Soil Physical Characteristics of The Mangrove Ecosystem in Bone Bay, Palopo City

10.18196/pt.v11i2.16646

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ABSTRACT

The distribution of mangrove plants is influenced by various factors, including the physical characteristics of the soil. The study was conducted to determine the physical characteristics of the soil in the mangrove ecosystem in Bone Bay, Palopo City. Soil sampling was performed using the purposive sampling method in five points with three replications based on the equations of growth and density of mangrove vegetation. Physical characteristics of the soil sample, including texture, color, permeability, bulk density, and soil porosity, were analyzed in the laboratory. The results showed that the dominant soil textures were squirming and sandy loam. The dominant soil color was very dark gray. Soil permeability is high and belongs to the fast criteria, with the highest value of 20.0 cm/hour at the fourth depth point of 0-30. The highest bulk density at the fourth depth point is 31-60 cm, with a value of 0.81 gr/cm3. At the same time, the porosity of the soil is classified as a high or good criterion, with the highest value found at the third depth point of 0-30 cm with a value of 77%. In the future, soil physical characteristics data can be used as preliminary information or databases for the government to organize and preserve mangrove forests.

Keywords: mangrove forest; soil characteristics; soil physical

ABSTRAK

Ada beberapa faktor yang mempengaruhi penyebaran tumbuhan mangrove, salah satunya faktor fisik tanah. Penelitian dilakukan dengan tujuan untuk mengetahui karakteristik fisik tanah pada ekosistem mangrove di Teluk Bone, Kota Palopo. Data Karakteristik Fisik Tanah yang diukur meliputi yaitu Tekstur, Warna, Permeabilitas, Bulk density dan Porositas tanah yang diperoleh dari hasil analisis sampel tanah di Laboratorium dengan pengambilan pada lima titik dengan tiga ulangan berdasarkan persamaan pertumbuhan dan kerapatan vegetasi mangrove. Hasil penelitian menunjukkan bahwa Tekstur tanah yang dominan adalah lempung berliat dan lempung liat berpasir. warna tanah yang dominan adalah very dark gray (abu-abu sangat gelap). Permeabilitasnya tinggi dan tergolong dalam kriteria cepat, dengan nilai tertinggi yaitu 20,0 cm/jam pada titik empat kedalaman 0-30 cm. Bulk density tertinggi pada titik empat dengan nilai 0,81 gr/cm3 kedalaman 31-60 cm. Sedangkan Porositas tanah tergolong tinggi atau kriteria baik, dengan nilai tertinggi terdapat pada titik tiga kedalaman 0-30 cm dengan nilai 77%. Kedepannya data karakteristik fisik tanah dapat menjadi informasi awal atau database bagi pemerintah untuk menata dan melestarikan hutan mangrove.

Kata kunci: *hutan mangrove; karakteristik tanah; fisik tanah*

INTRODUCTION

Mangrove forests have multiple benefits with a broad influence when viewed from social, economic, and ecological aspects (Delvian et al., 2017). In general, there are four types of plants found in mangrove forests, namely Api-Api trees (*Avicennia*), Mangroves (*Rhizophora*), Tanjang (*Bruguiera*), and Pedada (*Sonneratia*) (Shofanduri, 2018). However, *Rhizophora* sp. dominates in the mangrove forest ecosystem. It is a large tree, about 4-30 meters tall, with two root systems—support roots and hanging roots—that cause mangroves (*Rhizophora* sp.) to be frequently planted on the shore to break waves from the sea (Aziz et al., 2017). This distinctive feature distinguishes *Rhizophora* sp. from other

Article History
Received: 26 October 2022
Accepted: 26 July 2023

types of mangroves (Purwanti, 2016).

The soil's physical properties significantly affect the infiltration rate of vegetation (Musdalipa et al., 2018). Soil has physical characteristics that can be used as a parameter for the growth of mangrove vegetation. Strength and carrying capacity, soil ability to store water, drainage, plant root penetration, air system, and nutrient binding are all closely related to the physical properties of the soil (Mahmud et al., 2014). This causes the structure and composition of mangrove plants to have distinct boundaries, ranging from zones close to land to zones close to the ocean, and causes differences in the structure of mangrove plants from one area to another (Shofanduri, 2018). Each type of mangrove plant has different adaptability to environmental conditions, such as soil conditions, salinity, temperature, rainfall, and tides. Environmental factors such as soil texture, salinity, and tidal fluctuations greatly affect the existence and suitability of mangrove forests (Iswahyudi et al., 2019).

Bone Bay mangrove forest included in Palopo City's administration is precisely in Songka Village. The results of observations show that the mangrove ecosystem in Songka Village has experienced damage and reduction of vegetation due to illegal logging carried out by the community to meet their living needs, such as making pond land, settlements, building terminals, and farm roads, which are the result of conversion from mangrove forests (Karim et al., 2019). Mangrove ecosystems face severe problems, and various land expansion activities, such as urban development, cause this condition (Rustam et al., 2020). This phenomenon can cause changes in the physical properties of the soil, especially in the surface layer of the soil. Land change and expansion activities can certainly cause the loss of natural forms of mangrove forests, which are composed of typical types ranging from land formations in the form of Nipah types to the outermost formations of the coastline in the form of *Sonneratia* spp. and *Avicennia* spp. species (Indriyanto, 2010). This study aimed to analyze the physical characteristics of soil in the mangrove ecosystem in Songka Village, Palopo City. The Palopo City government is expected to consider this research in structuring and managing the mangrove ecosystem.

MATERIALS AND METHODS

Location Overview

This research was conducted from September to November 2021 in Songka Village, Palopo City. Songka is a village in South Wara District, Palopo, South Sulawesi, Indonesia. With an area of 4.6 km, Songka village has a mangrove ecosystem on the coastline of Bone Bay. Mangrove vegetation has been identified, and five species have grown, including *Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba, Avicennia marinna, and Xylocarpus granatum*. The first point (point 1) has experienced a reduction in vegetation due to activities carried out by the local community. The point is overgrown with mangrove vegetation species of *Rhizophora apiculata* and *Sonneratia alba*, which are equally dominant. The second point (point 2) is the same as point 1, which has experienced a reduction in vegetation due to activities carried out by the local community. The mangrove species that grow at this point are *Rhizophora apiculata, Sonneratia alba, and Xylocarpus granatum*, but the dominant species is *Sonneratia alba*. The third point (point 3) has relatively dense mangrove vegetation. This point is still overgrown with mangrove vegetation of *Rhizophora apiculata*, *Sonnaratia alba*, and *Avicennia marinna*, with the dominant species of *Rhizophora apiculata*. The fourth point (point 4) is a point that still has good density and vegetation growth, which is overgrown with mangrove vegetation species of *Rhizophora macronata*, *Sonnaratia alba*, and *Avicennia marinna*, with the most dominant species of *Rhizophora macronata*. The fifth point (point 5) still has a density and vegetation growth almost the same as point 4. The mangrove vegetation that grows at this point is *Rhizophora macronata* and *Sonnaratia alba*, and the most dominant species is *Rhizophora macronata*. The mangrove ecosystem in Songka Village, Palopo City, is not compact because of the damage caused by local community activities, resulting in the distribution of mangrove vegetation between ponds.

Soil Sampling

The primary data in this study are the physical characteristics of soil in mangrove ecosystems: texture color, permeability, bulk density, and soil porosity. The data were obtained from soil sampling analysis from 5 points with three replications so that 15 tests were carried out on the mangrove ecosystem in Songka Village, Palopo City.

Table 1. Coordinates of the sampling points in the mangrove ecosystem in Songka Village

NO	Y	X
1	-3.040880556	120.2253639
2	-3.041175575	120.2262139
3	-3.041752778	120.2290889
4	-3.040152778	120.2281556
5	-3.038497222	120.2274389

The determination of 8 soil sampling points was carried out intentionally (purposive sampling). At each sampling point, mangrove vegetation was determined to represent the front side, which is closer to the sea (points 4, 5, 6, 7, and 8), the middle side (points 1 and 2), and the back side (points 3). However, after re-observation, point 3 has been built as a terminal, and points 5, 6, and 7 have uniform vegetation in terms of growth and density so that it is made into one point. Based on these conditions, the number of sampling points in the mangrove ecosystem in Songka Village was five points (Table 1). The coordinates of the sampling points taken in the mangrove ecosystem in Songka Village are presented in Table 1.

Soil sampling was carried out using uPVC pipes of 2.5 inches at a depth of 0-100 cm with an interval of 0-30 cm, 31-60 cm, and 61-100 cm (Verisandria et al., 2018). The sample pipe was stuck into the ground, pressed, or hit lightly using a wooden beam until the sample pipe was embedded 100 cm deep. The top of the pipe was tightly closed, so the soil did not come out when the pipe was pulled out.

Sample pipes containing soil were covered with pipe covers and plastic bags. Then, they were labeled according to the sample names and stored in a non-reversed position for approximately three days.

The sampling pipes were cut with an interval depth of 0-30 cm, 31-60 cm, and 61-100 cm using a hacksaw, then the soil with the same interval depth was mixed or composited from 3 tests at five soil sampling points, resulting in 15 disturbed soil samples. The sample ring was taken at an interval depth from 3 tests at five soil sampling points, resulting in 15 whole soil samples.

The soil sample was then put into a zipper-lock or plastic bag and given a label name for each depth interval. Next, the sample was put into a box to be sent to the Soil Chemistry and Fertility Laboratory of the Department of Soil Science, Faculty of Agriculture, Hasanuddin University, for soil's physical characteristics analysis, including texture, permeability, bulk density, and soil porosity, and soil color was identified using the Munsell Book directly when cutting the sample pipe.

Soil Analysis

The data were analyzed using a quantitative descriptive method. Quantitative descriptive is used to describe and explain the facts of conditions in the field regarding the physical characteristics of the soil, namely texture, permeability, bulk density, and porosity of the soil obtained from the results of the analysis at the Soil Chemistry and Fertility Laboratory, Department of Soil Science, Faculty of Agriculture, Hasanuddin University.

RESULTS AND DISCUSSION

Soil Texture

Soil texture is essential to know because it can determine the physical properties of the soil. According to Qalbi et al. (2018), clay-textured soils have a higher nutrient-repellent ability and are more active in chemical reactions than coarse-textured soils. Meanwhile, sand-textured soils have a small surface area, so it is not easy to absorb (hold) water and nutrients (Kushartono, 2009). The results of the soil texture analysis can be seen in Table 2.

Table 2. Soil texture in the mangrove ecosystem in the village of Songka

Point	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture Class
1	0-30	42	13	44	Clay
	31-60	31	32	36	Clay Loam
	61-100	36	30	34	Clay Loam
2	0-30	31	39	31	Clay Loam
	31-60	45	25	30	Clay Loam
	61-100	56	13	31	Sandy-Clay Loam
3	0-30	61	12	27	Sandy-Clay Loam
	31-60	52	14	34	Sandy-Clay Loam
	61-100	51	15	35	Sandy Loam
4	0-30	52	14	34	Sandy-Clay Loam
	31-60	47	16	37	Sandy Loam
	61-100	43	26	31	Clay Loam
5	0-30	45	25	30	Clay Loam
	31-60	49	23	28	Sandy-Clay Loam
	61-100	45	25	30	Clay Loam

Source: Primary Data

Table 2 shows that the soil texture is different and the same at each point and depth. Point 1, with a depth of 0-30 cm, has a clay texture class, different from the texture class at points 2, 3, 4, and 5. Points 2 and 5 have the same texture class, namely Clay Loam. Points 3 and 4 also have the same texture class, Sandy-Clay Loam. At the same time, points 1 and 2, with a depth of 31-60 cm, have the same texture class, Clay Loam. Points 3 and 5 also have the same texture class, namely Sandy Clay Loam, which is in contrast to point 4, which has a Sandy Loam texture class. Then, points 1, 4, and 5, with a 61-100 cm depth, have the same texture class, Clay Loam. In contrast, points 2 and 3 have different texture classes, namely Sandy-Clay Loam and Sandy Loam.

The results of the soil texture analysis above show that the dominant soil texture at the study site squirms clay and sandy clay loam. Where at the study site, it is known that five species of mangrove vegetation grow, namely *Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba, Avicennia marinna, and Xylocarpus granatum*. At points 1 and 2, whose soil texture is Clay Loam grown by *Rhizophora apiculata, Sonneratia alba, and Xylocarpus granatum* species, the dominant mangrove vegetation is *Rhizophora apiculata*. Then points 3, 4, and 5 have dominant soil texture, namely Sandy-Clay Loam, which is grown by *Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba, and Avicennia marinna*, with dominant mangrove vegetation of *Rhizophora apiculata* and *Rhizophora macronata*.

Rhizophora apiculata generally grows on muddy, smooth, deep, and flooded soils during normal tides. *Rhizophora apiculata* does not like rigid substrates (with a high sand composition). This species dominance level can reach 90% of the vegetation that grows in a location. This species grows well in tidal waters, strongly influencing permanent freshwater input. *Rhizophora mucronata* grows in the same area as *Rhizophora apiculata* but is more tolerant of more complex substrates and sand. Generally, this species grows in groups, near or on tidal river embankments, and in river mouths and rarely produces in areas far from tidal waters (Baderan, 2019). The soil texture in this study is almost the same as that in Alasdowo Beach, where the soil texture is sandy, loam, and sandy loam, and Mangunharjo Beach has sandy loam, sandy, and clay loam soil textures that allow *Rhizophora mucronata*, *Rhizophora apiculata*, and *Rhizophora stylosa* to grow (Shofanduri, 2018). Furthermore, Susilo (2018) stated that the type of Rhizophora sp. was generally able to live on muddy and sandy substrates.

Differences in soil texture at the study site certainly affect soil fertility because soil texture is related to the exchange and buffering (containment) of plant nutrient ions in the soil. Sandy substrates have a deficient ability to absorb ions and water, which certainly affects the soil's ability to store water reserves or nutrients in the soil. Suppose the mangrove lacks water and nutrients, plant withers /dries and even dies. Clay or clay substrates have a smoother texture and have a smaller diameter than sand. This allows clay or clay substrates to retain water and nutrients that mangroves use for metabolic processes (Shofanduri, 2018).

Soil Color

Soil color is one of the physical properties of the soil that is more widely used for the description of soil character because it does not directly affect plants but indirectly affects its impact on soil temperature and humidity (Sulakhudin, 2019). Astiningrum et al. (2018) state that soil color is a clue to several other soil physical properties because soil color is influenced by several factors contained in the soil. Generally, the difference is influenced by the content of organic matter. The higher the organic matter, the darker the soil color will be. The soil color determination results can be seen in Table 3.

Table 3. Soil color in the mangrove ecosystem in Songka Village

Point	Depth (cm)	Soil Color
1	0-30	Very Dark Gray
	31-60	Very Dark Gray
	61-100	Very Dark Gray
2	0-30	Very Dark Gray
	31-60	Very Dark Gray
	61-100	Very Dark Raddish Gray
3	0-30	Very Dark Gray
	31-60	Very Dark Gray
	61-100	Very Dark Gray
4	0-30	Dark Gray
	31-60	Dark Gray
	61-100	Very Dark Gray
5	0-30	Very Dark Gray
	31-60	Very Dark Gray
	61-100	Very Dark Gray

Source: Primary data

Table 3 shows that points 1, 3, and 5, with a depth of 0-30 and 31-60 cm, have the same color, namely very dark gray, which is in contrast to point two at a depth of 61-100 cm, which has a very dark reddish gray color. Point 4, with a depth of 0-30 cm and 31-60 cm, is dark gray.

The results of the soil color analysis show that the dominant soil color at the research site is very dark gray. The dark color in the mangrove forest zone indicates the presence of high organic matter content, and the suspected high organic matter indicates that the mangrove forest zones have not undergone further nutrient leaching (Mahmud et al., 2014). This is in line with the research of Aziz et al. (2017) in Dolago Village, South Parigi District, Ngabang Regency, reporting the same soil color, namely dark gray to very dark gray. Riduan et al. (2018) state that dark-colored soil means it contains soil organic matter or has not undergone intensive nutrient leaching, so it is relatively fertile. On the other hand, light color or low organic material means that it has undergone nutrient leaching. So it is relatively poor in nutrients.

Riduan et al. (2018) state that soil color is a clue to several other soil physical properties because soil color is influenced by several factors in the soil, which generally affects the difference in organic matter content. The higher the organic matter, the darker the soil color will be. Organic matter also plays a vital role in creating soil fertility, so it is still possible to increase tree growth or growth in the volume of mangrove stands. According to Riyantini et al. (2020), the fertility of the waters around the mangrove forest area lies in the input of organic matter derived from litterfall.

Soil Permeability

Quantitatively, soil permeability/hydraulic conduction is the speed at which a liquid moves in porous media (Mulyono et al., 2019). This parameter gives a picture of the soil's roughness, the level of soil density, and the erodibility of the soil. Permeability shows the ability of the soil to pass through water. The determining factors of soil permeability are texture and porosity (Nurhartanto et al., 2021). The results of the analysis of soil permeability in mangrove ecosystems in Songka Village can be seen in Table 4.

Permeability is the speed at which the soil escapes a certain amount of water, expressed in the frequency and duration of water saturation (Nura'ban, 2018). Based on Table 4, the highest permeability is found at point 4 with a depth of 0-30 cm, with a value of 20.0 cm/hour, and the lowest is located at point 1 with a depth of 61-100 cm, with a value of 16.6 cm/hour. Thus, it can be said that the permeability value at the study site is still high or classified as a quick criterion because the results of soil texture observations in Table 2 are dominated by sand fractions with larger soil particles, making it easy to escape groundwater. This is different from the research Mahmud et al. (2014) conducted in Tumpapa Village with a low permeability value or classified as slow. This is because clay fractions dominate the soil texture with smaller particles that are difficult to pass or penetrate water. The permeability value is an important part of the hydrological cycle that can affect the amount of water in the soil (Luandra & Andayono, 2021).

Table 4. Soil permeability in the mangrove ecosystem in Songka Village

Point	Depth (cm)	Soil Permeability (cm/hour)
1	0-30	18.2
	31-60	19.3
	61-100	16.6
2	0-30	18.0
	31-60	19.9
	61-100	16.9
3	0-30	18.3
	31-60	19.3
	61-100	18.2
4	0-30	20.0
	31-60	18.4
	61-100	18.0
5	0-30	19.3
	31-60	16.7
	61-100	19.3

Source: Primary data

According to Suratman et al. (2020), clay-textured soils can retain water, provide high nutrients, and are more active in chemical reactions than coarse-textured soils. On the other hand, sand-textured soils have a small surface area, so absorbing (holding) water and nutrients is not accessible. The texture and structure of the soil influence the ability of the soil to retain water. Fine-textured soils have more water than coarse-textured soils. Therefore, sandy soils are generally easier to dry than loamy or clay-textured soils. Conditions of lack of water or excess water can interfere with plant growth. Soil that can hold water and availability of soil nutrients, namely soil with a clay or clay texture, has a larger surface area, thereby having a high ability to hold water and provide more nutrients (Rosman et al., 2019). From this statement, it can be concluded that clay texture is closely related to soil permeability. If the soil texture is classified as clay, the soil permeability value will be low or classified as slow.

Bulk Density (BD)

Bulk density indicates the weight of the soil mass in field conditions that have been dredged per unit volume. Eid & Shaltout (2016) state that the bulk density value is also increasing with the increasing depth of mangrove forests in the Red Sea of Egypt. Table 5 shows the bulk density analysis results on Songka Village mangrove ecosystems.

Table 5. Bulk density in the mangrove ecosystem in Songka Village

Point	Depth (cm)	Bulk Density (gr/cm^3)
1	0-30	0.70
	31-60	0.78
	61-100	0.63
2	0-30	0.55
	31-60	0.58
	61-100	0.78
3	0-30	0.64
	31-60	0.56
	61-100	0.71
4	0-30	0.78
	31-60	0.81
	61-100	0.64
5	0-30	0.72
	31-60	0.65
	61-100	0.71

Source: Primary data

Based on Table 5, all the same points and depths have different values. The highest value is found at point 4, with a depth of 31-60 cm, with a value of 0.81 gr / cm3, and the lowest value is at point 2, with a depth of 0-30 cm, which is 0.55 gr / cm3. The highest bulk density value is found at point 4 with a depth of 31-60 because the conditions at the soil sampling point still have a density, and mangrove vegetation growth is still good, so it has relatively high organic matter coming from mangrove branches and leaves, while the lowest bulk density at point 2 with a depth of 0-30 cm is due to human activities that carry out mangrove logging so that the soil on the surface is overcrowded. As a result of the felling of mangrove vegetation, the remaining leaves and branches inhibit water flow into the soil, and soil compaction occurs. The denser the soil, the higher the density, which means it is more difficult to penetrate the roots (Naharuddin et al., 2020). The presence of vegetation and litter can encourage soil structure formation that is lower in bulk density value. The looser the soil, the lower bulk density value (Pivic et al., 2020). The bulk density value in this study is higher than the research conducted by Indraiswari & Nurweda Putra (2018) in Natural Mangrove Forest, Jambrana, Bali, where the highest average bulk density value is 0.2 gr / cm^3, while the lowest average is 0.07 gr / cm^3.

The low value of bulk density above is because the constituents of mangrove soil particles are still dominated by sand. With so many macro pores, soils predominately of sand will have a deficient water-holding ability, so the soil density is low. In addition, the soil will be easily subjected to leaching. According to research by Hickmah et al. (2021), the large macropore space in sediments dominated by sand will cause low water-holding ability, so the sediment density is low. The supply of roots, litter, the alleged carbon content, and organic matter in the upper layers influence the bulk density of the soil (Indraiswari & Nurweda Putra, 2018).

Soil Porosity

Soil porosity is the ratio of the volume of all pores in the soil volume, expressed in percentage terms. Porosity includes the space between sand, silt, and clay particles and the distance between soil aggregates (Naharuddin et al., 2020). The results of the analysis of soil porosity can be seen in Table 6.

Table 6. Soil porosity in the mangrove ecosystem in Songka Village

Point	Depth (cm)	Porosity (%)
1	0-30	50
	31-60	36
	61-100	51
2	0-30	49
	31-60	49
	61-100	67
3	0-30	77
	31-60	60
	61-100	39
4	0-30	36
	31-60	64
	61-100	74
5	0-30	68
	31-60	59
	61-100	66

Source: Primary data

Table 6 shows that each point and the same depth have a different value. The highest value is found at point 3, with a depth of 0-30 cm, with a value of 77%, and the lowest is found at points 1 and 4, with a depth of 31-60 cm and 0-30 cm, with the same value of 36%. This indicates that the soil pores are >100%, so the soil pores are relatively high. According to Sarwono (2015), soil porosity is influenced by organic matter content, structure, pore size, and soil texture. The porosity of the soil is high if the organic matter is high. Based on Table 3, the soil color observed is very dark gray or dark, indicating that organic matter is high. Sukarman et al. (2020) state that dark-colored soil contains soil organic matter or has not undergone intensive nutrient leaching, so it is relatively fertile, while a light-colored or soft organic color means that it has undergone nutrient leaching, so it is relatively nutrient-poor. Then, the results of observations of soil texture in Table 2 show that the soil is dominated by sand fractions with larger pores, so the soil's ability to absorb water is more detailed.

Soil porosity largely determines the soil's ability to absorb water. The larger the soil pores, the smaller the soil's ability to absorb water, or vice versa. Porosity is inversely proportional to the bulk density, where if the porosity of the soil is high, then soil bulk density is low, and vice versa. Finer soils will cause reduced soil fill weight and high porosity (Naharuddin et al., 2020). The availability of organic matter affects soil porosity because organic matter helps form soil aggregates by forming granules and enlarging the existing soil's volume and pores so that the soil's porosity becomes high.

CONCLUSIONS

Based on the results of the study, it can be concluded that the soil in the mangrove ecosystem in Songka Village, Palopo City, has a dominant soil texture of clay loam and sandy loam, in which clay or loam substrates have an excellent ability to hold water and nutrients that are useful for mangrove soil fertility. The dominant soil color is very dark gray. The condition of soil color shows a good level of fertility with a high content of organic matter, which is also in line with the soil texture conditions of the study site. The soil permeability is high and classified as a fast criterion that can increase the infiltration rate, with the highest value of 20.0 cm/hour at point 4 with a depth of 0-30 cm and the lowest value of 16.6 cm/hour at point 1 with a depth of 61-100 cm. The highest bulk density is at point 4 with a depth of 31-60 cm with a value of 0.81 gr /cm3, and the lowest is at point 2 with a depth of 0-30 cm with a value of 0.55 gr / cm3. The porosity of the soil is classified as high or good criteria, showing the highest value found at point 3 with a depth of 0-30 cm with a value of 77% and the lowest at point 1 and four with a depth of 31-60 and 0-30 cm with the same value of 36%. The higher the bulk density value, the lower the soil porosity.

In the future, data on the physical characteristics of soil in the mangrove ecosystem in Bone Bay, Songka Village, and Palopo City can be preliminary information or a database for the government to arrange and preserve mangrove forests.

ACKNOWLEDGMENTS

The authors would like to thank the Ministry of Education and Culture of the Republic of Indonesia for supporting this research, and the Palopo City government that has also allowed the research to be carried out in the mangrove forest area in the Village of Songka.

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