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Research Paper

Secondary Succession of Vegetation in the Former Coal Mine Area PT. Bukit Asam Tbk

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Abstract
Open-pit mining activities cause environmental degradation such as decreased soil fertility and degradation of plantation. After mining activities are completed, land improvements will be carried out through post-mining reclamation. Low pH conditions, high metal concentrations and low organic matter are the main problems in post-mining activities reclamation land. Reclamation activities carried out by PT. Bukit Asam, Tbk runs continuously from time to time. Mining land that is no longer used for mining activities must immediately carry out land reclamation activities to preserve the environment and maintain ecosystem stability in coal mining areas. The reclamation efforts that have been carried out require vegetation analysis to determine the vegetation growing on the reclaimed land of various ages. This research aims to analyze vegetation using the transect method in reclamation areas aged 1 year, 3 years, 5 years, and natural land as a control. The research results show that all reclaimed land is ultisol soil which is acidic (pH 3.52 – 4.50), and the older the reclaimed land can increase the C-Organic, C-Total and C/N of the soil. The condition of land that is 5 years old also has lower soil temperatures and greater humidity than land that is younger. The Importance Value Index (INP) of seedlings, saplings, poles and trees on reclaimed land at 1 year old is smaller than at 5 years old. The common vegetation found on all reclaimed land of different ages is seedlings (*Mimosa pudica*), saplings (*Malaleuca cajuputi*), poles and trees (*Malaleuca cajuputi, Acacia mangium*).
Keywords
Vegetation Analysis, Succession Pattern, Reclamation

1. INTRODUCTION

The existence of the mining sector in Indonesia is a very important sector in improving the nation's economy. Many countries need the support of mining resources to maintain and improve prosperity. Mineral resources are a unit of geological order as part of the ecosystem (Eddy et al., 2010). South Sumatra is an area with very high mining activities. Many forests are encroached on and used as mining land because there are so many minerals contained in the earth. According to Hilwan et al. (2013), mineral and coal mining lands can be in jungle areas or other use areas (APL). The status of this area will determine the main purpose of land use for reclamation of ex-mining land: reforestation, planting plantation crops, planting food crops, becoming a livestock or fishing area, ecotourism location, wetland, etc.

Every coal mining company has an obligation to carry out reclamation of ex-mining areas and surrounding areas that are disturbed as a result of mining activity. The reclaimed area is carried out by arranging the overburden pile and then sowing topsoil. This area must immediately be given a layer of soil cover such as mulch and planting of ground cover vegetation to reduce the dispersion of rain on the soil surface. The results of reclamation are expected to have an impact on an ecosystem such as regulating the balance of carbon dioxide and oxygen in the air, improving soil properties, regulating water management and so on (Patiung et al., 2011).

Apart from that, it also affects the balance of the land surface ecosystem, reducing soil productivity and environmental quality. Also, the land surface becomes irregular, the soil fertility is low and prone to erosion so that the soil's carrying capacity for plants is low (Thoreau, 2014). PT. Bukit Asam is a coal mining company that has been around for quite a long time and has carried out many reclamation activities well in accordance with guidelines from the Ministry of Energy and Mineral Resources and the Ministry of Forestry. Therefore, this company realizes that it is very important to do so revegetation or land reclamation process after mining activities. This is important to do to maintain sustainability and minimize environmental damage (PTBA, 2021). Reclamation activities continue to be carried out by PT. Bukit Asam, Tbk runs continuously from time to time. Mining land that is no longer used for mining activities will immediately carry out land reclamation activities to

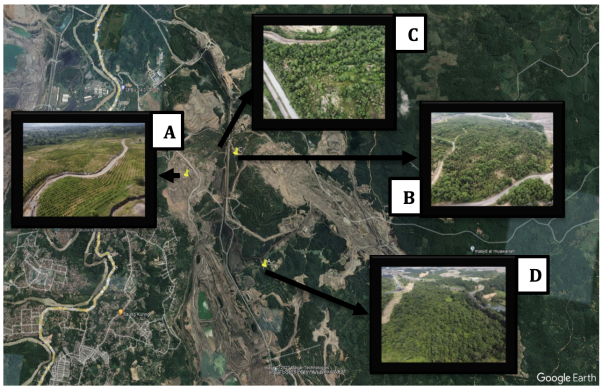

Figure 1. Research Sites Area

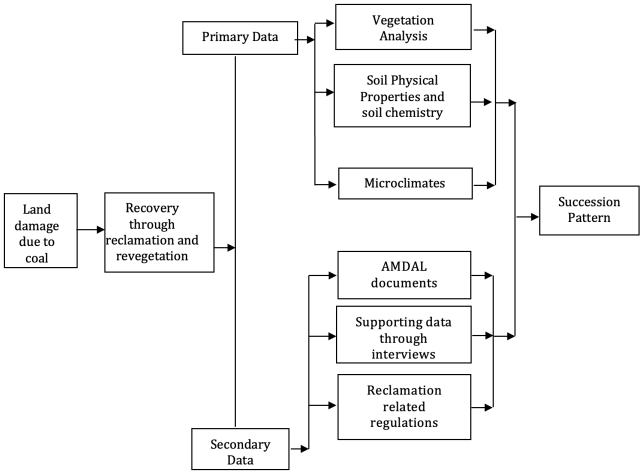

Figure 2. Flow Chart of the Field Research

preserve the environment and maintain ecosystem stability in the mining area of this company.

From the reclamation efforts that have been carried out, it is necessary to carry out vegetation analysis to determine the vegetation that grows on the reclamation land owned by PT. Bukit Asam, Tbk, so that a buffer forest composition can be formed to maintain the stability of the ecosystem at the coal mining location of PT. Bukit Asam, Tbk. This research was conducted to look at the ex-mining reclamation process at PT. Bukit Asam, Tbk with vegetation analysis based on plant age of 3 years, 5 years, 10 years, and natural land.

2. EXPERIMENTAL SECTION

2.1 Materials

This research was conducted from December 2022 to January 2023 at PT. Bukit Asam, Tbk, A State-Owned Mining company located in Tanjung Enim, South Sumatra Province. The tools used in this research include scissors, GPS (Global Positioning System), drones, labels, machetes, hoes, roll meters, raffia rope, soil tester. The research data which observed in this study is primary data and secondary data. Primary data was collected by analyzing vegetation using the transect method in reclamation areas with soil ages of 1 year, 3 years, 5 years, and natural land, as well as analyzing soil physical properties, soil chemistry, and microclimates as well as succession patterns. Meanwhile, secondary data was obtained through literature study, AMDAL documents and supporting data through interviews, as well as applicable government regulations, and the results of previous research.

2.2 Methods

Vegetation analysis was conducted on 3 plots using a double plot with a size of 20 m $\times$ 20 m, in which there were observation plots according to the seedling and understory level, 2 m $\times$ 2 m observation plots for observing seedling and understory plants, 5 m $\times$ 5 m for observation level stakes, 10 m $\times$ 10 m for observing plants at pole level, 20 m $\times$ 20 m for observing plants at tree level. Plots were randomly distributed according to land conditions at each reclamation age. The data is collected determine species density, relative density, species dominance, relative dominance, species frequency and relative frequency as well as the Important Value Index (INP). Then soil samples were taken using a hoe at a depth of 0˜20 cm for soil physical and soil chemical analysis in the laboratory PT. Bukit Asam, Tbk. Microclimates analysis was also carried out, data was taken using a Soil tester including soil temperature, soil humidity, light intensity and atmospheric temperature, measurements were carried out mid-day (12˜14.00) when the weather was sunny for 1 time.

3. RESULT

Vegetation in the three locations of the coal mine reclamation area in Banko Barat PT. Bukit Asam, Tbk described the succession pattern that occurred on forest land that is damaged until it reaches climax succession because of coal mining activities carried out by the company. According to Afany (2015) stating that the secondary succession process occurs only partial damage to natural communities and still leaves remnants of life. The remnants of life will develop again to form a climax community like the beginning. From the results of research in the field, obtained the fact that the land reclamation activities carried out by the company were very successful. This can be seen from changes in the structure and composition of vegetation from reclaimed land that is only 1 year old, 3 years old and 5 years old. Vegetation succession on PT. Bukit Asam, Tbk started with a predominance of seedling and sapling levels in the 1-year reclaimed land with an average number of seedling levels of 7.6 with an INP of 1.88%. At the stake level, the average number was 10 with an INP of 3.00%.

On the 1-year reclaimed land, no pole and tree levels were found due to the young age of the reclaimed land. In the 3-year reclamation area, pole and tree levels have been

Table 1. Average INP value of seedlings, saplings, poles and trees from reclaimed land of different ages.

Vegetation Condition	Succession (Year)							
	1		3		5		Natural Land	
	Amount	INP (%)	Amount	INP(%)	Amount	INP (%)	Amount	INP (%)
Seedling	7.6	1.88	10.6	2.63	5.66	1.66	6.33	2
Saplings	10	3	2	1	1.66	1	8.66	2.78
Poles	-	-	14.6	3	6.66	3	11.3	3.36
Trees	-	-	1	3	14.33	3	16.6	3.3

found. In this reclamation area, pole levels are dominated with an average number of 14.6 and an INP of 3.00%. On the 5-year reclamation land, the tree level is dominated by an average number of 14.33 with an INP of 3.00%, this shows that the land reclamation carried out by the company is very successful as can be seen from changes in the structure and composition of vegetation on the 5 year land. Meanwhile, for natural land as a treatment other than reclamation age, it is dominated by tree level with an average number of 16.6 and an INP of 3.30% (see Table 1).

The condition of the vegetation at each research location shows different vegetation composition. This is because each location has a different age and development. It can be seen that on reclaimed land that is 1 year old it is dominated by seedlings and saplings, while on reclaimed land that is 3 years old it is dominated by sapling level, pole level and seedling plants as its constituents, while on reclaimed land that is 5 years old vegetation is visible tree level, pole level, sapling level and seedling level are the components that can be said to have achieved ecosystem stability. This describes the succession process that occurs from the initial stages of succession to reaching the climax succession. According to Daryanto and Agung (2013), the succession process will end when the environment has reached a stable state or has reached a climax. A climax ecosystem can be said to have homeostasis, so it is able to maintain its internal stability.

Table 2 shows that the species on the 1 year, 3 year and 5 year reclaimed land for the seedling, sapling, pole and tree levels were found and were dominated by the *Malaleuca cajuputi* species. *Malaleuca cajuputi* is a species that is most often planted on this reclaimed land, because the soil conditions on this reclaimed land are acidic with low organic matter content so it is very suitable for the growth of the *Malaleuca cajuputi* species, this species can also grow well in flooded or dry conditions. *Malaleuca cajuputi* is included in the fast-growing species (FGS) category which can be used to accelerate the succession process on critical land (Suryanto et al., 2017). has good germination ability, so that growing young shoots can be done easily and is a potential type for reclamation of ex-mining land. Economically, the leaves of the *Melaleuca cajuputi* species are used to produce eucalyptus oil by PT Bukit Asam Tbk. It is hoped that PT. Bukit Asam, Tbk will be able to contribute to the community by empowering the processing of eucalyptus trees into eucalyptus oil which can ultimately become a superior product for the city of Tanjung Enim to support it as a tourist city in South Sumatra.

Table 3 shows that the actual pH of the soil in the reclaimed land for 1 year, 3 years, 5 years is 3.52 – 4.50. Meanwhile, the soil pH on natural land is 4.09. pH characteristics of reclaimed land and natural showed that the pH of the soil in these 4 fields is classified as acidic, both in the top layer (0 - 10 cm) and the bottom layer (10 - 20 cm). This happens because the soil on this land is Ultisol soil which tends to have high acidity. The soil pH on reclaimed land is almost close to the soil pH on natural land, this shows that the organic material content on reclaimed land has the same content as the organic material on natural land. Liming is highly recommended to increase soil pH as well as neutralize Al poisoning and increase plant nutrients, while the C-Organic condition of soil on reclaimed land for 1 year, 3 years and natural land is 0.28% - 0.67%, which is classified as a fertility level. low soil, on 5-year reclamation land of 1.75% is classified as medium soil fertility. The N-total of reclaimed land and natural land is 0.102 – 0.130, which is considered very low, but on reclaimed land it has increased from before the land reclamation, this is due to the large amount of vegetation and litter covering the surface of the land. Meanwhile, the C/N ratio on reclaimed land aged 1 year, 3 years and natural land ranges from 9 - 16, which is classified as a medium level of soil fertility, while on reclaimed land aged 5 years, it is 22, which is classified as a high level of soil fertility. This proves that 1 year, 3 year and 5-year land reclamation at PT. Bukit Asam, Tbk has succeeded and approached the natural land in this area.

The results of soil tester measurements show that the average soil temperature at reclaimed land and natural land locations is $27^{\circ}C - 30^{\circ}C$, soil moisture is 60.45% - 75.21%, light intensity is 100 fc – 250 fc, and atmospheric temperature is $30^{\circ}C - 32^{\circ}C$. This proves that at this research location the soil temperature and soil moisture at this location have wet and good soil, on reclaimed and natural land this shows that the photosynthesis process will take place optimally. In conditions like this, the glucose formation process will run well, so that the results of the photosynthesis process can be distributed properly throughout the plant body.

Table 2. Species of various vegetation from seedlings, saplings, poles, and trees from reclaimed land differ in age

Vegetation Condition	Vegetation Species from Reclaimed Land (Year)			
	1 3	5	Natural Land	
Seedling	*Malaleuca cajuputi* *Papalum comersionii lamk* *Ischaemum timorense kth*	*Mimosa pudica* *Papalum comersionii lamk* *Ischaemum timorense kth*	*Mimosa pudica* *Paspalum comersionii lamk* -	*Mimosa pudica* *Paspalum commersionii lamk* -
Sapling	*Malaleuca cajuputi* - - - - -	*Malaleuca cajuputi* - - - - -	*Malaleuca cajuputi* - - - - -	*Hibiscus tiliaceus* *Peronema canascenss* *Eurya acuminata dc* *Calameae* *Pterocarpus indicus* *Terminalia catappa*
Pole	- - - - - - -	*Malaleuca cajuputi* *Acacia mangium* - - - - -	*Malaleuca cajuputi* *Acacia mangium* *Pterocarpus indicus* - - - -	*Hibiscus tiliaceus* *Peronema canascenss* *Pterocarpus indicus* *Albizia chinensis* *Psidium guajava* *Terminalia catappa* *Acacia mangium*
Tree	- - - - - - -	*Acacia mangium* - - - - - -	*Malaleuca cajuputi* *Acacia mangium* - - - - -	*Hibiscus tiliaceus* *Peronema canascenss* *Pterocarpus indicus* *Albizia chinensis* *Archindendron pauciflorum* *Cyrtophyllum fragrans* *Acacia mangium*

Table 3. Soil Characteristics and Soil Chemistry from Different Lands Reclaimed at Different Ages

Location	Soil Characteristics and Chemistry					
	Type of Soil	pH Soil	C Organic (%)	C Total (%)	N Total (%)	C/N Total
1-Year Reclamation	Ultisol	4.5	0.64	1.35	0.122	11.089
3-Year Reclamation	Ultisol	4.07	0.67	1.3	0.13	9.998
5-Year Reclamation	Ultisol	3.52	1.75	2.9	0.126	22.951
Natural Land	Ultisol	4.09	0.28	1.03	0.102	10.09

Table 4. Results of Microclimate Measurements on Reclamation Land of Different Ages

Location	Microclimate			
	Soil Temperature	Humidity (%)	Light Intensity (fc)	Atmospheric Temperature
1-Year Reclamation	30° / 84 F	60,45 (Wet+)	250	31° C / 87 F
3-Year Reclamation	28° / 82 F	65,67 (Wet+)	175	30° C/ 82 F
5-Year Reclamation	28° / 82 F	70,01 (Wet+)	200	32° C/ 89 F
Natural Land	27° / 80 F	75,21 (Wet+)	100	32° C/ 89 F

4. CONCLUSION

The Changes in the structure and composition of vegetation from reclaimed land that is only 1 year old, 3 years old, and 5 years old are relatively good. Each coal mine reclamation area of PT. Bukit Asam, Tbk should be implemented continuous observation and maintenance so that developments in the dynamics of the structure and composition of the vegetation that make up each reclamation age strata and the diversity of communities in each area can be seen.

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