

ANALYSIS OF INFILTRATION IN VARIOUS LAND USE IN THE ALO RIVER SUB-REGION

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Abstract: In the Alo sub-watershed, the study compares the rates of various types of land use. The Alo sub-watershed is 7,959.98 areas in total. Measurement of infiltration rates for various land uses in the Alo sub-watershed and analysis of differences in infiltration rates for various land uses in the Alo sub-watershed are the problems at hand in this study. The Horton method was used in this study's infiltration measurements. This approach uses a model of time-dependent empirical equations. It is known that multiple infiltration categories exist for plantations, villages, vacant land, bushes, and woods in the infiltration rate class for the kind and usage of dry land used in this study's Alo sub-watershed. It has classes for Fast, Moderate, and Moderate infiltration rates. For the type of land use and paddy field, the infiltration rate falls into the category of being fairly slow. This is due to the high water content of paddy fields, which makes the infiltration process take a while to complete. As a result, the infiltration rate in the Alo sub-watershed, Tibawa District, Gorontalo Regency, and Gorontalo Province reveals that the medium class dominates in the Alo sub-watershed. The cumulative infiltration rate or total amount of infiltrated water is 123,899 mm/hour at point 14 types of vacant land, and 8,476 mm/hour at point 16, which is the smallest cumulative value. The infiltration rate class in the Alo sub-watershed, Tibawa District, Gorontalo Regency, and Gorontalo Province reveals that the Medium Class dominates the sub-watershed.

Keywords: land use, horton method, alo sub-watershed, infiltration, Gorontalo Region

INTRODUCTION

Infiltration is a very important component because basically, soil conservation is setting a relationship between rain intensity and infiltration capacity and surface runoff drainage. According to Setiawan, et al (2022), the infiltration rate can be determined by the size of an infiltration capacity and the rate of water supply (rain intensity) where as long as the rain intensity is less than the

infiltration capacity, the infiltration rate that occurs is the same as the rain intensity.

The Horton method is used to measure the infiltration in this study. This method is a time-dependent empirical equation model. This method has been widely used by previous researchers. Aidatul (2019) mapped the infiltration rate using the Horton method in the Tenggarang Sub-watershed, Bondowoso Regency. Yunagardasari, et al (2017) conducted a similar study, namely the

infiltration model for various land uses in Tulo Village, Dolo District, Sigi Regency.

This study will analyze the differences in the rate of various types of land use in the Alo sub-watershed. The Alo sub-watershed is located in the Tibawa District, Gorontalo Regency, which has an area of 7,959.98 ha. By this research, hopefully it can become a reference and additional knowledge for the community and local government in managing land for various purposes in the agricultural sector. The problems in this research are: (1) How to measure the infiltration rate of various types of land use in the Alo sub-watershed? and (2) How to analyze the difference in infiltration rate on various types of land use in the Alo sub-watershed?

The objectives of the research are as follows: (1) To measure the rate of infiltration on various types of land use in the Alo sub-watershed and (2) To analyze the differences in infiltration rates of various types of land use in the Alo sub-watershed.

LITERATURE REVIEW

1. Infiltration

Infiltration is the process by which water enters the soil, generally through the surface. The infiltration mechanism involves three main processes that do not affect each other, namely the process of entering rainwater through the pores of the soil surface, collecting rainwater in the soil, and the process of flowing water to other places (bottom, side, and top) (Arianto, et al. 2021).

The infiltration process is determined by the amount of water that enters the soil within the required time, which is called the infiltration rate (Badaruddin et al, 2021 in Hafiz, et al. 2023).

The infiltration rate can be measured in the field by measuring rainfall, surface runoff, and predicting other factors of the water cycle, or by calculating the infiltration rate by hydrographic analysis (Yunagardasari, et al. 2017). The infiltration rate will determine how much water will become surface runoff and how much water will enter the ground which will later become underground flow (Dipa, et al. 2021)

2. Determinants of Infiltration

The process of infiltration rate is influenced by several factors such as soil texture and structure, available water, organic matter content, and land cover with vegetation or plant debris (Reswari, et al. 2021).

In addition, there are also determinants of the infiltration rate which depend on the amount of water content in the soil. In the USDA taxonomy (1994), soil is a collection of natural objects found on the earth's surface which includes minerals, organic matter, contains living matter, and is able to provide life for living things on the earth's in general (Jaya, 2017). If the water that falls on the ground is dry, then the upper surface of the soil is wet, but the bottom is dry. At this time, there is a large difference in capillary forces between the surface of the soil and the one below it. Because of these differences, there is a capillary force acting together with gravity, resulting in infiltration (Arsyad, 1989) within (Hadisusanto, 2010).

3. Infiltration Measurement

According to Horton, the infiltration rate decreases with increasing time until it approaches a constant value. He expressed his view that the decrease in infiltration rate

is more controlled by factors operating at the soil surface than by the flow process in the soil. Factors that affect the reducing infiltration rates include land cover, closing of soil cracks, formation of soil crusts, destruction of land surface structures, and transport of fine particles on the soil surface by raindrops (G. Farida, et al. 2023)

Measurement of infiltration rate generally uses the Horton Model. The Horton Model is one of the well-known infiltration models in hydrology compared to other models. Horton recognized that the infiltration capacity decreases with increasing time until it approaches a constant value. He expressed his view that the decrease in infiltration capacity is more controlled by factors operating at the soil surface than by the flow processes in the soil. This model is very simple and more suitable for experimental data. The main weakness of this model lies in determining the parameters f_0 , f_c , and k , which are determined by data fitting. Even so, with the advances in computer systems this process can be done with a simple spreadsheet program (Arfan and Pratama, 2012 in Susanawati, et al. 2019).

4. Land

The land is a development resource that has unique characteristics, namely the area of land that is fixed due to changes in the area caused by natural processes (sedimentation) and reclamation processes (artificial) is very small; and has physical characteristics (rock type, mineral content, topography and so on) with suitability in accommodating activities or society that continues to grow (Dardak, 2008) in (Ake, 2018). Land resources are very important to meet all the necessities of life, so that, their

management and utilization must be carried out carefully and must be following their abilities so as not to reduce the usability and reduce the capability of the land.

5. Land Use

Land use is related to human activities that are directly related to land, land use on existing resources can cause impacts on land (Baja, 2012 in Rahmawati, 2023)

At different land uses, different types of vegetation and levels of land management will be found (Sun et al. 2018) in (Asrul, et al. 2021). According to (Hakim, 1986) in (Asrul, et al. 2021), these two things will also cause different infiltration rates. High infiltration rates not only increase the amount of water stored in the soil for plant growth but also reduce flooding and erosion activated by runoff.

RESEARCH METHODS

1. Research Stages

The initial pre-research stage starts with reviewing various literature such as national journals, textbooks, and research reports which aim to further support the research process related to infiltration analysis of various land uses in the Alo Sub-Das, then carry out an analysis of the study area through an initial survey in the field and conducting a review and determining the location of the research, besides that, this research is also carried out through a field method using a digital ring infiltrometer.

2. Research Implementation

This research was carried out through the following stages: (1) Cleaning the location to be measured; (2) Immerse the digital infiltrometer ring into the ground as deep as ± 3 cm above the ground surface; (3)

Then, the space between the inner ring and the outer ring is filled with water; (4) After that, the space in the outer ring is filled with water first to prevent water seepage into the inner ring and followed by filling the inner ring until it reaches the upper line; (5) Then, measuring and recording the decrease in the water level every 1-minute interval for 5 minutes in units of mm; (6) After that, water is poured back into the ring as soon as possible until the upper limit line if the water in the ring has been completely infiltrated; and (7) This was done three times in repetition to obtain a constant decrease in the water level.

A steady or constant infiltration rate has been achieved. Next, the infiltration model used is the Horton model, with the following equation:

$$f = f_c + (f_0 - f_c) e^{-Kt} \quad (1)$$

Information :

f : infiltration capacity at t

f_c : magnitude of infiltration at constant time

f_0 : amount of infiltration at baseline

k : Constant

e : Logarithmic base $\log (f - f_c)$

$$\log (f_0 - f_c) = e^{-Kt} \quad (2)$$

or

$$\log (f - f_c) - \log (f_0 - f_c) = e^{-Kt} \quad (3)$$

The analysis was carried out based on the results of infiltration measurements on various land uses in the Alo sub-watershed.

In determining the magnitude of the infiltration rate in the field, namely by using a certain classification. To determine the infiltration class, use the classification according to US Soil Conservation as shown in table 1 below.

Table 1. Infiltration Rate Parameters

Class	Classification	Infiltration Rate mm/hour
0	Very slow	<1
1	Slow	1-5
2	Slightly Slow	5-20
3	Moderate	20-63
4	Rather Fast	63-127
5	Fast	127-254

Source: Khonke, (1969)

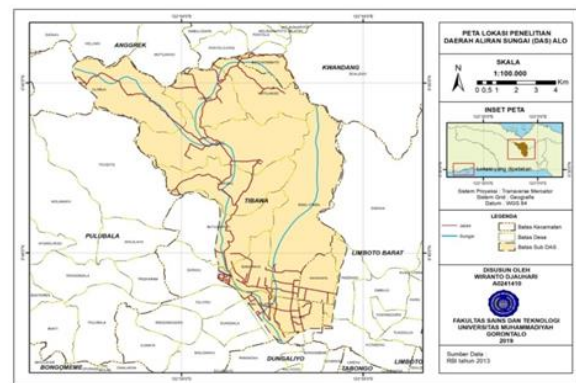


Figure 1. Research sites

RESULTS AND DISCUSSION

1. Measurement of Infiltration Rate in the Field

In this study, to determine the infiltration rate of each land use in the Alo sub-watershed at the research location, an infiltration rate measuring device, namely the Digital Ring Infiltrometer, was measured at each sampling point in the Alo sub-watershed. There are 21 sampling points spread across the Alo sub-watershed. The process of measuring infiltration rates on land in the Alo Sub-watershed initially chose a flat place to represent 1 land.

To start the measurement at the sampling point, start with cleaning the area from plants that can affect the infiltration rate. Then, stick the digital ring infiltrometer tool into the soil as deep as ± 3 cm above the ground surface.

After that, the space between the inner ring and the outer ring is filled with water. This filling begins by filling the outer ring with water to prevent water from seeping from the inner ring and continues by filling the inner ring with water until the upper line, after the inner ring and the outside are filled with water, measurements are taken by recording the decrease in the water level every 1-minute interval for 5 minutes in units (mm), then the water is poured back as soon as possible into the ring if the water has been completely infiltrated. This is repeated three times to obtain a constant decrease in the water level.

2. Calculation of Infiltration Rate Value

In knowing the magnitude of the infiltration rate for each soil in the Alo sub-watershed, Tibawa District, Gorontalo Regency, Gorontalo Province, the Horton method was used to calculate the infiltration rate. The Horton method has a calculation stage, namely knowing the values of t , f_0 , f_c , and k , which are obtained from measurement data that has been carried out in the field on the Alo sub-watershed, Tibawa District, Gorontalo Regency, Gorontalo Province.

3. Horton Method Infiltration

Parameters

The calculation of the infiltration rate is f_0 (initial infiltration rate), f_c (constant infiltration rate), and the determination for soil type (k) uses the Horton method with the initial stage of determining the infiltration capacity value and infiltration capacity graphs. After the infiltration parameter values are known, the Horton method infiltration rate can be calculated. The calculation of the infiltration rate parameter can be seen in the appendix.

4. Infiltration Capacity

The calculation of this infiltration capacity can be denoted as an f value with units of cm/hour or mm/hour. The way to calculate the infiltration capacity value is to divide the decrease in water (cm) by the time (hours). After that, if you already know the infiltration capacity, the next is to calculate the infiltration parameters, namely f_0 and f_c . After calculating the parameter values are presented in the Infiltration Capacity data or initial infiltration rate (cm/hour). The parameter data of infiltration rate at 21 survey location points are presented in table 2.

Table 2. Results of 21-Point Infiltration Rate Capacity Measurements

No	Land Code	f_0	f_c	t constant (hours)	UTM coordinates			
					X	Y	X	Y
1	LHNS	4.20	1.80	0.08	122° 53' 56.052" E	0° 38' 28.136" N	122,899	0.641
2	LHNS	3.60	3.48	0.08	122° 52' 51.760" E	0° 38' 37.380" N	122,881	0.644
3	LHNS	4.80	1.56	0.08	122° 50' 13.362" E	0° 42' 40.116" N	122,837	0.711
4	LHNP	2.40	0.72	0.08	122° 52' 30.036" E	0° 38' 47.604" N	122,875	0.647
5	LHNP	5.40	1.32	0.08	122° 51' 26.245" E	0° 39' 2.566" N	122,857	0.651
6	LHNP	11.40	4.16	0.08	122° 51' 20.881" E	0° 42' 49.895" N	122,856	0.714
7	LHNT	13.98	5.48	0.08	122° 52' 27.410" E	0° 39' 34.990" N	122,874	0.660
8	LHNT	28.98	8.28	0.08	122° 52' 32.476" E	0° 42' 49.653" N	122,876	0.714
9	LHNT	6.00	5.60	0.08	122° 48' 42.782" E	0° 44' 47.011" N	122,812	0.746
10	LHNPR	15.36	5.88	0.08	122° 51' 27.498" E	0° 41' 0.143" N	122,858	0.683
11	LHNPR	8.76	4.04	0.08	122° 50' 34.908" E	0° 42' 18.284" N	122,843	0.705
12	LHNPR	6.78	3.92	0.08	122° 49' 34.151" E	0° 43' 56.626" N	122,826	0.7324
13	LHNT	10.38	19.20	0.08	122° 51' 34.003" E	0° 41' 29.814" N	122,859	0.692

No	Land Code	fo	fc	t constant (hours)	UTM coordinates			
					X	Y	X	Y
14	LHNK	13.38	11.76	0.08	122° 51' 55,182" E	0° 42'5,318" N	122,865	0.701
15	LHNK	7.98	3.40	0.08	122° 52' 12.997" E	0° 42' 9.968" N	122,870	0.703
16	LHNSK	0.24	0.92	0.08	122° 51' 33.602" E	0° 41'38.037" N	122,859	0.694
17	LHNSK	10.98	2.64	0.08	122° 51' 10.793" E	0° 42'10.376" N	122,853	0.703
18	LHNSK	2.10	1.18	0.08	122° 49' 57.683" E	0° 43'50.098" N	122,833	0.731
19	LHNH	2.22	1.79	0.08	122° 51' 21.205" E	0° 43'12.304" N	122,856	0.720
20	LHNH	2.16	1.56	0.08	122° 50' 52.591" E	0° 43'22,293" N	122,848	0.723
21	LHNH	2.22	1.72	0.08	122° 52' 56.332" E	0° 44'58,160" N	122,882	0.749

Source: Results of Infiltration-Rate Measurements in the Field, 2019

Information :

LHNS = Paddy Field

LHNP = Residential Land

LHNT = Dry/Moorland

LHNPR = Plantation Land

LHNK = Empty Land

LHNSK = Shrubs

LHNT = Forest Land

From the table, it can be seen that the highest initial infiltration rate value was found at survey location point number 8 for the Moorland type, which was 28.98 mm/hour with a time constant of 0.08 hours. Meanwhile, the lowest initial infiltration rate was found at the survey location point number 16 for the Shrubland land type, which was 0.24 mm/hour with a time constant of 0.08 hours. From the infiltration capacity table above, it can be determined the initial infiltration rate (fo), final infiltration rate (fc), and constant t (hours).

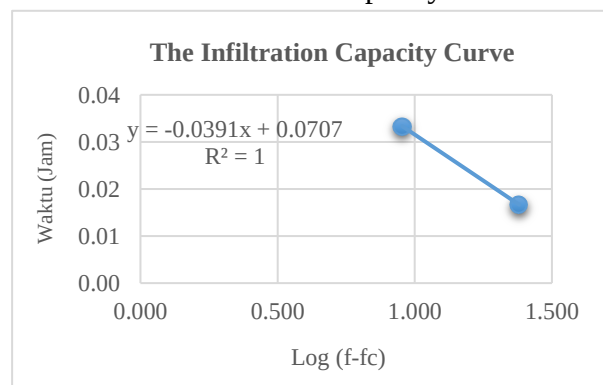
After knowing the value of the infiltration rate, a graph of the capacity of the infiltration rate is made to determine the relationship between the infiltration rate and time, where the longer the time used for research, the smaller the decrease in the infiltration rate that occurs. The relationship between time and infiltration rate is influenced by the water contained in the soil. The longer the time used in the research, the

greater the water contained in the soil. This causes the infiltration rate which was initially fast to slow even in saturated soil, the infiltration rate does not decrease.

5. Constants for Soil Type K

After knowing the capacity of the infiltration rate, then calculate the K value. The calculation is done by calculating the log value of the infiltration rate capacity that already exists at each observation station point on the Alo sub-watershed which is in the Alo sub-watershed, Tibawa District, Kabupaten Gorontalo, Gorontalo Province, to get the value of K, namely by making a linear regression equation curve $y = mX + c$ or $y = t$ and $X = \log(f - fc)$ from the graph, the value of K can be calculated. The following is a model of the infiltration capacity curve to determine the value of K. It can be seen in Table 3.

Table 3. Infiltration Capacity Curve



From this curve, we know the value of m (gradient) which will be included in the equation $K = -1/(m \log e)$ or $K = -1/(m \log 2.718)$ or $K = -1/0.434 m$.

The m gradient data is used to calculate the value of K . The data from the calculation of the value of K at the 21 survey location points is shown in table 4 below.

Table 4. K Value Calculation Result Data

Sample	Land Type	Equality	R2	K value
Land 1	Paddy Field	$y = -0.039x + 0.031$	1	58.9296
Land 2	Paddy Field	$y = -0.084x + 0.147$	1	127,301
Land 3	Paddy Field	$y = -0.029x + 0.031$	0.999	78.10669
Land 4	Settlement	$y = -0.019x + 0.028$	0.313	120.0077
Land 5	Settlement	$y = -0.018x + 0.034$	0.524	125.2254
Land 6	Settlement	$y = -0.036x + 0.046$	0.935	63.47514
Land 7	Moor	$y = -0.013x + 0.029$	1	168.1859
Land 8	Moor	$y = -0.0297x + 0.0755$	0.126	77.5807
Land 9	Moor	$y = 2.485x + 2$	1	-0.92696
Land 10	Plantation	$y = -0.1345x + 0.1558$	0.514	17.1312
Land 11	Plantation	$y = -0.024x + 0.033$	1	93.28532
Land 12	Plantation	$y = -0.036x + 0.033$	1	62.95485
Land 13	Vacant land	$y = -1.081 + 4$	1	2.129723
Land 14	Vacant land	$y = -0.079x + 0.033$	1	28.98299
Land 15	Vacant land	$y = -0.017x + 0.026$	1	132.4223
Land 16	Shrubs	$y = -0.020x + 0.041$	0.248	111.8518
Land 17	Shrubs	$y = -0.036x + 0.052$	0.543	62.95485
Land 18	Shrubs	$y = -0.033x + 0.024$	0.713	67.96895
Land 19	Jungle	$y = 0.045x + 0.033$	1	-50,419
Land 20	Jungle	$y = 0.075x + 0.033$	1	-30,722
Land 21	Jungle	$y = 0.056x + 0.033$	1	-41.1455

Source: Infiltration Rate Calculation Results, 2019

From the table, it can be seen that the highest K value is found at point number 7 of the Moorland type with a K value of 168.1859. While the smallest a K value is found at point number 9 of the Moor land type with K value of -0.92696. The R -value shows the number 1 at 12 land points. While 9 other land points show a number <1 . On the calculation of the equation based on the y value, then, most of it shows numbers with a total of 19 land points. While 4 other land points show positive numbers.

For graphs or diagrams during constant infiltration, see Appendix 4.

6. Calculation of the Infiltration Rate Value With the Horton Method

After knowing the value of K through the linear regression equation curve, the next thing to do is to calculate the value of the infiltration rate when it has reached a constant, and to calculate the cumulative infiltration rate or the total amount of water infiltrated at each point of the observation

station in the Alo sub-watershed located in Alo sub-watershed, Tibawa District, Gorontalo Regency, Gorontalo Province. The initial calculation of the infiltration rate uses the Horton method, namely calculating the value of the infiltration rate at constant times with the formula $f=fc + (fo-fc) e^{-kt}$. After the constant infiltration value is known, then calculate the Fc value, namely cumulative infiltration or the amount of water infiltrated with the formula $F(t)=fc \cdot t + \frac{1}{k}(fo-fc) (1-e^{-kt})$.

The following are the values at 21 points in the Alo sub-watershed, Tibawa District, Gorontalo Regency, Gorontalo Province. Can be seen in table 4 and table 5.

Table 5. Calculation of Infiltration Rate at Constant Time on Land in the Alo Sub-watershed

No	Land Code	Infiltration Rate (cm/hour)	Infiltration Rate (mm/h)
1	LHNS	1822	18,215
2	LHNS	3,480	34,800
3	LHNS	1,566	15,663
4	LHNP	0.720	7,201
5	LHNP	1,320	13,202
6	LHNP	4,209	42,091
7	LHNT	5,484	54,840
8	LHNT	8,322	83,218
9	LHNT	6030	60,305
10	LHNPR	8,288	82,881
11	LHNPR	4,047	40,467
12	LHNPR	3,942	39,42
13	LHNK	11,762	117,616
14	LHNK	11,919	119,195
15	LHNK	3,396	33,961
16	LHNSK	0.924	9,239
17	LHNSK	2,694	26,942
18	LHNSK	1,180	11,800
19	LHNH	26,168	261,682
20	LHNH	8,565	85,654
21	LHNH	15,262	152,624

Source: Infiltration Rate Calculation Results, 2019

From the table, it can be seen the highest infiltration rate value (mm/h) is at point number 19 Forest land types with a value of 261,682. While the smallest infiltration rate value (mm/h) is at point 4 types of residential land with a value of 7,201 presented in Appendix 7.

Table 6. The cumulative rate of land in the Alo sub-watershed

No	Land Code	Cumulative Rate (cm/hour)	Cumulative Rate (mm/h)
1	LHNS	2,305	23,045
2	LHNS	3,492	34,918
3	LHNS	2078	20,775
4	LHNP	0.895	8,950
5	LHNP	1,727	17,272
6	LHNP	5,580	55,801
7	LHNT	6.115	61,154
8	LHNT	11,609	116,085
9	LHNT	6015	60,150
10	LHNPR	11040	110,401
11	LHNPR	4,676	46,756
12	LHNPR	4,487	44,874
13	LHNK	11,091	110,912
14	LHNK	12,390	123,899
15	LHNK	3,829	38,287
16	LHNSK	0.848	8,476
17	LHNSK	4,285	42,852
19	LHNH	7,725	77,253
20	LHNH	4.166	41,662
21	LHNH	5,678	56,783

Source: Cumulative Rate Calculation Results, 2019

From calculating the infiltration rate at constant and cumulative times at all observation station points, also used the same method to obtain cumulative infiltration rate values at each observation station in the field. From the cumulative infiltration value at each observation station, it can be seen that the highest cumulative infiltration rate or amount of water infiltrated is at point 14, namely the type of

vacant land of 123,899 mm/hour, and the smallest cumulative value is found at point 16 of the Shrubland land type, namely of 8.476 mm/hour is presented in attachment 8.

7. Distribution of Calculation Sample Points Based on Land Use

From the calculation of the constant and cumulative infiltration rate at all observation station points in the Alo sub-watershed located in the Alo sub-watershed, Tibawa District, Gorontalo Regency, Gorontalo Province.

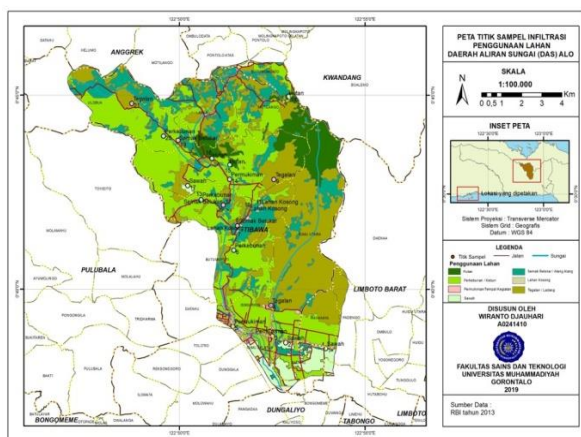


Figure 2. Infiltration sample point map

Then, a map of land use sample points is made to find out the location of the land use points where infiltration measurements will be carried out. This sample point map was created to simplify the measurement process in the field, which can be seen in figure 2. From the map of determining sample points for measuring infiltration rates in the Alo Sub-watershed, Tibawa District, Gorontalo Regency, Gorontalo Province made by the Geographic Information System above, we can see that for each land use, there are three points that have been spread across the Alo Sub-watershed area, then at that point it has been saved and will be used when heading to the field to carry out infiltration measurements, storing these coordinates using the Global Positioning System (GPS) tool. After everything has been prepared, then carry out the direct measurement method in the field and collect all the data needed for research purposes. The final results of this infiltration rate can be seen in table 7 below.

Table 7. Infiltration Rate Category

No	Land Code	Infiltration Rate (mm/h)	Land Use	Infiltration Rate (mm/h)	Information
1	LHNS	18,215	Paddy Field	18,215	A bit slow
2	LHNS	34,800	Paddy Field	34,800	Currently
3	LHNS	15,663	Paddy Field	15,663	A bit slow
4	LHNP	7,201	Settlement	7,201	A bit slow
5	LHNP	13,202	Settlement	13,202	A bit slow
6	LHNP	42,091	Settlement	42,091	Currently
7	LHNT	54,840	Moor	54,840	Currently
8	LHNT	83,217	Moor	83,217	Rather fast
9	LHNT	60,305	Moor	60,305	Currently
10	LHNPR	82,880	Plantation	82,880	Rather Fast
11	LHNPR	40,467	Plantation	40,467	Currently
12	LHNPR	39,426	Plantation	39,426	Currently
13	LHNK	117,616	Empty land	117,616	Rather fast
14	LHNK	119,195	Empty land	119,195	Rather fast
15	LHNK	33,961	Empty land	33,961	Currently

No	Land Code	Infiltration Rate (mm/h)	Land Use	Infiltration Rate (mm/h)	Information
16	LHNSK	9,239	Shrubs	9,239	A bit slow
17	LHNSK	26,942	Shrubs	26,942	Currently
18	LHNSK	11,800	Shrubs	11,800	A bit slow
19	LHNH	261,682	Forest	261,682	Fast
20	LHNH	85,654	Forest	85,654	Rather fast
21	LHNH	152,624	Forest	152,624	Fast

Source: results of analysis and calculations, 2019

From table 7, it can be seen that the rather slow category of infiltration rate class is found at six land points with land 1, 3, 4, 5, 16, and 18 respectively. Meanwhile, the infiltration rate class in the Moderate category was found at seven points of land with 2, 6, 7, 9, 11, 15, and 17 lands respectively. Infiltration rate class in the rather fast category is found in five (5) land points with land 8, 10, 13, 14 and land 20 respectively. Infiltration rate class the fast category is found in two points of land with land 19 and land 21 respectively. The map of the distribution of infiltration rates in the Alo Sub-watershed, Tibawa District, Gorontalo Regency, Gorontalo Province shows that the infiltration rate in the Alo sub-watershed which is in the Alo Sub-watershed, Tibawa District, Gorontalo Regency, Gorontalo Province, is dominated by the Medium class.

DISCUSSION

Research on the infiltration rate in the Alo sub-watershed using an information system application (GIS) in the Alo Sub-watershed, Tibawa District, Gorontalo Regency, Gorontalo Province was conducted from May to August 2019. After researching on the infiltration rate in the Alo sub-watershed, then, obtained 21 location points for the distribution of infiltration rates on the Alo sub-watershed which is in the Alo

Sub-watershed, Tibawa District, Gorontalo Regency, Gorontalo Province.

The highest K value was found at point 7 of the Moorland type with a K value of 168.1859. While the smallest K value is found at point 9 of the Moorland type also with a K value of -0.92696. Calculation of the infiltration rate at constant and cumulative times as at all observation station points, also uses the same method, to obtain cumulative infiltration rate values at each observation station in the field. From the cumulative infiltration value at each observation station, it can be seen that the highest cumulative infiltration rate or the amount of water infiltrated is highest at point 14 types of vacant land, which is 123,899 mm/hour and the smallest cumulative value is at point 16 types of shrubland, namely of 8.476 mm/hour.

Factors that influence the infiltration process are soil texture, soil structure, initial water supply, biological activity and organic elements, type and depth of litter, and other underground vegetation. Clay soils have a greater infiltration capacity than other similar soils. Water-saturated porous soils have a smaller capacity than dry soils. The rather slow category of infiltration rate was found at six points of land with land 1, 3, 4, 5, 16, and 18 respectively. Meanwhile, the medium category infiltration rate class was

found at seven points of land with each land 2, 6, 7, 9, 11, 15, and land 17. Infiltration rate classes are rather fast category found at five points of land with land 8, 10, 13, 14, and land 20 respectively. The fast categories infiltration rate class is found at two points of land with land 19 and land 21 respectively. The results of calculating the infiltration rate for all land uses show that the infiltration rate in the Alo sub-watershed which is in the Alo sub-watershed, Tibawa District, Kabupaten Gorontalo, Gorontalo Province, is dominated by the medium class.

In the infiltration process, the soil pores have a big influence, especially in the process of water absorption towards a constant. The pores are useful in determining the level of water infiltration into the soil are large pores. If all the pore space is filled with water, then, the soil mass is in a saturated condition. Meanwhile, if some of the pore space is occupied by water and the rest is filled with air, it can be said that the soil is in an unsaturated condition (Maro'ah, 2011).

In measuring the infiltration rate, it is also known that paddy fields have a higher water content than other fields because high water content will make the soil quickly saturated, thereby reducing the infiltration capacity of the soil. In addition, the organic matter found in paddy fields, dry fields, and plantations was also higher than the organic matter found in shrubs, vacant land, and forests. High soil organic matter can maintain the quality of the physical properties of the soil, so, it can help the development of roots in plants and the rate of the soil water cycle, namely through soil pores and soil aggregate stability (Wirosoedarmo, et al. 2009). Differences in land use can result in soil infiltration rates, thereby affecting the amount of infiltrated

water. This is related to land cover, soil moisture, and tillage. The high density of vegetation and the presence of groundcover plants can also increase the ability to store water thereby increasing the rate of soil infiltration. However, high ground cover can also cause the soil to become damp, so, the amount of water that enters the soil decreases.

The infiltration process generally occurs quickly at the beginning, which then slows down and is followed by constant conditions. Thus, it can be estimated how much water is needed by a type of soil in a certain area to wet it from dry conditions to a constant state of water humidity. The infiltration rate is tested to determine the speed and amount that enters or absorbs water vertically into the soil body. By observing or testing this characteristic, it is hoped that it will be able to provide an overview of the water requirements needed for a certain type of soil for certain types of plants at one time (Hadisusanto, 2010). Infiltration rate data can also be used to predict when runoff will occur if the soil type has received a certain amount of water either through rainfall or irrigation from a water reservoir on the soil surface.

Infiltration is also one of the phases of the hydrological cycle, therefore, it is important to know because it will affect surface runoff, flooding, erosion, availability of water for plants, groundwater, and availability of streams in the dry season. In concept, surface runoff is the flow of water that occurs after rain falls on the ground surface. In this regard, the infiltration capacity needs to be measured because the value of soil infiltration capacity is valuable information in one example, namely for the design and determination of irrigation

activities and the selection of various types of commodities to be planted in a field.

According to the research of Aidatul NF (2015), infiltration rates that tend to be moderate, fast, and rather fast can be categorized as optimal. With infiltration that occurs optimally, surface runoff will be controlled, so as to reduce flooding and erosion, besides that plants will also obtain water reserves bound by their roots and supply evapotranspiration needs. Therefore, in the process of measuring the infiltration rate in the Alo sub-watershed in this study, it is known that the infiltration rate class for the type and use of moorland, plantations, settlements, vacant land, shrubs, and forests have different categories of infiltration, each of which contains there is an infiltration rate class category Moderate, Fast, and Fairly Fast while the infiltration rate is in the rather slow category for land use and paddy field types. This is because paddy fields have a high water content, so, the infiltration process runs rather slowly, and the infiltration rate in the Alo sub-watershed, Tibawa District, Gorontalo Regency, Gorontalo Province is dominated by the middle class.

CONCLUSION

After conducting this research, it can be concluded that the highest K value is found at point 7 of the Moorland type with a K value of 168.1859, while, the lowest K value is found at point 9 of the Moorland type also with a K value of -0.92696. The R-value shows the number 1 at 12 land points. While 9 other land points show a number <1. On the calculation of the equation based on value then most of it shows numbers with a total of 16 while the other 5 land points show a positive number.

The highest infiltration rate (mm/hour) is found at point 19 of Forest land types with a value of 261,682. Meanwhile, the smallest infiltration rate (mm/hour) is found at point 4 of residential land types with a value of 7,201.

The highest cumulative infiltration rate or amount of water infiltrated was at point 14 types of vacant land, namely 123,899 mm/hour and the smallest cumulative value was at point 16, which was 8,476 mm/hour. So, it can be concluded that the infiltration rate class in Alo sub-watershed, Tibawa District, Gorontalo Regency, Gorontalo Province is dominated by the Medium Class.

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