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Assessment on the Land Health of Ex-Coal Mining Reclamation Area, Banjar Regency, South Kalimantan

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ABSTRACT

Background: Coal mining activities has negative impact to the environment, especially on the land use in the area surround the coal mining site. An area of PD Baramarta in Banjar Regency, South Kalimantan has been mined and they conducted reclamation to the post-mining site. **Objective:** This study aimed to assess the land use management of reclamation area after the coal mining in Regional Government Company Baramarta, Banjar Regency. **Methods:** Primary data were collected by observation and laboratory analysis while the secondary data obtained by documentation and literature study. Soil sampling was conducted compositely for 0-20 cm in depth and solum soil was identified until the depth of 120 cm. Sample of soil were taken for the analysis on: surface rocks, fractions composition, soil bulk density, porosity, permeability, pH, DHL, redox, and microbes numbers. We used land health evaluation to assess the land use management of reclamation area of Baramarta. The land health analysis were encompasses four components of analysis, i.e. land fertility, index of erosion risk, soil damage for biomass product and soil ability to absorb water (availability of ground water). **Results:** The results showed that the land health of PD Baramarta categorized as unhealthy land**.** The area has the erosion risk in very low to medium level. **Conclusion:** The reclamation and re-vegetation efforts for PD Baramarta ex-coal mining site area has not been success to improve the land quality, thus the goals of the reclamation program has not taken better effects**.**

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INTRODUCTION

Development of regional area commonly lead to the environment degradation, thus decrease the quality of environment services for surrounding areas and communities (Rahmawaty, 2002). The decrease of environment service was caused by the ecosystem damage that threatened the life of living things in the ecosystem, and human being surround the area. The damage also followed by the pollution of hazardous chemical compound and heavy metal from the mined land, e.g. coal, which mostly found in Kalimantan.

Specifically in this study, Banjar Regency in South Kalimantan has high potential resources of coal, thus many investors allocates their fund in the expectation for financial return in the future. Socio-economically, the presence of coal mining increases the local revenues and the life degree of local communities and new comers. However, the coal mining gave negative impacts to the environment land use, especially agriculture, thus the area is flood-risk and has the symptoms of degraded ecosystems, e.g. the extreme temperature changing, degradation of soil quality, and decreased population of soil microbes.

The Government Regulation No. 150 of 2000, Law No. 32 of 2009, and Ministry of Environment Regulation No. 7 of 2006 regulate the efforts of controlling and recovering the environment damage due to the mining activities. These regulations also showed the procedure to evaluate or assess the environment damage due to the coal mining activities. The Government Regency of Banjar obliges the owner of mining license to submit the reclamation and post-mining planning to obtain the license of production (Regional Regulation of Banjar Regency, No. 9 of 2011).

With the complex regulation on coal mining activities in the area, it was presumed that the management of coal mining has been planned the long term purpose of rehabilitation or reclamation after the coal mining stop being operated. The rehabilitation/reclamation plan should be progressive, correspond to the post-mining of land

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use spatial plan. However, practically the effort of rehabilitation or reclamation for the ex-mining area has not been optimum and emerge complex problems for the South Kalimantan Province. Thus, this study was aimed to assess the land use management on the reclamation area of ex-coal mining in Banjar Regency, South Kalimantan.

MATERIALS AND METHODS

Study Area:

This research was conducted in the site of coal mining owned by Regional Government Company Baramarta with total area 2,634.55 ha. The mining site is 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 three villages, i.e. Rantau Bakula; Rantau Nangka and Belimbing, Sungai Pinang District, Banjar Regency, South Kalimantan Province (Fig. 1). This area was being developed in the sectors of coal mining and forestry, due to its potential resources. The area of Baramarta is included in the area of permanent production forest and partially in protected forest area. The land use map from Banjar Regency mentioned Baramarta mining area as area of rubber plantations, mix plantations, green field, meadow, and bushes.

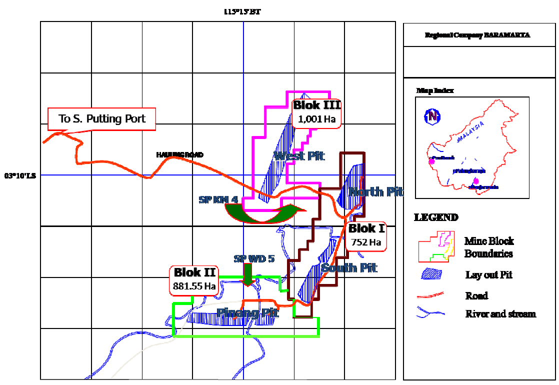

Fig. 1: Research Site of Coal Mining Baramarta.

Data Collection:

Data were collected by direct observation, laboratory analysis and literacy study on existing documents. Primary data were consisted of erosion rate at the mining site (either reclaimed or has not been reclaimed), while secondary data came from Landsat Imagery map and archives of Regional Government Company Baramarta such as map of land area, topography, watershed, and baseline.

Soil Sampling:

Soil sampling for the assessment on the erosion level was conducted refers to the Ministry of Environment Regulation No. 7 of 2006. Soil was sampled compositely by using soil auger for 0–20 cm in depth. The depth levels of soil solum were identified, thus the drilling continued until the depth of 120 cm. In every layer of the soil, the sample of soil were taken for the analysis on: (1) surface rocks, (2) fractions composition, (3) soil bulk density, (4) porosity, (5) permeability, (6) pH, (7) DHL, (8) redox, and (9) microbes numbers. The sampling for soil was conducted in zig zag crossed the contour line in minimum of 5 points which then composited (Fig. 2).

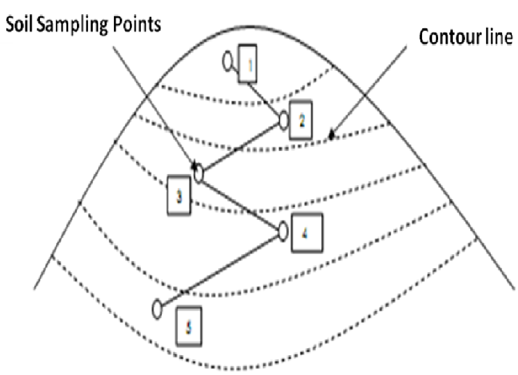

Fig. 2: Scheme of Soil Sampling in Zig Zag Source: Ministry of Environment Regulation No. 7 of 2006.

Data Analysis:

Land Health Assessment:

Criteria for land health were constructed from four components of analysis, i.e. land fertility, index of erosion risk, soil damage for biomass product and soil ability to absorb water (Table 1). The relation of the four components of analysis was described in Table 2.

Table 1: Criteria of parameter level for Land Health.

No.	Parameter	very low	low	medium	high	very high
1	Soil Fertility	1	2	3	4	5
2	Index of Erosion Risk	<1.0	1.01-2.00	2.01-3.00	3.01-4.00	>4.01
3	Availability of ground water (%)	<20% Deficit	20-30% Not normal	60-70% Normal	80-90% above Normal	90-95% Surplus
4	Soil damage for biomass production	76-100%	51-75%	26-50%	11-25%	0-10%

Table 2: Category for Land Health Assessment.

Parameter	Land Health Category		
	unhealthy	health	very health
Soil fertility	1-2 (very low – low)	3-4 (medium-high)	4-5 (high-very high)
Index of Erosion Risk	>4,01 (very high)	1.01-2.01 (medium-low)	<1.0-1.01 (very low-low)
Availability of ground water	< 20% - 30 % (very low-low)	60% - 80% (medium-high)	80% - 90% (high)
Soil damage for biomass production	>51 – 100 (very low–low)	> 31% - 50% (low-high)	> 0 - 30% (very high-high)

Soil Fertility:

The soil fertility was determined from the results of laboratory analysis of physical and chemical characteristics of the soil sample, estimation of erosion and availability of ground water, disposal and reclaimed or re-vegetated area. The parameters were compared to the standard criteria of physical and chemical soil characteristics. Permeability is the soil ability to pass the water and air. Quantitatively, soil permeability determined by the rate of water flow in the ground per unit of time on certain hydraulic gradient. Otherwise, the soil porosity is the percentage of soil volume that was not occupied by the solid soil particle (Foth, 1991).

Index of Erosion Risk:

Data of topography, plants coverage, and soil analysis were calculated and evaluated to determine the slope factor, plants and conservation factor, and soil erodibility. Climate data from the stations of climate observation in BMG Juata, Tarakan, was used to determine the index of erosivity. Erosivity of rain fall was determined by using the formula of Lenvain (DHV, 1989) and soil erodibility approached from type of soil or the calculation of Hammer (1978) formula, if the soil data was sufficient. The estimation on the number of soil erosion that can be tolerated was determined by Hammer (1981) formula, based on the equivalent depth and resources life of soil. The Index of Erosion Risk was calculated based on the comparison between occurred erosion (A) with tolerated erosion (EDT) according to the following formula.

$$Index\ of\ Erosion\ Risk = \frac{potential\ erosion}{tolerated\ erosion}$$

Description:

Potential erosion = number of soil erosion ($ton.ha^{-1}.year^{-1}$)

Tolerated erosion = number of soil erosion that can be tolerated ($ton.ha^{-1}.year^{-1}$)

Potential erosion was predicted by the equation of USLE (*Universal Soil Loss Equation)* stated by Wischmeter dan Smith (1978).

A = RKLSCP

Description:

A = Erosion ($ton.ha^{-1}.year^{-1}$)
R = rain erosivity
K = soil erodibility
L = Length of slope
S = Slope
C = coverage of vegetation
P = land management action towards erosion

Rain Erosivity:

Rain Erosivity (R) was calculated by the formula of Lal (1991), where EI_{30} is the multiplication of kinetic energy (E) with the rain intensity for 30 minutes (I_{30}).

$$R = \frac{\sum_{i=0}^{n} E_{30}}{100}$$

$$E = 1.213 + 0.890 \log I$$

Description:

n = amount of rain fall per year
E = kinetic energy ($kg.m.m^{-2}.mm^{-1}$)
I = rain intensity

The equation only applied for rain intensity of ≤76 76 $mm.hour^{-1}$. The use of this equation for Indonesia is less applied due to the limitation of unmeasured rain intensity and difficulty in calculating the E. We also use the equation of Bols

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(1978) to calculate the rain erosivity in following formula.

$$\mathbf{R = 6.19\, R_t^{1.21} N^{-0.47} R_m^{0.53}}$$

Description:

R = Rain erosivity (Jm^{-2})
R_t = total of monthly rainfall (cm)
N = number of days of monthly rain
R_m = maximum rainfall for 24 hours in the month

Soil Erodibility (K):

Soil Erodibility has been stated in the coefficient of K referred to Wischmeier and Smith (1978). Formula to determine the Factor of K was also developed by Utomo (1984) to converse the erosion unit from are to hectare in the following equation.

$$\mathbf{100\, K = 2.1 M^{1.14} (10^{-4})(12\text{-}a) + 3.25\, (b\text{-}2) + 2.5\, (c\text{-}3)}$$

Description:

M = (% dust + % fine sand)*(100 -% clay)
a = percentage of soil organic load (a = 1.72 *% C-ogranic)
b = value of structure code
c = value of soil permeability

Length of Slope (L) and Degree of Slope (S):

The value of L and S were calculated by using the following formula (Wischmeier and Smith 1978, Roose, 1977) or Table 3.

$$\mathbf{LS = (L^m/100) * (1.38 + 0.965\, S + 0.138\, S^2)}$$

Description:

L = the length of slope (meter)
m = constanta (0.5=slope > 4%, 0.4=slope 4% and 0.3=slope < 3%; Table 4)
s = slope (%)

Table 3: The value of Topography Factor for LS Combination.

Percent of slope	The Length of Slope (feet)											
	25	50	75	100	150	200	300	400	500	600	800	1000
0.2	0.060	0.069	0.075	0.080	0.086	0.092	0.099	0.105	1.110	0.114	0.121	0.126
0.5	0.073	0.083	0.090	0.096	0.104	0.110	0.119	0.126	0.132	0.137	0.145	0.152
0.8	0.086	0.098	0.107	0.113	0.123	0.130	0.141	0.149	0.156	0.162	0.171	0.179
2	0.133	0.163	0.185	0.201	0.227	0.248	0.280	0.305	0.326	0.344	0.376	0.402
3	0.190	0.233	0.264	0.287	0.325	0.354	0.400	0.437	0.466	0.492	0.536	0.573
4	0.230	0.303	0.357	0.400	0.471	0.528	0.621	0.697	0.762	0.820	0.920	1.01
5	0.268	0.379	0.464	0.536	0.656	0.758	0.928	1.07	1.20	1.31	1.52	1.69
6	0.336	0.476	0.538	0.673	0.824	0.952	1.17	1.35	1.50	1.65	1.90	2.13
8	0.496	0.701	0.859	0.992	1.21	1.41	1.72	1.98	2.22	2.43	2,81	3.14
10	0.685	0.968	1.19	1.37	1.68	1.94	2.37	2.74	3.06	3.36	3,87	4.33
12	0.903	1.28	1.56	1.80	2.21	2.55	3.13	3.61	4.04	4.42	4,11	5.71
14	1.15	1.62	1.99	2.30	2.81	3.25	3.98	4.59	5.13	5.62	6,49	7.26
16	1.42	2.01	2.46	2.84	3.48	4.01	4.92	5.68	6.35	6.95	8.03	8.98
18	1.72	2.43	2.97	3.43	4.21	3.86	5.95	6.87	7.68	8.41	9.71	10.9
20	2.04	2.88	3.53	4.08	5.00	5.77	7.07	8.16	9.12	10.0	11.5	12.9

Source : Wischmeier and Smith (1978)

Table 4: Slope (S) and Exponent (M) used to calculate LS.

S	M
< 1.0%	0.2
1.0< 3.0%	0.3
3.0 - < 5.0%	0.4
>5%	0.5

Source : (Wischmeier and Smith 1978)

Factor of Above Ground Vegetation Coverage (C) and Soil Management Conservation (P):

Factor of C is the ratio of erosion on the soil that covered by above ground vegetation compare to the erosion on soil without vegetation. It is processed in line with the contour of area with slope 9%. Factor C is essential in the estimation of erosion and become the vital source in the estimation (Renard *et al*., 1994). The value of C range between 0 and 1. One (1) stands for none vegetation and 0 for the complete coverage of vegetation (100%) by plants canopy and litters. The value of C for various types of plants and land use referred to the USDA *Agricultural Handbook* No. 537 (Wischmeier and Smith 1978) and Table 5. Otherwise, the value of P determined based on the Table 6. The USLE method has been used in all over the nations and already revised to adapt the local condition and limitation (Lal, 1991; Hudson, 1995).

Analysis of Soil Ability to Store Water for Plants:

The ability of land to store water for plants calculated based on the amount of water stored in the soil depth that accessible by the plants root. The amount of water was determined by the amount of water in the area capacity (AC) multiplied with the soil depth (D). Water in the area capacity implied the amount of water in the soil after water gravity runs out, while the soil depth determined from the soil profiles.

Analysis of Soil Damage for Biomass Production:

Ministry of Environment Regulation No. 7 of 2006 detemine the standard criteria on the status of soil damage for biomass production. It was consisted of physical, chemical, and biological characteristics of the soil. The fundamental soil characteristics determine the ability of soil to provide sufficient water and nutrient for living things, especially plants.

Table 5: Value of C for various Vegetations to Estimate Erosion based on USLE Method.

NO	Vegetation Cover	A (%)	E_1/E_0	Nilai C
1.	Open Area (with above ground plants)	0	0.05	1.l00
2.	Forest (with above ground plants)	25-35	0.90-1.00	0.001-0.002
3.	Forest (without above ground plants)	15-25	0.90-1.00	0.001-0.004
4.	Paddy field	43	0.59-0.61	0.1-0.2
5.	Corns	25	0.67-0.70	0.2
6.	Grass (planted)		0.85-0.87	0.004-0.001
7.	Legumes	20-25	0.62-0.69	0.2-0.4
8.	Cassava		0.62	0.2-0.8
9.	Peanuts	25	0.50-0.87	0.2-0.4
10.	Coffee		0.50-1.0	0.1-0.3
11.	Chocolate plantation		1.00	0.1-0.3
12.	Rubber plantation	20-30	0.90	0.2
13.	Palm oil plantation	30	1.20	0.1-0.3

Source: Morgan and Finney (1986)

Table 6: The Value of P in the Estimation of Erosion based on USLE Method.

Slope %	Inline slope	Vertical to the slope, no strip	Contour-based Management	Strip-based planting	Contour and Strip - based planting
2.0-7	1.0	0.75	0.50	0.37	0.25
7.1-12	1.0	0.80	0.60	0.45	0.30
12.1-18	1.0	0.90	0.80	0.60	0.40
18.1-24	1.0	0.95	0.90	0.67	0.45

Source: Leiser (1989)

RESULT AND DISCUSSION

Soil Fertility:

Soil fertility was determined based on the criteria of soil fertility by Research Institute of Bogor (1983). The parameters consisted of the content of organic matter/C-organic, Phosphor, Kalium, Cation Exchange Capacity (CEC), and base saturation (Table 8). The results showed that the soil fertility in the study area categorized as low fertility. The main cause of the low soil fertility was the low nutrient content. It was also stated that the soil fertility is also affected by the soil pH (McCall, 1980; Ketterings *et al.*, 2007) that affect the nutrient solubility and availability as well as the poisonous compounds. To make the land area into productive land, it would need the improvement for the soil fertility, correspond to the problems.

The problems of soil fertility in the study area of PD Baramarta were evaluated by the chemical characteristics of the soil (Table 8). The rate of base saturation was ranged very low (4.25%– 19.30%) especially in the depth of 0-30 cm. The main nutrient content was low, implied from the low N content (0.11-0.21%), P-available was very low (0.93-1.50 ppm), K-total was low to medium level (0.41–29.33 $mg.100g^{-1}$), Ca-exchange was very low to medium (1.14-9.31 $me.100g^{-1}$), Mg-change was very low to very high (0.42-8.45 $me.100g^{-1}$). Cation Exchange Capacity (CEC) was measured high to ery high level (30.0-79.11 $me.100g^{-1}$), while the organic compound categorized as low to medium (1.06-2.29%). Soil was included as very acid to fairly acid (pH 4.26-5.92). The condition of soil in the study area was dominated by sand fractions, thus without the organic matter, the effort of fertilizing and calcification will be useless. The calcification was expected to improve the pH soil condition and base saturation in the soil. The addition of organic matter (especially N) is very important to increase the soil fertility, aggregation, and formation of soil structure, as well as the ability of soil to store water, specifically for sites Natural Soil 1, Natural Soil 4, Reclaimed Soil 3 and Unreclaimed Soil 2 which has sand-textured soil.

Table 8. Rate of Soil Fertility in the Study Area.

No.	Soil Area	Chemical Characteristics					Status of Fertility
		CEC	Base Saturation	P_2O_5-total	K_2O-Total	C-org	
1	Natural Soil 1	Very High	Very Low	Medium	Medium	Low	Low
2	Natural Soil 2	Very High	Very Low	Very Low	Low	Low	Low
3	Natural Soil 3	High	Very Low	Very Low	Very Low	Low	Low
4	Natural Soil 4	Very High	Very Low	Very Low	Very Low	Low	Low
5	Reclaimed Soil 1	High	Very Low	Very Low	Low	Low	Low
6	Reclaimed Soil 2	Very High	Very Low	Very Low	Very Low	Low	Low
7	Reclaimed Soil 3	Very High	Very Low	Very Low	Low	Low	Low
8	Unreclaimed Soil 1	Very High	Very Low	Very Low	Low	Medium	Low
9	Unreclaimed Soil 2	Very High	Very Low	Very Low	Very Low	Low	Low
10	Unreclaimed Soil 3	Very High	Very Low	Very Low	Very Low	Low	Low

Source: Laboratory Analysis of Lambung Mangkurat University, 2014

Rain Erosivity Index:

Based on the rainfall data from the stations surround the area of study sites (Supplementary 1 and 2), the total monthly rainfall was 2,409.26 $mm.month^{-1}$ and the total number of monthly rain day was 179.30 days. The maximum rainfall for 24 hours was 475 $mm.month^{-1}$. Thus, the index of rain erosivity in the study area was 175,079.286 Jm^{-2}.

Estimation of Soil Erodibility (K), Length and Degree of Slope (LS), and Vegetation Coverage (C):

Factor of soil erodibility (K) was determined from the variables of physical and chemical characteristics of soil (Table 9) as the results of laboratory analysis. The study area has the slope degree 5-18% thus based on the table 5, the Constanta of M is 0.5. Otherwise, the length of slope in the study site was averaged ±10-25 meter. The LS factor was showed in the Table 10.

The factor of vegetation coverage (C) was obtained from references site of erosion in other similar areas. But we also use expertise judgment to assess the specific condition of the site. The prediction of C Factor in the study area was open area (1.00), forest with above ground plants (0.002), forest without above ground plants (0.004), and grass (0.001).

Table 9: Soil Erodibility (K).

Soil Sample	% dust	% Fine Sand	% Clay	M	C-org	a	b	c	K
Natural Soil 1	27.16	12.63	20.12	3178.4	1.61	2.769	2	3	0.19
Natural Soil 2	11.99	8.27	39.88	1218	1.19	2.047	3	4	0.13
Natural Soil 3	22.79	12.99	24.49	2701.7	1.48	2.546	2	3	0.16
Natural Soil 4	28.20	15.15	32.08	2944.3	1.33	2.288	3	4	0.24
Reclaimed Soil 1	22.11	12.90	30.36	2438.1	1.53	2.632	2	3	0.14
Reclaimed Soil 2	13.16	5.21	22.93	1415.8	2.08	3.578	2	3	0.07
Reclaimed Soil 3	28.68	20.90	39.83	2983.2	1.06	1.823	3	4	0.25
Unreclaimed Soil 1	20.34	55.51	32.36	5130.5	2.29	3.939	2	3	0.29
Unreclaimed Soil 2	16.05	6.32	49.99	1118.7	1.75	3.010	3	5	0.14
Unreclaimed Soil 3	19.76	14.05	28.41	2420.5	1.64	2.821	2	3	0.14

Tabel 10: The value of LS Factor.

No.	Location	LS
1.	Natural Soil 1	0.305
2.	Natural Soil 2	1.795
3.	Natural Soil 3	0.343
4.	Natural Soil 4	0.608
5.	Reclaimed Soil 1	0.483
6	Reclaimed Soil 2	1.468
7	Reclaimed Soil 3	2.020
8	Unreclaimed Soil 1	0.785
9	Unreclaimed Soil 2	0.334
10	Unreclaimed Soil 3	1.228

Soil Erosion based on USLE Method:

The level of erosion risk was the estimation of the maximum soil loss compared to the solum depth on each land unit, whether the efforts on land management and soil conservation improve the soil condition or not. The determination of erosion risk was referred to the Department of Forestry (1986) in the Supplementary 3. The solum depth in the study area was about ± 110 cm, thus the erosion risk in PD Baramarta ex-mining site was ranged from very low to medium level (Table 11).

Table 11: Soil Erosion ($ton.hectare^{-1}.year^{-1}$).

Location	R	K	LS	C	P	Erosion ($ton.hectare^{-1}.year^{-1}$)	Level of Erosion Risk
Natural Soil 1	110	0.19	0.305	0.01	0.25	0.02	Very Low
Natural Soil 2	110	0.13	1.795	0.01	0.25	0.06	Very Low
Natural Soil 3	110	0.16	0.343	0.01	0.25	0.02	Very Low
Natural Soil 4	110	0.24	0.608	0.01	0.25	0.04	Very Low
Reclaimed Soil 1	110	0.14	0.483	0.04	0.37	0.11	Very Low
Reclaimed Soil 2	110	0.07	1.468	0.04	0.45	0.20	Very Low
Reclaimed Soil 3	110	0.25	2.020	0.04	0.60	1.33	Very Low
Unreclaimed Soil 1	110	0.29	0.785	1	1	25.05	Medium
Unreclaimed Soil 2	110	0.14	0.334	1	1	5.15	Very Low
Unreclaimed Soil 3	110	0.14	1.228	1	1	18.92	Medium

Land Capacity to Store Ground Water :

Land capacity for ground water storage was used by plants to access the water that plants need. Land with sand textured has low water binding, thus water just passing through. The area capacity to store water ground in the study area was ranged from very low to medium level; however it was dominated by low level capacity (Table 12).

Table 12: Land Capacity for Ground Water Storage.

Location	Sand (%)	Land Capacity for Ground Water Storage
Natural Soil 1	38.09	Low
Natural Soil 2	39.86	Low
Natural Soil 3	39.73	Low
Natural Soil 4	24.57	Low
Reclaimed Soil 1	34.63	Low
Reclaimed Soil 2	58.70	Very Low
Reclaimed Soil 3	10.54	Medium
Unreclaimed Soil 1	41.79	Very Low
Unreclaimed Soil 2	27.64	Low
Unreclaimed Soil 3	37.78	Low

Status of Soil Damage for Biomass Production:

The results of analysis on the soil samples were showed in Table 13. We found that the degree of water release as one of the parameter on the soil damage is over the critical threshold. Therefore, the status of soil damage in the Baramarta ex-mining site is categorized as damaged (Government Regulation No. 150 of 2000).

Table 13: 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

Land Health Assessment:

The results of analysis on the components of land health were composed by the four previous analyses (Table 14). Based on the four analyses, and related to the land health, thus we obtained the status of land health for PD Baramarta ex mining site categorized as unhealthy land. It means that the reclamation and rehabilitation of the area has not improved the land quality in the study site.

Table 14: Components of Land Health Assessment.

No	Components	Results of Analysis
1	Soil Fertility	Low
2	Index of Erosion Risk	Very Low
3	Land Capacity for Ground Water Storage	Low
4	Soil Damage for Biomass Production	Damaged

Supplementary 1: Data of Rainfall in the Observation Station Period 2000-2009.

Month	Year										Average
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
January	205	223	240	320	158	213	372	357	463	244	295.86
February	171	215	276	413	86	156	242	206	338	297	251.75
March	203	162	126	179	27	467	171	259	471	167	233.38
April	189	205	152	147	159	166	300	296	277	209	213.25
May	141	41	258	106	230	334	162	197	228	173	211.00
June	158	390	228	76	364	109	313	151	124	112	184.63
July	387	314	92	47	288	74	36	112	46	64	94.88
August	76	379	259	8,0	126	214	125	104	103	76	125.88
September	133	86	159	4,0	283	52	54	116	37	91	99.00
October	80	215	251	57	312	348	259	210	24	143	200.50
November	223	173	249	136	433	388	211	370	181	192	270.00
December	162	187	291	188	164	254	56	475	295	110	229.13
Total	2,128	2,590	2,581	1,669	2,630	2,775	2,301	2,853	2,587	1,878	2,409.26

Source: Meteorology and Geophysics Agency of Samsudin Noer (2010)

Conclusion:

Although the erosion risk is very low to medium level, the land health status of PD Baramarta ex mining site is unhealthy. It indicates that the reclamation and re-vegetation efforts for PD

Baramarta ex-coal mining site area has not been success in improving the land quality, thus the goals of the reclamation program has not taken effects.

Supplementary 2: Number of Rain day in the Observation Station Period 2000-2009.

Month	Year										Average
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
January	10	27	18	6	5	24	23	23	23	21	18.00
February	13	25	24	5	15	21	19	19	20	20	18.10
March	6	13	20	3	21	17	18	18	23	15	15.40
April	8	19	19	11	15	24	15	15	23	19	16.80
May	6	21	16	20	18	20	12	12	14	20	15.90
June	8	25	8	16	15	24	17	17	12	11	15.30
July	9	17	10	24	10	10	10	9	9	9	11.70
August	6	24	1	22	11	13	2	5	9	8	10.10
September	2	18	3	17	11	7	12	6	13	11	12.00
October	6	22	13	21	18	23	20	5	12	14	10.00
November	5	24	15	21	21	19	20	14	16	18	17.30
December	9	24	15	19	17	10	22	21	20	14	17.10
Total	88	261	162	185	177	212	190	164	184	170	179.30

Source: Meteorology and Geophysics Agency of Samsudin Noer (2010).

Supplementary 3: Rate of Erosion Risk.

Solum (cm)	Maximum Erosion (ton.ha^{-1}.yr^{-1})				
	< 15	15 - 60	60 - 180	180 - 480	> 480
> 90	Very Low	Medium	Medium	Severe	Very Severe
60 – 90	Low	Severe	Severe	Very Severe	Very Severe
30 – 60	Medium	Very Severe	Very Severe	Very Severe	Very Severe
< 30	Severe	Very Severe	Very Severe	Very Severe	Very Severe

Source: Department of Forestry (1986)

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