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The Effectiveness of Post-Coal Mining Land Reclamation at PT. Jhonlin Baratama, Tanah Bumbu Regency

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Abstract

Coal mining alters environmental conditions, making land reclamation essential for restoring the functions of mined land. This study evaluated the effectiveness of post-mining reclamation at the Trambesi Pit operated by PT Jhonlin Baratama in Tanah Bumbu Regency. The descriptive quantitative assessment used 14 parameters covering soil quality, water quality, and revegetation. Soil quality scored 12 of 21 possible points, water quality 11 of 15, and revegetation 5 of 6. The overall score of 28 out of 42 (66.7%) classified reclamation at the site as effective under the assessment criteria. Soil organic carbon, phosphorus, potassium, and permeability, along with water turbidity, were identified as priorities for improvement. These findings can guide the company's soil management, water quality control, and vegetation maintenance to support the sustainable recovery of the site.

Keywords: Land Reclamation; Coal Mining; Soil Quality; Water Quality; Revegetation

INTRODUCTION

Coal mining is one of the economic activities that contributes to national development, particularly in South Kalimantan, a region with substantial coal resources. Nevertheless, open-pit mining activities can substantially alter landforms, disrupt soil structures, accelerate erosion, and reduce soil fertility, thereby affecting ecosystem stability (Thamrin & Raden, 2018). These environmental consequences indicate that mining activities

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should not be viewed solely in terms of mineral extraction and economic benefits but also in relation to long-term environmental management. Although coal mining generates employment opportunities and contributes to regional economic development, it also causes ecological disturbances, including land degradation and biodiversity loss (Yudhiman et al., 2023). Furthermore, the removal of topsoil during land clearing can deteriorate the physical and chemical properties of soil, consequently limiting vegetation growth in post-mining areas (Putra & Nuraini, 2017).

Post-mining land reclamation represents an essential measure for addressing these environmental impacts. It involves a series of activities aimed at reshaping, rehabilitating, and restoring disturbed land so that it can regain its environmental functions in accordance with its intended designation. The success of reclamation largely depends on the suitability of the applied techniques to the ecological characteristics of the affected land (Hirfan, 2016). Beyond fulfilling regulatory obligations, reclamation also represents a mining company's responsibility to maintain environmental sustainability and restore land productivity (Khotimah & Widayati, 2022). Accordingly, reclamation activities require systematic evaluation to determine whether the implemented restoration measures have achieved their intended environmental objectives (Rizki & Firmansyah, 2021).

In practice, reclamation outcomes vary across mining locations, indicating that the implementation of restoration measures does not always guarantee successful environmental recovery. Misbakhul et al. (2017) identified several challenges in reclamation projects across Indonesian mining areas, particularly concerning reclamation technologies and community participation. Similarly, Nugroho and Yasir (2017) highlighted that the existing criteria for evaluating post-mining reclamation in Indonesia do not fully represent the principles of ecological restoration. Research by Setyowati et al. (2017) further emphasized the importance of selecting plant species according to land characteristics, supported by appropriate maintenance and monitoring practices. These findings suggest that reclamation assessment should consider actual environmental conditions rather than merely examining the implementation of technical activities.

A comprehensive reclamation assessment requires indicators capable of objectively representing the extent of environmental recovery. Regarding soil conditions, physical characteristics and soil moisture may change as reclamation sites mature and vegetation develops (Sofya et al., 2017). Tambunan (2022) demonstrated that appropriate planting

schedules and vegetation maintenance are important elements of post-mining land reclamation. Furthermore, Burger et al. (2014) showed that soil and vegetation characteristics can serve as indicators of reclamation success by comparing restored areas with undisturbed reference sites. These findings establish soil quality as a fundamental component in determining whether reclaimed land can adequately support vegetation growth.

Water quality is another essential component because mining activities may generate acid mine drainage and increase the risk of environmental contamination. Silvia et al. (2016) found that reclamation in surface coal mining areas could improve soil quality and biodiversity, although erosion management remained an important concern. Changes in vegetation conditions also require attention, as long-term vegetation development can indicate the extent of ecosystem recovery following reclamation (Wilson et al., 2018). In addition, the recovery of soil microbial communities provides valuable information about the ecological condition of reclaimed mining soils (Jones et al., 2020). These findings demonstrate that reclamation assessment should incorporate interconnected environmental components rather than rely on a single indicator.

Soil, water, and vegetation collectively constitute an interconnected ecological system. Research on ecosystem services in reclaimed coal mining areas indicates that environmental restoration involves not only improvements in physical land conditions but also the recovery of ecological functions (Gupta et al., 2022). The effectiveness of reclamation is likewise influenced by the implementation of technical measures and their ability to improve the physical, chemical, and biological properties of soil (Islami et al., 2023). However, achieving the required environmental standards across multiple indicators remains a challenge in reclamation practices (Utin & Dyah, 2025). Therefore, an integrated assessment approach is necessary to provide a more comprehensive understanding of reclamation performance.

The research gap addressed in this study concerns the tendency of previous research to examine post-mining reclamation through separate dimensions, including soil characteristics, revegetation techniques, plant selection, and reclamation policies. Such approaches provide valuable insights but do not always explain how soil and water conditions interact with vegetation development throughout the ecosystem restoration process. Tang et al. (2025) emphasized the importance of jointly evaluating soil and vegetation recovery to assess ecosystem stability. The degradation of post-mining soils, particularly changes in their

physical and chemical properties, further demonstrates the need to examine multiple soil parameters (Rama et al., 2025). Moreover, understanding soil characteristics in relation to environmental conditions is essential for developing appropriate reclamation management strategies (Gunawan & Susanti, 2023). Consequently, further research is required to integrate soil quality, water quality, and revegetation quality into a unified assessment of reclamation effectiveness at a specific mining site.

The novelty of this study lies in the integration of three major environmental components—soil quality, water quality, and revegetation quality—to assess the effectiveness of post-coal-mining reclamation at the Trambesi Pit of PT Jhonlin Baratama. Water quality is incorporated because its characteristics influence environmental conditions and vegetation development in reclaimed areas (Lestari et al., 2024). Particular attention is also given to acid mine drainage, as acidic water conditions may inhibit vegetation growth and disrupt aquatic organisms (Sari et al., 2024). Meanwhile, plant survival and growth percentages provide an indication of vegetation adaptability to post-mining environmental conditions (Azhar et al., 2023). The integration of these components is grounded in ecosystem ecology, which conceptualizes the environment as an interconnected system in which biotic and abiotic components interact to maintain ecological functions and stability.

In response to these issues, this study employs a descriptive quantitative approach to examine the effectiveness of post-coal-mining land reclamation at the Trambesi Pit of PT Jhonlin Baratama, Tanah Bumbu Regency, South Kalimantan. Specifically, it evaluates soil quality, water quality, and revegetation quality through predetermined indicators and combines the assessment results to determine the overall level of reclamation effectiveness. An integrated approach is particularly relevant because ecosystem recovery depends on the interactions among soil conditions, water availability, and vegetation development (Sassenrath et al., 2023; Camila et al., 2023). These interactions are also reflected in changes in vegetation structure associated with soil characteristics in reclaimed areas (Yunanto et al., 2022). The findings are expected to provide empirical evidence of reclamation effectiveness and serve as an evaluation basis for improving the company's post-mining environmental management practices.

METHODS

This study employed a survey method using a descriptive quantitative approach. The survey method was selected because the research data were obtained through direct field observations and measurements of the biophysical conditions of post-coal-mining reclamation land. The descriptive quantitative approach was used to describe soil quality, water quality, and revegetation conditions, and subsequently assess reclamation effectiveness based on field measurements and laboratory test results. The study focused on the reclamation area of PIT Trambesi, operated by PT Jhonlin Baratama, at the Sungai Dua Site, Tanah Bumbu Regency, South Kalimantan, Indonesia.

The research design was developed around one main variable, namely the effectiveness of post-mining land reclamation, which was operationalized through three biophysical parameters. Soil quality was assessed using seven indicators: soil pH, organic carbon (C-organic), nitrogen (N), phosphorus (P), potassium (K), permeability, and soil texture. Water quality comprised five indicators: pH, carbon dioxide (CO_2), ammonia (NH_3), turbidity, and sulfate (SO_4). Revegetation was evaluated using two indicators: plant species composition and the percentage of plant growth. These parameters were used to describe the condition of the growing medium, the quality of the aquatic environment, and vegetation development within the reclamation area. The calculation of plant growth percentage followed the formula presented by Selong and Lawing (2023), while the classification of plant species composition referred to Kissinger (2022). The final assessment of reclamation effectiveness was based on the classification proposed by Sihotang (2025).

The study population comprised all post-coal-mining reclamation areas operated by PT Jhonlin Baratama, covering 103.14 hectares. The research sample was selected through non-probability sampling using a purposive sampling technique. The selected site was PIT Trambesi, which covers 55.2 hectares. This area was chosen because it represents the largest reclamation area among the company's reclamation pits, had entered the post-mining reclamation stage, and had undergone land maintenance. These characteristics provided suitable conditions for examining soil, water, and vegetation parameters. Accordingly, the sampling unit was a reclamation area rather than human participants.

Data were collected through field surveys, land-condition measurements, soil and water sampling for laboratory testing, vegetation observations, documentation, and the use of secondary data provided by the company. The research equipment included a laptop,

Microsoft Excel, a mobile-phone camera, and Avanza Maps. Primary data were used to describe the actual conditions of the research site, while secondary data served as supporting information for the reclamation assessment. The thesis does not provide information regarding instrument validity and reliability testing.

Data were analyzed using descriptive quantitative analysis by comparing measurement and laboratory results with the assessment criteria adopted in the study. Each soil and water indicator was classified as low, moderate, or high and assigned a score of 1, 2, or 3, respectively. Plant growth percentage was calculated by dividing the number of surviving plants by the total number of plants initially planted and multiplying the result by 100%. Plant species composition was also scored according to the established categories. Scores from all three parameters were aggregated to determine reclamation effectiveness using the ratio of the total score obtained to the maximum possible score, multiplied by 100%. The resulting percentage was classified into four levels: ineffective, moderately effective, effective, and highly effective.

RESULTS

Research Location

The research was conducted in the PIT Trambesi reclamation area, located in Simpang Empat District, Tanah Bumbu Regency, South Kalimantan Province, Indonesia. The administrative location of the research area is presented in Figure 1.

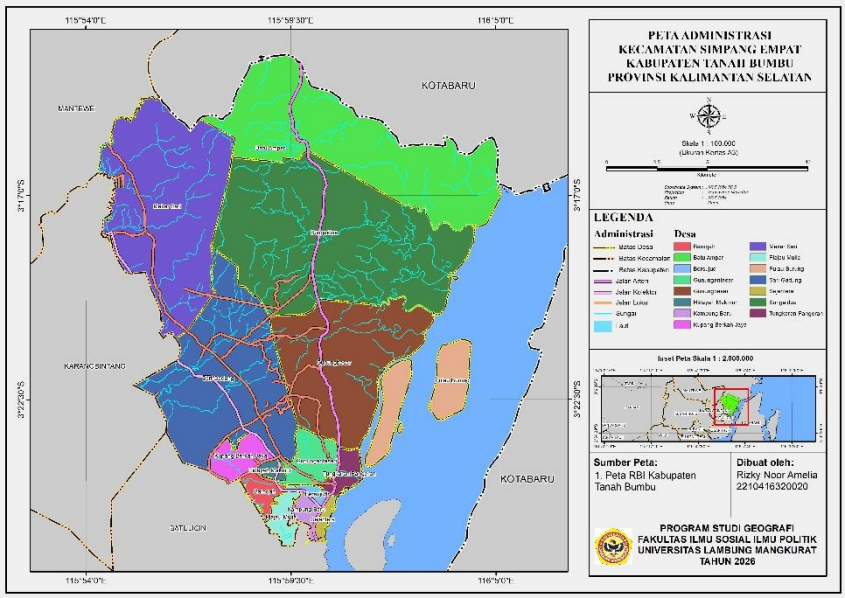

Figure 1. Administrative Map of Simpang Empat District, Tanah Bumbu Regency, South Kalimantan Province

Figure 1. Administrative Map of Simpang Empat District, Tanah Bumbu Regency, South Kalimantan Province shows the administrative location of Simpang Empat District, Tanah Bumbu Regency, South Kalimantan Province, where the PIT Trambesi reclamation area is located. The map provides an overview of the geographical position of the research area within the administrative boundaries of Tanah Bumbu Regency. This location serves as the basis for assessing post-coal-mining land reclamation effectiveness through three main aspects: soil quality, water quality, and revegetation.

Soil Quality

Table 1. Soil Quality Assessment Results in the PIT Trambesi Reclamation Area

Indicator	Measurement Results	Category	Score
Soil Ph	6.8	Neutral	3
Organic carbon (C-organic)	1.87%	Low	1
Nitrogen (N)	0.25%	Moderate	2
Phosphorus (P)	24.59 mg/100 g	Low	1
Potassium (K)	8.12 mg/100 g	Low	1
Permeability	1.84 cm/hour	Low	1
Soil texture	Silty clay loam	High	3

Source: Compiled by the researcher (2026)

Table 1. Soil Quality Assessment Results in the PIT Trambesi Reclamation Area shows that soil quality in the PIT Trambesi reclamation area obtained a total score of 12 out of a maximum

possible score of 21. Soil pH and soil texture received the highest scores, while organic carbon, phosphorus, potassium, and permeability were classified as low. Nitrogen was classified as moderate.

Water Quality

Table 2. Water Quality Assessment Results in the PIT Trambesi Reclamation Area

Indicator	Measurement Results	Category	Score
Water pH	7.6	Alkaline	2
Carbon dioxide (CO_2)	2.20 mg/L	High	3
Ammonia (NH_3)	0.08 mg/L	Moderate	2
Turbidity	104 NTU	High	1
Sulfate (SO_4)	35 mg/L	Low	3

Source: Compiled by the researcher (2026)

Table 2. Water Quality Assessment Results in the PIT Trambesi Reclamation Area shows that water quality obtained a total score of 11 out of a maximum possible score of 15. Carbon dioxide and sulfate received a score of 3, while water pH and ammonia received a score of 2. Turbidity received the lowest score of 1.

Revegetation

Table 3. Revegetation Assessment Results in the PIT Trambesi Reclamation Area

Indicator	Measurement Results	Category	Score
Plant species composition	11 species	High	3
Plant growth percentage	79%	Moderate	2

Source: Compiled by the researcher (2026)

Table 3. Revegetation Assessment Results in the PIT Trambesi Reclamation Area shows that revegetation obtained a total score of 5 out of a maximum possible score of 6. The reclamation area contained 11 plant species, while the plant growth percentage reached 79%. Of the 3,837 plants initially planted, 3,024 were recorded as surviving.

Overall Reclamation Effectiveness

Table 4. Summary of the Reclamation Effectiveness Assessment at PIT Trambesi

Assessment Aspect	Number of Indicaators	Total Score	Maximum Score
Soil quality	7	12	21
Water quality	5	11	15
Revegetation	2	5	6
Total	**14**	**28**	**42**

Source: Compiled by the researcher (2026)

Table 4. Summary of the Reclamation Effectiveness Assessment at PIT Trambesi shows that the overall reclamation assessment obtained a total score of 28 out of a maximum possible score of 42. Based on this comparison, the effectiveness of reclamation reached 66.67%, equivalent to approximately 67%. This percentage falls within the range of 61–80%, indicating that post-coal-mining land reclamation at PIT Trambesi is classified as effective.

DISCUSSION

The findings indicate that post-coal-mining land reclamation at PIT Trambesi achieved an effectiveness score of 66.67%, placing it within the effective category. This result suggests that reclamation activities have contributed positively to the recovery of the site's biophysical conditions, although restoration has not yet reached an optimal level across all indicators. Assessing soil quality, water quality, and revegetation together provides a broader understanding of reclamation performance than relying solely on the presence of vegetation. These components are interdependent: soil provides the physical medium and nutrients required for plant growth, while water conditions influence ecological processes and vegetation sustainability. This integrated perspective is consistent with the view that post-mining land recovery should be evaluated through the relationships among soil, water, and vegetation (Sassenrath et al., 2023; Camila et al., 2023).

The soil quality score of 12 out of 21 indicates that the reclaimed area has several characteristics that support vegetation growth, but still faces limitations in certain chemical and physical properties. The soil pH of 6.8, classified as neutral, represents a relatively favourable condition for plant development. Nitrogen content of 0.25% was classified as moderate, suggesting that this macronutrient was available at a reasonable level according to the study's assessment criteria. However, organic carbon (1.87%), phosphorus (24.59 mg/100 g), potassium (8.12 mg/100 g), and permeability (1.84 cm/hour) were all classified as low. These findings demonstrate that reclamation success cannot be determined by soil pH alone, as soil fertility also depends on organic matter, nutrient availability, and physical characteristics. This interpretation supports Rama et al. (2025), who discuss the depletion of organic matter and nutrients as characteristics of post-mining soil degradation, and Aryanti and Hera (2019), who emphasize the importance of soil physical and chemical properties for plant growth.

The low levels of organic carbon, phosphorus, and potassium indicate that the growing medium still requires improvement. Organic matter contributes to soil quality, while phosphorus and potassium are essential nutrients for plant development and physiological processes. Limited phosphorus availability may affect root development and plant metabolism, whereas potassium supports several physiological functions. These conditions highlight the importance of maintaining soil fertility throughout the reclamation process rather than focusing exclusively on the initial planting stage. Organic amendments and fertilizers may be considered as potential improvement measures, provided that their application is guided by soil test results and the actual requirements of the site. This interpretation is consistent with Maulidan and Putra (2024), who discuss the role of phosphorus in plant growth, and Lutfi et al. (2021), who identify potassium as an essential macronutrient.

Low soil permeability is another important finding because it indicates a limited capacity for water to move through the soil. In reclaimed areas, this condition may affect water infiltration and increase the potential for surface runoff during rainfall. Runoff may transport soil particles into nearby water bodies and contribute to increased turbidity. Therefore, permeability should not be interpreted in isolation but considered alongside water quality and vegetation conditions. The relationship between soil physical properties, erosion, and water movement is discussed by Syam et al. (2018), while Yunanto et al. (2025) identify soil characteristics as factors associated with vegetation structure and composition in reclaimed areas. In contrast, the silty clay loam texture recorded at PIT Trambesi received the highest score under the study's classification. Although this result represents a favourable texture classification, it does not negate the limitation indicated by the low permeability value.

Water quality obtained a score of 11 out of 15, indicating that most assessed parameters received relatively favourable scores, although turbidity remained a major concern. The water pH of 7.6 was classified as alkaline, while ammonia concentration of 0.08 mg/L was classified as moderate. Sulfate concentration of 35 mg/L received a score of 3, indicating a low concentration under the criteria adopted in this study. This finding is relevant to post-mining environmental assessment because elevated sulfate concentrations may be associated with sulfide mineral oxidation and acid mine drainage formation. Nevertheless, periodic sulfate monitoring remains necessary as part of water quality management. The importance of water quality in post-mining environmental recovery and the risks associated

with acid mine drainage are discussed by Lestari et al. (2024) and Sari et al. (2024), while Oktariani et al. (2025) emphasize sulfate management in addressing acid mine drainage.

Turbidity, recorded at 104 NTU and classified as high with a score of 1, was the water quality indicator requiring the greatest attention. High turbidity indicates the presence of suspended particles, which may originate from soil material or sediment entering the water body. This result can be considered alongside the low soil permeability, since limited infiltration may increase surface runoff and the transport of soil particles. However, this relationship represents an interpretation of the measured conditions rather than direct evidence of the sediment source. Further monitoring should therefore examine drainage channels, land-surface stability, and vegetation cover. Munggaran et al. (2024) associate high turbidity in post-mining areas with erosion and sedimentation, whereas Nair et al. (2024) relate decreasing turbidity to improvements in soil stability and water quality.

Revegetation received a score of 5 out of 6. The presence of 11 plant species was classified as high, whereas the plant growth percentage of 79% was classified as moderate. This difference indicates that species composition has reached a favourable classification, but plant survival has not yet reached the highest category. Consequently, revegetation success should not be evaluated solely by the number of species present; it should also consider plants' ability to survive and develop under post-mining conditions. The recorded species diversity indicates variation in the vegetation established at the site, while the 79% growth rate suggests that a proportion of planted individuals did not survive. This finding is consistent with Azhar et al. (2023), who identify plant growth percentage as an indicator of adaptation and survival, and Kissinger (2022), who uses plant species composition to assess vegetation diversity in reclaimed areas. Selecting adaptable species and maintaining vegetation after planting remain important for sustaining reclamation outcomes (Budi Yuwono et al., 2021).

The main contribution of this study lies in applying an integrated assessment of soil quality, water quality, and revegetation to evaluate reclamation effectiveness at a specific operational site, PIT Trambesi. The overall score of 66.67% demonstrates that reclamation can be classified as effective even when several individual biophysical indicators remain below optimal conditions. This finding highlights the importance of assessing multiple components simultaneously, since an aggregate score may conceal specific weaknesses within individual indicators. In practical terms, the results can guide the company in prioritizing

improvements to soil organic matter and nutrient availability, strengthening runoff and sediment management, and monitoring plant survival. An integrated assessment is particularly relevant because environmental recovery after mining does not necessarily progress at the same rate across all ecological components (Utin & Dyah, 2025).

Several limitations should be considered when interpreting these findings. First, the study focused exclusively on PIT Trambesi, selected through purposive sampling. Therefore, the findings describe the conditions of this particular site and cannot automatically be generalized to all reclamation areas operated by PT Jhonlin Baratama. Second, the assessment employed 14 indicators across three biophysical parameters and did not cover every dimension of ecosystem recovery, such as faunal diversity, soil microbial activity, or long-term changes in land conditions. Third, some revegetation data were obtained from company records; consequently, the assessment depends on the completeness and accuracy of records concerning planted and surviving trees. Finally, the measurements represent the conditions during the data collection period and do not establish long-term recovery trends. Future studies could include additional reclamation sites, conduct periodic monitoring, and incorporate further ecological indicators to provide a more comprehensive evaluation of reclamation effectiveness.

CONCLUSION

This study concludes that post-coal mining land reclamation at the Trambesi Pit of PT Jhonlin Baratama, Tanah Bumbu Regency, was classified as effective, achieving an effectiveness score of 66.7%. The assessment of three principal aspects, namely soil quality, water quality, and revegetation, indicates that reclamation activities have contributed to land recovery, although several parameters still require improvement. Soil quality received a score of 12 out of 21, indicating that soil pH and texture were relatively supportive of vegetation growth, whereas organic carbon, phosphorus, potassium, and permeability remained at low levels. Water quality obtained a score of 11 out of 15, with turbidity identified as a parameter requiring further attention. Meanwhile, revegetation achieved a score of 5 out of 6, reflected in the presence of 11 plant species and an overall plant growth rate of 79%. These findings address the research objective of determining reclamation effectiveness through the assessment of soil conditions, water quality, and revegetation performance.

This study provides a practical contribution by presenting a measurable evaluation of reclamation outcomes and identifying environmental parameters that require priority management. Assessing these three interrelated aspects offers a more comprehensive perspective on reclamation effectiveness, extending beyond planting success to include the environmental conditions that support land recovery. The findings may serve as an evaluation reference for the company in developing appropriate land management and maintenance strategies. Accordingly, improvements should prioritize soil organic matter and nutrient availability, turbidity control through drainage and erosion management, and continuous vegetation maintenance. Future research should incorporate additional environmental indicators, broader observation areas, and longer monitoring periods to provide a more comprehensive understanding of post-mining ecosystem recovery and support more sustainable post-mining land management practices.

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