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Changes In Soil Chemical Properties Due To Reclamation Of Bauxite Mining

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Abstract

This study aims to determine the characteristics of the chemical properties of the soil in the bauxite mining area according to the age of reclamation, the initial setting of the environment and the location that has not been reclaimed. The research variables were soil chemical properties including soil pH, N-total, P-total, C-organic, potassium (K), base saturation (KB) and cation exchange capacity (CEC). Sampling at a depth of 0-20 cm as many as 3 (three) samples at one location, there are 5 (five) sampling locations, namely the initial environmental baseline location, mining sites that have not been reclaimed, reclaimed land aged 1 year, reclaimed land aged 2 years, and 5 year old reclaimed land. The data was processed using the Variety Print Test method on the observed variables to determine differences in soil chemical properties at bauxite mining sites according to the age of reclamation, land has not been reclaimed and the initial environmental baseline and to find out which location gives a significant difference using the LSD Test (Least Significant Difference). The results of the study found significant differences in soil chemical properties according to the age of reclamation, the location has not been reclaimed and the initial environmental tone at the bauxite mining site for soil chemical properties, namely soil pH, N-total, P-total, C-organic, potassium, and base saturation. However, the chemical properties of the soil, namely the Cation Exchange Capacity, did not show significant differences according to the age of reclamation, the location has not been reclaimed and the initial setting of the environment. Soil pH conditions are in the acidic category with a pH value of <5. N-total condition, P-total and C-Organic decreased with the age of reclamation and the location has not been reclaimed with the value of each parameter still under the initial environmental baseline conditions before bauxite mining. Reclamation of ex-bauxite mining land really needs to be managed and improved through regular maintenance in order to improve soil conditions, especially soil chemical properties by providing organic matter, P and N elements and vegetation needs to be maintained optimally.

Keywords: Soil Chemical Properties, Bauxite Mining, Reclamation Age, Environmental Baseline

Introduction

Indonesia is a country with abundant natural resources, especially mining commodities such as coal, nickel, bauxite, copper and so on, this makes the mining sector the largest contributor to Indonesia's economic development (Agus et al., 2014). Bauxite is one of the important mining commodities in Indonesia with the average production of bauxite increasing in meeting the demand for exports and the alumina industry (Supriadi et al., 2016). Mining commodities in the form of bauxite are scattered in several provinces in Indonesia, including Central Kalimantan Province.

East Kotawaringin Regency is a district with the largest potential for bauxite commodity in Central Kalimantan Province which is spread over several sub-districts, including Cempaga Hulu District. In the Cempaga Hulu sub-district there are 2 (two) companies located in one mining area, namely PT. Citra Mentaya Mandiri and PT. □□□□ Borneo Pratama.

Bauxite mining activities have the potential to have an impact on the environment, including changes in soil fertility, low soil pH, reduced ability of the soil to hold water, inadequate supply of nutrients for plants, erosion and exposure to rocks containing sulphides, resulting in the potential for acid mine drainage and disruption of the ecosystem environment (Siegel, 2002; Gardner, J. H., & Bell, 2007; Phillips, 2012; Mensah, 2015; Abdullah et al., 2016; Lee et al., 2017; Kusin, 2018; Samal et al., 2020; Lewis, S., & Rosales, 2020; Dresse et al., 2021; Islam, 2021; Rosli et al., 2021). Ex-mining land usually suffers damage after the end of mining activities, rehabilitation efforts are needed (Krishnapillay et al., 2007; Higueras et al., 2013; Everingham et al., 2018; Djaya,, et al., 2018; Fuad, 2018; Fajri & Garsetiasih, 2019; Kuan et al., 2020).

In accordance with the advancement of bauxite mining in the mining business permit area, reclamation works have been carried out in various ex-mining regions of PT. Citra M□□□□□□ Mandiri and PT. Duta Borneo Pratama. Several studies in research have been conducted on ex-mining area by carrying out environmental reclamation efforts. Mukhopadhyay, Maiti, and Masto, R. E. (2014), about the development of a mine soil quality index (MSQI) for evaluating reclamation success: a chronosequence study; Chauhanand Silori (2011), about the successful reclamation of bauxite residue through afforestation activities in South India; Larneyand Angers (2012), about the role of organic amendment Soil development in a 2–21-year-old coalmine reclaimed spoil with trees: a case study from the Sonepur-Bazari opencast project; Ladand Samant (2015), Impact of bauxite mining on soil: a case study of bauxite mines at Udgiri, Dist-Kolhapur, Maharashtra State, India; Liu et al. (2017), shows whether there are differences in soil conditions in the initial environmental baseline before and after bauxite mining, so it is necessary to analyze the chemical properties of the soil at the reclamation site according to age group, unreclaimed land, and the initial environmental baseline to demonstrate appropriate environmental management conditions in post-bauxite mining activities.

Environmental management in post-mining activities is critical to preserving the state of the former bauxite mining area. In an effort to establish the environmental impact, chemical characteristics of soil on ex-mining land were analyzed in order to determine the extent of change in environmental conditions before and after bauxite mining activities were carried out. The findings can be incorporated into a long-term environmental management strategy for the former bauxite mining site.

The study's goal was to identify the chemical properties of the soil in the bauxite mining area based on the age of reclamation, the initial setup of the environment, and the position of the former bauxite production that has not been reclaimed.

Research methods

Place and time

The research was conducted on former bauxite mining land according to the age of reclamation, initial environmental baseline and land that has not been reclaimed at PT. Citra Mentaya Mandiri and PT. Duta Borneo Pratama is located in the Cempaga Hulu District, East Kotawaringin Regency, Central Kalimantan Province. The research location consists of 5 (five) locations, namely land reclamation for 1 year, land reclamation for 2 years, land reclamation for 5 years, land that has not been reclaimed and environmental baseline. The research was conducted from July to August 2021.

Tools and materials

The tools used in the study were stationery, label paper, sample ring, sample plastic, soil squeegee, machete, hoe, shovel, 5 m meter, 50 mesh sieve, scale, Erlenmeyer, GPS Garmin 64s, pH and EC meters and camera. The materials used are soil samples at the mining site according to the age of reclamation and the initial environmental baseline before and after bauxite mining and land that has not been reclaimed.

Research design

This research is an observation on field conditions related to soil conditions, especially the chemical properties of the soil according to the age of reclamation, the initial setting of the environment and the land that has not been reclaimed. Literature study was conducted before sampling to determine the parameters studied. Determination of the sampling location at a depth of 0-20 cm as many as 3 (three) samples at one location, there are 5 (five) sampling locations, namely the initial environmental baseline location, mining sites that have not been reclaimed, reclaimed land aged 1 year, reclaimed land aged 2 years, and the reclaimed land is 5 years old. then the sample is labeled according to the location for laboratory analysis with the aim of knowing the chemical properties of the soil.

Research variable

Parameters of soil chemical properties according to age group of reclamation, environmental baseline and land that has not been reclaimed include soil pH, N-total, P-total, C-organic, Potassium (K), Base Saturation (KB) and Cation Exchange Capacity (CEC) .

Data analysis

Parameters of soil chemical properties after going through a laboratory analysis related to soil pH, N-total, P-total, C-organic, Potassium (K), Base Saturation (KB) and Cation Exchange Capacity (CEC) were then processed using the Variety Print Test method on variables observed to determine the differences in soil chemical properties at the bauxite mining location according to the age of reclamation, land that has not been reclaimed and the initial environmental baseline. Follow-up tests were carried out to find out which locations gave a significant difference using the Least Significant Difference (LSD) Test.

Results and Discussion

General Condition of Research Site

The research location is in the mining business permit area for production operations of PT. Citra Mentaya Mandiri with an area of 494 ha and PT. Duta Borneo Pratama with an area of 429 ha which is administratively located in the area of Sudan Village, Parit and Bukit Raya, Cempaga Hulu District, East Kotawaringin Regency, Central Kalimantan Province. The status of the area in the mining business permit area is a forest area for conversion products, other use areas and waters.

The research location has a humid tropical climate with temperatures ranging from 19˚C-23˚C and the highest rainfall is from October to March ranging from 200-350 mm/year, while the dry months are from June to August.

In general, the research location consists of 2 (two) morphological units, namely lowland morphological units occupying 59% of the area with an elevation of 10-24 masl and undulating hills morphology units occupying 41% of the area with an elevation of 15-54 masl.

Soil Chemical Properties

The results of soil analysis in the laboratory, the state of the chemical properties of the soil at the research site, which consists of:

Soil pH

The results of the laboratory analysis in Table 1 show that the pH of the soil on the ex-bauxite mining area with a depth of 0-20 cm is classified as acidic because the pH value at all sampling locations is in the pH value < 5. The lowest pH value is found in the initial environmental baseline. with an average pH value of 3.71 while the highest pH value was found at the reclamation site in the second year with an average pH value of 4.91.

The results of the variance test for soil pH obtained an F-count value of 70,132 when compared to the F-table 3,478 where the value (0.05) which means that the age of reclamation, the location that has not been reclaimed, the initial environmental baseline is significantly different to the soil pH. The LSD test (Least Significant Difference) was used to find out which location gave a difference in soil pH. The results of the variance test and LSD test showed that there was a significant difference between locations, the soil pH conditions at the initial baseline location were significantly different from the soil pH at the reclamation site in the first year. However, the soil pH at the reclamation site in the first year was not significantly different from the soil pH at the unreclaimed location, the fifth year reclamation site and the second year reclamation site.

N-Total

The results of the laboratory analysis in Table 1 show that the N-total condition decreased from the initial environmental baseline conditions to locations that have not been reclaimed and locations that have been reclaimed on ex-bauxite mining areas. The highest N-total value was found in the initial environmental baseline with an average of 0.353, while the lowest N-total value was found in the fifth year reclamation site with an average of 0.243. This occurs due to loss of organic matter due to mining processes in stripping topsoil or due to leaching due to high rainfall.

The results of the variance test for N-total obtained an F-count value of 13.715 when compared to F-table 3,478 where the value (0.05) which means that the age of reclamation, the location that has not been reclaimed, the initial baseline of the environment is significantly different from the total N. The LSD (Least Significant Difference) test was used to find out which locations gave the difference in the N-total. The results of the variance test and LSD test showed that there were significant differences between locations, the N-total condition at the initial baseline location was significantly different from the N-total at the fifth year reclamation site and the location that had not been reclaimed. However, the N-total at the initial baseline location was not significantly different from the N-total at the reclamation site in the first year and the reclamation site in the second year.

P-Total

The results of the laboratory analysis in Table 1 show that the lowest P-total condition is found in the fifth year reclamation location of 125.007 while the highest P-total condition is at the initial baseline location. This indicates a decrease in the P-total condition at the ex-bauxite mine site that occurred because it was suspected that during the reclamation activities there was no added P element so that the P-total at the reclamation site decreased.

The results of the variance test for P-total obtained an F-count value of 5.430 when compared to the F-table of 3.478 where the value (0.05) which means that the age of the reclamation, the location that has not been reclaimed, the baseline of the environment is significantly different from the P-total. The LSD (Least Significant Difference) test was used to find out which locations gave the difference in the P-total. The results of the variance test and LSD test showed that there were significant differences between locations, the P-total condition at the initial baseline locations was significantly different from the P-total at all reclaimed locations according to age, namely the first year, second year, fifth year and locations that had not been reclaimed.

C-Organic

The results of the laboratory analysis in Table 1 show that the C-Organic state decreased from the initial environmental conditions. The lowest organic C-value with an average of 1.320 at the reclamation site in the second year, while the C-organic value in the initial environmental baseline had an average of 12.927. This indicates a decrease in C-organic conditions at the ex-bauxite mining site that occurred because it was suspected that during reclamation activities, C-organic materials were not added, such as cover crops, vegetation on the soil surface, so that the C-organic condition in locations that had not been reclaimed and that had been reclaimed decreased. with the age of reclamation.

The results of the variance test for C-organic obtained an F-count value of 75.310 when compared to the F-table of 3.478 where the value (0.05) which means that the age of reclamation, the location that has not been reclaimed, the initial environmental baseline is significantly different from organic C. The LSD test (Least Significant Difference) was used to find out which location gave the difference in organic C. The results of the variance test and LSD test showed that there were significant differences between locations, the condition of C-organic at the initial baseline location was significantly different from that of C-organic in all reclaimed locations according to their age, namely the first year, second year, fifth year and locations that had not been reclaimed. .

Potassium (K)

The results of the laboratory analysis in Table 1 show that the condition of Potassium is different at the initial environmental location, the location that has not been reclaimed and that has been reclaimed. The highest Potassium value with an average of 479.453 was found at the reclamation site in the first year, while the lowest Potassium value with an average of 152.467 was at the reclamation site in the second year. This shows a decrease in the value of Potassium according to the age of reclamation where in the fifth year of reclamation the value of Potassium is still below 400.

The results of the variance test for Potassium obtained the F-count value of 38.662 when compared to the F-table of 3.478 where the value (0.05) which means that the age of reclamation, the location that has not been reclaimed, the initial environmental baseline is significantly different from Potassium. The LSD (Least Significant Difference) test was used to find out which location gave the difference in Potassium. The results of the variance test and LSD test showed that there were significant differences between locations, the condition of Potassium at the reclamation site in the first year was significantly different from the condition of Potassium at the reclamation site in the fifth and second years, the location that had not been reclaimed and the location of the initial environmental baseline. However, the condition of potassium at the reclamation site in the fifth year was significantly different from the potassium condition at the initial hue location, the location was not reclamation and the second year reclamation. Meanwhile, the condition of Potassium in the initial environmental setting was not significantly different from the condition of Potassium at the location not yet reclamation and the reclamation location in the second year.

Base Saturation (KB)

The results of the laboratory analysis in Table 1 show that the base saturation condition is different at the initial environmental baseline location, the reclamation location according to age and the location that has not been reclaimed. The highest base saturation value with an average of 0.018 is found in the fifth year reclamation site, while the lowest base saturation value with an average of 0.005 is found in the first and second year reclamation sites. This shows that base saturation increases with the age of reclamation but the value is different from the initial environmental conditions.

The results of the variance test for base saturation obtained an F-count value of 16.008 when compared to F-table 3,478 where the value (0.05) which means that the age of the reclamation, the location that has not been reclaimed, the baseline of the environment is significantly different from base saturation. The LSD (Least Significant Difference) test is used to find out at which location the difference in base saturation. The results of the variance test and LSD test showed that there were significant differences between locations, the base saturation conditions at the initial environmental baseline locations were significantly different from the base saturation conditions at the reclamation sites in the first year, the second year and locations that had not been reclaimed. However, the base saturation condition was not significantly different from the base saturation condition at the fifth year reclamation site.

Cation Exchange Capacity (CEC)

The results of the laboratory analysis in Table 1 show that the state of the highest Cation Exchange Capacity with an average of 47,093 is in the reclamation site in the first year and the lowest Cation Exchange Capacity with an average of 43,573 is in a location that has not been reclaimed. However, along with the age of reclamation, there is a decrease in the value of the Cation Exchange Capacity where in the fifth year reclamation location the value is below the first year reclamation location. Meanwhile, at the initial baseline location, the value of the Cation Exchange Capacity is still below the value of the Cation Exchange Capacity at the reclamation site in the first year. This is due to the low organic matter at the reclamation site according to age and it is suspected that no organic matter has been added to the former bauxite mine site.

The results of the variance test for Cation Exchange Capacity obtained an F-count value of 0.761 when compared to F-table 3.478 where the value (0.05) which means that the age of reclamation, the location that has not been reclaimed, the baseline of the environment is not significantly different from the Cation Exchange Capacity. The LSD test was discontinued because there were no differences found according to the age of reclamation, the location has not been reclaimed, the initial environmental baseline at the former bauxite mining site so that there is no location that gives a significant difference to the Cation Exchange Capacity.

Table 1 Results of Laboratory Analysis of Soil Chemical Properties

parameter	depth	average value				
		initial hue	land has not been reclaimed	1st year reclamation	2nd year reclamation	5th year reclamation
pH	0-20cm	3,713	4,780	4,737	4,910	4,873
N-total	0-20cm	0.353	0.247	0.327	0.310	0.243

P-total	0-20cm	218,213	168,767	161,767	135,760	125.007
C-organic	0-20cm	12,927	3,197	2,553	1,320	1,670
Potassium	0-20cm	167,817	163.950	479,453	152,467	319,810
Base Saturation	0-20cm	0.016	0.007	0.005	0.005	0.018
Cation Exchange Capacity	0-20cm	46,673	43,573	47,093	45,493	44,730

Source: data processed from laboratory results of soil chemical properties

Conclusion

The conclusion obtained from this study is that there are significant differences in the chemical properties of the soil according to the age of reclamation, the location that has not been reclaimed and the initial environmental tone at the bauxite mining site for soil chemical properties, namely soil pH, N-total, P-total, C-organic, Potassium. , and Base Saturation. However, the chemical properties of the soil, namely the Cation Exchange Capacity, did not show significant differences according to the age of reclamation, the location has not been reclaimed and the initial setting of the environment. The pH of the soil at the research site is in the acidic category with a pH value of <5. The condition of N-total, P-total and C-Organic decreased with the age of reclamation and the location had not been reclaimed with the value of each parameter still under the initial environmental baseline conditions before bauxite mining.

Reclamation activities of ex-bauxite mining land need to be managed and improved through regular maintenance in order to improve soil conditions, especially soil chemical properties by providing organic matter, P elements and N elements and vegetation needs to be maintained optimally. There needs to be supervision from related parties, namely bauxite mining companies and local governments to involve the community to maintain and improve reclaimed land through education and socialization as well as training so that the goal of reclamation of ex-bauxite mining land is achieved and sustainable.

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