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Estimation of infiltration rate for different land cover at Maldad village (Sangamner Tehsil), Maharashtra, India

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Abstract
The design and evaluation of surface irrigation systems of a site requires reliable data of infiltration which could be provided by an infiltration model. In this study, Horton's infiltration model has been estimated for the soil located in a field of Shramshakti College of Agricultural Engineering and Technology, Maldad, Maharashtra using the infiltration data obtained from four different locations in the field using double ring infiltrometer. The decay constant of the Horton's infiltration model was obtained using graphical method. The Horton's model for infiltration rate obtained by formula $f = fc + (fo-fc)\ e^{-kt}$, where, f is infiltration capacity at any time t, fc is final steady state infiltration capacity, fo is initial infiltration capacity. k is Horton's decay coefficient which depends upon soil characteristics and vegetation cover.
The main aim of this study was to determine the infiltration rate of soil of Maldad village using double ring infiltrometer. In this study test were done by pouring water into the rings of 30 cm diameter and 60 cm diameter which is hammered into the soil 25 cm. From the given study the average infiltration rate for four different plots of Maldad village was found as 5.84 cm/hr. The characteristic constants Fc is found to be 10 cm. In the different plots of selected village, the double ring infiltrometer method was found suitable. Remark: From the obtained results we conclude that the irrigation methods and cropping patterns will be drip irrigation and sprinkler irrigation methods and crops would be taken as Sweet Corn, Okra, Radishes, Eggplant, Carrots, Pole Beans, Spinach, Beat Root, Onion, respectively.

Keywords: Cumulative infiltration, double ring infiltrometer, graphical method, Horton's infiltration model, infiltration rate

Introduction
The flow of water through the surface of the soil is termed as infiltration. The water which is infiltrated replenishes the moisture deficiency in the soil while the excess water which moves downward by gravity force is responsible for building ground water table. Although a negligible proportion of soil water is present on earth compared to the total water present on earth surface, it is of para- mount importance for plant life. The infiltration rates are necessary for estimation of groundwater recharge, effective rainfall and effective design of irrigation systems (Michael, 1978) [18]. The use of infiltration models in quantifying infiltration plays a major role in watershed management. Also, being one of the most important components of hydro- logic cycle. It is becoming essential to estimate infiltration rate and cumulative infiltration for complex analysis of watershed. Efficiency in the application of irrigation water is of great economic importance especially to countries with limited water supplies (Akinbile *et al*., 2006) [14]. The infiltration Process of a particular site can be assessed effectively using double ring infiltrometer, however, it becomes a tedious task to obtain infiltration data by this method which can otherwise be obtained in comparatively easier and reliable manner using infiltration model developed for the particular site of study. Therefore, infiltration models should be developed using the infiltration data available for different sites at various antecedent moisture conditions and suitable models should be developed or constants of existing infiltration models should be modified using standard methods. Ring infiltrometers are commonly used for *in situ* measurement of infiltration characteristics. The infiltrometer can employ for 2 concentric rings, and correspondingly it is Called a single-ring or double-ring infiltrometer. The double-ring infiltrometer is preferred because the outer ring helps in reducing the error that may result from lateral flow in the soil. There is less effect of ring size on the results when using the double- ring:

1. Maintain equal depths, but only measure flow into inner ring.
2. Outer ring will supply most of the horizontal at flow, so inner rings give mainly vertical

The Horton's equation (Horton, 1933, Horton, 1938) [15-16] is one of the most widely used semi-empirical models. The classical exhaustion process in nature is used in the Horton equation to derive the infiltration capacity variation with the time during rain. All of the process affecting the rate of change of filtration capacity are linearly proportional to the infiltration capacity remaining to be performed (Horton, 1941) [17]. Although the Horton equation is semi-empirical, it reveals the similar pattern of infiltration rate decline from the initial infiltration rate to the stable infiltration rate as other physically based models such as green-ampt model and the Philip model (Beven, 2004) [5].

Material and Method

Study Area

The present investigation was carried out on the infiltration rate of soil of Maldad village in the Sangamner tehsil. This is located in the region of northern Maharashtra. It is located 93 km towards North from district head quarter Ahmednagar. It is situated at an altitude 509 m from MSL at 1957 North latitude and 74 20' E longitude. The average annual rainfall of this area is about 476 mm.

The infiltration data was obtained from infiltration tests conducted by double ring infiltrometer at four different locations selected randomly in the field adjacent to the Agricultural Engineering College in Maldad, Maharashtra. The soil texture in the field was sandy loam. The inner cylinder and outer cylinder used in the double ring infiltrometer test were 30 cm and 60 cm diameter respectively. A hammer was used to drive the cylinder into the soil at 25 cm depth. The water was filled into the inner cylinder up to the point rod set at desired level and the time interval was not noted at various intervals to obtained the depth of infiltration. observed infiltration data were used to evaluate the parameters of the Horton's infiltration model which was then used to estimate infiltration data. Horton (1940) gave the following equation to obtained infiltration rate.

$$f = fc + (fo - fc)\, e^{-kt} \quad (1)$$

Where,

f =infiltration capacity at any time t.

fc = final steady state infiltration capacity. fo = initial infiltration capacity.

k = Horton's decay coefficient which depends upon soil characteristics and vegetation cover.

Graphical method: (Fadadu, M. H. *et al.* (2018) [11]. Application of Horton's infiltration model for the soil of Dediapada, India. In this method, a linear graph plot of infiltration rate (cm/hr) vs. time t (min) was drawn and the area under the graph (Fc) where the infiltration rate becomes constant was taken. The value of Fc is used to obtain the value of the decay constant k in the Horton's equation.

$$k = \frac{fo - fc}{Fc} \quad (2)$$

The value of fc was obtained simply by observing the constant of infiltration rate after a significant time had passed while the value of fo was obtained by projecting the graph on y-axis (infiltration rate). The values of the parameters obtained for the Horton's infiltration model was used to estimate infiltration rate which were compared with the observed infiltration rate. The coefficient of determination was used as the measure of performance. As for accumulated infiltration depth (fp), the Horton's equation was integrated using minimum and maximum time limits that were taken during the observation. The accumulated infiltration depth was evaluated using the following equation:

$$\mathbf{F} = \int_0^t \boldsymbol{fc} + (\boldsymbol{fo} - \boldsymbol{fc})\boldsymbol{e}^{-\boldsymbol{kt}}\boldsymbol{dt}$$

Result and Discussion

The experiment was carried out with a view to study the infiltration rate of soil of Maldad village of Sangamner tehsil. The obtained result of infiltration is used for suggesting irrigation practices. Infiltration of study area is found out by double ring infiltrometer using Horton's equation and its value is 5.84 cm/hr. From the obtained infiltration result the soil type for Maldad village is sandy loam and silt loam.

Fig. 1 Average Infiltration rate vs Time graph for cultivated lands for Maldad village

Table 1: Average Infiltration rate for cultivated lands for Maldad village.

Sr. No.	Elapsed time (min)	Elapsed time (hr)	Average infiltration rate (cm/hr) $\mathbf{F} = \int_0^t \mathbf{fc} + (\mathbf{fo} - \mathbf{fc})\mathbf{e}^{-\mathbf{kt}}\mathbf{dt}$	fo-fc	Ln (fo-fc)
1	5	0.083	8.99	4.51	1.50
2	10	0.166	7.63	3.15	1.14
3	15	0.25	6.42	1.94	0.66
4	25	0.416	5.98	1.5	0.40
5	35	0.583	5.75	1.27	0.23
6	45	0.75	5.61	1.13	0.12
7	60	1	5.07	0.59	-0.52
8	75	1.25	4.93	0.45	-0.79
9	90	1.5	4.84	0.36	-1.02
10	110	1.833	4.53	0.05	-2.99
11	130	2.166	4.48	0	

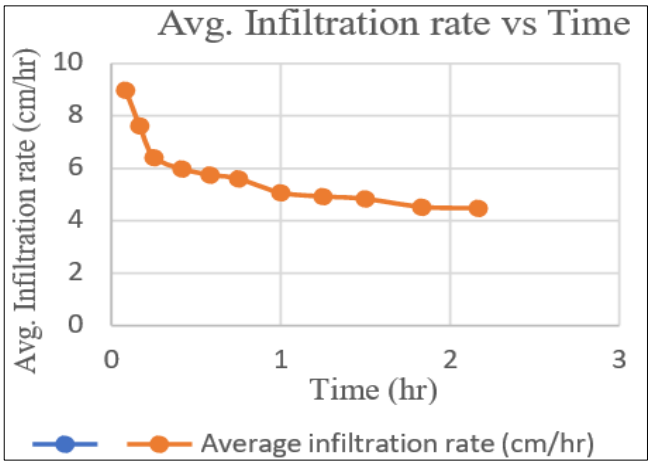

Fig 1: Avg Infiltration rate vs Time

Conclusion

From the present study following conclusions are drawn: From the present study the average infiltration rate for four different plots of Maldad village at an interval of 15 days was found as 5.84 cm/hr. The characteristic constant Fc is found to be 10 cm. In the different plots of selected village, the double ring infiltrometer method was found suitable. The infiltration rate for Maldad village of sangamner tehsil was found to be approximately constant after one and half hour.

From this study it was found that the type of soil of this area is sandy loam and silt loam. The obtained results we conclude that the irrigation methods and cropping patterns will be drip irrigation and sprinkler irrigation methods and crops will be taken were Sweet Corn, Okra, Radishes, Eggplant, Carrots, Pole Beans, Spinach, Beat Root, Onion, respectively.

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