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Study of Success Level of Reclamation Plant on the Post-mining Land of PT. Kitadin Site Embalut

M. Taufan Tirkaamiana [a], Jumani [a*], Joni Praktino [a], Zikri Azham [a] and Ismail [a]

[a] Forestry Study Program, Faculty of Agriculture, University of 17 Agustus 1945 Samarinda, Indonesia.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Coal mining activities in Indonesia are generally or usually carried out using an open pit mining system which results in negative impacts such as loss of forest vegetation, loss of animals and plants (flora and fauna), as well as damage and loss of soil layers around the coal mining area. To overcome the problem of land damage or changes due to mining is to carry out reclamation. The research aims to determine the reclamation process on post-coal mining land and to assess the level of success of reclamation of revegetation. The research was carried out from mid-April 2023 to the end of May 2023 in the post-mining land revegetation reclamation area of PT Kitadin Site Embuat which is located in Emputar Village, Tenggarong Seberang District, Kutai Kartanegara Regency, East Kalimantan Province. The research results show that (1) the reclamation process on PT Kitadin's post-coal mining land begins with land use activities (filling cover soil, spreading root zone soil, and controlling erosion), revegetation activities, and other forms of reclamation

**Corresponding author: E-mail: Jumaniani@gmail.com;*

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activities; and (2) revegetation of the PT Kitadin Site Embulant at the Homogeneous Educational Forest and Heterogeneous Educational Forest locations was declared successful with a plant survival percentage reaching 94.5%, however, the soil pH parameter was declared unsuccessful because the soil pH value at the Homogeneous Educational Forest location was only 4.80 (classified as acid).

Keywords: Reclamation; post-coal mining land'open-pit mining techniques.

1. INTRODUCTION

Indonesia is a country that has quite large natural resources, one of which is the coal mining sector. Indonesia's coal reserves currently reach 38.84 billion tons [1] (ESDM, 2023). Kalimantan holds 62.1% of the largest total potential reserves and coal resources in Indonesia, namely 88.31 billion tons of resources and reserves of 25.84 billion tons. Coal mining is one of the largest foreign exchange contributors to the country. Based on data from the Ministry of Energy and Mineral Resources, in 2022 the coal mining sector will contribute PNBP (Non-Tax State Revenue) of 175.5 trillion IDR. The magnitude of the PNBP achievement cannot be separated from the high coal prices in 2022.

PT Kitadin is a domestic investment company engaged in the mining business with Production Operation Mining Business License No. 540/006/IUP-OP/MB-PBAT/III/2013 dated 18 March 2013 with area code KTN 2013 006 OP. Based on the Regional Spatial Plan Map of East Kalimantan Province and the Regional Spatial Plan of Kutai Kartanegara Regency, the PT Kitadin coal mining area is included in the Non-Forestry Cultivation Area or Other Use Area.

It was stated by Ahmad [2] and [3] that coal mining activities are generally carried out using open-pit mining techniques. This method has a big impact, namely making the land surface open, making the land vulnerable to erosion and sedimentation, health problems for humans, destruction of plant and animal habitats, and decline in natural beauty/water quality and soil/groundwater levels. Furthermore, it was stated by Stefanus [4] and [5] that open-pit mining systems can cause land degradation, changes in drainage patterns and systems, and changes in microclimate.

To reduce and improve the negative impacts of mining activities, every coal mining company is required to carry out reclamation activities for ex-mining land [6]. Reclamation is an activity carried out throughout the stages of a mining business to organize, restore, and improve the quality of the environment and ecosystem so that it can function again according to its intended purpose [7]. Ex-mining reclamation activities should be covered as a whole and not only assess physical environmental improvements but also be carried out with community development activities [8,9].

Revegetation activities are one of the reclamation activities that seek to repair and restore vegetation cover through planting and maintenance activities [10,11]. Revegetation creates creating accelerated succession of land cover by established vegetation, the catalytic effect of revegetation is expected through changes in conditions under the canopy (increasing soil moisture, reducing temperature, etc., increasing vegetation structure towards climactic levels, and producing a layer of organic litter and humus in the early years of plant growth [12-14].

To determine the success of revegetation in ex-coal mining land reclamation activities, an assessment needs to be carried out as an effort to review the return of ex-coal mining land to its original habitat so that restoration of ex-coal mining land can be effectively and efficiently implemented in the field.

Based on the description above, research was carried out to know the reclamation process on post-coal mining land and to assess the level of success of revegetation reclamation carried out by PT Kitadin Site Embalut on post-mining land.

2. METHODOLOGY

2.1 Time and Location

The research was carried out from mid-April 2023 to the end of May 2023 in the post-mining land revegetation reclamation area of PT Kitadin Site Embalut which is located in Embalut Village, Tenggarong Seberang District, Kutai Kartanegara Regency, East Kalimantan Province.

2.2 Materials and Tools

The materials used are the Minister of Energy and Mineral Resources Decree document

Number 1827 K/30/MEM/2018 and, the PT Reclamation Plan Document. Kitadin, Reclamation Location Map, Ribbons, and stakes as plot boundaries. The tools used are GPS, meter, compass, earth drill, plastic samples, stationery, laptop, and cellphone.

2.3 Research Activities

2.3.1 Literature study

Literature study directed at searching for information data through documents, both written documents, photographs, and electronic documents that can support the writing process.

2.3.2 Plotting

Determination of plots is carried out randomly, but taking into account factors such as accessibility to the location of sample plots, distribution of sample plots, availability of plots with a certain planting age, all of which can be seen on the revegetation map. After determining the location of the object to be researched, a plot measuring 40 m x 25 m is prepared to carry out vegetation analysis.

2.4 Collected Data

The collected data consists of:

(a) primary data obtained directly through field observations in the revegetation area, namely: (1) types and number of trees in the revegetation area; (2) plant health; and (3) soil pH; And
(b) secondary data obtained from various sources, including companies, agencies, and institutions related to supporting research data such as Mine Closure Plan documents, Reclamation Plan Documents, Reclamation Implementation Reports, void management data, water and soil test results certificate data, as well as other data.

2.5 DATA ANALYSIS

2.5.1 Percentage of plant life

The percentage of plant life is carried out by observing the types and number of plants in the research plot, then a recapitulation is carried out regarding the number of types between fast-growing types and local types in the research plot. To assess the success rate of planting, it is calculated using the formula:

$$T = Hi / Ni \times 100\%$$

Information: T = Percentage of plant life (%); Hi = number of live plants in the measuring plot, and Ni = number of plants that should be in the measuring plot.

The plant survival percentage category is classified as good if the growth ratio is > 80%, medium category if the growth ratio is 60–80%, and poor category if the growth ratio is < 60%.

2.5.2 Plant health

Plant health is carried out by observing the plants in the sample plot. After that, an assessment is carried out using the criteria of healthy, unhealthy, and miserable. Plants are said to be healthy if they grow fresh, have straight stems, a dense canopy, and are free from disease. Plants are said to be unhealthy if the plants are not fresh, the stems are not straight, the canopy is not dense, and is attacked by disease. A plant is said to be miserable if the condition of the plant begins to dry out, the number of leaves is very small and the color of the dominant leaves turns yellow.

2.5.3 Soil pH Measurement

Soil pH measurements are carried out in the laboratory on composite soil samples. The measurement results are said to be in good criteria if the pH level is 5 - 6, medium criteria if the pH level is 4.5 - <5.

Evaluation of the success rate of this research only refers to the criteria for successful revegetation as presented in Table 1.

3. RESULTS AND DISCUSSION

3.1 General Description of Research Locations

PT. Kitadin holds a Production Operation Mining Business Permit based on the Decree of the Regent of Kutai Kartanegara number 540/006/IUP-OP/MB-PBAT/III/2013 which comes into effect from 18 March 2013 to 25 February 2022. PT Kitadin is located in the villages of Embalut, Separi village, Bangun Rejo village and Kerta Bhuana village and Manunggal Jaya village, Tenggarong Seberang sub-district, Kutai Kartanegara Regency, East Kalimantan Province with an area of 2,973 hectares, PT coal mining area. Kitadin is included in the Non-Forestry Cultivation Area or Other Use Area.

PT Kitadin has a Certificate of Environmental Feasibility (SKKL) No. P-660.2/09/DPMPTSP/ III.3-1/KL/04/2019 of 2019 issued by the Head of DPMPTSP Kutai Kartanegara on behalf of the Regent of Kutai Kartanegara on April 22, 2019, and has been declared effective through Online Single Submission for Analysis Documents Environmental Impact.

Next PT. Kitadin has received approval for the Final Feasibility Study which was approved by the East Kalimantan Provincial Energy and Mineral Resources Service No: 541.23/2005/I-Minerba dated 29 May 2019.

Based on the Schmidt-Ferguson climate classification, the PT Kitadin area is classified as type B, namely "wet" with a Q value of 22.6%.

In general, the location of PT Kitadin Site Embalut has a relatively flat land surface contour because it is a swamp area and former residential areas as well as rice fields that have been cleared. A small part is a hilly area.

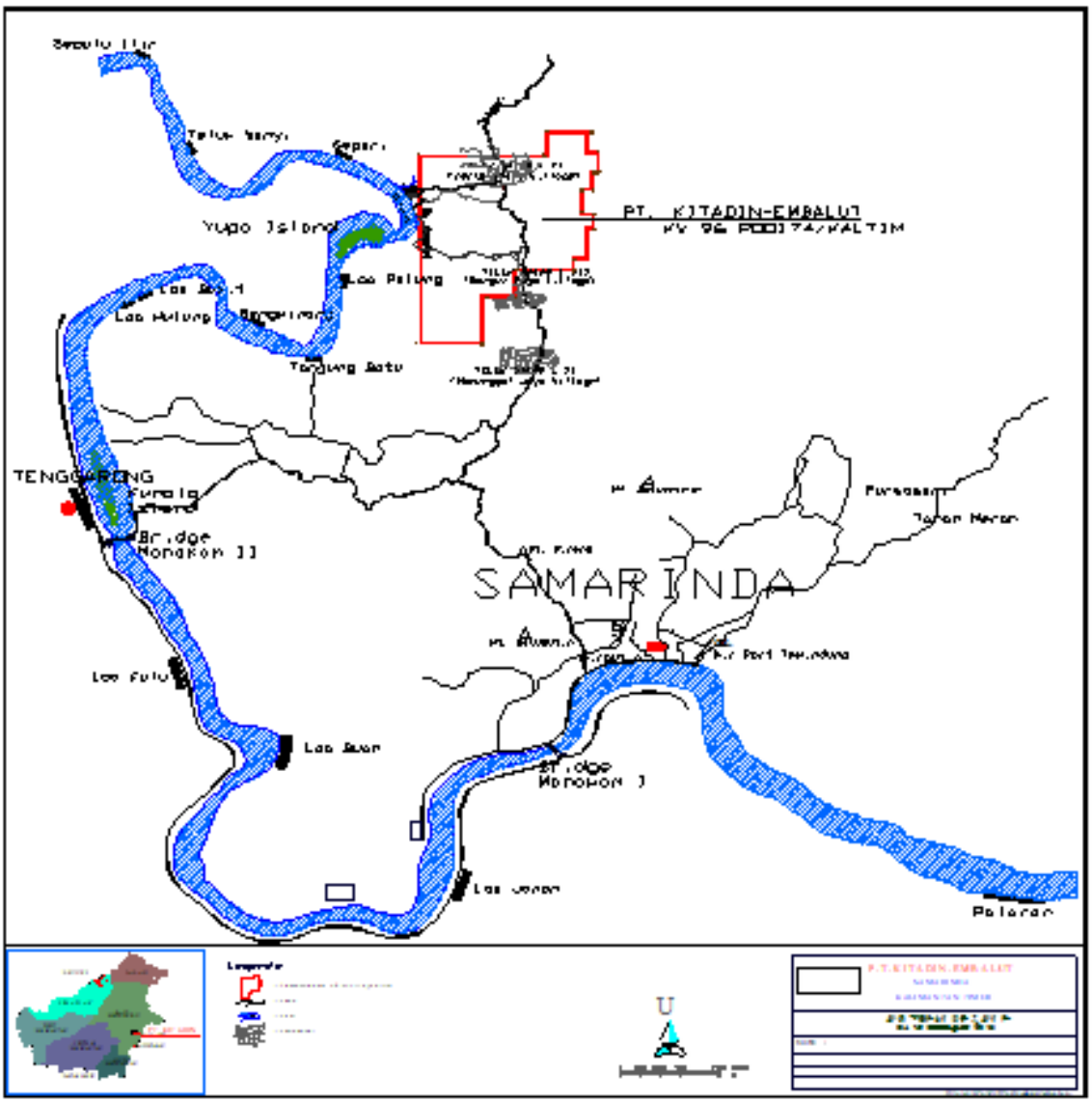

Fig. 1. IUP Location PT Kitadin Area

Table 1. Criteria for successful reclamation

No	Reclamation Activities	Activity Object	Parameters	Plan	Realization	Standards of Success
1	Land Use	a. Land surface arrangement	The size of the area laid out	……ha	…… ha	According to the plan
			Embankment stability	-		There were no avalanches
		b. Backfilling of ex-mining land	The area covered	…… ha	…… ha	According to the plan
			Embankment stability	-		There were no avalanches
		c. Spreading the root zone soil	The size of the area spread	…… ha	…… ha	- Good (>75%) - Medium (50-75%)
			Soil pH	-	-	- Good (5-6) - Medium (4,5 - <5)
		d. Erosion control and water management	Drainage channel	-		There is no active erosion and sedimentation in the reclamation area
			Erosion control building	-		There are no erosion grooves
2	Revegetation	a. Planting	- Planting area: - Cover crop - Fast-growing plants - Local plants	-		- Good (Growth >80%) - Medium (60-80% growth)
		b. Management of acid mine water generator materials	Material management	-		According to the plan
			- Erosion control building	-		According to the plan
			- Sediment settling pond	-		According to the plan
3	Completion	a. Header closure	-			Accepted if ≥ 80%
		b. Maintenance	- Fertilization	-		According to the plan

	- Control of weeds, pests and diseases	-	Control based on analysis results
	- Embroidery	-	According to the number of dead plants.

Source: Decree of the Minister of Energy and Mineral Resources of the Republic of Indonesia No 1827K/30//2018

3.2 Reclamation Implementation Process

3.2.1 Land use

According to Ministry of Energy and Mineral Resources [15], the use of ex-mining land is carried out through several activities, namely backfilling in ex-mining holes according to predetermined elevations, spreading topsoil, and creating erosion control channels. Land stewardship activities carried out by PT Kitadin are presented in Fig. 2, 3, and 4.

Fig. 2. Cover filling

Fig. 3. Distribution of soil

Fig. 4. Construction of erosion control channels

After filling the cover soil, the next process is filling the root zone soil or filling the topsoil. The topsoil is taken at the topsoil accumulation location. Topsoil is spread with a thickness of about 30 cm. PT. Kitadin has several topsoil accumulation locations, including areas S22GSB1, S17GS, and S12GN. Topsoil must be collected at one accumulation location during the land-clearing process for the production process [10].

After the topsoil has been spread, water channels are made around the land arrangement area. The channel functions as an erosion control so that the topsoil that has been spread is not eroded by surface water runoff when it rains.

The size of the area to be reclaimed must be reported when preparing the Reclamation Plan Document which is prepared for 5 years. PT Kitadin's land use for 2019 – 2022 is presented in Table 2.

Table 2 shows that the average level of realization of PT Kitadin's land use in 2019-2022 has reached 86.4% of the predetermined plan, even in 2021 and 2022 the realization of land use reached more than 100%. However, in 2020 the realization of land use only reached 35.6% and was quite far from the plans that had been set. Based on information from PT Kitadin's Mine Engineering team, several factors caused the low realization of land use in 2020, including (1) the mining sequence in the S17GS pit area was not according to plan due to high rainfall; (2) hard material for material balancing is limited so progress for stockpiling is hampered, and (3) the landfill area that has reached the target elevation experiences sliding.

3.2.2 Revegetation

Revegetation is an effort to repair and restore vegetation cover through planting and maintenance activities [12]. Revegetation activities begin with planting cover crops. Types of cover crops used at PT. Kitadin is a type of *Centrosema pubescens, Colopoginium mucunoides, Pueraria javanica*. Cover crops have several functions, including preventing erosion by resisting the destructive power of raindrops that fall and flow over the surface of the land [15].

The species planted as pioneer plants are fast-growing plants with a planting distance of 4 m x 4 m. Planting is carried out in planting holes measuring 40 cm x 40 cm x 40 cm filled with manure and compost. The planting distance for fast-growing plants is 4 m x 4 m. After the plants are 3 years old, proceed with planting insert plants with local plant species from Kalimantan with a spacing for insert plants of 4 m x 8 m.

Table 2. Land Use 2019-2022

No	Locations	2019 (hectare)		2020 (hectare)		2021 (hectare)		2022 (hectare)	
		Plan	**Actual**	**Plan**	**Actual**	**Plan**	**Actual**	**Plan**	**Actual**
1.	Location 1(S22GN)	22.43	31.81	13.8	4.42	71.59	34.90	50	24.98
2.	Location 2 (S22GN_2)	7.84	15,85	3.82	-	27.59	78.37	103.38	119.80
3.	Location 3 (POND A)	17.31	21,74	18.75	-	21.17	24.70	16.8	43.80
4.	Location 4 (S22GSB)	29.36	23,93	13.31	3.42	22.19	12.11	10.6	6.94
5.	Location 5 (S12GN)	30.50	-	46.87	30.7	-	-	-	3.23
6.	Location 6 (S17GS)	-	-	10.12	-	24.70	51.18	32	30.39
7.	Location 7 (S17GS_2)	-	23.03	13.15	1.14	-	-	-	-
Total		107.44	93.33	119.30	42.38	167.24	201.26	212.78	218.97
Percentage (%)		86,8		35,6		120,3		103	
Achievement		86,4%							

Source: Reclamation Implementation Document PT. Kitadin 2019-2022

Fig. 5. Planting fast-growing plants

Fig. 6. Insertion planting of local plants

The target number of reclamation plants per hectare is 625 fast-growing plants and 300 local-type insert plants. So the total number of plants per hectare of the reclamation area is 925 plants. Fast-growing plants are *Albizia saman, Hibiscus tilliaceus L., Senna siamea, Enterolobium cyclocarpum, Paraserianthes falcataria, and Gmelina. Local plants are Arenga pinnata, Tamarindus indica, Pterospermum javanicum, Shorea laevis, Lagerstroemia speciosa, Agathis dammara, Duabanga moluccana, Durio zibethinus, Aquilaria malaccensis, Melaleuca leucadendra, Nauclea orientalis, Neolamarckia cadamba, Psidium guajava, Calliandra calothyrsus, Dryobalanops aromatica, Reutealis trisperma, Dipterocarpus acutangulus, Terminalia catappa, Vitex pubescens Vahl, Macaranga bancana, Swietenia macrophylla, Mangifera indica*, Alse odaphne insignis, *Shorea leprosula*, *Shorea assamica, Shorea acuminatissima. Palaquium rostratum, Alstonia scholaris, Baccaurea motleyana, Adenanthera pavonina, Peronema canescens, Mimusops elengi,* and *Eusideroxylon zwageri* (Data Source Nursery PT. Kitadin).

After planting activities are completed, routine care and maintenance activities are carried out. Care and maintenance for planting ages 1 year is carried out every 4 months, while for planting ages 2 years and 3 years it is carried out every 6 months. Maintenance activities include cleaning weeds and replanting dead plants.

To increase the nutrient content in the soil, fertilization activities are carried out to support plant growth so that they can grow well. The types of fertilizer used by PT Kitadin include

manure, compost, urea, SP 36, NPK, and Ponska fertilizer.

3.2.3 Other forms of reclamation

To determine the reclamation of other forms of ex-coal mining land, based on the results of public consultation activities, it was agreed that ex-mining ponds should be used as reservoirs, then other land would be used for rice fields, animal feed land, cattle and chicken farms, corn and fruit gardens, integrated agriculture, and agricultural tourism. Details of plans for other forms of reclamation activities on former PT Kitadin coal mining land is presented in Table 3.

3.2.4 Criteria for successful revegetation

3.2.4.1. Percentage of plant life

The percentage of plant life is known through sampling in plot areas that have been created in homogeneous and heterogeneous educational forest locations. The sampling locations represent existing revegetation growth. The planned number of plants includes 63 fast-growing plants and 31 local insert plants with a plot size of 0.1 hectare. So the total planned plants in the plot are 94 plants. The actual number of plants in the plot will be compared with the planned number of plants to be planted to calculate the percentage of plant survival. Data on the live percentage of fast-growing plants and local plants is presented in Table 4,

Based on Table 4 shows that at the Heterogeneous Educational Forest reclamation location, the number of living plants ranges from 86 - 102 plants with a percentage of live plants ranging from 91.4 - 100%, while at the Homogeneous Educational Forest reclamation location the number of living plants ranges from 83 - 91 plants with the percentage of plant survival ranged from 88.3 – 96.8%. Meanwhile, overall the percentage of plant life in the two locations reached 94.5% (including the good category).

Table 3. Other forms of reclamation program PT. Kitadin

No	Program Type	Area (hectare)	Total Locations
1	Former Mining Pool	153.14	6 Locations
2	Rice field	74	2 Locations
3	Cattle farm	206	3 Locations
4	Animal Feed Land	113	5 Locations
5	Cornfield	100	3 Locations
6	Fruit Garden	26,5	1 Location
7	Integrated Agriculture	16	1 Locations
8	Chicken coop	4,17	2 Locations
9	Agricultural Tourism	4	1 Location

Source: PT. Post-Mining Plan Document. Kitadin

Table 4. Percentage of plant life

No	Location	Plot	Ni	Hi	T (%)	Information
1	Homogeneous	1	94	87	92.5	Plot size 25 m x 40 m
	Education	2	94	91	96.8	
	Forest	3	94	83	88.3	Pioneer Type Planting Distance 4 m x 4 m
Average				87	92,5	
2	Heterogeneous	1	94	92	97.8	
	Education	2	94	102	100	Planting distance for local types 4 m x 8 m
	Forest	3	94	86	91.4	
Average				93	96,4	
Total Achievement		94,5%				

Source: Primary Data processed 2023

Information: Ni = Number of plants that should be in the measuring plot; Hi = Number of live plants in the measuring plot; and T = Percentage of plant life

The number of plants that did not reach 100% in each plot was due to the plants dying due to pests, falling, and some being exposed to waterlogging due to poor drainage. In the Homogeneous Educational Forest reclamation area, several plants died due to pest attacks, and the places where they grew were flooded with water.

Pests that attack reclamation plants such as sengon usually come from the *Ganoderma* sp type. Ganoderma sp is a pathogenic fungus that can cause root rot disease in *Paraserianthes falcataria* plants. Ganoderma sp is difficult to detect because its symptoms are similar to those of other root diseases [16].

This percentage of plant life is higher than the research results reported by [17] that the percentage of plant life in reclamation activities of ex-coal mining land. A case Study of Mining Business Permits in Tanah Bumbu Regency, South Kalimantan Province is only around 13.88 – 51.08%. Another research result reported by [18] was that the percentage of plant life in ex-mining land reclamation activities at PT. Pipit Mutiara Jaya, Sesayap District, Tana Tidung Regency, North Kalimantan Province is only 76 - 81%.

3.4.2.2 Plant health

Plant health observations are grouped into three categories, namely healthy plants, less healthy plants, and miserable plants. In calculating the percentage of plants, the number of plants that are classified as healthy will be the value of the percentage of plant health. The percentage of plant health is calculated from the number of healthy plants compared to the number of plants at the observation location. The results of research on plant health levels are presented in Table 5.

The research results in Table 5 show that the highest percentage of plant health is found in plot two of the Heterogeneous Educational Forest location with a percentage value of 98% and the lowest percentage is in plot three of the Homogeneous Educational Forest location with a percentage value of 85.5%. Overall the percentage of plant health at this location reached 92.5%. The results of another study reported by Gunawan et al. [18] stated that plant health during the reclamation of ex-coal mining land in the case study of mining business permits in Tanah Bumbu Regency, South Kalimantan Province was only 70.35%. The results of other research reported by [19] stated that plant health in ex-mining land reclamation activities at PT. Pipit Mutiara Jaya Sesayap District, Tana Tidung Regency, North Kalimantan Province is only 81.5 – 85.1%.

The research results also showed that the low value of the lowest percentage of plant health at the Homogeneous Education Forest location was due to the plants being planted not being able to adapt to the post-mining land, especially the local ironwood plant (*Eusideroxylon zwageri*). According to [20], naturally ironwood (*Eusideroxylon zwageri*) grows well in wet tropical forests, on land that is not flooded with water at an altitude of 500 – 625 meters above sea level, and in flat areas near rivers. The soil where ironwood grows is generally sandy, the soil has an acid reaction (low pH) and low soil fertility (low N, P, and K nutrient content).

Table 5. Plant health level

NO	Location	Plot	Number of Plants	Plant Health Category			(%)
				Healthy	Unhealthy	Miserable	
1	Homogeneous Education Forest	1	87	78	5	4	89.6
		2	91	85	4	2	93.4
		3	83	71	7	5	85.5
Average				77	6	4	89
2	Heterogeneous Education Forest	1	92	87	4	1	94.5
		2	102	100	2	0	98
		3	86	82	2	2	95.3
Average				89	3	1	96
Total Achievement							92,5%

Source: Primary Data Processed 2023

3.4.2.3 Plant species composition

The composition of plant types planted in the revegetation area consists of a combination of fast-growing species and long-life local plants. The percentage of local plants is calculated based on the number of local plants compared to the total number of plants in the plot, presented in Table 6.

The research results in Table 6 show that the highest percentage of local plant species is found in the plots of three Heterogeneous Educational Forest locations with a percentage value reaching 53.4% and the lowest percentage is found in plot three in the Homogeneous Educational Forest location with a percentage value of 38.5%. Overall, the percentage of local plant species in the two locations reached 42.9%.

3.4.2.4 Soil quality

The criteria for assessing soil quality in post-mining land reclamation are only based on the soil pH quality parameter. However, PT Kitadin annually carries out a complete soil quality analysis in an accredited laboratory to determine the nutrient content in the soil and as material for the company's internal evaluation. The criteria for soil pH quality are said to be "good" if the pH level is 5 - 6, whereas if the soil pH level is 4.5 - <5 it will fall into the "medium" criteria [15]. Soil quality data at the research location is presented in Table 7.

Table 6. Percentage of local plant types

No	Locations	Plot	Total Plants	Plant Type		Percentage of Local Types (%)
				Pioneer	Local	
1		1	87	52	35	40.2
		2	91	51	40	43.9
	Homogeneous Education Forest	3	83	51	32	38.5
Average				51	35	40.8
2		1	92	53	39	42.3
		2	102	61	41	40.2
	Heterogeneous Education Forest	3	86	40	46	53.4
Average				51	41	45
Percentage of Total Local Plant Types						42,9

Source: Primary Data Processed 2023

Table 7. Soil quality data (pH and Texture)

No	Parameters	Method	Unit	Homogeneous Education Forest		Heterogeneous Education Forest	
				0-30	30-60	0-30	30-60
A. Chemical Analysis							
1	pH H2O (1:2.5)	Electrode	-	4,80	5,25	5,35	5,70
2	pH. KCl 1N (1:2.5)	Electrode	-	3,45	3,75	4,25	4,35
B. Physical Analysis							
1	Silt	Pipet	%	45,00	40,00	40,00	33,00
2	Clay	Pipet	%	21,00	30,00	16,00	21,00
3	Sand	Sieve	%	34,00	30,00	44,00	46,00
4	Texture	Triangle Texture	-	Loam	CL	Loam	Loam

Source: PT Kitadin Land Data

Based on Table 7 above, shows the texture of loam to clay loam; The pH of the soil in the Heterogeneous Education Forest is by the standard standards, namely 5.35 at a soil depth of 0-30 cm, and 5.70 at a soil depth of 30-60 cm. Meanwhile, in the Homogeneous Education Forest, the soil pH quality still does not meet the success criteria because the soil pH at a depth of 0-30 cm is still at 4.80 even though at a soil depth of 30-60 cm it already meets the success criteria, namely pH 5.70. This situation was explained by [21] that coal mining at PT Kitadin uses an open mining system, in which land clearing and excavation of soil and overburden occurs. The rate of reaction between sulfide minerals contained in the overburdened rock and coal that is in direct contact with air will cause acid to form, causing the soil to react acidly (low pH) and generally have a low level of soil fertility. As research results reported [17] show, the soil pH on former coal mining land ranges from 5.12 – 5.28 with the dominant level of soil fertility being very low.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusion

Based on the results of research and discussions carried out at the post-mining land reclamation location of PT Kitadin Site Embalut, the following conclusions can be drawn:

1. The reclamation process on PT Kitadin's post-coal mining land begins with land management activities including filling up cover soil, spreading root zone soil and controlling erosion, revegetation activities including planting cover crops, fast-growing plants, local insert plants and maintenance activities, as well as other forms of reclamation activities by PT's Postmining Plan Document. Kitadin.
2. Revegetation of the PT Kitadin Site Embalut at the Homogeneous and Heterogeneous Educational Forest locations was declared successful with a plant survival percentage reaching 94.5%, however, the soil pH parameter was declared unsuccessful because the soil pH value at the Homogeneous Educational Forest location was only 4.80 (classified as acid).

4.2 Suggestions

The suggestions that can be put forward are as follows:

1. To increase the pH of the soil at the Homogeneous Education Forest location, liming can be carried out.
2. Carry out intensive care and cleaning of weeds to prevent disease in plants, especially local types of plants.
3. Improve drainage in the revegetation area to prevent plants from dying due to waterlogging.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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