International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

Pore Characteristics at Different Depths of Cultivated and a Fallow Land in Vertisol from Jeneponto South Sulawesi

Masria[1], Christianto Lopulisa[2], Hazairin Zubair[3], dan Burhanuddin Rasyid[4]

[1]Graduate School of Hasanuddin University

[2, 2, 4]Department of Soil Science Faculty of Agriculture Hasanuddin University

Abstract: ***Pore characteristics were describe the quantity, size, distribution, continuity, and stability of the soil pores and are strongly influenced by the amount of organic matter, the type and amount of clay, moisture, soil compaction, land management and land use. Common land uses in Jeneponto Regency are Cultivated and follow. This research aims to know pore characteristic at different depths on Cultivated field and a follow. Location, Thesoil sampling, is located respectively in Bajipamae, Punagaya Village, Bangkala Subdistrict, Jeneponto Regency. Soil samples were taken at depths of 0-15, 15-30, 30-45, and 45-60 cm at three points for each type of land used. Observation parameters include organic materials, texture, total pores, pore size distribution and pore stability. The results showed no real effect between land use type and depth of soil to organic matter and sand distribution, significantly affect the distribution of silt, and real interaction on the distribution of clay. Total soil porosity is significantly affected by the depth of soil. Land use and soil depth have a significant effect on pore diameter <0.2 µ or micropore, and no significant effect on pores of > 28.8 µ, 8.6-28.8 µ, and 0.2-8.6 µ pore diameters and pore stability.***

Keywords: Pore Characteristics, different depths, Follow and Cultivation Land, and Vertisol

1. Introduction

Soil porosity is defined as a functional space that connects the body of the soil to its environment [1]. Soil pore plays an essential role in determining the physical, chemical and biological properties of the soil [2],[3],[4],[5],[6],[7].

Pore characteristics illustrate the amount, size, distribution, continuity and stability of the soil pore [8]. Soil pore characteristics play a significant role in determining the movement of water in the soil and affecting the soil's ability to retain water [8],[9]. As a system, each character will affect each other. Any changes to one character will affect the other. Changes to the pores will reduce the number, size, and quantity of pores [10].

The soil pore system is strongly influenced by many factors such as the amount of organic matter, type and amount of clay, moisture, soil compaction and soil management [11],[12], [13],14].

The shape and number of pores are strongly influenced by soil clay content [15], [16]. Vertisol is a soil with high clay content. The clay content of vertisol is over 30% in all horizons, with montmorillonite being the dominant clay mineral [17]. One of the essential properties of montmorillonite is it is expanded and shrinking properties associated with changes in groundwater content [18]. The process of expanding and shrinking of the soil with high clay content significantly affects the pore changes [19],[20].

The most common pore characterization is the pore size distribution [21], [6],[22] . The distribution of pore size is essential in understanding various processes in soil such as the availability and movement of water in the soil [23], [2], [24], [22]. Aydin *et al*. (2004) found that the process of expanding and shrinking on clays such as Vertisol can cause destruction and clay movements that cause clogged pores [25], this is a phenomenon that can disrupt pore stability because it reduces the size and number of pores. Thus in addition to the amount of pore, other pore characters such as, pore size distribution and pore stability are essential pore characters observed.

Ulfiyah (2014) reported that based on the map delineation results in Jeneponto, there is about 800 ha of dryland soil that can be ascertained as vertisol [26]. Until now there is no semi-detailedlevel soil map level so that the possibilities of soil classified as grumusol and mediteranwere Vertisol.

Common land use types on Vertisol in Jeneponto are seasonal cultivated and fallow fields. Given the pore nature is strongly influenced by the land use system, the research to determine the pore characteristics of the two types of land use is considered necessary.

2. Methods

2.1. Soil

Soil sampling were located in BajipamaeandPunagaya Village, Bangkala Subdistrict, Jeneponto Regency. A total of 24 soil samples were taken from Vertisoldeveloped on limestone. The land where the soil sampling is selected from two types of land usethat is cultivated (C) and fallow (F) land. The two fields are located on the same stretch with a slope of 0-8%. Soil sampling was done using a sample ring at depths of 0-15, 15-30, 30-45, and 45-60 cm for porosity analysis and pore size distribution. For sampling pore stability analysis was done by intact aggregate sampling technique. Sampling is done as many as 3 points which are used as replication on each type of land used.

2.2 Soil Analysis

Organic material is analyzed by a walkey and Black method, soil texture was analyzed by hydrometer method. Porosity is determined by the weight value of particle content and weight by using a gravimetric method as follows: Number of pores (% volume) = (1 BI / BJP) X 100%, where BI is bulk density and BJP is particle density of 2.65 (Hillel, 1986) [27]. Determination of pore size distribution using Pressure Plate method of apparatus on pF 1, pF 2, pF 2.54 and pF 4.2 (Capillarity and pF curve equations) (Richard and Fireman, 1943) [27]. Pore diameter> 28.8 μ is the difference between total pore and pF 2, pore diameter 8.6-28.8 μ (pF 2), pore diameter 0.2-8.6 μ (pF 2.54-2), pore diameter <0.2 μ (pF 4.2) (de Bootd, 1972) [28]. The determination of pore stability is based on the value of aggregate stability since the pores are on the aggregate of the soil. The determination of aggregate stability and aggregate size distribution follows De Leenheer and De Boodt (1959) in De Boodt, De Leenheer, and Kirkham (1961)[29]. Next set the aggregate stability index.

2.3. Statistic Analysis

The result data were analyzed by using variance analysis and followed by LSD at 5% level using STAR (Statistical Tool for Agricultural Research)

3. Result and Discussion

Table 1: Descriptive statistic of soil properties and pore characteristics

Soil properties and Pore Characteristics	Parameter		
	Means	St. Dev	CV (%)
Organic matter (%)	4.61	0.3242	6.83
Sand (%)	1.58	0.4584	34.11
Silt (%)	25.19	8.7	21.66
Clay (%)	73.23	8.71	7.34
Porosity (%)	56.68	4.16	5.98
Pores Size Distribution (μ)			
> 28.8	4.12	3.78	83.32
8.6-28.8	13.1	6.69	53.44
0.2-8.6	17.65	4.27	24.76
< 0.2	32.21	2.89	5.21
Pore Stability	36.96	7.02	18.55

The results of statistical analysis in Table 1 show the properties of the soil spread usually. The smallest coefficient variance (CV) was found in pores < 2 μ diameter of 5.21% and the most substantial CV for pore diameter> 28.8 μ was 83.32%. According to Juri *et al*., (1989) soil porosity has a CV of about 10%, the diversity of water content at 15 bar has a CV ranging from 15 to 50%, and soil properties associated with water and gas movement can have CV > 100% [30].

Table 2: Distribution of Sand, Silt, and clay in cultivated and Fallow land at various depths of soil

Sifat Tanah	Organic Matter		Sand		Silt		Clay	
Depths	C	F	C	F	C	F	C	F
0-15 cm	4.495±0.25	4.346±0.27	1.500±0.29	1.667±0.33	10.500±2.02	28.333±1.45	88.00a±1.73	70.00a±1.15
15-30 cm	4.410±0.24	4.870±0.04	1.500±0.29	1.667±0.33	16.500±4.91	29.667±1.67	82.00a±4.62	68.67a±1.33
30-45 cm	4.845±0.10	4.676±0.24	1.500±0.29	1.667±0.33	28.500±1.44	34.333±2.40	70.00b±1.15	64.00a±2.65
45-60 cm	4.730±0.10	4.493±0.09	1.500±0.29	1.667±0.33	27.000±0.58	26.667±6.17	71.50b±0.87	71.67a±6.36

Note : numbers followed by different letters are statistically different (P<0.05) C is cultivated and F is fallow

3.1. Organic Matter

The result of variance analysis in Table 2 shows that land used type and depth of soil have no significant effect on the amount of organic matter. Soil organic matter in the study area about 4.61 %.Research Ristori et al. (1992) reported that organic content of Vertisol in Tanzania was 2.9%, in Texas around 2.17%, and Zimbabwe at 2.20% [31]. Dudal (1965), reported that Vertisol growing in Africa has an organic content ranging from 0,5-2% [32], in Mexico some of Vertisol has an organic material content of 2.8% [33].

There is no difference in the status of organic matter either on the ground or the ground used for maize cultivation. As with other soil types, organic matter in vertisol is formed by the effects of vegetation and land use and the effect of temperature on tropical regions such as Indonesia[33]. Soil under legumes vegetation usually have a relatively high organic material and slowly decreases if it continues to be used for cultivatedland [34]. The high content of organic matter is caused by the limited use of land only once a year and the soil that is consumed by vegetation. Loss and replenishment of organic matter are influenced by land management practices such as cropping, fertilizing and planting systems with legumes and grasses [35].

In addition to limited land use, the process of expanding and shrinking in vertisol can affect the process of mineralization of organic materials and microbial development [24]. Clay mineral in Vertisol increases the protection against organic material due to the complex bonding between organic and clay materials [36] and the traps of organic and microbial matter in aggregates [37].

3.2. Soil Texture

The variance analysis indicate that land used type and soil depth do not affect the distribution of sand but affect silt distribution (Table 3), and there is an interaction between land used type and depth of soil to clay distribution.

Table 3: Effect Land Used Type and Level of Soil Depth on silt Particle Distribution

Parameter	Silt (%)
Land Use	
Cultivated	20.62 b
Fallow	29.75 a
Depths	
0-15 cm	19.42 c
15-30 cm	23.08 bc
30-45 cm	31.42 a
45-60 cm	26.83 ab

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Based on LSD further test at 5%, it is seen that the interaction of soil depth of the type of land used shows that the clay distribution on cultivated land decreases withsoil depth, whereas in the fallow land there is no difference of clay content at a various depth of soil (Table 2). Comparison of land used type interaction at soil depth level showed that the real difference of clay content between fallow and cultivation land occurred at soil depth of 0-15 and 0-30 cm, and at 30-45 and 45-60 cm soil depth there was no significant difference of clay content between cultivated and fallow land (Fig 1).

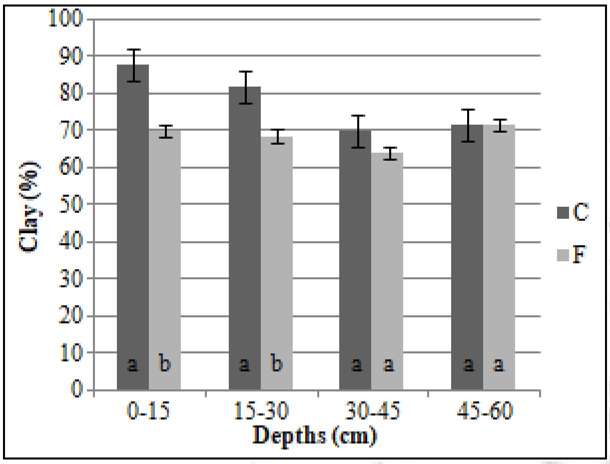

Figure 1: Distribution of Clay on Cultivated Land and Fallow at various depths of the Land
Note: numbers followed by different letters are statistically different (P<0.05)

3.3. Pore Characteristics

3.3.1 Porosity

Table 4: Porosity and pore stability in cultivated and fallow Land at various depths of soil

	Porosity		Pores Stability	
Depths	C	F	C	F
0-15 cm	60.756 ±1.42	60.565±2.10	31.320±3.19	39.805±6.63
15-30 cm	55.093±2.29	53.020±3.42	32.813±1.86	33.910±0.40
30-45 cm	54.843±2.18	59.245±0.88	40.126±7.12	38.195±3.72
45-60 cm	52.956±0.00	56.980±1.31	35.676±3.09	43.865±0.22

The result of variance analysis shows that there is no significant difference of total porosity of soil in fallow and cultivated land, the difference inded is found in soil depth level where soil porosity decreases with increasing of soil depth. The high porosity of the soil in the surface area is caused by the input of good organic matter in the form of maize crop residue embedded in the cultivated land and crop residue that grow on the fallow field. The total porosity will increase depending on the amount and type of compost material added [38], [11], [16]. Garza et al. (2009) reported that the addition of organic matter in the form of maize residue could increase the total porosity in Vertisol soil [39].

3.3.2. Pore Size Distribution

The results of variance analysis showed no significant difference for pore diameter> 28.8 μ, 8.6-28.8 μ, and 0.2-8.6 μ on cultivation area and fallow field, as well as soil depth level. However the real difference is that on the micropore (diameter of < 0.2 μ. Further LSD test results at 5% indicated that the cultivated area has a amount of micropores of 33.67% and it is significantly different with the fallow area which is about 30.75%. The level of soil depth affects the number of micropores, where the micropore increases with increasing soil depth. The soil pore system is strongly influenced by soil organic matter, clay content and type, moisture, compaction and soil management[11], [12], [13], [14]. The result of the analysis showed that there was no real difference of organic material with increasing of soil depth, higher clay content at soil surface did not causehigh amount of micropore on the surface, this was caused by plant root activity at 0-15 cm depth causing the aggregation process to increase the number of micropores diameter.

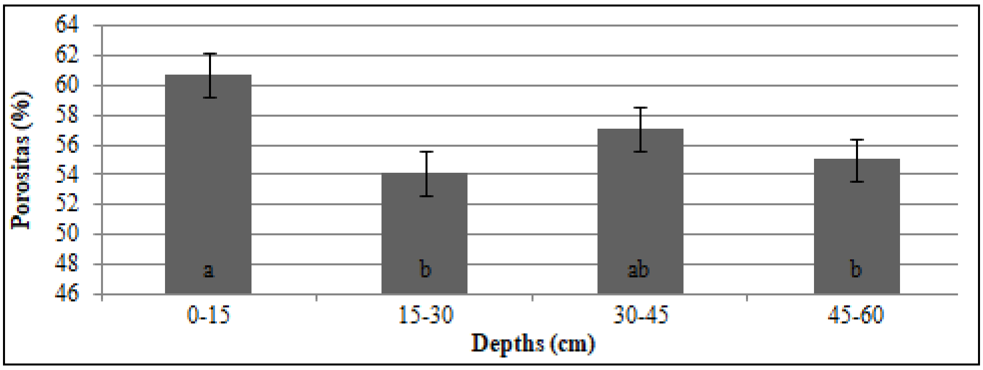

Figure 2: Soil Porosity at various depths of soil
Note: numbers followed by different letters are statistically different (P<0.05)

Table 5: Pore Size Distribution on Cultivated and Fallow Land at Various Depths of Soil

Depths	Pore Size Distribution (μ)							
	>28.8		8.6-28.8		0.2-8.6		<0.2	
	C	F	C	F	C	F	C	F
0-15 cm	5.000 ±3.06	2.000 ±0.00	18.000±4.51	10.000±1.15	19.000±5.69	21.500±1.44	31.000 ±0.56	27.500±1.44
15-30 cm	3.333 ±0.88	1.500 ±0.29	10.000±4.18	16.333±2.89	15.667±3.33	15.500±1.44	33.666 ±0.67	33.500±0.87
30-45 cm	5.333 ±2.40	9.500 ±3.75	9.000±6.39	11.333±0.58	19.667±0.33	16.500±1.44	34.333 ±1.33	30.000±1.15
45-60 cm	2.333 ±0.33	4.000 ±1.15	15.500±6.49	14.667±0.29	18.333±0.88	15.000±0.58	35.666 ±0.67	32.000±0.58

3.3.3. Pore Stability

The results of variance analysis showed no effect of land used type and soil depth on pore stability (Table 4). Soil pore stability ranges from 28.33 to 51.28% and is classified instability index class is not steady until somewhat steady. In general, soil aggregate stability is determined by the amount of organic matter as well as iron oxide in the soil. The organic matter cycle is instrumental in influencing soil aggregation through the process of humification, the activity of soil microorganisms and exudates produced by soil microorganisms [40], [41]. Studies show that there is a contradiction of the role of organic matter in soil aggregation. Whitbread et al. (1998) state that there is a correlation between the amount of organic C and aggregate formation in Vertisol (Gray Clay) [42], but there is no correlation between organic C and aggregate formation in Vertisol (Black Earth). Furthermore, Bravo-Garza and Bryan (2010) reported that intensive land use correlated with aggregate reduction and organic C loss, but no association was found for the same parameters on uninterrupted land [33].

The process of expanding and shrinking on smectite can affect the process of mineralization of organic matter and microbial activity[24]. Smectite improves the protection of organic materials due to the complex bonding of organic and clay materials [36] and the traps of organic and microbial matter in aggregates [37]. Pore changes due to expanding and contracting processes affect microbial activity that ultimately affects the rate and yield of mineralization [43]. Provision of organic matter increases the formation of macroaggregates (> 200 mm), but the process of expanding and contracting effects macroaggregate formation and stabilization [39].

4. Conclusion

The result of statistic analysis shows that there is no real effect between land use type and depth of soil to organic matter and sand distribution, real significant effect on silt distribution, and real interaction on clay distribution. Total soil porosity is significantly affected by soils depth. Land use type and soil depth have a significant effect onmicropore(diameter <0.2 μ) and no significant effect on pores of diameters > 28.8 μ, 8.6-28.8 μ, and 0.2-8.6 μ pore diameters and pore stability.

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