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Reclamation performance assessment at PT. Trubaindo Coal Mining in Melak field, West Kutai, East Kalimantan Province, Indonesia

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Abstract
Trubaindo Coal Mining Ltd. was established on March 13, 1990, as a subsidiary of Banpu Company. Based in Thailand, Banpu operates within the coal mining industry. Mining activities can have adverse effects, including habitat disruption for flora and fauna, morphological alterations, and reduced soil productivity. To mitigate these impacts, reclamation activities are essential. In compliance with PERMENHUT Number P.60/Menhut-II/2009 and the Minister of Energy and Mineral Resources Decree No. 1827 K/30/MEM/Year 2018, assessing the success of reclamation efforts is a critical step. This study aims to assess and evaluate reclamation activities conducted during the production operation phase at Trubaindo Coal Mining Ltd., focusing on land areas within Pit 3000 BK-04 NB and Pit 4500/P6200 BK03-04 SB1. The research employed a quantitative descriptive method, which included observations on land preparation, revegetation efforts, and final land stabilization. The findings revealed reclamation success rates of 87.3 and 83.1, indicating that the reclamation efforts were generally acceptable but required further improvements. Recommendations include soil pH correction, enhancement of drainage channels, and effective management of weeds, pests, and plant diseases.

1. Introduction

PT. Trubaindo Coal Mining (TCM) is a coal mining company that obtained its license from the Department of Mining on August 15, 1994, under Perjanjian Karya Pengusahaan Pertambangan Batubara (PKP2B) Contract No. 017/PK/PTBA-TCM/1994. The company's concession area spans 22,687 hectares and is located in Melak District, West Kutai Regency, East Kalimantan Province. This concession is divided into two regions: the Northern Block and the Southern Block. The PKP2B area of PT TCM lies within the Kutai Basin, which is geologically categorized based on the plate tectonic concept [1]. Consequently, PT TCM's mining activities are situated within an area formed by four primary rock formations derived from the Kutai beds.

The production operation stage of mining encompasses various activities, including construction, extraction, processing and/or refining, development and utilization, transportation, and sales. These activities also involve implementing environmental impact control measures as outlined in the feasibility study [2]. Mining activities inevitably alter the environment, causing habitat disruptions for flora and fauna, morphological changes, and reduced soil productivity. Therefore, reclamation becomes an essential part of mining operations [3]. Reclamation activities are initiated during the operational phase of mining and are carried out continuously until all mining activities have ceased [4]. These reclamation stages aim to restore the natural environment to its original state, as mandated by the Minister of Energy and Mineral Resources Regulation No. 26 of 2018 on the implementation of good mining practices and the supervision of minerals and coal [5]. Reclamation performance assessment is crucial to ensuring that reclamation efforts meet expectations. Thus, it is necessary to conduct assessments that measure the progress and effectiveness of reclamation activities performed by the company, with a focus on reclamation success using specific evaluation parameters.[6].

2. Literature Review

Reclamation

Reclamation is the process of restoring or rehabilitating degraded land and vegetation to ensure they function optimally in accordance with their designated purposes [7]. It encompasses activities conducted throughout the various stages of mining operations to organize, restore, and enhance the quality of the environment and ecosystems, enabling them to regain their intended functionality [8]. Reclaiming former mining areas goes beyond merely improving post-mining environmental conditions to create a healthy ecosystem. It also aims to enhance the environment to a state that surpasses its original condition, while taking into account the potential for remaining mineral resources.

Implementation of Reclamation in the Production Operation Phase

Reclamation involves a series of measures to stabilize mined land and is an integral component of the overall mining plan. This means that reclamation is not a separate, supplementary step, but an ongoing process that begins with the initial planning stage and continues through the extraction phase, culminating in the new land use after post-mining activities [9]. Reclamation activities encompass land contouring, topsoil management, sediment and erosion control, and cover crop planting. Landscaping efforts involve backfilling pits, landforming, ensuring slope stability, and managing the topsoil. The approach to topsoil management depends on the available volume of topsoil and the results of the overburden analysis [10] . Sedimentation and erosion processes during the third stage of reclamation are primarily caused by water, which leads to the detachment, transportation, deposition, and sedimentation of soil particles as a result of rainfall impact [11] . In cover crop planting, the effectiveness of these crops in supporting soil recovery is highly dependent on the level of soil degradation. It is recommended that cover crops be planted during the first and second years of the reclamation process [12]. The ultimate goal of reclamation is to restore mined land to a safe, stable condition that is resistant to erosion, making it suitable for future reuse [13].

Reclamation activities are executed in accordance with the approved annual environmental management plan (RTKPL) and must be completed within the designated timeframe. During the reclamation process, mining companies are accountable for ensuring that the agreed-upon conditions or final outcomes are met. The implementation of reclamation includes land stewardship, revegetation, and ongoing maintenance efforts [14].

Reclamation Performance Assessment

The assessment of reclamation performance refers to the Decree of the Minister of Energy and Mineral Resources No. 1827 K/30/MEM of 2018, which pertains to Good Mining Practices in Mineral and Coal Mining Activities. This assessment is divided into two categories: reclamation success criteria for the exploration stage and reclamation success criteria for the production operation stage. The success criteria for reclamation during the production operation stage are outlined in Matrix 16 of the Ministerial Decree No. 1827 K/30/MEM of 2018 on Good Mining Practices [15].

3. Methodology

The figure shown in the diagram, labeled "Figure 1", illustrates the methodology used in the study assessing the success rate of reclamation during the production operation stage at PT. Trubaindo Coal Mining, Melak District, West Kutai Regency, East Kalimantan Province. It outlines a structured process starting from literature review, through primary and secondary data collection, followed by data processing, and culminating in the formulation of conclusions and recommendations.

Research Type

This study uses a quantitative research method, where the researcher will directly visit the field to conduct research, collect samples, and test them at recognized institutions.

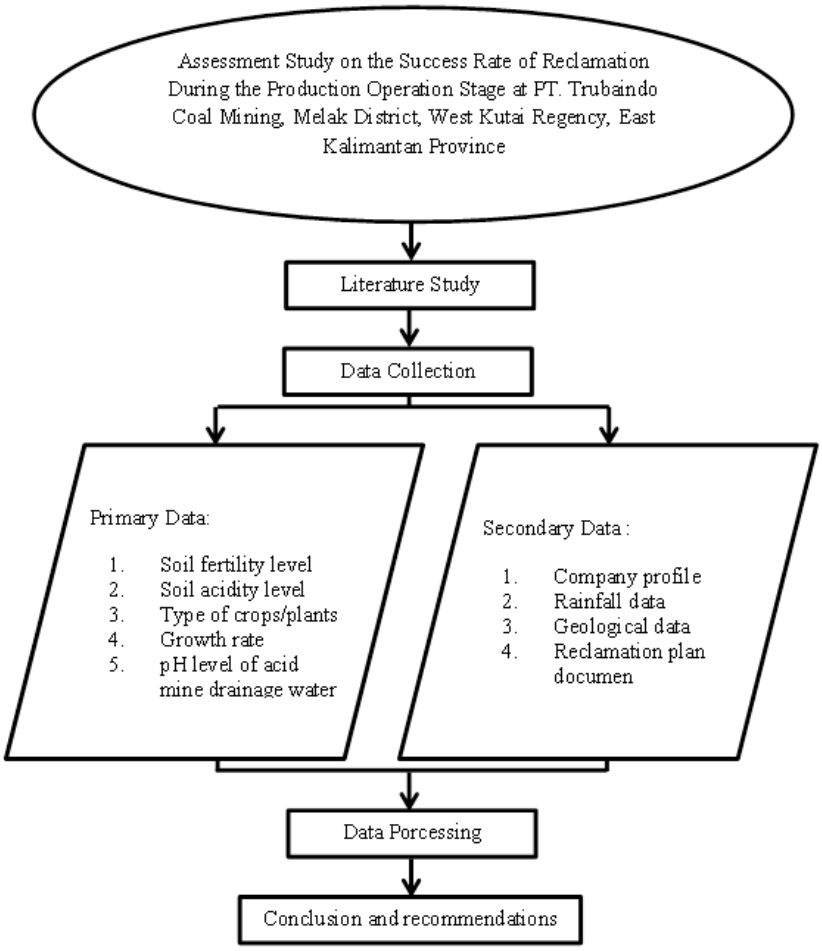

Figure 1. Flow chart of the Research

Data Processing

During the data processing stage, the data collected through field research undergo both descriptive and quantitative analysis to organize the research effectively. Specifically, for assessing the success level of reclamation operations, the data processing focuses on land reclamation, revegetation, and final settlement.

Data Analysis and Conclusion

The data analysis and conclusion stage aims to draw interim conclusions (analysis). These conclusions are further processed in the discussion section and referenced against the Reclamation Plan Document (RP). Final conclusions are drawn by correlating the results of data processing and laboratory tests with the research questions. These conclusions represent the final recommendations based on all the issues discussed. The data processing stages for the success rate of reclamation during the production operation phase include land stewardship, revegetation, and final settlement.

4. Results and discussions

Reclamation of Former Mining Land

The land surface management activities at PT. Trubaindo Coal Mining are focused on the rehabilitation of former mining areas. In 2022, reclamation activities at PT. Trubaindo Coal Mining targeted two areas: the Pit 3000 BK 04 NB stockpile area, covering 16.08 ha (160,800 m²), and the Pit 4500/Pit 6200 BK 03-04 SB1 stockpile area, covering 6.35 ha (63,500 m²). The primary material used for land arrangement is overburden (OB), mainly composed of sandstone, with some clay and silt materials. Additionally, soil tip material is employed for land contouring.

Figure 2. Reclamation Land of Pit 3000 BK 04 NBand Reclamation Land of Pit 4500/Pit 6200 BK 03-04 SB1

The actual area reclaimed was consistent with the planned area as outlined in the reclamation plan document: Pit 3000 BK 04 NB, covering 16.08 ha (160,800 m²), and Pit 4500/Pit 6200 BK 03-04 SB1, covering 6.35 ha (63,500 m²). PT. Trubaindo Coal Mining demonstrated exceptional performance in land arrangement activities, achieving 100% of the planned area, which is considered excellent. The stability of the embankments in the reclamation areas was ensured, with a topsoil thickness of 60 cm, meeting the required specifications, and no incidents of landslides occurred.

The successful reclamation of the specified areas in PT. Trubaindo Coal Mining, achieving 100% of the targeted land arrangement, aligns well with best practices noted in reclamation literature. Studies such as those by Persada et al. emphasize the necessity of achieving planned reclamation targets to ensure land stability and prevent erosion [6]. The absence of landslides and the maintenance of stable embankments at PT. Trubaindo are indicative of the effectiveness of the current practices. However, ongoing monitoring and adaptive management strategies are critical to maintaining these successes in the face of environmental changes and unforeseen ecological dynamics [4, 7].

Revegetation

In accordance with the Minister of Forestry and Plantation Decree No. 146 of 1999, "revegetation" refers to efforts aimed at restoring former mining areas through planting and maintenance activities. It involves a series of initiatives to enhance and rehabilitate the vegetation that has been damaged due to mining operations.

For the revegetation activities at PT. Trubaindo Coal Mining, plant selection is based on the suitability of the species to the soil type or planting medium. The plants used in the revegetation process include three categories: fast-growing plants, companion plants, and cover crops. Fast-growing plants are spaced 4x4 meters apart, while companion plants are planted at a spacing of 2x2 meters between the fast-growing species. Cover crops are introduced by direct seeding into the planting media or topsoil.

For the Pit 3000 BK 04 NB area, Johar wood is the chosen fast-growing plant, while Sengon wood is used for Pit 4500/Pit 6200 BK 03-04 SB1. Figure 2 provides a visual representation of the reclamation land at Pit 3000 BK 04 NB and Pit 4500/Pit 6200 BK 03-04 SB1, showcasing the areas where reclamation activities have been implemented. Figure 3 depicts the condition of vegetation at Pit 3000 BK 04 NB and Pit 4500/Pit 6200 BK 03-04 SB1, illustrating the progress and success of the revegetation efforts undertaken in these areas.

In evaluating the success of the revegetation process, PT. Trubaindo Coal Mining has achieved commendable results. The plant growth percentage for Pit 3000 BK 04 reached 97.91%, and for Pit 4500/Pit 6200 BK 03-04 SB1, it reached 96.9%. Based on these results, the company has met the standard for plant growth performance, as the target of over 90% was exceeded, earning a rating of 5 for the success of the revegetation efforts.

Figure 3. Plant condition of Pit 3000 BK4 NB Plant condition Pit 4500/Pit 6200 BK 03-04 SB1

The selection of plant species suitable for the specific soil types at PT. Trubaindo and the strategic spacing employed are commendable practices that have evidently contributed to the high growth rates observed. This is consistent with successful outcomes in similar contexts, such as the work by Dariah et al., which underscores the significance of selecting appropriate species to enhance biodiversity and ecosystem recovery on reclaimed lands [12]. The impressive growth rates exceeding 90% in both targeted areas surpass the standard benchmarks for plant growth performance in reclamation projects and mirror the findings from Wicaksono et al. about the importance of tailored revegetation strategies [14]. Nonetheless, literature suggests a need for long-term assessments beyond initial growth rates to evaluate the sustainability and ecological integration of the planted species, as discussed by Ido et al. [9]. Future strategies might benefit from incorporating diverse plant species to ensure broader ecological benefits and resilience [13, 15].

Reclamation Performance Assessment

In accordance with the Minister of Forestry Regulation No. P. 60/Menhut-II/2009, the reclamation performance assessment is conducted by evaluating the success of reclamation efforts in the field. This assessment follows the criteria outlined in the indicators for the success rate of reclamation during the production operation stage. The evaluation is then carried out using the following formula:

TN = TS/SM x N.....(1)

Description:

TN = Total Evaluation Score
TS = Total Score for Each Criterion
SM = Maximum Score for Each Task
N = Number of Criteria

The maximum possible total score is 100.

a. Pit 3000 BK 04 NB reclamation performance assessment
   1) For land arrangement, the value is calculated using the equation: value = $\frac{36}{40}\ x\ 60 = 54$
   2) For revegetation, the value is calculated using the equation: value = $\frac{20}{25}\ x\ 20 = 16$
   3) For maintenance, the value is calculated using the equation: value = $\frac{13}{15}\ x\ 20 = 17{,}3$

   Based on the calculation of the total evaluation score, the criteria and conclusions are as follows:
   - **Total score > 80**: Good (Reclamation implementation results are fully acceptable)
   - **Total score between 60 and 80**: Moderate (Reclamation implementation is accepted with recommendations for improvement)
   - **Total score < 60**: Poor (Reclamation results are unacceptable)

   After the evaluation, the total reclamation score is 87.3%, indicating that while the reclamation implementation is acceptable, further improvements are necessary.

b. Calculation of Pit 4500/Pit 6200 BK 03-04 SB1reclamation success score

1) For land arrangement, the value is calculated using the equation: Value = $\frac{35}{40}\ x\ 60 = 52{,}5$
2) For revegetation, the value is calculated using the equation: Value = $\frac{20}{25}\ x\ 20 = 16$
3) For maintenance, the value is calculated using the equation: Value = $\frac{11}{15}\ x\ 20 = 14{,}6$

The total assessment of reclamation after evaluation is 83.1%, which means that the results of reclamation implementation are acceptable but improvements are needed.

The use of a structured scoring system for evaluating reclamation success at PT. Trubaindo provides a quantifiable and systematic approach to assess the outcomes, similar to the methodologies employed by Zerizghy et al. [7]. The scores indicating that reclamation efforts are generally successful but recommend further improvements are particularly insightful. They align with the broader academic discourse that effective reclamation is an ongoing process requiring continuous improvement, as noted by Erong et al. [15]. Such assessments should not only focus on immediate post-reclamation outcomes but also include long-term monitoring to ensure that reclamation benefits persist and adapt over time [3, 11].

5. Conclusion

Reclamation activities on former mining land at Pit 3000 BK04, covering an area of 16.08 hectares, and Pit 4500/Pit 6200 BK 03-04 SB1, covering 6.35 hectares, began with land surface leveling, revegetation, and plant maintenance using Sengon and Johar tree species. The reclamation success rate, according to Minister of Energy and Mineral Resources Decree No. 1827 K/30/MEM/Year 2018, Matrix 16, is 87.3% for Pit 3000 BK04 and 83.1% for Pit 4500/Pit 6200 BK 03-04 SB1. These results are categorized as moderate, meaning the reclamation is generally acceptable, but improvements are required.

Recommendations for PT. Trubaindo Coal Mining include conducting evaluations on soil pH, drainage channels, and final completion processes such as weed, pest, and disease control. The soil pH in the reclamation areas shows acidic properties, with Pit 3000 BK04 having a pH of 4.2 and Pit 4500/Pit 6200 BK 03-04 SB1 a pH of 4.3. To raise the pH to a more normal level (around 6), dolomite lime is recommended. The required amount of dolomite lime is 6.19 tons/ha for Pit 3000 BK04 and 5.88 tons/ha for Pit 4500/Pit 6200 BK 03-04 SB1. The discussion has highlighted the importance of both maintaining current successful practices and incorporating adaptive management strategies to address potential future challenges. Recommendations for PT. Trubaindo include; Implementing long-term ecological monitoring programs to track the sustainability of revegetation efforts [9, 12]. Expanding the variety of plant species used in revegetation to enhance ecological resilience and biodiversity [13, 14]. Engaging with local communities and stakeholders to integrate traditional knowledge and preferences into reclamation planning, ensuring that the reclaimed land meets broader social and ecological needs [5, 8].

Further recommendations include periodic evaluations of erosion and sediment control. This can be achieved by cleaning sediment from drainage channels every three months and clearing vegetation in these areas. Additionally, regular checks for weeds, pests, and diseases should be conducted, with control measures implemented on a quarterly basis.

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