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Soil and vegetation structure in reclamation area of Post-Mining Coal, Banjar Regency, South Kalimantan

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Abstract

This research was aimed to assess the soil and vegetation structure in reclamation post-mining coal area of Banjar Regency, South Kalimantan, Indonesia. This study was conducted in ex-mining coal site of Regional Government Company Baramarta, Banjar Regency, South Kalimantan. Data was collected by field observation, lab analysis and documentation. Plot areas for the vegetation data were used transect method with size 40 × 25 m. Plot 20 × 20 m for trees, 5 × 5 m for stake and 2 × 2 m for seedling. Important value index was used for vegetation analysis which encompasses relative density, relative frequency, and relative dominance. Soil sampling was taken compositely for 50 g to be analyzed further in the laboratory to assess its physical and chemical characteristic. Total of 10 sites was sampled i.e. 4 natural soil sites, 3 reclaimed soil sites, and 3 sites of unreclaimed soil. Standard criteria to determine the soil damage was referred to the Government Regulation No. 150 of 2000 and the Ministry of Environment Regulation No. 7 of 2006. The highest Important Value Index (IVI) for trees and poles was Mahang (*Macaranga gigantea)*, bamboo (*Bamboosa* sp) for stakes and ferns (*Cyclosorus* sp dan *Geichenia* sp) for ground surface plants. The results showed different physical and chemical characteristic between natural area, reclaimed and unreclaimed area, which implied that the reclamation activities improved chemical characteristic of the soil. The status of soil damage in Baramarta ex-mining site is categorized as damaged, due to its degree of water released that exceeds critical threshold. Different physical and chemical characteristic between natural area, reclaimed and unreclaimed area implied that the reclamation activities improved the chemical characteristic of the soil.

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Introduction

Mining sector is one of the beneficial revenue for national income. It was recorded in 2007 that the national income from public tax from mining sector reached 24,000 billion rupiah (ESDM, 2007). However, besides national income, mining industry (especially, open-pit mining method) has side effects of severe environmental damage, primarily to the forest and shrubs vegetation as dominant plants for soil surface cover on the mined land area. Mining activities also affect the underground water quality due to the pollution of heavy metals from the waste of mining process. Mining activities leave open-pit to be a huge hole due to excavation, which also decreased the soil quality.

The degraded soil quality directly affects the biomass production formed by the vegetation, e.g. trees, shrubs, soil microbes. Therefore, local agency is responsible regarding this matter and they conduct assessment on the reclamation area, post-mining activities. The assessment was purposed to evaluate the level of soil damage for biomass production by identify and characterize the soil quality. The evaluation for ex-mining area was regulated in the Government Regulation No. 150 of 2000. This regulation contained the controlling threshold that should be obeyed by actors in the mining sectors. The evaluation results were expected to be the considerations towards the local government program to improve the soil quality on the reclaimed ex-mining land area. The status determination of soil damage for biomass production was needed as an effort in controlling the soil damage.

South Kalimantan Government, especially Banjar Regency has been set a Regency Regulation about the management of mineral and coal mining in Banjar Regency as stated in Regional Regulation of Banjar Regency, No. 9 of 2011. This regulation act as reference for the actors in mining sectors to plan a thorough reclamation or rehabilitation program for the land area after the mining activities completed. However, the process of reclamation or rehabilitation takes times and still giving effect of damage towards the physical and chemical properties of the soil in the area, thus affecting the life continuity of living things in the reclamation area and pollution to the surrounding waters and agriculture field.

Therefore, it is important to know the existing condition of the ex-mining area which in the process of reclamation for further policy making regarding this matter. This study was aimed to assess the soil characteristic and vegetation structure in the reclamation of ex-mining coal area, Banjar Regency, South Kalimantan. The outcome of this study was expected to be beneficial input for optimization of the management on ex-mining coal land area and minimize the degraded environment quality within the area.

Materials and methods

Study Area

Research site is the area of coal mining owned by Regional Government Company Baramarta, 75 km from Banjarmasin City and 65 km from Martapura City with total area 2,634.55 ha. Geographically located in 115^o 11' 40.5" – 115^o 17' 23" East and 3^o 8' 23" – 3^o 13' 8.0" South. The area of coal mining including the villages of Rantau Bakula; Rantau Nangka and Belimbing, District of Sungai Pinang, Banjar Regency, South Kalimantan Province (Fig. 1). Besides coal mining, the area was also being developed in the forestry sector. The area of Baramarta is included in the area of permanent production forest and partially in protected forest area. The map of land use published by the Banjar Regency mentioned that Baramarta mining area categorized as area for rubber plantation, mix plantation, green field, meadow, and bushes.

Most of the soil (77.62%) in the area of Banjar Regency is finely textured, consisted of clay, sand, and dust, while 14.39% medium textured, including clay, sandy clay, and dust. The rest 5.39% are coarse, including clay and sand dust (National Land Office of Banjar Regency, 2013). According to Research

Institute of Bogor (1983), in Banjar Regency we can found the soil type of organosol, humus glei with main compound of alluvial and plains physiographic. The soil is also including the complex soil of red yellow podsolic and Laterite, Latosol soil with main compound of frozen rocks, and Latosol soil with the main rock sediment and metamorphic subtance. Total of 95% area of mining site dominated by Latosol or equal to Oxisol soil, while in the west side mostly consist of Cambisol.

These types of soil have low soil nutrient and susceptible to erosion. Top soil of this type of soil is less beneficial for plants growth with fertility level of low to very low. Dominant climate in Banjar Regency is climate type B, a wet climate with relative humidity 63%-100%. Annual rainfall about 2000-2500 mm, daily rainfall 9.5-18.6 mm and rainy day per month is 12.3-15.6 days per month. Average temperature range about 20.0°C – 36.20°C.

Data collection

Data collection was conducted by field observation, analysis in laboratory and literature study on existing documents from local government of Banjar Regency and Regional Government Company Baramarta. Primary data were consisted of plants/ vegetation structure, soil type and morphology; either at the reclaimed or has not been reclaimed site Otherwise, secondary data were included Landsat Imagery map and documents such as map of land area, topography, watershed, and baseline. Data of soil type and percentage of plants growth also taken from secondary data which archived by the company.

Plot area

Plot area for the vegetation analysis was made refer to the Ministry Regulation of Forestry No. P.60/Menhut-II/2009, with scale size 1:10.000. Plots were cited from perpendicular point of vertical and horizontal transect intersection, sized 40 × 25 m as following scheme (Fig. 2). Total 10 location of observation site for soil sampling, consisted of four sites of natural soil, three sites of reclaimed soil, and three sites of unreclaimed soil.

Vegetation Structure

The identification of trees species was conducted in the forest area surround the coal mining site by vegetation analysis. Plot determination was focused on the area surround mining site which has been reclaimed. Transects were made in length of 380m and width of 20m. Track for the observation was determined purposively around the reclamation area. Observation plots were consisted of 20m x 20m plots for tress observation. Within the trees plot, we also made 5m x 5m plots and 2m x 2m, for stake and seedling respectively. Classification for the growth level of vegetation was modified from Arief (2001):

1. Seedling: plant height < 1.5m
2. Stake: plant height >1.5m and plants with diameter <10cm,
3. Trees: poles, main trees, big trees, with diameter >10cm.

Collected data of trees included the trees species, number of trees in each plot for the level of stake and trees.

Soil Sampling

Sites of soil sampling were determined purposively, based on the land unit to represent each land feature. On the research site, we also observed other parameters such as gradient, visual appearance of erosion risk, land use, management level, and the depth of soil solum. Sample of soil was taken compositely until 20 cm in depth, at the plot area for vegetation analysis, 5 point in each plot. One point at the center of the plot, and 4 other points symmetrically. The composite of the 5 points were taken 50 g to be analyzed in the laboratory. Soil sample was also taken from the disturbed soil due to the previous mining activities to assess its physical and chemical characteristic. The sampling of soil and its surround area was referred to the Guideline for Soil Description (FAO, 2006). Soil sample for assessing soil bulk density or the physical sample of soil was taken by using ring sampler in the depth of 0–20 cm. It was taken every 5 years by the company, or when the biomass production was decreased drastically.

Data analysis

Vegetation Analysis: Vegetation data were analyzed by calculated the Important Value Index (IVI) for every species of trees. Otherwise, for the inventory of local trees species and the arrangement on the utilization of local trees was analyzed qualitatively. Components of seedling's data that used to determine IVI for seedlings are relative density and relative frequency, while stake and trees' IVI composed of relative density, relative frequency and relative dominance (Kusmana, 1997).

$$\text{Density} = \frac{\text{number of Individu}}{\text{plot area } (\text{m}^2)}$$

$$\text{Relative Density} = \frac{\text{species density}}{\text{total density of all species}} \times 100\%$$

$$\text{Frequency} = \frac{\Sigma \text{ sub plot of species found}}{\Sigma \text{ all sub plot}}$$

$$\text{Relative Frequency} = \frac{\text{species frequency}}{\text{total frequency of all species}} \times 100\%$$

$$\text{Dominance} = \frac{\text{basal area of species}}{\text{plot area } (\text{m}^2)}$$

$$\text{Relative Dominance} = \frac{\text{species dominance}}{\text{total dominance of all species}} \times 100\%$$

$$\text{Important Value Index} = \text{relative density} + \text{relative frequency} + \text{relative dominance}$$

The high value of IVI was not the only criteria in species selection, because high IVI does not guarantee the ecological superiority of a tree species. Criteria of IVI determined based on the Ministry of Forestry Decision No. 200/Kept-IV/1994 (Table 1).

Analysis of soil damage for biomass production: The evaluation of soil damage was determined with following mechanism:

1. Determined the *threshold value* of soil characteristic and potential soil erosion based on the standard criteria for soil damage for biomass production. Based on the Government Regulation No. 150 of 2000, soil is considered as damaged soil if one of parameters for standard criteria of soil damage was exceeded.
2. Determine the key characteristic factor of soil parameter which indicates the soil damage.

Based on the Ministry of Environment Regulation No. 7 of 2006, the standard criteria to determine the status of soil damage for biomass production were consisted of physical, chemical and biological characteristics of the soil. These basic soil characteristics determine the soil ability in providing sufficient water and nutrient for living things, especially for plants. Phases in assessing the standard criteria for soil damage are:

1. Identification of initial soil condition; by secondary data exploration including climate, topography, land cover, potential cause of soil damage (natural or anthropogenic). Identification was conducted to know the potential damaged area.
2. Analysis of basic soil characteristics; observed parameters were surface rocks, fraction composition, soil bulk density, porosity, permeability, soil pH, , DHL, redox, and microbes number.
3. Comparison of observation data with the standards criteria which regulated in the Government Regulation No. 150 of 2000 and Ministry of Environment Regulation No. 7 of 2006. If any of the parameter thresholds was exceeded, then the soil was considered as damaged soil.

Results and discussion

Vegetation analysis

Natural vegetation surround the mining site area were mostly consisted of old shrubs mixed with remaining trees along the riverside and hills area. Extensive coal mining in Meghalaya, India also created unfavourable habitat for plants. Herbaceous species was found in much higher number in the mined area than in the unmined area (Sarma, 2005). Small scale agriculture was not intensively cultivate, thus allowed the young trees to grow. The young grew trees is similar to the preceding plants or it could be the new pioneer trees which more tolerant to the changes of environmental condition, where the existence of these plants indicate the succession. Open forest condition and the abundance of growing young trees formed the type of bushes plants growth. Similarly in the reclaimed mined area in Virginia, USA that showed the early succession site dominated by thick herbaceous plants and small patches of young trees (Carozzino *et al.*, 2011).

Based on the structure of the tree stands, natural vegetation that identified at the study site for category of tree with diameter > 20 cm was relatively small in number and no dominant species. Visually, the canopy coverage for various natural vegetations considered in medium level (40-60%), dominated by shrubs as ground surface plants of grass and litter.

Table 1. Criteria of important value index (IVI).

IVI of Trees (%)	Criteria
> 240	Very Good
180 – 239	Good
120 – 179	Medium
60 – 119	Bad
< 60	Very Bad

Important value index (IVI)

Observed vegetation in Baramarta mining site area consisted of several growth level, i.e. seedlings, stake, poles and trees. We found seven species of trees (Table 5), 15 species of poles (Table 6), 13 species of stakes (Table 7), and 11 species of seedlings and ground surface plants (Table 8). The highest importance value index (IVI) for the level of trees and poles was Mahang (*Macaranga gigantea)*, whereas for the level growth of stakes was bamboo (*Bamboosa* sp) and for seedling and ground surface plants was ferns (*Cyclosorus* sp dan *Geichenia* sp).

Table 2. Soil texture of PD Baramarta.

No	Soil Area	Texture (%)				
		sand	dust	clay	fine sand	Class of tecture
1.	Natural Soil 1	38.09	27.16	20.12	12.63	Sandy clay loam
2.	Natural Soil 2	39.86	11.99	39.88	8.27	Sandy clay
3.	Natural Soil 3	39.73	22.79	24.49	12.99	Sandy clay loam
4.	Natural Soil 4	24.57	28.20	32.08	15.15	Clay loam
5.	Reclaimed Soil 1	34.63	22.11	30.36	12.90	Sandy clay loam
6.	Reclaimed Soil 2	58.70	13.16	22.93	5.21	Sandy clay loam
7.	Reclaimed Soil 3	10.54	28.68	39.83	20.90	Clay loam
8.	Unreclaimed Soil 1	41.79	20.34	32.36	5.51	Sandy clay loam
9.	Unreclaimed Soil 2	27.64	16.05	49.99	6.32	Clay
10.	Unreclaimed Soil 3	37.78	19.76	28.41	14.05	Sandy clay loam

Source: Laboratory Analysis of Lambung Mangkurat University, 2014.

The high value of IVI on the vegetation of Mahang, bamboo, and ferns implied that these vegetations also have high value of relative density, frequency, and dominance. This condition indicates that these species was encountered evenly along the transect line and has evenly frequency and density. High IVI for these three species also suggest their ability to grow in the degraded environment (Sarma, 2005). Criteria of IVI for each species of vegetations included in the least important, because all the IVI < 60%. It means that the species found has less important role in the ecosystem or in each location plot. Thus if the ecosystem get disturbance on one of the species of vegetation, then there would be less effect to the other species in the same category of growth level.

Physical characteristic of soil

The result of soil physical characteristic was expected to describe the real soil physical condition in the 10 observation sites. The real condition of the area was consisted of open area which has been and has not been reclaimed, and natural closed land area with its vegetation cover. The land use change into open area changed several physical conditions, e.g. change in porosity lead to the permeability of soil towards water and air, thus affect the soil ability to store ground water. Comparison of reclaimed sites and unreclaimed sites besides the number of vegetation, that the reclaimed site has higher ability to store water (Cejpek *et al.*, 2013).

Table 3. Soil type characteristic of Baramarta mining site.

Characteristic	Plinth podzolic	Haplic podzolic	Gley alluvial
Solum	Deep (< 150 cm)	Deep	Deep (>90 cm)
Upper layer texture	Dusty loam	Dusty clay loam	Clay
Lower layer texture	Clay loam	Loam	Clay
Upper layer structure	Crumb, lump, medium and weak	Granular to cubic	Thin organic layer
Layer structure	Angular lump, medium	Lump, to angular lump	sediment
Consistency	Friable to firm	Friable to firm	Limy, plastically
Hue of Upper layer	yellowish brown (10YR 5/4)	Dark brown (10YR 3/2)	Reddish brown (5YR 3/2)
Hue of Lower layer	yellowish red (10/YR 4/3 – 5YR 5/8)	Reddish brown	Brown (7,5 YR 5/2) and yellowish brown (10 YR 4/6)
Other	Plinth and rust > 10%	More micro pores, high iron oxide	Blocked drainage
Potential development	Agriculture, with specific maintenance on its iron oxide and low humus	Grassland, cropland, and shrubs; specific maintenance for agriculture by liming and fertilizing	-

Table 4. Chemical characteristic of soil in the Baramarta mining site.

Soil Area	C	N	P_2O_5	K_2O	Fe-dd	P_2O_5 tsd	pH	Ca-dd	Mg-dd	Na-dd	K-dd	Al-dd	H-dd	CEC	Base saturation
	(%)		Mg.100gr^{-1}		ppm		H_2O	Me.100g^{-1}							(%)
Natural Soil 1	1.61	0.18	24.28	29.23	1.43	8.64	5.16	8.31	8.45	0.79	0.60	0.00	2.49	94.10	19.30
Natural Soil 2	1.19	0.12	6.0	10.95	1.50	1.79	5.27	2.58	0.62	0.04	0.27	0.00	1.82	53.16	6.59
Natural Soil 3	1.48	0.11	5.96	0.41	1.04	1.78	5.92	1.54	0.51	0.04	0.10	0.00	2.42	30.00	7.28
Natural Soil 4	1.33	0.16	7.93	5.69	1.20	3.30	5.18	1.14	0.62	0.04	0.19	0.00	1.80	46.74	4.25
Reclaimed Soil 1	1.53	0.15	4.22	11.25	0.93	0.31	5.34	2.76	0.42	0.04	0.33	0.00	1.25	26.64	13.34
Reclaimed Soil 2	2.08	0.14	4.08	5.64	1.19	4.76	5.17	3.38	0.61	0.04	0.19	0.00	1.79	65.42	6.45
Reclaimed Soil 3	1,06	0.16	2.32	11.35	1.09	2.56	5.09	5.35	0.64	0.23	0.22	0.00	1.25	79.11	8.14
Unreclaimed Soil 1	2.29	0.20	2.46	17.82	1.15	1.80	4.91	4.07	0.91	0.11	5.05	0.00	1.98	74.00	13.70
Unreclaimed Soil 2	1.75	0.20	0.45	6.66	1.06	1.05	4.26	5.44	1.09	0.26	0.23	0.00	2.84	59.77	11.74
Unreclaimed Soil 3	1.64	0.21	7.95	5.70	1.05	0.15	4.84	2.69	0.83	0.10	0.19	0.00	1.81	55.66	6.85

Source: Laboratory Analysis of Lambung Mangkurat University, 2014.

Soil texture

Soil texture is one of soil physical characteristic which is relatively stable, determined by the fraction percentage of sand, dust, and clay. Fraction of sand was varied between 10.54%– 58.70%, dust ranged 11.99%-28.68%, clay 20.12%-49.99%, and fine sand 5.21%-5.51% (Table 2). Soil texture affect the growth of tree growth in mined area. It related to its hydrology properties that affected by the soil composition. Oak trees in mined area in Rapoca reclamation, Virginia prefer sandier soil to grow (Showalter *et al.*, 2005).

Soil type

Soil type in Baramarta mining site area consisted of three types of soil, namely plinth podzolic, haplic podzolic, and gley alluvial.

These three types of soil were characterized by several following feature (Table 3). Plinth podzolic and haplic podzolic were still has potential development onto agriculture. However, it needs the pre-treatment to the soil due to its high iron oxide content.

Table 5. Vegetation structure of trees in Baramarta mining site.

No	Local Name	Taxonomy	Relative Density	Relative Dominance	Relative Frequency	IVI
1	Ara	*Ficus dependen*	16.66	13.83	16.66	47.15
2	Kwini	*Mangifera* sp	8.33	7.22	8.33	23.88
3	Lomu	*Canarium decumanum*	8.33	8.43	8.33	25.09
4	Mahang	*Macaranga gigantean*	16.66	20.27	16.66	53.59
5	Medang	*Alseodaphne penuicularis*	16.66	13.66	16.66	46.98
6	Rengas	*Gluta renghas*	16.66	16.64	16.66	49.96
7	Tarap	*Arthocarpus* sp	16.66	19.92	16.66	53.24
TOTAL			99.96	99.97	99.96	299.89

Table 6. Vegetation structure of poles in Baramarta mining site.

No	Local Name	Taxonomy	Relative Density	Relative Dominance	Relative Frequency	IVI
1	Ara	*Ficus dependen*	6.66	3.79	4.35	14.80
2	Keruing	*Dipetercarpus* sp	3.33	3.22	4.35	10.90
3	Resak	*Vatica* sp	10	6.14	8.69	24.83
4	Kempas	*Koomppasia*	6.67	5.41	8.69	20.77
5	Kwini	*Mangifera* sp	3.33	3.53	4.35	11.21
6	Lomu	*Canarium decumanum*	3.33	5.06	4.35	12.76
7	Langsat	*Aglaia dooko*	3.33	6.27	4.35	13.95
8	Mahang	*Macaranga gigantean*	23.34	19.22	17.39	59.95
9	Metangur	*Callophylum* sp	3.33	3.71	4.34	11.38
10	Meranti	*Shorea* sp	3.33	2.37	4.34	10.04
11	Mersawa	*Anisoptera*	6.66	5.01	4.35	16.02
12	Nyatoh	*Palaquium* sp	3.33	4.77	4.35	12.45
13	Salam	*Scygium polyantum*	3.33	3.93	4.34	11.60
14	Tarap	*Arthocarpus* sp	13.34	19.42	13.04	45.80
15	Talok	*Grewiera exelsa*	6.66	8.12	8.69	23.47
TOTAL			99.97	99.99	99.97	299.90

Bulk density, porosity, and permeability

The result for bulk density in the mining site showed the bulk density was ranged 1.22-1.33 gr.cm^{-3}. Thus, it implied that porosity and density of the soil in the mining site has not been relatively condensed. Bulk density in ex-mined area under succession is decreased gradually along with the years (Cejpek *et al.*, 2013). Otherwise, higher bulk density indicates that the soil will inhibit the root growth because the soil was condensed and lack of oxygen due to lack of soil pores (Landon, 1984).

Table 7. Vegetation structure of stakes in Baramarta mining site.

No	Local Name	Taxonomy	Relative Density	Relative Dominance	Relative Frequency	IVI
1	Bamboo	*Bamboosa* sp	15.38	20.2	15	50.58
2	Banggris	*Shorea* sp	7.69	10.69	10	28.28
3	Dadap	*Erytrina lithosphherma*	5.13	3.70	5	13.38
4	Resak	*Vatica* sp	15.38	4.89	5	25.27
5	Keruing	*Dipetercarpus* sp	5.13	7.97	10	23.10
6	Langsat	*Aglaia dooko*	2.56	3.75	5	11.31
7	Mahang	*Macaranga gigantean*	10.25	12.18	10	32.43
8	Mangosteen	*Garcinia* sp	2.56	3.14	5	10.70
9	Medang	*Alseodaphne penuicularis*	5.13	6.72	5	16.85
10	Meranti	*Shorea* sp	2.56	3.14	5	10.70
11	Mersawa	*Anisoptera*	10.25	6.37	5	21.62
12	Forest banana	*Musa* sp	7.69	8.3	10	25.99
13	Rengas	*Gluta renghas*	10.25	10.01	10	30.26
TOTAL			99.96	99.98	100	299.90

Total pores space is the difference of comparison between bulk density and particle density which ranged 41.67% - 43.52%. Permeability is related to the class of soil texture because the rate of water movement. The finer texture the soil, the slower water movement becomes. Soil texture of Baramarta mining site formed from different soil parent material, i.e. sand and clay. Permeability in the sand textured soil is faster because the soil porosity consisted of macro pores, whereas clay textured soil is slower due to its micro pores.

Table 8. Vegetation structure of seedlings in Baramarta mining site.

No	Local Name	Taxonomy	Relative Density	Relative Dominance	IVI
1	Bamboo	*Bamboosa* sp	3.12	10	13.12
2	Ilalang	*Imperata cylindrica*	18.72	12.5	31.22
3	Resak	*Vatica* sp	1.56	5	6.56
4	Krinyuh	*Eupatorium odorata*	12.48	12.5	24.98
5	Mahang	*Macaranga gigantean*	1.56	2.5	4.06
6	Ferns	*Cyclosorus* sp and *Geichenia* sp	28.08	15	43.08
7	Pandan	*Pandanus* sp	1.56	2.5	4.06
8	Forest banana	*Musa sp*	6.25	10	16.86
9	Rattan	*Dendrocamalus*	7.79	10	17.18
10	Tarap	*Arthocarpus* sp	3.12	5	8.12
11	Other grass	-	18.21	12.5	30.71
TOTAL			99.87	100	199.95

Table 9. Laboratorium analysis on the parameters for soil damage.

No.	Parameter	Unit	mixed dry land agriculture - shrubs				Critical Threshold	Exceed/Not
1.	Solum thickness	cm	110	110	110	110	<20	Not
2.	Surface rocks	%	0	0	0	0	>40	Not
3.	Composition of rough fraction	% colloid	42.42	39.42	73.60	52.17	<18	Not
		% quartz sand	30.18	20.59	1.61	9.38	>80	Not
4.	Bulk density	$g.cm^{-3}$	1.34	1.21	1.18	1.38	>1.4	Not
5.	Total porosity	%	44.33	51.25	49.11	39.95	<30;>70	Not
6.	Degree of water release	$cm.hour^{-1}$	0.47	0.45	0.43	0.42	<0.7;>8.0	Exceed
7.	pH H_2O (1:2.5)	-	5.32	5.42	5.41	4.51	<4.5;>8.5	Not
8.	DHL	$mS.cm^{-1}$	0.251	0.326	0.336	0.032	>4	Not
9.	Redox	mV	361	331	305	358	<200	Not
10.	Microbes	$Cfu.g^{-1}$ soil	>100	>100	>100	>100	<100	Not

Chemical characteristic of soil

Several components of soil chemical characteristic are strongly related to the soil fertility, such as pH, organic compound, nutrients, cation exchange capacity, and other compound (Table 4). Almost all the chemical characteristics in ten observation site, even some were varied, but generally in the lack condition, which is unfavorable for plants to grow. Besides, the favorable condition of soil for plant growth is the sustainability of organic compound within the soil. The lab analysis found that pH range in the observation site was 4.2 to 5.92, which were tending to acidic. Otherwise, favorable pH for plants growth is 6.0 - 6.5 (McCall, 1980). The pH condition in natural soil area was tended to a bit acidic, 5.92 - 5.18. It was getting more acidic for the unreclaimed soil area with 4.26 – 4.91. pH was less acidic in the reclaimed soil area with pH 5.09 - 5.34. The acidic condition has significant effect on the number of vegetation that lives in the area (Tamás and Kovács, 2005). Thus we assumed the cause that reclaimed area has more species to be found than unreclaimed area. Acidity modeled as positive relations to the productivity; higher pH means a better soil quality (Showalter *et al.*, 2005).

C-organic in the observed area was ranged from medium to low level, as well as Nitrogen content. However, the N content in unreclaimed areas was higher than reclaimed and natural area. Phosphor content in the observation sites was mostly in the low classification level, about <15 $mg.100gr^{-1}$, except for natural soil 1 with medium phosphor content for 24.28 $mg.100gr^{-1}$. Thus most of the area is needed to be fertilized if the area would be developed into agriculture area. However, the phosphor content was tend to be lower in the unreclaimed area than reclaimed and natural area. Phosphor is needed by plants due to its functions as defense towards pest and diseases trigger the root growth and activate the growth of the plant tissue. Kalium content in the observation sites were varied from low to high. However, Kalium content tend to high in natural soil, but only slightly different in the soil area which has been reclaimed or has not been, in the low level.

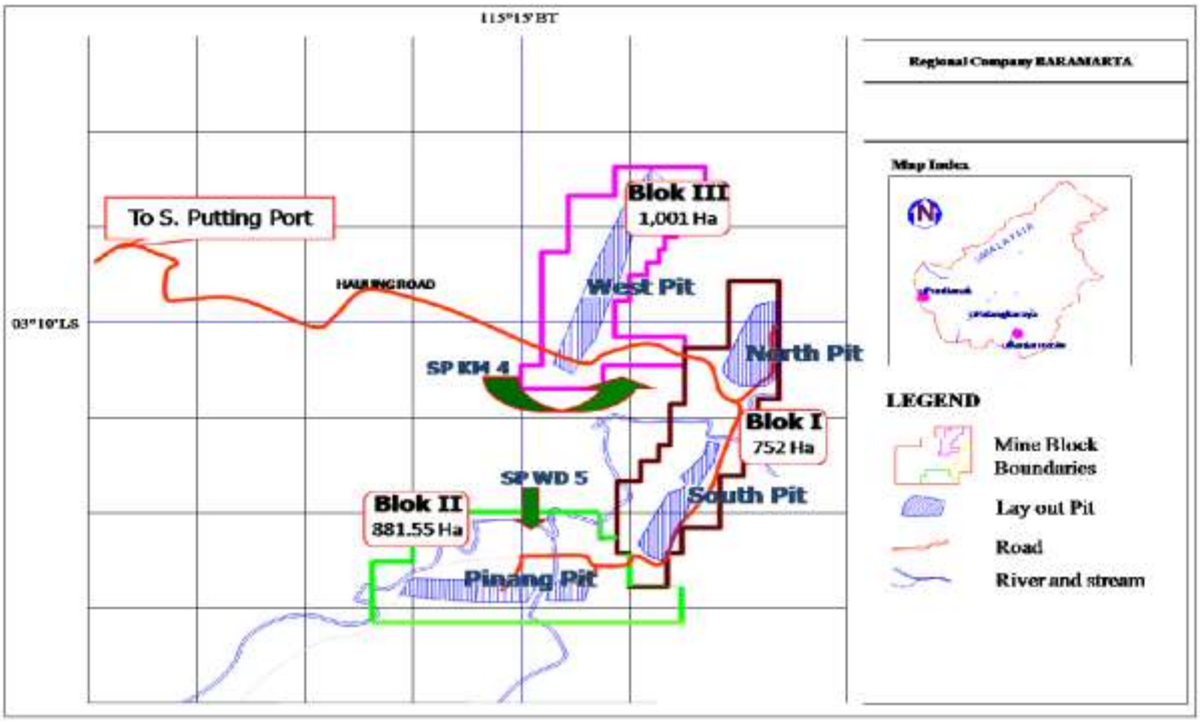

Fig. 1. Research Site of Coal Mining Baramarta.

The nutrients nitrogen (N), phosphorous (P), and potassium (K) were found to be significant components for the vegetation growth. Although these nutrients are not intrinsic properties for the mine spoils, their abundance variation is an indicator the progress of reclaimed area. The higher levels of these nutrients in some sites would have positive effect on the vegetation growth (Showalter *et al.*, 2005).

Cation Exchange Capacity (CEC) in the study area was categorized in the high to very high level, although it tended to be higher than reclaimed and natural area. Base saturation of the soil was ranged 6.45 – 19.30% which was categorized in the very low level. The base saturation indicates the need of cations for plant and implied the number of cations in the exchange complex of soil. Thus, we assumed that the negative capacity of this exchange complex originates from permanent capacity, which means that CEC changes were caused by the pH changes (Ketterings *et al.*, 2007).

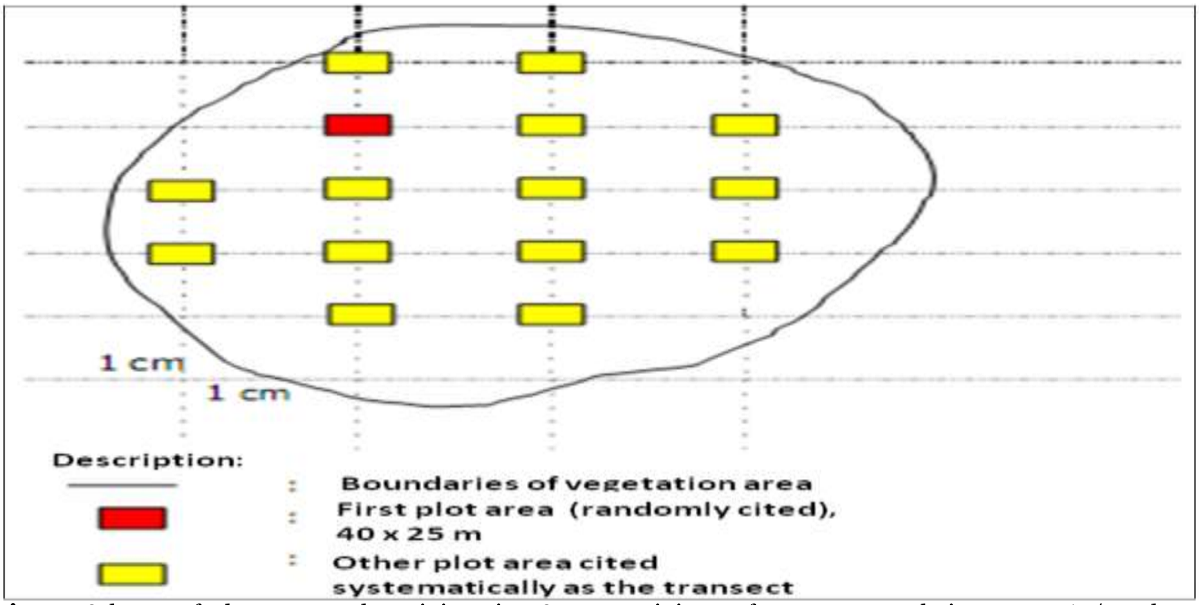

Fig. 2. Scheme of plot area at the mining site. Source: Ministry of Forestry Regulation No. P.60/Menhut-II/2009.

Status of soil damage for biomass production

Government Regulation of Republic of Indonesia No. 150 of 2000 stated that soil damage for biomass production was caused by the changes of soil characteristics beyond the standard criteria for the soil damage. Lab analysis on the soil samples described in Table 9. From the lab test we found that one of the parameter on the soil damage criteria, i.e. the degree of water release in over the critical threshold. Thus, the status of soil damage in the Baramarta ex-mining site is categorized as damaged.

Biomass production, such as microorganism biomass is correlated to the vegetation growth, thus it is one of good indicator for the soil health (Showalter *et al.*, 2005). Thus, if the soil condition is damaged, then the soil is not health enough for the vegetation growth. Therefore, it is important to reclaim the ex-mining area by re-vegetation and soil amendment.

Conclusion

The vegetation on each growth level is less importance to its ecosystem, thus need to be improved. The difference of physical and chemical characteristic between natural area, reclaimed and unreclaimed area implied that the reclamation activities improved the chemical characteristic of the soil. The degree of water release as one of soil damage criteria is over the critical threshold. Thus, the status of soil damage in the Baramarta Ex-mining Site reclamation area is categorized as damaged.

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