Jurnal Pembelajaran Dan Biologi Nukleus p-ISSN: 2442-9481
Vol 11 (2): 785 - 804, June 2025 e-ISSN: 2685-7332

Land Use-Driven Variation in Soil Physical Properties: A Case Study from Wotan Village, Panceng Subdistrict, East Java

Moh. Mislahul Abid, Maroeto Maroeto(*), Moch. Arifin

Study Program of Agrotechnology, Faculty of Agriculture,
Pembangunan Nasional "Veteran" Jawa Timur University
Jl. Rungkut Madya, Gn. Anyar, Surabaya, East Java 60294, Indonesia

***Corresponding Author:** maroeto@upnjatim.ac.id

Submitted February 02 Nd 2025 and Accepted May 30 Th 2025

ABSTRACT

Background: *The physical characteristics of soil under different land uses influence its potential for optimal productivity. Wotan Village, located in Panceng District, Gresik Regency (part of the northern limestone mountains), can maximize land use by considering the type of crops and land suitability based on soil physical properties. The mismatch in land use in Wotan Village is likely due to poor soil physical properties, as the soil is formed from weathered limestone. Limestone soils are dominated by fine fractions in their texture, and their texture and structure are generally unsuitable for use as planting media. This study aims to analyze the physical characteristics of soils under various land-use types and to determine the effect of different land uses on soil physical properties.* **Methodology:** *The research employed a purposive sampling method. Soil samples were collected from three types of land use: plantation, dryland farming, and rainfed rice fields, at two depths (0-20 cm and 20-40 cm) with five replications. Laboratory analyses were conducted on soil physical parameters, including texture, bulk density, particle density, total pore space, and permeability.* **Findings:** *The results showed that the soils in the three land-use types had clay loam, silty clay, and clay textures. Bulk density ranged from 1.10 to 1.24 g/cm³ for rainfed rice fields at a depth of 20 cm. Particle density ranged from 2.46 to 2.603 g/cm³. Total pore space ranged from 52.46% to 56.31%. Permeability ranged between 0.80 and 1.21 cm/hour, classified as moderately slow. Differences in land use had no significant effect on soil physical properties.* **Contribution:** *The findings provide a reference for farmers regarding the physical properties of soils in limestone areas.*

Keywords: *Soil Physical Properties; Land Use; Plantation Land; Dryland Farming; Rainfed Rice Fields*

https://doi.org/10.36987/jpbn.v11i2.7484

INTRODUCTION

Soil is the uppermost layer of the Earth's crust, formed from a mixture of mineral and organic materials, and serves as a growth medium for plants. Soil particles originate from rocks that have disintegrated through chemical and physical processes. Chemical weathering may occur under the influence of oxygen, carbon dioxide, and water, while physical weathering may result from the effects of erosion, wind, and human activities (Awal et al., 2021). The components of soil consist of three main parts: solids, water, and air. Air is generally considered to have no direct technical influence, whereas water plays a significant role in determining the technical properties of soil tanah (Wibisono et al., 2016).

Physical properties refer to the characteristics of soil related to its natural form and condition, including texture, structure, bulk density, porosity, permeability, and color (Desa & Sigi, 2016). These factors play a dominant role in influencing land use, particularly in relation to oxygen availability, water mobility within the soil, and ease of root penetration. According to Bintoro et al., (2017), the physical characteristics of soils under different land-use types vary considerably, with permeability ranging from moderately slow, moderate, moderately rapid, to rapid; porosity ranging from relatively poor to good; and bulk density ranging from low to moderate to high. These properties directly affect the soil's potential for optimal productivity.

Soil physical properties contribute significantly to plant growth and yield and can generally be classified into three main aspects: (1) acting as a physical substrate for the availability of nutrients, water, and gasses essential for plants, while also offering support for plant roots; (2) controlling the accessibility of water for vegetation; and (3) controlling the supply of gases essential for plant growth (Rachman, 2019). Among the various factors influencing plant growth, soil physical properties are considered highly important. Bulk density tends to increase with soil depth, both in high-yielding and low-yielding areas (Al-Musyafa et al., 2016). This is further supported by the findings of Kastanya et al., (2019), who reported that soil physical properties are influenced by land use, including organic matter content, porosity, rooting, drainage, color, and soil compaction. Therefore, proper soil management is crucial to prevent land degradation.

The northern region of Gresik Regency-which includes Panceng, Ujung Pangkah, Sidayu, Bungah, Dukun, and Manyar Districts-forms part of the Northern Limestone Mountains, characterized by relatively low soil fertility (particularly in Panceng District). A portion of this area lies within the downstream zone of the Bengawan Solo River, which flows into the northern coast of Gresik Regency, specifically in Ujungpangkah District. This downstream region holds high potential for development, offering land suitable for industry, fisheries, plantations, and settlements (Fitri et al., 2023). The utilization of limestone soils in Indonesia as part of efforts to enhance agricultural production has not been widely implemented. The challenges and constraints in exploiting this type of marginal land are primarily related to the quality of the growth medium, which greatly affects plant metabolism, growth, and development. Limestone soils, also known as Mediterranean soils, are formed from the weathering of limestone rock (Sir et al., 2019).

Wotan Village is located in Panceng District, Gresik Regency, covering an area of 612 km² at an altitude of 20 meters above sea level (BPS Kabupaten Gresik, 2016). The village comprises five land-use types: plantations, dryland farms, irrigated rice fields, rainfed rice fields, and forests. Optimal land utilization can be achieved by aligning crop types and land-use practices with the soil's physical characteristics. The primary factor suspected to cause land-use mismatch in Wotan Village is the poor physical quality of the soil, as it is formed from weathered limestone. Limestone soils are dominated by fine fractions in their texture, which negatively affect subsurface water flow and, consequently, the plant root zone. According to Rahayu & Yuliani (2016), the structure and texture of limestone soils are unsuitable for use as a planting medium. Therefore, a detailed investigation into the physical properties of soils under different land-use practices in Wotan village, Panceng district, Gresik regency is required to obtain a clearer understanding of soils derived from limestone parent rock material.

METHOD

This research was conducted in Wotan Village, Panceng District, Gresik Regency. The study employed a survey method combined with laboratory analysis. Soil sampling sites were established via a purposeful random sampling method, informed by the degree of land utilization in Wotan Village, Panceng District, Gresik Regency. The selection process was supported by a 1:30,000 scale administrative map of Wotan Village, a 1:30,000 scale land-use map of Wotan Village, and rainfall data for Panceng District.

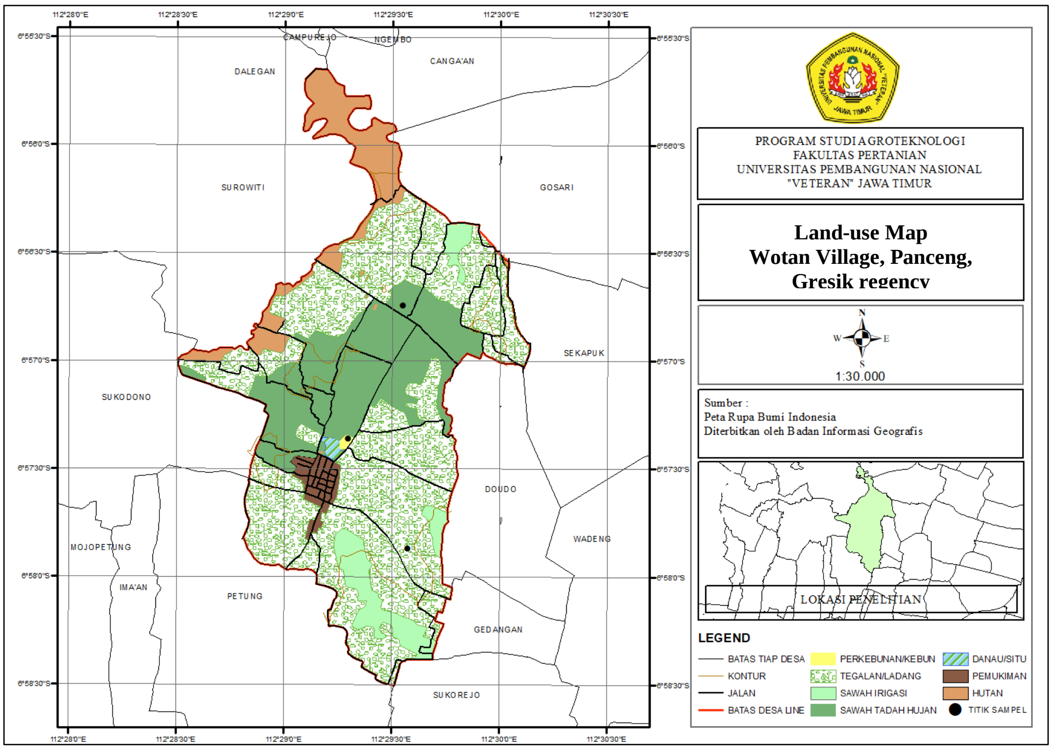

Figure 1. Wotan Village Land-Use Map

Soil samples were collected from three sampling points with five replications for each of the three land-use types: plantation, dryland farming, and rainfed rice fields. For each land-use type, undisturbed soil samples were taken with a ring sampler at two depths: 0–20 cm and 20–40 cm. For each form of land use, disturbed soil samples were also taken from the same three sampling locations at depths of 0–20 cm and 20–40 cm. These samples were then put in plastic bags for additional examination.

Table 1. Parameters for Soil Physical Property Analysis

No.	Parameters	Measurement Unit	Analytical Method
1.	Texture	% Particle fraction	Pipet
2.	Bulk Density	g/cm^3	Gravimetri
3.	Partikel Density	g/cm^3	Picnometer
4.	Total Porosity	%	Comparison of Bulk Density and Particle Density
5.	Permeability	cm/h	Constant Head Permeameter

Soil sample analysis was carried out at the Soil Resources Laboratory, Faculty of Agriculture, Universitas Pembangunan Nasional "Veteran" Jawa Timur. The analyses included soil texture, bulk density, particle density, total porosity, and soil permeability. Soil texture was determined using the pipette method, bulk density using the gravimetric method, particle density using the pycnometer method, total porosity by comparing bulk density and particle density, and permeability using the constant head permeameter method. All analyses were conducted in the laboratory and subsequently processed to determine the physical characteristics of soils under different land-use types. The data were analyzed using quantitative descriptive statistics with Microsoft Excel 2007, followed by statistical analysis to evaluate whether land-use differences significantly influenced the soil physical properties in Wotan Village, Panceng District, Gresik Regency.

RESULT AND DISCUSSION

Description of the Study Area

This study was carried out at Gresik Regency, which is situated between 7 - 8° South Latitude and 112 - 113° East Longitude. Except for Panceng District, which is 25 meters above sea level, the majority of the area is lowland, with elevations ranging from 2 to 12 meters. Panceng District consists of 14 villages, one of which is Wotan Village, covering an area of 6.61 km². Geographically, Wotan Village is situated on a plain with an elevation of 477 meters above sea level. The village receives an annual rainfall ranging from 2,000 to 3,000 mm, with the rainy season lasting for 5–6 months. The average annual temperature is approximately 26 °C. The majority of Wotan Village residents work as farmers, with primary agricultural products including rice and several horticultural crops such as maize, legumes, and tuber crops like cassava, gadung (*Dioscorea hispida*), and sweet potatoes. Land-use distribution in Wotan Village includes plantations, dryland farms, rainfed rice fields, irrigated rice fields, forests, lakes, and settlements. Based on the topographic map published by the Geospatial Information Agency of the Republic of Indonesia in 2021, dryland farms dominate the area, covering 387.39 ha or 58.52 % of the total land area, followed by rainfed rice fields at 155.24 ha (23.45 %). Plantations cover 0.98 ha (0.14 %), irrigated rice fields 40.08 ha (6.05 %), lakes 2.21 ha, settlements 15.50 ha, and forests 60.51 ha. Wotan Village is bordered by Sukodono Village to the west, Petung Village to the south, Doudo and Gedangan Villages to the east, and Sekapuk Village to the north.

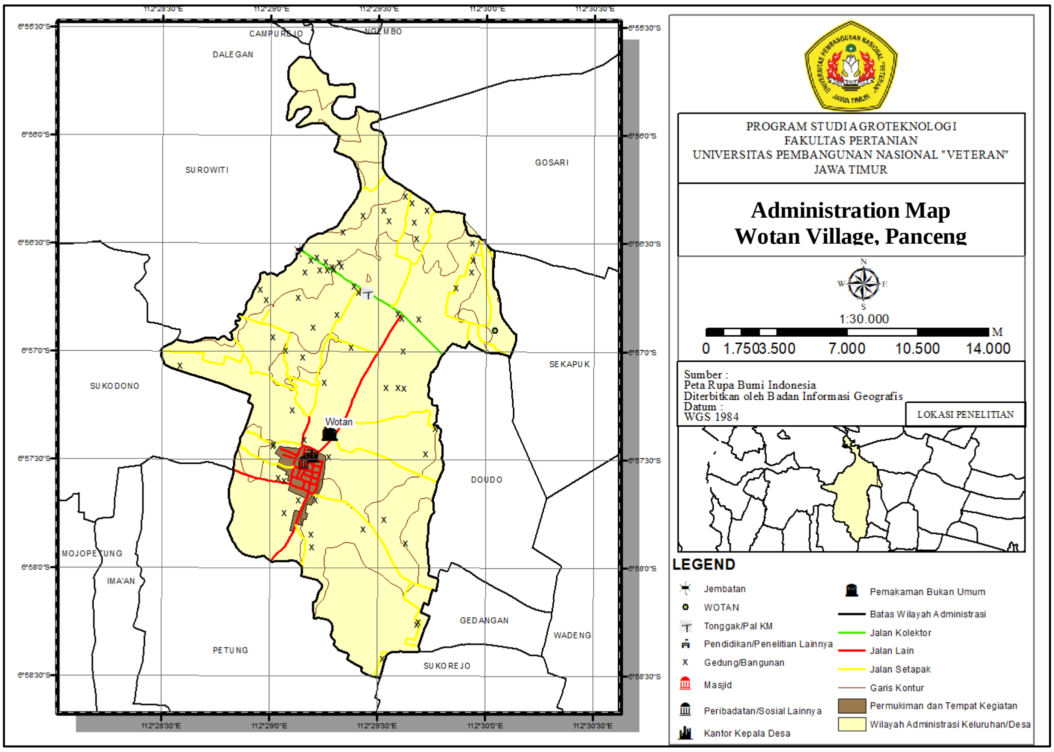

Figure 2. Administrative Map of the Study Area

Rainfall in Panceng District

The climate classification at the research site was determined using the Oldeman classification system, which is based on the ratio between the number of wet months and dry months within a year. Rainfall data were obtained from the climatology station in Panceng District to determine the climate type influencing land use patterns and soil characteristics in the study area.

Table 2. Rainfall Data for Panceng District in 2019–2023

Month	Year					Total (mm)	Mean (mm)
	2019	2020	2021	2022	2023		
January	379	332	317	186	387	1601	320.2
February	230	171	220	285	316	1222	244.4
March	414	267	133	374	283	1471	294.2
April	297	259	175	350	312	1393	278.6
May	114	158	62	251	63	648	129.6
June	114	61	-	70	115	360	90

Month	Year					Total (mm)	Mean (mm)
	2019	2020	2021	2022	2023		
July	35	180	37	200	40	492	98.4
August	4	41	60	70	-	175	43.75
September	2	10	76	44	-	132	33
Oktober	200	120	-	261	-	581	193.667
November	203	141	94	173	106	717	143.4
Desember	259	264	82	150	73	828	165.6

Based on the model presented in Table 2, it can be determined that the number of Wet Months (WM) in Panceng District is eight, the number of Moist Months (MM) is two, and the number of Dry Months (DM) is two. Thus, Q = 2/8 × 100% = 0.25, which corresponds to the B2 climate type, indicating that rice can be cultivated twice a year using short-maturity varieties, with a short dry season sufficient for secondary crops (palawija).

Soil Physical Properties under Different Land-Use Types

Soil Texture

Based on the results of the study, the soil texture was composed of three fractions: clay, silt, and sand. The relative proportion (in percentage) of these fractions is referred to as soil texture. Sand particles, which have larger diameters, possess smaller surface areas compared to silt and clay. A greater number of pore spaces between soil particles facilitates better air and water movement. Silt has a much larger surface area than sand, allowing for greater nutrient absorption by plant roots. Clay-textured soils have a high capacity to retain water. The results of the soil texture analysis are presented in Table 3.

Table 3. Soil Texture at The Study Site

Sample	Depth (cm)	Land Use Type	Fraction (%)			Textural Class
			Sand	Silt	Clay	
K1	0-20	Plantation	6.4	53.2	40.4	Clay Loam
K2	20-40		6.2	55.6	38.2	Silty Clay Loam
T1	0-20	Dryland/Cropland	5.4	50.8	43.8	Clay Loam
T2	20-40		6.2	56.2	37.6	Silty Clay Loam
S1	0-20	Rainfed Rice Field	5.8	34.0	60.2	Clay
S2	20-40		5.6	32.4	62.0	Clay

The comparison of sand, silt, and clay fractions across different land uses and soil depths is presented in Table 3. The results of the soil texture analysis at the study site indicate variations in fraction values. The dominant fraction at the study site is silt.

The land uses classified as clay loam texture (Table 3) are plantation land at a depth of 0 - 20 cm and dryland fields at a depth of 0 - 20 cm. The plantation land at a depth of 0-20 cm has an average fraction content of 6.4% sand, 53.2% silt, and 40.4%

p-ISSN: 2442-9481
e-ISSN: 2685-7332

clay. Meanwhile, the dryland fields at a depth of 0-20 cm have an average fraction content of 5.4% sand, 50.8% silt, and 43.8% clay. Clay loam soils contain a relatively high proportion of silt, giving them a smooth and slightly slippery texture when touched, a slightly sticky characteristic when wet, and the ability to be easily shaped into balls or rolls. Clay loam texture is classified as moderately fine. Fine-textured soils have a large surface area, a high capacity to retain or bind water, and small particle sizes (Annisa & Prijono, 2023).

The land uses classified as silty clay loam texture (Table 3) are plantation land at a depth of 20 - 40 cm and dryland fields at a depth of 20 - 40 cm. The plantation land at this depth has an average fraction content of 6.2 % sand, 55.6 % silt, and 38.2 % clay. Meanwhile, the dryland fields at the same depth have an average fraction content of 6.2 % sand, 56.2 % silt, and 37.6 % clay. Soils with a silty clay loam texture feel smooth and slightly slippery to the touch, are sticky, and can be formed into firm balls and shiny rolls. Silty clay loam soils are characterized as slightly fine-textured, less porous, and capable of providing sufficient nutrients for plants, thus influencing land productivity and stability. Dryland fields generally exhibit silty clay textures in deposition zones and sandy clay textures in residual zones. Such textures impact the soil's capacity to store water and nutrients required by plants (Ruci, 2018). Furthermore, clay-textured soils have a relatively balanced ability to retain and drain water, preventing both water shortages and waterlogging. Clay soils also have a balanced composition of coarse and fine fractions, making clay an ideal texture. This is because their nutrient absorption capacity is generally higher than that of sandy soils, while their drainage, aeration, and ease of tillage are better than those of clay soils (Umin & Anasaga, 2019). Hanafiah (2014) further strengthens this statement, explaining that the ideal composition of soil pores is not solely determined by the dominance of silt but rather by a balanced combination of sand, silt, and clay fractions, as found in clay-textured soils, to ensure optimum availability of water, air, and nutrients.

The soil texture in rainfed rice fields at a depth of 0 - 20 cm (Table 3) falls into the clay class, with an average fraction content of 5.8 % sand, 34 % silt, and 60.2 % clay. At a depth of 20 - 40 cm, the rainfed rice fields are also classified as clay, with an average fraction content of 5.6 % sand, 32.4 % silt, and 62 % clay. Clay-textured soils feel smooth to the touch, sticky when wet, and hard when dry. Because of its dense particles, clay soils have low permeability, making it difficult for water to penetrate or drain. Clay-rich soils, on the other hand, have a high water-holding capacity and cation exchange capacity. This is due to clay fractions' high specific surface area, which allows them to adsorb water molecules and cations (Nurdianto et al., 2022).

Fine-textured soils (dominated by clay) are typically cohesive and difficult to break apart. Nevertheless, if rainfall intensity or surface runoff is strong enough to disrupt the bonds between particles, suspended sediments may form and be easily transported by runoff. Clay-textured soils have the advantage of storing water effectively; however, they tend to harden when dry. Therefore, proper tillage and soil management are required to maintain a crumbly structure (Rusnanda, 2016).

Bulk Density of Soil

Soil bulk density is one of the most routinely determined physical qualities of soil because it is closely related to root penetration, soil drainage, aeration, and other physical features. Table 4 shows the findings of the soil bulk density analysis at Wotan Village.

Table 4. Results of Soil Bulk Density Analysis at the Study Site

No.	Sample	Depth (cm)	Land Use	Soil Bulk Density (g/cm^3)
1.	K1	0 - 20	Plantation	1.14
2.	K2	20 - 40		1.14
3.	T1	0 - 20	Dryland Field	1.10
4.	T2	20 - 40		1.09
5.	S1	0 - 20	Rainfed Rice Field	1.13
6.	S2	20 - 40		1.24

The laboratory analysis of soil bulk density at the study site (Table 4) shows values ranging from 1.10 to 1.24 g/cm³. The lowest bulk density was found in dryland fields at a depth of 0–20 cm, with a value of 1.09 g/cm³. This result is consistent with Mansyur (2023), who reported that dryland fields typically have soil bulk density values of around 1.01 g/cm³. The lower bulk density in the dryland fields at a depth of 0–20 cm is attributed to the higher organic matter content compared to plantation land and rainfed rice fields. Lower bulk density also corresponds to a higher percentage of total soil porosity. This finding is in line with Anwar et al., (2024), who stated that the addition of organic matter can loosen the soil or reduce bulk density, thereby increasing total soil porosity.

The highest soil bulk density value (Table 4) was found in rainfed rice fields at a depth of 20 – 40 cm, with an average of 1.24 g/cm³. The higher bulk density in this land use is attributed to soil compaction during rice harvesting. Farmers at the study site use heavy machinery (combine harvesters) during harvesting, which causes soil compaction and consequently increases soil bulk density. Limbong et al., (2017) reported that soil compaction limits the storage and availability of water and air in the soil, inhibits root respiration, reduces water uptake, decreases nutrient availability, and lowers microbial activity. The increase in soil bulk density due to the use of heavy machinery is also consistent with the findings of Darmawati et al., (2019), who explained that the pressure exerted by machinery wheels compresses soil pores, forcing out water and air, thereby narrowing pore spaces, increasing soil density, and ultimately raising bulk density values. In addition, the higher bulk density in the rainfed rice fields at a depth of 20-40 cm also indicates lower organic matter content compared to plantation land, dryland fields, and the upper layer (0-20 cm) of rainfed rice fields. Soil bulk density can be reduced through the addition of organic matter. Yulina et al., (2023) stated that the incorporation of organic matter (C-organic) decreases soil bulk density and increases total porosity, as organic matter promotes the formation of soil aggregates. Similarly, Ranesa et al., (2024) explained that the addition of organic matter influences soil water availability by improving soil structure and enhancing the soil's water retention capacity. Furthermore, Putri et al., (2020) emphasized that soil bulk density and total porosity significantly affect soil permeability. High bulk density values are generally associated with lower total porosity and slower permeability rates.

Particle Density of Soil

Particle density is the mass of soil solids divided by the total volume of soil, excluding pore spaces. Soil particle density is crucial for converting soil water content from a gravimetric to a volumetric basis (% volume) in order to compute total soil porosity. Soil particle density can be impacted by numerous factors, including soil mineral composition and organic matter concentration. The results of the soil particle density analysis across all land units (Table 5) show relatively similar values. Soil particle density in all land uses ranged from 2.46 to 2.60 g/cm³. The lowest particle density was observed in dryland fields at a depth of 20 - 40 cm, with a value of 2.46 g/cm³, whereas the highest value was recorded at the third sampling point, in rainfed rice fields at a depth of 20 - 40 cm, with a value of 2.60 g/cm³.

Table 5. Results of Soil Particle Density Analysis at the Study Site

No.	Sample	Depth (cm)	Land Use	Soil Particle Density (g/cm^3)
1.	K1	0 - 20	Plantation	2.56
2.	K2	20 - 40		2.58
3.	T1	0 - 20	Dryland Field	2.48
4.	T2	20 - 40		2.46
5.	S1	0 - 20	Rainfed Rice Field	2.59
6.	S2	20 - 40		2.60

The highest soil particle density, found in rainfed rice fields with a dominant clay fraction, results in lower soil permeability in this land use. This is consistent with Sipangkar (2023), who stated that an increase in soil particle density within the same volume causes soil particles to become more compact, thereby reducing pore size. The narrowing of pores makes it more difficult for water to flow, leading to a decrease in soil permeability rate. Furthermore, when soil particle density values are too high and consequently reduce permeability, the addition of organic matter does not directly affect particle density. This is in line with Andi et al., (2023), who explained that the incorporation of organic matter does not directly influence soil particle density, as this property is primarily determined by parent material and soil texture.

Total Porosity

Based on Table 6, the calculated total soil porosity at the study site ranged from 52.46 to 56.31%. The order of total porosity values from lowest to highest according to land use (Table 6) is as follows: S2, T2, K2, T1, K1, and S1. The lowest total porosity value was found in rainfed rice fields at a depth of 20 - 40 cm, while the highest value was recorded in rainfed rice fields at a depth of 0 - 20 cm.

The lowest total soil porosity value, found in rainfed rice fields at a depth of 20 - 40 cm, is attributed to soil compaction caused by the use of heavy machinery (combine harvesters) during the rice harvesting season. In addition, the lower porosity value is also influenced by the soil texture in rainfed rice fields, which is dominated by clay particles. This dominance of clay results in lower total porosity and slower permeability rates. This finding is consistent with Sandi et al., (2024), who reported that the low porosity value in maize fields was caused by soil texture dominated by clay. Clay particles contain more micropores than macropores, which makes the soil denser and less porous, thereby reducing total porosity. This statement is further supported by Mahdi (2018), who explained that the abundance of micropores in clay-dominated soils allows the soil to retain greater amounts of water.

Table 6. Results of Total Soil Porosity Analysis at the Study Site

No.	Sample	Depth (cm)	Land Use	Total Porosity (%)
1.	K1	0 - 20	Plantation	55.60
2.	K2	20 - 40		55.46
3.	T1	0 - 20	Dryland Field	55.52
4.	T2	20 - 40		55.15
5.	S1	0 - 20	Rainfed Rice Field	56.31
6.	S2	20 - 40		52.46

The highest total soil porosity value (Table 6) was found in rainfed rice fields at a depth of 0-20 cm. The high porosity value is influenced by the higher organic matter content in the soil, which results in lower bulk density. This is consistent with (Megayanti et al., 2022), who reported that an increase in total soil porosity is affected by higher organic matter content and lower bulk density, leading to the formation of more pore spaces and consequently increasing total porosity. Moreover, total soil porosity also affects soil permeability. Masria et al., (2016) explained that greater total porosity and aggregate stability enhance soil permeability. Similarly, the increase in rapid drainage pores and available water pores with improved aggregate stability contributes to greater water movement within the soil.

Table 7. Results of Soil Permeability Analysis at the Study Site

No.	Sample	Depth (cm)	Land Use	Permeability (cm/hour)*	Category
1.	K1	0 - 20	Plantation	1.19	Moderately Slow
2.	K2	20 - 40		0.93	Moderately Slow
3.	T1	0 - 20	Dryland Field	1.14	Moderately Slow
4.	T2	20 - 40		0.98	Moderately Slow
5.	S1	0 - 20	Rainfed Rice Field	1.21	Moderately Slow
6.	S2	20 - 40		0.80	Moderately Slow

*Classification of Uhland and O'Neil (1951)

Permeability

The rate of soil permeability can be influenced by the value of total soil porosity, where higher porosity corresponds to higher permeability, allowing water and certain substances to move more rapidly. In general, permeability increases as soil becomes more porous. Likewise, the wetter (moister) the soil, the higher its permeability value. In contrast, in drier soils, some pores are filled with air, which obstructs water flow. The results of the soil permeability analysis at the study site are presented in Table 7.

Based on Table 7, the soil permeability at the study site ranged between 0.80 and 1.21 cm $hour^{-1}$. The lowest value was observed in rainfed rice fields at a depth of 20–40 cm, whereas the highest was recorded in rainfed rice fields at a depth of 0–20 cm. Across all land-use types and soil depths, the permeability was consistently categorized as moderately slow. Such moderately slow permeability typically reflects soils with a relatively compact structure and reduced total porosity, thereby limiting the rate of water transmission through the soil matrix. This finding aligns with the observations of Penhen et al., (2022), who emphasized that slight compaction decreases pore size distribution, particularly the proportion of macro-pores, thus impeding water movement. The degree of pore connectivity is a critical determinant of soil permeability, as limited pore continuity can substantially restrict hydraulic conductivity, and in extreme cases, the permeability may approach near-zero values when dominated by micro-pores.

The lowest permeability value, observed in the rainfed rice fields at a depth of 20-40 cm, was attributed to soil compaction and a low total pore space. When associated with soil texture, the dominance of the clay fraction at this depth contributed significantly to the reduced soil permeability. This finding is consistent with the statement of Mulyono et al., (2019), who reported that fine-textured soils generally exhibit low permeability values. Similarly, Saputra et al., (2018) emphasized that clay particles, being the smallest soil fraction, tend to result in soils with relatively high total porosity but dominated by micro-pores or capillary pores, which restrict infiltration rates. Consequently, soils with a higher clay content exhibit lower permeability, and vice versa.

The highest permeability value, observed in the rainfed rice fields at a depth of 0 - 20 cm, this was associated to the soil's high organic matter level. The organic matter content is inversely related to soil bulk density; higher organic matter levels lead to lower bulk density values. A lower bulk density, in turn, increases the total pore space, thereby enhancing soil permeability. This is consistent with the findings of Alista & Soemarno (2021), who stated that higher permeability is associated with greater pore space, enabling plant roots to more easily penetrate the soil and absorb nutrients. Easier root penetration also indicates the presence of good soil drainage conditions.

In addition to the influence of organic matter content, the higher permeability value in the rainfed rice fields at a depth of 0 - 20 cm was also attributed to the use of chicken manure fertilizer. Farmers in the study area commonly applied poultry manure from layer chicken farms before the planting season, which increased the organic matter content in the soil. This practice contributed to a higher total pore space and, consequently, enhanced soil permeability. Thaharah et al., (2024) confirmed this by reporting that the application of chicken manure at a rate of 20 t ha^{-1} had a significant effect on soil permeability. Similarly, Panataria et al., (2025) emphasized that although the nutrient content of manure is not particularly high, it has other advantages, such as improving soil physical properties including permeability, total pore space, soil structure, and water-holding capacity.

The Influence of Land Use Differences on Soil Physical Properties
Soil Bulk Density

The t-test was conducted to determine whether there were significant differences in soil bulk density among different land use types, namely plantation land (K), dryland farming (T), and rainfed rice fields (S), at both soil depths of 0-20 cm and 20-40 cm. The t-table value used as a reference was 2.776, at a 5% significance level with the appropriate degrees of freedom (df) according to the number of samples in each group.

Table 8. Results of the T-Test for Soil Bulk Density Based on Land Use at Depths of 0-20 cm and 20-40 cm

Depth (cm)		T-test
	K1 : T1	0.159
0-20	T1 : S1	0.245
	K1 : S1	0.460
	P2 : T2	0.053
20-40	T2 : S2	8.975
	K2 : S2	0.006
5%		2.776

Note: K = Plantation; T = Dryland Field; S = Rainfed Rice Field

The results of the T-test at a soil depth of 0–20 cm (Table 8) show that all pairs of land-use types produced calculated *t* values smaller than the critical *t* value. The calculated values were as follows: Plantation (K1) vs. Dryland Field (T1): $t = 0.1595$, Dryland Field (T1) vs. Rainfed Rice Field (S1): $t = 0.2459$, and Plantation (K1) vs. Rainfed Rice Field (S1): $t = 0.4604$. Since all *t* values < 2.776, it can be concluded that there is no statistically significant difference in soil bulk density at a depth of 0–20 cm among the land-use types. This condition indicates that land-use activities have not significantly affected soil bulk density in the topsoil layer. This is most likely due to the homogeneity of the upper soil layer, which is still influenced by the accumulation of organic matter from the surface and the relatively uniform activity of microorganisms across all land-use types. In addition, soil tillage activities are generally more frequently carried out in the upper layer, which results in looser soil structure and a more uniform bulk density among land uses. Organic matter content also tends to be higher at the surface, thereby contributing to the reduction of bulk density values. Although there may be visually observable differences in soil bulk density between dryland fields, plantations, and rainfed rice fields, these differences are not statistically significant enough to demonstrate a real effect of land-use type on bulk density in this soil layer.

In contrast to the upper layer, at a depth of 20–40 cm (Table 8), a slight decrease in significance values was observed for several land-use pairs, as shown in the following results: Plantation (K2) vs. Dryland Field (T2): $t = 0.0533$, Dryland Field (T2) vs. Rainfed Rice Field (S2): $t = 8.97541$, and Plantation (K2) vs. Rainfed Rice Field (S2): $t = 0.0064$. Nevertheless, most of the calculated *t* values remained below the critical *t* value (2.776), leading to the statistical conclusion that there is no significant difference in soil bulk density at a depth of 20 – 40 cm among the three land-use types. However, it is noteworthy that at this depth, the calculated *t* values for some land-use pairs are extremely small, indicating a practical tendency toward differences in bulk density. For instance, the difference between dryland fields and rainfed rice fields (t = 8.97541) suggests a very narrow margin of statistical significance, although in practice there may be actual differences in soil physical properties due to varying land management practices. Intensive soil tillage, for example, can increase bulk density because frequent tillage reduces pore space, making it smaller compared to soils that are never tilled (Sinaga et al., 2020).

Soil Partikel Density

The *t*-test was conducted to determine whether there were significant differences in soil particle density among various land-use types at two soil depths (0-20 cm and 20-40 cm). The calculated *t* values for each land-use pair at both depths are presented in Table 9.

Table 9. Results of t-Test for Particle Density Based on Land Use at Soil Depths of 0-20 cm and 20-40 cm

Depth (cm)	T test	
0-20	K1 : T1	0.060
	T1 : S1	0.024
	K1 : S1	0.100
20-40	K2 : T2	0.103
	T2 : S2	0.069
	K2 : S2	0.172
5 %		2.776

Note: K: Plantation; T: Dryland; S: Rainfed Rice Field

Based on Table 9, all calculated t-values from each pairwise comparison were smaller than the t-table value (2.776). This indicates that there was no significant difference in soil particle density between plantation, dryland, and rainfed rice field at both depths. In general, soil particle density is more influenced by the mineral composition of the soil rather than land use. The main soil-forming minerals, such as quartz, feldspar, and clay minerals, have relatively constant densities; therefore, even with changes in land-use systems, soil particle density does not undergo significant variations. This finding is in line with the statement of Juliani et al., (2022), who emphasized that soil particle density becomes a limiting factor in soil tillage activities in agricultural land. It is also supported by the results of previous studies Yunanda et al., (2022) which revealed that soil particle density does not easily change in a short period of time, since it is closely related to the mineral composition of the soil. Therefore, these results are consistent with the general understanding that land use does not have a significant effect on soil particle density.

Soil Total Porosity

Statistical analysis using the t-test was conducted to determine whether there were significant differences in soil total pore space values among different land-use types, namely plantation (K), dryland (T), and rainfed rice field (S), at two soil depths (0-20 cm and 20-40 cm).

Table 10. Results of the T-Test on Total Pore Space Based on Land Use at Soil Depths of 0-20 cm and 20-40 cm

Depth (cm)		T test
	K1 : T1	0.463
0-20	T1 : S1	0.314
	K1 : S1	0.342
	K2 : T2	0.426
0-40	T2 : S2	0.067
	K2 : S2	0.016
5 %		2.776

Note: K = Plantation; T = Dryland; S = Rainfed Rice Field

The results of the t-test on total soil porosity at a depth of 0-20 cm (Table 10) show the following: Plantation (K1) versus Dryland (T1) yielded a calculated t-value of 0.463, Dryland (T1) versus Rainfed Rice Field (S1) yielded 0.314, and Plantation (K1) versus Rainfed Rice Field (S1) yielded 0.342. All three calculated t-values are smaller than the t-table value (2.776), indicating that there is no statistically significant difference in total soil porosity among the three land-use types at this depth. These findings suggest that land-use activities have not yet significantly affected soil pore structure in the upper soil layer. The characteristics of total soil porosity are strongly influenced by organic matter content and soil biota activity. This is consistent with the findings of Surya et al., (2017), who stated that organic matter incorporated into the soil exerts a long-term effect, thereby enhancing soil porosity.

The results of the t-test on total soil porosity at a depth of 20-40 cm (Table 10) show the following: Plantation (K2) versus Dryland (T2) had a calculated t-value of 0.426, Dryland (T2) versus Rainfed Rice Field (S2) had 0.067, and Plantation (K2) versus Rainfed Rice Field (S2) had 0.017. All calculated t-values are also below the t-table value (2.776), which again indicates that the differences in total soil porosity among the three land-use types are not statistically significant. In general, total soil porosity is an important indicator of soil physical quality because it is directly related to the soil's capacity to store and supply water and air to plant roots. According to Pangaribuan et al., (2020), low water-holding capacity in soil porosity results in nutrients being leached quickly, reducing their availability to plants.

Soil Permeability

Permeability refers to the ability of soil to transmit water through its pores. This property plays a crucial role in soil drainage and the availability of water for plants. The permeability coefficient depends on the average pore size, which is influenced by particle size distribution, particle shape, and soil structure (Mansyur, 2023). In this study, a t-test was conducted on soil permeability values to assess the significance of differences among three land-use types: plantation (K), dryland (T), and rainfed rice field (S), at two soil depths: 0-20 cm and 20-40 cm. The t-table value used was 2.776, with a significance level of 0.05.

Table 11. Results of the T-Test on Soil Permeability Based on Land Use at Soil Depths of 0-20 cm and 20-40 cm

Depth (cm)		T test
0-20	K1 : T1	0.476
	T1 : S1	0.460
	K1 : S1	0.484
20-40	K2 : T2	0.465
	T2 : S2	0.374
	K2 : S2	0.414
5 %		2.776

Note: K = Plantation; T = Dryland; S = Rainfed Rice Field

The results of the t-test on soil permeability at a depth of 0-20 cm (Table 11) are as follows: Plantation (K1) versus Dryland (T1) had a calculated t-value of 0.477, Dryland (T1) versus Rainfed Rice Field (S1) had 0.461, and Plantation (K1) versus Rainfed Rice Field (S1) had 0.484. All calculated t-values are less than the t-table value (2.776), indicating that there is no significant difference in soil permeability among land-use types at this depth. This suggests that, despite variations in land use, soil permeability in the upper layer remains relatively uniform. The topsoil layer is typically influenced by the accumulation of organic matter from litter and the activity of soil biota, which help maintain soil structure and pore spaces. The availability of organic matter also strongly affects soil biota activity at the surface, which tends to reduce bulk density and increase total soil porosity (Khair et al., 2017).

The results of the t-test on soil permeability at a depth of 20-40 cm are as follows: Plantation (K2) versus Dryland (T2) had a calculated t-value of 0.466, Dryland (T2) versus Rainfed Rice Field (S2) had 0.374, and Plantation (K2) versus Rainfed Rice Field (S2) had 0.414. All three calculated t-values are also below the t-table value, indicating that there is no statistically significant difference in soil permeability among land-use types at this depth. Several factors can influence soil permeability, including soil texture and total porosity (Yendani et al., 2024). Therefore, it can be concluded that differences in land use do not have a significant effect on total soil porosity at the study site, and consequently, land-use differences also do not significantly affect soil permeability.

CONCLUSION

The physical properties of soil in Desa Wotan vary according to land-use type and soil depth. Soil texture is dominated by silt and clay fractions, with classifications of silty clay loam, clay loam, and clay. Soil bulk density ranges from 1.10 to 1.24 g/cm^3, while particle density ranges from 2.46 to 2.60 g/cm^3. Total soil porosity values are approximately 52.46 – 56.31%, and permeability rates range from 0.80 to 1.21

cm/h, all falling into the slightly slow category. The best soil physical properties were observed in plantation land at 20 – 40 cm depth and dryland at 20–40 cm depth, both with a silty clay loam texture. Differences in land use did not significantly affect any of the soil physical parameters statistically, although visual data presentation showed some variation. Further research on soil chemical properties is needed to provide comprehensive information for students and farmers regarding land use in Wotan Village, Panceng District, Gresik Regency.

REFERENCES

Andi, D.L., Sofyan, A., Hartati, T. M., & Hasan, A. D. A. (2023). Study of Changes in the Physical Properties of Inceptisol Soil Through the Application of Organic Matter from Banana Peel Waste. *Jurnal Pertanian Khairun*, *2*(2), 200-204. **[*In Indonesian language*]**

Al-Musyafa, M. N., Afandi, A., & Novpriansyah, H. (2016). Study of Soil Physical Properties in High and Low Yield Pineapple (Ananas comosus L.) Plantations at PT. Great Giant Pineapple, Central Lampung. *Jurnal Agrotek Tropika*, *4*(1), 66–69. https://doi.org/10.23960/jat.v4i1.1903 **[*In Indonesian language*]**

Alista, F. A., & Soemarno, S. (2021). Analysis of Soil Permeability in Upper and Lower Layers of Robusta Coffee Plantations. *Jurnal Tanah Dan Sumberdaya Lahan*, *8*(2), 493–504. https://doi.org/10.21776/ub.jtsl.2021.008.2.20 **[*In Indonesian language*]**

Annisa, D. W., & Prijono, S. (2023). Analysis of Saturated Soil Hydraulic Conductivity in Various Types of Shade on Smallholder Coffee Plantations in Sumbermanjing Wetan Subdistrict. *Jurnal Tanah Dan Sumberdaya Lahan*, *10*(1), 15–23. https://doi.org/10.21776/ub.jtsl.2023.010.1.2 **[*In Indonesian language*]**

Anwar, A. H. M., Prasetyo, T. B., & Yulnafatmawita, Y. (2024). The Role of Biochar and Compost in Improving Water Retention and Sweet Corn (Zea mays L. var. saccharata) Production in Coarse-Textured Soil. *Agrikultura*, *35*(2), 238–249. https://doi.org/10.24198/agrikultura.v35i2.53995 **[*In Indonesian language*]**

Awal, F. R., Feranie, S., & Tohari, A. (2021). Physical Characteristics of Residual Soil on Landslide-Prone Slopes along the Bogor-Ciawi-Sukabumi Toll Road, Bogor Regency. *Conference proceeding of Seminar Nasional Fisika 2021*, *7*, 415–419. **[*In Indonesian language*]**

Badan Informasi Geospasial Republik Indonesia. (2021). *Regulation of the Geospatial Information Agency Number 6 of 2023 on the Implementation of Toponymy*. 1–67. https://peraturan.bpk.go.id/Details/269427/peraturan-big-no-6-tahun-2023. Accessed on January 15Th 2025 **[*In Indonesian language*]**

Bintoro, A., Widjajanto, D., & Isrun. (2017). Physical Characteristics of Soil in Several Types of Land Use. *E-J. Agrotekbis*, *5*(4), 423–430. **[*In Indonesian language*]**

BPS Kabupaten Gresik. (2016). Regional Statistics for Panceng Subdistrict, Gresik Regency, 2016. In *3525150.1617.* Volume 11(Issue 1). https://gresikkab.bps.go.id/id/publication/2016/09/26/41c1d29d9e462e57c3a db12c/panceng-subdistrict-regional-statistics-2016.html. Accessed on January 15Th 2025 **[*In Indonesian language*]**

Darmawati, D., Suhardi, S., & Sapsal, M. T. (2019). The Effect of Combine Harvester Trajectories on Soil Compaction During Operation. *Jurnal Agritechno*, *12*(1), 1–8. https://doi.org/10.20956/at.v12i1.181 **[*In Indonesian language*]**

Desa, D. I., & Sigi, O. (2016). Physical Properties of Soil in Several Land Uses in Oloboju Village, Sigi District, Biromaru, Sigi District. *E-J. Agrotekbis*, *4*(3), 227–234. http://jurnal.untad.ac.id/jurnal/index.php/agrotekbis/index **[*In Indonesian language*]**

Fitri, M. R., Riyadi., Ayu Larasati, D., & Prasetya S. P. (2023). The Potential of Karst Landscapes on the North Coast of Gresik as a Source of Social Studies Learning for Junior High School Students. *Jurnal Dialektika Pendidikan IPS*, *3*(2), 140–146. https://doi.org/10.26740/penips.v3i2.55072. **[*In Indonesian language*]**

Hanafiah, K. A. (2014). *Fundamentals of Soil Science*. First Edition. Jakarta: Rajawali Pers. www.rajagrafindo.co.id **[*In Indonesian language*]**

Juliani, R., Soemeinaboedhy, I.N., & Bustan. (2022). The Impact of Cocopeat Application and Incubation on Changes in Soil Physical Properties in Dry Land in North Lombok Regency. *Jurnal Ilmiah Mahasiswa Agrokomplek*, *1*(3), 243–249. https://doi.org/10.29303/jima.v1i3.1483 **[*In Indonesian language*]**

Kastanya, P. G., Ufie, C., & Puturuhu, F. (2019). Physical Characteristics of Soil According to Land Use Types in Tawiri District in Accordance with Ambon City Spatial Planning. *Jurnal Budidaya Pertanian*, *15*(2), 68–79. https://doi.org/10.30598/jbdp.2019.15.2.68 **[*In Indonesian language*]**

Khair, R. ., Utomo, M., & Banuwa, I. . (2017). The Effect of Long-Term Soil Cultivation and Nitrogen Fertilisation on Bulk Density, Total Pore Space, and Hardness. *Agrotek Tropika*, *5*(3), 175–180. **[*In Indonesian language*]**

Limbong, W. M. M., Sabrina, T., & Lubis, A. (2017). Improvement of Several Physical Properties of Watermelon-Cultivated Rice Fields Through the Application of Organic Materials. *Jurnal Agroekoteknologi Universitas Sumatera Utara*, *5*(1), 152–158. **[*In Indonesian language*]**

Mahdi, N. T. (2018). Soil Water Retention Curve and Specific Water Capacity for Three Different-textured Soils. *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS), 11*(9), 43–49. https://doi.org/10.9790/2380-1109024349

Mansyur, N. I. (2023). Physical Characteristics of Soil in Several Marginal Land Areas Used for Horticultural Crop Cultivation. *Jurnal Ilmiah Respati*, *14*(2), 1411–7126. https://ejournal.urindo.ac.id/index.php/pertanian **[*In Indonesian language*]**

Masria, M., Lopulisa, C., Zubair, Zubair, H., & Rasyid, B. (2016). Pore Characteristics and Their Relationship with Permeability in Vertisol Soil from Jeneponto, South Sulawesi. *Ecosolum: Jurnal of Soil Science and Environment. 7*(1), 38–45. https://doi.org/10.20956/ecosolum.v7i1.5209 **[*In Indonesian language*]**

Megayanti, L., Zurhalena, Z., Junedi, H., & Fuadi, N. A. (2022). Study of Several Physical Properties of Soil Planted with Oil Palm at Different Ages and Slopes (Case Study of Oil Palm Plantation in Simpang Tuan Village, Mendahara Ulu Subdistrict, East Tanjung Jabung). *Jurnal Tanah Dan Sumberdaya Lahan*, *9*(2), 413–420. https://doi.org/10.21776/ub.jtsl.2022.009.2.22 **[*In Indonesian language*]**

Mulyono, A., Rusydi, A. F., & Lestiana, H. (2019). Soil Permeability of Various Land Use Types in the Cimanuk Coastal Alluvial Soil, Indramayu. *Jurnal Ilmu Lingkungan*, *17*(1), 1. https://doi.org/10.14710/jil.17.1.1-6 **[*In Indonesian language*]**

Nurdianto, F., Cyio, M. B., & Toana, M. R. C. (2022). Analysis of Soil Physical Properties in the Development of Oil Palm (Elaeis quineensis Jacq.) Plantations in North Laemanta Village, Kasimbar Subdistrict, Parigi Moutong Regency. *Agrotekbis: Jurnal Ilmu Pertanian (e-Journal)*, *10*(5), 601–609. **[*In Indonesian language*]**

Panataria, L. R. M. K. S., Sitorus, E., & Susanti, R. (2025). The Effect of Urea Fertiliser and Chicken Manure Application on the Growth and Production of Maize (Zea mays L.). *Jurnal Agroplasma, 12*(1), 356–366. https://doi.org/10.36987/agroplasma.v12i1.7228 **[*In Indonesian language*]**

Pangaribuan, E. A. S., Darmawati, A., & Budiyanto, S. (2020). Growth and Yield of Pakchoy Plants in Sandy Soil with Biochar and Cow Manure Fertiliser. *Agrosains : Jurnal Penelitian Agronomi*, *22*(2), 72. https://doi.org/10.20961/agsjpa.v22i2.42093 **[*In Indonesian language*]**

Penhen, N., Hartati, T. M., & Ladjinga, E. (2022). Determination of Infiltration Rate and Soil Permeability in Several Land Uses in Jambula Subdistrict. *Conference proceeding of Seminar Nasional Pertanian 2022 by Khairun University*, *2*(1), 152-157. https://ejournal.unkhair.ac.id/index.php/agri/article/view/5729/3663 **[*In Indonesian language*]**

Putri, K. Y., Utomo, M., Afrianti, N. A., & Afandi, A. (2020). The Effect of Long-Term Soil Cultivation and Nitrogen Fertilisation Systems on Soil Permeability in Corn (Zea mays L.) Plantations at the Lampung State Polytechnic. *Jurnal Agrotek Tropika*, *8*(3), 547. https://doi.org/10.23960/jat.v8i3.4454 **[*In Indonesian language*]**

Rachman, L. M. (2019). Characteristic and Variability of Soil Physical Properties and Evaluation. *Conference proceeding of Seminar Nasional Lahan Suboptimal 2019 "Smart Farming yang Berwawasan Lingkungan untuk Kesejahteraan Petani", September*, 132–139. **[*In Indonesian language*]**

Rahayu, Y. S., & Yuliani. (2016). The Application of Teak Leaf Mulch in Improving Nutrient Levels and Physical Properties of Calcareous Soil. *Conference proceeding of Seminar Nasional Biologi 2016 by Universitas Negeri Surabaya*. 213-217 **[*In Indonesian language*]**

Ranesa, S. S., Tejowulan, R. S., & Padusung. (2024). The Effect of Organic Matter Content on the Growth and Yield of Chili Plants under Water Stress Conditions.

Journal of Soil Quality and Management, *1*(1), 79–86. **[*In Indonesian language*]**

Ruci, A. S. D. (2018). Soil Consistency Characteristics in Various Land Uses in Bojong Koneng Village, Babakan Madang Subdistrict, Bogor Regency. *Undergraduated Theses of Fakultas Pertanian Dan Peternakan, Institut Pertanian Bogor*. **[*In Indonesian language*]**

Rusnanda, R. T. (2016). Analysis of Clay Soil Stabilisation on Soil Bearing Capacity Improvement. *Jurnal Teknik Sipil*, 14(1), 1-11. https://repository.usm.ac.id/files/journalmhs/C.141.14.0050-20200824084847.pdf. **[*In Indonesian language*]**

Saputra, D. D., Putrantyo, A. R., & Kusuma, Z. (2018). The Relationship between Soil Organic Matter Content, Soil Bulk Density, Porosity, and Permeability in Salak Plantation Land in Purwosari Subdistrict, Pasuruan Regency. *Jurnal Tanah Dan Sumberdaya Lahan*, *5*(1), 647–654. **[*In Indonesian language*]**

Sinaga, S., Amelia, V., & Batubara, R. D. (2020). The Effect of Land Use and Slopes on The Physical Properties of Land in Kurun Sub-District, Gunung Mas District. *Agrienvi*, *14*(2), 59–65. https://doi.org/10.36873/aev.2020.14.2.59

Sir, T. M. W., Lay, R. R., & Bunganaen, W. (2019). Stabilisation of Clay Soil in Niukbaun Village Using a Mixture of Limestone and Cement. *Jurnal Teknik Sipil*, *8*(2), 179–192. **[*In Indonesian language*]**

Surya, J. A., Nuraini, Y., & Widianto. (2017). Study of Soil Porosity in Providing Several Types of Organic Materials in Robusta Coffee Plantation. *Journal of Soil and Land Resources*, *4*(1), 463–471.

Thaharah, P. A. N., Haris, A., & Fachruzi, I. (2024). The Effect of Palm Oil Boiler Ash and Chicken Manure on the Physical and Chemical Properties of Soil in Post-Coal Mining Areas. *Acta Solum*, *3*(1), 35–40. https://doi.org/10.20527/actasolum.v3i1.2785 **[*In Indonesian language*]**

Umin, M., & J.P. Anasaga, A. (2019). Physical Characteristics of Soil in Cassava (Manihot esculenta Crantz) Cultivation Areas in Walogai Tengah Village. *Agrica*, *12*(1), 23–33. https://doi.org/10.37478/agr.v12i1.9 **[*In Indonesian language*]**

Wibisono, M. G., Sudarsono, & Darmawan. (2016). Characteristics of Andisols with Breccia and Lahar Parent Material from the Northeastern Part of Mount Gede, West Java. *Jurnal Tanah Dan Iklim*, *40*(1), 61–70. **[*In Indonesian language*]**

Yendani, D., Ilyas, I., & Arabia, T. (2024). Study of Soil Weight and Permeability with and without Empty Oil Palm Bunches in Oil Palm Plantations in Kaway XVI Subdistrict, West Aceh Regency. *Jurnal Ilmiah Mahasiswa Pertanian*, *9*(3), 355–360. https://doi.org/10.17969/jimfp.v9i3.31556 **[*In Indonesian language*]**

Yulina, H., Wiwik Ambarsari, & Fadhillah Laila. (2023). The Effect of Organic Matter on Soil Bulk Density, Moisture Content, Total Nitrogen, Organic Carbon, and Pakcoy Yield in Indramayu Regency. *Conference proceeding of Seminar Nasional Pembangunan Dan Pendidikan Vokasi Pertanian*, *4*(1), 475–496. https://doi.org/10.47687/snppvp.v4i1.672 **[*In Indonesian language*]**

Yunanda, F., Soemeinaboedhy, I. N., & Silawibawa, I. P. (2022). The Effect of Applying Various Organic Fertilisers on Soil Physical Properties, Soil Chemistry, and Groundnut (Arachis hypogaea L.) Production in Kediri District. *Jurnal Ilmiah Mahasiswa Agrokomplek*, *1*(3), 294–303. **[*In Indonesian language*]**

How To Cite This Article, with *APA style* :
Abid, M. M., Maroeto, M., & Arifin, M. (2025). Land Use-Driven Variation in Soil Physical Properties: A Case Study from Wotan Village, Panceng Subdistrict, East Java. *Jurnal Pembelajaran dan Biologi Nukleus*, *11*(2), 785-804. https://doi.org/10.36987/jpbn.v11i2.7484

Conflict of interest : The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contributions : All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was submited by [**Moh Mislahul Abid**]. All authors contributed on previous version and revisions process of the manuscript. All authors read and approved the final manuscript.