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Evaluation of Soil Physicochemical Properties across Distinct Land Use Systems at Bina Widya Campus, Universitas Riau

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ABSTRACT

Land use is one of the key factors influencing both the physical and chemical properties of soil, including characteristics such as soil color and texture. This study aimed to characterize the physicochemical properties and fertility criteria of soils under different land use types. Five land use categories were selected for investigation: shrubs, grasses, Eucalyptus sp., mixed plantations, and oil palm. Each land use type consisted of three replications. Soil sampling was conducted at five designated points per land use type, with samples collected from a depth of 0–30 cm, resulting in a total of 75 samples. The research was carried out over a three-month period from April to July 2022 using a land survey approach and purposive sampling technique. The observed parameters included soil color, texture, permeability, pH, total nitrogen (N), total phosphorus (P), total potassium (K), organic carbon (C), base saturation, and cation exchange capacity (CEC). The results revealed that the soil color was predominantly black (2.5Y 2/1), with a sandy loam texture. Soil permeability ranged from moderately fast to fast (6.33–23.68 $cm \cdot h^{-1}$), while soil pH was acidic (4.75–5.11). Total nitrogen was categorized as low (0.11–0.18%), total phosphorus as very low (10.73–27.56 $mg \cdot 100g^{-1}$), and total potassium as very low to low (3.60–10.87 $mg \cdot 100g^{-1}$). Organic carbon content was low to moderate (1.49–2.45%), base saturation was very low (3.37–13.59%), and CEC was classified as very low to low (4,39 - 8,62 cmol (+).kg^{-1}).

Keyword: Land Uses, Soil Chemical Properties, Soil Physical Properties

ABSTRAK

Penggunaan lahan merupakan salah satu faktor yang mempengaruhi karakteristik fisik tanah seperti warna dan tekstur tanah serta kimia tanah. Penelitian ini bertujuan untuk mengetahui karakterisasi sifat fisiko-kimia tanah dan kriteria kesuburan tanah dalam penggunaan lahan yang berbeda. Penggunaan lahan pada penelitian ini yaitu belukar, rumput, *Eucalyptus* sp., kebun campuran, dan kelapa sawit. Setiap penggunaan lahan dilakukan 3 kali pengulangan. Titik pengeboran yang dilakukan yaitu 5 titik pada setiap penggunaan lahan dan sampel diambil pada kedalaman 0-30 cm. Jumlah total sampel adalah 75 sampel. Metode yang digunakan adalah metode survei dan purposive sampling. Parameter yang diamati adalah warna tanah, tekstur tanah, permeabilitas, pH tanah, N total, P total, K total, C organik, kejenuhan basa, dan kapasitas tukar kation. Hasil penelitian menunjukkan bahwa warna tanah didominasi oleh warna hitam (2,5Y 2/1), tekstur tanah didominasi oleh lempung berpasir, permeabilitas tergolong agak cepat sampai cepat (6,33 – 23,68 cm.jam^{-1}), pH tanah tergolong asam (pH 4,75 – 5,11), N total tanah tergolong rendah (0,11 – 0,18%), P total tergolong sangat rendah (10,73 - 27,56 mg.$100g^{-1}$), K total tergolong sangat rendah hingga rendah (3,60 - 10,87 mg.$100g^{-1}$), C organik tergolong rendah hingga sedang (1,49 - 2,45%), kejenuhan basa tergolong sangat rendah (3,37 – 13,59%), dan kapasitas tukar kation (KTK) tergolong sangat rendah hingga rendah (4,39 - 8,62 cmol (+).kg^{-1}).

Keyword: Penggunaan Lahan, Sifat Fisik Tanah, Sifat Kimia Tanah

1. Introduction

Soil has an important role in plant growth and production as a growth medium for plant roots, where plants rest, providers of nutrients and water for plants (Foth, 1998). Land cover can be interpreted as a type of expanse of objects that cover the surface of the earth while land use is a type of activity that takes place on the surface of the earth (Bhayunagiri, 2012). One type of land cover that is very beneficial for human life and other organisms that live in it is forests. Forests are habitats for living things both flora and fauna, play an important role in regulating the hydrological system, producing oxygen, and absorbing carbon dioxide so that forests are known as the lungs of the world (Seprina, *et al*., 2018). The increase in land needs is increasing along with the increasing population for various purposes such as meeting the needs for clothing, shelter, and food. One way out to meet the needs of the land is to encroach on forest land (Izzudin, 2013).

Forest land conversion is the change of forest tree functions into non-forest areas such as agricultural areas, plantations, and settlements. Land use and vegetation will affect soil properties, such as physical, chemical, and biological properties of the soil (Azmul and Irmasari, 2016). Land use that is not within its means and without taking into account conservation measures will encourage an increase in degraded land (Saidi, 1995). Different soil properties cause each plant to have different reactions. Land use affects the physical condition of the soil such as soil color and texture and soil chemistry e.g. soil organic content (Muslim, *et al.*, 2020). In primary forest land use, the soil texture is clayey while agroforestry land and cocoa plantations have sandy loam soil texture. In cocoa plantations, the porosity value obtained was the highest at 54,04%, then on agroforestry land 53,47%, and primary forest 49,93% (Tolaka, *et al.*, 2013). In addition, soil pH and total K in coffee plantation land use are higher than primary forest and agroforestry land. As for the C organic parameter and cation exchange capacity (CEC) of primary forests are higher than agroforestry and coffee plantations (Rahmah, *et al.*, 2014).

This study aims to identify the physical and chemical properties of soil in the Bina Widya campus area of Universitas Riau. The data obtained can be used for database input and reference for research or sustainable land processing activities.

2. Method

This research was conducted in Bina Widya campus area of Universitas Riau using survey methods and determining the location of sampling points using purposive sampling methods in 5 land uses, namely shrubs, grasses, *Eucalyptus* sp, mixed plantations, and oil palm. Each land uses was carried out 3 repetitions and each repeat location had 5 sampling points with a depth of 0-30 cm determined diagonally on an area of 40 m x 40 m so that the number of sample points amounted to 75 points. The observed data was processed descriptively using SPSS Statics 26 for windows.

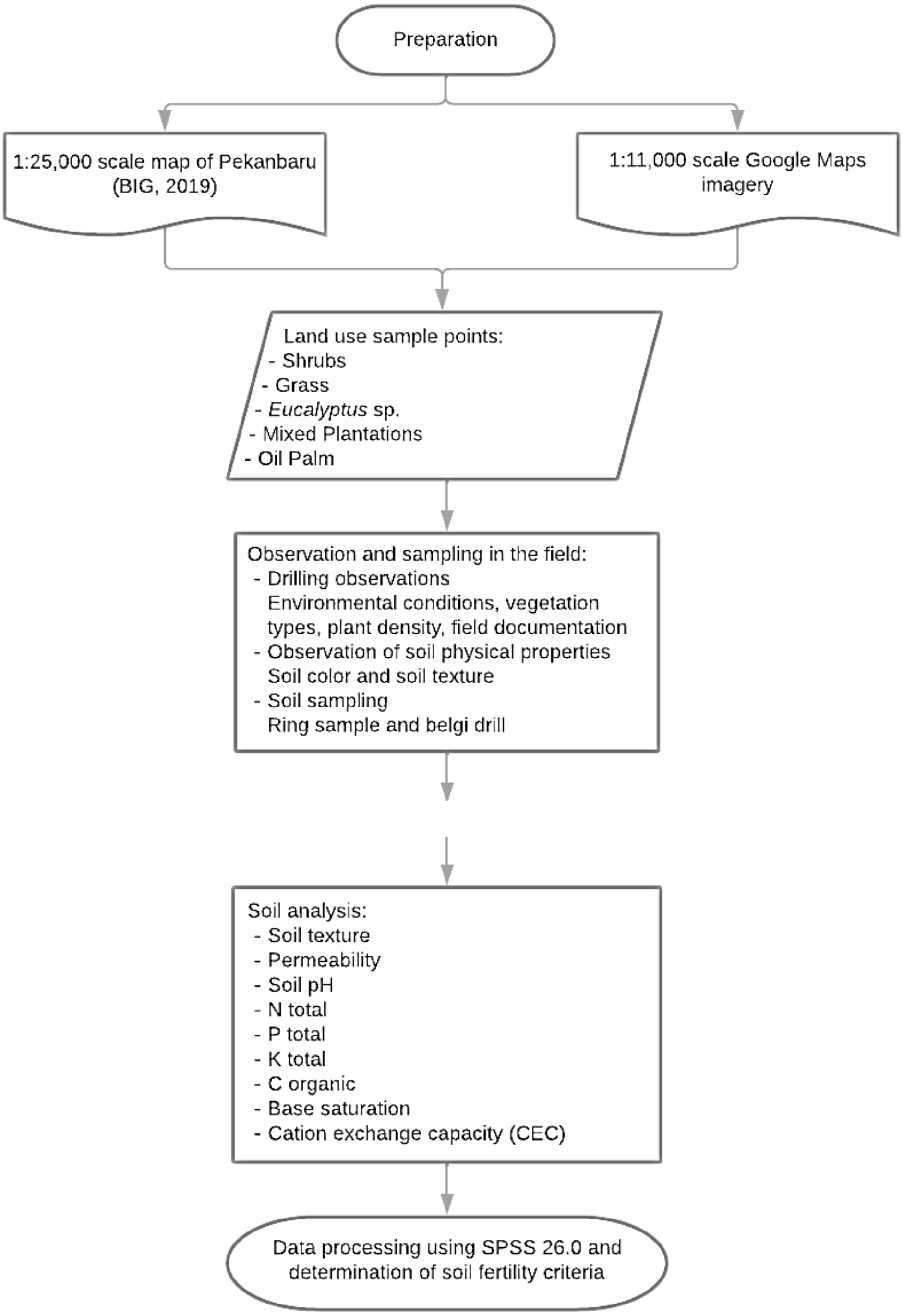

Figure 1. Research implementation flow

3. Result and Discussion

3.1. Physical characteristics of land uses

Soil color is determined by comparing soil samples with the Munsell Soil Color Chart that expressed in three units, namely hue, value, and chroma. The results of the study (Table 1) showed that the top layer of each land use was black with mixed plantations having the darkest color of 2.5Y 2/1 (black) with a thickness of 19 cm. The color of the bottom layer was found to be the brightest color, namely in the use of oil palm land with observations of 10YR 8/8 (yellow) as deep as 48 cm. One of the causes of differences in soil color is influenced by differences in organic matter content. The higher the organic matter content, the darker the soil color while the lower layers generally contain low organic matter. Soil color is also influenced by the amount of Fe compounds in the soil. In addition, the process of burning land that occurs on the ground surface can also change the color of the soil (Meli, *et al.*, 2018). The results of soil chemical analysis prove that the organic matter content in mixed plantations has the highest content reaching 2,96% so that mixed plantations have a darker soil color than other land use locations.

Table 1. Depth, soil color, and soil thickness in various land uses

Land Use	Depth (cm)	Soil Color	Thickness (cm)
Shrubs	0-20	2.5Y 2/1 (*black*)	15,5
	20-40	2.5Y 3/2 (*very dark grayish brown*)	34,5
	40-60	2.5Y 5/4 (*light olive brown*)	10
Grass	0-20	2.5Y 2/1 (*black*)	17
	20-40	2.5Y 4/2 (*dark grayish brown*)	20
	40-60	10YR 8/6 (*yellow*)	23
Eucalyptus sp.	0-20	2.5Y 2/2 (*black*)	16
	20-40	2.5Y 4/2 (*dark grayish brown*)	31
	40-60	2.5Y 7/6 (*yellow*)	13
Mixed Plantations	0-20	2.5Y 2/1 (*black*)	19
	20-40	2.5Y 3/2 (*very dark grayish brown*)	8
	40-60	2.5Y 7/4 (*pale yellow*)	33
Oil Palm	0-20	2.5Y 2/1 (*black*)	2
	20-40	10YR 6/6 (*brownish yellow*)	10
	40-60	10YR 8/8 (*yellow*)	48

The soil texture class criteria are determined using the soil texture class guide. Based on the results of the study, the dominant texture classification is sandy clay found in grass land use, *Eucalyptus* sp., mixed plantations, and oil palm. While the clay sand soil texture class is only found in shrubs. Soil that contains too much sand is not good for plant growth because it has a small surface area so it is difficult to absorb or hold water and nutrients while soil that contains a lot of silt is stronger in holding water compared to sandy soil because it has small pores and water responsiveness slowly so that water is held by the soil for a long time. The clay-textured soil has a large surface area so that it can hold water and provide higher nutrients (Foth, 1998). Based on the results of the study (Table 2) the dominant soil texture classification is sandy loam. The use of grassland containing the highest clay (18%) has the ability to escape water rather quickly, meaning that the ability to hold water in that location is better than the use of shrubs land containing the highest sand (80%) so that the ability to escape water is also fast.

Table 2. Fractional values of sand, dust, clay, and soil texture classification

Land Use	Fractions (%)			Classification
	Sand	Silt	Clay	
Shrubs	80	11	9	Loamy sand
Grass	54	28	18	Sandy loam
Eucalyptus sp.	57	27	16	Sandy loam
Mixed Plantations	71	17	12	Sandy loam
Oil Palm	65	20	15	Sandy loam

Porosity or pore space is a cavity between soils filled with water or air. Pores greatly determine soil permeability, if the pores in the soil are large, the faster the soil permeability (Hanafiah, 2014)). Based on the results of the study (Table 3), the highest permeability value was found in the shrubs (23,68 cm.hour^{-1}) with a fast permeability class while the lowest permeability value was found in grass vegetation land use (6,33 cm.hour^{-1}) with a rather fast permeability class. The value of soil permeability in each land use tends to be rather fast to fast. The slow or fast rate of soil permeability can be influenced by the magnitude of soil porosity, where the greater the porosity, the greater the rate of soil permeability, so that the movement of water and certain substances moves quickly (Bintoro, *et al.*, 2017)). The part of the soil volume that is not filled with solid matter both mineral matter and organic matter is called the pore space of the soil. The total pore space consists of the space between sand, dust, and clay particles and the space between soil aggregates. If the distribution of the pore size of a soil is dominated by large pores (macro pores) then the soil has a low ability to store moisture (Arifin, 2011).

Table 3. Soil permeability in various land uses

Land Use	Permeability (cm.hour^{-1})	Classification
Shrubs	23,68	Fast
Grass	6,33	Rather Fast
Eucalyptus sp.	10,81	Rather Fast
Mixed Plantations	22,89	Fast
Oil Palm	14,77	Rather Fast

3.2. Chemical characteristics of land uses

The pH value of the soil is determined by electrometric methods. Based on the results of soil pH analysis (Table 4) it can be seen that the pH criteria for all land use is acidic, with the lowest average pH of 4,75 in *Eucalyptus* sp. and the highest average pH of 5,11 in mixed plantations. The low pH value in this study was influenced by the availability of cations in the soil. Soil pH is a factor that affects the availability of potassium and phosphorus in the soil so that if the soil pH is high, the availability of cations in the soil increases so that the absorption of nutrients by plants increases (Mautuka, *et al*., 2022). Cation exchange capacity (CEC) is the ability of soil to absorb and exchange or re-release. Cations in the soil such as Ca^{2+}, Mg^{2+}, Na^{+}, NH^{4+}, and can be absorbed by plant roots, then exchanged by H^{+} ions and released into the soil (H_2O) (Putri, *et al*., 2019). The results of CEC analysis (Table 4) found that the average value of CEC was lowest in land use *Eucalyptus* sp. which is 4,39 cmol (+).kg^{-1} with very low criteria and the highest in mixed plantations which is 8,62 cmol (+).kg^{-1} with low criteria. The increasing content of soil CEC, the ability of the soil to absorb and provide nutrients for plants will be greater. When nutrients are available in the soil and can be absorbed into plant tissues, the growth and quality of plants will increase (Djumali and Mulyaningsih, 2014). Another factor that affects soil acidity is the high rainfall at the time of the study. Areas with high rainfall generally have acidic soils. This is due to the process of washing alkaline from the absorption complex and lost through drainage water. In the alkaline state after washing, the Al and H cations remain so that the dominant cation causes the soil to react acidically (Meli, *et al.*, 2018). High rainfall also affects the value of alkaline saturation in the soil because it causes leaching of alkaline cations thereby reducing alkaline saturation in the soil (Winarso, 2005). Based on the results of the study (Table 4), the alkaline saturation of land use is very low with the lowest average base saturation value in land use *Eucalyptus* sp. which is 3,37% and the highest in mixed plantations is 13,59%. Base cations are generally easily washed, so if the base saturation value is low, it can be traced that the soil has undergone washing (Rofik, *et al.,* 2019).

The results of the total N analysis showed that land use had low total N levels with the lowest average value in *Eucalyptus* sp. land use. (0,11%) and the highest average in mixed plantations (0,18%). low total N is caused by low soil organic C content, leaching process, and evaporation into the air (Syahputra, *et al.,* 2015). The loss of N in gaseous form is greater than the loss in leached form. Low levels of N in plants can make plants wither to death. Plants that wither to death can affect the low production of dry weight in plants (Nariatih, *et al.*, 2013). One of the factors that affect the total N value is organic matter, if the organic matter is low then the total N value is also low, and vice versa so that if an increase in organic matter levels occurs then the N in the soil will also increase (Meli, *et al.,* 2018). Based on Table 4, the highest C organic matter was found in mixed plantations (2,45%) with medium criteria and the lowest was found in *Eucalyptus* sp. (1,49%) with low criteria. The high C organic in mixed plantations land use is due to the presence of many plant roots and grasses that are weathered in sufficient quantities, thus affecting the value of C organic.

The presence of phosphorus is usually relatively small, with fewer levels than nitrogen levels, because phosphate sources are fewer than nitrogen sources. The natural source of phosphorus is the weathering of mineral rocks (Basyuni, 2009). Based on the results of the total P analysis (Table 4), it can be seen that the lowest average total P in oil palm land use is 10,73 mg.100g^{-1} with very low criteria and the highest in mixed plantations is 27,56 mg.100g^{-1} with medium criteria. The high total P value in mixed plantations land use is because the land is a testing ground for agricultural students so that fertilization, land processing, or replacement of crop commodities are often carried out. Soil P and K levels are not other than influenced by the parent material and the level of soil management. Land that has a high level of land use intensification results in P and K residues in the soil that come from fertilization (Nursyamsi, *et al.,* 2007). Potassium (K) is the third nutrient after N and P needed by plants in large quantities and is absorbed by plants greater than these two elements (Sucherman, 2014). Based on the results of the analysis (Table 4), the lowest average total K in oil palm land use was 3,6 mg.100g^{-1} with very low criteria and the highest in mixed plantations at 10,87 mg.100g^{-1} with low criteria. Potassium in soil has a mobile nature so that it is easily lost through the washing process or carried away by the flow of water movement (Sofyan, *et al.*, 2000).

Table 4. Soil chemical properties in various land uses

Soil Properties	Land Use				
	Shrubs	Grasses	*Eucalyptus* sp.	Mixed Plantations	Oil Palm
Soil pH	4,77	4,82	4,75	5,11	4,98
N Total	0,12% (low)	0,16% (low)	0,11% (low)	0,18% (low)	0,16% (low)
P Total	12,64 mg.100g^{-1} (very low)	11,12 mg.100g^{-1} (very low)	10,78 mg.100g^{-1} (very low)	27,56 mg.100g^{-1} (medium)	10,73 mg.100g^{-1} (very low)
K Total	5,09 mg.100g^{-1} (very low)	5,39 mg.100g^{-1} (very low)	3,95 mg.100g^{-1} (very low)	10,87 mg.100g^{-1} (low)	3,60 mg.100g^{-1} (very low)
C Organic	2,17% (medium)	1,72% (low)	1,49% (low)	2,45% (medium)	2,30% (medium)
Base Saturation	3,81% (very low)	5,20% (very low)	3,37% (very low)	13,59% (very low)	4,08% (very low)
CEC	6,63 cmol (+).kg^{-1} (very low)	7,64 cmol (+).kg^{-1} (low)	4,39 cmol (+).kg^{-1} (very low)	8,62 cmol (+).kg^{-1} (low)	8,30 cmol (+).kg^{-1} (low)

4. Conclusion

Based on the research that has been done, it can be concluded that: 1) The value of soil physical and chemical properties parameters depends on the type of land use; 2) Physical properties of soil in the land use of shrubs, grasses, *Eucalyptus* sp, mixed plantations, and oil palm which included soil color are dominated by black (2.5Y 2/1), soil texture is dominated by sandy loam, soil porosity is classified as porous to good (55,84 - 67,73%), permeability is classified as rather fast to fast (6,33 - 23,68 cm.hour^{-1}); and 3) Chemical properties of soil in the land use of shrubs, grasses, *Eucalyptus* sp, mixed plantations, and oil palm which included soil pH is classified as acidic (pH 4,75 - 5,11), N total soil is classified as low (0,11 - 0,18%), P total is classified as very low (10,73 - 27,56 mg.100g^{-1}), K total is classified as very low to low (3,60 - 10,87 mg.100g^{-1}),C organic is classified as low to medium (1,49 - 2,45%), base saturation is classified as very low (3,37 - 13,59%), and cation exchange capacity (CEC) is classified as very low to low (4,39 - 8,62 cmol (+).kg^{-1}).

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