International Journal of Engineering

Journal Homepage: www.ije.ir

Comparison of Experimentally and Theoretically Determined Infiltration in Coarse Textured Soil

T. N. Wickramaarachchi*, T. Venukanan, R. Diluckshanaraj

Department of Civil and Environmental Engineering, Faculty of Engineering, University of Ruhuna, Hapugala, Galle, Sri Lanka

P A P E R I N F O

Paper history:
Received 04 September 2017
Received in revised form 23 October 2017
Accepted 21 Januray 2018

Keywords:
Coarse Textured Soil
Double Ring Infiltrometer
Horton's Model
Infiltration
Single Ring Infiltrometer

A B S T R A C T

Though it is vital to estimate infiltration as one of the key factors in effective management of water resources, only few studies have been carried out either to determine the infiltration or to compare the performance of infiltration models for coarse textured soils. Thus, the present study was conducted to accomplish two objectives. First to estimate the Horton's infiltration model parameters for coarse textured soils (particle size distribution greater than 0.075 mm, according to the Unified Soil Classification System) and to compare the infiltration capacities estimated by the model with those measured in the field. Second to measure the infiltration in the coarse textured soil using both single and double ring infiltrometers and to compare them. Study location was Hapugala area in Galle District, Sri Lanka. In this study, the least squares fitting technique was employed to estimate the Horton's model parameters from the field measured data. A good agreement was found between the model estimated infiltration values and those measured at field. Horton's infiltration model estimations fitted very well with much coarse textured soil. The highest difference between the single and double ring infiltrometer measurements were also observed for the much coarse textured soil. Overall, the infiltration measurements by the double ring infiltrometer were 20-35% lower, on average, than that of the single ring infiltration measurements suggesting considerably high infiltration along the lateral direction in the single ring compared to the double ring infiltrometer.

doi: *10.5829/ije.2018.31.06c.04*

1. INTRODUCTION

Infiltration is the process by which water enters into the ground through the soil surface and infiltration rate is the speed at which water seeps into the soil. Infiltration is an important component in the hydrologic cycle. Thus it is vital to estimate the infiltration as one of the key factors in effective management of water resources.

Field infiltration measurement is often a time consuming and laborious thus many studies have been carried out to test the applicability of hypothetical infiltration models to estimate the infiltration. Though tedious, infiltrometers and rainfall simulators have been commonly used to measure field infiltration [1-6]. Studies have showed that double ring infiltrometers limit the infiltration in lateral direction [1, 3] and their successful application to evaluate infiltration rates in stormwater runoff basins located on coarse textured soils [7]. Several infiltration models have also been developed and their performances have been evaluated, particularly, by testing the compatibility with measured data [8-11]. Successful application of Horton's infiltration model in estimating infiltration has been shown by several studies [12-15].

Infiltration is affected by both natural processes and human actions. According to Horton [16], soil texture found to be the strongest influencing factor for infiltration. Effect of initial soil moisture content on infiltration rate has been assessed [17, 18] and variation of steady state infiltration capacity with soil texture has been revealed [19, 20]. Dashtaki et al. [21] investigated the site dependence performance of infiltration models. However not many studies have been carried out to compare the performance of infiltration models for coarse textured soil and to compare single and double

*Corresponding Author Email: *thushara@cee.ruh.ac.lk* (T. N. Wickramaarachchi)

Please cite this article as: T. N. Wickramaarachchi, T. Venukanan, R. Diluckshanaraj, Comparison of Experimentally and Theoretically Determined Infiltration in Coarse Textured Soil, International Journal of Engineering (IJE), IJE TRANSACTIONS C: Aspects Vol. 31, No. 6, (June 2018) 886-893

ring infiltrometer measurements for coarse textured soil. Thus, future studies on infiltration determination in coarse textured soil have been recommended by Mirzaee et al. [22] in filling the existing lacuna.

Purpose of the present study is twofold. First to estimate the Horton's infiltration model parameters for coarse textured soil and to compare the infiltration capacities estimated by the model with those measured in the field. Second to measure the infiltration in coarse textured soil using both single and double ring infiltrometers and to compare them.

2. MATERIALS AND METHODS

2. 1. Study Site Field infiltration measurements were carried out at two locations in the Faculty of Engineering, University of Ruhuna located in Hapugala area (6°5'1" N and 80°11'38" E) in Galle District, Sri Lanka. Identification of these two experiment sites was principally based on the highest difference in the particle size.

Mean annual rainfall in the area is about 2000 mm and average temperature varies from 24°C to 32°C. Soil in the study area has been classified as coarse grained soil according to the Unified Soil Classification System [23]. Sieve analysis was carried out to assess the particle size distribution in five selected sites in the study area. Among the five sites, two with the highest difference in the particle size were selected to measure the infiltration. Site 1 with 26% gravel and 74% sand content; Site 2 with 12% gravel and 88% sand content. Surface conditions and slope across the experiment sites were found as similar as possible.

2. 2. Field Measurements

Determination of Soil Texture Soil texture is the major factor that affects infiltration [2, 16]. The soil texture of the study area was determined by sieve analysis, a mechanical analysis method. Results showed that the texture of the soil in the two selected sites is predominantly coarse grained soil, i.e. particle size bigger than 0.075 mm [23]. Fraction of sand (0.075 mm to 4.75 mm) and gravel (4.75 mm <) at Site 1 and Site 2 are shown in Table 1.

Measurement of Infiltration Capacity of Soil Ring infiltrometers are commonly used to determine water infiltration of the soil [1, 3, 4, 14]. Infiltration measurements in this study were carried out using single and double ring infiltrometers. Single ring infiltrometer consisted of a ring having 30 cm diameter. Diameters of the two rings, inner and outer rings of the double ring infiltrometer, were 30 cm and 55 cm, respectively. All the rings were having a height of 25 cm.

Double ring infiltrometers are designed to prevent the lateral spread of water from the inner ring to the outer ring. The purpose of the outer ring is to act as a buffer zone promoting one dimensional, vertical flow beneath the inner ring. Studies have been conducted and revealed that double ring infiltrometers improve the measurements by avoiding the lateral flow [1, 3, 24].

Before commencement of the experimental runs, ground cover has been removed without disturbing the soil surface. Infiltrometer rings were driven into the soil to a depth of 10 cm. Infiltration measurements were made by ponding water into the ring infiltrometers. When measuring with the double ring infiltrometer, the water levels in both rings were kept at a constant head throughout the measurements. Infiltration measurements were conducted until the infiltration rate reached a constant value. Observations recorded were used to calculate the amount of infiltration through the single and double ring infiltrometers at Site 1 and Site 2.

Both single and double ring infiltrometer measurements were conducted simultaneously at Site 1 and Site 2, twelve times, during June-August, 2016. A total of forty eight (2 x 2 x 12) infiltration experiments were conducted in the field.

2. 3. Horton's Infiltration Model Horton proposed a three parameter equation to define the infiltration of water into soil [25]. Horton's equation has been identified as one of the most popular empirical models simulating infiltration of water into soils [26].

The Horton's infiltration model (Equation 1) derived from work and energy principles includes initial infiltration capacity, final steady state infiltration capacity, and a soil specific constant. Infiltration capacity is defined as the maximum rate at which a given soil when in a given condition can absorb rain as it falls.

$$f = f_c + (f_0 - f_c)e^{-kt} \tag{1}$$

f =infiltration capacity (mm/min) at time t
f_0= initial infiltration capacity (mm/min)
f_c= final steady state infiltration capacity (mm/min)
k= empirical constant (min^{-1})

By arranging Equation (1) as per the form shown in Equation (2), value of f could be plotted as a straight line on semi-logarithmic paper in terms of t and the value of k could be determined from this line.

TABLE 1. Particle size distribution of soil at Site 1 and Site 2

	Sand (0.075 mm to 4.75 mm) %	**Gravel (4.75 mm<) %**
Site 1	74	26
Site 2	88	12

This has the advantage that the line represents all the data and usually gives a more accurate value of k than would be derived from two selected points on a curve [25].

$$f - f_c = (f_0 - f_c)e^{-kt} \tag{2}$$

3. RESULTS AND DISCUSSION

3. 1. Estimation of the Horton's Infiltration Model Parameters

From the observations of each experimental measurement, f_o and f_c were determined, and *ln (f-fc/fo-fc)* vs. t (derived from Equation (2)) was plotted. From the slope of the line of best fit, k value and coefficient of determination (R^2) value were determined for each set. Ranges of values obtained are shown in Table 2. The best fit lines with the highest R^2 for both single and double ring infiltrometer at Site 1 and Site 2 are shown in Figure 1.

According to Gray and Norum [17], initial soil moisture content influences both the infiltration rate and the amount of infiltration. The initial antecedent soil moisture content in the study area during the experimental runs lied between 6.59% and 16.67%.

3. 2. Comparison of Measured and Modeled Infiltration

In this study, the ability of Horton's model to estimate infiltration was evaluated by the least squares fitting to the measured infiltration data. According to literature [21, 27, 28], both the correlation coefficient (r) and the root mean square error (*RMSE*) could be used to check the fit between the modelled and the measured infiltration (Table 3). Horton's model was fitted to experimental infiltration data to find the values of fitting parameters that give the best fit between the model and experimental data. Comparison between the modelled and measured data was carried out by means of r values and *RMSE* values. According to these goodness-of-fit statistics, the highest r value and the smallest *RMSE* value were selected as the best fit.

Overall, there was a good fit between the Horton's model estimated and the measured infiltration capacities. Twenty four out of forty eight experimental data had a correlation coefficient greater than 0.92. This finding agreed with the findings by Al-Azawi [12] and Ogbe et al. [14] who showed successful application of Horton's model to coarse textured soils. Table 4 presents the Horton's parameter values that best fit the data together with the goodness-of-fit statistics.

Measured *fo*, *fc* and k values given in Table 2 and Table 4 were compared with the literature values, in terms of average and range between the minimum and maximum values.

At Site 1, the k values ranged from a minimum of 0.02 to a maximum of 0.03 with a standard deviation of 0.02. k values at Site 2, ranged from a minimum of 0.03 to a maximum of 0.04 with a standard deviation of 0.01. These ranges were concordant with that obtained by Söderberg [4] for coarse textured soil. The ranges in k were higher in Site 2 (having 12% gravel and 88% sand), compared to Site 1 (having 26% gravel and 74% sand).

Brouwer et al. [19] has stated *fc* values according to the soil texture. According to him, for sandy soils, *fc* is greater than 0.5 mm/min which is similar to the *fc* values obtained in this study. As per the *fo* and *fc* values obtained in this study, the ratio of *fo/fc*, permeability indication ratio, was greater than 5. This agreed with McCuen [29] who showed permeability indication ratio greater than 5 for soils with high permeability.

When fitting to the Horton's model, both single and double ring infiltrometer measurements showed the highest r and the lowest *RMSE* at Site 1 compared to the measurements taken at Site 2. In terms of accuracy, Horton's infiltration model estimated the infiltration capacity in the order; double ring at Site 1 > single ring at Site 1> double ring at Site 2 > single ring at Site 2.

TABLE 2. Ranges of values obtained from experimental measurements

	Site 1		Site 2	
	Single ring infiltrometer	**Double ring infiltrometer**	**Single ring infiltrometer**	**Double ring infiltrometer**
Number of experimental runs	12	12	12	12
R^2, max*- min**	0.99 - 0.83	0.96 - 0.83	0.97 - 0.78	0.93 - 0.77
f_o (mm/min), max*- min**	5.5-2.1		4.0-2.6	
f_c (mm/min), max*- min**	0.81-0.53		0.74-0.46	
k (min^{-1}), max*- min**	0.03 – 0.02		0.04 – 0.03	
Initial soil moisture content (%), max*- min**	13.95 – 6.59		16.67 – 7.42	

max*=maximum; min**=minimum

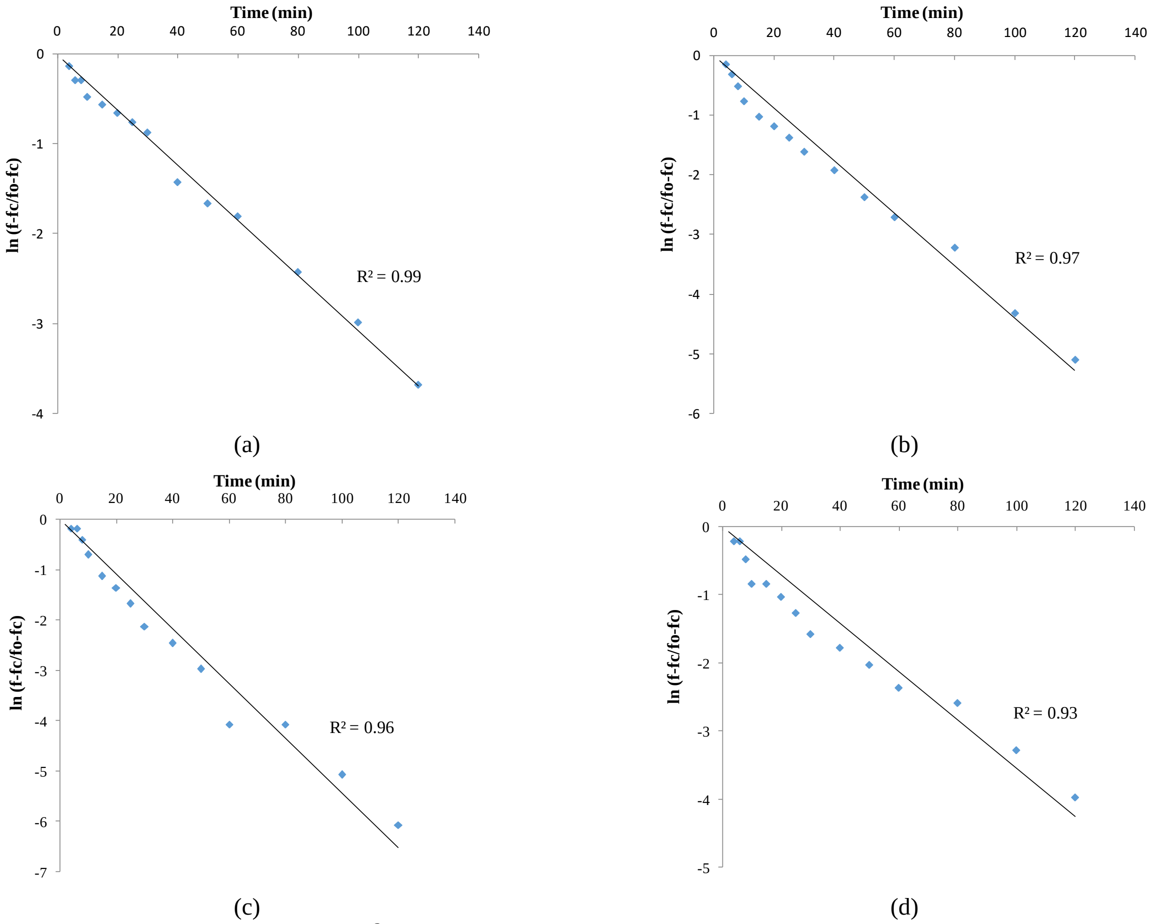

Figure 1. The best fit lines with the highest R^2 (a) Single ring infiltrometer at Site 1; (b) Single ring infiltrometer at Site 2; (c) Double ring infiltrometer at Site 1; (d) Double ring infiltrometer at Site 2

TABLE 3. Criteria to evaluate the fit between modelled and measured infiltration

Criterion	Equation
Correlation Coefficient (r)	$r = \left[\frac{N(\sum I_m I_e) - (\sum I_m)(\sum I_e)}{\sqrt{[N\sum I_m^2 - (\sum I_m)^2]}\sqrt{[N\sum I_e^2 - (\sum I_e)^2]}}\right]$
Root Mean Square Error ($RMSE$)	$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(I_e - I_m)^2}{N}}$

N – Number of observations; I_m – measured value; I_e – estimated value

TABLE 4. Horton's parameter values that best fit the data and goodness-of-fit statistics

	f_o	f_c	k	r	$RMSE$
Single ring infiltrometer at Site 1	5.5	0.80	0.03	0.99	0.13
Double ring infiltrometer at Site 1	3.5	0.65	0.02	0.99	0.12
Single ring infiltrometer at Site 2	3.9	0.70	0.04	0.98	0.18
Double ring infiltrometer at Site 2	2.6	0.46	0.03	0.97	0.16

Site 1 was having 14% more gravel content compared to Site 2. Hence the present study revealed that the Horton's model estimations were best described by the measurements taken at much coarse textured soil.

Figure 2 illustrates the best fit between the Horton's model estimated and measured infiltration. According to Figure 2, the model estimated initial infiltration capacities were higher compared to the measured and that was common to all experimental runs. However, the match between the modeled and measured data improved with time.

Irregularities observed in the field measured infiltration rates may be due to errors resulting during field experimentation. According to Reynolds et al. [30], the possible limitations of the infiltrometer test are soil disturbance during installation of the ring and possible edge flow during the experiment.

3. 3. Comparison of Single and Double Ring Infiltrometer Measurements

Experimental measurements carried out at each site by using the single and double ring infiltrometers were cross compared. Examples representing these measurements are shown in Figures 3 and 4.

Initial soil moisture content has a great influence on the infiltration rate [18]. Increase in initial soil water content decreases the infiltration rate during the early stages of infiltration and as the time of water application increases, the effect of initial moisture content decreases. According to Table 2, the initial soil moisture content at Site 2 was greater than that of Site 1 resulting higher initial infiltration rate at Site 1 as shown in Figure 4.

Figures 3 and 4 illustrate that both single and double ring infiltrometer measurements were close to each other at Site 2 except for the initial infiltration rates. Higher initial infiltration rates in the single ring suggested a rapid lateral flow particularly at the beginning of measurements. However in most experimental runs at Site 2, the single and double ring measurements stabilized to become parallel over time with a difference of 0.2 mm/min infiltration rate. However at Site 1, there existed a significant difference between the single and double ring infiltrometer measurements throughout the entire measurement period. Across all measurements at Site 1, significantly higher infiltration measurements were observed in the single ring compared to the double ring.

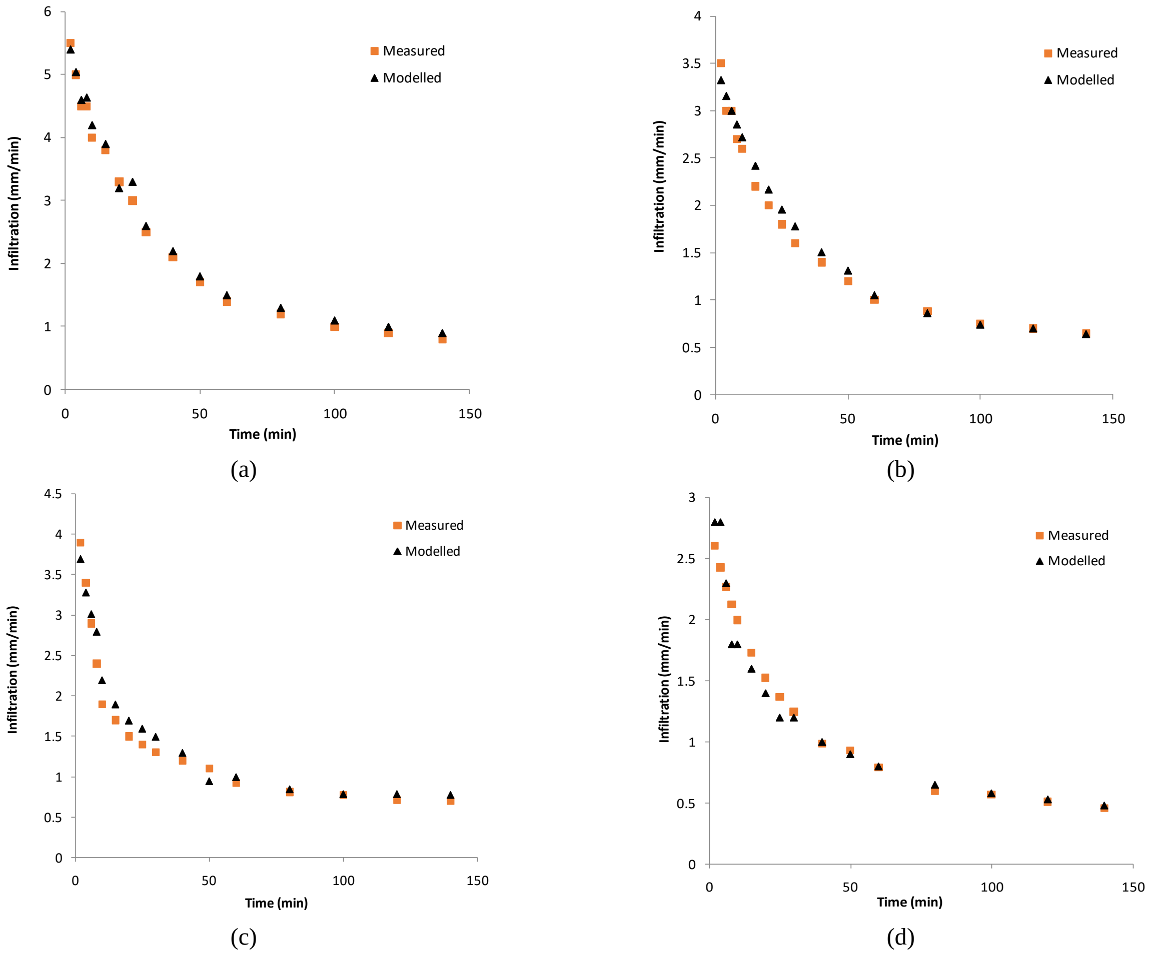

Figure 2. The best fit between the Horton's model estimated and measured infiltration (a) Single ring infiltrometer at Site 1; (b) Double ring infiltrometer at Site 1; (c) Single ring infiltrometer at Site 2; (d) Double ring infiltrometer at Site 2

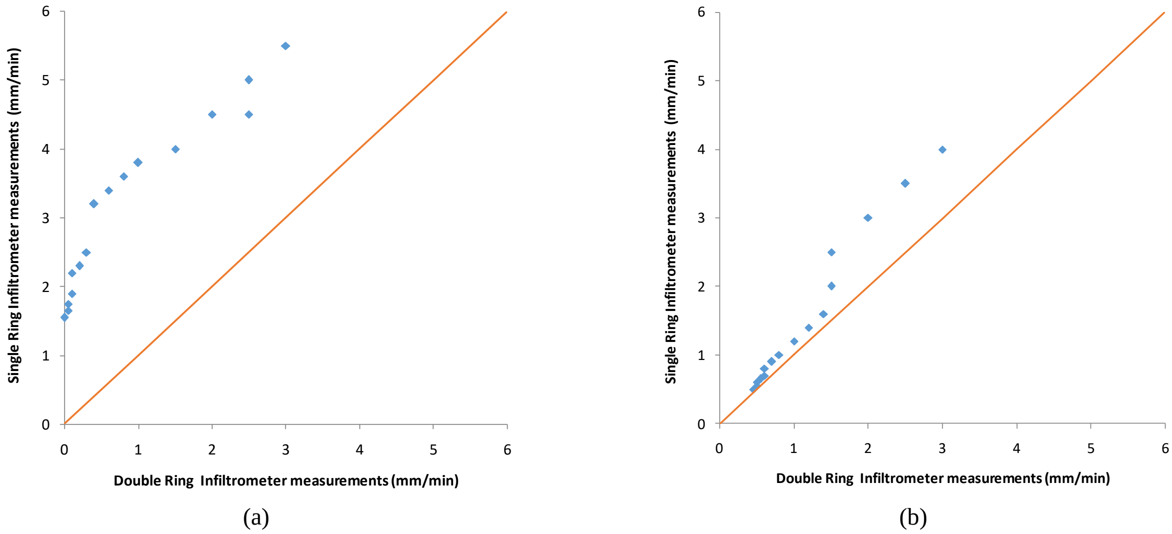

Figure 3. Infiltration measurements; Single vs. double ring infiltrometer (a) Site 1; (b) Site 2

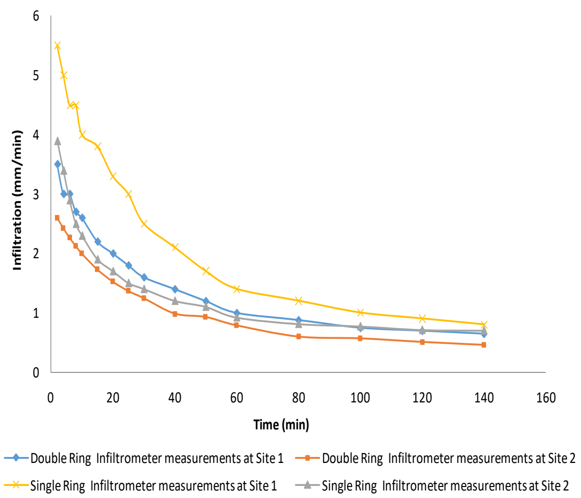

Figure 4. Cumulative infiltration vs. time

That might be attributed to the more gravel content at Site 1 compared to Site 2 which facilitated lateral infiltration. Overall, the infiltration measurements by the double ring infiltrometers were lower than that of the single ring values. Comparing the single ring infiltrometer measurements with the double ring infiltrometer measurements, the infiltration mesurements given by the double ring infiltrometers were 20% and 35% lower on average at Site 2 and Site 1, respectively. According to Byars [3] this finding validates the hypothesis that in the double ring infiltrometer, the outer ring acts as buffer preventing water moving laterally from the inner ring to the outer ring, resulting lesser infiltration values compared to the single ring infiltrometer.

4. CONCLUSION

Fitting the estimated parameters into the Horton's infiltration model yielded calculated infiltration capacities similar to those measured at field for both single and double ring infiltrometer measurements. Approach employed in this study, the least square fitting technique, gave a clear indication of successful performance of the Horton's model in estimating the infiltration capacities of coarse textured soil. However, the Horton's model was best described by the measurements taken at much coarse textured soil.

The highest difference between the single and double ring infiltrometer measurements were observed for the much coarse textured soil. Higher infiltration measurements given by the single ring compared to the double ring infiltrometer suggested considerably high infiltration along the lateral direction in the single ring facilitated by much coarse textured soil. However further studies are recommended to find the accuracy of single versus double ring infiltrometer measurements for coarse textured soils, which could not be established within the framework of this study.

5. ACKNOWLEDGEMENT

The authors gratefully acknowledge University of Ruhuna, Sri Lanka for providing technical and financial support for the study.

6. REFERENCES

1. Burgy, R.H. and Luthin, J. N., "A Test of the Single and Double Ring Types of Infiltrometers", ***Transactions, American Geophysical Union***, Vol. 37, No. 2, (1956), 189-192.

2. Johnson, A.I., "A field method for measurement of infiltration", U.S. Geological Survey Water-Supply Paper 1544-F, Washington DC: US GPO, USA, (1963), 27-35.
3. Byars, C.J., "Direct measurement of infiltration through a Playa wetland using automated double ring infiltrometers", MSc Thesis, Graduate Faculty, Texas Tech University, USA, (2014).
4. Söderberg, M.H., "Measuring soil infiltration rates in cultivated land - A case study of Ifakara, Tanzania", MSc thesis, Department of Physical Geography, Stockholm University, Sweden, (2015).
5. Verbist, K., Torfs, S., Cornelis, W.M., Oyarzún, R., Soto, G. and Gabriels, D., "Comparison of single and double ring infiltrometer methods on stony soils", ***Vadose Zone Journal***, Vol.8, (2010), 462-475.
6. Verbist, K. M. J., Cornelis, W. M., Torfs, S. and Gabriels, D., "Comparing Methods to Determine Hydraulic Conductivities on Stony Soils", ***Soil Science Society of America Journal***, Vol. 77, No. 1, (2013), 25-42.
7. Bean, E.Z. and Dukes, M.D., "Evaluation of Infiltration Basin Performance on Coarse Soils", ***Journal of Hydrologic Engineering***, Vol. 21, No. 1, (2016), doi: 10.1061/(asce)he.1943-5584.0001258.
8. Mishra, S.K., Tyagi, J.V. and Singh, V.P., "Comparison of infiltration models", ***Hydrological Processes***, Vol. 17, No. 13, (2003), 2629-2652.
9. Shukla, M.K., Lal, R. and Unkefer, P., "Experimental evaluation of infiltration models for different land use and soil management systems", ***Soil Science***, Vol. 168, No. 3, (2003), 178-191.
10. Araghi, F.P., Mirlatifi, S.M., Dashtaki, S.G. and Mahdian, M.H., "Evaluating some infiltration models under different soil texture classes and land uses", ***Iranian Journal of Irrigation and drainage***, Vol. 4, No. 2, (2010), 193-205.
11. Zakwan, M., Muzzammil, M. and Alam, J., "Application of spreadsheet to estimate infiltration parameters", ***Perspectives in Science***, Vol. 8, (2016), 702-704.
12. Al-Azawi, S.A., "Experimental evaluation of infiltration models", ***Journal of Hydrology***, Vol. 24, No. 2, (1985), 77-88.
13. Berndtsson, R., "Application of infiltration equations to a catchment with large spatial variability in infiltration", ***Hydrological Science Journal***, Vol. 32, No. 3, (1987), 399-413.
14. Ogbe, V.B., Jayeoba, O.J. and Ode, S.O., "Comparison of four soil infiltration models on a sandy soil in Lafia, Southern Guinea Savanna Zone of Nigeria", ***Production Agriculture and Technology***, Vol. 7, No. 2, (2011), 116-126.
15. Dagadu, J.S. and Nimbalkar, P.T., "Infiltration studies of different soils under different soil conditions and comparison of infiltration models with field data", ***International Journal of Advanced Engineering Technology***, Vol. 3, No. 2, (2012), 154-157.
16. Horton, R.E., "The role of infiltration in the hydrologic cycle", ***Transactions, American Geophysical Union***, Vol. 14, No. 1, (1933), 446-460.
17. Gray, D.M. and Norum, D.I., "The effect of soil moisture on infiltration as related to runoff and recharge", in Proceedings of Hydrology Symposium No. 6, November 1967, National Research Council of Canada, (1967), 133-150.
18. Tindall, J.A., Kunkel, J.R. and Anderson, D.E., "Unsaturated zone hydrology for scientists and engineers", 1st edition, Prentice Hall, New Jersey, (1999), 624-630.
19. Brouwer, C., Prins, K., Kay, M. and Heibloem, M., "Irrigation water management: Irrigation methods", Training Manual No. 5, FAO-Food and Agriculture Organization of the United Nations, Rome, (1988).
20. Zhang, Z., Zhu, Z., Wang, Y., Fu, W. and Wen, Z., "Soil infiltration capacity and its influencing factors of different land use types in Karst slope", ***Transactions of the Chinese Society of Agricultural Engineering***, Vol. 26, No. 6, (2010), 71-76.
21. Dashtaki, S.G., Homaee, M., Mahdian, M.H. and Kouchakzadeh, M., "Site dependence performance of infiltration models", ***Water Resources Management***, Vol. 23, No. 13, (2009), 2777-2790.
22. Mirzaee, S., Zolfaghari, A.A., Gorji, M., Dyck, M. and Dashtaki, S.G., "Evaluation of infiltration models with different numbers of fitting parameters in different soil texture classes", ***Archives of Agronomy and Soil Science***, Vol. 60, No. 5, (2013), 681-693.
23. ASTM D2487-06, "Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)", ASTM International, West Conshohocken, PA, (2006).
24. Chowdary, V., Rao, M. and Jaiswal, C., "Study of infiltration process under different experimental conditions", ***Agricultural Water Management***, Vol. 83, No. 1, (2006), 69-78.
25. Horton, R.E., "An approach towards a physical interpretation of infiltration capacity", Proceedings of Soil Science Society of America, Vol. 5, (1940), 399-417.
26. Philip, J.R., "The theory of infiltration: 4. sorptivity and algebraic infiltration equations", ***Soil Science***, Vol. 84, No. 3, (1957), 257-264.
27. Turner, E.R., "Comparison of infiltration equations and their field validation with rainfall simulation", MSc. Thesis, Faculty of the Graduate School, University of Maryland, USA, (2006).
28. Zolfaghari, A.A., Mirzaee, S. and Gorji, M., "Comparison of different models for estimating cumulative infiltration", ***International Journal of Soil Science***, Vol. 7, No. 3, (2012), 108-115.
29. McCuen, R.H., "Hydrologic analysis and design", 2nd edition, Prentice Hall, New Jersey, (1998), pp. 814.
30. Reynolds, W.D., Bowman, B.T., Brunke, R.R., Drury, C.F. and Tan, C.S., "Comparison of tension infiltrometer, pressure infiltrometer, and soil core estimates of saturated hydraulic conductivity", ***Soil Science Society of America***, Vol. 64, No. 2, (2000), 478-484.

Comparison of Experimentally and Theoretically Determined Infiltration in Coarse Textured Soil

T.N. Wickramaarachchi, T. Venukanan, R. Diluckshanaraj

Department of Civil and Environmental Engineering, Faculty of Engineering, University of Ruhuna, Hapugala, Galle, Sri Lanka

PAPER INFO

Paper history:
Received 04 September 2017
Received in revised form 23 October 2017
Accepted 21 Januray 2018

Keywords:
Coarse Textured Soil
Double Ring Infiltrometer
Horton's Model
Infiltration
Single Ring Infiltrometer

چکیده

اگرچه برای ارزیابی فیلترشدن به عنوان یکی از عوامل کلیدی در مدیریت موثر منابع آب ضروری است، تنها تعداد کمی از مطالعات انجام شده برای تعیین میزان فیلتر شدن و یا مقایسه عملکرد مدل های فیلترشدن برای بافت خاک با دانه بندی مناسب انجام شده است. بنابراین، مطالعه حاضر برای انجام دو هدف انجام گردید. ابتدا برای ارزیابی پارامترهای مدل فیلتراسیون هورتون برای خاک با دانه بندی درشت است (توزیع اندازه ذرات بیش از 0.075 میلی متر، بر اساس سیستم طبقه بندی یونی یک شکل و هارمونی) و مقایسه ظرفیت صافی نمودن برآورد شده توسط مدل با آنهایی که در این زمینه اندازه گیری شده است. دوم برای اندازه گیری فیلترشدن در خاک متخلخل با ذرات درشت با استفاده از سنجش های تک و دو حلقه ای فیلترشدن و مقایسه آنها با یکدیگر می باشد. میدان مورد مطالعه منطقه Hapugala در منطقه گالیل، سریلانکا بوده است. در این مطالعه، برای اندازه گیری پارامترهای مدل هورتون از داده های اندازه گیری میدانی، روش تطبیق حداقل مربعات مورد استفاده قرار گرفت. انطباق خوبی بین مقادیر مدل فیلترشدن و داده های مطالعاتی که در چنین حوزه ها اندازه گیری شده بود، حاصل گردید. برآورد مدل فیلترشدن هورتون با بافت خاک دانه بندی درشت بسیار مناسب است. بیشترین تفاوت بین اندازه گیری فیلترشدن تک و دو حلقه ای برای بافت خاک با دانه بندی درشت ترمشاهده گردید. به طور کلی، اندازه گیری های فیلترشدن توسط خاک با دانه بندی درشت دو حلقه به طور متوسط 20-35٪ کم تر از اندازه گیری های فیلترشدن تک حلقه ای است. فیلترشدن قابل توجه ای در امتداد جهت جانبی در فیلتراسیون حلقه تک ای نسبت به فیلتراسیون دو حلقه ای مشاهده گردید.

***doi**: 10.5829/ije.2018.31.06c.04*