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Characteristics of Soil Chemical Properties and Soil Fertility in Land Types in Several Villages of North Rantau District, Labuhanbatu Regency

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Abstract

Soil chemical characteristics and fertility status are crucial for evaluating potential obstacles to using land for agricultural purposes and plantations. This study aimed to assess soil's chemical properties and fertility status in home gardens and agricultural land across several sub-districts in the Rantau Utara District. The experiment was conducted over three months, from September 2024 to November 2024, in the sub-districts of Aek Paing, Pulo Padang, Padang Matinggi, Rantauprapat, and Sirandorung. A survey methodology was employed, followed by composite soil sampling at 0-20 cm depth. The composite soil samples were analyzed in the laboratory, measuring parameters such as soil pH, organic carbon (C), total nitrogen (N), carbon-to-nitrogen (C/N) ratio, available phosphorus (P), exchangeable base cations, cation exchange capacity (CEC), and base saturation. Data were analyzed using the soil chemical status assessment criteria and soil fertility assessment criteria established by the Bogor Soil Research Center. The results indicated that: (1) the chemical properties of the soil in home gardens and agricultural land across various sub-districts in Rantau Utara District exhibited a soil pH ranging from very acidic to acidic, organic carbon content varying from low to high, total nitrogen levels classified as low to moderate, C/N ratios from moderate to high, available phosphorus levels from very low to moderate, CEC classified as relatively very low, and base cations categorized as very low to moderate. Furthermore, the chemical fertility status of the soil in agricultural land across these sub-districts was classified as very low to low.

Keywords: Agricultural Land, Chemical Properties of Soil Rantau Utara, Soil Fertility, Survey

1. Introduction

The term "fertile land" is used to describe soil with a sufficient nutrient content to support plant growth. Sufficient nutrient content in the soil will facilitate plant growth, thereby enabling the production of high-quality and abundant products. As a medium for plant growth, the soil exhibits a range of properties and characteristics, including physical, chemical, and biological properties. These properties interact and influence one another, collectively influencing plant growth (Lesmana, R. 2019).

The primary challenge in employing dry land for agricultural purposes is the low soil fertility level resulting from chemical constraints that impede plant growth. The potential for cultivating food crops and vegetables has not been fully realized due to several obstacles, including a dearth of information regarding the characteristics of chemicals and soil, as well as the status of the soil in the area where the plant is cultivated (Martunis, 2017).

Therefore, efforts need to be made to increase land productivity. Although the land potential is quite extensive, the development of food crop cultivation is still not optimal due to the many obstacles faced, including limited data/information on soil characteristics and soil fertility status in crop cultivation areas/areas, making it difficult to increase land productivity such as difficulty in determining the type and dosage of fertilizer that is right to support optimal production (Siregar et al., 2021).

Rantau Utara District is one of 9 Districts in Labuhanbatu that has quite a large opportunity to develop the agricultural sector, especially food crop agriculture. One of the basic capital for this purpose is a large enough land area that has the potential for food crop cultivation.

The initial step that can be taken is to gain an understanding of the soil conditions, which will enable the

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identification of the optimal soil management strategy. An understanding of soil fertility conditions allows for the determination of appropriate land management strategies. The findings of Lubis et al. (2024) indicate that the soil fertility status on oil palm plantation lands (*Elaeis guineensis* Jacq.) in Pulo Padang Village is relatively low. Consequently, management measures are required to enhance soil fertility.

Evaluating soil chemical properties is diagnosing soil nutrient deficiencies and determining the required types and amounts of nutrients. This is a standard method employed in assessing soil chemical properties (Karnilawati et al., 2022). The approach of soil analysis or soil sample testing is a general method of soil testing, a chemical analysis activity in a laboratory. This method is simple, fast, cheap, precise, and reproducible, and it is used to estimate the availability of nutrients. In a broader sense, soil testing involves the interpretation, evaluation, and preparation of fertilizer recommendations from soil test results and soil sampling (Fitriyani et al., 2023).

2. Material and Methods

2.1. Research Site and Time

This research was conducted on soil fertility in home yards and agricultural land in several sub-districts in Rantau Utara District with coordinates N: 980220,34,210 and E: 020230,35,210 with a height of 28 meters above sea level. The experiment was conducted for 3 (three) months, namely from September 2024 to November 2024, in the sub-districts of Aek Paing, Pulo Padang, Padang Matinggi, Rantauprapat, Sirandorung which is presented in Figure 1. Analysis of soil chemical properties was conducted at the Soil Chemistry and Fertility Laboratory, Faculty of Science and Technology, Labuhanbatu University.

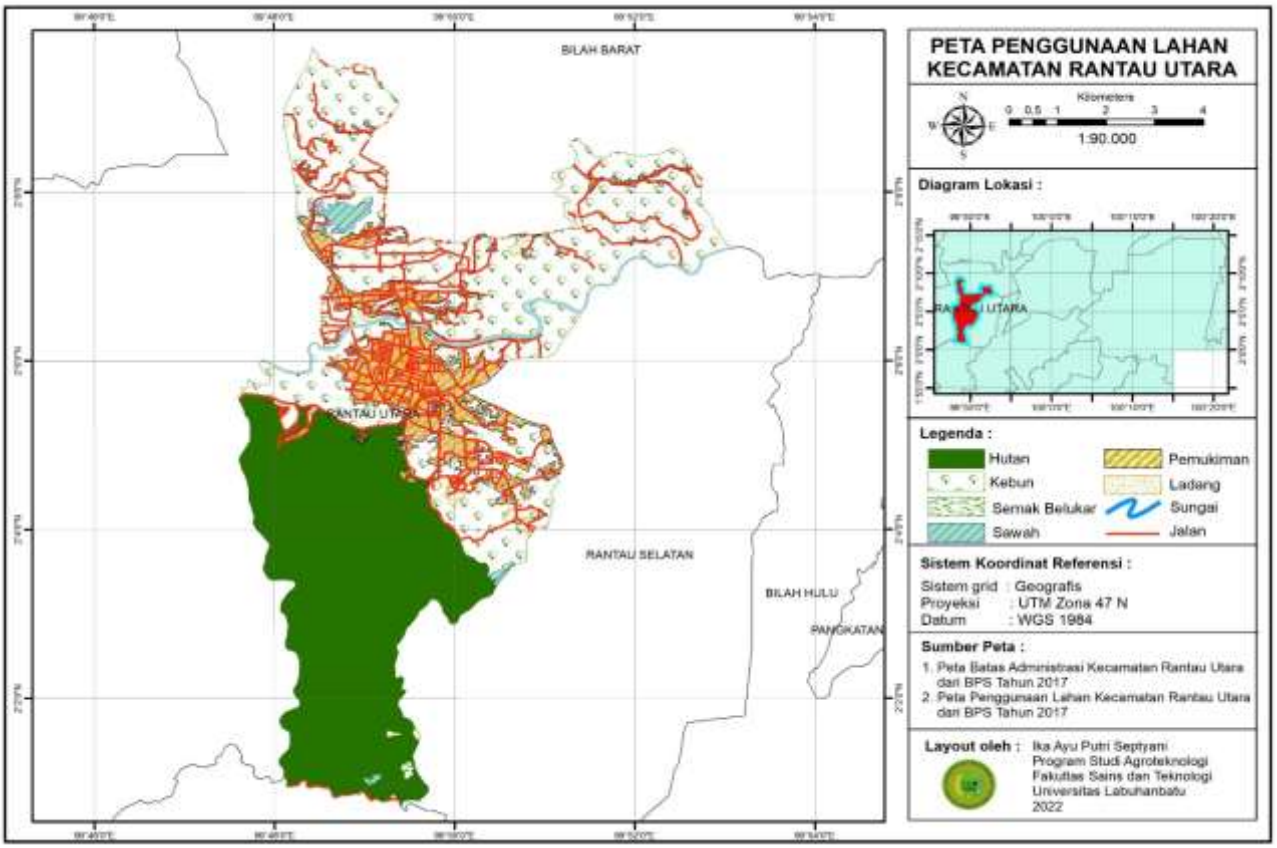

Figure 1. Land Use Map in North Rantau District

2.2. Research Method

This study used a survey system followed by taking composite soil samples at 0-20 cm depth. The composite soil samples were then analyzed in the laboratory. The tools used in this study were GPS, shovels, bags, label paper, cameras, rulers, scales and laboratory equipment. This study used a survey method. Soil sampling was carried out using purposive sampling based on the type of use, namely rice field plots, mixed gardens, and horticulture. The soil was taken compositely with a 0-20 cm depth.

Each plot was taken from 3 different points to represent the entire plot. There were 3 soil samples to be analyzed. The primary data collected were: (1) soil pH was determined using the H2O extraction method, (2) organic C was determined using the Walkley and Black method, (3) total N was determined using the Kjeldahl method, (4)

available P was determined using the Bray I method, (5) available K was determined using the Bray I method, (6) exchangeable base cations were determined using the 1 N NH4Oac pH 7 extraction method, (7) acid cations (Al and H) were determined using the 1 N KCl extraction method, (8) CEC and base saturation were determined by calculation. Analysis of the characteristics of soil chemical properties used the soil chemical status assessment criteria (Harahap et al., 2024), while soil fertility status used the soil fertility assessment criteria from the Soil Research Center (PPT, 1995).

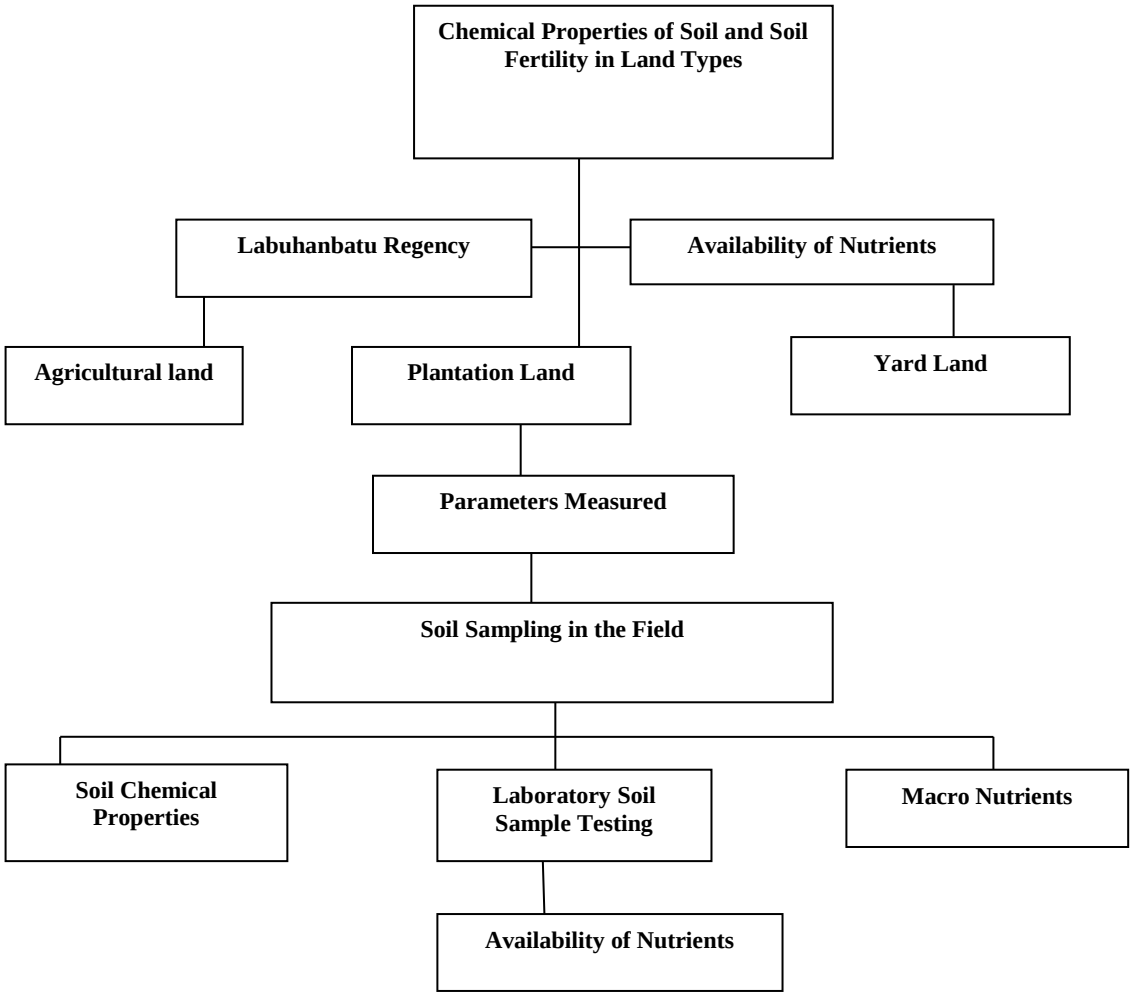

Figure 2. Research flow diagram

3. Results and Discussion

3.1. Soil Texture

Data from the results of the analysis of the physical properties of soil in the laboratory from soil samples from several sub-districts of Rantau Utara District, Labuhanbatu Regency, are presented in Table 1. The laboratory analysis results show that in the soil in the yard and agricultural land in several villages in the Labuhanbatu area, some of the soil grains are dominated by sand, especially fine sand. Soil dominated by sand particles generally has a low water retention capacity and does not have plastic and adhesive properties.

Table 1. Results of Soil Texture Analysis in the Laboratory

No	Soil Texture	Sirandorung	Rantauprapat	Padang Matinggi	Pulo Padang	Aek Paing,
1	Dust (%)	13.50	13.90	17,80	17.20	8.30
2	clay (%)	22.20	11.00	30,40	31.50	24.70
3	Sand (%)	64.00	75.10	51,80	51.30	67.00
Soil Texture Class		Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam

Hamid et al. (2019) and Gunawan et al., (2019) state that sand is a separate grain that stands alone and mainly acts as a soil framework. Sand grains have a small surface area. Therefore, they play a small role in soil chemical events in large pores so that aeration runs smoothly but has a very low water storage capacity (Erlansyah et al.,2024).

3.2. Chemical Properties of Soil

Data from the results of the analysis of chemical properties of soil in the laboratory from soil samples in Aek Paing Village, Pulo Padang, Padang Matinggi, Rantauprapat, Sirandorung, Rantau Utara District, Labuhanbatu Regency are presented in Table 2. The results of Table 2 show that laboratory analysis shows that the soil pH in the yard and agricultural land of several sub-districts in Rantau Utara District ranges from 3.97 to 5.48 (categorized as very acidic to acidic). This condition is caused by the exchange complex on the surface of the colloid and soil solution being dominated by acid cations, especially Al^{3+} cations so that the soil pH is low. This condition is supported by the results of soil analysis, which show that Al saturation is very high. As explained by Soekamto et al. (2023), in soil that reacts acidically, Al becomes very soluble and is the cause of acidity or contributor of H^+ ions. The released H^+ ions cause low soil pH for the soil solution.

Table 2. Results of Chemical Properties Analysis in the Laboratory

No	Parameter	Sirandorung	Rantauprapat	Padang Matinggi	Pulo Padang	Aek Paing,
1	pH H_2O	4,52 (SM)	5,48 (M)	4,65 (SM)	4,99 (SM)	3,97 (SM)
2	C-organic (%)	4,76 (T)	3,16 (T)	3,74 (T)	1,71 (R)	1,84 (R)
3	N total (%)	0,46 (S)	0,22 (S)	0,25 (S)	0,16 (R)	0,15 (R)
4	C/N ratio	10,35 (S)	14,41(S)	15,65 (T)	10,69 (S)	12,07 (S)
5	P availability (ppm)	21,85 (S)	1,49 (SR)	0,78 (SR)	4,52 (SR)	2,32 (SR)
6	Ca^{++}	1,23me (SR)	2,43 me (R)	0,62 me (SR)	3,32 me (R)	0,23 me (SR)
7	Mg^{++}	0,29 me (SR)	1,56 me (S)	0,33 me (SR)	1,42 me (S)	0,08 me (SR)
8	K^+	0,50 me (S)	0,32 me (R)	0,20 me (R)	0,26 me (R)	0,18 me (R)
9	Na^+	0,08 me (SR)	0,06 me (SR)	0,08 me (SR)	0,12 me (R)	0,14 me (R)
10	Cation Exchange Capacity	4,26 me (SR)	4,93 (SR)	3,21 me (SR)	7,11 me (SR)	4,63 me (SR)
11	Base Saturation (%)	50,33 (S)	87,82 (ST)	37,81 (S)	71,88 (T)	13,49 (SR)
12	Aluminum Saturation (%)	49,67 (ST)	12,32 (R)	62,19 (ST)	28,15 (S)	86,71 (ST)

Notes : SR = Very Low, S = Medium, ST= Extremely High, T = High; R=Low, SM = Very Sour, M= Sour

In the analysis parameters of C-Organic Soil, the soil in the yard and agricultural land of several sub-districts in Rantau Utara District ranges between showing that the organic C content of the soil in the yard and agricultural land of several villages in Labuhanbatu Regency ranges between 1.71% - 4.76% (categorized as low to high). The variation in the organic C content (organic matter) in these lands is due to differences in the types and amounts of vegetation growing on the land. Munawar (2013) stated that soil organic matter is all the carbon in the soil from the remains of plants/vegetation and animals that have died. Most sources of soil organic matter are plant/vegetation tissues. Different sources and amounts of organic matter will also have different effects on the organic matter contributed to the soil.

The results of laboratory analysis show that the total N content of soil on yard land and farmland in several villages in North Rantau Subdistrict is in the range of 0.15% - 0.46% (classified as low to medium). This situation is caused by vegetation that contributes organic matter to the soil, is poor in N content, and the supply of organic matter from vegetation that grows on the ground is small, and the organic material has not fully decomposed. Wicaksono et al. (2023) stated that the tillage layer generally contains 0.02 - 0.40% N. The soil N content depends on the environmental conditions such as climate and vegetation. Vegetation that grows on the soil and the speed of its decomposition are factors that cause changes to the N content in the soil.

The laboratory analysis results show that the total N content of soil on yard land and farmland of several farms in several villages in Rantau Utara Subdistrict is in the range of 10.35 - 15.75 (classified as medium to high). This situation shows that the organic matter contributed to the soil comes from plants that contain much cellulose, and the level of decomposition of organic matter is slow to very slow. According to Sulakhudin S (2017), a high C / N ratio causes the availability of abundant energy for soil organisms so that they can develop rapidly. Inorganic N compounds available in the soil are quickly converted into organic N forms in the body of soil organisms; at this stage, the decomposition rate of organic matter is at its lowest. It is stated by Pa et al. (2023) that the C / N value of organic matter added to the soil will determine the reaction/speed of its decomposition in the soil; a high C / N ratio indicates that decomposition is not yet advanced or has just begun.

Based on the results of laboratory analysis it shows that the total P content of the soil in the yard and agricultural land of several agricultural businesses in several sub-districts in North Rantau District is between 0.79 ppm - 21.85 ppm (categorized as very low to moderate). This condition is caused by the soil being formed from parent material (rocks/minerals) that are poor in P elements, and the P content in organic matter is also low. As stated by Mpia et al. (2023), P in the soil comes from the disintegration of minerals containing P, such as apatite, and the decomposition of organic matter. The solubility of inorganic P compounds and organic P in the soil is generally very low, so only a small portion of the soil P is in the soil solution (available P). In addition, it can also be caused by low soil pH, so high Al solubility causes P to become unavailable. As stated by Munawar (2011), in

acidic soil (low pH), soluble P will react with Al and Fe and other hydrous oxides to form Al-P and Fe-P compounds that are relatively less soluble, so plants cannot absorb P.

Based on the results of laboratory analysis it shows that the content of exchangeable base cations in yard land and farmland in several villages in North Rantau District shows that the content of exchangeable base cations, namely Ca^{++} is 0, 24 - 3.32 me 100 g^{-1} soil (classified as very low to low), Mg^{++} is 0.07 - 1.55 me 100 g^{-1} soil (classified as very low - medium), K^{+} is 0.17 - 0.49 me 100 g^{-1} soil (classified as low to medium), and Na^{+} is 0.07 - 0.17 me 100 g^{-1} soil (classified as low). This situation is caused by the rock/mineral constituent soil in the area being poor in the content of base cations; besides that, it can also be caused by the Labuhanbatu area having high rainfall, so the base cations have been leached. As stated by Maryani et al. (2024), in young soils where weathering is not advanced and relative leaching is small, then base cations such as Ca and Mg are cations that occupy a lot of colloidal surfaces, but if weathering is advanced and large leaching due to high rainfall, the number of base cations decreases, and minerals containing these base cations will disappear due to leaching. Besides the mineral content and leaching process, it can also be caused by the fact that the base cations are reduced because they are absorbed by plants and vegetation (transported by the harvest), and there is no return of base cations either through fertilization or liming.

The laboratory analysis results indicate that the CEC of soil in yards and agricultural land in several sub-districts in Rantau Utara District is between 3.20 and 7.1 me 100 g-1 soil, categorized as very low. This condition results from the prevalence of sand-dominated soil particles, which possess a limited colloid surface area, resulting in a diminished CEC. Furthermore, the soil's low pH also affects its CEC. As elucidated by Hakim et al. (1986), the CEC of soil is contingent upon the intrinsic and extrinsic attributes of the soil, including pH, texture or clay content, clay mineralogy, and organic matter.

Based on the results of laboratory analysis and calculations of the number of cations, it shows that the base saturation (KB) of the soil in yardlands and agricultural lands in several sub-districts in Rantau Utara District is between 10.23 - 87.80% (categorized as very low to very high) and Al saturation ranges from 12.20 - 86.61% (categorized as low to very high). Although it has a high KB value in some places, the area contains very low to moderate base cations and very low CEC. This condition shows that most of the soil's colloid surfaces (exchange complexes) are dominated by acid cations, especially Al, causing the Al saturation in most places to be classified as very high. Rahmawaty et al. (2020) state that base saturation describes the relative proportion of exchangeable bases in soil colloids. In soils in areas that have experienced advanced weathering, most of the exchange complexes on the colloid surface are occupied by Al cations. Furthermore, Harahap et al. (2020) stated that the KB percentage is a comparison between the dominant amount adsorbed on the colloid surface.

3.3. Soil Chemical Fertility Status

PPT Bogor has developed a methodology for assessing the fertility status of soil chemical properties, which is based on the status of soil KTK, base saturation value, organic matter content, and available P. The results of soil analysis are then linked to the assessment criteria for the fertility status of soil chemical properties, which indicate that the status of soil chemical fertility in yard land and agricultural land in several sub-districts in the Rantau Utara District area is classified as very low to low.

4. Conclusion

The chemical properties of the soil in yards and agricultural land in several sub-districts in the Rantau Utara District are as follows: the soil pH is classified as very acidic to acidic, the organic C content is classified as low to high, the total N is classified as low to moderate, the C/N ratio is classified as moderate to high, the available P is classified as very low to moderate, the CEC is classified as very low, the base cations are classified as very low to moderate, and the Al saturation is classified as low to very high. The chemical fertility status of the soil in yards and agricultural land in several sub-districts in the Rantau Utara District is classified as very low to low.

Suggestion: In light of the findings of the research, several recommendations can be put forth, namely: To enhance the chemical profile of the soil, it is essential to implement a multifaceted approach encompassing the application of both organic and inorganic fertilizers, the provision of lime, and further investigation into the impact of diverse methodologies, formulations, and dosages of fertilization on the alterations in the chemical attributes of the soil.

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