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Soil classification in karstic lowland of Baraja (BRA) land system in Mangarabombang District Takalar Regency

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Abstract. Soil characteristics in Mangarabombang Subdistrict Takalar Regency, according to some expert opinions, are classified as Vertisols soil order, but in the RePPPRot Land System Review Map, it's still classified as an Inceptisols soil order. Therefore more detailed research is needed regarding the soil order at that location. According to Soil Taxonomy at the sub-group category, this research aims to determine the types of soil in the karstic lowland of Baraja (BRA) land system. The method used is the toposequence transect and the analysis of physical and chemical properties, including soil color, structure, texture, bulk density, C-organic, CEC, pH, COLE, electrical conductivity, and bases saturation. These research results are the soil in the Baraja land system is undulating (34 masl), and flat (20 masl) was classified as Vertisol Order with the Lithic Haplusterts Sub-Group with limestone as a parent rock. The soil is characterized by open and closed fractures periodic, and there is lithic contact. The soil in flat areas (10 masl) was classified as Inceptisol soil with the Vertic Haplustepts Sub-Group with highly weathered limestone as parent rock. A cambic horizon characterizes the soil with thin lamellae and an alteration process, but it has fractures closed and open periodically. Soil types formed in the karstic lowland of Baraja (BRA) land system in Mangarabombang Sub-District was Vertisol with the Lithic Haplusterts Sub-Group and Inceptisols with the Vertic Haplustepts Sub-Group. The type of soil formed is affected by dominant factors, including climate (low rainfall), the parent material (limestone), and topography.

1. Introduction

Mangarabombang is one of the districts which is located in the south and is approximately 7 kilometres from the capital city of Takalar Regency. The Mangarabombang District area is around 100.50 km² or 17.74% of the total of the Takalar Regency. Given the characteristics of the area and population and the suitability of the existing land, Mangarabombang District is directed as an agricultural development area, rice fields, dry land, and horticultural agriculture [1].

Land systems are combined information based on ecological principles relating to rock types, hydro-climates, landforms, soils, and organisms. The same land system will have the same combination of ecological or environmental factors, a land system consisting of a combination of source rock, soil, and topography. The land system will greatly affect the characteristics of the existing soil and soil-forming factors such as climate, vegetation/organism, and time [2].

The land system that can be found is based on the Land System RePPPRot Map at a scale of 1: 250,000 in the Takalar Regency, especially Mangarabombang District, namely the Baraja land system (BRA), which is in the form of flat to undulating karstic plains [3]. At this scale, one of the information



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obtained regarding the characteristics and types of soil formed in the area is classified as the Inceptisols soil order. However, according to several Takalar Regency experts, especially Mangarabombang District, the Baraja land system (BRA) is already classified as the Vertisol Order. So it is necessary to do more detailed research related to the classification of soil in the area.

Soil classification, mainly in the subgroup categories, can give much information about soil characteristics, particularly in grain size, cation exchange capacity, soil temperature, and soil depth, useful for land management [4,5]. Soil classification is a way of classifying soil based on the similarity of soil properties and characteristics, then giving it a name so that it is easy to remember and distinguish. Each type of soil has specific properties and characteristics, potentials, and constraints for certain uses. One of the most popular and newest soil classification system methods today is the USDA's soil taxonomic classification system [6].

The USDA land classification 2014 contains a variety of up-to-date information, including the addition of criteria on the lower horizon of the identifier, sub-order, to the family category. The classification system has specialties in terms of naming, the definition of horizon character, and other characteristics that make it easier for us to determine the type of land, in addition to the open system means open with the development of science so as not to close the possibility of additional land types in the future [7].

Based on the description, it is necessary to carry out Soil Classification in the Karstic Lowland System (BRA) in Mangarabombang District, Takalar Regency from the order category to the great group following the specific location characteristics, to complete the information about the area so that it becomes the first step for used as a guide in preparing a plan for land resource management and development of agricultural commodities that are appropriate and have great potential in the region.

This study aims to determine soil types at the great group level in the Baraja land system (BRA) in Mangarabombang District, Takalar Regency (According to the USDA Soil Taxonomy System [7]).

2. Methods

Observations, descriptions of soil profiles, and soil sampling were conducted in October 2020-January 2021 in Mangarabombang District, Takalar Regency, located at coordinates 5°32'15"S dan 109°27'47"E (figure 1). Soil profile opening and soil sampling are carried out based on toposequence (based on topography) (figure 2). Soil analysis was carried out at the Laboratory of Chemistry and Soil Fertility, Department of Soil Science, Faculty of Agriculture, Hasanuddin University, Makassar.

The tools used in this research were GPS, ArcGIS 10.3, camera, computer, a set of survey tools, and soil analysis tools. The materials used in this research were intact soil samples and disturbed soil samples, profile entry list, Second Edition USDA Soil Taxonomy Key Twelve, chemical materials used in the analysis, Mangarabombang district climate data, and work map of research location. The soil methods included; texture with a hydrometer, bulk density with gravimetry, pH, electrical conductivity, c-organic, Cation Exchange Capacity (CEC) with titration, Base saturation with titration, and soil shrinking-swelling with Coefficient of Linear Extensibility (COLE).

6 3. Results and discussion

3.1. Profile location

Soil profiles in the research area were taken in one topographic sequence in the Baraja land system (BRA) (figure 2). Profile 1 is located at an altitude of 34 masl, a relatively gentle area with limestone as the parent material. Profile 2 is located at an altitude of 20 masl, which is relatively plain with limestone as the parent material, ± 1,000 m from profile 1. Profile 3 is located at an altitude of 10 masl, which is relatively a plain area with weathered limestone as the parent material, ± 2,000 m apart from profile 1. The distance between each profile is ± 1,000 m.

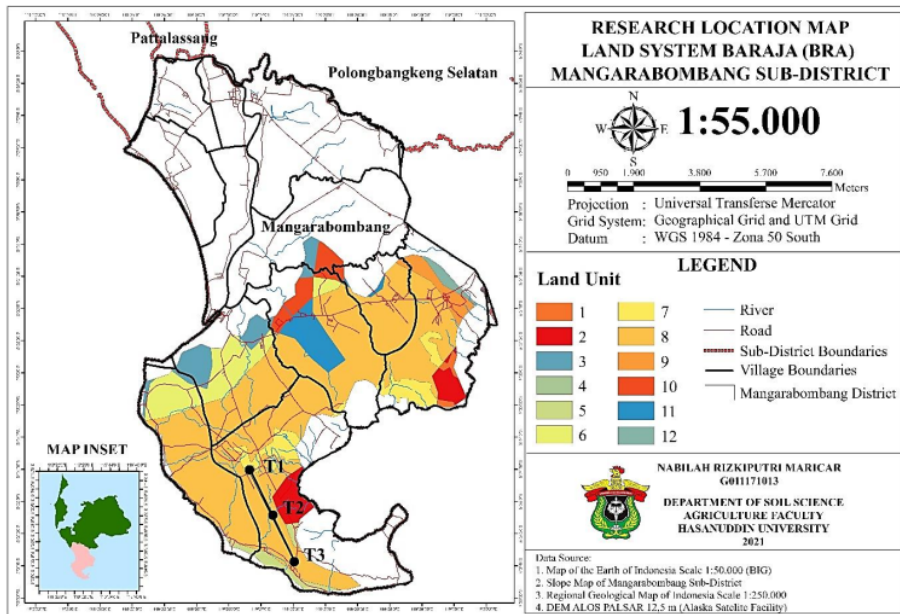


Figure 1. Research location map.

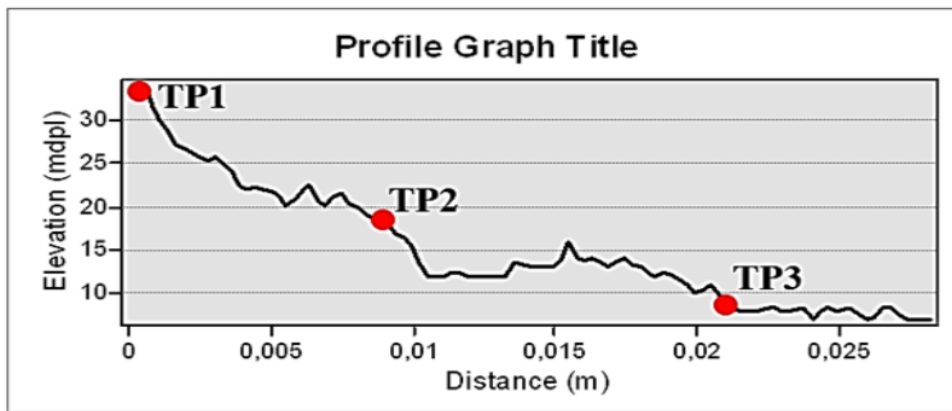


Figure 2. Cross section profile.

3.1.1. *Profile 1.* This profile is located at the coordinates 119°26'48.9"E and 5°34'29.4"S and located in Laikang Village, Mangarabombang District, Takalar Regency. This profile represents the geological formation of Temt (limestone Tonasa Formation) with bare land use, slope 3-8% with a sloping or undulating area with various vegetation including grass, shrubs, and palmyra trees. The parent material is limestone.

Soil solum is classified as a medium with a thickness of 60 cm with an effective rooting depth of 40 cm. A Horizon is 0-10 cm thick, B horizon is 10-40 cm thick, CR horizon is 40-60 cm thick, and the RC horizon >60 cm thick (figure 3). The morphology of the A horizon profile is black (2.5Y 2.5/1), clay

texture, granular to blocky structure, medium coarse and fine roots, macropores with very sticky consistency, clear horizon boundaries. The soil bulk density is 1.18 gr/cm^3 , and the soil shrinking-swelling is very high with a value of 0.22, the soil reaction (pH) is 6.84, the CEC is high with a value of 27.71 cmol/kg, base saturation is high with a value of 65.1%, electrical conductivity is classified as very low with a value of 0.27 dS/m and C-organic 2.93%. The soil from carbonate rocks has been characterized by a high content of clay fraction [8].

The B horizon profile morphology is dark reddish-brown (5YR 2.5/2), clay texture, blocky structure, medium coarse and fine roots, and macropores with sticky consistency and clear horizon boundaries. The soil content weight is 1.22 gr/cm^3 , the soil shrinking-swelling is very high with a value of 0.14, the soil reaction (pH) is 6.89, the CEC is classified as moderate with a value of 24.46 cmol/kg, saturation the base is classified as high with a value of 61.4%, C-organic 1.94%, and the electrical conductivity is classified as very low with a value of 0.23 dS/m.

The CR horizon profile morphology is pale yellow (10YR 8/2), clay texture, blocky structure, medium coarse and fine roots, and macropores with sticky consistency, clear horizon boundaries. The soil bulk density is 1.31 gr/cm^3 , the soil shrinking-swelling is high with a value of 0.07, the soil reaction (pH) is 6.92, the CEC is classified as moderate with a value of 24.78 cmol/kg, saturation the base is classified as a medium with a value of 44.3%, C-organic 0.59%, and the electrical conductivity is classified as very low with a value of 0.18 dS m.

The soil in profile 1 has fractures that open and close periodically to belong to the Vertisol order. The sub-order is Usterts, namely other Vertisols if they are not irrigated throughout the year, have fractures with a width of 5 mm or more, reaching a thickness of 25 cm or more, within 50 cm of the mineral soil surface, for 90 cumulative days or more each year, in the normal years [7]. Included in the great Haplusterts group because it does not have one of the other group properties and has an ustic soil moisture regime [7, 9]. Included in the Lithic Haplusterts subgroup, namely Haplusterts, which have lithic contact within 50 cm of the mineral soil surface [7].



Figure 3. Cross-section *Lithic Haplusterts* profile 1.

3.1.2 Profile 2. This profile is located at the coordinates $119^{\circ}27'11.2''\text{E}$ and $5^{\circ}35'12''\text{S}$ and located in Laikang Village, Mangarabombang District, Takalar Regency. This profile represents the geological formation of Temt (limestone Tonasa Formation) with dry land use, slopes of 0-3% with a flat area with a variety of vegetation including grass, palmyra trees, and shrubs. The parent materials are limestone.

Soil solum is classified as deep with a thickness of 150 cm with an effective root depth of 30 cm. A horizon A is 0-20 cm thick, B horizon is 20-80 cm thick, CR horizon is 80-150 cm thick, and RC horizon is >150 cm thick (figure 4). A horizon profile's morphology is dark grey (10YR 4/1), clay texture, granular to blocky structure, medium-fine roots, macropores with sticky consistency, gradual horizon boundary. The bulk density of the soil is 1.1 gr/cm³, the soil shrinking-swelling is very high with a value of 0.32, the soil reaction (pH) is 6.91, the cation exchange capacity (CEC) is high with a value of 30.74 cmol/kg, saturation the base is classified as a medium with a value of 55.3%, C-organic 2.50%, and the electrical conductivity is classified as very low with a value. 0.30 dS/m.

The B horizon profile morphology is dark greyish brown (10 YR 3/2), clay texture, blocky structure, medium-fine roots, and there are macropores with very sticky consistency, the horizon boundary gradually. The soil content weight is 1.12 gr/cm³, the soil shrinking-swelling is very high with a value of 0.20, the soil reaction (pH) is 6.93, the cation exchange capacity (CEC) is classified as moderate with a value of 22.33 cmol/kg, saturation the base is classified as high with a value of 74.2%, C-organic 1.61%, and the electrical conductivity is classified as very low with a value. 0.22 dS/m.

The morphology of the CR horizon profile is white (7.5YR 8/1), clay texture, blocky structure, medium-fine roots, macropores with very sticky consistency, and gradual horizon boundary. Soil content weight 1.23 gr/cm³, the soil shrinking-swelling is very high with a value of 0.14, soil reaction (pH) 6.97, CEC is classified as moderate with a value of 19.66 cmol/kg, base saturation classified as high with a value of 74.2%, C-organic 1.03% and electrical conductivity classified as very low with a value. 0.26 dS/m.

The soil in profile 2 has fractures that open and close periodically to belong to the Vertisol order. The sub-order is Usterts, namely other Vertisols if they are not irrigated throughout the year, have fractures with a width of 5 mm or more, reaching a thickness of 25 cm or more, within 50 cm of the mineral soil surface, for 90 cumulative days or more each year, in the normal years [7]. Included in the great Haplusterts group because it does not have one of the other group properties and has an ustic soil moisture regime [7,9]. Included in the Lithic Haplusterts subgroup, namely Haplusterts, which have lithic contact within 50 cm of the mineral soil surface [7].

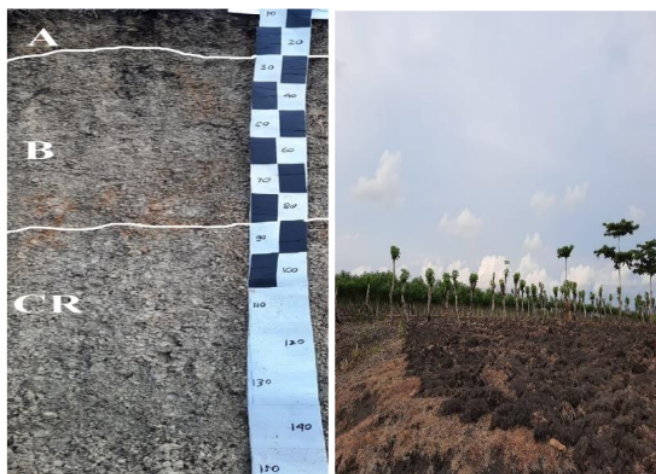


Figure 4. Cross-section *Lithic Haplusterts* profile 2.

3.1.3. Profile 3. This profile is located at the coordinates 119°27'30.5" and 5°35'56.4"S and located in Laikang Village, Mangarabombang District, Takalar Regency. This profile represents the geological formation of Temt (limestone Tonasa Formation) with dry land use, slope 0-3% with a flat area with various vegetation including grass and shrubs. The parent material is weathered limestone.

Soil solum is classified as shallow with a solum thickness of 40 cm with an effective rooting depth of 40 cm (figure 5). The A horizon is 0-10 cm thick, the B horizon is 10-28 cm thick, the CR horizon is 28-40 cm thick, and the R horizon is >40 cm thick. A horizon profile morphology is dark olive-grey (2.5Y 3/2), clay texture, granular to blocky structure, medium-fine roots, macropores with very sticky consistency, clear horizon boundary. Soil content weight is 1.1 gr/cm³, and the soil shrinking-swelling is very high with a value of 0.32, soil reaction (pH) 6.87, CEC is high with a value of 30.34 cmol/kg, base saturation classified as moderate with a value of 51.3%, C-organic 2.57% and very low electrical conductivity 0.37 dS/m.

The B horizon profile morphology is olive-grey (5Y 3/2), clay texture, blocky structure, medium-fine roots, macropores with sticky consistency, and clear horizon boundaries. The soil bulk density is 1.15 gr/cm³, and the soil shrinking-swelling is very high with a value of 0.27, the soil reaction (pH) is 6.91, the CEC is high with a value of 25.26 cmol/kg, the saturation of the base classified as a medium with a value of 43.5%, C-organic 1.03% and very low electrical conductivity 0.42 dS/m.

The morphology of the CR horizon profile is olive yellow-grey (2.5Y 6/6), clay texture, blocky structure, medium-fine roots, and there are macropores with sticky consistency, clear horizon boundaries. The soil bulk density is 1.27 gr/cm³, the soil shrinking-swelling is high with a value of 0.07, the soil reaction (pH) is 6.98, the CEC is moderate with a value of 20.41 cmol/kg, the saturation of the base classified as a medium with a value of 56.4%, C-organic 1.31%, and the electrical conductivity is classified as very low 0.25 dS/m.

The soil in profile 3 has a cambic horizon characterized by the presence of thin lamellae and an alteration process so that it belongs to the Inceptisol order [7]. The sub-order is Ustepts which is another Inceptisol that has an ustic moisture regime [7,9]. Included in the great group Haplustepts because it does not have one of the other group properties. Included in the Vertic Haplustepts subgroup because there are fractures that open and close periodically [7].

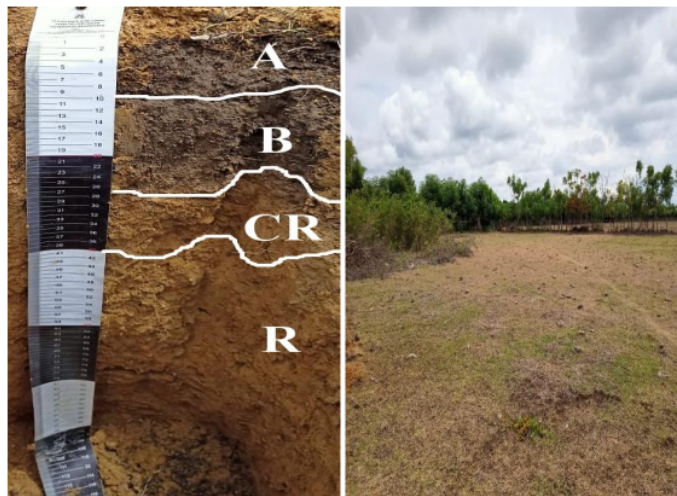


Figure 5. Cross-section *Vertic Haplustepts* profile 3.

3.2. Soil classification and forming factors

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The soil classification in the Mangarabombang District can be seen in table 1.

Table 1. Soil Classification of sub-group categories in Baraja (BRA) land system of the Karstic Lowland, Mangarabombang District according to USDA 2014.

Profile point	Horizon characteristics	Other characteristics	Ordo	Sub Ordo	Group	Sub Group
TP. 1	-	Fractures that open and close periodically	Vertisol	Usterts	Haplusterts	Lithic Haplusterts
TP. 2	-	Fractures that open and close periodically	Vertisol	Usterts	Haplusterts	Lithic Haplusterts
TP. 3	Cambic	Thin lamella and the alteration process	Inceptisol	Ustepts	Haplustepts	Vertic Haplustepts

3.2.1. *Lithic Haplusterts*. This type of soil is found in profiles 1 and 2. The main material, namely limestone, is in a wavy (34 masl) and flat (20 masl) area. This land includes developed lands characterized by periodic open and closed fractures and lytic contact. Soil forming factors that influence climate (low rainfall), the parent material so that the properties of this soil have properties similar to the parent material that is alkaline and the topography is wavy to flat [10,11].

3.2.2. *Vertic Haplustepts*. This type of soil is found in profile 3. The parent material, namely weathered limestone, is in a flat area with an altitude of 10 meters above sea level. This land includes newly developed soil, characterized by a cambic horizon (presence of thin lamellae and alteration processes). Soil forming factors that influence are source rock and topography (slope position). In general, this soil's formation process runs rather slowly due to changes in the parent material, thus showing less intensive weathering (developing soil), but this soil has fractures that open and close periodically. Some of the properties of this soil still have properties that resemble the parent material. A flat slope with low rainfall also affects soil formation's rapid and slow process [10,11].

3.3. The Relations of the baraja land system (BRA) of the karstic lowland with the characteristics of the formed soil

Based on the RePPPRot Land System Map (1988), the Baraja land system (BRA) is in the form of flat to bumpy karstic plains in dry areas, with a slope of 2-10%. Types of source rock found in the Baraja land system (BRA) are limestone (limestone), coral (coral), and marl (marl). The soil order in the Baraja land system (BRA) is Inceptisol.

However, after conducting more detailed research related to soil classification in the Baraja land system (BRA), there is a process of soil development (pedogenesis) so that the type of soil in the land system has changed over time from the category of the Inceptisol order (young soils that have not been developed further) to the order Vertisols. This occurs because of accumulating minerals 2:1, and the second is the expansion and contraction process that occurs periodically to form slickenside or micro-relief [12].

Vertisol soil is one of the orders in the taxonomy of soils that expands when exposed to water, contracts, and becomes hard when dry [13]. The unique property of vertisols is associated with shrinking- swelling, resulting in vertical mixing (pedoturbation), lateral shear, cracks, slickensides, and gilgai [12,14]. Soils are an important part of agriculture as a nutrient source for plants and organisms. Most of the nutrient sources are derived from parent rock [15]. The parent material of vertisol is sediment dominated by smectite clay or weathering of rocks containing smectite. The distribution is mainly in tropical, semi-arid sub-humid, and Mediterranean climatic areas, which differ between dry and wet seasons [16,17]. Gilgai is a microtopography and is also called a crabhole [8]. Vertisols contain 30-90% clay [19]. Besides that, according to [20] One of the characteristics of vertisol is the presence of the montmorillonite mineral who makes this type of soil expand when wet and shrink when dry causing slickenside to form.

4. Conclusions 4

Soil types formed in the karstic lowland of Baraja (BRA) land system in Mangarabombang Sub-District, Takalar Regency was Vertisol with the Lithic Haplusterts sub-group and Inceptisols with the Vertic Haplustepts sub-group. The type of soil formed is affected by dominant factors, including climate (low rainfall), the parent material (limestone), and hilly to flat topography.

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