AVAILABILITY OF TOPSOIL FOR RECLAMATION OF FORMER PT XYZ MINING LAND, SUNGAI RAYA, SOUTH KALIMANTAN

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Abstract

Reclamation is one of the activities that must be carried out by mining companies. Reclamation is an activity that aims to return the former mining land to its initial hue and according to its designation. The process of returning ex-mining land requires soil that has good nutrients. Soil that contains good nutrients is on the surface called shoot soil. The reclaimed land of PT. XYZ covers an area of 145 Ha. This study aims to calculate the volume of topsoil needed for the reclaimed land of PT. XYZ and how much eroded soil is eroded so that the actual volume of topsoil can be known. The method used is to make a test pit to calculate the thickness of the topsoil. The volume of eroded soil is calculated using the USLE method. The data used for the USLE are rainfall data, drought factors, plant types, and soil conservation factors. The data required for the study were the thickness of the topsoil in a 21 Ha area and the annual rainfall. Thickness data collection with test wells. The number of test well points in an area of 21 Ha is 172 points. The determination of test wells is based on distance; the distance between test wells is 5 meters. The company's soil bank is 358,659 m3. The availability of topsoil volume in two pits is 101,253 m3. The eroded topsoil is 36,406 m3. The volume of topsoil needed in the reclamation process is 290,000 m3. The volume of soil that has been stored in the soil bank is totaled with the available topsoil minus the eroded topsoil, which is 423,506 m3. The topsoil available for land reclamation is sufficient so that the reclamation process can run well

Keywords: erosion, mining, reclamation, topsoil, volume

Introduction

Mining is an activity that changes the landscape, so a process is needed to restore it to its original hue, even though it cannot be done under the original conditions. The problems of land degradation and the threat of erosion are major challenges in coal mining operations, especially in tropical areas that experience high rainfall [1]. To address this, land reclamation is a crucial effort to restore the post-mining ecosystem. Reclamation is an activity that is required for companies to restore conditions such as the initial hue. Reclamation is an activity carried out by a mining business to organize, restore, and improve the quality of the environment and ecosystem so that it can function as before [2]. One of the most critical aspects of successful reclamation is topsoil management, which provides the essential growth medium for revegetation. PT. XYZ South Kalimantan is a coal mining company that has a mining business license area of 145 hectares. According to Government Regulation No. 78/2010 concerning post-mining reclamation, all companies are obliged to carry out reclamation activities even though mining activities have not ended.

Reclamation should be carried out as soon as possible on former mining land that has been completely exploited, even though the mining activity as a whole has not been completed, because there are still deposits of mining materials that have not been mined. One of the key components in the land reclamation process, with the arrangement of post-mining land, requires peak soil. Topsoil is the uppermost layer of soil that is rich in nutrients, organic matter, and biological activities that are important for plant growth. This topsoil is essential because plants cannot grow without this layer. The top layer of soil, also known as topsoil, must be well-maintained as it is the optimal medium for plant growth. Mining activities often result in the excavation or removal of topsoil

layers, which have the potential to reduce land quality and hinder the natural process of ecosystem recovery. The unavailable topsoil in the mining area causes the revegetation stage to require the purchase or import of topsoil that still has the same characteristics to be used for planting revegetation plants [3]. The loss of topsoil due to erosion poses a significant risk that can undermine the success of reclamation programs. Recent studies, such as a case study in East Kalimantan, have highlighted the importance of erosion control for successful revegetation (Suryanto et al., 2020). The series of reclamation activities starts from the land arrangement in the disposal area (overburden rock placement area) so that it is stable from the geotechnical aspect (not prone to landslides). The next process is the spread of topsoil on a disposal bed >0.15 meters thick as planting medium [4]. The topsoil leveling method adjusts the amount of topsoil and the character of the cover layer, including: (1) The soil leveling method, is carried out if the amount of topsoil and the amount of cover is large enough to cover the former mining land; (2) Soil stubby method, namely the accumulation of topsoil with a certain height and distance; (3) Pot method, namely the creation of planting holes to fill the top soil [5]. Calculating the availability of topsoil used in reclamation activities is very necessary because it determines the success of the reclamation process. Topsoil availability reviews involve identifying the soil resources that exist around the mine site, including an assessment of their quality and quantity. This will aid in the planning and implementation of effective land reclamation by ensuring the availability of adequate topsoil to restore land affected by mining activities.

The process of erosion of the topsoil or topsoil layer by water or wind is erosion. Erosion can cause the need for topsoil to be reduced, so calculations are needed to calculate the eroded topsoil. The erosion process occurs in important variables obtained based on the model, one of which is the Universal Soil Loss Equation (USLE) [6]. The calculation of eroded topsoil uses the USLE method. Before carrying out the reclamation process, it is necessary to calculate the available topsoil, so it can be carried out. The soil leveling method was chosen for the arrangement of the topsoil. The soil leveling system is used for the topsoil spreading method because the topsoil layers are available relatively abundantly. The success of reclamation using this method is very high.

The formulation of the problem in this study is how much topsoil is available for reclaimed land with an area of 145 Ha. The study aims to calculate the amount of topsoil available for reclamation. This research was conducted at PT. XYZ, Sungai Raya, South Kalimantan in an area of 145 Ha, with samples of 172 test wells with a distance between test wells of 5 m.

Materials and Methods

The materials studied are topsoil and cover soil. The volume of topsoil and cover soil will be calculated so that the topsoil needed in the reclamation process can be estimated. The research period is from January to December 2022. This study focuses on calculating the topsoil available for reclaimed land with an area of 145 Ha. The research location is in South Kalimantan with a coordinate point of 115°15'11.49" E 2°53'48.29" LS Figure 1. The primary data needed are the coordinates of the test well and the thickness of the topsoil. Data collection was carried out in an area with an area of 21 hectares.

Figure 1. The Study Area

Analyzing data is a way of processing data and interpreting the results of data processing [7]. Data

analysis is needed to calculate the topsoil availability and how much topsoil is eroded during January-December 2022. The data analysis process includes: primary data processing and retrieval of literature sources. Calculation of erosion soil using the USLE Method, calculation of the available shoot resistance, and Calculation of the topsoil needs by calculating the soil thickness and area. The volume of topsoil (V) is the amount of topsoil required. Area (A) is the area to be reclaimed. The thickness of the topsoil (t) is the planned thickness of the topsoil.

$$V = A \times t \quad (1)$$

Calculating the availability of topsoil for the reclamation process using Equation 2. The volume of topsoil availability (V_{KTP}) is the amount of topsoil that will be used by the reclamation process. The volume of the topsoil pile (V_{TTP}) is the volume of topsoil available in the stockpile. The volume of topsoil in a pit (V_{TPP}) is the amount of topsoil obtained in the pit excavation process. Topsoil erosion volume (V_{ETP}) is the amount of topsoil eroded. Calculation of the volume of topsoil in the pit or reclaimed land in Equation 3. The volume of topsoil in a pit (VTPP) is the amount of topsoil present in a pit. Area (A) is the area of the pit, and the thickness of the topsoil (t) is the thickness of the topsoil in the pit.

$$V_{KTP} = (V_{TTP} + V_{TPP}) - V_{ETP} \quad (2)$$

$$V_{TPP} = A \times t \quad (3)$$

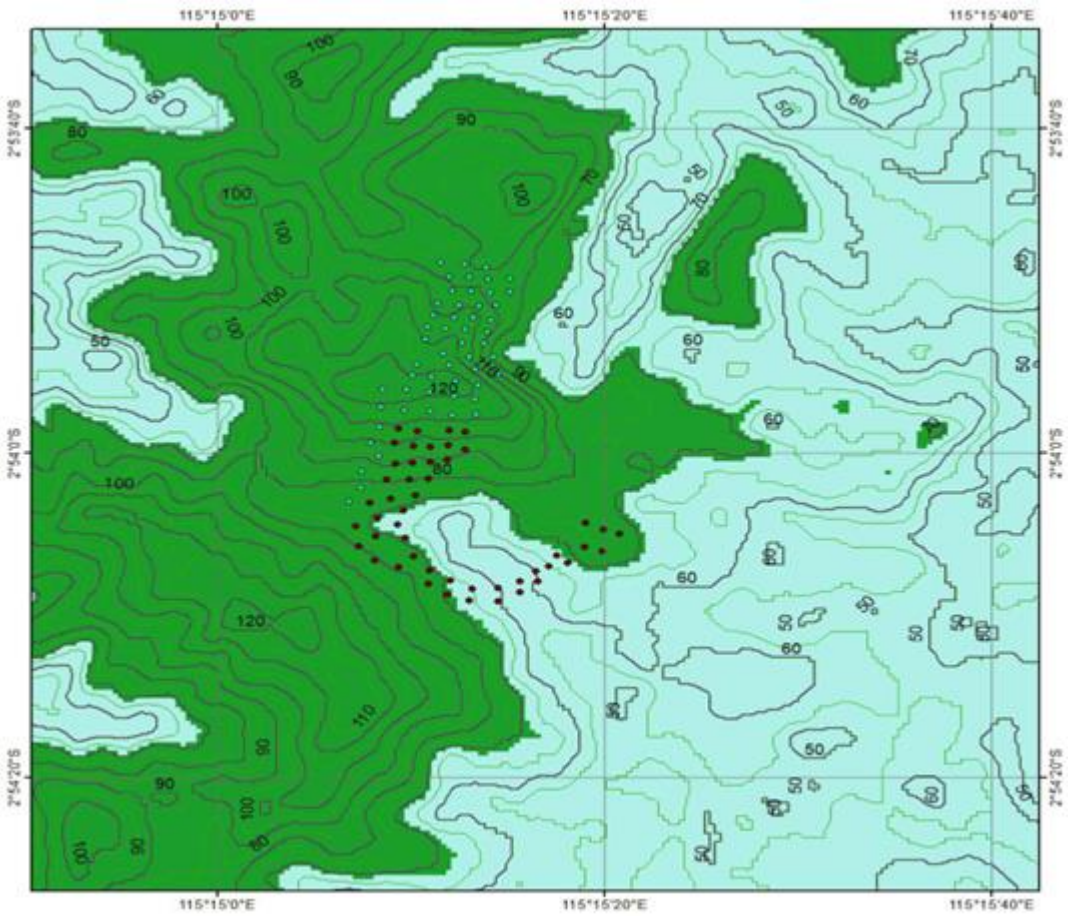

Figure 2. Map Test Pit

The USLE equation used to calculate topsoil erosion uses Equation 4. Rainfall erosion (R) is the ability of rain to erode the soil, the determining factors are rain intensity, rainfall diameter, rainfall speed, and wind speed factor. The soil erodibility index (K) is the level of sensitivity of a soil type to erosion. The properties of the soil that are affected are physical, mechanical, hydrological, chemical, rheology/lithology, mineralogy, biology, soil profile characteristics, soil depth, and properties of soil layers. Slope slope (LS) is a value to determine the slope and length of the slope. The more slope a land has, and the longer the slope, the greater the erosion. The crop management index (C) is a comparison number related to annual soil loss in areas with the same vegetation (Seran, 2022). The soil/land conservation effort index (P) is a special action factor for soil conservation, namely the comparison between the amount of erosion from the soil that is treated with special conservation measures [8].

$$A = R \times K \times LS \times C \times P \qquad (4)$$

Results

A test well is needed to measure the thickness of the top soil, 172 test well points with a distance of 5 meters between the test wells in the mine pit area in Figure 2. Based on the test well, the average thickness of the topsoil is 0.940 meters. Topsoil measurements were made in two pit areas as shown in Figure 2. The research area based on the geological sheet is included in the Warukin formation, as shown in Figure 3. The Warukin Formation has a layer in the form of clay with thin inserts of fine sandstone and coal [10].

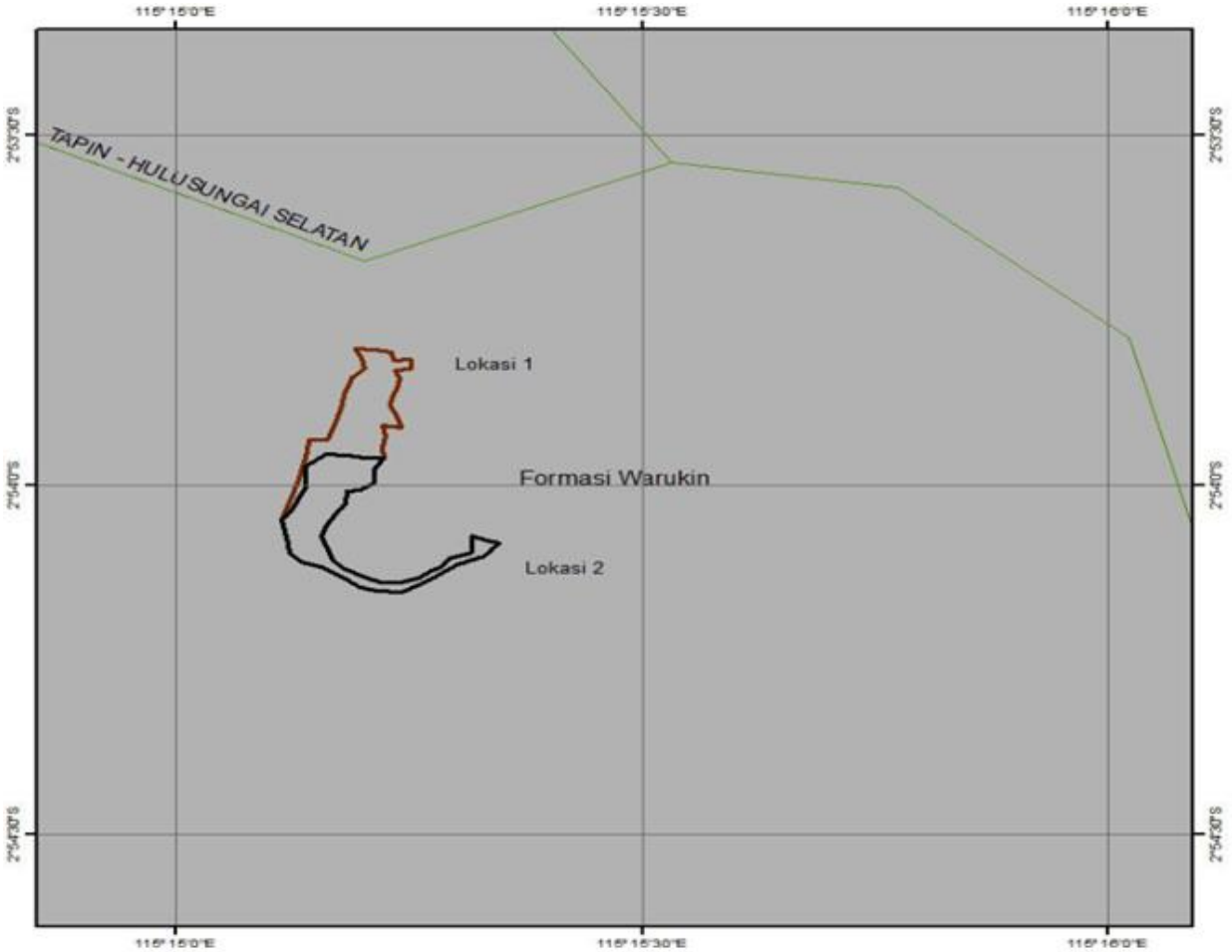

Figure 3. Formation Geology

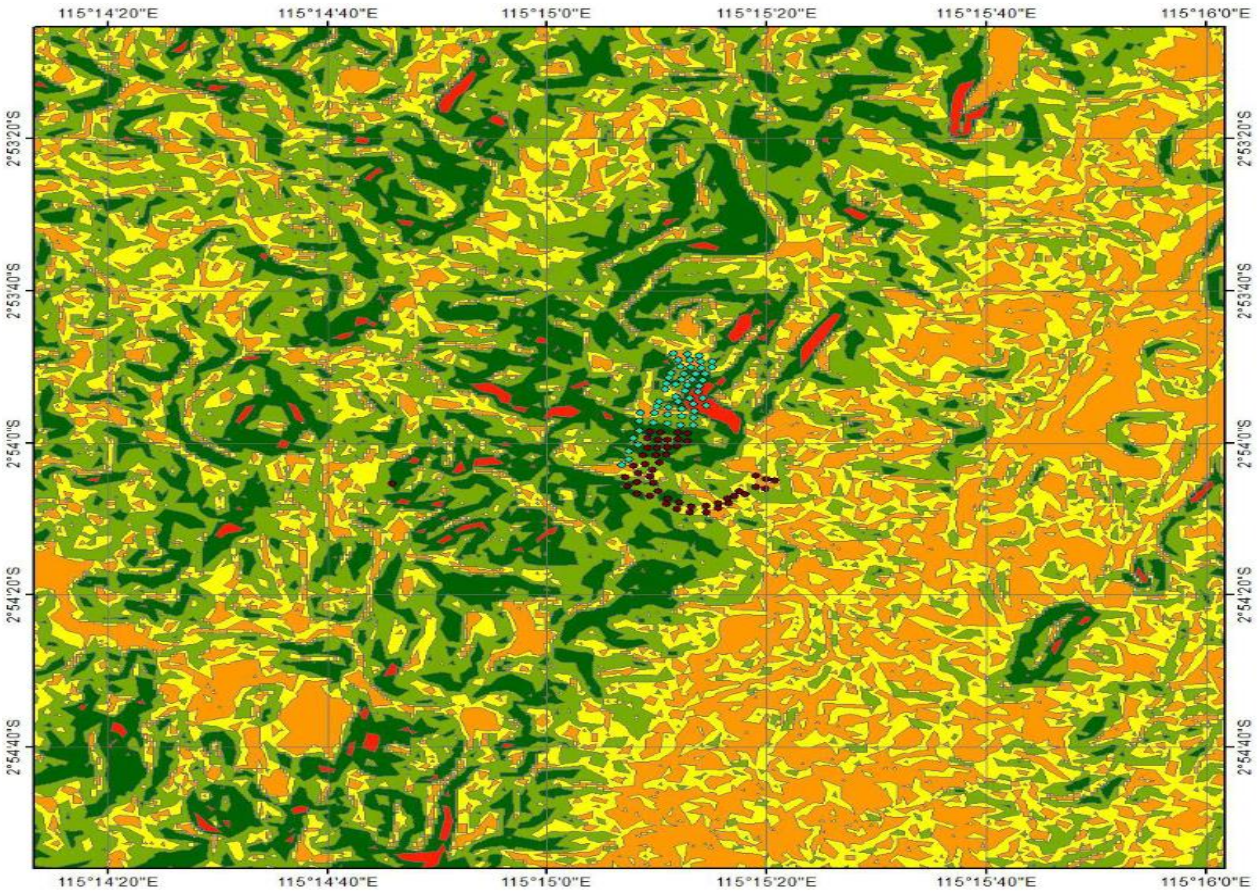

Figure 4. Slope Map

The thickness of the sandstone is fine-grained to medium brownish, which is five meters. There are three soil conditions in Sungai Raya District, namely the Mountainous Red Yellow Podsolik Complex with an area of 3,670 m^2 [9]. The Red and Yellow Podsolic Complex Lathosol and Lithosol, with an area of 150 m2, and Orgonosol Gleihumus with an area of 4,276 m2. The location of the study is in Sungai Raya District so the type of soil after sampling is Podsolic Yellowish Red Mountains with a soil erodibility value (K) of 0.166.

The slope of the study area can be seen in Figure 3. The classification of the slope of the study area is minimized by the slope class of 15-25 %, which means the slope. The slightly steep slope makes the water rate faster so that the loss of topsoil is even greater. Loss of topsoil is something that can be detrimental to companies in the reclamation process. The slope of the study area is 9° and 22%, so the value of length and slope (LS) is 0.69. Plant factor (C) is a value used to assess land cover. This value is divided into three parts, namely natural forests, planting less than one year, and planting more than one year. Natural forests obtained a value of 0.001, with the type of forest plants not disturbed by a lot of debris. Planting less than one year has a value of 0.5 with plantation crops with poor soil cover. The planting value is more than one year, with a value of 0.1, with the type of mixed garden plants with high fastness. The rain erosion value (R) is a value used to assess the potential erosion caused by the intensity and duration of rain. The R-value can be seen in Table 1. The conservation practice value (P) is a value used to assess how efficient soil conservation is in reducing erosion. The P value for natural forests and planting more than one year is 0.1 due to the

planting of low-ground cover crops in high-density plantation crops. Anchorage of less than one year has a P value of 0.5 because it has a moderate density.

Table 1. Rain Eroticism Value

No.	Month	R
1	January	105.05
2	February	277.45
3	March	105.62
4	April	64.71
5	May	93.49
6	June	30.46
7	July	30.26
8	August	29.13
9	September	85.74
10	Oktober	34.68
11	November	74.79
12	December	127.74

The results of the calculation of the USLE method in February, which has a high R-value from January to December, using Equation 4, are as follows:

Where:

R : 277 KJ/Ha LS : 0.69

C : (Natural forest 0.001)(Plantation<1 year 0.5) (Plantation>1 year 0.5)

K : 0.166 P : (Natural forest 0.1)(Plantation<1 year 0.5) (Plantation>1 year 0.1)

Natural Forest Calculation

A = R x K x LS x C x P

A = 277.45 x 0.166 x 0.69 x 0.001 x 0.1

A = 0.003

Calculation of Planting <1 year

A = R x K x LS x C x P

A = 277.45 x 0.166 x 0.69 x 0.5 x 0.5

A = 7.944

Calculation of Planting >1 year

A = R x K x LS x C x P

A = 277.45 x 0.166 x 0.69 x 0.5 x 0.1

A = 1,589

The soil eroded in February, according to the USLE method, was 9,563 m3. The results of the calculation of soil erosion using the USLE method can be seen in Table 2.

Table 2. Soil Eroded

Month	Natural Forest	Planting <1 year	Planting >1 year
January	0.001	3.008	0.602
February	0.003	7.945	1.589
March	0.001	3.024	0.605
April	0.001	1.853	0.371
May	0.001	2.677	0.535
June	0.000	0.872	0.174
July	0.000	0.866	0.173
August	0.000	0.834	0.167
September	0.001	2.455	0.491
Oktober	0.000	0.993	0.199
November	0.001	2.142	0.428
Desember	0.001	3.658	0.732
Total	**0.012**	**30.327**	**6.066**

Natural Forest Calculation

A = R x K x LS x C x P

A = 277.45 x 0.166 x 0.69 x 0.001 x 0.1

A = 0.003

Calculation of Planting <1 year

A = R x K x LS x C x P

A = 277.45 x 0.166 x 0.69 x 0.5 x 0.5

A = 7.944

Calculation of Planting >1 year

A = R x K x LS x C x P

A = 277.45 x 0.166 x 0.69 x 0.5 x 0.1

A = 1,589

The soil eroded in February, according to the USLE method, was 9,563 m3. The results of the calculation of soil erosion using the USLE method can be seen in Table 2.

The number of test holes excavated was 80 points for Pit 1 with an area of 85,998 m^2 and an average topsoil thickness of 0.43 m. The volume of topsoil in the Pit 1 area is 37,784 m^3. There are 92 test holes in Pit 2, which have an area of 126,652 m2 and an average thickness of 0.501 m, so the volume of topsoil in Pit 2 is 63,469 m^3. The total amount of topsoil carried out by the test pit is 101,253 m^3 with a test pit area of 21 Ha. The company's soil bank is 358,659 m^3. The need for topsoil in the reclamation process, with the soil leveling method where the planned thickness of the topsoil is 0.24 m, the volume required is 290,000 m^3 with a reclamation area of 145 Ha.

Calculation using the USLE method obtained eroded soil in natural forests, which is 0.012 m^3. For

planting less than 1 year, 30.3291 $m^{3,}$ and for planting more than 1 year, an eroded soil of 6,066 m^3. The total topsoil eroded for one year in the area is 36,406 m^3. The largest R-value is in February, so it affects the amount of eroded topsoil in natural forests of 0.003 m^3, for planting under one year, 7,944 $m^{3,}$ and for planting more than one year, 1,589 m^3. The topsoil that is least eroded in the month that has a small R-value is August, with a value of 29.13, so the topsoil that is eroded in that month in natural forests is 0.00033 m^3, for planting less than one year is 0.8341 m3, and planting more than one year is 0.167 m^3. The topsoil that is eroded for one year is 36,406 m^3.

The volume of topsoil of the test pit after subtracting the eroded topsoil was 64,847 m^3. The topsoil available for the reclamation process is 423,506. The volume required for the reclamation process is 290,000 m^3, while the volume of topsoil available is 423,506 $m^{3,}$ so the topsoil used for the reclamation process is sufficient.

Discussion

This study provides a clear and actionable quantitative framework for assessing soil availability and potential erosion in post-mining land management. This research fills a critical methodological gap in reclamation planning by integrating material estimates and erosion measurements in a comprehensive way. The key finding is clear: the total volume of topsoil available is 423,506 m^3, which is more than enough to meet the reclamation needs of the 145-hectare area, estimated at 290,000 m^3. The excess volume of 133.506 m^3 guarantees the management team that the material for reclamation is available, even after accounting for potential material loss from erosion. This allows companies to make better strategic decisions, such as optimizing topsoil allocation and avoiding unanticipated costs from importing materials.

This study integrates the Universal Soil Loss Equation (USLE) to quantify the risk of erosion, which is a vital component of the proposed framework. The analysis definitively shows that several factors influence soil erosion. These factors include the soil erodibility value (K-value) of 0.166, indicating significant soil sensitivity to erosion; the topography with an average slope of 9° (22%), resulting in a length-scale ratio (LS) of 0.69, indicating topography's contribution to the risk of erosion; and the rain erosion value (R-value) that fluctuates seasonally, reaching its peak in February (277.45). It is estimated that a total of 36,406 cubic meters of topsoil were eroded over the course of a year. This is essential data for mine managers to use when deciding how to control erosion, especially during the rainy months. They need to protect the topsoil, which is vital for revegetation.

The proposed framework is a critical contribution to more efficient and sustainable reclamation practices. This approach is superior to traditional methods because it is not fragmented and relies on precise estimates. It uses a predictive, data-driven tool for decision-making. Researchers can accurately measure the availability of topsoil and calculate the potential impact of erosion. This allows mining managers to make more precise plans. These plans can increase the success of revegetation and ecological function in post-mining land. This framework optimizes material allocation and reduces uncertainty in the reclamation process, ensuring more responsible and sustainable mining practices.

Conclusion

The results of the calculation of the availability of topsoil for the reclamation process of 145 Ha are very sufficient, with the details of the available topsoil being 423,506 m^3, the volume of topsoil required for the reclamation process is 290,000 m^3, and the remaining available topsoil is 133,506 m^3.

The topsoil that was eroded by calculation using the USLE method was 36,406 m^3.

Acknowledgments

The author would like to thank P2M Politeknik Negeri Malang for providing support in the form of finance, facilities, or legality to this research. Students who have assisted in the process of collecting and processing data are Arif Ramadhani, Dimas Adi, Kukuh, Shella, and Puji.

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