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REHABILITATION OF FORMER MINING LAND AT PT RAJA KUTAI MAKMUR, BADAK BARU VILLAGE, MUARA BADAK DISTRICT, KUTAI KARTANEGARA REGENCY

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Abstract

Post-mining land generally exhibits low nutrient levels, requiring soil enhancement via the use of chemical or organic amendments. The application of fertilizers and lime markedly affects soil conditions and can improve soil fertility. Soil fertility is essential as a substrate for plant growth to support reforestation or reclamation initiatives. After the planting medium is properly prepared, it can be inhabited with plant species appropriate for the site's conditions. This study's methodology involves assessing land conditions through the analysis of soil characteristics and the measurement of soil pH in the designated area. The study's results indicated that the soil texture in the research region is classified as sandy loam and loamy sand, with an average pH of 4.5. To enhance soil conditions, 100 grams of lime is necessary for each planting hole, totaling 625 trees. Therefore, 62.5 kg of dolomite lime per hectare is required for soil rehabilitation in the post-mining region.

Keywords: Soil, Post-Mining Land, Fertilizer, Dolomite Lime

1. INTRODUCTION

The environmental damage caused by mining activities can be seen in the deterioration of land quality, reflected in the decline of physical, chemical, and biological properties of the soil. The mining system used is open-pit mining (surface mining), which disrupts soil conditions, leading to soil compaction due to heavy equipment activity on its surface.

Soil management aims to restore acidic and nutrient-deficient soil, improving fertility through fertilization. The nutrient status in soil constantly changes depending on seasons and land management practices. Soil serves as a medium for plant growth and a supplier of nutrients. Based on particle size, soil is a mixture of sand, silt, and clay.

Soil fertility can be assessed through soil testing and analysis. Certain chemical elements in soil can be toxic to plant growth, triggered by high soil acidity resulting from oxidation of sulfide-containing compounds. The chemical properties of sulfide-bearing soil can be identified by measuring pH levels to determine soil acidity. Based on test results, appropriate fertilization can be recommended based on soil conditions.

Given this context, it is necessary to manage and improve soil conditions in former mining areas to provide a fertile medium for plant growth. The key issue to be studied here is how land management can enable its use as a planting medium. The aim of this research is to determine the type and dosage of fertilizer required for former coal mining land, referring to soil acidity test results.

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In former coal mining land, recovery efforts must include lime application as an initial step to support plant growth. The commonly used type of lime is dolomite lime. The application of dolomite lime can increase soil pH, reduce aluminum saturation, increase calcium and magnesium levels, and improve soil physical and biological properties. According to research by Ramadhan (2017), dolomite lime application can raise soil pH from 4.5 to 5.6. Another study (Lawing, Y.H., 2021) found that dolomite lime increased soil pH from an acidic level of 4.47 to a range of 5.3-6.2.

2. RESEARCH METHOD

The materials used include dolomite lime to neutralize soil pH, a pH meter to measure soil acidity levels, a soil acidity classification table, and chemical soil fertility range criteria to compare with the pH conditions of the research area. The research was conducted at CV. Indra Berjaya, located in Anggana Village, Anggana District, Kutai Kartanegara Regency, East Kalimantan Province, covering approximately 100 hectares. The study was carried out in Seam 22 R07, a former coal mining site that has undergone revegetation.

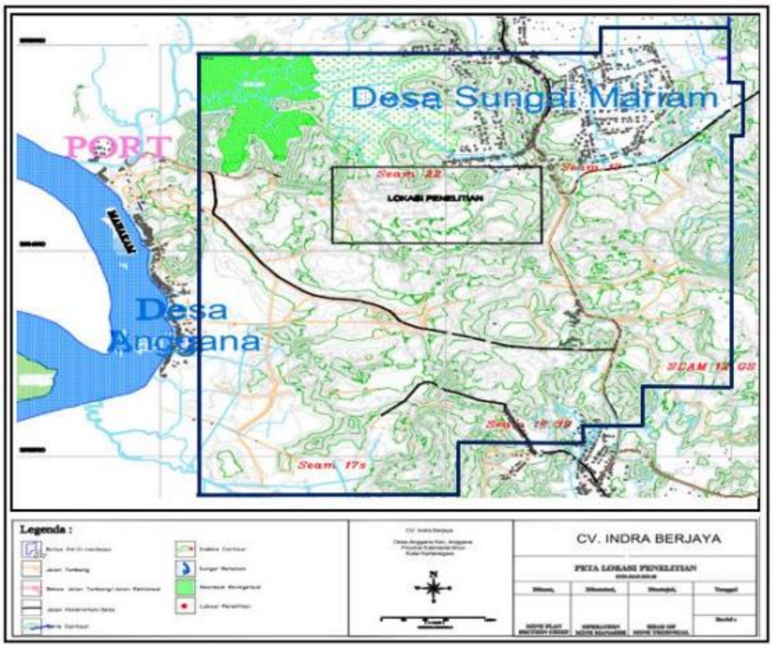

Figure 1. Research Location

The first stage in managing former mining land involves identifying the type of soil in the research area to assess its potential for soil restoration. The second stage includes a general analysis of the post-mining soil conditions, covering factors such as soil texture, structure, and acidity levels. The next step is to develop a strategy for improving land quality through fertilizer application.

This study employs a descriptive comparative method, where soil analysis data is compared with a soil acidity classification table to assess soil fertility status. Post-mining land has extreme characteristics, making it difficult for most tree species to grow properly. Three extreme conditions in post-mining land include: Soil acidity levels below pH 3, Incomplete land structuring, Low water retention capacity of the soil. These extreme conditions can be

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addressed by improving soil quality through lime application or the addition of organic materials (Mansur, 2010).

The chemical condition of former mining land indicates low soil fertility, low pH, and nutrient deficiencies, alongside high levels of heavy metals due to sulfide solutions. Essential nutrients such as Sulfur (S), Nitrogen (N), and Phosphorus (P) are limited, and the soil reaction remains acidic. Soil acidity leads to an increase in Iron (Fe) or similar iron compounds, which originate from damaged soil due to rainfall, producing sulfuric acid (Mansur, 2010).

Soil pH levels are influenced by the presence of H^+ (hydrogen ions) and Al^{3+} (aluminum ions) in the soil solution, along with other elements in the soil. The concentration of H^+ and OH^- ions, soil minerals, rainfall, and parent materials all contribute to soil acidity. The parent material determines soil pH based on its mineral composition, nitric acid from rainfall, organic matter, and soil texture. Clay-textured soil has colloids with a high cation exchange capacity (CEC), allowing soil with abundant cations to dissociate, leading to acidic reactions. Lime application is necessary to neutralize soil acidity, eliminate the toxic effects of aluminum (Al), and directly supply calcium (Ca) for plants. Problems caused by acidic soil include aluminum toxicity, which leads to high aluminum saturation. Aluminum toxicity directly damages plant roots, inhibits growth, and obstructs calcium and phosphorus absorption and translocation.

Table 1. Soil Acidity Classification

pH	**Classification**
< 4.5	Very Acidic
4.5 – 5.5	Acidic
5.6 – 6.5	Slightly Acidic
6.6 – 7.5	Neutral
7.6 – 8.5	Slightly Alkaline
> 8.5	Alkaline

When soil becomes excessively acidic, certain methods are employed to reduce acidity levels, such as the application of fertilizers and lime. The fertilizers used are generally organic, as they can improve the chemical, physical, and biological properties of the soil. Organic fertilizers can include poultry manure, cattle manure, or compost. The use of organic fertilizers and lime (calcite/dolomite) is essential since they can reduce the solubility of toxic substances (Fe, Al, and Mn), preventing toxicity to plants and environmental contamination. Mine tailings are generally acidic due to sulfide metal oxide content. Since plants rarely grow well in soil with a pH ≤ 4.5, an increase in pH above 4.5 is necessary. Adding various types of lime is the most effective way to improve soil pH. The acidic and basic properties of tailings determine the need for lime (Directorate General of Mineral and Coal, 1993). The chemical quality of post-coal mining land gradually improves in line with the progression of revegetation (Adman & Gunawan, 2010). Soil condition improvements include increasing soil aeration, applying topsoil and organic matter, as well as base fertilization and lime application. If the soil is too acidic, liming is required. The types of lime used to raise soil pH are calcite and dolomite. The required amount of calcite and dolomite depends on the acidity level, soil type, and plant species.

3. RESULTS AND DISCUSSION

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1. Soil Physical Properties

- Soil Texture The analysis of soil physical properties at the IUP PT. Indra Berjaya site shows that the dominant soil particle fractions are silt and clay. The soil texture falls into the categories of loamy sand and sandy loam.
- Soil Permeability The permeability of the surface layer of the backfilled soil is classified as slow to moderate, with a value of 3.83 cm/hour. Clay-textured soils, due to their finer particle size, have a larger surface area per unit weight, giving them a strong ability to retain water (Hardjowigeno, 2007). However, soils with a high clay content make root development difficult, as the roots struggle to spread due to low soil porosity. Plant roots also face challenges in penetrating dense soil structures, preventing proper root system development. The clay content tends to contribute to soil acidity (Tambunan, 2008).

2. Soil Chemical Properties

a. Soil pH

The soil in the IUP PT. Indra Berjaya area is acidic, with a pH range of 4.26 - 4.63 (classified as very acidic to acidic). Soil fertility indicates the potential presence of elements that may be toxic to plant growth, particularly due to high soil acidity caused by the oxidation of sulfide-containing compounds, such as pyrite. The chemical characteristics of soils containing sulfide minerals can be identified through pH measurements in H_2O_2, which result in highly acidic conditions. During reclamation, a precise analysis of lime requirements is essential to ensure that soil pH aligns with the needs of the intended plant species. Soil acidity is a key chemical property influencing soil fertility status. Higher acidity increases the solubility of metals, which may become toxic to plants (Ministry of Environment, 2005). Low soil pH leads to high solubility of Fe and Al, causing iron and aluminum toxicity symptoms (Rosmarkam & Yuwono, 2002).

b. Nitrogen, Phosphorus, and Potassium Content

Soil sample analysis at PT. Indra Berjaya indicates the following nutrient levels: Nitrogen (N): 0.04% (very low) to 0.07% (very low) Phosphorus (P): 3.28 ppm (very low) to 5.32 ppm (low) Potassium (K): 34.27 ppm (moderate) to 54.29 ppm (high)

3. Soil Improvement

a. Use of Fertilizers and Agricultural Lime

The restoration of post-mining land through the application of appropriate doses of organic and inorganic fertilizers, along with proper plant maintenance, can enhance the chemical and biological properties of soil disturbed by mining activities, making it suitable and beneficial for revegetation (Lawing, Y. H, 2020). Fertilization is carried out to stimulate plant growth and should be spread around the plants at a distance of approximately 10 - 15 cm from the plant stem.

Chemical soil analysis has shown that the soil in the IUP PT. Indra Berjaya area lacks nitrogen (N) and phosphorus (P). To fulfill these nutrient deficiencies, in addition to the initial application of dolomite lime, the selection of animal manure and NPK fertilizers can be utilized both before planting and during maintenance. Fertilization is performed twice a year—initial fertilization (manure) at planting and again at six months. NPK fertilizer is applied to pioneer and secondary plants. The cover soil in the study area is acidic, with an average pH of 4.5, and features sandy loam and loamy sand textures.

Dolomite lime is a source of calcium (Ca) at 30% and magnesium (Mg) at 19%, which helps increase soil pH. The finer its particles, the better its effectiveness. Lime application is carried out by mixing it with soil in the plow layer, a method that accelerates soil reaction

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(Rosmarkam & Yuwono, 2002). Soil calcium fertilization is more efficient because Ca is absorbed directly through the roots into the plant. If the soil has an acidity level of pH <5, 100 grams of dolomite lime per planting hole should be added to facilitate nutrient absorption by plant roots (Sumarna, 2012).

If lime is applied to each planting hole, the total lime requirement is calculated as follows: 100 grams/hole × number of plants per hectare = 100 grams/hole × 625 plants = 62,500 grams/planting hole Thus, 62.5 kg/ha of dolomite lime is required for application in each planting hole.

b. Soil Fertility Level

The nitrogen (N) content ranges from 0.04% to 0.07% (very low), while the phosphorus (P) content ranges from 3.28 ppm to 5.32 ppm (very low).

Nitrogen (N)

The nitrogen (N) in soil originates from organic matter, biological fixation by microorganisms, fertilizers, and rainwater (Hardjowigeno, 2007). Based on soil analysis, the total nitrogen content in the study area is very low. This condition arises due to the vegetation contributing organic matter to the soil being nitrogen-poor, as well as the limited organic matter supply from growing vegetation, which has not fully decomposed. Additionally, climatic conditions, such as rainfall, influence nitrogen content in the soil by washing nitrogen away with water.

Phosphorus (P)

The optimal availability of this essential nutrient for plants occurs at a pH range of 5.5 - 7.0. The available phosphorus (P) content in the study area is very low, mainly because the soil originates from parent material (rocks/minerals) with low phosphorus levels. As a result, only a small fraction of soil phosphorus exists in a soluble form (available P).

One of the main factors influencing phosphorus availability is soil pH. Phosphorus is readily absorbed at near-neutral pH levels (6 - 7). In acidic soils, phosphorus binds with aluminum (Al) and iron (Fe), rendering it unavailable for plant uptake during growth. One effective solution to this problem is to increase phosphorus availability through fertilization. Phosphorus deficiency (Hardjowigeno, 2007) can lead to stunted plant growth and dwarfism.

Table 2. Criteria for Soil Chemical Fertility Classes

Chemical Properties	Very Low	Low	Moderate	High	Very High
C (%)	< 1	1 - 1.9	2.0 - 3.0	3.01 - 5.0	> 5
N (%)	< 0.1	0.1 - 0.2	0.2 - 0.5	0.51 - 0.75	> 0.75
C/N Ratio	< 1.5	1.5 - 10	11 - 14	15 - 50	> 50
P_2O_5 Brai 1 (ppm)	< 10	10 - 15	16 - 25	26 - 35	> 35
K_2O HCl 25% (meq/100g)	< 10	10 - 20	21 - 40	41 - 60	> 60
CEC (Cation Exchange Capacity) (meq/100g)	< 5	5 - 16	17 - 24	25 - 40	> 40
Na (meq/100g)	< 0.1	0.1 - 0.3	0.4 - 0.7	0.8 - 1.0	> 1.0
Mg (meq/100g)	< 0.4	0.4 - 1.0	1.1 - 2.0	2.1 - 8.0	> 8.0
Ca (meq/100g)	< 2	2 - 5	6 - 10	11 - 20	> 20
Base Saturation (%)	< 20	20 - 35	36 - 50	51 - 70	> 70
pH	4.5 - 5.5	5.6 - 6.5	6.6 - 7.5	7.6 - 8.5	> 8.5

Based on soil chemical analysis, it is concluded that the soil fertility level in the study area is very low, with a pH below 5. Therefore, 100 grams of lime should be applied to each planting

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hole before planting. One week after lime application, well-matured organic fertilizer can be added. The organic fertilizer used comes from cattle manure or broiler chicken manure. The organic fertilizer is left for 1-2 weeks, after which plant seedlings can be planted in each hole (Lawing, Y.H., 2020).

4. CONCLUSION

From the research results, it is concluded that the study area has an average soil pH of 4.5. To increase soil pH, 100 grams of dolomite lime per hole should be applied. Chicken manure can be added to improve soil structure. Later, when the plants mature, NPK fertilizer will be necessary to stimulate plant growth.

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