This site consists of various land covers like natural forests, plantation, shrubs, etc. Even though this company has been operating more than 10 years, but the information about soil characteristics from each land cover is still limited. It is caused by the work priority that focused on coal extraction. Unfortunately, the challenge of soil management is not only in small scale, but also occurs in landscape. The connectivity of each land cover become important aspects that should be considered to find the optimum solution. Therefore, this study aimed to identify the variation of soil characteristics from different land cover around coal mining concession area managed by PT Borneo Indobara. The outcome will provide sufficient information for managers to formulate the adaptative strategies of soil conservation in every land cover.

Materials and Methods

Study Area

This study was conducted in coal mining concession area managed by PT Borneo Indobara. It is located in Tanah Bumbu District, South Kalimantan Province (Figure 1). The geographical coordinates of this site is E115˚54'38" 115˚39'00" and S3˚35'30" 3˚36'30". Topography is predominantly by hilly areas with the slope level of 8−26%. Altitude ranges from 20−52 m dpl. Annual rainfall reaches 2,291.7 mm year^{-1} with the highest rainfall occurs in January by approximately 352.3 mm months^{-1}. The mean daily temperature is 27.7˚C with a minimum of 22.7˚C and a maximum of 35.2˚C. Dry periods are relatively longer than 4 months from Juli to November.

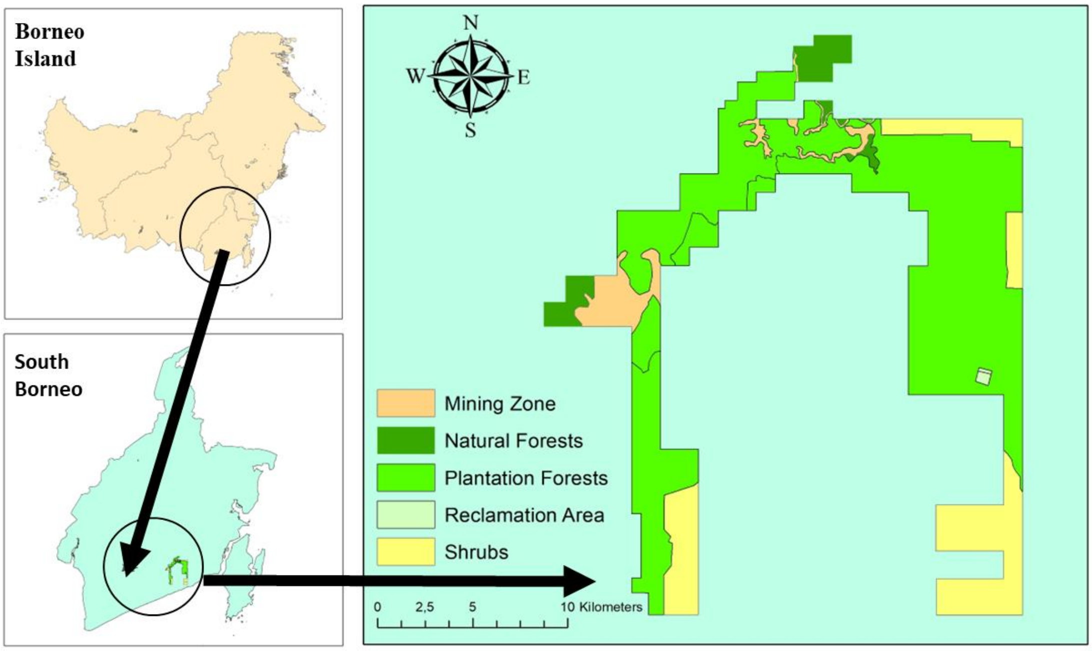

Figure 1. Sketch of study area in coal mining concession managed by PT Borneo Indobara

PT Borneo Indobara had total coal mining concession around 24,100 ha. This area was divided into 4 blocks to facilitate the exploration activities, namely Batulaki, Bunati, Kusan, and Girimulya. Before becoming the coal mining area, this area had various land cover, such as oil palm plantation, natural forests, plantation forests, etc. However, several land covers have removed due to the impact of mining exploration. Among those sites, Girimulya still had land cover variation since it was the last block to mine the coal deposit based on company planning.

Data Collection

Data were collected around 3 months from August to October 2020. It consisted of three important phases, namely site stratification, soil survey, and laboratory analysis. The objective of site stratification was to identify the land cover variation around coal mining concession area. This step was required to design the location for soil sampling. The spatial approach was applied to facilitate site stratification using the most updating image from Google Earth. There were four land covers that found in the study area, including natural forests, plantation forests, shrubs, and reclamation area. Then, sampling points was distributed randomly in every land cover with three replicates. The coordinate of every point was saved to GPS for facilitating the tracking process in the field.

In every sampling location, the soil sample was taken at the depth of 0−10 cm, 0−20 cm, and 0−30 cm (Wirabuana et al., 2021a). Then, these samples were composited for each sampling position before brought to the laboratory for quantifying their characteristics. There were two parameters used to identify soil variation among land cover, i.e. texture and organic carbon content. Soil texture was determined using Pipette (Alam et al., 2020)method while soil organic carbon was quantified using Walkley and Black Method (Estefan et al., 2013).

Statistical Analysis

Data analysis was processed using R software version 4.1.2 with a significant level of 5%. The *dplyr* and *agricolae* packages were used to support the data processing (De Mendiburu and Simon, 2015). The first stage was started by descriptive analysis to identify the range of data distribution, including mean, standard deviation, and standard error (Wirabuana et al., 2021b). This step was also carried out to asses the coefficient of variation and the coefficient of precision (Table 1). Both parameters was generally used to assess the accuracy and precision from data obtained by sampling method (Santos and Dias, 2021).

Then, the second stage was focused on assumption tests. There were two assumptions tests that applied for data evaluation, namely normality tests and homogeneity variance tests (Beyene, 2016; Ghasemi and Zahediasl, 2012). These tests was executed twice wherein the first round was conducted using actual data and the second round was undertaken using logarithmic natural transformation from data. However, the second round was only processed if the actual data did not follow normal distribution nor has heterogeneous variance. Based on the preliminary test, it has been confirmed that data did not fulfill both assumptions. Therefore, this study used non-parametric test to get a conclusion from data. In this context, comparison mean of soil characteristics among land covers were examined using Kruskall-Walis test and followed by Nemenyi test (Alam et al., 2020).

Tabel 1. Summary statistics of soil variation from four land cover types

Land cover	Parameter	Unit	Summary Statistics			
			Mean	SE	CV (%)	P (%)
NF	Sa	%	55.86	2.40	7.43	4.29
	Si	%	12.65	0.71	9.70	5.60
	Cl	%	31.48	1.78	9.80	5.66
	C-org	%	4.24	0.62	25.21	14.55
PF	Sa	%	15.97	1.95	21.16	12.22
	Si	%	29.71	2.84	16.53	9.54
	Cl	%	54.33	1.75	5.59	3.23
	C-org	%	4.44	0.14	5.30	3.06
RA	Sa	%	35.39	0.93	4.55	2.63
	Si	%	11.00	0.64	10.07	5.81
	Cl	%	53.61	1.56	5.05	2.91
	C-org	%	1.14	0.09	13.27	7.66
SH	Sa	%	67.23	0.86	2.21	1.28
	Si	%	5.11	0.27	14.76	5.25
	Cl	%	27.66	1.21	7.56	4.36
	C-org	%	3.38	0.09	4.55	2.63

Note: NF (natural forests), PF (plantation forests), RA (recalamation area), SH (shrubs), Sa (sand), Si (silt), Cl (clay), C-org (soil organic carbon)

Results and Discussion

Summarized results of the observation demonstrated that soil characteristics among land covers relatively varied (Table 1) wherein there was a significant different of particle-size distribution and soil organic carbon (Figure 2). The highest sand fraction was recorded in shrubs (67.23±0.86%) while the greatest silt fraction was discovered in plantation forests (29.71±2.84%). Compared to others, the clay content was relatively equal in plantation forests and reclamation area by around 53−54%. These were substantially higher around 30% than the proportion of clay fraction in natural forests and shrubs. On another side, this study noted the highest soil organic carbon was found in plantation forests (4.44±0.14%), and followed by natural forests (4.24±0.62%), shrubs (3.38±0.09%), as well as reclamation area (1.14±0.09%).

The presence of soil variation from different land cover indicated there was an interaction between vegetation and soil around coal mining concession area. This finding was also confirmed by previous studies that documented the influence of vegetation on soil properties (Silva et al., 2018; Toru and Kibret, 2019; Wei et al., 2019). In this context, there were two processes which accomodated the relationship between vegetation and soil, including nutrients cycle and erosion. For explanation, soil with dense vegetation would have better fertility than soil with low vegetation density since there were higher litterfall accumulation sourced from vegetation above it (Duan et al., 2019; Lei et al., 2019). Several literatures explained that litterfall was classified as natural organic matters from plants that composed of nutrients such as N, P, and K (Castellanos-Barliza et al., 2018; Tongkaemkaew et al., 2018; Wongprom et al., 2022). Other studies also recorded around 50% of litterfall was composed of carbon elements (Park et al., 2020; Sadono et al., 2020;Wirabuana et al., 2021b). When litterfall was decomposed, its nutrients content, especially its carbon, would release into soil (Giweta, 2020). Therefore, it could be understood why the soil organic carbon in natural and plantation forests were considerably higher than shrubs and reclamation area.

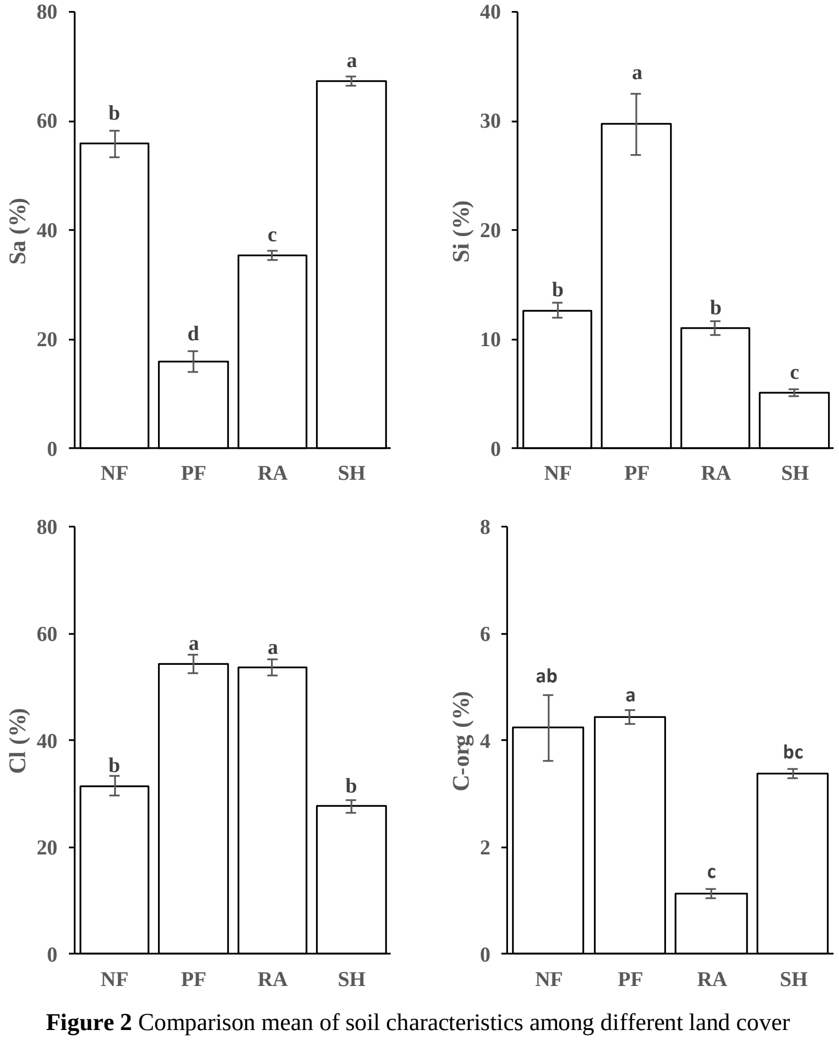

Figure 2 Comparison mean of soil characteristics among different land cover

The vegetation above soil could also minimize erosion because it reduced the direct contact between rainfall and soil through their canopy layer (Moisa et al., 2021). The occurrence of soil erosion could decline soil fertility because it leached top soil layer which contained a lot of nutrients (Novara et al., 2018). This explanation also supported our finding wherein the soil fertility in shrubs and reclamation area was relatively lower than natural and plantation forests. However, the soil erosion was a natural process that contributed to weathering process. Soil having high weathering intensity, generally dominated by clay content and also had low fertility (Alam et al., 2020). Interestingly, this study found the soil fertility in plantation forests was equal statistically with natural forests even though the clay content was substantially higher (Figure 2). This condition could be happened because before converting into mining concession area, this site was managed as a commercial plantation forests wherein there were intensive silvicultural treatments, mainly related to fertilization. The application of fertilization could significantly improves soil fertility even though the nutrient availability was naturally limited (Purwanto and Alam, 2020). This effort was generally conducted in plantation forests, especially that located in mature soil (Amezquita et al., 2018; Halomoan et al., 2015; Wirabuana et al., 2020).

Overall, this study realized the different type of vegetation and its density become the main factor that caused the soil variation around coal mining concession area. Despite this site would be excavated for coal exploration, it would be better for managers to formulate soil conservation strategies to minimize the impact of mining activities on the environmental condition. These efforts would reduce the risk of soil degradation after mine closure and also had a potential to accelerate the reclamation activities for ecosystems restoration.

Conclusion

This study concluded there were high variation of soil characteristics from different land covers around coal mining concession area. Soil texture indicated greater variation than soil organic carbon wherein the composition of sand, silt, and clay was significantly different between land covers. The highest soil organic carbon was recorded in the plantation forests while the lowest was found in reclamation area. It indicated the implementation of soil and water conservation strategies should be determined carefully based on the specific condition in every land cover.

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Pandu Yudha Adi Putra Wirabuana <pandu.yudha.a.p@ugm.ac.id> Fri, Jul 8, 2022 at 3:20 PM
To: Eko Handayanto <editor.jdmlm@ub.ac.id>

Dear Editor of Journal Degraded and Mining Lands Management,

Thank you for giving us an opportunity to revise our article entitled "A comparison of soil characteristics from four land covers around coal mining concession area in South Kalimantan". The suggestions from the Editor and Reviewer are immensely helpful to improve our article.
We have made revision following suggestions and it has been approved by all authors. Enclosed, we send the revised manuscript. We hope the revised version is more suitable to Journal of Degraded and Mining Lands Management. Thank you for your attention.

Sincerely yours,
Pandu
[Quoted text hidden]
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Pandu Yudha Adi Putra Wirabuana, M.Sc.
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Universitas Gadjah Mada
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Research Article

A comparison of soil characteristics from four land covers around coal mining concession area in South Kalimantan

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Coal mining, land covers, reclamation, soil conservation, texture

Abstract

Understanding soil characteristics is importantly required to determine the alternative strategies of land management, particularly related to the scheme of soil and water conservation. This study investigated soil characteristics from four land covers around the coal mining concession area, located in South Kalimantan. Soil survey was conducted using a purposive sampling method with three replicates in each land cover. The soil samples was were taken at depths of 0−10 cm, 11−20 cm, and 21−30 cm. Then, these samples were composited before being brought to the laboratory for quantifying their characteristics, such as texture and organic carbon content. Data analysis was processed using non-parametric test with a significant level of 5%. Comparison average of soil characteristics between land covers was evaluated using Kruskal-Wallis test and followed by Nemenyi-test. Results found that soil characteristics from four land covers were significantly different in texture and organic carbon content. The highest sand fraction was noted in shrubs (67.23±0.86%) while the greatest silt fraction was recorded in plantation forests (29.71±2.84%). Compared to other land covers, the clay content in plantation forests and reclamation area was relatively equal by around 53−54%. On another side, The highest soil organic carbon was found in plantation forests with ranging of (4.44±0.14%) and followed by natural forests (4.24±0.62%), shrubs (3.38±0.09%) and reclamation area (1.14±0.09%). These findings indicated there were high variations of soil characteristics from different land covers around the coal mining concession area. Therefore, we suggest to that the managers to apply adaptive strategies in supporting soil conservation efforts based on the soil characteristics in each site.

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Introduction

Soil is a component of natural resources that plays important roles in maintaining environmental stability. Besides supplying water and nutrients for plants (Sadono et al., 2021), soil also has fundamental contributions to support biogeochemical cycles and energy flow in the ecosystems (Smith et al., 2015). Numerous studies also report that soil characteristics directly correlates to the vulnerability ~~of~~ to natural disaster like flood and landslide (Djukem et al., 2020). Considering to these strategic positions, it is important to apply soil conservation efforts for minimizing the risk of degradation. This challenge has become the most essential issue in many commercial sectors, one of them is the coal mining industry.

During the last periods, the existence of the coal mining business has provided a high contribution to increase gross domestic product. This industry also gives a lot of work opportunities for people who live around its concession. In fact, some literature~~s~~ explain the presence of coal mining ~~industry~~ industries can accelerate the effort of rural development, particularly from corporate social responsibility programs. However, the activity of coal mining exploration also has negative impacts on the environment, mainly related to ~~the~~ soil degradation (Ma et al., 2019). For example, the coal mining industry commonly uses open~~-~~ pit~~-~~ systems wherein it is conducted by removing vegetation cover (Kuzevic et al., 2022). Consequently, the rate of run-off and erosion will occur~~s~~ more rapidly. This circumstance can reduce soil fertility because the ~~amount~~ number of top~~-~~soil layers have been leached (Lulu et al., 2022). Moreover, the use of chemical compounds can also cause soil contamination (Mourinha et al., 2022). Thus, the effort of reclamation will be more difficult to implement because ~~the~~ soil contamination can stimulate plant stress (Li et al., 2018). It will make plants die or demonstrate detrimental growth (Chibuike and Obiora, 2014). Therefore, ~~the~~ integrated soil management is necessary to minimize the impacts of coal mining activity on soil degradation. This scheme ~~is only possible to formulate if there are~~ can only be formulated if there is comprehensive information about soil characteristics around the coal mining concession area.

As one of the mining enterprises, PT Borneo Indobara has received a permit to manage a coal mining concession area located in South Kalimantan. This site ~~consists of~~ comprises various land covers like natural forests, plantations, shrubs, etc. Even though this company has been operating for more than 10 years, ~~but~~ the information about soil characteristics from each land cover is still limited. It is caused by the work priority that ~~focused~~ focuses on coal extraction. Unfortunately, the challenge of soil management is not only in a small scale, but also occurs in the landscape. The connectivity of each land cover becomes important aspects that should be considered to find the optimum solution. Therefore, this study aimed to identify the variation of soil characteristics from different land cover around the coal mining concession area managed by PT Borneo Indobara. The outcome will provide sufficient information for managers to formulate the adaptative strategies ~~of~~ for soil conservation in every land cover.

Materials and Methods

Study Area

This study was conducted in a coal mining concession area managed by PT Borneo Indobara that~~. It~~ is located in Tanah Bumbu District, South Kalimantan Province (Figure 1). The geographical coordinates of this site is E115˚54'38" 115˚39'00" and S3˚35'30" 3˚36'30". Topography is predominantly by hilly areas with ~~the~~ a slope level of 8−26%. Altitude ranges from 20~~–~~ to 52 m ~~dpl~~ above sea level (asl). Annual rainfall reaches 2,291.7 mm year^{-1}~~.~~ with the highest rainfall ~~occurs~~ occurring in January by approximately 352.3 mm months^{-1}. The mean daily temperature is 27.7˚C with a minimum of 22.7 ˚C and a maximum of 35.2 ˚C. Dry periods are relatively longer than 4 months, from ~~Juli~~ July to November.

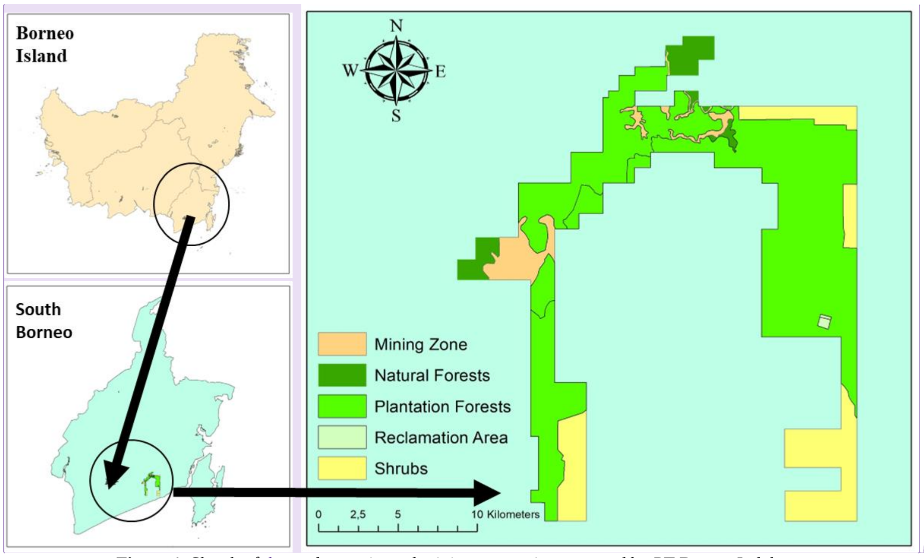

Figure 1. Sketch of the study area in coal mining concession managed by PT Borneo Indobara

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PT Borneo Indobara had a total coal mining concession of around 24,100 ha. This area ~~was~~ is divided into 4 blocks to facilitate ~~the~~ exploration activities, namely Batulaki, Bunati, Kusan, and Girimulya. Before becoming the coal mining area, this area had various land cover, such as oil palm plantations, natural forests, plantation forests, etc. However, several land covers have been removed due to the impact of mining exploration. Among those sites, Girimulya still had land cover variation since it ~~was~~ is the last block to mine the coal deposit based on company planning.

Data Collection

Data were collected around 3 months from August to October 2020. ~~It~~ This study consisted of three important phases, namely site stratification, soil survey, and laboratory analysis. The objective of site stratification was to identify the land cover variation around the coal mining concession area. This step was required to design the location for soil sampling. The spatial approach was applied to facilitate site stratification using the most updating image from Google Earth. There were four land covers ~~that~~ found in the study area, including natural forests, plantation forests, shrubs, and reclamation areas. Then, sampling points ~~was~~ were distributed randomly in every land cover with three replicates. The coordinate of every point was saved to GPS for facilitating the tracking process in the field.

In every sampling location, the soil samples ~~was~~ were taken ~~at~~ the depths of 0−10 cm, 0−20 cm, and 0−30 cm (Wirabuana et al., 2021a). Then, these samples were composited for each sampling position before being brought to the laboratory for quantifying their characteristics. There were two parameters used to identify soil variation among land cover, i.e. texture and organic carbon content. Soil texture was determined using the Pipette method (Alam et al., 2020) ~~method~~ while soil organic carbon was quantified using Walkley and Black ~~Method~~ method (Estefan et al., 2013).

Statistical Analysis

Data analysis was processed using R software version 4.1.2 with a significant level of 5%. The *dplyr* and *agricolae* packages were used to support the data processing (De Mendiburu and Simon, 2015). The first stage ~~was~~ started ~~by~~ with descriptive analysis to identify the range of data distribution, including mean, standard deviation, and standard error (Wirabuana et al., 2021b). This step was also carried out to assess the coefficient of variation and the coefficient of precision (Table 1). Both parameters ~~was~~ were generally used to assess the accuracy and precision ~~from~~ of data obtained by the sampling method (Santos and Dias, 2021).

Then, the second stage was focused on assumption tests. There were two assumption~~s~~ tests that were applied for data evaluation, namely normality tests and homogeneity variance tests (~~Beyene, 2016;~~ Ghasemi and Zahediasl, 2012; Beyene, 2016). These tests ~~was~~ were executed twice, wherein the first round was conducted using actual data, and the second round was undertaken using ~~logarithmic natural~~ natural logarithmic transformation from data.

However, the second round was only processed if the actual data did not follow normal distribution nor ~~has~~ had heterogeneous variance. Based on the preliminary test, it has been confirmed that the data did not fulfi~~l~~l both assumptions. Therefore, this study used non-parametric test to get a conclusion from the data. In this context, the comparison means of soil characteristics among land covers ~~were~~ was examined using Kruskall-Walis test and followed by the Nemenyi test (Alam et al., 2020).

Tabel 1. Summary statistics of soil variation from four land cover types

Land covers	Parameters	Unit	Summary of Statistics			
			Mean	SE	CV (%)	P (%)
NF	Sa	%	55.86	2.40	7.43	4.29
	Si	%	12.65	0.71	9.70	5.60
	Cl	%	31.48	1.78	9.80	5.66
	~~C-org~~ Organic C	%	4.24	0.62	25.21	14.55
PF	Sa	%	15.97	1.95	21.16	12.22
	Si	%	29.71	2.84	16.53	9.54
	Cl	%	54.33	1.75	5.59	3.23
	~~C-org~~ Organic C	%	4.44	0.14	5.30	3.06
RA	Sa	%	35.39	0.93	4.55	2.63
	Si	%	11.00	0.64	10.07	5.81
	Cl	%	53.61	1.56	5.05	2.91
	~~C-org~~ Organic C	%	1.14	0.09	13.27	7.66
SH	Sa	%	67.23	0.86	2.21	1.28
	Si	%	5.11	0.27	14.76	5.25
	Cl	%	27.66	1.21	7.56	4.36
	~~C-org~~Organic C	%	3.38	0.09	4.55	2.63

Note: NF (natural forests), PF (plantation forests), RA (recalamation area), SH (shrubs), Sa (sand), Si (silt), Cl (clay), C-org (soil organic carbon), SE =….?, CV = ….?, P = ….?

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Results and Discussion

Summarized results of the observation demonstrated that soil characteristics among land covers relatively varied (Table 1), wherein there was a significant ~~different~~ difference ~~of~~ in particle-size distribution and soil organic carbon (Figure 2). The highest sand fraction was recorded in shrubs (67.23±0.86%), while the greatest silt fraction was discovered in plantation forests (29.71±2.84%). Compared to others, the clay content was relatively equal in plantation forests and reclamation areas by around 53−54%. These were substantially higher, around 30%, than the proportion of clay fraction in natural forests and shrubs. On another side, this study noted the highest soil organic carbon was found in plantation forests (4.44±0.14%)~~, and~~ followed by natural forests (4.24±0.62%), shrubs (3.38±0.09%), as well as reclamation area (1.14±0.09%).

The presence of soil variation from different land cover indicated there was an interaction between vegetation and soil around the coal mining concession area. This finding was also confirmed by previous studies that documented the influence of vegetation on soil properties (Silva et al., 2018; Toru and Kibret, 2019; Wei et al., 2019). In this context, there were two processes which accommodated the relationship between vegetation and soil, including nutrient~~s~~ cycle and erosion. For explanation, soil with dense vegetation would have better fertility than soil with low vegetation density since there ~~were~~ was higher litterfall accumulation sourced from vegetation above it (Duan et al., 2019; Lei et al., 2019). Several ~~literatures~~ kinds of literature explained that litterfall was classified as natural organic matter~~s~~ from plants that are composed of nutrients such as N, P, and K (Castellanos-Barliza et al., 2018; Tongkaemkaew et al., 2018; Wongprom et al., 2022). Other studies also recorded around 50% of litterfall was composed of carbon elements (Park et al., 2020; Sadono et al., 2020; Wirabuana et al., 2021b). When litterfall was decomposed, its nutrient~~s~~ content, especially its carbon, would release into the soil (Giweta, 2020). Therefore, it could be understood why the soil organic carbon in natural and plantation forests were considerably higher than in shrubs and reclamation area.

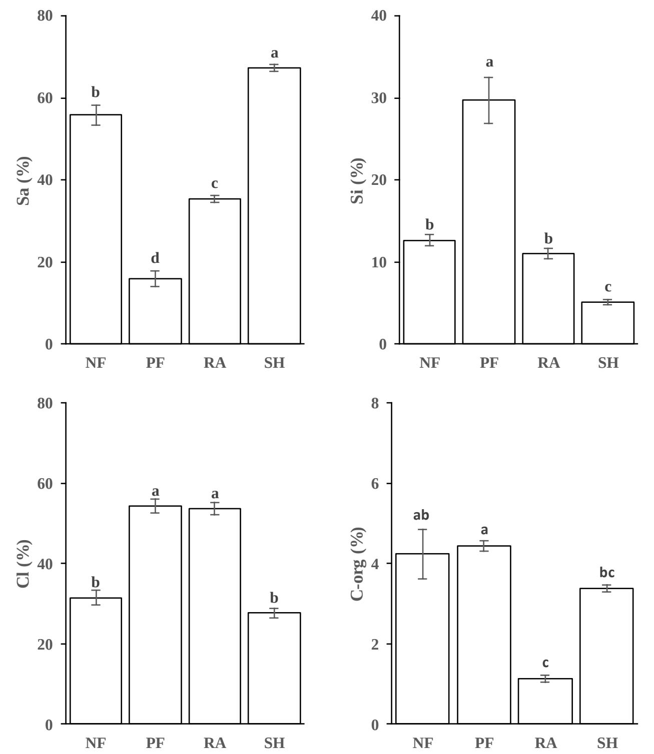

Figure 2 Comparison mean of soil characteristics among different land cover

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The vegetation above the soil ~~could~~ can also minimize erosion because it ~~reduced~~ reduces the direct contact between rainfall and soil through their canopy layer (Moisa et al., 2021). The occurrence of soil erosion ~~could~~ can decline soil fertility because it ~~leached~~ leaches top soil layer, which ~~contained~~ contains ~~a lot of~~ nutrients (Novara et al., 2018). This explanation also ~~supported~~ supports our finding wherein the soil fertility in shrubs and reclamation areas was relatively lower than in natural and plantation forests. However, ~~the~~ soil erosion ~~was~~ is a natural process that ~~contributed~~ contributes to weathering process. Soils that have ~~having~~ high weathering intensity, are generally dominated by clay content and also ~~had~~ have low fertility (Alam et al., 2020). Interestingly, this study found ~~the~~ that soil fertility in plantation forests was equal statistically ~~with~~ to natural forests even though the clay content was substantially higher (Figure 2). This condition could ~~be~~ have happened because before converting into a mining concession area, this site was managed as a commercial plantation forest~~s~~ wherein there were intensive silvicultural treatments, mainly related to fertilization. The application of fertilization ~~could~~ can significantly improve~~s~~ soil fertility even though the nutrient availability ~~was~~ is naturally limited (Purwanto and Alam, 2020). This effort ~~was~~ is generally conducted in plantation forests, especially those that are located in mature soil (Halomoan et al., 2015; Amezquita et al., 2018; ~~Halomoan et al., 2015;~~ Wirabuana et al., 2020).

Overall, this study realized the different types of vegetation and ~~its~~ their density become the main factor that caused the soil variation around coal mining concession areas. Despite the fact that this site would be excavated for coal exploration, it would be better for managers to formulate soil conservation strategies to minimize the impact of mining activities on the environmental condition. These efforts ~~would~~ will reduce the risk of soil degradation after mine closure and also ~~had~~ have ~~a~~ the potential to accelerate the reclamation activities for ecosystems restoration.

Conclusions

This study concluded there were high variations of soil characteristics from different land covers around coal mining concession areas. Soil texture indicated greater variation than soil organic carbon, wherein the composition of sand, silt, and clay was significantly different between land covers. The highest soil organic carbon was recorded in the plantation forests, while the lowest was found in the reclamation area. It indicated the implementation of soil and water conservation strategies should be determined carefully based on the specific condition ~~in~~ of every land cover.

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Introduction

Soil is a component of natural resources that plays important roles in maintaining environmental stability. Besides supplying water and nutrients for plants (Sadono et al., 2021), soil also has fundamental contributions to support biogeochemical cycles and energy flow in the ecosystems (Smith et al., 2015). Numerous studies also report that soil characteristics directly correlates to the vulnerability of to natural disaster like flood and landslide (Djukem et al., 2020). Considering to these strategic positions, it is important to apply soil conservation efforts for minimizing the risk of degradation. This challenge has become the most essential issue in many commercial sectors, one of them is the coal mining industry.

During the last periods, the existence of the coal mining business has provided a high contribution to increase gross domestic product. This industry also gives a lot of work opportunities for people who live around its concession. In fact, some literatures explain the presence of coal mining industry industries can accelerate the effort of rural development, particularly from corporate social responsibility programs. However, the activity of coal mining exploration also has negative impacts on the environment, mainly related to the soil degradation (Ma et al., 2019). For example, the coal mining industry commonly uses open--pit- systems wherein it is conducted by removing vegetation cover (Kuzevic et al., 2022). Consequently, the rate of run-off and erosion will occurs more rapidly. This circumstance can reduce soil fertility because the amount number of top soil layers have been leached (Lulu et al., 2022). Moreover, the use of chemical compounds can also cause soil contamination (Mourinha et al., 2022). Thus, the effort of reclamation will be more difficult to implement because the soil contamination can stimulate plant stress (Li et al., 2018). It will make plants die or demonstrate detrimental growth (Chibuike and Obiora, 2014). Therefore, the integrated soil management is necessary to minimize the impacts of coal mining activity on soil degradation. This scheme is only possible to formulate if there are can only be formulated if there is comprehensive information about soil characteristics around the coal mining concession area.

As one of the mining enterprises, PT Borneo Indobara has received a permit to manage a coal mining concession area located in South Kalimantan. This site consists of comprises various land covers like natural forests, plantations, shrubs, etc. Even though this company has been operating for more than 10 years, but the information about soil characteristics from each land cover is still limited. It is caused by the work priority that focused focuses on coal extraction. Unfortunately, the challenge of soil management is not only in a small scale, but also occurs in the landscape. The connectivity of each land cover becomes important aspects that should be considered to find the optimum solution. Therefore, this study aimed to identify the variation of soil characteristics from different land cover around the coal mining concession area managed by PT Borneo Indobara. The outcome will provide sufficient information for managers to formulate the adaptative strategies of for soil conservation in every land cover.

Materials and Methods

Study Area

This study was conducted in a coal mining concession area managed by PT Borneo Indobara that. It is located in Tanah Bumbu District, South Kalimantan Province (Figure 1). The geographical coordinates of this site is E115˚54'38" 115˚39'00" and S3˚35'30" 3˚36'30". Topography is predominantly by hilly areas with the a slope level of 8−26%. Altitude ranges from 20– to 52 m dpl above sea level (asl). Annual rainfall reaches 2,291.7 mm year^{-1}. with the highest rainfall occurs occurring in January by approximately 352.3 mm months^{-1}. The mean daily temperature is 27.7˚C with a minimum of 22.7 ˚C and a maximum of 35.2 ˚C. Dry periods are relatively longer than 4 months, from Juli July to November.

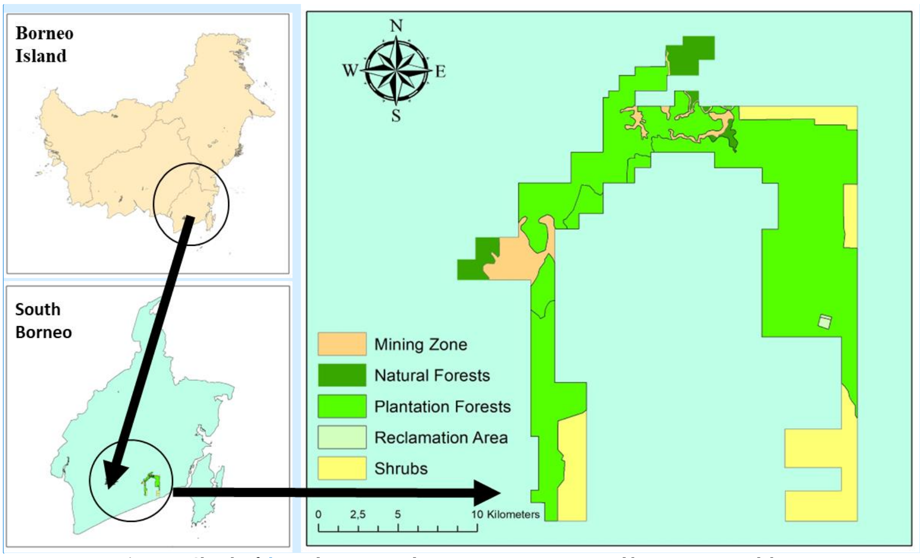

Figure 1. Sketch of the study area in coal mining concession managed by PT Borneo Indobara

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PT Borneo Indobara had a total coal mining concession of around 24,100 ha. This area was is divided into 4 blocks to facilitate the exploration activities, namely Batulaki, Bunati, Kusan, and Girimulya. Before becoming the coal mining area, this area had various land cover, such as oil palm plantations, natural forests, plantation forests, etc. However, several land covers have been removed due to the impact of mining exploration. Among those sites, Girimulya still had land cover variation since it was is the last block to mine the coal deposit based on company planning.

Data Collection

Data were collected around 3 months from August to October 2020. It This study consisted of three important phases, namely site stratification, soil survey, and laboratory analysis. The objective of site stratification was to identify the land cover variation around the coal mining concession area. This step was required to design the location for soil sampling. The spatial approach was applied to facilitate site stratification using the most updating image from Google Earth. There were four land covers that found in the study area, including natural forests, plantation forests, shrubs, and reclamation areas. Then, sampling points was were distributed randomly in every land cover with three replicates. The coordinate of every point was saved to GPS for facilitating the tracking process in the field.

In every sampling location, the soil samples was were taken at the depths of 0−10 cm, 0−20 cm, and 0−30 cm (Wirabuana et al., 2021a). Then, these samples were composited for each sampling position before being brought to the laboratory for quantifying their characteristics. There were two parameters used to identify soil variation among land cover, i.e. texture and organic carbon content. Soil texture was determined using the Pipette method (Alam et al., 2020) method while soil organic carbon was quantified using Walkley and Black Method method (Estefan et al., 2013).

Statistical Analysis

Data analysis was processed using R software version 4.1.2 with a significant level of 5%. The *dplyr* and *agricolae* packages were used to support the data processing (De Mendiburu and Simon, 2015). The first stage was started by with descriptive analysis to identify the range of data distribution, including mean, standard deviation, and standard error (Wirabuana et al., 2021b). This step was also carried out to assess the coefficient of variation and the coefficient of precision (Table 1). Both parameters was were generally used to assess the accuracy and precision from of data obtained by the sampling method (Santos and Dias, 2021).

Then, the second stage was focused on assumption tests. There were two assumptions tests that were applied for data evaluation, namely normality tests and homogeneity variance tests (Beyene, 2016; Ghasemi and Zahediasl, 2012; Beyene, 2016). These tests was were executed twice, wherein the first round was conducted using actual data, and the second round was undertaken using logarithmic natural natural logarithmic transformation from data.

However, the second round was only processed if the actual data did not follow normal distribution nor has had heterogeneous variance. Based on the preliminary test, it has been confirmed that the data did not fulfill both assumptions. Therefore, this study used non-parametric test to get a conclusion from the data. In this context, the comparison means of soil characteristics among land covers were was examined using Kruskall-Walis test and followed by the Nemenyi test (Alam et al., 2020).

Tabel 1. Summary statistics of soil variation from four land cover types

Land covers	Parameters	Unit	Summary of Statistics			
			Mean	SE	CV (%)	P (%)
NF	Sa	%	55.86	2.40	7.43	4.29
	Si	%	12.65	0.71	9.70	5.60
	Cl	%	31.48	1.78	9.80	5.66
	C-org Organic C	%	4.24	0.62	25.21	14.55
PF	Sa	%	15.97	1.95	21.16	12.22
	Si	%	29.71	2.84	16.53	9.54
	Cl	%	54.33	1.75	5.59	3.23
	C-org Organic C	%	4.44	0.14	5.30	3.06
RA	Sa	%	35.39	0.93	4.55	2.63
	Si	%	11.00	0.64	10.07	5.81
	Cl	%	53.61	1.56	5.05	2.91
	C-org Organic C	%	1.14	0.09	13.27	7.66
SH	Sa	%	67.23	0.86	2.21	1.28
	Si	%	5.11	0.27	14.76	5.25
	Cl	%	27.66	1.21	7.56	4.36
	C-orgOrganic C	%	3.38	0.09	4.55	2.63

Note: NF (natural forests), PF (plantation forests), RA (recalamation area), SH (shrubs), Sa (sand), Si (silt), Cl (clay), C-org (soil organic carbon), SE =….?, CV = ….?, P = ….?

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Results and Discussion

Summarized results of the observation demonstrated that soil characteristics among land covers relatively varied (Table 1), wherein there was a significant difference in particle-size distribution and soil organic carbon (Figure 2). The highest sand fraction was recorded in shrubs (67.23±0.86%), while the greatest silt fraction was discovered in plantation forests (29.71±2.84%). Compared to others, the clay content was relatively equal in plantation forests and reclamation areas by around 53−54%. These were substantially higher, around 30%, than the proportion of clay fraction in natural forests and shrubs. On another side, this study noted the highest soil organic carbon was found in plantation forests (4.44±0.14%) followed by natural forests (4.24±0.62%), shrubs (3.38±0.09%), as well as reclamation area (1.14±0.09%).

The presence of soil variation from different land cover indicated there was an interaction between vegetation and soil around the coal mining concession area. This finding was also confirmed by previous studies that documented the influence of vegetation on soil properties (Silva et al., 2018; Toru and Kibret, 2019; Wei et al., 2019). In this context, there were two processes which accommodated the relationship between vegetation and soil, including nutrient cycle and erosion. For explanation, soil with dense vegetation would have better fertility than soil with low vegetation density since there was higher litterfall accumulation sourced from vegetation above it (Duan et al., 2019; Lei et al., 2019). Several kinds of literature explained that litterfall was classified as natural organic matter from plants that are composed of nutrients such as N, P, and K (Castellanos-Barliza et al., 2018; Tongkaemkaew et al., 2018; Wongprom et al., 2022). Other studies also recorded around 50% of litterfall was composed of carbon elements (Park et al., 2020; Sadono et al., 2020; Wirabuana et al., 2021b). When litterfall was decomposed, its nutrient content, especially its carbon, would release into the soil (Giweta, 2020). Therefore, it could be understood why the soil organic carbon in natural and plantation forests were considerably higher than in shrubs and reclamation area.

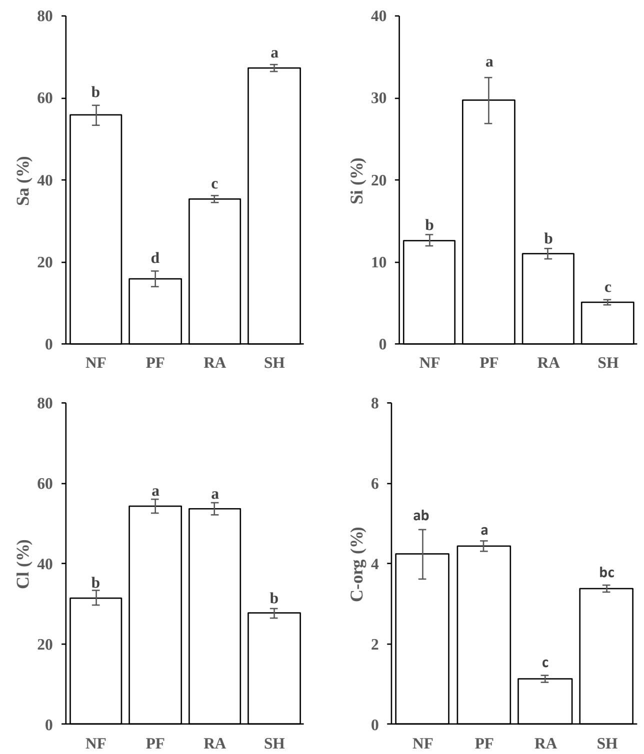

Figure 2 Comparison mean of soil characteristics among different land cover

The vegetation above the soil can also minimize erosion because it reduces the direct contact between rainfall and soil through their canopy layer (Moisa et al., 2021). The occurrence of soil erosion can decline soil fertility because it leaches top soil layer, which contains nutrients (Novara et al., 2018). This explanation also supports our finding wherein the soil fertility in shrubs and reclamation areas was relatively lower than in natural and plantation forests. However, soil erosion is a natural process that contributes to weathering process. Soils that have high weathering intensity, are generally dominated by clay content and also have low fertility (Alam et al., 2020). Interestingly, this study found that soil fertility in plantation forests was equal statistically tonatural forests even though the clay content was substantially higher (Figure 2). This condition could have happened because before converting into a mining concession area, this site was managed as a commercial plantation forest wherein there were intensive silvicultural treatments, mainly related to fertilization. The application of fertilization can significantly improve soil fertility even though the nutrient availability is naturally limited (Purwanto and Alam, 2020). This effort is generally conducted in plantation forests, especially those that are located in mature soil (Halomoan et al., 2015; Amezquita et al., 2018; Wirabuana et al., 2020).

Overall, this study realized the different types of vegetation and their density become the main factor that caused the soil variation around coal mining concession areas. Despite the fact that this site would be excavated for coal exploration, it would be better for managers to formulate soil conservation strategies to minimize the impact of mining activities on the environmental condition. These efforts will reduce the risk of soil degradation after mine closure and also have the potential to accelerate the reclamation activities for ecosystems restoration.

Conclusions

This study concluded there were high variations of soil characteristics from different land covers around coal mining concession areas. Soil texture indicated greater variation than soil organic carbon, wherein the composition of sand, silt, and clay was significantly different between land covers. The highest soil organic carbon was recorded in the plantation forests, while the lowest was found in the reclamation area. It indicated the implementation of soil and water conservation strategies should be determined carefully based on the specific condition of every land cover.

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Research Article

A comparison of soil characteristics from four land covers around coal mining concession area in South Kalimantan

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Abstract

Understanding soil characteristics is importantly required to determine the alternative strategies of land management, particularly related to the scheme of soil and water conservation. This study investigated soil characteristics from four land covers around the coal mining concession area located in South Kalimantan. Soil survey was conducted using a purposive sampling method with three replicates in each land cover. The soil samples were taken at depths of 0−10 cm, 11−20 cm, and 21−30 cm. Then, these samples were composited before being brought to the laboratory for quantifying their characteristics, such as texture and organic carbon content. Data analysis was processed using non-parametric test with a significant level of 5%. Comparison average of soil characteristics between land covers was evaluated using Kruskal-Wallis test and followed by Nemenyi-test. Results found that soil characteristics from four land covers were significantly different in texture and organic carbon content. The highest sand fraction was noted in shrubs (67.23±0.86%) while the greatest silt fraction was recorded in plantation forests (29.71±2.84%). Compared to other land covers, the clay content in plantation forests and reclamation area was relatively equal by around 53−54%. On another side, The highest soil organic carbon was found in plantation forests with ranging of (4.44±0.14%) and followed by natural forests (4.24±0.62%), shrubs (3.38±0.09%) and reclamation area (1.14±0.09%). These findings indicated there were high variations of soil characteristics from different land covers around the coal mining concession area. Therefore, we suggest that the managers to apply adaptive strategies in supporting soil conservation efforts based on the soil characteristics in each site.

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This study was conducted in a coal mining concession area managed by PT Borneo Indobara that is located in Tanah Bumbu District, South Kalimantan Province (Figure 1). The geographical coordinates of this site is E115˚54'38" 115˚39'00" and S3˚35'30" 3˚36'30". Topography is predominantly by hilly areas with a slope level of 8−26%. Altitude ranges from 20 to 52 m above sea level (asl). Annual rainfall reaches 2,291.7 mm year$^{-1,}$ with the highest rainfall occurring in January by approximately 352.3 mm months^{-1}. The mean daily temperature is 27.7˚C with a minimum of 22.7 ˚C and a maximum of 35.2 ˚C. Dry periods are relatively longer than 4 months, from July to November.

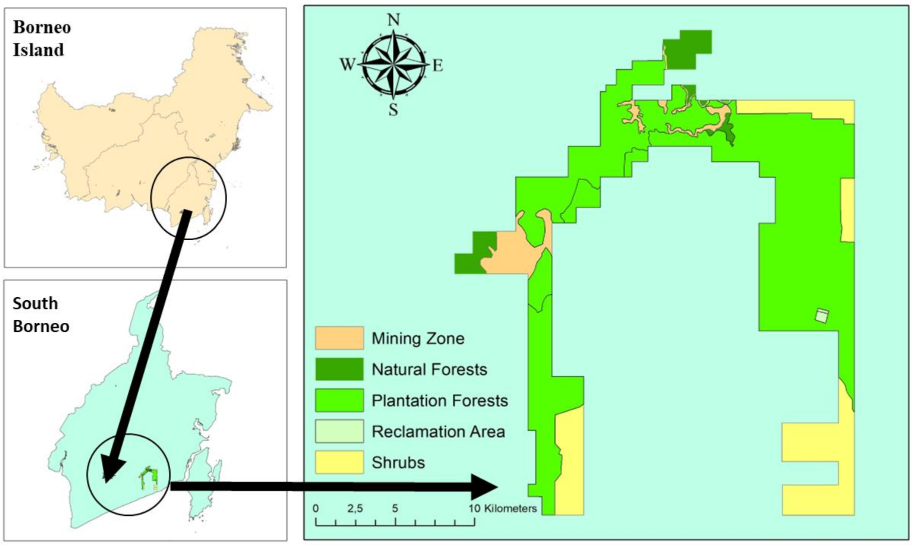

Figure 1. Sketch of the study area in coal mining concession managed by PT Borneo Indobara

PT Borneo Indobara had a total coal mining concession of around 24,100 ha. This area is divided into 4 blocks to facilitate exploration activities, namely Batulaki, Bunati, Kusan, and Girimulya. Before becoming the coal mining area, this area had various land cover, such as oil palm plantations, natural forests, plantation forests, etc. However, several land covers have been removed due to the impact of mining exploration. Among those sites, Girimulya still had land cover variation since it is the last block to mine the coal deposit based on company planning.

Data Collection

Data were collected around 3 months from August to October 2020. This study consisted of three important phases, namely site stratification, soil survey, and laboratory analysis. The objective of site stratification was to identify the land cover variation around the coal mining concession area. This step was required to design the location for soil sampling. The spatial approach was applied to facilitate site stratification using the most updating image from Google Earth. There were four land covers found in the study area, including natural forests, plantation forests, shrubs, and reclamation areas. Then, sampling points were distributed randomly in every land cover with three replicates. The coordinate of every point was saved to GPS for facilitating the tracking process in the field.

In every sampling location, the soil samples were taken the depths of 0−10 cm, 0−20 cm, and 0−30 cm (Wirabuana et al., 2021a). Then, these samples were composited for each sampling position before being brought to the laboratory for quantifying their characteristics. There were two parameters used to identify soil variation among land cover, i.e. texture and organic carbon content. Soil texture was determined using the Pipette method (Alam et al., 2020) while soil organic carbon was quantified using Walkley and Black method (Estefan et al., 2013).

Statistical Analysis

Data analysis was processed using R software version 4.1.2 with a significant level of 5%. The *dplyr* and *agricolae* packages were used to support the data processing (De Mendiburu and Simon, 2015). The first stage started with descriptive analysis to identify the range of data distribution, including mean, standard deviation, and standard error (Wirabuana et al., 2021b). This step was also carried out to assess the coefficient of variation and the coefficient of precision (Table 1). Both parameters were generally used to assess the accuracy and precision of data obtained by the sampling method (Santos and Dias, 2021).

Then, the second stage was focused on assumption tests. There were two assumption tests that were applied for data evaluation, namely normality tests and homogeneity variance tests (Ghasemi and Zahediasl, 2012; Beyene, 2016). These tests were executed twice, wherein the first round was conducted using actual data, and the second round was undertaken using natural logarithmic transformation from data. However, the second round was only processed if the actual data did not follow normal distribution nor had heterogeneous variance. Based on the preliminary test, it has been confirmed that the data did not fulfil both assumptions. Therefore, this study used non-parametric test to get a conclusion from the data. In this context, the comparison means of soil characteristics among land covers was examined using Kruskall-Walis test and followed by the Nemenyi test (Alam et al., 2020).

Tabel 1. Summary statistics of soil variation from four land cover types

Land covers	Parameters	Unit	Summary of Statistics			
			Mean	SE	CV (%)	P (%)
NF	Sa	%	55.86	2.40	7.43	4.29
	Si	%	12.65	0.71	9.70	5.60
	Cl	%	31.48	1.78	9.80	5.66
	Organic C	%	4.24	0.62	25.21	14.55
PF	Sa	%	15.97	1.95	21.16	12.22
	Si	%	29.71	2.84	16.53	9.54
	Cl	%	54.33	1.75	5.59	3.23
	Organic C	%	4.44	0.14	5.30	3.06
RA	Sa	%	35.39	0.93	4.55	2.63
	Si	%	11.00	0.64	10.07	5.81
	Cl	%	53.61	1.56	5.05	2.91
	Organic C	%	1.14	0.09	13.27	7.66
SH	Sa	%	67.23	0.86	2.21	1.28
	Si	%	5.11	0.27	14.76	5.25
	Cl	%	27.66	1.21	7.56	4.36
	Organic C	%	3.38	0.09	4.55	2.63

Note: NF (natural forests), PF (plantation forests), RA (recalamation area), SH (shrubs), Sa (sand), Si (silt), Cl (clay), C-org (soil organic carbon)

Results and Discussion

Summarized results of the observation demonstrated that soil characteristics among land covers relatively varied (Table 1), wherein there was a significant ~~different~~ difference ~~of~~ in particle-size distribution and soil organic carbon (Figure 2). The highest sand fraction was recorded in shrubs (67.23±0.86%), while the greatest silt fraction was discovered in plantation forests (29.71±2.84%). Compared to others, the clay content was relatively equal in plantation forests and reclamation areas by around 53−54%. These were substantially higher, around 30%, than the proportion of clay fraction in natural forests and shrubs. On another side, this study noted the highest soil organic carbon was found in plantation forests (4.44±0.14%)~~, and~~ followed by natural forests (4.24±0.62%), shrubs (3.38±0.09%), as well as reclamation area (1.14±0.09%).

The presence of soil variation from different land cover indicated there was an interaction between vegetation and soil around the coal mining concession area. This finding was also confirmed by previous studies that documented the influence of vegetation on soil properties (Silva et al., 2018; Toru and Kibret, 2019; Wei et al., 2019). In this context, there were two processes which accommodated the relationship between vegetation and soil, including nutrient~~s~~ cycle and erosion. For explanation, soil with dense vegetation would have better fertility than soil with low vegetation density since there ~~were~~ was higher litterfall accumulation sourced from vegetation above it (Duan et al., 2019; Lei et al., 2019). Several ~~literatures~~ kinds of literature explained that litterfall was classified as natural organic matter~~s~~ from plants that are composed of nutrients such as N, P, and K (Castellanos-Barliza et al., 2018; Tongkaemkaew et al., 2018; Wongprom et al., 2022). Other studies also recorded around 50% of litterfall was composed of carbon elements (Park et al., 2020; Sadono et al., 2020; Wirabuana et al., 2021b). When litterfall was decomposed, its nutrient~~s~~ content, especially its carbon, would release into the soil (Giweta, 2020). Therefore, it could be understood why the soil organic carbon in natural and plantation forests were considerably higher than in shrubs and reclamation area.

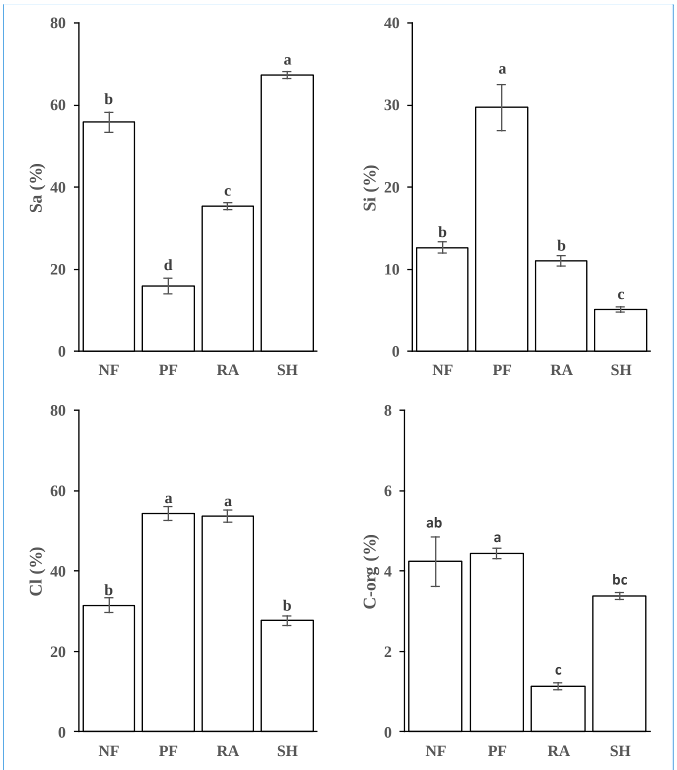

Figure 2 Comparison mean of soil characteristics among different land cover

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The vegetation above the soil ~~could~~ can also minimize erosion because it ~~reduced~~ reduces the direct contact between rainfall and soil through their canopy layer (Moisa et al., 2021). The occurrence of soil erosion ~~could~~ can decline soil fertility because it ~~leached~~ leaches top soil layer, which ~~contained~~ contains ~~a lot of~~ nutrients (Novara et al., 2018). This explanation also ~~supported~~ supports our finding wherein the soil fertility in shrubs and reclamation areas was relatively lower than in natural and plantation forests. However, ~~the~~ soil erosion ~~was~~ is a natural process that ~~contributed~~ contributes to weathering process. Soils that have ~~having~~ high weathering intensity, are generally dominated by clay content and also ~~had~~ have low fertility (Alam et al., 2020). Interestingly, this study found ~~the~~ that soil fertility in plantation forests was equal statistically ~~with~~ to natural forests even though the clay content was substantially higher (Figure 2). This condition could ~~be~~ have happened because before converting into a mining concession area, this site was managed as a commercial plantation forest~~s~~ wherein there were intensive silvicultural treatments, mainly related to fertilization. The application of fertilization ~~could~~ can significantly improve~~s~~ soil fertility even though the nutrient availability ~~was~~ is naturally limited (Purwanto and Alam, 2020). This effort ~~was~~ is generally conducted in plantation forests, especially those that are located in mature soil (Halomoan et al., 2015; Amezquita et al., 2018; ~~Halomoan et al., 2015;~~ Wirabuana et al., 2020).

Overall, this study realized the different types of vegetation and ~~its~~ their density become the main factor that caused the soil variation around coal mining concession areas. Despite the fact that this site would be excavated for coal exploration, it would be better for managers to formulate soil conservation strategies to minimize the impact of mining activities on the environmental condition. These efforts ~~would~~ will reduce the risk of soil degradation after mine closure and also ~~had~~ have ~~a~~ the potential to accelerate the reclamation activities for ecosystems restoration.

Conclusions

This study concluded there were high variations of soil characteristics from different land covers around coal mining concession areas. Soil texture indicated greater variation than soil organic carbon, wherein the composition of sand, silt, and clay was significantly different between land covers. The highest soil organic carbon was recorded in the plantation forests, while the lowest was found in the reclamation area. It indicated the implementation of soil and water conservation strategies should be determined carefully based on the specific condition in of every land cover.

Acknowledgements

The authors deliver our their gratitude to PT Borneo Indobara that which allows and supports this study in their coal mining concession area. The authors We are also grateful to Mr. Kinanto Prabu and Mr. Chairul Anwar, who facilitate the process of data collection. In addition, the authors are also thankful to the reviewers for their suggestions to improve this article.

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Research Article

A comparison of soil characteristics from four land covers around coal mining concession area in South Kalimantan

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Coal mining, land covers, reclamation, soil conservation, texture

Abstract

Understanding soil characteristics is importantly required to determine the alternative strategies of land management, particularly related to the scheme of soil and water conservation. This study investigated soil characteristics from four land covers around the coal mining concession area located in South Kalimantan. Soil survey was conducted using a purposive sampling method with three replicates in each land cover. The soil samples were taken at depths of 0−10 cm, 11−20 cm, and 21−30 cm. Then, these samples were composited before being brought to the laboratory for quantifying their characteristics, such as texture and organic carbon content. Data analysis was processed using non-parametric test with a significant level of 5%. Comparison average of soil characteristics between land covers was evaluated using Kruskal-Wallis test and followed by Nemenyi-test. Results found that soil characteristics from four land covers were significantly different in texture and organic carbon content. The highest sand fraction was noted in shrubs (67.23±0.86%) while the greatest silt fraction was recorded in plantation forests (29.71±2.84%). Compared to other land covers, the clay content in plantation forests and reclamation area was relatively equal by around 53−54%. On another side, The highest soil organic carbon was found in plantation forests with ranging of (4.44±0.14%) and followed by natural forests (4.24±0.62%), shrubs (3.38±0.09%) and reclamation area (1.14±0.09%). These findings indicated there were high variations of soil characteristics from different land covers around the coal mining concession area. Therefore, it is recommended for managers to apply adaptive strategies in supporting soil conservation efforts based on the soil characteristics in each site.

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Introduction

Soil is a component of natural resources that plays important roles in maintaining environmental stability. Besides supplying water and nutrients for plants (Sadono et al., 2021), soil also has fundamental contributions to support biogeochemical cycles and energy flow in the ecosystems (Smith et al., 2015). Numerous studies also report that soil characteristics directly correlates to the vulnerability to natural disaster like flood and landslide (Djukem et al., 2020). Considering to these strategic positions, it is important to apply soil conservation efforts for minimizing the risk of degradation. This challenge has become the most essential issue in many commercial sectors, one of them is the coal mining industry.

During the last periods, the existence of the coal mining business has provided a high contribution to increase gross domestic product. This industry also gives a lot of work opportunities for people who live around its concession. In fact, some literature explain the presence of coal mining industries can accelerate the effort of rural development, particularly from corporate social responsibility programs. However, the activity of coal mining exploration also has negative impacts on the environment, mainly related to soil degradation (Ma et al., 2019). For example, the coal mining industry commonly uses open-pit systems wherein it is conducted by removing vegetation cover (Kuzevic et al., 2022). Consequently, the rate of run-off and erosion will occur more rapidly. This circumstance can reduce soil fertility because the number of topsoil layers have been leached (Lulu et al., 2022). Moreover, the use of chemical compounds can also cause soil contamination (Mourinha et al., 2022). Thus, the effort of reclamation will be more difficult to implement because soil contamination can stimulate plant stress (Li et al., 2018). It will make plants die or demonstrate detrimental growth (Chibuike and Obiora, 2014). Therefore, integrated soil management is necessary to minimize the impacts of coal mining activity on soil degradation. This scheme can only be formulated if there is comprehensive information about soil characteristics around the coal mining concession area.

As one of the mining enterprises, PT Borneo Indobara has received a permit to manage a coal mining concession area located in South Kalimantan. This site comprises various land covers like natural forests, plantations, shrubs, etc. Even though this company has been operating for more than 10 years, the information about soil characteristics from each land cover is still limited. It is caused by the work priority that focuses on coal extraction. Unfortunately, the challenge of soil management is not only in a small scale, but also occurs in the landscape. The connectivity of each land cover becomes important aspects that should be considered to find the optimum solution. Therefore, this study aimed to identify the variation of soil characteristics from different land cover around the coal mining concession area managed by PT Borneo Indobara. The outcome will provide sufficient information for managers to formulate the adaptative strategies for soil conservation in every land cover.

Materials and Methods

Study Area

This study was conducted in a coal mining concession area managed by PT Borneo Indobara that is located in Tanah Bumbu District, South Kalimantan Province (Figure 1). The geographical coordinates of this site is E115˚54'38" 115˚39'00" and S3˚35'30" 3˚36'30". Topography is predominantly by hilly areas with a slope level of 8−26%. Altitude ranges from 20 to 52 m above sea level (asl). Annual rainfall reaches 2,291.7 mm year$^{-1,}$ with the highest rainfall occurring in January by approximately 352.3 mm months^{-1}. The mean daily temperature is 27.7˚C with a minimum of 22.7 ˚C and a maximum of 35.2 ˚C. Dry periods are relatively longer than 4 months, from July to November.

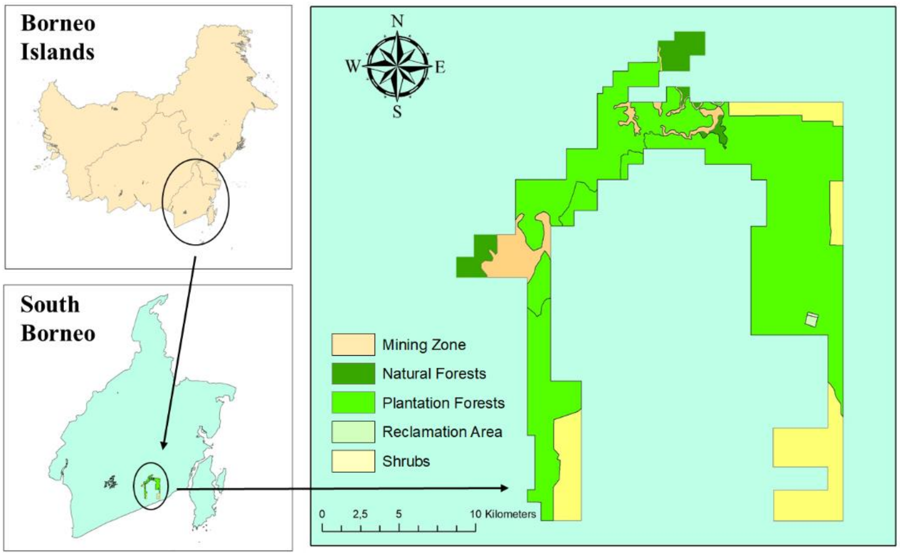

Figure 1. Sketch of the study area in coal mining concession managed by PT Borneo Indobara

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Data Collection

Data were collected around 3 months from August to October 2020. This study consisted of three important phases, namely site stratification, soil survey, and laboratory analysis. The objective of site stratification was to identify the land cover variation around the coal mining concession area. This step was required to design the location for soil sampling. The spatial approach was applied to facilitate site stratification using the most updating image from Google Earth. There were four land covers found in the study area, including natural forests, plantation forests, shrubs, and reclamation areas. Then, sampling points were distributed randomly in every land cover with three replicates. The coordinate of every point was saved to GPS for facilitating the tracking process in the field.

In every sampling location, the soil samples were taken the depths of 0−10 cm, 0−20 cm, and 0−30 cm (Wirabuana et al., 2021a). Then, these samples were composited for each sampling position before being brought to the laboratory for quantifying their characteristics. There were two parameters used to identify soil variation among land cover, i.e. texture and organic carbon content. Soil texture was determined using the Pipette method (Alam et al., 2020) while soil organic carbon was quantified using Walkley and Black method (Estefan et al., 2013).

Statistical Analysis

Data analysis was processed using R software version 4.1.2 with a significant level of 5%. The *dplyr* and *agricolae* packages were used to support the data processing (De Mendiburu and Simon, 2015). The first stage started with descriptive analysis to identify the range of data distribution, including mean, standard deviation, and standard error (Wirabuana et al., 2021b). This step was also carried out to assess the coefficient of variation and the coefficient of precision (Table 1). Both parameters were generally used to assess the accuracy and precision of data obtained by the sampling method (Santos and Dias, 2021).

Then, the second stage was focused on assumption tests. There were two assumption tests that were applied for data evaluation, namely normality tests and homogeneity variance tests (Ghasemi and Zahediasl, 2012; Beyene, 2016). These tests were executed twice, wherein the first round was conducted using actual data, and the second round was undertaken using natural logarithmic transformation from data. However, the second round was only processed if the actual data did not follow normal distribution nor had heterogeneous variance. Based on the preliminary test, it has been confirmed that the data did not fulfil both assumptions. Therefore, this study used non-parametric test to get a conclusion from the data. In this context, the comparison means of soil characteristics among land covers was examined using Kruskall-Walis test and followed by the Nemenyi test (Alam et al., 2020).

Tabel 1. Summary statistics of soil variation from four land cover types

Land covers	Parameters	Unit	Summary of Statistics			
			Mean	SE	CV (%)	P (%)
NF	Sa	%	55.86	2.40	7.43	4.29
	Si	%	12.65	0.71	9.70	5.60
	Cl	%	31.48	1.78	9.80	5.66
	Organic C	%	4.24	0.62	25.21	14.55
PF	Sa	%	15.97	1.95	21.16	12.22
	Si	%	29.71	2.84	16.53	9.54
	Cl	%	54.33	1.75	5.59	3.23
	Organic C	%	4.44	0.14	5.30	3.06
RA	Sa	%	35.39	0.93	4.55	2.63
	Si	%	11.00	0.64	10.07	5.81
	Cl	%	53.61	1.56	5.05	2.91
	Organic C	%	1.14	0.09	13.27	7.66
SH	Sa	%	67.23	0.86	2.21	1.28
	Si	%	5.11	0.27	14.76	5.25
	Cl	%	27.66	1.21	7.56	4.36
	Organic C	%	3.38	0.09	4.55	2.63

Note: NF (natural forests), PF (plantation forests), RA (recalamation area), SH (shrubs), Sa (sand), Si (silt), Cl (clay), Organic C (soil organic carbon), SE (standard error), CV (coefficient of variation), P (coefficient of precision)

Results and Discussion

Summarized results of the observation demonstrated that soil characteristics among land covers relatively varied (Table 1), wherein there was a significant difference in particle-size distribution and soil organic carbon (Figure 2). The highest sand fraction was recorded in shrubs (67.23±0.86%), while the greatest silt fraction was discovered in plantation forests (29.71±2.84%). Compared to others, the clay content was relatively equal in plantation forests and reclamation areas by around 53−54%. These were substantially higher, around 30%, than the proportion of clay fraction in natural forests and shrubs. On another side, this study noted the highest soil organic carbon was found in plantation forests (4.44±0.14%) followed by natural forests (4.24±0.62%), shrubs (3.38±0.09%), as well as reclamation area (1.14±0.09%).

The presence of soil variation from different land cover indicated there was an interaction between vegetation and soil around the coal mining concession area. This finding was also confirmed by previous studies that documented the influence of vegetation on soil properties (Silva et al., 2018; Toru and Kibret, 2019; Wei et al., 2019). In this context, there were two processes which accommodated the relationship between vegetation and soil, including nutrient cycle and erosion. For explanation, soil with dense vegetation would have better fertility than soil with low vegetation density since there was higher litterfall accumulation sourced from vegetation above it (Duan et al., 2019; Lei et al., 2019). Several kinds of literature explained that litterfall was classified as natural organic matter from plants that are composed of nutrients such as N, P, and K (Castellanos-Barliza et al., 2018; Tongkaemkaew et al., 2018; Wongprom et al., 2022). Other studies also recorded around 50% of litterfall was composed of carbon elements (Park et al., 2020; Sadono et al., 2020; Wirabuana et al., 2021b). When litterfall was decomposed, its nutrient content, especially its carbon, would release into the soil (Giweta, 2020). Therefore, it could be understood why the soil organic carbon in natural and plantation forests were considerably higher than in shrubs and reclamation area.

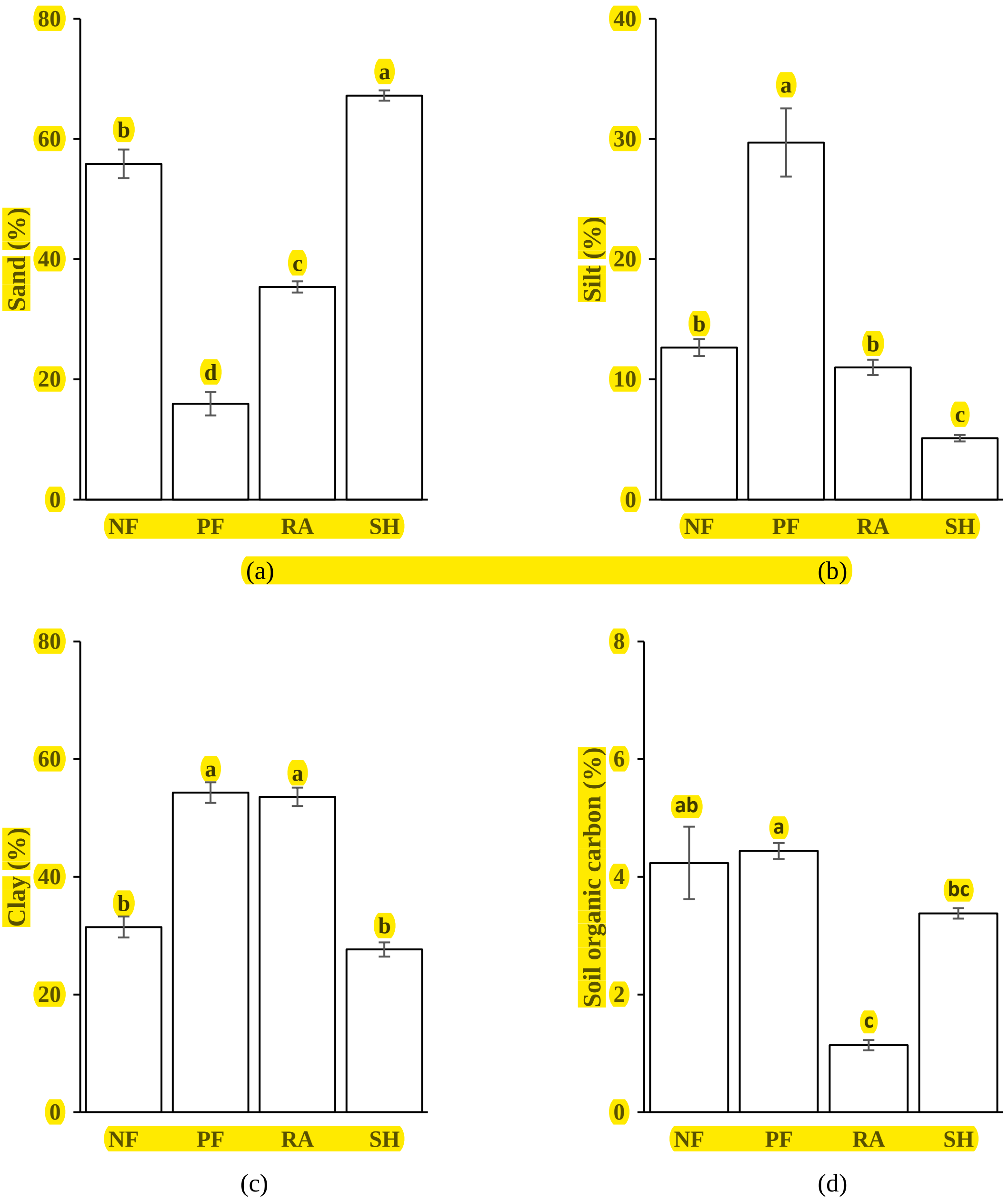

Figure 2 Comparison mean of soil characteristics among NF (natural forests), PF (planted forests), RA (reclamation area), and SH (shrubs). The different letter above graph indicated a significant different based on the results of statistical analysis

The vegetation above the soil can also minimize erosion because it reduces the direct contact between rainfall and soil through their canopy layer (Moisa et al., 2021). The occurrence of soil erosion can decline soil fertility because it leaches top soil layer, which contains nutrients (Novara et al., 2018). This explanation also supports our finding wherein the soil fertility in shrubs and reclamation areas was relatively lower than in natural and plantation forests. However, soil erosion is a natural process that contributes to weathering process. Soils that have high weathering intensity, are generally dominated by clay content and also have low fertility (Alam et al., 2020). Interestingly, this study found that soil fertility in plantation forests was equal statistically to natural forests even though the clay content was substantially higher (Figure 2). This condition could have happened because before converting into a mining concession area, this site was managed as a commercial plantation forest wherein there were intensive silvicultural treatments, mainly related to fertilization. The application of fertilization can significantly improve soil fertility even though the nutrient availability is naturally limited (Purwanto and Alam, 2020). This effort is generally conducted in plantation forests, especially those that are located in mature soil (Halomoan et al., 2015; Amezquita et al., 2018; Wirabuana et al., 2020).

Overall, this study realized the different types of vegetation and their density become the main factor that caused the soil variation around coal mining concession areas. Despite the fact that this site would be excavated for coal exploration, it would be better for managers to formulate soil conservation strategies to minimize the impact of mining activities on the environmental condition. These efforts will reduce the risk of soil degradation after mine closure and also have the potential to accelerate the reclamation activities for ecosystems restoration.

Conclusions

This study concluded there were high variations of soil characteristics from different land covers around coal mining concession areas. Soil texture indicated greater variation than soil organic carbon, wherein the composition of sand, silt, and clay was significantly different between land covers. The highest soil organic carbon was recorded in the plantation forests, while the lowest was found in the reclamation area. It indicated the implementation of soil and water conservation strategies should be determined carefully based on the specific condition of every land cover.

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Research Article

A comparison of soil characteristics from four land covers around a coal mining concession area in South Kalimantan

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Abstract

Understanding soil characteristics is important to determine the alternative strategies of land management, particularly those related to the scheme of soil and water conservation. This study investigated soil characteristics from four land covers around the coal mining concession area located in South Kalimantan. A soil survey was conducted using a purposive sampling method with three replicates in each land cover. Soil samples that were taken at depths of 0-10 cm, 11-20 cm, and 21-30 cm, were composited before being brought to the laboratory to quantify their characteristics, such as texture and organic carbon content. Data analysis was processed using a non-parametric test with a significant level of 5%. Comparison average of soil characteristics between land covers was evaluated using the Kruskal-Wallis test and followed by Nemenyi-test. Results found that soil characteristics from four land covers significantly differed in texture and organic carbon content. The highest sand fraction was noted in shrubs (67.23±0.86%), while the greatest silt fraction was recorded in plantation forests (29.71±2.84%). Compared to other land covers, the clay content in plantation forests and reclamation area was relatively equal by around 53-54%. On another side, The highest soil organic carbon was found in plantation forests with ranging of (4.44±0.14%) followed by natural forests (4.24±0.62%), shrubs (3.38±0.09%), and reclamation area (1.14±0.09%). These findings indicated there were high variations of soil characteristics from different land covers around the coal mining concession area. Therefore, it is recommended for managers to apply adaptive strategies in supporting soil conservation efforts based on the soil characteristics in each site.

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Introduction

Soil is a component of natural resources that plays important roles in maintaining environmental stability. Besides supplying water and nutrients for plants (Sadono et al., 2021), soil also has fundamental contributions to support biogeochemical cycles and energy flow in the ecosystems (Smith et al., 2015). Numerous studies also report that soil characteristics directly correlates to the vulnerability to natural disasters like flood and landslide (Djukem et al., 2020). Considering to these strategic positions, it is important to apply soil conservation efforts to minimize the risk of degradation. This challenge has become the most essential issue in many commercial sectors, one of them is the coal mining industry.

During the last periods, the existence of the coal mining business has provided a high contribution to increase gross domestic product. This industry also gives a lot of work opportunities for people who live around its concession. In fact, some literature explains the presence of coal mining industries can accelerate the effort of rural development, particularly from corporate social responsibility programs. However, the activity of coal mining exploration also has negative impacts on the environment, mainly related to soil degradation (Ma et al., 2019). For example, the coal mining industry commonly uses open-pit systems, wherein it is conducted by removing vegetation cover (Kuzevic et al., 2022). Consequently, the rate of run-off and erosion will occur more rapidly. This circumstance can reduce soil fertility because the number of topsoil layers has been leached (Lulu et al., 2022). Moreover, the use of chemical compounds can also cause soil contamination (Mourinha et al., 2022). Thus, the effort of reclamation will be more difficult to implement because soil contamination can stimulate plant stress (Li et al., 2018). It will make plants die or demonstrate detrimental growth (Chibuike and Obiora, 2014). Therefore, integrated soil management is necessary to minimize the impacts of coal mining activity on soil degradation. This scheme can only be formulated if there is comprehensive information about soil characteristics around the coal mining concession area.

As one of the mining enterprises, PT Borneo Indobara has received a permit to manage a coal mining concession area located in South Kalimantan. This site comprises various land covers like natural forests, plantations, shrubs, etc. Even though this company has been operating for more than 10 years, the information about soil characteristics from each land cover is still limited. It is caused by the work priority that focuses on coal extraction. Unfortunately, the challenge of soil management is not only on a small scale but also occurs in the landscape. The connectivity of each land cover becomes an important aspect that should be considered to find the optimum solution. Therefore, this study aimed to identify the variation of soil characteristics from different land cover around the coal mining concession area managed by PT Borneo Indobara. The outcome will provide sufficient information for managers to formulate adaptative strategies for soil conservation in every land cover.

Materials and Methods

Study area

This study was conducted in a coal mining concession area managed by PT Borneo Indobara which is located in Tanah Bumbu District, South Kalimantan Province (Figure 1). The geographical coordinates of this site are E115˚54'38” 115˚39'00” and S3˚35'30” 3˚36'30”. Topography is predominantly by hilly areas with a slope level of 8−26%. Altitude ranges from 20 to 52 m above sea level (asl). Annual rainfall reaches 2,291.7 mm year$^{-1,}$ with the highest rainfall occurring in January by approximately 352.3 mm months^{-1}. The mean daily temperature is 27.7˚C with a minimum of 22.7 ˚C and a maximum of 35.2 ˚C. Dry periods are relatively longer than 4 months, from July to November. PT Borneo Indobara had a total coal mining concession of around 24,100 ha. This area is divided into 4 blocks to facilitate exploration activities, namely Batulaki, Bunati, Kusan, and Girimulya.

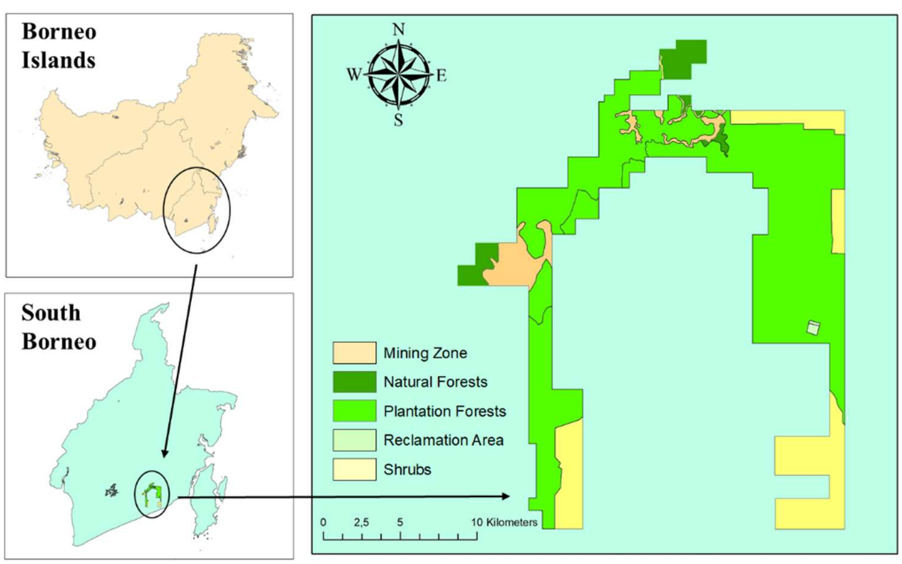

Figure 1. Sketch of the study area in coal mining concession managed by PT Borneo Indobara.

Before becoming the coal mining area, this area had a various land cover, such as oil palm plantations, natural forests, plantation forests, etc. However, several land covers have been removed due to the impact of mining exploration. Among those sites, Girimulya still had land cover variation since it is the last block to mine the coal deposit based on company planning.

Data collection

Data were collected around 3 months from August to October 2020. This study consisted of three important phases, namely site stratification, soil survey, and laboratory analysis. The objective of site stratification was to identify the land cover variation around the coal mining concession area. This step was required to design the location for soil sampling. The spatial approach was applied to facilitate site stratification using the most updating image from Google Earth. There were four land covers found in the study area, including natural forests, plantation forests, shrubs, and reclamation areas. Then, sampling points were distributed randomly in every land cover with three replicates. The coordinate of every point was saved to GPS to facilitate the tracking process in the field.

In every sampling location, the soil samples were taken at depths of 0-10 cm, 0-20 cm, and 0-30 cm (Wirabuana et al., 2021a). Then, these samples were composited for each sampling position before being brought to the laboratory for quantifying their characteristics. There were two parameters used to identify soil variation among land cover, i.e. texture and organic carbon content. Soil texture was determined using the Pipette method (Alam et al., 2020), while soil organic carbon was quantified using Walkley and Black method (Estefan et al., 2013).

Statistical analysis

Data analysis was processed using R software version 4.1.2 with a significant level of 5%. The *dplyr* and *agricolae* packages were used to support the data processing (De Mendiburu and Simon, 2015). The first stage started with descriptive analysis to identify the range of data distribution, including mean, standard deviation, and standard error (Wirabuana et al., 2021b). This step was also carried out to assess the coefficient of variation and the coefficient of precision (Table 1). Both parameters were generally used to assess the accuracy and precision of data obtained by the sampling method (Santos and Dias, 2021). Then, the second stage was focused on assumption tests. There were two assumption tests that were applied for data evaluation, namely normality tests and homogeneity variance tests (Ghasemi and Zahediasl, 2012; Beyene, 2016). These tests were executed twice, wherein the first round was conducted using actual data, and the second round was undertaken using natural logarithmic transformation from data. However, the second round was only processed if the actual data did not follow normal distribution nor had heterogeneous variance. Based on the preliminary test, it has been confirmed that the data did not fulfil both assumptions. Therefore, this study used a non-parametric test to get a conclusion from the data. In this context, the comparison means of soil characteristics among land covers was examined using Kruskall-Walis test and followed by the Nemenyi test (Alam et al., 2020).

Table 1. Summary statistics of soil variation from four land cover types.

Land covers	Parameters	Unit	Summary of Statistics			
			Mean	**SE**	**CV (%)**	**P (%)**
NF	Sa	%	55.86	2.40	7.43	4.29
	Si	%	12.65	0.71	9.70	5.60
	Cl	%	31.48	1.78	9.80	5.66
	Organic C	%	4.24	0.62	25.21	14.55
PF	Sa	%	15.97	1.95	21.16	12.22
	Si	%	29.71	2.84	16.53	9.54
	Cl	%	54.33	1.75	5.59	3.23
	Organic C	%	4.44	0.14	5.30	3.06
RA	Sa	%	35.39	0.93	4.55	2.63
	Si	%	11.00	0.64	10.07	5.81
	Cl	%	53.61	1.56	5.05	2.91
	Organic C	%	1.14	0.09	13.27	7.66
SH	Sa	%	67.23	0.86	2.21	1.28
	Si	%	5.11	0.27	14.76	5.25
	Cl	%	27.66	1.21	7.56	4.36
	Organic C	%	3.38	0.09	4.55	2.63

Note: NF (natural forests), PF (plantation forests), RA (recalamation area), SH (shrubs), Sa (sand), Si (silt), Cl (clay), Organic C (soil organic carbon), SE (standard error), CV (coefficient of variation), P (coefficient of precision).

Results and Discussion

Summarized results of the observation demonstrated that soil characteristics among land covers relatively varied (Table 1), wherein there was a significant difference in particle-size distribution and soil organic carbon (Figure 2). The highest sand fraction was recorded in shrubs (67.23±0.86%), while the greatest silt fraction was discovered in plantation forests (29.71±2.84%). Compared to others, the clay content was relatively equal in plantation forests and reclamation areas by around 53−54%. These were substantially higher, around 30% than the proportion of clay fraction in natural forests and shrubs. On another side, this study noted the highest soil organic carbon was found in plantation forests (4.44±0.14%), followed by natural forests (4.24±0.62%), shrubs (3.38±0.09%), as well as reclamation areas (1.14±0.09%). The presence of soil variation from different land cover indicated there was an interaction between vegetation and soil around the coal mining concession area. This finding was also confirmed by previous studies that documented the influence of vegetation on soil properties (Silva et al., 2018; Toru and Kibret, 2019; Wei et al., 2019).

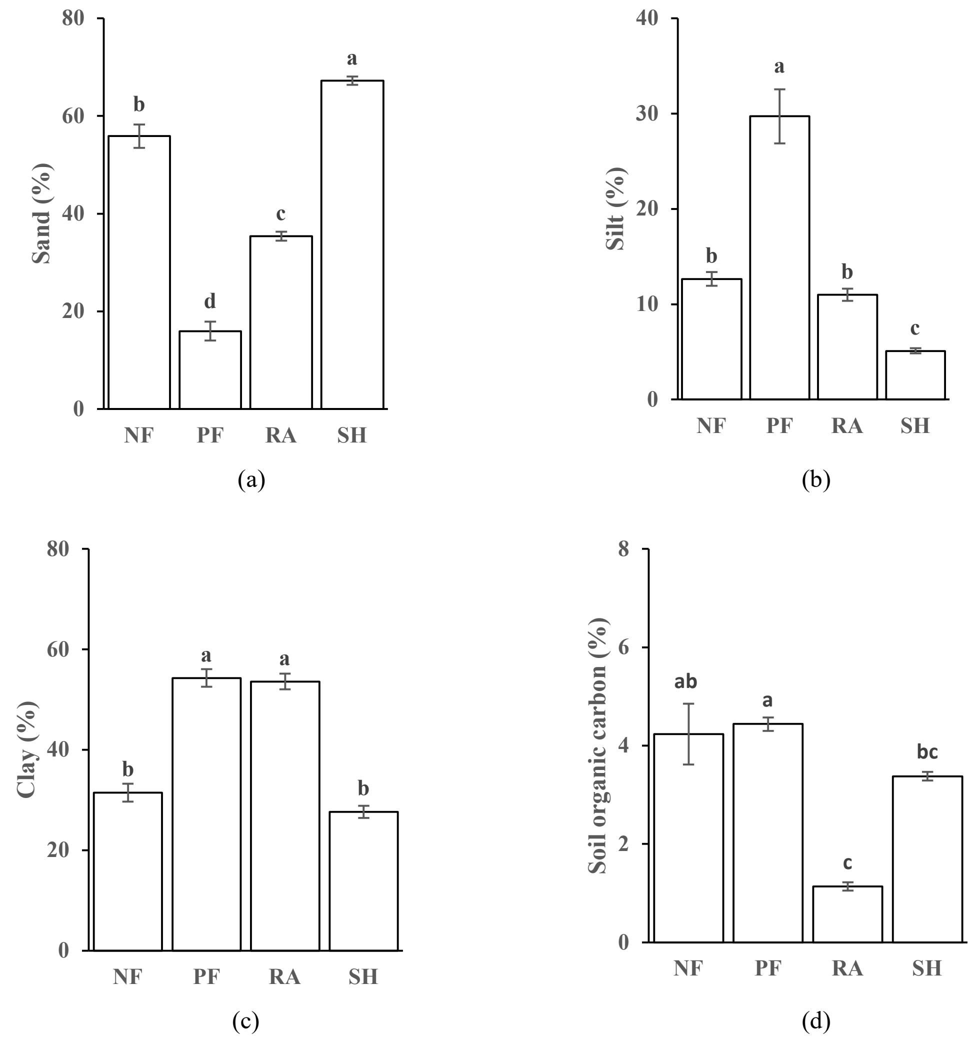

Figure 2 Comparison mean of soil characteristics among NF (natural forests), PF (planted forests), RA (reclamation area), and SH (shrubs). The different letters above the graph indicate a significant difference based on the results of the statistical analysis.

In this context, there were two processes that accommodated the relationship between vegetation and soil, including the nutrient cycle and erosion. For explanation, soil with dense vegetation would have better fertility than soil with low vegetation density since there was higher litterfall accumulation sourced from vegetation above it (Duan et al., 2019; Lei et al., 2019). Several kinds of literature explained that litterfall was classified as natural organic matter from plants that are composed of nutrients such as N, P, and K (Castellanos-Barliza et al., 2018; Tongkaemkaew et al., 2018; Wongprom et al., 2022). Other studies also recorded around 50% of litterfall was composed of carbon elements (Park et al., 2020; Sadono et al., 2020; Wirabuana et al., 2021b). When litterfall was decomposed, its nutrient content, especially its carbon, would release into the soil (Giweta, 2020). Therefore, it could be understood why the soil organic carbon in natural and plantation forests were considerably higher than in shrubs and reclamation area.

The vegetation above the soil can also minimize erosion because it reduces the direct contact between rainfall and soil through their canopy layer (Moisa et al., 2021). The occurrence of soil erosion can decline soil fertility because it leaches the top soil layer, which contains nutrients (Novara et al., 2018). This explanation also supports our finding wherein the soil fertility in shrubs and reclamation areas was relatively lower than in natural and plantation forests. However, soil erosion is a natural process that contributes to weathering process. Soils that have high weathering intensity are generally dominated by clay content and also have low fertility (Alam et al., 2020). Interestingly, this study found that soil fertility in plantation forests was equal statistically to natural forests even though the clay content was substantially higher (Figure 2). This condition could have happened because before converting into a mining concession area, this site was managed as a commercial plantation forest wherein there were intensive silvicultural treatments, mainly related to fertilization. The application of fertilization can significantly improve soil fertility even though nutrient availability is naturally limited (Purwanto and Alam, 2020). This effort is generally conducted in plantation forests, especially those that are located in mature soil (Halomoan et al., 2015; Amezquita et al., 2018; Wirabuana et al., 2020).

Overall, this study realized the different types of vegetation and their density become the main factor that caused the soil variation around coal mining concession areas. Despite the fact that this site would be excavated for coal exploration, it would be better for managers to formulate soil conservation strategies to minimize the impact of mining activities on the environmental condition. These efforts will reduce the risk of soil degradation after mine closure and also have the potential to accelerate the reclamation activities for ecosystem restoration.

Conclusions

This study concluded there were high variations of soil characteristics from different land covers around coal mining concession areas. Soil texture indicated greater variation than soil organic carbon, wherein the composition of sand, silt, and clay was significantly different between land covers. The highest soil organic carbon was recorded in the plantation forests, while the lowest was found in the reclamation area. It indicated the implementation of soil and water conservation strategies should be determined carefully based on the specific condition of every land cover.

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5 messages

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Dear Authors,

We are pleased to inform you that your revised manuscript entitled **"A comparison of soil characteristics from four land covers around a coal mining concession area in South Kalimantan"** has been **accepted** for publication in the Journal of Degraded and Mining Lands Management.

We are sending herewith the Acceptance Letter and the Galley Proof of your article for proofreading. The article is likely to come in Vol. 10. No. 1 (October 2022). Please kindly go through it keenly and point out any mistakes. After this stage, the authors will be responsible for any errors in the final manuscript. Kindly send the corrections (if any) back to us through this email address **before 23 July 2022**.

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Kindest regards

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#8	Sustainability Science	11.0	96th percentile
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#10	International Soil and Water Conservation Research	10.1	95th percentile
#11	Biological Conservation	9.9	94th percentile
#12	Remote Sensing in Ecology and Conservation	9.9	94th percentile
#13	Land Use Policy	9.9	93rd percentile
#14	Geology, Ecology, and Landscapes	8.0	92nd percentile
#15	Metabarcoding and Metagenomics	7.9	92nd percentile

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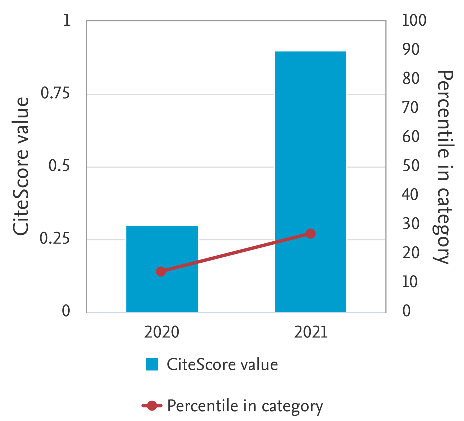

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☆	#16	Journal of the Association of Environmental and Resource Economists	7.8	91st percentile
☆	#17	Ecological Engineering	7.7	91st percentile
☆	#18	Geography and Sustainability	7.4	90th percentile
☆	#19	Perspectives in Ecology and Conservation	7.2	90th percentile
☆	#20	Ecological Engineering: X	7.1	89th percentile
☆	#21	One Ecosystem	7.0	89th percentile
☆	#22	Resources	6.4	88th percentile
☆	#23	Landscape Ecology	6.3	88th percentile
☆	#24	Zoological research	6.2	87th percentile
☆	#25	Wildlife Monographs	6.2	87th percentile
☆	#26	Forest Ecology and Management	6.2	86th percentile
☆	#27	Animal Conservation	5.9	86th percentile
☆	#28	Ecosystems and People	5.8	85th percentile
☆	#29	International Journal of Tourism Research	5.7	85th percentile
☆	#30	Restoration Ecology	5.7	84th percentile
☆	#31	Biodiversity and Conservation	5.7	84th percentile
☆	#32	Forest Ecosystems	5.5	83rd percentile
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☆	#34	Environment and Planning B: Urban Analytics and City Science	5.2	82nd percentile
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☆	#36	Journal of Tourism Futures	5.1	81st percentile
☆	#37	Applied Vegetation Science	5.1	80th percentile
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☆	#39	Oryx	4.6	79th percentile
☆	#40	Nature Conservation	4.5	79th percentile
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☆	#43	Environmental Conservation	4.5	77th percentile
☆	#44	Endangered Species Research	4.4	77th percentile

☆	Rank	Source title	CiteScore 2021	Percentile
☆	#45	Journal of Wildlife Management	4.4	76th percentile
☆	#46	Conservation Physiology	4.4	76th percentile
☆	#47	Ecology and Evolution	4.4	75th percentile
☆	#48	Environmental Geotechnics	4.4	75th percentile
☆	#49	Aquatic Conservation: Marine and Freshwater Ecosystems	4.3	74th percentile
☆	#50	Bird Conservation International	4.3	74th percentile
☆	#51	Journal of Soils and Water Conservation	4.2	73rd percentile
☆	#52	Journal for Nature Conservation	4.2	73rd percentile
☆	#53	Journal of Coastal Conservation	3.9	72nd percentile
☆	#54	Anthropocene Coasts	3.9	72nd percentile
☆	#55	Rangeland Ecology and Management	3.9	71st percentile
☆	#56	Area Development and Policy	3.9	71st percentile
☆	#57	Journal of Insect Conservation	3.9	70th percentile
☆	#58	Landscape Research	3.7	70th percentile
☆	#59	Tropical Conservation Science	3.6	69th percentile
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☆	#61	Human Dimensions of Wildlife	3.6	68th percentile
☆	#62	Journal of Mountain Science	3.5	67th percentile
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☆	#66	International Zoo Yearbook	3.2	65th percentile
☆	#67	IForest	3.2	65th percentile
☆	#68	European Journal of Wildlife Research	3.1	64th percentile
☆	#69	Landscape and Ecological Engineering	3.1	64th percentile
☆	#70	Parks	3.1	63rd percentile
☆	#71	Natural Resource Management and Policy	3.0	63rd percentile
☆	#72	Fisheries	3.0	62nd percentile
☆	#73	Journal of Tourism and Cultural Change	3.0	62nd percentile

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☆	#75	Nature Conservation Research	2.9	61st percentile
☆	#76	Diversity	2.9	60th percentile
☆	#77	Ecological Management and Restoration	2.8	60th percentile
☆	#78	Mires and Peat	2.6	59th percentile
☆	#79	International Journal of Geoheritage and Parks	2.5	59th percentile
☆	#80	European Countryside	2.5	58th percentile
☆	#81	Pacific Conservation Biology	2.5	58th percentile
☆	#82	Aquatic Mammals	2.4	57th percentile
☆	#83	Tuexenia	2.4	57th percentile
☆	#84	Emu	2.3	56th percentile
☆	#85	Journal of Landscape Ecology(Czech Republic)	2.3	55th percentile
☆	#86	Human-Wildlife Interactions	2.3	55th percentile
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☆	#101	Annales Zoologici Fennici	1.8	47th percentile
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☆	#103	Conservation Science and Practice	1.8	46th percentile
☆	#104	Biodiversity Science	1.8	46th percentile
☆	#105	Journal of Design and Built Environment	1.6	45th percentile
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☆	#116	Ursus	1.4	39th percentile
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☆	#118	Journal of Fish and Wildlife Management	1.4	38th percentile
☆	#119	Conservation Evidence	1.4	38th percentile
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☆	#121	Ecological Restoration	1.4	37th percentile
☆	#122	International Journal of Forestry Research	1.3	36th percentile
☆	#123	Eco.mont	1.3	36th percentile
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☆	#128	Agriculture and Forestry	1.1	33rd percentile
☆	#129	Acta Prataculturae Sinica	1.0	33rd percentile
☆	#130	International Journal of Conservation Science	1.0	32nd percentile
☆	#131	Natur und Landschaft	1.0	32nd percentile
☆	#132	Journal of Rangeland Science	1.0	31st percentile

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☆	#133	Journal of Digital Landscape Architecture	1.0	30th percentile
☆	#134	Journal of Environmental Protection and Ecology	1.0	30th percentile
☆	#135	Journal of New Zealand Grasslands	0.9	29th percentile
☆	#136	e-Review of Tourism Research	0.9	29th percentile
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☆	#138	Journal of the Bombay Natural History Society	0.9	28th percentile
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☆	#149	Revista de Urbanismo	0.7	22nd percentile
☆	#151	Zpravy Lesnickeho Vyzkumu	0.7	21st percentile
☆	#152	Journal of Marine and Island Cultures	0.7	21st percentile
☆	#153	Landscape Journal	0.6	20th percentile
☆	#154	Malayan Nature Journal	0.6	20th percentile
☆	#155	Biota Colombiana	0.6	19th percentile
☆	#156	Asian Journal of Conservation Biology	0.6	19th percentile
☆	#157	Alam Cipta	0.6	18th percentile
☆	#158	Forestry Ideas	0.6	17th percentile
☆	#158	Sylvia	0.6	17th percentile
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☆	#164	Sociologia Urbana e Rurale	0.4	14th percentile
☆	#165	Springer Geography	0.4	14th percentile
☆	#166	Asia-Pacific Journal of Innovation in Hospitality and Tourism	0.4	13th percentile
☆	#167	Acta Scientiarum Polonorum, Administratio Locorum	0.4	13th percentile
☆	#168	Journal of People, Plants, and Environment	0.4	12th percentile
☆	#169	ArchiDOCT	0.4	12th percentile
☆	#170	Journal of Landscape Ecology	0.4	11th percentile
☆	#171	Silva Gabreta	0.4	11th percentile
☆	#172	Ecologia Balkanica	0.4	10th percentile
☆	#172	Neilreichia	0.4	10th percentile
☆	#174	Changjiang Liuyu Ziyuan Yu Huanjing/Resources and Environment in the Yangtze Valley	0.3	9th percentile
☆	#175	Advances in Asian Human-Environmental Research	0.3	9th percentile
☆	#176	Landschap	0.3	8th percentile
☆	#177	Landscapes	0.3	8th percentile
☆	#178	Ri-Vista	0.3	7th percentile
☆	#179	Nakhara: Journal of Environmental Design and Planning	0.3	7th percentile
☆	#180	British Wildlife	0.2	6th percentile
☆	#181	Studies in the History of Gardens and Designed Landscapes	0.2	5th percentile
☆	#182	Acta Geographica Universitatis Comenianae	0.1	5th percentile
☆	#183	Atelie Geografico	0.1	4th percentile
☆	#184	Banko Janakari	0.1	4th percentile
☆	#185	Sustainable Mediterranean Construction	0.1	3rd percentile
☆	#186	Architecture and Urban Planning	0.1	3rd percentile
☆	#187	Journal of Nanjing Forestry University (Natural Sciences Edition)	0.1	2nd percentile
☆	#188	Ecology, Economy and Society	0.1	2nd percentile

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☆	#189	Revista Mexicana de Ciencias Forestales	0.1	1st percentile
☆	#190	Folia Malacologica	0.0	0th percentile
☆	#190	Ochrona Zabytkow	0.0	0th percentile
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Papers dealing with results of original research, and critical reviews on aspects directed to the management of degraded and mining lands covering topography of a landscape, soil and water quality, biogeochemistry, ecosystem structure and function, and environmental, economic, social and health impacts are welcome. Journal of Degraded and Mining Lands Management is published in a single volume every year. Each volume consists of four issues, normally published in October, January, April and July.

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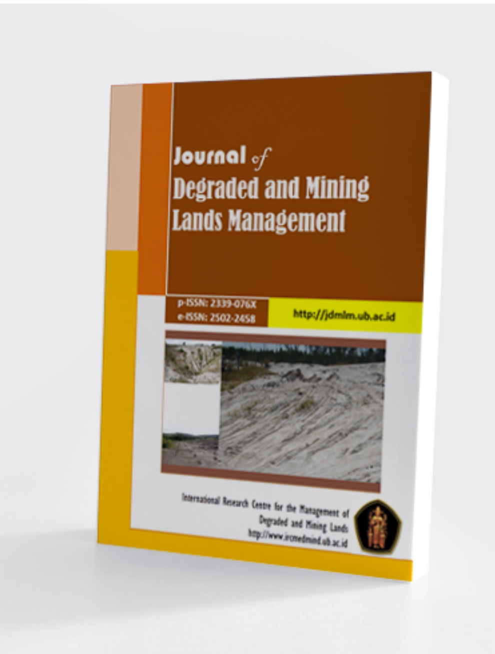

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