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Full Length Research Article

Analysis of Alfisol Soil Infiltration Rate on Various Land Cover and Its Effect on Soil Erodibility in Mount Bromo Special Purpose Forest Area, Indonesia

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ABSTRACT

Plant canopies can protect the soil surface from raindrops and rooting activities that cause changes in biophysical properties. A low infiltration rate will reduce the soil's capacity to store water to be low, resulting in a high soil erodibility value. This research aims to obtain infiltration values on different land cover, analyze the effect of land cover on soil infiltration rate, and analyze the effect of soil infiltration rate on soil erodibility. The research includes exploratory, descriptive research with a purposive sampling method. The study results show an increased soil infiltration rate can reduce soil erodibility. The infiltration rate of 74-year-old mahogany land cover ranged from 1.94–3.03 cm/hour, 50-year-old mahogany 1.61 cm/hour, old pine 1.53–1.89 cm/hour, old tapped pine 1.54–3.43 cm/hour, young pine 0.48–1.60 cm/hour, young pine 0.37–0.61 cm/hour, and 5-year-old sonokelling 0.56–0.73 cm/hour. The highest infiltration value is in 74-year-old mahogany and the lowest in young pine. The highest soil erodibility value is in young tapped pine and the lowest in 50-year-old mahogany. Erodibility is the sensitivity of soil to erosion. It is easier to erode if its erodibility value is higher; conversely, erosion is less likely to occur if its erodibility value is lower. An increase in soil infiltration rate can reduce soil erodibility.

1. Introduction

The Mount Bromo Special Purpose Forest Area (KHDTK Gunung Bromo) is a forest area that acts as a regulator of environmental balance because it can maintain the balance of water management and act as a water catchment area, as well as preventing natural disasters such as erosion and flooding. According to Kertész et al. (2019), the continuous change in forest land use for ecotourism activities can result in land degradation that endangers ecosystem services. Erosion is a manifestation of the impact of land degradation. Ojo et al. (2023) stated that soil erodibility is a factor considered in soil conservation actions for erosion estimation. Erosion is important to study because land that experiences erosion that exceeds the allowable limit causes a decrease in soil productivity and triggers soil damage. It is the basis for determining appropriate conservation measures to preserve the forest. Soil erodibility is whether or not the soil is easy to erode, which is influenced by several factors, namely structure, texture, soil organic matter, and permeability. According to Garg et al. (2022), the higher the soil erodibility value, the easier the soil erodes.

Soils with small clay content can easily destroy soil because clay is an adhesive for soil aggregates, so the soil erodibility value is high.

The KHDTK Gunung Bromo has a high diversity of land cover with varying ages and slopes. According to Drupadi et al. (2021), this area has an undulating to hilly topography and has an Alfisol soil type. The undulating to hilly topography causes the land to be easily degraded due to erosion. According to Rochman et al. (2021), alfisol is soil with a high density, so plant roots have difficulty penetrating the soil, containing organic matter, pore aeration, and low water binding capacity. This causes the infiltration rate in the Mount Bromo area to be low. According to Hanifa and Suwardi (2022), a low infiltration rate will cause a low water retention capacity, resulting in a high soil erodibility value. Low infiltration means that most rainwater on the ground surface is surface runoff, and only a small portion reaches the soil surface. According to Zhu et al. (2024), land cover significantly impacts infiltration. In this case, plant roots and soil texture influence infiltration. The management of the KHDTK Gunung Bromo can be optimized by utilizing various land covers. Here, the land map units show land cover that functions for biodiversity conservation. According to Nugraha et al. (2024), in a setting where cash-crop gardens are dominant, maintaining traditional agroforestry and mixed-garden (*talun*) areas is one technique that could preserve landscape biodiversity and support a more sustainable way of life. Singh et al. (2016) stated that land cover also affects the other natural components of soil fertility, soil erosion, ecology, biodiversity, air quality, and water regime.

Infiltration has a big role in the hydrological cycle because there are processes that are not interdependent but interrelated, namely the process of entering rainwater into the soil through the soil surface, the process of collecting rainwater related to the availability of groundwater, and the process of flowing water from one place to another. Proper forest management is needed so that the hydrological balance can be maintained. Kiptiah et al. (2020) stated that knowing the value of soil infiltration is important to determine the amount of surface runoff and ensure that plant water reserves are met. Counting the infiltration value using the Horton method found that the higher the soil density, the smaller the infiltration rate. Soil physical properties that affect soil susceptibility to erosion also affect soil infiltration rates. Research on infiltration in the KHDTK Gunung Bromo has been conducted. Still, it has not been correlated with soil erodibility factors, so this research is expected to provide information on infiltration rates in each land cover. With this research, it is expected that the data generated can be a reference for determining management recommendations and conservation actions for KHDTK Gunung Bromo as a sustainable forest area.

2. Materials and Methods

2.1. Study Area

This research was conducted in the field and the laboratory. Field observations for sampling, calculation of soil infiltration, and observation of soil structure were carried out in the KHDTK Gunung Bromo UNS Karanganyar Regency, Central Java Province, Indonesia (**Fig. 1**). Administratively, KHDTK Gunung Bromo is bordered by Sewurejo Village, Mojogedang District to the north, Delingan Village, Karangnyar District to the east, Gedong Village and Delingan Village, Karanganyar Regency to the south, and Gedong Village, Karanganyar Regency to the west. The KHDTK Gunung Bromo has an area of 126,291 ha and is 200–325 meters above sea level (masl). Soil organic matter analysis was conducted at the Soil Chemistry and Fertility

Laboratory. Permeability and texture analysis were performed at the Laboratory of Soil Physics and Conservation, Faculty of Agriculture, Sebelas Maret University, Surakarta. The research was conducted from August to December 2023.

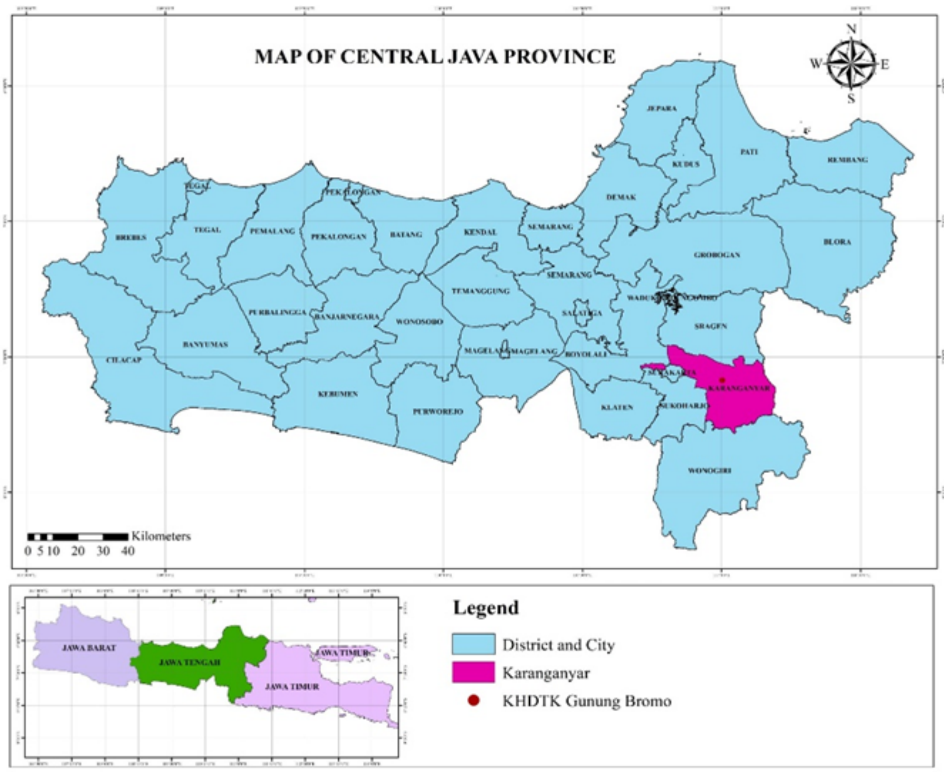

Fig. 1. Research location in Central Java Province.

2.2. Soil Sampling

This study implemented a field survey approach and laboratory analysis. Explorative, descriptive research solves problems broadly based on the results of observations in the field. The method used in soil sampling is purposive sampling, which determines the land map unit (SPL) based on the overlay of thematic maps of land cover and land slope. The purpose of this method is for researchers to select samples based on specific criteria relevant to the goals and focus of the research. In this case, the requirements are based on age, plant type, and slope gradient. This method also aims for efficiency in time and resources and accuracy in variable measurement. Purposive sampling can be used to ensure that the selected sample truly represents the entire area of KHDTK Gunung Bromo. The scale used for making the SPL is 1:10,000. The types of land cover used are old pine, old tapped pine, young tapped pine, young pine, 74-year-old mahogany, 50-year-old mahogany, and 5-year-old sonokelling. Old tapped pine and young tapped pine are pines from which the resin has been harvested. Old pine trees are ready to be felled and their wood harvested. Young pine trees are not yet ready to be tapped and harvested for their wood. For mahogany, it is ready to be harvested for its wood. Woesono and Pamungkas (2022) stated that the division of pine clusters is based on the growth of pine that meets the growing conditions for tapping (old tapped pine and young tapped pine), pine to be cut down and utilized for timber (old pine), and pine that should not be tapped because it is in the vegetative phase so as not to disturb the growth of pine (young pine). The slope used is five slope classes, namely 0–8%, 8–15%, 15–25%, 25–40%, and > 40%. The resulting SPL will be the location of sampling observations, field observations, and laboratory analysis. There are 23 SPLs, where each SPL is taken 3 times so that 69 sample points are obtained (**Fig. 2**). The repetition of the study is recommended at least 3 times to minimize the possibility of data errors in the research. Soil samples were taken at depths ranging from 0–10 cm. Soil samples from the research location were dried for 3–4 days to reduce the water content in the soil. The next step was pulverization and sieving using a 2 mm soil sieve (texture analysis) and a 0.5 mm soil sieve (soil organic matter analysis). Measure soil infiltration using tools such as a double ring-infiltrometer, wooden block, hammer, ruler, and stopwatch, while the materials used are water and soil on various land covers.

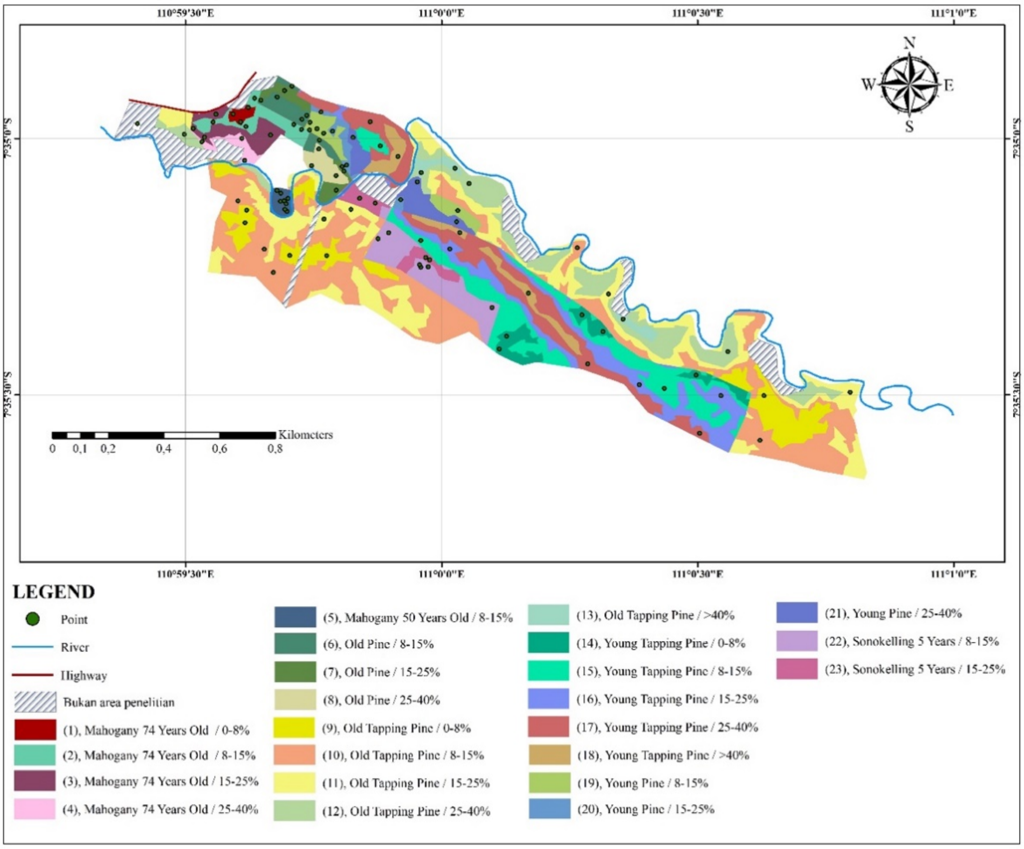

Fig. 2. KHDTK Gunung Bromo land map unit.

2.3. Sample Analysis

Field observations were conducted to calculate soil infiltration rates using a double-ring infiltrometer and observe soil structure. Infiltration measurement with a double ring infiltrometer with a ring depth of 15 cm, an inner diameter of 8 cm, and an outer diameter of 10 cm. The inner ring is smaller than the outer ring, creating a difference in water pressure that allows water to seep into the soil easily. The height of the ring is deep enough to ensure that water does not overflow into the surface of the ground during the test. Laboratory analysis includes soil organic matter, texture, structure and soil permeability. Laboratory analysis begins with the preparation of soil samples. This analysis comprises gas chromatography-mass spectrometry (GC-MS) because it measures the type and content of compounds in the sample quantitatively and qualitatively. Data from laboratory measurements were used to determine soil erodibility values (K values) and soil infiltration rates. Infiltration measurements were made using a double-ring infiltrometer and then analyzed using the infiltration rate equation model proposed by Horton with Equation 1:

$$ft = fc + (f_0 - f_c)e^{-k.t} \quad (1)$$

where ft is infiltration rate (cm/h), fc is constant infiltration rate depending on soil type (cm/h), f_0 is initial infiltration rate (cm/h), e is 2,718, k is reduction rate constant, t is the time interval (hours)

Factors that affect the value of soil erodibility (K value) are texture, structure, organic matter, and soil permeability. The relationship between these factors and the K value, according to Pebrian et al. (2014), is expressed in the following Equation 2:

$$K = \frac{2.7132\ M^{1.14}\ (12 - a) + 3.25\ (b - 2)\ 10^{-4} + 2.5\ (C - 3)}{100} \quad (2)$$

where M is (percent fine sand and dust) × (100 – percent clay), a is percent soil organic matter, b is soil structure code, and c is soil permeability class.

2.4. Statistical Analysis

Data from laboratory analysis was subsequently analyzed using SPSS (Statistical Product and Service Solutions) software. The main analysis is the analysis of variance (ANOVA) with a 95% confidence level to determine the effect of land cover differences on infiltration rate and soil erodibility. Suppose the results showed a significant effect (p-value < 0.05), Duncan's multiple range test (DMRT) was conducted at the 5% level to determine significant differences between groups and continued with the correlation test to determine the closeness and direction of the relationship between infiltration rate and soil erodibility, as well as other supporting parameters. A simple linear regression test aims to determine the effect of soil infiltration rate on soil erodibility. A multiple regression test aims to determine the joint effect of infiltration rate and other soil properties on soil erodibility.

3. Results and Discussion

3.1. Analysis of Soil Parameters

The soil properties on various land covers in KHDTK Gunung Bromo are presented in **Table 1**. Land cover significantly impacts organic matter, permeability, dust percentage, clay percentage, sand percentage, and erodibility (**Table 2**). The results of laboratory analysis showed that soil organic matter of 74-year-old mahogany cover ranged from 4.14–4.97%, 50-year-old mahogany 3.52%, old pine 4.02–4.09%, old tapped pine 2.81–3.22%, young pine 2.81–3.22%, tapped pine 2.56–3.78%, young pine 1.80–3.51%, and 5-year-old sonokelling 2.41–3.54%. Soil organic matter content is in the low to high category. According to Soaloon et al. (2020), there is a lot of litter and worms on forest land, so the process of breaking down organic matter occurs and results in high soil organic matter values, while areas without vegetation result in the formation of a crust layer and hardening of the soil structure due to high surface flow.

Soil permeability is the ability of soil to pass water through the soil layers. Permeability in **Table 2** shows a very significant value (0.000), indicating a very real influence between land cover and permeability. The results of laboratory analysis showed that the permeability value of 74-year-old mahogany land cover ranged from 1.80–2.12 cm/hour, 50-year-old mahogany 1.62 cm/hour, old pine 1.71–2.08 cm/hour, old tapped pine 1.41–2.01 cm/hour, young tapped pine 1.12–1.43

cm/hour, young pine 1.16–1.51 cm/hour, and 5-year-old sonokelling pine 0.80–0.84 cm/hour. Permeability values are categorized as low and moderate to slow. Low soil permeability values cause water to not move freely on the soil surface, increasing the risk of inundation. Land cover plants can form soil pores, improve soil structure, and form soil aggregates through existing plant roots that affect soil permeability. Masria et al. (2018) stated that pore stability affects soil permeability. The stability of soil aggregates influences soil pore stability. Water movement will be faster in soil pores that occupy stable soil aggregates than in soil pores that occupy unstable aggregates. Soil pores that are in unstable soil aggregates result in soil aggregates that are easily destroyed so that soil pores will be closed, and water movement will be slow. Water movement in the soil will be good if the soil has large soil pores and good inter-pore relationships.

Table 1. Results of physical and chemical properties analysis of soil on various land cover in KHDTK Gunung Bromo

SPL	Infiltration (cm/hour)	Organic matter (%)	Permeability (cm/ hour)	Erodibility	Structure	Dust (%)	Clay (%)	Fine sand (%)
1	3.03*	4.14	1.83	0.42	Blocky	41.93	35.03	17.30
2	1.94	4.44	1.68	0.33	Blocky	39.38	41.44	16.06
3	2.52*	4.97	1.80	0.23	Medium granular	32.77	51.97	7.62
4	2.51	4.88	2.12	0.30	Blocky	36.03	47.45	13.38
5	1.61	3.52	1.62	0.12	Thin granular	16.87	66.66	9.35
6	1.89	4.09	1.97	0.25	Blocky	29.18	53.98	10.27
7	1.53	4.09	2.08	0,28	Blocky	33.81	49.70	11.52
8	1.62	4.02	1.71	0.37	Medium granular	33.74	41.55	19.84
9	2.69*	3.22	1.41	0.18	Thin granular	29.12	49.78	14.68
10	3.43*	3.09	1.45	0.15	Medium granular	35.51	53.76	4.48
11	2.51	2.89	1.48	0.29	Blocky	28.23	54.67	14.34
12	1.54	2.99	2.01	0.29	Medium granular	33.39	48.33	14.68
13	2.00	2.81	1.55	0.25	Blocky	36.88	40.30	16.98
14	1.60	3.78	1.16	0.26	Medium granular	31.17	52.38	9.93
15	0.78	2.99	1.16	0.31	Medium granular	36.45	45.42	9.69
16	1.07	2.89	1.43	0.31	Blocky	30.63	49.32	12.40
17	0.48	2.56	1.12	0.33	Blocky	24.06	55.55	16.71
18	0.55	3.08	1.28	0.43	Medium granular	38.89	36.04	20.44
19	0.61	3.51	1.51	0.16	Thin granular	21.36	60.99	13.74
20	0.45	1.82	1.30	0.25	Medium granular	22.05	60.37	14.24
21	0.37	1.80	1.16	0.50	Blocky	40.40	33.61	19.99
22	0.73	2.41	0.84	0.24	Blocky	25.63	61.65	8.43
23	0.56	3.54	0.80	0.23	Blocky	24.44	63.44	7.07

Note: * = high infiltration.

Soil structure is the arrangement of soil particles that bind each other between the grains. **Table 1** shows that 74-year-old mahogany and old tapped pine have the highest infiltration rates. Soil with that land cover has a fine granular, medium granular and blocky. This structure is ideal for water and air circulation because it is neither overly solid nor crumbly. With this type of land cover, the soil will likely have a structure allowing good water movement. The role of vegetation in forming soil structure is in its root system. According to the research of Yahya et al. (2022), the soil root system in vegetation results in increased soil organic carbon, which is related to the improvement of soil aggregates and the formation of soil structure. Organic matter acts as an adhesive material between soil particles to form a soil aggregate.

The land cover of 74-year-old mahogany and old tapped pine has the highest infiltration rate (**Table 1**). This indicates that the condition of the land cover significantly influences the volume of water that enters the soil. In addition, the plants' age significantly impacts the soil penetration conditions. This land cover supports the development of ideal conditions for water to penetrate the soil. More water can get to the soil when it has a robust root system because it can survive the damage that rains cause to soil aggregates.

Table 2. The results of ANOVA of land cover on soil physics variables

Variable	N	p-value (sig.)
Organic material	69	0.000**
Permeability	69	0.000**
Dust percentage	69	0.003**
Clay percentage	69	0.015*
Fine sand percentage	69	0.006**
Erodibility	69	0.020*

Notes: * = significant ($p < 0.05$), **= highly significant ($p < 0.01$).

The soil texture in KHDTK Gunung Bromo is dominated by clay texture, where the percentage of clay is higher than the percentage of dust and water. Clay-dominated soils can hold water better than sand-dominated soils. This is related to its adsorption surface area. The ANOVA test results in **Table 2** show that land cover significantly affects the percentage of dust, with a significance value of 0.003, and the percentage of fine sand, with a significance value of 0.006. The ANOVA test in **Table 2** also shows that land cover significantly affects the percentage of clay with a significance value of 0.015. The soil texture in the KHDTK Gunung Bromo is dominated by the percentage of clay with an average value of 50.15%, the percentage of dust is 31.39%, and the percentage of fine sand is 13.18%. Sarminah et al. (2018) stated that dominant vegetation affects soil organic matter input, can shape soil texture, and affects the soil pore system.

3.2. Effect of Land Cover on Infiltration and Soil Erodibility

The results of the ANOVA analysis in **Table 3** show a significance value of (0.000), meaning that different land cover significantly affects the soil infiltration rate. This is in line with the research of Cui et al. (2022); in general, the soil under forest vegetation can store high water. Based on **Fig. 3**, the results of the calculation of the infiltration rate on land cover of 74-year-old mahogany land cover ranged from 1.94–3.03 cm/hour, 50-year-old mahogany was 1.61 cm/hour, old pine ranged from 1.53–1.89 cm/hour, old tapped pine ranged from 1.54–3.43 cm/hour, young tapped pine ranged from 0.48–1.60 cm/hour, young pine ranged from 0.37–0.61 cm/hour, and 5-

year-old sonokelling ranged from 0.56–0.73 cm/hour. Infiltration rates are slow to moderate. The roots of vegetation allow water to infiltrate into the soil. The highest infiltration value in 74-year-old mahogany land cover is with an average value of 2.49 cm/hour. The increasing age of the stand will result in increased infiltration capacity. Mahogany land cover is 74 years old and has a large root size, and mahogany plants have a tight planting distance. The planting distance for mahogany is 600 cm x 600 cm. Lozano et al. (2018) stated that infiltration is a hydrological process that can be enhanced by increasing land cover, involving several parameters such as bulk density, soil organic carbon content, soil porosity, and particle size. Karahan and Yalim (2022) stated that soil infiltration rate is an important and accurate indicator of soil quality and fertility. Soil characteristics and land cover type are the most influential criteria for all situations that produce the best outcomes in infiltration assessments. As a result, a thorough understanding of infiltration is needed for various land cover conditions. Kandari et al. (2024) stated that land cover functions as a green open space that manages climate stability and as a tool for conservation efforts.

Table 3. The results of ANOVA of land cover effect on soil infiltration rate and soil erodibility

Variable	N	p-value (sig.)
Infiltration	69	0.000**
Erodibility	69	0.020*

Notes: * = significant ($p < 0.05$), ** = highly significant ($p < 0.01$).

Fig. 3. Infiltration rate on various land cover in KHDTK Gunung Bromo.

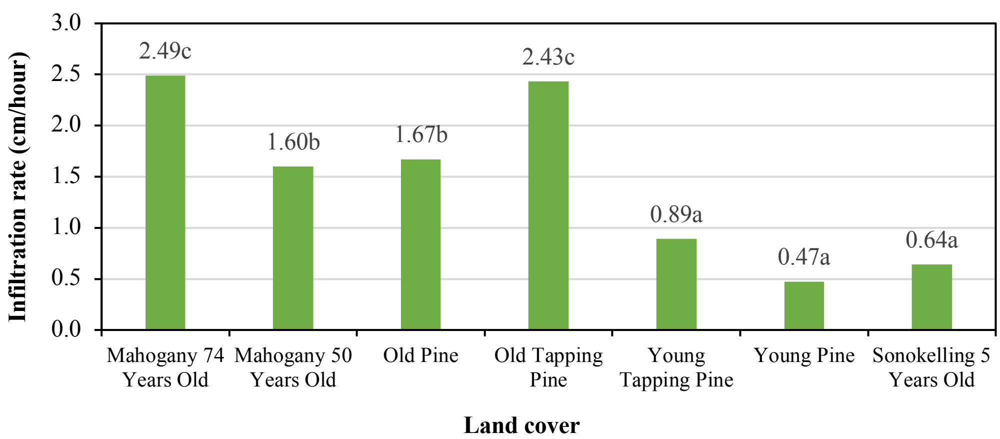

Fig. 4. Results of Duncan's multiple range test of land cover on soil infiltration rate (Numbers followed by different letters are significantly different in the Duncan test at $\alpha = 5\%$).

The ANOVA analysis showed very significant results, and Duncan's multiple range test (DMRT) was carried out to determine the differences in the soil infiltration rates on various land covers in the KHDTK Gunung Bromo. **Fig. 4**, the results of the DMRT show that there is a significant difference in the type of land cover of mahogany 74 years against mahogany 50 years, old pine, young tapped pine, young pine, and sonokelling 5 years, but not significantly different from the land cover of old tapped pine. The highest infiltration rate was found in 74-year-old mahogany land cover at 2.49 cm/hour. According to Alfayed and Riefani (2022), mahogany has a taproot system that facilitates water absorption far from the soil surface. The more plant roots result in increased soil infiltration and groundwater recharge by the roots. The young pine land cover has the lowest infiltration, which is 0.47 cm/hour. According to Méllo et al. (2022), land cover is related to water resource management. The soil, plants, and the atmosphere have a relationship that affects humidity and runoff coefficient.

Based on **Fig. 3**, the results of the infiltration calculation based on Land Map Units show a decrease. Moving towards the right, the land unit is dominated by land cover with younger vegetation. The area has relatively young plants. This results in a root system that is not yet well-developed to help absorb water into the soil and protect the soil from rainwater erosion. The young plants also have not yet contributed much organic matter, so the soil's water absorption capacity is still not very good. This causes a low infiltration rate.

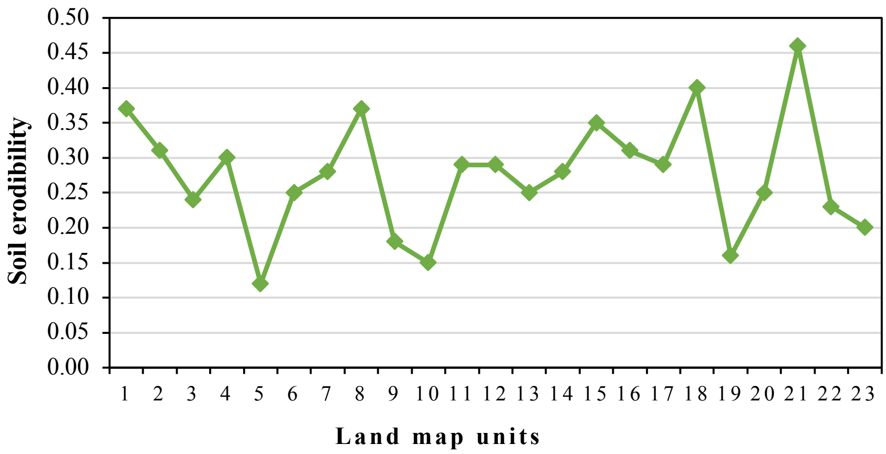

Fig. 5. Soil erodibility on various land cover in KHDTK Gunung Bromo.

Erodibility in **Table 3** shows a significant value (0.019), meaning there is a real influence between land cover and soil erodibility. Soil erodibility in the KHDTK Gunung Bromo is categorized as low to high. **Fig. 5** shows the results of calculating the soil erodibility rate on Land Map Units. The value of soil erodibility in the 74-year-old mahogany land cover ranges from 0.23–0.42, 50-year-old mahogany is 0.12, old pine ranges from 0.25–0.37, old tapped pine ranges from 0.15–0.29, young tapped pine ranges from 0.26–0.43, young pine ranges from 0.16–0.50, and 5-year-old sonokelling ranges from 0.23–0.24. Mamo and Wedajo (2023) stated that changes in land cover have an important effect on soil erosion rates. This is in accordance with Li et al. (2023), stating that the use of land cover can help to decrease soil erosion while increasing woodland area has a significant positive effect on minimizing soil erosion. Jeloudar et al. (2018) stated that vegetation increases aggregate stability caused by organic matter, which can reduce soil erodibility. Due to the varying soil texture classes, soil particle size distribution around vegetation influences soil erodibility. According to Stanchi (2015), soil erodibility is influenced by the condition of the aggregates. Stable soil aggregates will reduce the impact of erosion, and the soil most susceptible to erosion is soil with weak aggregates.

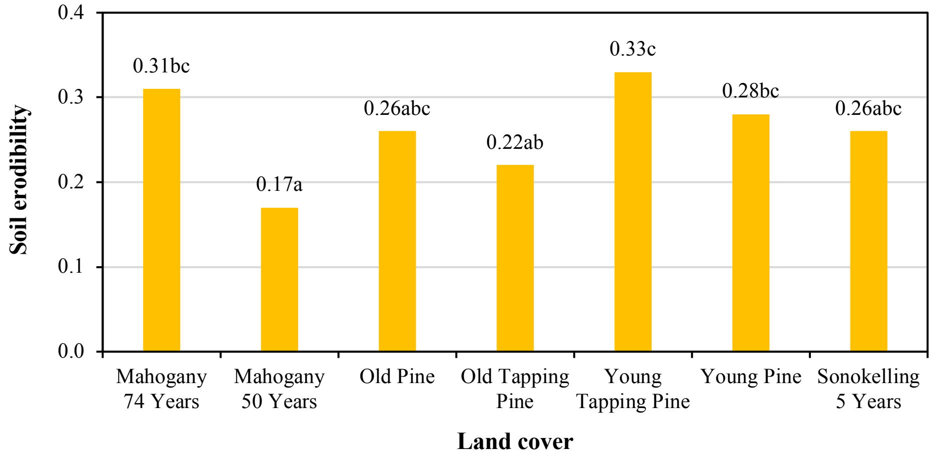

Fig. 6. Results of Duncan's multiple range test of land cover on soil erodibility (Numbers followed by different letters are significantly different in the Duncan test at α = 5%).

Based on **Fig. 6**, the results of the DMRT between each land cover and soil erodibility show that the young tapped pine land cover has the highest average of 0.33 due to the activity of tapping pine sap so that the soil around the young tapped pine land becomes trampled and soil compaction occurs. Wang and Zhang (2021) stated that variations in soil erodibility related to soil bulk density during one season of growth. The 50-year-old mahogany land cover of 0.17 is the lowest average soil erodibility. Chen et al. (2018) stated that vegetation could influence hydrological and associated soil erosion processes by enhancing rainfall reception and evapotranspiration, increasing water infiltration into the soil and recharging the groundwater.

3.3. Correlations of Soil Properties on Infiltration Rate and Soil Erodibility

The correlation analysis shows that soil erodibility is significantly correlated (r = -0.204*) with soil infiltration rate with a negative correlation direction (**Table 4**). Soil infiltration rate is closely related to soil erodibility as it relates to the distribution of soil on the surface. Soil infiltration does not directly affect soil erodibility but through soil physical properties that affect soil erodibility. Soils dominated by fine dust and sand particles have high erosion sensitivity, are easily washed away by water, and have a rapidly decreasing infiltration capacity. This is because dust and fine sand have very weak cohesion between particles.

Table 4. Correlation analysis between infiltration and soil physical properties

Correlation	Sig.	N	Pearson correlation
Infiltration and erodibility	0.049	69	-0.238*
Infiltration and organic matter	0.001	69	0.445**
Infiltration and permeability	0.000	69	0.488**
Infiltration and dust percentage	0.007	69	0.323**
Infiltration and clay percentage	0.238	69	-0.144
Infiltration and fine sand percentage	0.045	69	0.242*

Notes= *: significant ($p < 0.05$), **: highly significant ($p < 0.01$).

Correlation analysis shows that organic matter is highly correlated (r = 0.405**) with soil infiltration rate with a positive correlation direction (**Table 4**). This is in line with the research of Delima et al. (2018), which states that soil organic matter is closely related to vegetation. The thickness of plant litter is related to the content of organic matter, which will trigger the activity of soil microorganisms so that porosity will increase and affect the infiltration rate's magnitude. Zulkarnain et al. (2013) stated that soil organic matter is an adhesive and is porous to improve soil aggregation and soil pore space. Stable soil pore space results in increased soil ability to pass water down and be absorbed by the soil matrix so that the water binding capacity also increases.

Permeability is highly correlated (r = 0.475**) with soil infiltration rate with a positive correlation direction, stating that permeability is an important factor affecting soil infiltration rate (**Table 4**). The relationship between permeability and soil infiltration rate is very close because both parameters are related to water entry into the soil matrix. Margolang and Sembiring (2015) stated that permeability and infiltration are closely related to the total soil pore space. Soil with a high total soil pore space causes the speed of the water rate in the soil pores to be greater, so the permeability and infiltration are greater.

Correlation analysis shows that the percentage of dust is very significantly correlated (r = 0.335**) with soil infiltration rate with positive correlation direction (**Table 4**). Gao et al. (2023) state particle size significantly affects erosion rates. Meli et al. (2018) stated that soil dominated by dust particles will have a lot of meso rather porous pores so that the soil will have enough pore space for water movement so that the soil's ability to pass water is high, but its water binding ability is low. The correlation value in **Table 4**, correlation analysis shows that the percentage of fine sand is significantly correlated (r = 0.243*) with soil infiltration rate with a positive relationship direction. Liu et al. (2020) stated that soils with high fine dust and sand particles will make the soil susceptible to erosion. A high percentage of sand in a soil causes the soil to pass water into the soil easily. The negative effect between the percentage of clay and the infiltration rate indicates that the increase in soil infiltration rate will occur when the soil has a small clay content. Gabor (2023) stated that the content of clay directly affects the soil's ability to retain water because the surface area of clay is larger.

Table 5. The results of ANOVA of infiltration rate effect on soil erodibility

	Sum of squares	df	Mean square	F	Sig.
Between group	0.038	1	0.038	4.013	0.049*

Note: *= significant ($p < 0.05$).

The ANOVA test results show that soil infiltration rate significantly affects soil erodibility (**Table 5**). Factors affecting the value of soil erodibility are soil resistance to external destructive forces and the ability of soil to absorb water. Garg et al. (2022) stated that soils dominated by sand particles cause the soil to be easily destroyed, so water absorption is low and soil erodibility is high. Soil dominated by sand particles indicates low clay content in the soil. Clay can function to bind water and aggregate adhesive material so that the soil is not easily decomposed. Other factors that affect soil erodibility are soil management, chemical and biological properties, and soil profile characteristics.

Soil infiltration does not directly affect soil erodibility but through soil physical properties that affect soil erodibility. Wang et al. (2015) stated that runoff and soil erodibility are high when the soil is in an uncovered state. Soil with appropriate land cover can reduce runoff and soil erodibility. Lin et al. (2019) stated that soil erodibility remains the main factor in estimating soil erosion values. This is still effective and widely used. Yu et al. (2023) indicated that soil erodibility factors are properties, topography, climate, vegetation, and human activities. Huang et al. (2022) noted that soil erodibility is a significant characteristic in evaluating soil erosion vulnerability and must be present in soil erosion prediction models. It is also required for soil and water conservation management. Soil erodibility was negatively correlated with sand content but positively related to clay content. The soils of forests were more resistant to erosion than produced soils.

4. Conclusions

The infiltration rate in the 74-year-old mahogany land cover ranged from 1.94–3.03 cm/hour, 50-year-old mahogany was 1.61 cm/hour, old pine was 1.53–1.89 cm/hour, old tapped pine was 1.54–3.43 cm/hour, young tapped pine was 0.48–1.60 cm/hour, young pine was 0.37–0.61 cm/hour, and 5-year-old sonokelling was 0.56–0.73 cm/hour. Infiltration rates are slow to moderate. Infiltration rates are slow to moderate. Land cover affects infiltration rate and soil erodibility in KHDTK Gunung Bromo. The highest infiltration value is in 74-year-old mahogany and the lowest in young pine. The highest soil erodibility value is in young tapped pine and the lowest in 50-year-old mahogany. Differences in soil infiltration and soil erodibility values are influenced by plant age, plant rooting, plant height, and crown area. Differences in soil infiltration and soil erodibility values are influenced by plant age, plant rooting, plant height, and crown area. An increase in soil infiltration rate can reduce soil erodibility. Erodibility is the sensitivity of soil to erosion. It is easier to erode if its erodibility value is higher; conversely, erosion is less likely to occur if its erodibility value is lower. The hydrology, mineralogy, and soil's physical, chemical, and biological characteristics all affect its erodibility. The erodibility value can be used for decision-making in land management.

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