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# Study of Infiltration Characteristics of Locally Soils

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*Abstract:* **Infiltration is defined as the percolation of water through soil and it is an important parameter in the hydrological modelling of runoff, irrigation management, watershed modelling etc. At catchment level, infiltration characteristic is one of the dominant factors in determining the flooding condition. The infiltration rate is determined by soil characteristics including ease of entry, storage capacity, and transmission rate through the soil. The soil texture and structure, vegetation types and cover, water content of the soil, soil temperature, and rainfall intensity all play a role in infiltration rate. In this study, the variation of cumulative infiltration has been studied using double ring infiltrometer by considering Karnal, Kurukshetra and Ambala district of Haryana state. It was observed that there is wide variation in infiltration characteristics. Dimensional analysis can help in determining a systematic arrangement of the variables of the present problem by combining dimensional variables to form non dimensional parameters. An Attempt was made to develop a relationship among the different parameters using dimensional analysis technique and measured cumulative infiltration. Non-linear regression was used to develop relationship between cumulative infiltration and time.**
**Keywords: hydraulic conductivity; infiltration; double ring infiltrometer and water content.**

## 1. INTRODUCTION

Infiltration, which is defined as the percolation of water through soil is an important parameter in the hydrological modelling of runoff, irrigation management, watershed modelling etc (Chahinian, et al., 2005; Dahan, et al., 2007). Infiltration capacity varies in space and time due to soil heterogeneities, meteorological characteristics, clogging processes and temperature fluctuations, as well as other processes. As this is mainly controlled by the top few centimeters of soil, an estimation of infiltration capacity of the topsoil is required for any successful long-term performance of hydro-geological investigations (Pedretti eta al., 2012).

**Chowdary.et al (2005)** has studied the infiltration process under different experimental conditions. In this study, an attempt was made to evaluate the effect of head of ponding, diameter of ring infiltrometer and depth of penetration on cumulative infiltration. The effectiveness of a double ring infiltrometer on reducing lateral flow was also studied. It shows that the lateral component of infiltration is reduced by three to six times with double ring infiltrometer. The excess amount of lateral component estimated with single or double ring infiltrometer is to be taken into account while designing an irrigation system. Further, a dimensionless equation was developed to predict the cumulative infiltration and the results are found very close to the observed data.

## 2. METHODOLOGY

Infiltration rate usually is determined from field data. Many different methods and types of equipment have been used for measuring infiltration rate, but the principal methods are flooding of basins or furrows, sprinkling (to simulate rain), and measuring water entry from cylinders (infiltrometer rings). The rate of subsidence of the water surface, or the rate of flow required maintaining a constant level in a large basin, or a very large ring infiltrometer is taken as a measure of the infiltration rate. If smaller infiltrometer rings are used, the rate of flow or subsidence for the period during which the wetting front is moving downward through the enclosed part of the soil column is taken as the infiltration rate.

In this study a double ring infiltrometer has been used for measuring infiltration.

The instrument essentially consists of:

I. Two rings having diameter 30cm and 60 cm.

II. Total height of the infiltrometer is 30 cm.

III. A steel rod having 4 cm x 4 cm and 70 cm in length.

IV. A hammer of 2.5 kg weight.

V. A spade to collect the remove the sample from site.

VI. A measuring scale having 30 cm in length.

VII. A knife and stopwatch.

VIII. Equipment for writing records.

IX. A sufficient amount of water for reading.

### 2.1 Measurement Procedure

The measurement is taken in the inner cylinder; the outer cylinder is used only as a tool to ensure that water from the inner cylinder will flow downwards and not laterally. Water is supply uniformly inside the ring without disturbance of soil surface. A measuring scale is placed in the inner cylinder note down the initial water level of the inner cylinder .The water level in the outer cylinder is kept at the same level as the water level in the inner cylinder.
The measured data F(t) are then plotted into a graph for the visual check of the measured data. Infiltration rate mm/hr. is also plotted in graph.
The measured data are analysed based on the known Philip's infiltration equations (Philip,1957):

Where F(t) is cumulative infiltration, S is sorptivity, t is time and A is a parameter.
The measurement provide values of F(t) and t in the equation (3.5),the parameter S and A need to be determined, so the line described by equation (3.5) fits the measured points as well as possible. the method of non-linear regression is applied to find out unknown parameter A and S. When parameter A and S are known, infiltration rate f(t) can be calculated for any given time according to the second Philip's equation. Steady-state infiltration rate after a long time of infiltration (the line of the infiltration rate is parallel to the horizontal axis of time) remains constant and its value is close to the value of saturated hydraulic conductivity K.

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Where K is a saturated hydraulic conductivity and m is a constant equal to 0.66667(2/3).the calculated value of K is then used for soil classification according to table 1

**Soil classification according to range of hydraulic conductivity.**

| Soil (according the relative permeable) | Approximate rang of saturated hydraulic conductivity(m) |
|---|---|
| Highly impermeable | $< 10^{-10}$ |
| Impermeable | from $10^{-8}$ to $10^{-10}$ |
| Lowly (poorly) permeable | from $10^{-6}$ to $10^{-8}$ |
| Permeable | from $10^{-4}$ to $10^{-6}$ |
| Highly permeable | $> 10^{-4}$ |

## 3. VARIABILITY OF INFILTRATION CHARACTERSTIC

In this study, an effort has been made to determine the cumulative infiltration and infiltration characteristics by using a double ring infiltrometer.

### 3.1 Details of The Field Study Area

The study area selected is of three districts of the Haryana state. Infiltration tests were conducted in different sites in the Haryana state at different locations. To deal with the infiltration characteristics, the experiments have been carried out at 9 different locations of the study site. For understanding the infiltration properties, experiments have been conducted for 3 hours at each site.

**Fig.1Double Ring Infiltrometer (NIT, Kurukshetra)**

### Variation of Cumulative Infiltration

The experiments were conducted by using double ringinfiltrometer. The outer and inner cylinder of the infiltrometer was both filled with water. But the level of water in the both cylinder is same, the level of water that infiltrates into the soil has been measured. The time in minutes and infiltration in mm has been calculated using the methodology (Phillip's equation). The graph was time in x-direction and cumulative infiltration in y-direction and infiltration rate is also at y-direction. From the equation for the cumulative infiltration curve, different parameters such as coefficients A and S were determined, for determining the hydraulic conductivity of the soil.

### Variation of Infiltration Rate

The infiltration rate is determined from the observed data and the infiltration capacity decreases with time and ultimately, it should reach a constant rate, caused by filling of soil pores with water, which reduces the capillary suction. From the data it was found that all the data points are not converging to a steady state conditions. Hence, all the plots are not considered for further study. The variation of infiltration rate with time is plotted for all the locations. The variation of cumulative infiltration and infiltration rate with time for different location is plotted.

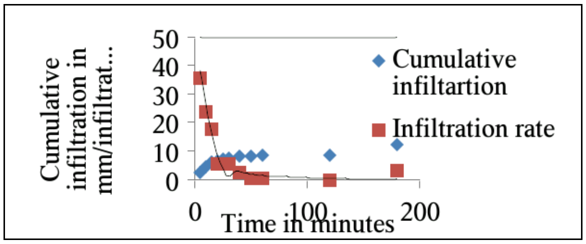


**Fig.2.1 Cumulative infiltration and infiltration rate with time at Ambala City**

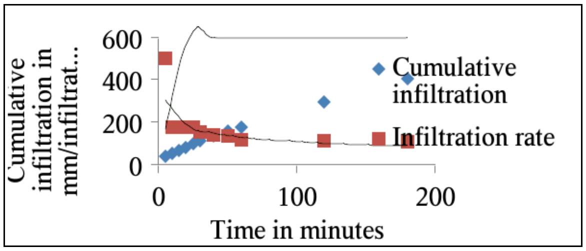


**Fig.2.2 Cumulative infiltration and infiltration rate with time at Ambala Cant**

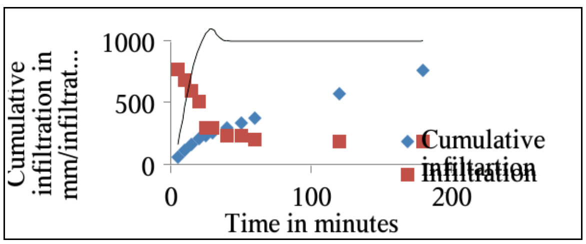


**Fig.2.3 Cumulative infiltration and infiltration rate with time at Markanda river, Shahabad (Ambala).**

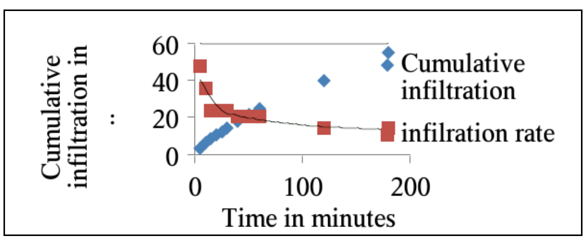


**Fig.2.4 Cumulative infiltration and infiltration rate with time at NIT Kurukshetra**

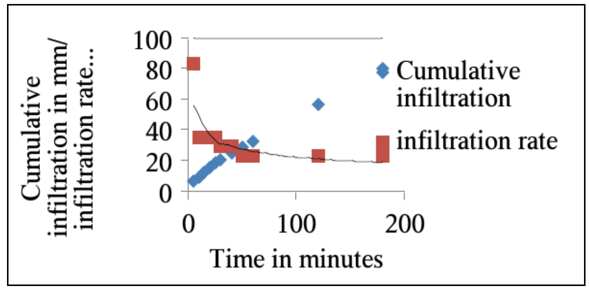


**Fig.2.5 Cumulative infiltration and infiltration rate with time at Dhirpur Vilage (Kurukshetra)**

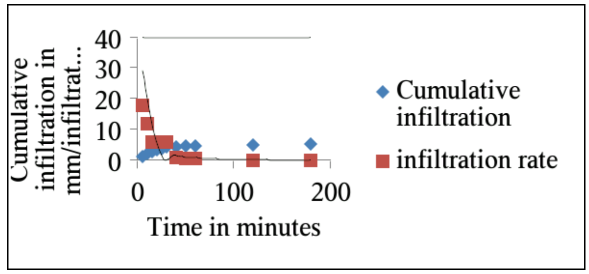


**Fig.2.6 Cumulative infiltration and infiltration rate with time at Shanadi village (Kurukshetra)**

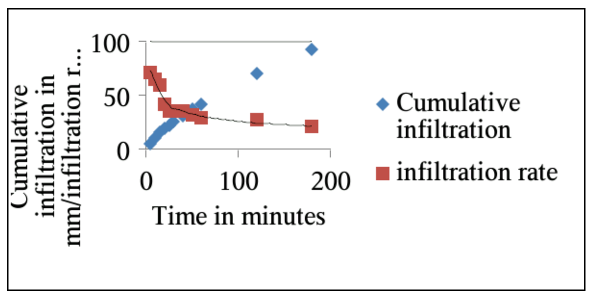


**Fig.2.7 Cumulative infiltration and infiltration rate with time at Sector-5 (Kurukshetra)**

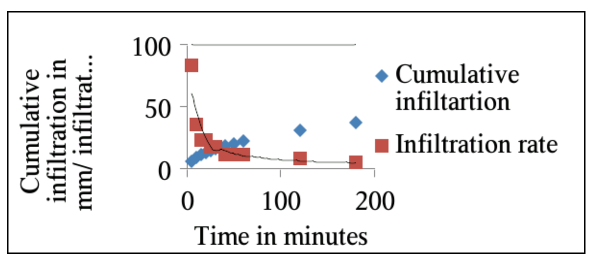


**Fig.2.8 Cumulative infiltration and infiltration rate with time at Sector-7 (Karnal)**

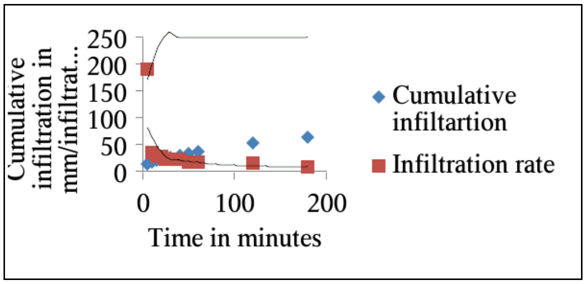


**Fig.2.9 Cumulative infiltration and infiltration rate with time at Nilokheri (Karnal)**

It can be observed that there is a lot of variation in the infiltration rate from time to time. It is mainly due to the meteorological properties also. Initial infiltration rate is very high and after 60 minutes the infiltration rate is low.

**Variation of Hydraulic Conductivity (K)**

The hydraulic conductivity is determined from the value of coefficient A. Hence for understanding the variation of hydraulic conductivity, the variation of A and S are listed in table 3 and the same has been shown in where A is constant and S is sorptivity (Phillip's equation).

| Site Number | Location | S Sorptivity | A (cm/) | K (m/ |
|---|---|---|---|---|
| 1 | Ambala City | 0.1871 | 7.2947E-4 | 1.09E-5 |
| 2 | Ambala Cant | 1.8886 | 1.9515E-2 | 2.92E-4 |
| 3 | Markanda river Shahabad | 5.051 | 0.720 | 1.08E-2 |
| 4 | Nit Kurukshetra | 0.2669 | 2.5488E-3 | 3.82E-5 |
| 5 | Dhirpur village Kurukshetra | 0.2507 | 5.0742E-3 | 7.61E-5 |
| 6 | Shandi village Kurukshetra | 0.1274 | 7.2152E-4 | 1.08E-5 |
| 7 | Sector-5 Kurukshetra | 0.4756 | 4.0867E-3 | 6.12E-5 |
| 8 | Sector-7 Kurukshetra | 0.4334 | 7.2946E-4 | 1.09E-5 |
| 9 | Nilokheri (Karnal) | 0.6560 | 2.4607E-4 | 4.79E-6 |

## 4. RESULTS AND DISCUSSIONS

In Site number 2 and 3, the value of hydraulic conductivity was between $10^{-4}$ – $10^{-6}$ so the soil is permeable and in site number 1,4,5,6,7,8 and 9, the value was less than $10^{-4}$ so the soil is highly permeable.

### 4.1 Cumulative Infiltration

The observations on cumulative infiltration measured on different locations for varying ponding head using double ring infiltrometer at 0.1 m depth of penetration were analysed the process of infiltration and effect of water content and ponding head. The variation of cumulative infiltration with time was plotted for each experimentfrom fig 4.1, it may be observed that power form of relationship between cumulative infiltration F(t) with time (t), similar to Kostikov form of infiltration relationship was found to fit more appropriate for varying ponding head.

Cumulative infiltration measured with 0.3m diameter ring at 0.1m depth of penetration was considered as the cumulative infiltration without lateral flow for180 minof infiltration process. The data of cumulative infiltration and time were used to find the constants k and α from the equation

F (t) = k

**Table 5 relation between k and α by using non-linear regression**

| Site no. | K | A | |
|---|---|---|---|
| 1 | 0.095 | 0.273 | 0.880 |
| 2 | 0.058 | 0.705 | 0.999 |
| 3 | 0.267 | 0.680 | 0.996 |
| 4 | 0.007 | 0.726 | 1 |
| 5 | 0.008 | 0.748 | 0.998 |
| 6 | 0.056 | 0.258 | 0.842 |
| 7 | 0.013 | 0.712 | 1 |
| 8 | 0.054 | 0.457 | 0.999 |
| 9 | 0.101 | 0.447 | 0.992 |

## CONCLUSIONS

From the field study, a large variation in cumulative infiltration has been observed in Haryana and in the same district itself there is a large variation in infiltration parameter particularly saturated hydraulic conductivity. .

1. All the 9 sites have been divided into 2 groups (Permeable and highly permeable) with similar hydraulic conductivity characteristics. It is noted that different infiltration rates are observed for same soil due to the variation in water content.

2. The variation of cumulative infiltration with respect to time is measured by K the value of k and α can be calculated for different location by use of table 6 which has been generated by this study.

3. As water content increases then cumulative infiltration and infiltration rate decreases.

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