Determining Infiltration Rate from Infiltration Measurement with Flooding Method by Turftech Infiltrometer

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Civil and Environmental Science Journal
Vol. 02, No. 01, pp. 035-043, 2019

Determining Infiltration Rate from Infiltration Measurement with Flooding Method by Turftech Infiltrometer

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Received 15-12-2018; revised 21-01-2019; accepted 10-03-2019

Abstract. The density of the soil in this study estimate parameters with a dry bulk density. variation of soil density based on urban land us and then grouped into heavy, medium, and high-density soil. the rate of infiltration testing is performed by using turftech infiltrometer. and then analyzed with an infiltration horton modification models. the specification of turftech double ring infiltrometer are 6.03 cm for inner ring diameter and 10.79 cm for outer ring diameter. the result of infiltration rate observations is infiltration rate for higher density soil and land slope had low influences. the results showed that the turftech ifiltrometer that is used produced well results with 87% accuracy compared with the horton equation infiltration rate model. for the measurement results feasibility, then the turftech infiltrometer unable to represent for the land slope and density, because from the regression test the relationship between land slope and density toward infiltration rate was not significant and obtained average of 38% from the obtained r^2.

Keywords: density soil, land slope, landuse, turftec infiltromete, urban landflow

1. Introduction

The water that falls on the soil surface will flow as the flow of runoff and some will go into the ground. This condition is strongly influenced by various things, including the following the intensity of rainfall, the porosity of the soil, the soil mass density, soil water content, soil texture, soil structure, density soil, the slope of the land, the content of soil organic matter and the vegetation surface [5].

Hydrological cycle is the movement of water into the air, then falls to the earth's surface again as rain. The rain that falls to the ground most any are directly flows to the sea and some seeped into the ground. The water that seeped into the ground is called infiltration. Infiltration is the part that is missing on the flow of runoff that occurs [2]. The concept of urban drainage especially at surface runoff, in water balance concept, tell that infiltration is a factor of rainwater loss in the urban drainage process [1], so the need for the study of the consequences of losing because the process of infiltration.

This assessment can be done in various ways. How the measurement that is include with flooding and sprinkling [4]. The flooding methode is to inundate the lands in a tube to get high water is constant. While sprinkling ways is to use a piece of land which is conditioned [10], then artificial rain was made to consider the value of the magnitude of the loss and runoff infiltration happens.

2. Material and Methods

2.1 Material

The method of detension is used more to know the rate of infiltration directly in the field [12]. Weakness in these tools is the depth of observation is limited to 20 centimeters in size, so the water detention on operational measurement is limited. Yet with limitations and weaknesses that this research was conducted to find out how the accuracy in terms of size and the diameter and depth of the tool in the measurement of the rate of infiltration is produced. Infiltration rate observations in the field will be calibrated with the model equations of Horton with the equation as follows:

$$f = fc + (fo - fc)\, e^{-kt};$$

$i \geq fc$ dan k = constan

Description:

f = rate of infiltration at time t (mm/min)

fc = the rate of infiltration when constant (mm/min)

fo = the rate of infiltration of the beginning (mm/min)

k = constant geophysical

t = time

e = 2.718

The equation is used because of Horton's equation in General can illustrate the process of infiltration rate that occurs mainly in the field of masculinity [6]. Infiltration capacity is the ability of soil to absorb water in the surface or surface water flow in the inner corner, which by itself with a permeation surface water flow that would be very influential. Obviously the larger the infiltration capacity then the flow of water at ground level was further reduced. In contrast, the small capacity of infiltration caused the abundance of soil pores are clogged, then the flow of surface water increases or increases [3].

Sarief [11] suggests that the higher the density of the soil, then the infiltration will be getting smaller. The density of this land can be caused by the influence of rainfall pressure on the soil surface. The ground is covered by plants usually have a greater rate of infiltration than land surface that is open [8]. This is caused by rooting plants that cause higher soil porosity, so more water and increase on a surface covered by vegetation, it can absorb the energy of the rain and mashed so it was able to maintain a high infiltration rate [9].

2.2 Methods

This research was carried out at 4 locations that have the texture of silt loam soil. The data retrieved is the primary data that are the direct observation in the field. The analysis is done with statistics linking the analysis of influence of soil density against the infiltration rate of the measurement results, the slope of the land against the infiltration rate and the rate of infiltration between measurements in the field with the measurement results with the Horton equation Turftech Infiltrometer [7,13]. Measurement by using the tool turftec infiltrometer is easy to do, because the tool easy to carry everywhere and strongly support in determining the rate of infiltration in the field. This tool uses the concept of a double ring (double ring infiltrometer). Its size varies. For this research tool used has an inside diameter 6.03 cm and 10.79 cm to outer diameter. The tools used can be seen more clearly in Figure 1.

The use of this tool helps planners determine the mobilization of design of urban drainage. At issue is whether the size of the tool, using the concept of the double ring affects the results of the measurement of the rate of infiltration. Therefore, in this research aims to know the accuracy of the tool Turftec Infiltrometer with 3 parameters are taken, i.e. density, slope, and her grain size.

External condition that occurs will be found in research done in the field. Observations of other parameters is done, namely by taking soil samples and tested for numbers pore, moisture content of the start and end, the weight of soil type, soil grain composition between the sand, mud and dust. This is intended so that the analysis can reach its limitations.

The influential parameters required are used to find out the rate of infiltration is the density of soils, land slope, soil grain size composition. The density of the ground known by measuring the weight of the contents is soil dry soil at the site of research using the tool Sandcone, Figure 2. The slope of the land is known beda by measuring the height between the point location measurements at a distance of 100 meters using a Theodolite, whereas soil grain size composition known by testing in soil science laboratories.

Figure 1. Turftec Infiltrometer

Figure 2. Sand Cone

Execution of measurements was done at 5 locations in Malang research randomly. Each location research repeated with three observation points in the same location. The purpose of this study is to know how the rate of infiltration of the variation of density, grain size and slope the ground (sand, silt, and clay).

3. Results and Discussion

The results of soil testing at the laboratory obtained a variety of constituent composition of soil grains. The large number of granular composition test results obtained from the hydrometer in the laboratory. For details on the calculation of the hydrometer all locations can be seen in attachment. Each location has a composition research of soil granules of different compilers. Grain size composition of soil can be classified according to the USDA (United States Department of Agriculture) obtained the following results.

Table 1. Composition and soil texture

Location Research	Soil grain size (φ)			Soil Texture
	Sand (%)	*Silt* (%)	*Clay* (%)	
Madyopuro	32.4	50.7	16.9	*silt loam*
Tlogomas	25.6	52.2	22.2	*silt loam*
Sukun	22.8	57.6	19.6	*silt loam*
Bunulrejo	37.8	47.6	18.6	*silt loam*
GOR Ken Arok Buring	6.0	68.1	25.9	*silt loam*

The results of the laboratory tests at the ground, land size composition of the research for the largest silt was 68.1% and a low of 47.6%, while for the highest level of clay was 25.9%, lowest 16.9%, so that the average for the level of composition for the sand is 24.92%, silt was 55.24%, and clay was 20.64%. But the location of the samples taken all belongs on the silt loam soil texture.

Table 2. The Results of the Analysis of Parameters Influencing Infiltration Rate

Location Reasearch	Water Content(w) (%)	Bulk Density (γ_d) (gr/cm^3)	Porosity (n) (%)	Degree of Saturation (Sr)	Slope (s)
Madyopuro	16.39	1.64	33.9	0.795	0.0063
Tlogomas	21.68	1.62	35.2	0.997	0.0020
Sukun	33.25	1.13	51.3	0.731	0.0018
Bunulrejo	23.30	1.36	45.2	0.701	0.0007
GOR Ken Arok Buring	17.70	1.60	38.5	0.734	0.0002

The use of Turfthec Infiltrometer to measure the rate of infiltration and infiltration capacity is known to its accuracy by doing research through the application of variables that affect the process of infiltration in the soil. Land that has the capability of holding water is the fraction of clay. Whereas the lands are containing high dust that can hold water available for plants [11]. Coarse-textured soils have a high infiltration capacity, while the textured soil soil infiltration capacity have small delicate, so with a fairly low rainfall will cause surface runoff [8].

3.1 The results of measurement and calculation of Infiltration Rate

The measurement in field retrievied the alue of the rate of infiltration (*f*), the value of the initial infiltration rate (*fo*), and the value of constanly infiltration rate (*fc*). The data will be analyzed using the method of Horton.

Table 3. Data Measurment and calculation result

No	t test (minute)	High water level (cm)	Increments t (minute)	Difference in the down (cm)	Difference in dow (mm)	f guest (mm/minute)
Start	0	13.5				
1	3	12.7	3	0.80	8.00	2.6667
2	6	12.3	3	0.40	4.00	1.3333
3	9	12	3	0.30	3.00	1.0000
4	12	11.7	3	0.30	3.00	1.0000
5	15	11.4	3	0.30	3.00	1.0000
6	18	11.2	3	0.20	2.00	0.6667
7	21	11	3	0.20	2.00	0.6667
8	24	10.8	3	0.20	2.00	0.6667
9	27	10.6	3	0.20	2.00	0.6667
10	30	10.4	3	0.20	2.00	0.6667
11	33	10.2	3	0.20	2.00	0.6667
12	36	10	3	0.20	2.00	0.6667
13	39	9.8	3	0.20	2.00	0.6667
14	42	9.6	3	0.20	2.00	0.6667
15	45	9.4	3	0.20	2.00	0.6667

According to Table 3, depicts the results of measurement on site Bunulrejo. Infiltration rate constant (fc) is 0667 mm/minute. As for fo (the initial infiltration rate) is 2,667 mm/minute. The process of infiltration from rate start fo up to start constant is in 18 minutes. The calculation to get the equation of Horton can be seen in table 4 below.

Table 4. Infiltration Rate Equation calculations with Formulas Horton

Time (minute)	f (mm/minute)	fc	f-fc	log (f-fc)
0				
3	2.6667	0.6667	2.0000	0.3010
6	1.3333	0.6667	0.6667	-0.1761
9	1.0000	0.6667	0.3333	-0.4771
12	1.0000	0.6667	0.3333	-0.4771
15	1.0000	0.6667	0.3333	-0.4771
18	0.6667	0.6667	0.0000	
21	0.6667	0.6667	0.0000	
24	0.6667	0.6667	0.0000	
27	0.6667	0.6667	0.0000	
30	0.6667	0.6667	0.0000	
33	0.6667	0.6667	0.0000	
36	0.6667	0.6667	0.0000	
39	0.6667	0.6667	0.0000	
42	0.6667	0.6667	0.0000	
45	0.6667	0.6667	0.0000	

fc = 0.6667
fo = 2.6667
k = 0.1917 (k = -1/0.434*m) (K = -1/(0.434*-12.09)
e = 2.718
f = $fc+(fo-fc)e^{-Kt}$

Based on the above calculations, so then produced a curve in Figure 4, i.e. the rate of Infiltration equation curves with the formula Horton. The formula for the area of Bunulrejo is Horton

$f = 0.67 + (2.667\text{-}0.667)e^{-0.1917t}$ or

$f = 0.67 + 2\ e^{-0.1917t}$

and then created a table of the results of analysis, calculation of f measurements, f observations, and f Horton formula, it could see at Table 5.

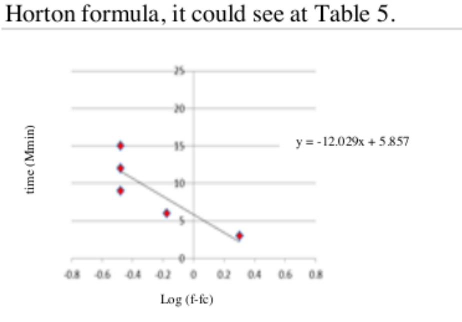

Figure 3. Parameter k for Horton's Formula

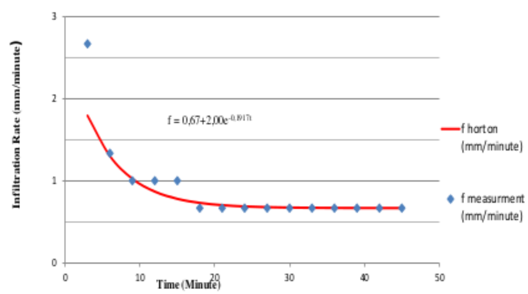

Figure 4. Infiltration rate of Measurement and Calculation of Horton formula

Table 5. The value of the rate of Infiltration of f calculation, f measurement, and f the f Horton

No	t test (minute)	f Measurment (mm/minute)	f calculation (mm/minute)	f horton (mm/minute)
Start	0			
1	3	2.6667	1.9890	1.7921
2	6	1.3333	1.4460	1.2999
3	9	1.0000	1.2000	1.0230
4	12	1.0000	1.0512	0.8672
5	15	1.0000	0.9487	0.7795
6	18	0.6667	0.8724	0.7302
7	21	0.6667	0.8126	0.7024
8	24	0.6667	0.7642	0.6868
9	27	0.6667	0.7239	0.6780
10	30	0.6667	0.6897	0.6730
11	33	0.6667	0.6601	0.6702
12	36	0.6667	0.6342	0.6687
13	39	0.6667	0.6113	0.6678
14	42	0.6667	0.5908	0.6673
15	45	0.6667	0.5723	0.6670

Based on a comparison of the rate of infiltration measurements with models Horton (Figure 5) can note that the model could be used in Horton prediction value of the rate of infiltration in the field because of the difference in value is not so much with the measurements in the field, i.e. have a swift determination of 87.2%. The mean value of that formula can be used to calculate the Horton the rate of infiltration parameters with soil texture. But for the other parameters, such as slope needs to be tested again. Analysis to observe infiltration capacity is using several parameters. The parameters are the soil texture, soil treatment, and slope.

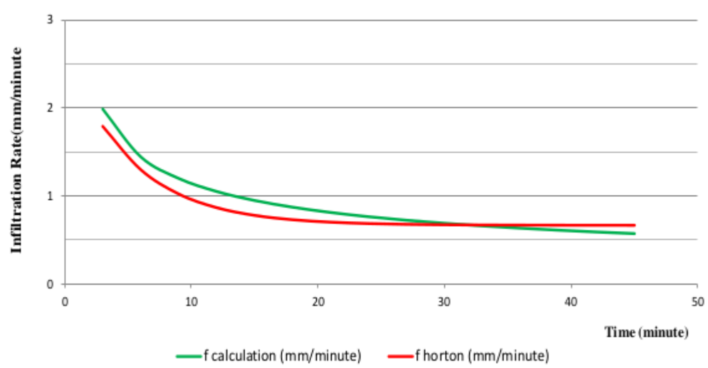

Figure 5. Infiltration Rate in Measurment, Calculation, and Horton Formula

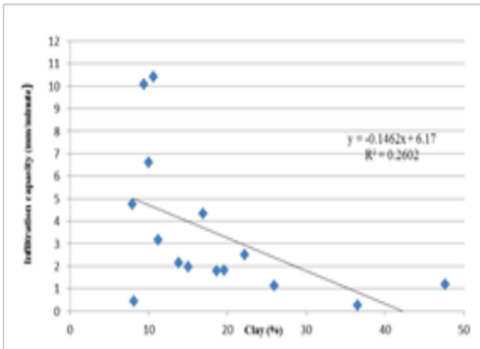

Figure 6. Influence of clay against the result f (mm/min)

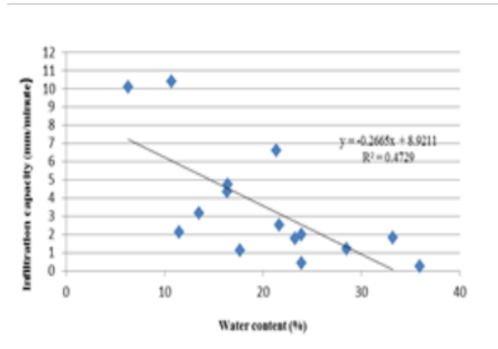

Figure 7. The influence of water content against the result f (mm/min)

From Figure 6 above obtained value R^2 = 0.260 means that 26% of the capacity of infiltration is affected by the composition of clay. This shows the curve of the relation between the percentage of clay and infiltration capacity above likely deserves to be used with a value of R^2 is significant. It can be seen from the distribution of the data shows that the larger the value of infiltration capacity then the smaller content of clay in the soil. In fact many of the supposed lack of composition in soil clays then will also affect the magnitude of the rate of infiltration. But this is because the land is not necessarily clay composition, but there are still other soil constituents such as sand and silt. With a very small grain size then it will have a very pore space meetings and causing the clays are if exposed to water will easily in saturated conditions, so that at least the content of clay in the soil will not effect much against the magnitude of the rate of infiltration.

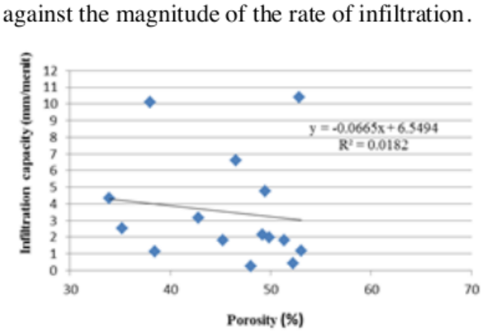

Figure 8. The Influence of soil Porosity against to infiltration rate (mm/min)

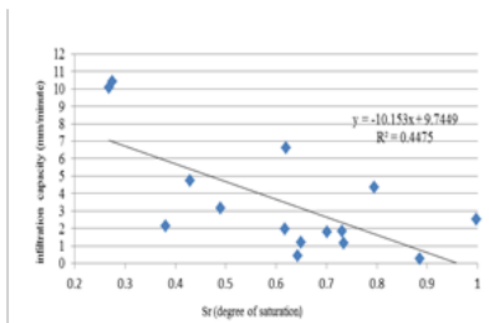

Figure 9. The Influence of Sr against to f (mm/min)

From Figure 8 above obtained value R^2 = 0.018 means 1.8%. This curve shows the relationship between porosity and infiltration capacity of above is not feasible for use because it has a very low R^2. Previously explained that the porosity is a large number of pore space in soil. In fact, should be the more pore space in the soil then the rate of infiltration will be even greater, and vice versa. The pore spaces of note on the land there are three constituent elements, namely the land itself, the water and the air. Water and air are the element that occupies a space pore. The larger pore spaces in the soil, it will be more and more of the elements water and air that will occupy a space pore. On testing the rate of infiltration on soil water that seeped into the unknown land would occupy pore space.

While in Figure 9 the obtained value R^2 = 0.447 means 44.7%, showing the curve of the relation between the degree of saturation and infiltration capacity above deserves to be used as it has the R^2.

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Keep in mind to degrees of saturation or Sr = 1 is saturated with ground water, while Sr = 0 is the ground with dried state. Therefore, in accordance with the actual theory explaining that the lower the value of the degree of saturation means ground in very dry conditions, then the rate of infiltrasinya will be even greater and in the greater degree of saturation value means land in a State of saturation of the water, then the rate of infiltrasinya will be getting smaller. From Figure 10 obtained a value of R2 = 0.029 means 2.9% the capacity of infiltration is affected by slope parameter. This shows the relationship between the slope of the curves and infiltration capacity of above is not feasible for use because it has a very low R^2.

This is due to the measurement of the rate of infiltration performed on site with a small slope or can be said to be the location of the flat. Besides measuring the rate of infiltration in the field who use the tool Turftec Infiltrometer has a very small measurement area. So, although performed on the steep slope of the site and will not affect the great small rate of infiltration. The slope of the land may be aware that the more oblique or steep a location, then that will effects is the rate of surface runoff, while the rate of infiltrasinya will not affect much. As for Figure 11 gained value R2 = 0.046 means 4.6% density and capacity of infiltration above is not feasible for use because it has a very low R^2. Based on the test results, low density had a lower rate of infiltration than locations with high density and medium. In fact, should be the smaller the value soil density of a location.

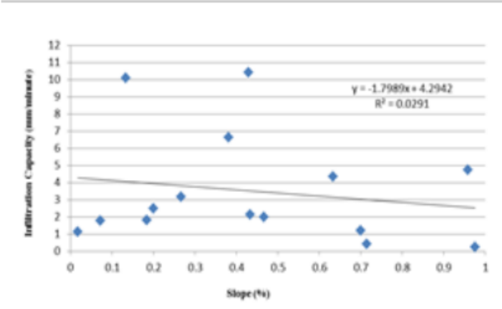

Figure 10. The influence of Slope towards the result f

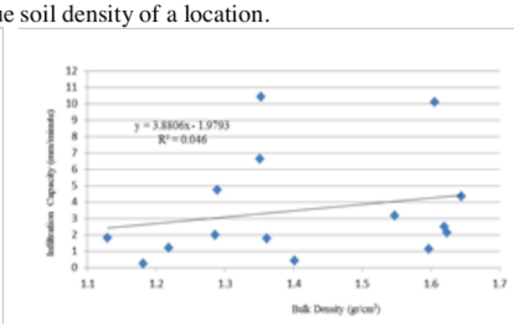

Figure 11. The influence of Bulk Density against f (mm/min)

4. Conclusions

Formula rate equation is Horton infiltration well for field testing by parameters of soil conditions and the measurement method with DOS flooding. It is based on the rate of infiltration testing of measurement results, the results of the calculation of the formula results, and Horton to reach 87.2%. Influence of parameters of soil conditions, porosity, soil texture, no significant effect against the rate of infiltration with measurements using turftec infiltrometer. This is due to the size of the infiltrometer turftec sink only 10 cm. The density and the slope are not signifan effect on the rate of infiltration of the results of measurements and calculations of Horton, so it can be inferred that the tools can not be used Turftech infiltrometer to measure the rate of infiltration with the parameters of the soil conditions, density, and slope.

Acknowledgement

This research is funded by Kemenristek DIKTI as a doctoral scholarship program at Brawijaya University. The author appreciates the help from Hydrological Laboratory in Brawijaya University.

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