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Determination Of Exchangeability Cations (Ec), Texture And C-Organic Content In Mineral Soils and Peat

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Abstract. EC or can be called exchangeable cation is a nutrient cation found in the soil. This is useful for indicating the degree of alkaline saturation, which indicates that the more saturated the soil base, the more fertile the soil will be. This study aims to obtain supporting information to obtain soil conditions that show the quality of the land as a growing medium. The method used for texture analysis on this soil refers to SNI 3423.03:1994 and C-Organic content analysis refers to SNI 4720.13:1998. The cation level test was carried out using NH_4OAc solution with a Microwave Plasma Atomic Emission Spectroscopy (MP-AES) instrument. This instrument has a principle, namely atomic emission which is a form of energy produced by an atom when it returns to the ground state (Ground State) of the excited state (Excitation State). The results of this cation level test with analyte concentrations of K, Ca, Na and Mg with sample code SJ2022-01826 successively 0.65; 3,59; 0.82 and 0.94. The amount of cation content in fertile soil is worth at least 6 mg / L in accordance with the provisions of the Chemical Technical Manual.

Keywords : Exchangeability Cations, MP-AES, NH_4OAc

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Introduction

Soil is an important factor in cultivation, especially as a growing medium. However, the soil is not absolute, meaning that although it is suitable, it can still be managed until it is suitable for planting *Eucalyptus Sp*. *Eucalyptus Sp.* plants can grow well in lowland to highland areas (0 - 1,800 meters above sea level / MDPL), with rainfall of 2,000 - 5,000 mm per year. The plant also needs fertile soil that has enough water, is not affected by the climate and has good nutrient shelf life [1].

One of the chemical properties of the soil is alkaline saturation. Alkaline saturation is the ratio between the number of alkaline cations and the number of all cations (meaning alkaline cations plus acid cations) present in the soil tissue complex. Alkaline cations are generally nutrients that are indispensable for plants. Base nutrients or alkaline nutrient cations are Ca, Mg, Na, and K which can be measured in an Exchangeable Cation (EC) test [2].

If a field has poor pH conditions for planting, then we can increase soil fertility by increasing the alkaline saturation value of the soil. One of the efforts to increase the saturation value of the base can be done by liming or applying NPK fertilizer, Dolomite fertilizer, KCl fertilizer, etc. By knowing the value of alkaline saturation, we are able to determine soil fertility. The soil is said to be fertile if the alkaline saturation is ≥80%, it is said to be moderate if it is 80-50% and infertile if it is ≤50% [3].

Another factor that determines the quality of the land soil that is good for planting is the texture and content of C-Organic. The texture of the soil is a combination of clay, dust, and sand. The combination of these three elements must be balanced so that a good soil texture is obtained. The good soil texture is determined based on the type of plant to be used. If the land owned does not have the desired texture, then the soil can be converted into the desired texture by adding sand, clay, or organic fertilizers [4].

Soil texture testing can be done using the Hydrometric method which is assisted by an instrument in the form of a soil hydrometer. In this method, a chemical solution in the form of Sodium Polyphospate ($NaPO_3$) or Na-Hexametaphospate [$(NaPO_3)_{13}$] can be used to extract the elements to be analyzed or rather break down the sand, clay and dust elements that unite in the soil sample so that the percentage of content can be measured. This test is also assisted by several other instruments such as thermometers to measure the temperature of the solution and so on [5].

The soil also contains C-Organic which is used as an indicator of other soil fertility determinants. The content of C-Organic in the soil is very important, especially in the process of growing and developing plants planted on the land. Organic matter in the soil containing the element carbon is called C-Organic. This element is one of the elements needed by the soil to increase fertility so that planting can be carried out in the soil because C-Organic itself is one of the foods for soil microorganisms that carry out soil mineralization processes and recycle organic matter in the soil. These microorganisms can also be used as a food source for higher organisms that can help the process of dilation of soil pores such as ants so that water and air can flow properly (Mayer et al., 2020). [6]

C-Organic measurements in soil can be done using the Walkley and Black method which uses Redox Titration with compounds in the form of Potassium Dichromate (K2Cr_2O_7) or usually called Dichromatometric Titration. In this experiment, qualitative results will be obtained in the form of knowing the presence of C-Organic elements in the sample and quantitatively the amount of C-Organic content in the soil sample [7].

Experimental

A. Exchangeable Cation Test (EC)

This testing process begins with the processing of soil samples that were originally still in the form of chunks of soil, dried for 48 hours so that the water content in them is lost, then continued by grinding the soil that has dried using a milling tool until the soil particles become smaller or can be said to be finer. Then sifting is carried out to filter the soil sample and not forget the sample is put into the sample container / plastic that has been labeled so that there are no technical errors such as mixing sample sequences and the like.

After completing the processing of soil samples, proceed with the manufacture of NH_4OAc chemical solution using Ammonium

Acetate powder as much as 154.16 gr which will later be dissolved with a small amount of water and stirred until saturated using a stirrer. After the solution is thoroughly mixed, it is put into a measuring flask of 2000 ml and added aquades to the limit.

Sample preparation is carried out for analysis by mixing soil samples that have been treated and weighed with an analytical balance weighing 2.5 grams and adding a chemical solution of NH_4OAc to extract the desired elements from the sample so that it can be analyzed qualitatively and quantitatively. The extraction process is assisted by a shaker to homogenize the solution and sample. The process is carried out for 120 minutes with a shaker speed of 120 turns / minute. Then continued with the filtration process with Whatmann filter paper No.42 and the filtrate was analyzed using an instrument in the form of a Microwave Plasma Atomic Emission Spectroscopy (MP-AES). The analysis process with instruments will identify the presence of elements to be known (qualitative analysis) and provide the number of elemental presence (quantitative analysis) in the form of mg / l [8].

The instrument used, namely the Microwave Plasma Atomic Emission Spectroscopy (MP-AES) uses the principle, namely atomic emission which is a form of energy produced by an atom when it returns to the ground state of the excited state (Excitation State). This situation occurs because atoms in the ground state are given external energy which in this experiment is in the form of heat / heat energy from the plasma produced by the Torch on the instrument so that it enters an excited state. Once this external energy is stopped, the atom will return to the ground state while releasing energy in the form of light intensity in a certain wave which will be dispersed by the Monochromator so that it can be read by the Detector and converted into an electrical signal to be transferred and read on the computer. This tool produces the data obtained in the form of mg / l [9].

B. Soil Texture Test

Soil texture testing is carried out using the Hydrometry method and an instrument in the form of a Type 152H soil hydrometer which functions based on the principle of Archimedes' Law which states that "objects that are immersed in the fluid experience an upward force as heavy as the fluid is transferred" so that later the density of the liquid substance will be calculated [10].

This testing process has the same process as the Exchangeable Cation Test (EC) for soil management, and for the process of making a chemical solution in the form of Kalgon, it is carried out by weighing 80 g of Sodium Polyphospate powder. Then a little aquadest is added and stirred with a stirrer until smooth / saturated solution. Then put in a measuring flask 2000 ml and add aquadest to the limit while shaking.

Then proceed with weighing soil samples with as much as 50g. After that, a 20 ml solution of Kalgon (Sodium Polyphospate) was added to break down the components of dust, clay and sand that were fused in the soil sample and also added 150 ml of aquaades before dispersing. Stirring is carried out to speed up the process and dispersed in the dispenser so that the solution can be extracted perfectly for 5 minutes. The dispersed solution is poured into a cylindrical glass of 1000 ml to be ready for analysis and added aquadest to the limit. After this process, it is necessary to allow the dispersed solution to stand so that it can completely split the clay, sand and dust components in it for 12 hours. When it is ready to be analyzed, take measurements / analysis with a soil hydrometer as much as 2 measurements. Measurement I is carried out by shaking the solution while adding a 70% alcohol solution to remove the foam on the surface of the solution and facilitate the reading of the tool. After stirring ±20 seconds, measure with a hydrometer and wait 40 seconds before reading the tool. While waiting, use a thermometer to measure the temperature of the solution. Read the measurement results of the tool and record the results. The value of the measurement is entered into the formula below:

Formula 1:

$$\%Sample\ Weight = \left[\frac{(100 - \%Water\ Content)}{100}\right]$$

For measurement II is carried out after 2 hours after measurement I, this is because the sand content which is the heaviest component falls to the bottom of the cylindrical glass and then the clay content can be measured in it. Measurement 2 has the same measurement method except that no shaking is carried out and the addition of 70% alcohol to it [11] . The value of the measurement is entered into the formula below:

Formula 2:

$$\%Sand = 100 - \left(\frac{Hydrometer\ Sight\ I}{\%Sample\ Weight} \times 100\right)$$

$$\%Clay = \left(\frac{Hydrometer\ Sight\ II}{\%Sample\ Weight} \times 100\right)$$

$$\%Dust = 100 - (\%Sand + \%Clay)$$

C. C-Organic Content Test

Testing on the content of C-Organic in mineral soil and peat samples to be determined to obtain data on the content of organic matter in the soil. This is necessary to indicate soil fertility because the higher the C-Organic content in the soil, the soil has a large supply of organic matter and the soil will become more fertile for cultivation. This test can also be used to determine the presence of soil microorganisms which help the soil fertilization process as well as food from high organisms which are also important in soil fertilization. For example, the higher the C-Organic content which is the food element of the soil microorganism, the more the presence of these microorganisms and this makes other high organisms such as ants that install them will be in large numbers as well. Ants themselves can also play a role in helping to enlarge pores in the soil which makes the soil have a good enough space for air and water to pass through [12].

Testing the soil C-Organic content in this laboratory is carried out using the Walkley and Black methods, namely Redox Titration using Potassium Dichromate ($K_2Cr_2O_7$) compounds. After the soil sample was treated, the coarse sample (2MM) was weighed with an analytical balance sheet with mineral soil weighing 0.2000 g and for peat 0.0400 g.

After weighing, a sample of $K_2Cr_2O_7$ was added using 5 ml of Finnpipette as a solution of reagent compounds to trigger changes that occurred later in the analysis process. H_2SO_4 of 10 ml was also added to the solution to speed up the sample extraction process. Let stand for 30 minutes during the extraction process then add aqueous 100 ml and let it rest for 15 minutes. Phosporic Acid (H_3PO_4) of 5 ml was added which aims to form a $Fe[HPO_4]+$ complex by capturing Fe_3+ and thereby preventing premature oxidation of Difenylamine (DPA) indicators. Added Difenylamine indicator (DPA) [$C_{12}H_{11}N$] to indicate the equivalence point and end point of titration. The addition of the DPA indicator changes the orange solution to black. Analysis was carried out with titration tools in the form of burettes and Erlenmeyer, with a titrant for the pentiter, namely $FeSO_4$ and the titrate, namely the sample solution. As long as the analysis occurs, the equivalent point will be marked by a change in black to deep purple, and the end point is a change in the color of the solution to green. The value of the measurement is entered into the formula below:

Formula 3:

$$Sample\ Weight\ (BKM) = Sample\ Weight\ (g) \times \left[\frac{(100 - Water\ Content\ (\%))}{100}\right]$$

$$Difference = Last\ Titration\ Volume - First\ Titration\ Volume$$

Formula 4:

$$\%\ C - Organic = \left[\frac{(Mean\ m\ Blanko - Difference)}{Sample\ Weight\ (BKM)}\right] \times \mathrm{NFeSO4} \times 0{,}30 \times \mathrm{f}$$

Information:

Mean m Blank $= \frac{(F1+F2+F3)}{3}$

f = 1.30

N $FeSO_4$ = 1.1

Formula 5:

%Organic Matter = 1.724 x % C-Organic (BKM)

Results and Discussion

The tests carried out are divided into 3, namely the determination of Exchangeable Cations (EC) of mineral and peat soils, the determination of mineral soil texture and the determination of C-Organic content in mineral soils and peatlands. The results obtained from the analysis carried out by the author are as follows:

1) Exchangeable Cation (EC)/Alkaline Saturation

Based on the data below, it can be known the content+ of nutrient cations in the form of K+, Ca+, Na+ and Mg+ which will later be used to determine the alkaline state / saturation of the soil analyzed. + As the data below attached, shows that the percentage of nutrient cations present is in relatively small amounts for mineral soils. The cause of the nutrient cation content in the soil at low levels is this can be due to the influence of soil composition which causes the soil to lack water, air circulation that is not smooth and soil-fertilizing microorganisms that cannot live and develop. This naturally occurs due to environmental changes due to temperature and weather. So that by using the data obtained from the analysis above, we will be able to overcome the ugliness of the soil by adding fertilizer like NPK, Urea or others. Unlike peat soil that have a high contents, mineral soil usually have a low nutrient contents that need to be fixed by adding fertilizer. Data in **Table 1**. below is obtained from the analysis of cation content data with instruments in the form of MP-AES and for measurement of relief data such as water content obtained from the analysis of the moisture content of soil samples using the Gravimetric method.

Table 1. Mineral Exchangeable Cation (EC) Test Results

No. Lab	No. Position	Heavy Sample	Power Water	Heavy Sample (BKM)	Analyte Concentration (mg/l)			
					Na	Ca	Mg	K
BLK-01	1	-	-	-	0,00	0,00	0,00	0,00
BLK-02	2	-	-	-	0,00	0,00	0,00	0,00
BLK-03	3	-	-	-	0,00	0,00	0,00	0,00
REFF	4	2,50	4,92	2,38	0,66	3,21	0,90	0,62
SJ2022-01825	5	2,50	0,781	2,48	0,86	3,64	1,07	0,97
SJ2022-01826	6	2,50	0,649	2,48	0,82	3,59	0,94	0,65
SJ2022-01827	7	2,50	0,452	2,49	0,70	1,39	0,90	0,46
NREFF	8	2,50	4,92	2,50	0,67	4,04	0,92	0,64

2) Mineral Soil Texture

Based on **Table 2**. below, a percentage of the constituent components of the soil, calls sand and clay, will be obtained from the measurement value I and measurement II using the Hydrometer instrument. After that, use the data below assisted by the data in **Table 3**. to define a Texture Class using the help of a texture triangle by the USDA.

Table 2. Results of Mineral Soil Texture Measurement with Hydrometer

No. Lab	Position No.	% Water Content (BKM)	Sample Weight % (BKM)	Reading Hydrometer I	Reading Hydrometer II
BLK	1		-	0	0
REFF	2	4,197	50.00	10	8
SJ2022-01911	3	0,89	50.00	10	3
SJ2022-01911	4	1,00	50.00	8	2
SJ2022-01911	5	2,14	50.00	8	2
DPL-01	6	0,89	50.00	9	2

So, this test aims to determine the texture of mineral soil on the land to be planted by industrial forest plants as wood producing materials for industries such as pulp and paper. This test is also used to obtain the state of soil texture and composition which will later be used as one of the determining indicators of land quality (Site Class). Every company have it's own site class that need to be done. So using this test will help it to have a great production on industrial forest wood due to the fact that the soils has a good condition for planting.

The soil itself consists of 3 main components, namely sand, clay and dust. And this test aims to determine the percentage of each component in the soil sample to later determine the soil texture with the help of the texture triangle that has been established by the USDA (United States Department of Agriculture) and later find out what management and countermeasures need to be done to the land. Using value of the measurements will give a great advantages for finding solutions to the problem which may interfere with the tree planting process for the industrial production. For example, soil with a high clay content has a texture that is sometimes hard, then poor air circulation due to lack of space for air cavities in it is also difficult to absorb water even though it has the ability to retain water and good nutrient cations. Conversely, a sand content that is too high, causes an air and water circulation system that is too good so that it does not have the ability to keep water and good nutrient content. This can be overcome by changing the composition of the soil by adding clay, sand or dust.

Based on the contents of the data in **Table 2.** Above can later be used to determine the contents of **Table 3**. By using the following **Formula 1**. and after that, it will be assisted by the **Formula 2**, then the results of the hydrometer reading I will give % sand in the soil sample and the hydrometer II reading will give % clay in the soil sample, which by adding up % sand and % clay and entering it into the formula below will get % dust.

Based on the results of **Table 3**. above, it can be said that the soil texture in the sample has a texture in the form of sandy clay except for the REFF soil texture (reference) which has a sandy clay texture class.

Table 3. Percentage Results of Mineral Soil Texture Constituent Components

Sand (%)	Clay (%)	Dust (%	Class Texture
-	-	-	-
78,70	17,04	4,26	Sandy Loam
79,25	6,22	14,52	Sandy Clay Loam
83,22	4,20	12,59	Sandy Clay Loam
82,61	4,35	13,04	Sandy Clay Loam
81,33	4,15	14,52	Sandy Clay Loam

3) C-Organic Content

Table 4. C-Organic Content Test Results

No. Lab	No. Position	Heavy Sample (g)	Power Water (%)	Heavy Sample (BKM)	FeSO Volume Requirement$_4$ (ml)		
					Early Vol.	Vol.End	Difference
BLK-01	1	-	-	-	0,00	5,80	5,80
BLK-02	2	-	-	-		11,60	5,80
BLK-03	3	-	-	-		17,40	5,80
REFF	4	0,2000	1,22	0,19756		22,15	4,75
SJ2022-01940	5	0,2001	0,08	0,19984	0,00	5,25	5,25
SJ2022-01941	6	0,2002	0,02	0,19996		11,00	5,75
SJ2022-01942	7	0,2000	0,01	0,19998		16,45	5,45
DPL-01	11	0,2001	0,10	0,19980		16,30	5,20

Based on **Table 4**. above, data is obtained which will provide results on the percentage of C-Organic content and organic matter in the soil sample as attached to **Table 5**. The data is calculated using **Formula 3**. and using it, will provide information about the titration value of the C-Organic test sample to be used in finding the value of the actual C-Organic dan Organic Matter content of the sample as shown in **Table 5.**

C-Organic test is use for determine the value of the carbon element in the soil that serves to fertilize it. Also by carrying out this test, it can be indicated the presence of soil-fertilizing microorganisms which will later be increased in number if necessary. Lack of organic carbon content in the soil can cause plants to grow less nutrients, and microorganisms in the soil lack of food sources. And it can harm the industrial process.

The data listed as attached to Table 5 will be obtained if value of **Table 4.** Is calculated using the **Formula 4**. and **Formula 5.** for finding data from the percentage of C-organic and organic matter.

Table 5. Percentage of C-Organic Content and Organic Matter

%C-Organic (BKM)	% Organic Matter
Mean m Blanko	- - -
2,28	3,93
1,18	2,03
0,10	0,17
0,75	1,3
1,29	2,22

Based on the data of **Table 5**. above, it can be concluded that the percentage content of C-Organic and organic matter in the soil sample is relatively low, it needs to be addressed. C-Organic content tends to be low on mineral soils and high on peat soils composed of a lot of organic matter. A simple way to fixed it by adding some fertilizer that containing high value of carbon inside it like biochar or something familiars.

Conclusion

Based on the research conducted, it can be concluded that the three tests are very useful for providing information about soil fertility levels. Because the Exchangeable Cation Test (EC) provides information in the form of the content of nutrient cations / nutrients in the soil in the form of alkaline saturation levels (K+, Ca2+, Na+ and Mg+), and for the C-Organic Content Test provides data in the form of a percentage of the amount / content of C-Organic elements (organic carbon) in the soil used by microorganisms in the soil that play a role in increasing soil fertility as food. Also for the Texture Test, it is useful in providing a percentage value of the mineral soil preparation components, namely sand, clay and dust that affect the soil as a planting medium.

Research data show that mineral soils contain low levels of c-organic nutrients and cations, different from peat soils which have high values. while the results of texture testing show the texture class of mineral soils, namely soil in the form of sandy loam.

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