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INFILTRATION STUDIES IN INDIA

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PREFACE

Infiltration is an important process in the hydrologic cycle. The understanding of infiltration process and the knowledge of infiltration rates of soils is essential to develop an integrated crop, soil and water management plan. The fact that infiltration process marks the transition from fast moving surface water to slow moving ground water emphasizes its importance in hydrologic investigations.

With the objective of producing thematic maps of infiltration characteristics of soils of India, the National Institute of Hydrology, Roorkee has started the compilation of infiltration data available from all over the country. This report is the first step in this direction. It is expected that this compilation will be helpful in planning further experiments on different soils throughout the country.

This report is based on the field studies conducted by the Regional Centres of the Institute at Jammu and Belgaum and also on the results of field studies obtained from other organisations such as State Ground Water Departments, All India Land Use Survey and Planning, National Bureau of Soil Survey & Land Use Planning etc. This report has been prepared by Dr. Rajiv Sinha, Scientist 'B' and Dr. Sudhir Kumar, Scientist 'C' under the guidance of Dr. K.K.S. Bhatia, Scientist 'F' and Sri B.P. Roy, Scientist 'E' & Head, Hydrological Investigation Division. Sri Rajan Vatsa, SRA and Sri Rm.P. Nachiappan, SRA helped at various stages of preparation of this report.

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DIRECTOR

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ABSTRACT

For optimum and sustainable use of soil, water and land resources, soil infiltration studies are of vital importance. Important hydrological parameters such as surface runoff, soil moisture, evaporation, ground water recharge etc. are influenced by infiltration properties of soils and therefore these studies are important to improve irrigation projects efficiency and drainage design of any particular area.

Infiltration studies in India have been done by a variety of organisations such as State Ground Water Departments, All India Land Use Survey and Planning, National Bureau of Soil Survey & Land Use Planning, National Institute of Hydrology (NIH), Roorkee and its regional centres. But all these studies have been extremely scattered and no compiled document on infiltration properties of soils of the country exist. The main objective of this report is to first produce a compilation of all the existing data on infiltration rates of soils of different states and then to point out the gaps in these studies so that further studies in this field may be planned. The present report first deals with the basic concepts of infiltration and measurement techniques for infiltration rates including recent development in instrumentation for the same. Then, the existing data on infiltration rates of soils have been presented state wise and broad interpretation from these data have been made.

1.0 INTRODUCTION

Infiltration is an important component of the hydrologic cycle and is defined as the process of entry of water through the soil surface. Generally, infiltration has a high initial rate that diminishes during continued rainfall to a nearly constant lower rate. Earlier, the term infiltration was used to denote the difference between rainfall and runoff in small areas. The rate at which water enters into the soil at a given moment is known as the "infiltration rate".

Keeping in view the importance of infiltration process in the hydrologic cycle, the National Institute of Hydrology has taken up the task of producing an infiltration map of India similar to the landuse, soil type, rainfall, and evapotranspiration maps. For this, the infiltration data from all over the country is proposed to be collected through field experiments. As a first step, it was decided to compile the data/ information already available with various agencies/ organisations and to identify the existing gaps before starting the experiments on different soils throughout the country. The task of compiling complete information relating to infiltration is very difficult. The correspondence and visits were made to various organisations involved in the infiltration studies and the information obtained has been presented in the report. Undoubtedly, the complete data/information could not be compiled. Even then, this report presents an useful documentation of the status of infiltration studies in India, in particular, and the state of art of the infiltration technology, in general. The report will prove to be a handy document for the scientists and researchers working in the area of land, water and vegetation management.

2.0 INFILTRATION : DEFINITION AND CONCEPTS

Quantitatively, infiltration rate is defined as the volume of water passing into the soil per unit area per unit time (Fig.1a)and has the dimension of velocity (L/T). This rate depends on number of factors viz. physico- chemical properties of the soil, vegetation and landuse pattern, rainfall intensity and duration, and surface slope. Under special circumstances wherein the rainfall exceeds the ability of the soil to absorb water, infiltration proceeds at a maximal rate which is called soil's "infiltration capacity" (Horton, 1940). This term is not an apt choice as pointed out by Richards (1952), since it implies an extensive aspect rather than an intensive aspect as is more appropriate to a flux. More recently, Hillel(1971)has coined the term "infiltrability" to designate the infiltration flux resulting when water at atmospheric pressure is made freely available at the soil surface. This single word replacement avoids the extensity-intensity contradiction in the term infiltration capacity and allows the use of the term infiltration rate in the ordinary literal sense to represent the surface flux under any set of circumstances.

2.1. Infiltration and hydrology

Infiltration rate is of great interest to the hydrologist as it influences many of the hydrological parameters, such as, surface runoff, soil moisture, evaporation and evapotranspiration, ground water recharge and spring flow rates. It is also of interest to the agriculturists and conservationists/ environmentalists. The knowledge of infiltration properties can help agriculturists in adopting proper irrigation methods and irrigation schedule. The conservationists/ environmentalists can derive the information on soil erosion (as runoff depends on infiltration) and in turn the sedimentation rate in reservoirs using the infiltration data.

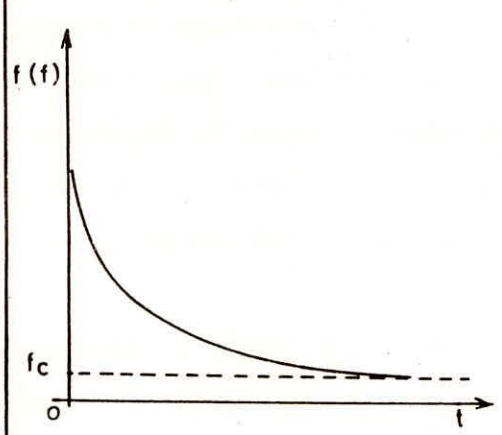


Fig. 1(a)- Typical Infiltration Curve.

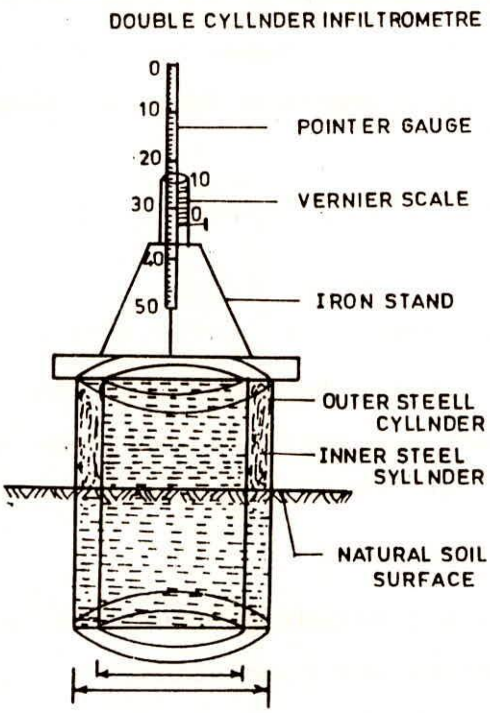


Fig.1(b) Equipment Measuring. Infiltration Rate

Infiltration is one of the most important processes responsible for modifying precipitation and converting it to runoff and additions to soil moisture storage. The infiltration process and other hydrological processes are inter-related through a common dependence on soil moisture conditions. Thus, simulation of any hydrological system can not be achieved without taking into account the infiltration process.

Infiltration studies are mainly addressed to variety of applications for managing water resources. The design of methods for flood mitigation and erosion control are often based on estimates of peak discharge derived from predictions of infiltration rate. Water conservation procedures require computation of cumulative infiltration to produce estimates of runoff yield. Similarly, in exploiting water resources for plant growth from rainfall or irrigation, an assessment of cumulative infiltration becomes necessary for calculation of an optimal level of productivity. This assessment embodies efficient water use and maintains an acceptable level of erosion control.

2.2. Factors affecting infiltration

Once the importance of infiltration process has been established, it is useful to go into the details of various factors which affect the infiltration. Some of the most common factors affecting infiltration are as follows :

(i) Soil properties (including structure, grain size and its distribution, porosity and compactness)
(ii) Soil moisture
(iii)Landuse characteristics
(iv) Rainfall (amount and duration)
(v) Soil surface slope , and
(vi) Climate

The following sections deal with these aspects in detail.

2.2.1. *Effect of soil properties*

Musgrave and Horton (1964) have shown that infiltration characteristics are affected by the grain size distribution in the soil. In sands, the grains are relatively stable, while soils with appreciable amounts of clay may provide large pores but swells appreciably upon wetting. During a storm, sands may slowly rearrange themselves into a more dense mix than before. In silts and clays, the soil aggregates break due to the impact of raindrops, causing the clay and silt particles to flow and penetrate the existing pores, thus clogging them and greatly reducing infiltration.

Rauzi and Fly (1968) found that the unfavorable surface soil conditions markedly reduce water intake rates. They found that compact or blocky clay sub soils have low intake rates. Clay soils with good structure have an intake rate 3-4 times more than that of the dense clay soils with poor structure. Therefore,the degree of surface soil compactness is a major factor affecting infiltration rate. Agrawal et al (1974) studied the soils in the Hissar region, India and observed that as the sand content decreased and silt plus clay content increased, infiltration rate decreased. However, the Hissar sandy loam soils had lower infiltration than the Saffidon loam soils due to unstable structure.

Many experiments have shown that size and distribution of pores are greatly influenced by the organic matter content which controls the stability of soil aggregates in water. The addition or removal of organic matter therefore changes the prevailing permeability.

2.2.2. Effect of Soil Moisture

Horton (1940) studied the maximum and minimum infiltration rates of a soil and concluded that the maximum infiltration rate for a given soil occurs at the beginning of the rain. Horton further indicated that the infiltration rate decreases rapidly because of changes in the surface soil structure and increase in soil moisture, and then, gradually approaches to a somewhat stable minimum value. Powell and Beasley (1967) reasoned that when the soil is dry an initially high infiltration rate is primarily the result of the filling of the pore spaces larger than the capillary size. Once these pores are filled, the infiltration is due to the advance of water by capillary potential.

Green (1962) also concluded that surface sealing diminishes the effect of antecedent moisture on infiltration because the hydraulic conductivity of immediate soil surface controls water flow into the soil and surface sealing does not allow suction gradients to control the rate of infiltration.

2.2.3. Effect of landuse

Musgrave and Horton (1964) established that vegetation is one of the most significant factors affecting infiltration of water. Vegetation protects the soil surface from rainfall impact. Massive plant root systems, such as grass, keeps the soil unconsolidated and porous. The organic matter from crops promotes a crumb structure and improves permeability. Forest litter, crop residues and other humus material protect the soil surface.

The density of herbaceous vegetation is closely related to infiltration. Packer(1951) for instance found that the percent of the soil covered by living or dead plant remains was closely related to runoff, and therefore, to infiltration. Fibrous-rooted vegetation, such as wheat grass, has been found to be much more effective in controlling runoff than tap-rooted annual weeds (Lull 1964).

The great influence of vegetation cover on infiltration is further evidenced by the fact that bare-soil infiltration capacity can be increased 3 to 7.5 times with good permanent forest or grass cover, but little or no increase results with poor row crops (Jens and McPherson, 1964).

2.2.4. Effect of Rainfall

Linsley et al (1949) have reported that rainfall intensity has little effect on the rate of infiltration when it exceeds the capacity rate. This agrees with the findings of Schreiber and Kineaid (1967), but disagrees with those of Fletcher (1960). Willis (1965) has found that the infiltration rate of a bare soil was reduced by an increase in Kinetic Energy of rainfall which is the function of the velocity of impact of raindrops and of the rainfall intensity. Local experiments on the variation of infiltration capacity with rainfall intensity showed predominant variation for bare soil, as noted by Horner and Jens (1942), and a lesser amount of variation for sodded areas.

Duley and Kelly (1939) found that when the rate of water input was sufficient to give runoff, a fairly definite amount of water entered the soil and any excess of this intake appeared in the runoff. He observed that the rapid reduction in the rate of intake by cultivated soil, as rainfall continuously fell on the soil surface, was accompanied by the formation of a thin, compact layer at the soil surface, and that the water was able to pass this layer very slowly. He postulated that this thin, compact surface layer was apparently the result of severe structural disturbance due in part to the beating effects of the rain-drops, and in part, to an assorting action, as water flowed on the soil surface, fitting fine particles around the larger once to form a relatively impervious seal.

2.2.5. Effect of Soil Surface Slope

Duley and Kelley (1939) tested soils on different slopes and noted that there was a tendency for the amount of water intake to decrease slightly with increase in slope. The greatest intake was found on gentle slopes.

2.2.6. Effect of climate

Apart from rainfall, the most important climatic effect on infiltration is due to freezing effects. Frozen ground affects infiltration. If frozen when very dry, some soils are fluffed up and frost is discontinuous, as in the honey comb and stalactite types. A soil under this condition may be as permeable as, or even more permeable than, frost-free soil. On the other hand, if the soil is frozen while saturated, concrete frost often results in the form of a very dense, nearly impermeable layer often results. Trimble (1958) found that in the North East infiltration was zero on concrete frost in the open and forest area, but was not affected where soil was transversed by large holes in which water had not frozen.

3.0. INFILTRATION ESTIMATION AND MEASUREMENT TECHNIQUES

The estimation of infiltration rates is required for the calculation of runoff for design purposes and also for assessing the effect of land use changes. The three step sequence, i.e. surface entry, transmission and exhaustion of storage presents difficulties in the measurement of infiltration. For the most part, hydrologists determine the rate and amount of infiltration in-soak and attempt to correlate this with various combinations of soil, vegetation and antecedent soil moisture. There are two general approaches to determine the infiltration capacity of a soil cover and soil moisture complex. One of these is the analysis of hydrographs of runoff from natural rainfall on plots and watersheds. The other is the use of infiltrometers with artificial application of water to enclosed sample areas.

3.1. Empirical relations for estimation of infiltration rate

Many empirical and physical relationships have been developed to express infiltration/recharge as a function of amount of clay in the soil or amount of the total quantity of water infiltrated into the soil. The empirical equations or models have been developed by applying the principles governing soil water movement for simplified boundary or initial conditions. These models generally correlate infiltration as measured by one of the methods to some property or properties of the soil vegetative system. This involves evaluation of constant or parameters for a specific geographical location. The physically based models on the other hand are more complicated and use the theory of continuity of mass and soil water movement with certain simplified assumptions. They normally employ numerical methods for the solution of governing differential equations and are extremely valuable in analysing the effect of various factors on the infiltration process. The use of a particular equation or model depends on the intended purpose and the accuracy desired.

In the Indo-Gangetic plains, an empirical exponential relationship between fractional recharge (infiltration capacity) and clay content of the soil has been developed (Datta, 1975; Goel et al, 1977).

$$F = 0.40 \exp (-0.046 \, . \, Acp),$$

where F = Recharge (infiltration capacity), and

Acp = Average clay content of soil in percent.

Two more empirical formulae are used in the Indo Gangetic plains, commonly known as the Amritsar Formula and the Chaturvedi formula for recharge. The Amritsar formula has been developed for Upper Indus basin (in Punjab), whereas the Chaturvedi formula is for Upper Yamuna basin.

Amritsar formula : $Re = 3.9(p-40.6)1/2$ (Sehgal, 1973)

Chaturvedi formula $Re = 3.5(p-38)2/3$ (Chaturvedi, 1946)

where, Re = Estimated groundwater recharge in cm.

p = Precipitation + supplemental irrigation in cm.

3.2. Infiltrometers

Infiltrometers are the simplest and the most convenient equipment to measure infiltration rate for soils which involves artificial application of water to enclosed areas. Infiltrometers can be classified into two general groups :

A. Rainfall Simulators, with the water applied in the form and at the rate comparable with natural rainfall, and

B. Flooding type, with the water applied in a thin sheet upon an enclosed area and usually in a manner to obtain a constant head.

In India only flooding type infiltrometers are used, which may vary in size, quantity of water required, and measuring device for water level changes. Among the two types of flooding infiltrometers, mainly double ring infiltrometers are used, but sometimes single ring infiltrometers are also used.

3.2.1. Single Ring Infiltrometer

It consists of a metal cylinder which is driven into the soil to a short distance (nearly 15 cm). The measurement of infiltration is done by observing the rate of fall in water surface through a graduated column, or by adding water manually at selected time intervals to maintain a particular level. Refinements to the technique involve the introduction of an outer ring as a buffer and devices for monitoring a constant head of supply

3.2.2. Double ring Infiltrometer

The most common type consists of two shallow concentric rings of sheet metal (Fig.1b), usually ranging from 22.5 to 90 cm diameter. They are placed with their lower edges a few cms below the ground surface and with the upper portion projecting above (as shown in Fig.1b). Water is now applied in both compartments 'a' and 'b' and is always kept at same level in both. The function of the outer ring is to prevent the water within inner space from spreading over a larger area after penetrating below the bottom of the ring. From the rate at which water is added to the inner ring in order to maintain a constant level, the infiltration rate and its variation with time are determined. A plot of infiltration rate in cm/hr vs time is shown in Fig.1a.

3.3. Recent Developments in Infiltrometers in India

There have been significant technological developments in the infiltrometers in India with a view to automatize the operation and thus to minimise the errors in the field. However, presently they are in resting stage.

3.3.1. Microprocessor-based Ring Infiltrometer

The National Institute of Hydrology, Roorkee has developed a Microprocessor based Ring Infiltrometer which is a double ring (flooding type) infiltrometer with an electronic recording device, developed by National Institute of Hydrology, Roorkee. In this infiltrometer, a 8085 microprocessor has been used in the memory module to store the infiltration rate data automatically at a pre-determined time step. This portable device can record upto 1000 values. A special constant head device based on Marriot's arrangement has also been developed to maintain a constant head in the rings. The main advantage of this type of infiltrometer is its easy operation. Once the equipment is installed in the field, no skilled personnel is required for taking the readings during the infiltration test. Human errors are minimised to a great extent by this automation of the infiltrometer. The data stored in the microprocessor can be retrieved directly on to a personal computer and can be analysed easily.

3.3.2. Portable Rainfall Simulator Infiltrometer

Bhardwaj and Singh (1992) have developed a portable rainfall simulator infiltrometer at the Indian Institute of Technology, Kharagpur. The design of this rainfall simulator infiltrometer is based on the existing designs of Adam et al. (1957) and Tricker (1979) and it incorporates some modifications to improve field performance and portability. The portable rainfall simulator infiltrometer consists of the following principal components (i) Drop forming mechanism, (ii) Water reservoir, (iii) Pressure head regulator, (iv) Wind shield and stand, and (v) Infiltration cylinder and runoff collector. Though a number of rainfall simulator infiltrometers are available, the main advantage of this new infiltrometer is its portability (weighs about 15 kg).

4.0. INFILTRATION STUDIES IN DIFFERENT STATES OF INDIA

India is a vast country with a total geographical area of 329 million hectare. As per the available information infiltration studies have been carried out in few states and that too at few places. The present status of infiltration data available for different states is present next.

4.1.Andhra Pradesh

The infiltration tests were carried out by All India soil and land use survey organisation for 75 soil series. Data available for Andhra Pradesh are reproduced in Table 4.1.1.

Table 4.1.1 : Infiltration data for Andhra Pradesh

District	Taluk	Village	Soil series	Infilt. rate (cm/hr)
Adilabad	Mudhol Nirmal	Mahagaon	Basar	5.4
Medak	Sangareddy	BudaPalli	Debbavagu	3.0
Adilabad	Mudhal Nirmal	Mahagaon	Ekgaon	1.8
Guntur	Palnad	Sirigiripadu	Loyapalli	8.7
Medak	Zahcerabad	PeddachelMada	Mamdapur	8.2
Adilabad	Mudhol Nirmal	Pardi	Masalga	1.3
Adilabad	Mudhol Nirmal	Mahagaon	Mogli	1.9
Adilabad	Mudhol Nirmal	Mahagaon	Mudhol	1.0
Adilabad	Mudhol Nirmal	Mahagaon	Nimba	2.9
Guntur	Palnad	Sirigiripadu	Palli	10.9
Adilabad	Mudhol Nirmal	Mahagaon	Pardi	1.3
Medak	Zaheerabad	Pipalpalli	Pipalpalli	3.8
Guntur	Palmad	Sirigiripadu	Srigiri	1.7
Adilabad	Mudhol Nirmal	Mahagaon	Tanur	1.8
Adilabad	Mudhpol Nirmal	Kotalgaon	Timmapur	0.8
Adilabad	Mudhol Nirmal	Hald	Yelwi	4.2

An interesting observation from Table 4.1.1 is that whereas the highest infiltration rates of 10.9 cm/hr and 8.7 cm/hr are recorded in the Guntur district at Sirigiripadu village for Palli and Loyapalli soil series respectively, the same locality also records one of the lowest value (1.7 cm/hr) for Sirigiri soil series. Although no data is available about the soil type at these localities, this large variations may be related to the grain size distribution at different test sites.

4.2. Bihar

The data on Infiltration for the Bihar state extracted from the Publication of All India Soil and Land Use Survey "Infiltration Studies in 75 Soil Series is presented below:

Table 4.2.1 : Infiltration data for Bihar

District	Village	Soil series	Infilt. rate (cm/hr)
Santhal Pargana	Belkupi	Hatiapathar	4.2
Santhal Pargana	Bahiata	Jarmundi	0.8
Santhal Pargana	Lachnipur	Lachnipur	12.0
Santhal Pargana	Singlibad	Pubaro	6.8

4.3. Delhi

The infiltration studies carried out by All India soil and land use organization are presented below:

Table 4.3.1 : Infiltration data for Delhi

District	Taluk	Village	Soil series	Infilt. rate (cm/hr)
Delhi	Mehrauli block	Bijwasan	Asola	1.8
Delhi	Mehrauli block	Bijwasan	Bijwasan	2.2
Delhi	Mehrauli block	Bijwasan	Khanpur	5.8
Delhi	Mehrauli block	Rajokari	Maidangarhi	4.8
Delhi	Mehrauli block	Malawan	Malwan	0.8
Delhi	Mehrauli block	Bharthal	Naib Sarai	2.8
Delhi	Mehrauli block	Rangpuri	Shoorpur	1.1

All the data in the Table 4.3.1 come from the Mehrauli block from different soil series leading to a large variation in infiltration rates. The highest and lowest infiltration rates are 5.8 cm/hr and 0.8 cm/hr respectively.

4.4 Gujarat

The infiltration data available for the Gujarat state, presented in Table 4.4.1, have been grouped as per soil texture. The lowest and highest infiltration rates for coarse to medium textured soils are 0.38 cm/hr and 14.22 cm/hr respectively, for medium textured soils are 0.34 cm/hr and 8.05 cm/hr respectively, for coarse to fine textured soils are 0.03 cm/hr and 9.13 cm/hr, for medium to fine textured soils are 0.06 cm/hr and 5.43 cm/hr and for fine textured soils the values are 0.05 cm/hr and 0.34 cm/hr respectively.

Table 4.4.1 : Infiltration data for Gujarat state

Soil texture	District	Taluk	Infilt. rate (cm/hr)
Coarse to medium	Baroda	Chhotaudepur	0.9-1.16
	Panchmahal	Bariagodhra	0.38-5.43
	Kheda	Kopadvan	3.35-16.62
	Sabarkantha	Idar	0.83-5.79
	-do-	Meghraj	0.38-3.84
	-do-	Malpur	1.38-2.50
	Banaskantha	Palanpur	14.22
	-do-	Dhanera	0.86-10.35
	-do-	Vadgam	3.15-21.61
	-do-	Dhanera	1.45-11.70
	-do-	Palanpur	2.4-11.9
	Kachchh	Nakhtrana	4.6-14.3
	-do-	Bhuj	0.21-8.80

Medium	Panchmahal	Lunawada	0.34-4.68
	Sabarkantha	Bayad	0.82-8.05
	-do-	Khedbrahma	0.49-1.52
	-do-	Modasa	1.48-8.62
	-do-	Vijaywad	0.06-1.96
	Banaskantha	Danta	1.78-2.47
	Amreli	Kodinar	0.9-6.0
	Junagadh	Veraval	0.10-0.60
Coarse to fine	Valsad	Dharampur	0.03-1.74
	Bharuch	Nadod	0.07-4.70
	Baroda	Chhotaudepur	0.49-3.32
	Baroda	Jeppur	0.03-1.17
	Panchmahal	Halol	0.30-1.52
	-do-	Kalol	0.16-9.13
	-do-	Godhra	0.34-2.18
	-do-	Limkhada	0.71-4.21
	-do-	Jhalod	0.44-4.08
	-do-	Devgadh	0.5-3.6
	-do-	Santrampur	0.069-3.7
	-do-	Zalod	0.15-6.1
	-do-	Santrampur	0.06-1.15
	-do-	Devgadh	0.35-7.65
Medium to fine	Dangs	Ahwa	0.55-0.81
	-do-	-do-	0.35-1.18
	-do-	-do-	0.41-2.16
	Valsad	Vansada	0.10-0.36
	-do-	Dharmpur	0.079-1.29
	-do	-do-	0.12-0.65
	-do-	-do-	0.10-0.74
	Surat	Mangrol	0.41-1.80
	-do-	Vyara	0.03-0.97
	Dangs & Surat	Sangadh	0.24-0.48
	Surat	Nizar	0.09-0.70
	-do-	Mangrol	0.37-0.54
	-do-	Vyara	0.09-0.52

	Bharauch	Saghra	0.06-0.79
	-do-	Dediapada	0.15-1.22
	-do-	-do-	0.07-0.52
	-do-	-do-	0.076-0.11
	Baroda	Naswadi	0.086-0.52
	Baroda	Chhotaundepur	0.24-1.51
	Panchmahah	Devagadh	1.13-3.85
	Kheda	Thasara	0.09-0.79
	Ahmedabad	Ahmedabad	0.02-4.38
	-do-	-do-	0.10-5.45
	Sabarkantha	Himatnagar	0.32-8.16
	-do-	Bhiloda	0.024-4.11
	Banaskantha	Danta	0.29-4.31
	Rajkot	Rajkot	0.14-0.36
	Rajokot	Padadhari	0.08-2.68
	Rajkot	Morbi	0.45-4.30
	Rajkot	Padadhari	0.07-0.64
	Rajkot	Upleta	0.18-4.52
	Bhavnagar	Ghoga	0.06-1.9
	-do-	-do-	0.20-0.38
	-do-	Savarkundala	0.39-2.54
	-do-	Palitana	0.32-1.85
	Jamnagar	Lalpura	0.4-4.4
	Jamnagar	Bhanvad	0.21-6.97
	Junagadh	Una	0.06-4.55
	-do-	Junagadh	0.08-1.35
	Junagadh	Bhesan	0.16-0.92
	Rajkot	Paddhari	0.12-0.28
	Dangs	Ahwa	0.12-0.34
	Jamnagar	Jodia	0.02-0.11
	Rajkot	Paddhari	0.09-0.22
	Rajkot	Khambhali	0.12-0.56
Fine	Valsad	Vansda	0.07-0.17
	Surat	Mangrol	0.20-0.67
	-do-	Mandvi	0.05-0.12
	-do-	Mangrol	0.22-0.34

Baroda	Chhotaudepur	0.08-0.12
Ahmedabad	Dhandhuka	0.097

4.5. Jammu and Kashmir

Infiltration studies have been carried out by the Western Himalayan Regional centre of NIH at Jammu (NIH Technical Report no. 163) and the results are reproduced in Table 4.5.1. Field tests were conducted at different locations (Fig.2) for soils under different landuses such as bare, agriculture, grass and forest lands. It was observed that the initial infiltration capacities for bare, agriculture, grass and forest land varied from 12.0-18.0, 17.0-24.0, 12.0-36.0, and 18.0-72.0 cm/hr. The final infiltration capacities for the same landuses varied from 0.3-2.4, 1.2-3.0, 0.3-6.3, and 0.6-1.2 cm/hr respectively. Further, the infiltration curves for different soils for Jammu region were developed and it was concluded that the average initial infiltration capacity was highest for sandy loam soils in the study area.

Table 4.5.1 :Infiltration rates for soils in Jammu region

Landuse	Site	Soil Type	Infilt. rate (cm/hr)
Bare land	Hiranagar	Silt Loam	0.60
	Mansar	Clay Loam	2.40
	Pounichak	Silt Loam	0.70
	Rui	Sandy Loam	0.30
Agricultural Land	Palas	Silt Loam	1.20
	Billawar	-----	1.20
	Domana	Loam	3.00
Grass Land	Akhnoor	Clay Loam	1.20

Fig. 2. Index Map Showing Test Sites of Jammu Region

	Birpur	Loam	0.30
	Jandrah	Clay Loam	0.90
	Kathua	Sandy Loam	0.60
	Miraliya	Clay Loam	6.30
	Miransaheb	Clay Loam	0.70
	Ramnagar	Clay Loam	0.70
	Surinsar	Clay Loam	3.00
	Nagrota	Silt Loam	5.00
Forest Land	Palas	Silt Loam	0.70
	Kud	Loam	1.20
	Manthal	Loam	0.60

4.6. Karnataka

The Infiltration studies carried out by All India Soil and Land use Survey organization are presented in Table 4.6.1.

Table 4.6.1 : Infiltration data for Karnataka

District	Taluk	Village	Soil series	Infilt. rate (cm/hr)
Bidar	Bidar	Almapur	Basanthpur	12.00
Bidar	Aurad	Jamgi	Chimkod	7.3
Bidar	Bidar	Almapur	Gadgi	8.5
Bidar	Aurad	Wadgaon	Kundagol	2.2
Bidar	Bidar	Almapur	Malegaon	12.8
Bidar	Bidar	Almapur	Nandgaon	6.0
Bidar	Aurad	Sorhally	Sorhally	2.8
Bidar	Aurad	Kowtha	Sulttanpur	1.8

Rao and Karanth (1988) have carried out studies on infiltration characteristics in the Budigere basin. The map of the basin along with infiltration test sites are shown in Fig.3a. The experiments were carried out in stream beds, tank beds, cultivated areas, and uncultivated areas to study the relative infiltration characteristics. Figure 3b shows the typical infiltration capacity curves for the area. Using Horton's equation, the initial rate of infiltration and k were obtained and are tabulated in Table 4.6.2.

Table 4.6.2 :Infiltration test data for the Budigere basin

Location	Soil type	Duration of test (min.)	Int. rate (cm/hr)	Final rate (cm/hr)	k (hr^{-1})
Stream bed					
Manchappanahalli	Sand	240	49.8	34.0	2.226
Gummanhalli	-do-	300	34.6	22.5	1.240
Bandakodiganahalli	-do-	300	22.7	12.0	2.940
Arsinakunte	Sand & silt	240	3.8	0.6	2.082
Huvinaikanahalli	-do-	200	6.5	0.6	2.688
Settigere	-do-	240	33.7	1.4	2.988
Daddajala	-do-	300	9.2	1.0	3.024
Minakunte Hosur	-do-	300	38.0	13.5	1.878
Tank bed					
Gummanahalli	Silty clay	330	4.7	2.0	1.218
-do-	-do-	360	4.9	1.3	1.038
Manchappanahalli	-do-	350	3.2	0.3	1.980
-do-	-do-	285	3.3	0.4	1.980
Budigre	-do-	420	6.0	2.4	0.894
-do-	-do-	270	3.7	0.5	1.374
Bagalur	-do-	300	4.2	0.8	1.728
-do-	-do-	330	8.1	2.4	0.863
Bandakodiganahalli	-do	300	9.4	3.0	2.082
-do-	-do-	340	8.2	1.8	2.082
Doddojala	-do-	340	11.0	1.2	1.878
Chikkajala	-do-	330	4.0	2.0	2.433

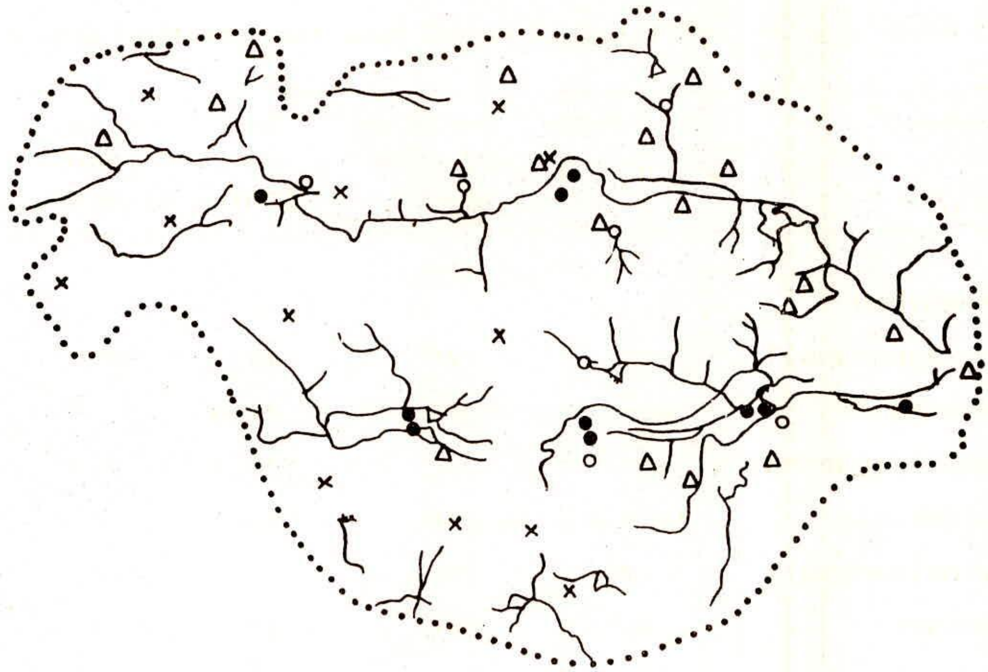


FIG.3a : MAP OF BUDIGERE BASIN SHOWING INFILTRATION TEST SITE

o STREAM BED
x CULTIVATED LAND
Δ UNCULTIVATED LAND
● TANK BED

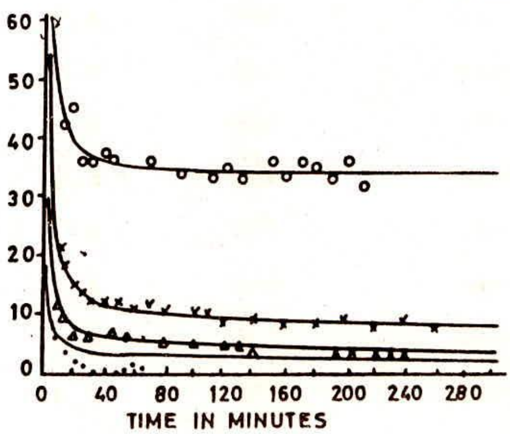


FIG.3b:TYPICAL INFILTRATION CAPACITY CURVES

Cultivated fields					
Manchanappanahalli	Red loam + silt	300	18.3	3.2	1.782
Begur	do	240	9.1	0.6	1.470
Marenahalli	do	300	18.1	8.0	1.218
Chokkanahalli	do	320	39.5	13.0	0.852
Japalatti	do	360	24.3	10.0	1.746
Doddajala	do	280	85.0	25.0	2.130
Satanur	do	360	20.3	6.0	1.56
Gummanahalli	do	332	28.1	18.0	0.558
Bandakodiganahalli	do	330	8.5	4.8	2.510
Bainhalli	do	300	6.6	3.0	5.374
Gadenahalli	do	300	4.6	2.4	3.892
Yertigenehalli	do	300	5.9	1.8	4.512
Narayanapura	do	300	5.3	1.2	2.433
Vidyenepur	Loam, silt+ sand	300	20.0	7.5	4.828
Misiginahalli	Red loam + silt	240	7.1	3.0	2.337
Uncultivated land					
Chowappanahalli	silty loam	300	14.2	5.8	1.434
Bagalur	do	300	9.2	3.6	1.158
Budigere	do	360	5.3	1.6	2.916
Sibgahalli	do	240	7.1	3.0	2.337

Ranganna et al (1991) conducted infiltration tests using Double Ring Infiltrometer in the Pavanje River Basin of Dakshina Kannada District, Karnataka. Figure 4a shows the Pavanje river basin with infiltration test sites. Table 4.6.3 summarizes the infiltration data and the representative infiltration curves are shown in Fig.4b. Using Horton's equation (Horton, 1933), initial and final rate of infiltration were computed (Table 4.6.3). In general, the infiltration rates exceeded 2.5 cm/hr. The large variability in the infiltration rate was attributed to soil type, moisture content and underlying lithology.

Table 4.6.3 : Infiltration data for Pavanje basin, Karnataka

Location	Soil type	Duration of test (min.)	Int.infil rate (cm/hr)	Fin.infil. rate (cm/hr)
KERC campus	Laterite	180	16.08	6.80
KERC campus	Laterite	155	20.16	2.80
KERC campus	Laterite	225	18.00	4.16
KERC campus	Laterite	266	24.00	7.28
KERC campus	Laterite	325	18.00	4.50
Haleyangadi	Loamy sand	240	18.96	1.76
Chelairu Padavu	Laterite	180	15.84	3.76
Tokuru Kemral	Laterite	195	21.84	3.12
Tokuru	Laterite	135	06.00	2.23
Bajpe	Laterite	225	22.00	4.80
Permude	Sandy soil	270	64.80	19.28
Kompadavu	Laterite	195	17.52	6.64
Mijar	Laterite	210	12.00	2.80
Niddodi	Laterite	195	15.84	2.00
Katil	Laterite	225	14.50	1.60
Chitrapu	Sandy soil	300	54.48	20.80
Yekkar	Laterite	180	17.81	3.20
Bellairu	Sandy clay	120	11.76	3.24
Surinje	Sandy clay	-	28.19	5.83
Mennabettu	Clay soil	-	3.35	0.57

It is observed from Table 4.6.3 that the infiltration rates are the highest in sandy soils (20.8 cm/hr, Chitrapu station) followed by 19.28 cm/hr at Permude station. But the infiltration rates do not have any apparent relationship with topography. Statistical analysis was also carried out to know the relations between each infiltration test. The mean, median, and range values for f_o, f_c, and k in respect of all 20 tests are graphically represented in Fig.4c.

The NIH Regional Centre at Belgaum has conducted infiltration tests in the Malaprapha and Ghataprapha sub-basin and the data are reproduced in Tables 4.6.4 and 4.6.5.

Table 4.6.4 : Infiltration Test Data for Malaprabha Sub-Basin

Site	Taluk	Soil Type	Infil. rate (cm/hr)
Kankumbi	Khanapur	Laterite mixed Forest	5.86
Jamboti	Khanapur	Lateritic forest soil	3.63
Khanapur	Khanapur	Granitic Clayey Sandy	2.06
Avradi	Bailahongal	Black Cotton Soil	5.80
Savatgi	-do-	Red Sandy Soil	4.80
Bubarkatti	-do-	Silty clay	1.50
Gudikatti	-do-	Red Sandy Soil	5.40
Narendra	Dharwar	Red Laterite Soil	2.80
Gumgol	Navalgund	Black Cotton Soil	1.20
Shirkol	-do-	-do-	1.20
Bhadrapura	-do-	-do-	1.20
Kondikoppa	-do-	-do-	3.90
Kadadi	Gadag	-do-	0.90
Ron	Ron	-do-	1.90
Jakkali	Ron	-do-	2.80
Itagi	Ron	-do-	2.70
Gajendragarh	Ron	Clayey Loam	1.20
Timmapur	Badami	Black Clay Loam	3.20
Agsarkoppa	-do-	Black Cotton Soil	1.40

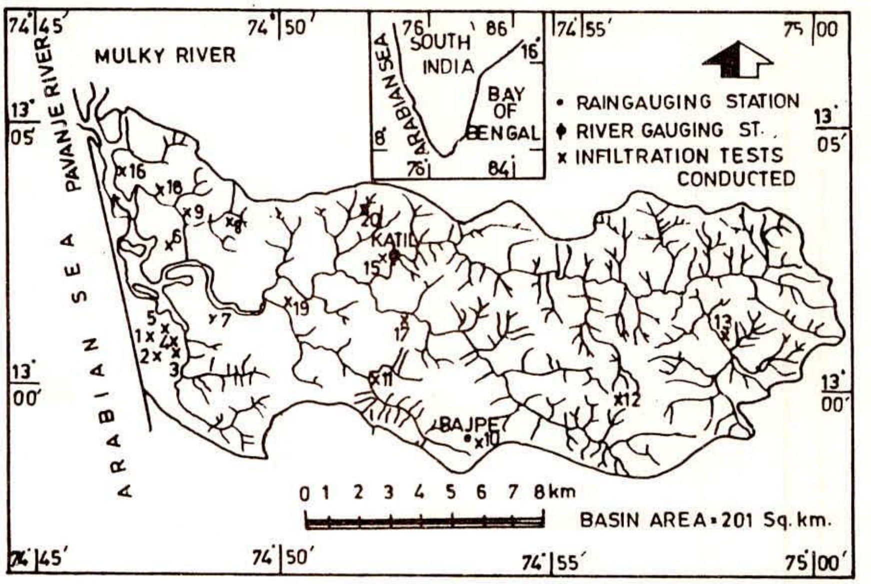


Fig.4(a) Pavanje River Basin Showing Infiltration Test Sites

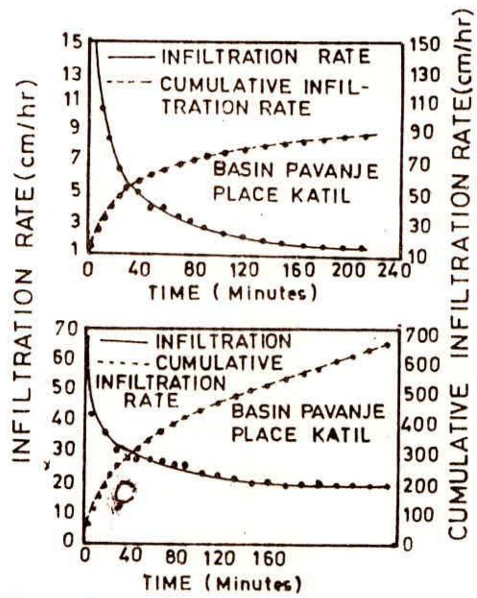


Fig.4(b) Infiltration Curve

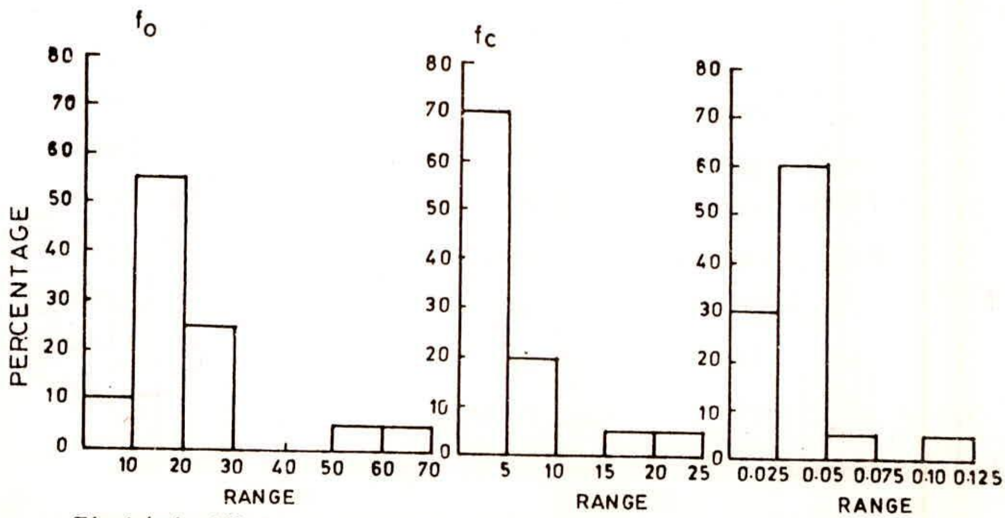


Fig4(c) Histograms Showing f_o, f_c and k

Kankankoppa	-do-	Mixed Clayey Loam	0.80
Murdi	-do-	Clayey Loam	1.60
Nandikeshwar	Hungund	Mixed Clayey Loam	1.40
Kelur	-do-	Mixed Sandy Loam	23.10
Badami	Badami	Red Sandy Loam	9.60
Asoga	Khanapur	Heavy Loam	3.00
Jamboti	-do-	Medium Loam	2.40
Kankumbi	-do-	Sandy Loam	3.00
Kankumbi	-do-	-do-	5.10
Jamboti	-do-	Medium Loam	3.30
Bamanavadi	Belgaum	Heavy Loam	0.90
Santbastvadi	-do-	Clay	1.20
Uchod cross	Khanapur	Clay	2.40
Kusmoli	-do-	Heavy Loam	3.60
Gangoli	-do-	Light Loam	3.30
Gunji	-do-	Heavy Loam	1.50
Manturgi	-do-	Medium loam	1.20

It is observed from Table 4.6.4 that mixed sandy loam records very high infiltration rate of 23.10 cm/hr. The lowest infiltration rates (0.90 - 1.50 cm/hr) are recorded by Black Cotton soils/silty clay soils except at Avradi site where Black Cotton soil records an infiltration rate of 5.80 cm/hr. Different grades of loamy soils record moderate infiltration rates ranging from 1.40-9.60 cm/hr.

In the Ghataprabha basin (Table 4.6.5), the highest infiltration rate of 17.0 cm/hr is recorded in red sandy loam and the lowest of 0.60 cm/hr is in red clayey loam.

Table 4.6.5 : Infiltration Test Data for Ghataprabha Sub-Basin

Site	Taluk	District	Soil Type	Infil. rate (cm/hr)
Kaitnal	Gokak	Belgaum	Red Sandy Loam	2.50
Kolvi	-do-	-do-	-do-	1.00
Mamdapur	-do-	-do-	-do-	17.00
Maldinni	-do-	-do-	Mixed Sandy Loam	2.50
Mudalgi	-do-	-do-	-do-	4.00
Saidapur	Jamakhandi	-do-	Red Clayey Loam	0.90
Lokapur	Mudhol	-do-	-do-	0.60
Gaddam Keri	Bagalkot	-do-	Mixed Soil	1.80
Bagalkot	Bagalkot	-do-	-do-	1.60
Daddi	Sankeshwar	-do-	Heavy Loam	0.90
Daddi	-do-	-do-	Medium Loam	2.10
Waghroli	Gadinglaj	Kolapur	Heavy Loam	3.30
Watangi	-do-	-do-	Medium Loam	3.60
Chandgad	Chandgarh	-do-	Light Loam	8.40
Gudavali	-do-	-do-	-do-	4.80
Nagvey	-do-	-do-	Heavy Loam	13.20
Turkevadi	-do-	-do-	Medium Loam	2.40
Turkevadi	-do-	-do-	-do-	7.20
Halkarni	-do-	-do-	-do-	10.20
Shirgaon	-do-	-do-	Heavy Loam	1.80
Kovad	-do-	-do-	Medium Loam	16.50
Kovad	-do-	-do-	-do-	2.10

Table 4.6.6 summarizes the infiltration data for a few more sites in Dharwar, Raichur, Bijapur, and Gulberga district of Karnataka conducted by DAU, Dharwar. The infiltration rate values presented in Table 4.6.6 generally represent a rather low infiltration ranging from 0.20-4.0 cm/hr with the only one high value of 8.0 cm/hr at Hungund site.

Table 4.6.6 : Infiltration data based on the tests conducted by DAU.

Location	Taluk	District	Soil Type	Infil.rate (cm/hr)
Devihosur	Haveri	Dharwar	Chlorite Schist	1.20
Dharwar	Dharwar	Dharwar	Shale	2.00
Raichur	Raichur	Raichur	Granite Gneiss	0.30
Bijapur	Bijapur	Bijapur	Deccan Trap	0.90
Kajjidoni	Bagalkot	Bijapur	Limestone	4.00
Yediapur	Shorapur	Gulbarga	Granite Gneiss	1.70
Mudhbal	Shahapur	do	Limestone	1.30
Arabgunji	Jewargi	do	Basalt	0.80
Hansurya	do	do	do	0.20
Hungund	Hungund	Bijapur	Mixed Sandy Loam	8.00

4.7. Madhya Pradesh

The All India soil and land use survey carried out Infiltration studies for 75 soil series covering River Valley Projects. The areas covered under M.P. alongwith site location, soil series & infiltration rate are presented in Table 4.6.1.

Table 4.7.1 : Infiltration data for Madhya Pradesh

District	Taluk	Village	Soil series	Infilt. rate (cm/hr)
Bilaspur	Jahangir	Baijalpur	Baijalpur	0.8
Bilaspur	Jahangir	-	Basai	0.8
Bilaspur	Mungeli	Raidih	Basantala	11.8
Bilaspur	Jahangir	Khamarpalli	Dhorma	1.0
Bilaspur	Jahangir	Pakildih	Fulwari	1.1
Bilaspur	Mungeli	-	Ganjar	1.6
Bilaspur	Jahangir	Jongra	Jatri	1.6
Bilaspur	Mungeli	Chhertaur	Jakaria	1.6
Bilaspur	Jahangir	Karmadi	Karmadi	1.6
Raigarh	Jashpurnagar	Patratoli	Keradeeh	1.6
Raigarh	Jashpurnagar	Duldula	Koni	1.0
Bilaspur	Jahangir	Jhalnala	Kutela	2.2
Raigarh	Jashpurnagar	Patrapalli	Mayali	3.2
Bilaspur	Jahangir	Birgahni	Nawegaon	1.7
Bilaspur	Mungali	Amlipalli	Parsada	1.3
Raigarh	Jashpurnagar	Duldula	Sarangadani	1.7
Bilaspur	Jahangir	Govabanda	Sovabahar	2.1
Bilaspur	Jahangir	Jawahangar	Tamnar	4.3

It follows from Table 4.7.1 that Bilaspur district records the highest (1.2 cm/hr) as well as the lowest (0.8 cm/hr) infiltration rates at Raidih and Bajalpur villages respectively. At other sites, moderate infiltration rate values range from 1.0 to 4.3 cm/hr.

4.8. Maharashtra

Data pertaining to Maharashtra from the report on Infiltration Studies in 75 Soil Series published by the All India Soil and Land Survey are presented in Table 4.8.1. From the very limited data for Maharashtra, a rather low infiltration, ranging from 0.8 cm/hr to 2.0 cm/hr is reflected.

Table 4.8.1 : Infiltration data for Maharashtra

District	Taluk	Village	Soil series	Infilt. rate (cm/hr)
Dhulia	Sindkheda	Chhertanr	Jatwada	2.0
Dhulia	Sindkheda	Alkalkosh	Mandana	2.0
Sholapur	Barsi Osmanabad	Chincholi	Pangri	1.4
Sholapur	Barsi Osmanabad	Kari	Ramling	1.9
Sholapur	Osmanabad	Vedgaon	Tambola	0.8
Dhulia	Sindkheda	Vani	Ukai	1.4

4.9. Punjab

Infiltration studies were carried out by Singh et al using cylinder infiltrometer at 6 selected sites on different soils on Kasur Nallah(drainage system) in the Amritsar & Gurdaspur districts of Punjab as shown in Fig.5a. The infiltration data have been summarized in Tables 4.9.1 and 4.9.2.

Table 4.9.1: Infiltration data for soils of Kasur Nallah.

Location	Soil texture	Initial rate (cm/hr)	Final rate (cm/hr)
Dhariwal	Sandy loam	2.32	0.32
Batala	-do-	5.24	0.28
Shahzada	-do-	0.70	0.20

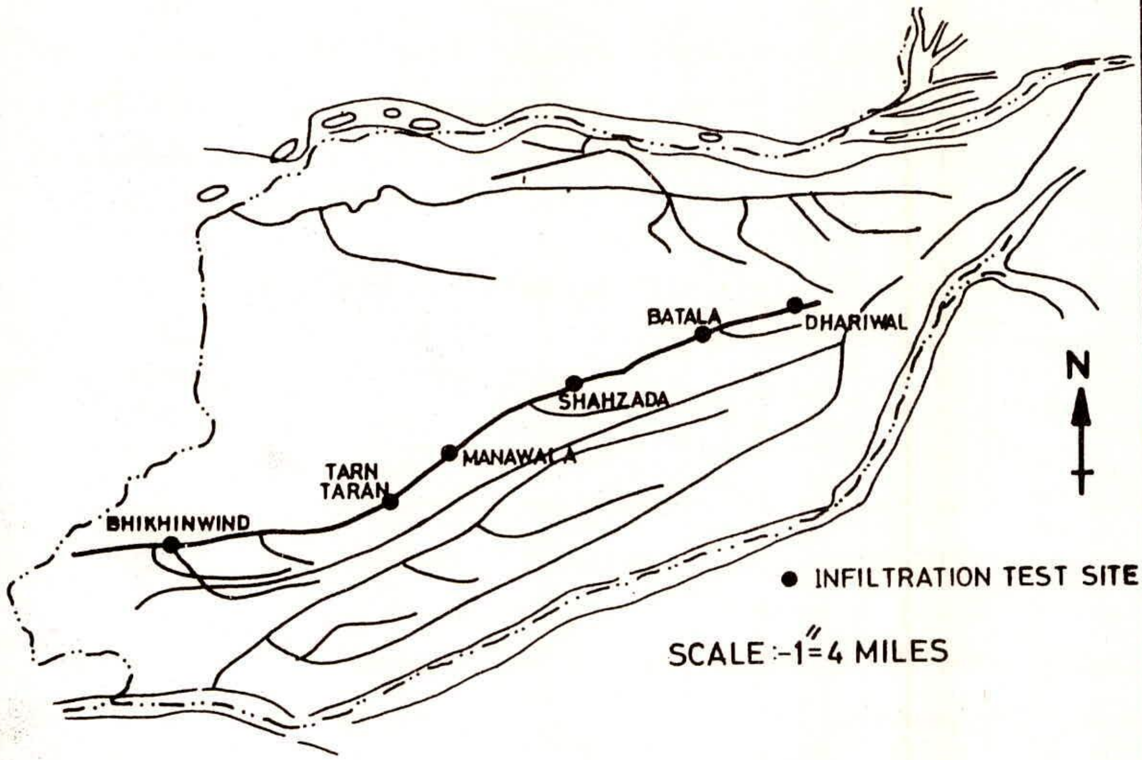


FIG.5a:MAP OF KASUR NALLAH (DRAIN)

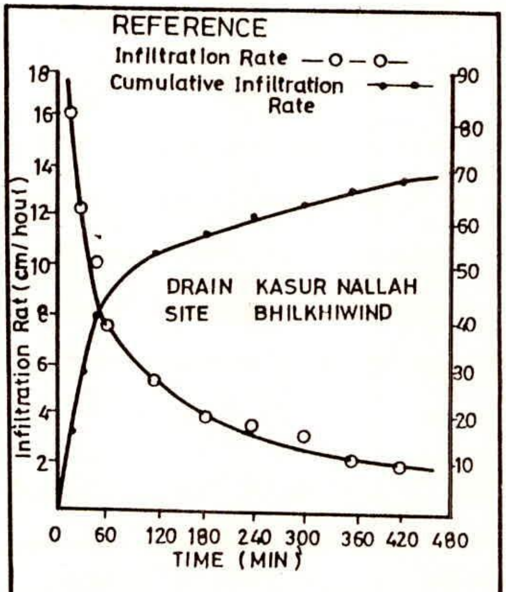


FIG.5b:INFILTRATION CURVES

Manawala	-do-	3.16	0.18
Tarn Taran	Loamy sand	3.86	0.78
Bhikniwind	-do-	16.32	2.04

From the Table 4.9.1, it is observed that infiltration rates are higher in Loamy-Sand soil than the sandy-loam soil. But the infiltration rates do not have any apparent relationship with topography. High value of basic infiltration is due to large porosity. Representative infiltration rate curves of Bhikhiwind site of this drain have been plotted as shown in Fig.5b.

Further studies were carried out in Ferozpur, Faridkot, Gurdaspur, Amritsar, Kapurthala , Patiala, and Sangurpur districts. The infiltration rates at different places were determined through the infiltrometer test conducted in the field for sodic and alkaline soils (Table 4.9.2).

Table 4.9.2: Infiltration rates for soils of Punjab.

District	Block	clay content (%)	Av.Infilt. rate (cm/hr)
Light textured saline and water logged soils			
Ferozpur	Ghalli Khurd	10.7	1.45
-do-	Guru Har Shahai	11.96	0.60
-do-	Jallalabad	23.02	0.28
-do-	Fazilka	10.27	2.07
Faridkot	Faridkot	10.47	1.03
-do-	Muktsar	11.37	1.94
Medium to heavy alkaline soils			
Gurdaspur	Dera Baba Nanak	25.00	0.16
Amritsar	Ajnala	20.48	0.48

-do-	Majitha	21.68	0.44
Kapurthala	Bhulath	19.69	0.17
-do-	Sultanpur Dodhi	22.87	0.27
Patiala	Sirihind	20.91	0.35
-do-	Patiala	25.75	0.22
-do-	Nabha	17.35	0.07
-do-	Samana	25.07	0.19
Sangrur	Bhawanigarh	21.45	0.21

The major findings of the work are as follows :

(i) Light textured saline and water-logged soils have moderate infiltration rate and is varying from about 1 cm/day to 2 cm/day. Such conditions exist in Ghalli Khurd, Guru Har Sahai, Jallalabad, Fazilka, Faridkot and Muktsar blocks of the Ferozpur and Faridkot districts of the Punjab State (Table 4.9.2).

(ii) Soils with medium to heavy texture are alkaline in nature with predominance of carbonates and bicarbonates and infiltration rate is low in such cases. Such conditions exist in Kalanaur, Ramdass, Bulath, Sultan Pur Lodhi, Sirhind, Nabha, Samana and Bhawanigarh blocks of Gurdaspur, Amritsar, Kapurthala, Patiala and Sangrur Districts of the Punjab State (Table 4.9.2).

(iii) In Gandiwind block which forms part of the command area of the extensive irrigation system of the Bari Doab near Amritsar in the Punjab State, infiltration rates of 0.39 cm/hour for Loamy soil, 0.75 cm/hour for cultivated sandy loam soil and 0.23 cm/hour for deteriorated sandy loam soil have been recorded.

In general, it was concluded that low infiltration rate may be due to the hard compacted soil found on the surface. Deep ploughing of the soil resulted in increase in the basic infiltration rate of the soil. The infiltration rate of the ploughed land was found to be 5.5 cm/day.

4.10. Rajasthan

Joshi et al (1982) have investigated the infiltration characteristics of Arid Zone soils of western Rajasthan. Infiltration studies were carried out in 14 different locations comprising of a variety of soil types e.g. deep, coarse textured aeolian sand, medium textured, moderately deep alluvial soils and shallow soils underlained by rocky and gravelly strata. The results of the infiltration tests are presented in Table 4.10.1.

Table 4.10.1: Infiltration data for western Rajasthan

Location	Soil series	Soil texture	Infit. rate (cm/hr)
(a) Medium to moderately fine textured soils			
Baorikhurd	Mathania	s	7.2
Balarava	-do-	s	10.8
Balarava	Borabas	ls to scl	8.4
Kankani	-do-	sl to cl	10.8
Dajjar	-do-	sl to cl	6.0
Kankani	Bhavi	l to cl	2.4
(b) Coarse to moderately coarse textured soils			
Agolai	Chirai	lfs to sl	7.1
Rampura	Dune	fs to ls	18.0
Khari-Bhavad	-do-	fs to ls	6.6
Basanilaccha	Chirai	ls	12.0
Basanilaccha	Chirai	ls	18.0
(c) Shallow soils			
Rampura	Jajiwal	sl	12.2
Balarava	Plateou	fs to ls	3.6
Kankani	-do-	sl to gl	0.8

(sl-sandyloam,scl-sandyclayloam,cl-clayloam,ls-loamysand, fs-fine sand,gl-gravellyloam,l-loam,lfs-loamyfinesand)

It is clear from Table 4.10.1. that the infiltration rate decreases from 18-6 cm/hr for very deep sandy soils and 10.8-1.25 cm/hr for deep medium textured soils to 1.2 to 0.8 cm/hr for shallow soils. Higher content of coarse sand in soils of Mathania series (Balrava and Barori Khurd) and Dune series (Rampura) were associated with high infiltration rate, whereas Chirai soils of Agolai containing more of fine sand was associated with relatively low infiltration rate. Similarly, shallow soils underlain by concretionary zone showed higher infiltration rate than those underlain by the rock.

Shankarnarayan and Kar (1983) carried out infiltration tests at 117 sites of different landuse, soil type and geomorphic units in the Upper Luni basin, Rajasthan (Fig.6). Out of these, 64 tests were carried out in agricultural lands (mostly sandy soils), 12 in heavy soils in wheat fields (present fallow), 32 in open scrub lands (Grazing lands) and 4 in dune complex (duny sand). In all the four catchment of the upper Luni Basin (Bandi, Guhiya, Luni, and Jojri), the infiltration rate varied with soil depth, soil texture, initial soil moisture, and surface cover. Table 4.10.2 indicates that the average one hour infiltration in coarse, medium and moderately fine soils varies from 12.62 to 22.99, 7.45 to 12.65 and 3.50 to 7.90 cm/hr respectively.

TABLE 4.10.2: Infiltration characteristics in Upper Luni Basin

Catchment	Soil group	Soil texture	Soil depth (cm)	Soil moisture Average (%)	Soil moisture Range (%)	One hr infilt Average (cm)	One hr infilt Range (cm)
Bandi	s-l	Coarse	>100	4.37	2.11-6.91	15.95	4.39-38.15
	sl-l	Medium	40-100	5.38	2.28-7.29	12.65	2.24-29.40
	scl-sicl	Mod.fine	45-100	5.35	2.22-9.60	5.10	1.30-13.02
Guhiya	s-ls	Coarse	20-100	2.03	1.46-2.58	14.57	7.07-22.40
	sl-l	Medium	40-100	4.08	2.04-6.66	7.45	3.57-14.38
	scl-sicl	Mod.fine	30-95	6.14	3.96-8.83	3.50	3.43-10.00
Luni	s-ls	Coarse	40-100	3.02	0.38-8.31	22.99	3.78-67.00

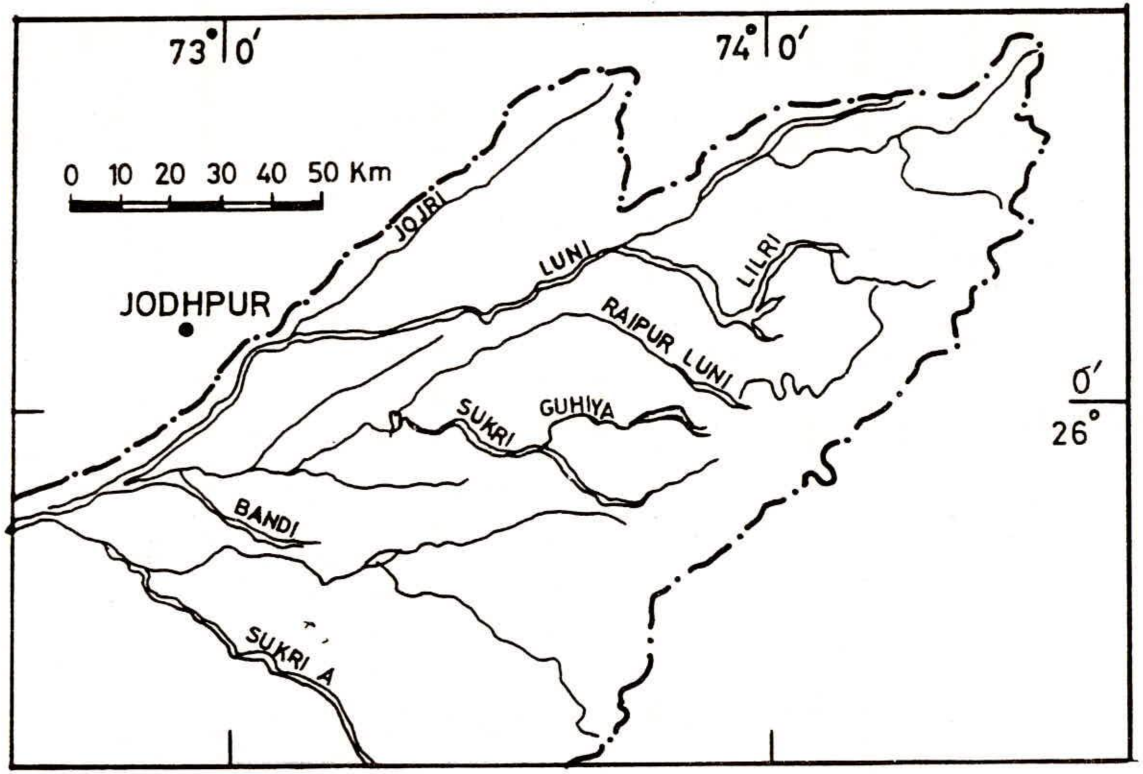


FIG. 6 THE LUNI BASIN - NORTHWEST INDIA

	sl-l	Medium	40-100	5.06	1.22-18.19	12.15	1.22-34.95
	scl	Mod.fine	40-100	6.10	4.45-8.10	7.90	3.71-14.60
Jojri	s-ls	Coarse	40-100	6.10	4.45-8.107	12.62	4.97-32.32
	sl-l	Medium	30-100	7.47	3.71-13.47	10.82	2.36-26.47

(scl-sandy clay loam, sicl-silty clay loam, sl-sandy loam, l-loam, s-sand, ls-loamy sand)

Shankarnarayan (1982) carried out detailed studies in the Guhiya watershed in the Upper Luni basin and established a clear influence of soil texture on the infiltration characteristics and showed that the infiltration process is much more accelerated in coarse soils than in fine and medium soils. Thirty seven sites in various soil groups viz. coarse, medium and moderately fine soils were selected for carrying out infiltration tests. One hour infiltration test yielded infiltration rates of 3.43 - 10 cm/hr for sandy clay loam to silty clay loam soils, 3.57 - 14.38 cm/hr for sandy loam to loamy soils and 7.07 - 22.4 cm/hr for sandy to loamy sand soils (see Table 4.10.3). Soil thickness ranges from 30-100 cm except at 8 locations where depth is greater than 1 m. The initial soil moisture in upper 0-20 cm of soil, which mainly influences infiltration process, ranges from 1.5 to 6.7 percent.

Table 4.10.3: Infiltration characteristics in the Guhiya watershed

Soil group	Soil texture	Soil depth (cm)	1hr infiltration (cm)	
			Range	Total
scl-sicl	Mod.fine	30-95	3.43-10.00	3.50
sl-l	Medium	40-100	3.57-14.38	7.45
s-ls	Coarse	20-100	7.07-22.40	14.57

(scl-sandy clay loam, sicl-silty clay loam, sl-sandy loam, l-loam, s-sand, ls-loamy sand)

Table 4.10.4. shows the variation in infiltration rate with respect to landuse and soil type. Infiltration rate varies from 3.6 cm/hr for agricultural land with loamy soil to 22.4 cm/hr for agricultural land with loamy sand soil.

Table 4.10.4: Landuse & infiltration characteristics, Guhiya watershed, Luni basin, Rajasthan

Present landuse	Vegetation	Soil type	1 hr infilt. (cm)
Agricultural fallow	-	Loam	10.06
	-	Loamy sand	10.34
	Trees	Loamy sand	12.12
	Thin grasses	Loamy clay	10.08
	Bushes	Loam	7.25
	Grasses	Loamy sand	22.40
	Trees, thin grass	-do-	11.75
	-	Sandy loam	14.38
	-	Loam	6.18
	-	Loam	9.15
	-	Fine sandy loam	4.91
	-	Loam	3.57
	Barren	Silty loam	6.26
	Barren	Clay loam	6.30
Oran	Thin grass	Fine sandy loam	5.18
	Barren	Loam	4.16
	Trees,grass	Silty clay	5.53
Controlled grazing	Thick grass	Clay loam	3.43
Barren long fallow	Barren	Sandy loam	2.92
Gravvely waste	Grasses, bushes	Sandy loam	6.56
Irrigable fallow	-	Silty clay loam	4.72
	-	Loam	3.40
Open scrub	Bushes	Loamy sand	14.48
	Grass, bushes	Loam	5.71

Mathematical models were developed using both, Phillip's equation and best fit line, through the data collected in Guhiya Watershed. In the Phillip's two parameter equation, the two variables which affect the infiltration process are sorptivity (S) and the gravity component (A). The Sorptivity values are greater in fine soils and the values of 'A' are greater in coarse soils where the soil pores are greater the Phillip's equation can be put in the form of:

$$I = St + At,$$

where I = the cumulative infiltration in time 'b'

S = Sorptivity (infiltration due to capillarity)

A = Infiltration due to gravity

The infiltration rates of the soils of Guhiya watershed of Upper Luni Basin observed in the field are close to the calculated value from Phillip's equation. The average infiltration rate for moderately fine soils is about 6.7 cm/hr whereas the average I_{∞} value derived by Phillip's equation is about 5.7 cm/hr. The value derived by best fit method is 3.5 cm which is very low. In coarse soils, both the models give values close to the actual value obtained from field tests.

4.11. Tamilnadu

Infiltration studies on different soils under various landuses were conducted at Ootacamund, Tamil Nadu (Rege and Srinivasan, 1959). The soil having a miscellaneous type of vegetation (Shola) had a mass infiltration of 12.5 cm for a period of 3 hours while for that under broom (Cytisus scoparius) had 11.25 cm for the same period. The infiltration data for the above two vegetative covers indicate that the quantity and rates of infiltration are very high during the first 15 minutes of observation. The higher total intake of water by the soil under the miscellaneous vegetation (Shola) is probably due to the lighter nature of the soil existing there. However, the soils under both these surface covers have exhibited better intake than those under other conditions namely, grass, and cultivated land. Further it is seen that of all types of landuses, excepting miscellaneous vegetation (Shola), the rate of infiltration is the greatest under cultivated condition during the initial stage of 15 minutes, 5.6 cm and 1.25 cm during the subsequent 165 minutes.

Regarding the grassland, the intake was the poorest during the I st 15 minutes (hardly 2.5 cm) but during the subsequent period of 165 minutes, the infiltration was nearly 3.75 cm which was much higher than the obtained in the cultivated land (i.e.1.25 cm for the same period). The initial low intake may be attributed to the compaction of soil caused by indiscriminate and excessive grazing by cattle and sheep over a long period. It is, however, clearly indicted that the soil under broom(Cytisus scoparius) has shown greater rate of water intake (3.75 cm per hour). Though it is a firmer soil, the aggregates have been developed well due to the constant addition of leaf litter of the protected growth of perennial broom which is a leguminous plant.

Further infiltration studies were conducted on cultivated land at the Soil Conservation Research Centre, Ootacamund (Shrinivas, Poornachandran and Thomas, 1967). The soils of the area are lateritic in origin and have developed from gneissic rock. They are clay to clay loam in texture with porosity upto 57 per cent. The soils are non-erodible with dispersion ratio of less than 7 and are deep to very deep. Bench terraces were formed about 10 years prior to the start of infiltration studies. Two sets of tests were made (a) dry test at the existing soil moisture level; (b) wet test about 24 hours after wetting. The readings were taken at 5, 10, 15, 30, 45, 60,120,150 and 180 minutes.The cumulative infiltration were computed for each time interval. The initial rate of water intake in the soil was quite rapid and after about 60 minutes the rate became constant. The amounts of infiltration during successive time intervals under wet run are shown in Table 4.11.1.

Table 4.11.1: Amount of infiltration (cm) on cultivated land during successive time intervals (min.) - wet run (Ootacamund)

Month	0-5	5-10	10-15	15-30	30-45	45-60	60-90	90 -120	120 -150	150 -180	Tot. 0-180
March	0.8	0.8	0.7	2.1	2.1	2.1	4.4	4.4	3.8	3.5	24.7
April	0.2	0.2	0.2	0.6	0.6	0.6	1.2	1.2	1.1	1.1	7.1
May	0.6	0.5	0.4	1.2	1.2	1.1	2.2	2.1	2.1	2.1	13.3
June	0.3	0.5	0.3	0.9	0.9	0.9	1.8	1.8	1.8	1.8	10.8
July	0.1	0.1	0.3	0.3	0.3	0.6	0.6	0.6	0.6	0.6	3.9
August	2.3	1.9	1.8	5.2	5.0	5.0	9.0	8.4	7.5	7.5	53.6

Table 4.11.1 shows that water continued to infilter into the soil even after prolonged period, which is the main reason for less runoff. Table 4.11.2 gives the initial infiltration rate and the initial soil moisture percentage under dry run.

Table 4.11.2: Values of initial infiltration rate (cm/hr) Under dry run, Ootacamund

Month	Initial soil Moisture (%)	Initial infiltration rate (cm/hr)
March	14.2	18.0
April	23.5	12.0
May	22.0	14.0
June	38.9	3.6
August	25.0	51.6

4.12. Uttar Pradesh

In Uttar Pradesh infiltration studies have been carried out at few places. The All India Soil and Land Use survey, New delhi has conducted infiltration tests in river valley projects for soil conservation (All India Soil & Land Use Survey, 1981). These tests have been carried out in Ram Ganga catchment, mainly in the districts of Almora and Paurigarhwal (Table 4.12.1)

Table 4.12.1: Infiltration data from U.P.(Ref:75 Soil series)

District	Taluk	Village	Soil series	Infil.rate (cm/hr)
Almora-Paurigarhwal	Ranikhet	Adalikhal	Adalikhal	9.8
Almora	Ranikhet	Bhikiasain	Amgadhera	10.9
Almora	Ranikhet	Bhikiasain	Bhikiasain	5.4
Paurigarhwal	Landsdown	Chinwali	Chinwali	4.7
Paurigarhwal-Almora	Landsdown	Dhumakot	Dhumakot	2.8
Etah	Etah	-	Kasi Nagle	3.6
Almora	Ranikhet	Bhikiasain	Manhat	8.6
Etah	Etah	Sakit	Sakit	1.3
Paurigarhwal	Landsdown	Sangalia	Sirohi	5.5

Ground Water Investigation organisation (T.M. No. 46/87, 1987) has carried out infiltration tests along the Hindon river in the district Saharanpur (Fig. 7 and Table 4.12.2).

Table 4.12.2: Infiltration test data along the Hindon river, Saharanpur

Site no.	Soil type	Infiltration rate (cm/hr)
51	Sand	16.8
18	Sand	8.4
19	Sand	13.2
21	Sand	43.8
23	Sand	10.2
25	Sand	60.0

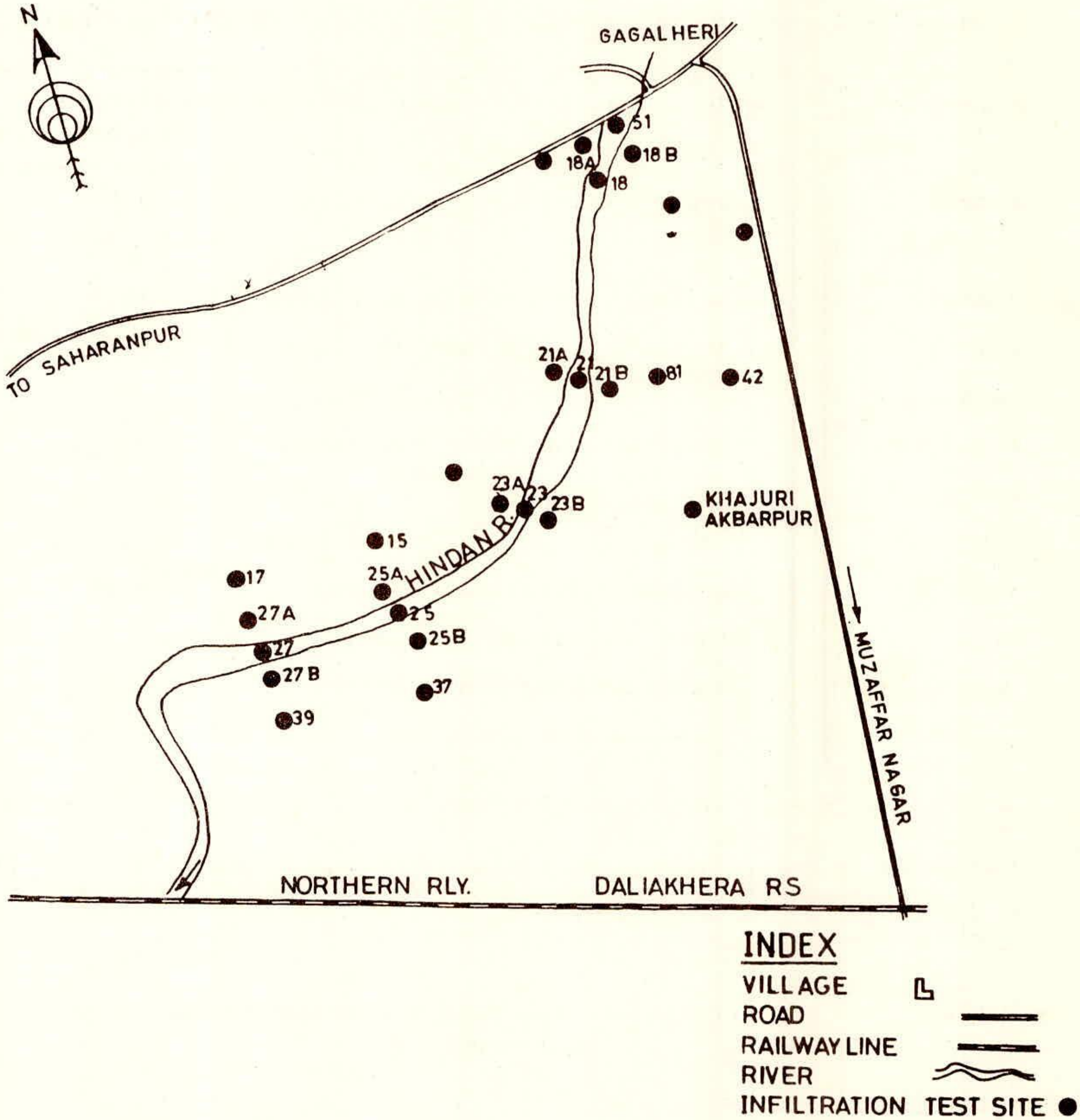


Fig. 7 - Index Map Showing Infiltration Test Sites Under Hindon River Project Area Distt. Saharanpur

27	Sand	51.9
18A	Sandy loam	7.2
21A	Sand	12
23A	Silt loam	5.4
27A	-	19.2
18B	Loamy sand	2.7
21B	Loamy sand	8.2
25B	Loam	22.5
9	Silt	2.4
12	Silt loam	7.8
14	Silt loam	0.3
15	Loamy sand	1.08
17	Loam	7.8
28	Silt	3.6
31	Silt	4.2
34	Silt loam	2.61
37	Silt loam	6.6
40	Silt	0.6
42	Silt	4.8

The Ground Water Department, Govt. of U.P. has carried out some infiltration tests in different parts of U.P. and the results are presented in the Table 4.12.3.

Table 4.12.3 Infiltration data from U.P.(Ground Water Deppt, UP)

District	Block	Village	Soil Type	Infit.rate (cm/hr)
Varanasi	Cholapur	Babhanpura	Silt loam	6.150
Varanasi	Cholapur	Danaganj	Silt loam	1.41
Bareilly	Alampur	Bhampura	Silt loam to sand	3.84
Bareilly	Alampur-Zafrabad	Panwara	Silt loam	2.86
Bareilly	Alampur-	Balliya	Silt loam	0.963

	Zafrabad			
Bareilly	Alampur-Zafrabad	Pathra	–	7.65
Agra	Fatehabad	Bilauni	–	0.86
Farrukhabad	Kannauj	Akbarpur	–	0.90
Lucknow	Chinhat	Simra	–	0.40
Lucknow	Chinhat	Vijaipur	–	0.58-1.24
Lucknow	Chinhat	Kanchanpur	–	2.8
Aligrah	Akarabad	Dhubiya	–	1.16
Aligrah	Akarabad	Kalianpur	–	0.65
Aligrah	Akarabad	Nagala Sartaj	–	0.63
Aligrah	Akarabad	Vijaygarh	–	0.38
Sultanpur	Bhadar	Sansarpur	–	0.72
Sultanpur	Bhadar	Piparpur	–	1.98
Sultanpur	Bhadar	Kalyanpur	–	0.72
Sultanpur	Bhadar	Ghoraha	–	2.10
Hardoi	Sandila	Mahsona	–	0.54
Hardoi	Sandila	Lamsera	–	3.24
Hardoi	Sandila	Tilai khurd	–	0.90
Hardoi	Bahendar	Raise	–	1.20
Hardoi	Kachhona	Malhupur	–	0.60
Hardoi	Kachhona	Sunni	–	1.30
Hardoi	Kachhona	Kakuhi	–	0.84

Infiltration investigation of the soils of the Bhaintan watershed in Tehri-Garwal has been carried out by Mohan and Gupta (1983). The results are presented in Table 4.12.4 along with description of sites.

Table 4.12.4: Infiltration rates for various land uses in Bhaintan Watershed, Tehri Garhwal, U.P.

Site location and Description	Av. Infiltration rate, cm/hr			
	I hr	II hr	III hr	IV hr
Forest lands:				
i) Kathkore: thin forest with scanty litter deposit, surface soil predominently gravelly on precipitous slopes.	5.20	3.20	2.05	2.00
ii) Bhagori: Land under good herbaceous cover and trees; soil interspersed with small proportion of gravesl.	3.25	2.00	1.45	0.35
iii) Malas: Thin fnrest; soil having large pebbles and stones.	4.95	2.80	1.30	1.25
iv) Tachla: Thin density forest; soils having gravels on surface.	3.20	2.05	1.10	1.10
Crop lands:				
i) Kathkore: Well terraced land under regular cropping; surface soil having moderate proportion of pebbles	5.45	3.75	3.95	3.85
ii) Bhagori: Good terraced land; double cropped surface soil having small proportion of gravels.	2.40	1.75	0.85	0.80
iii) Bhaintan: (a) improved terraces under double cropping, gravelly surface soil; (b) poorly terraced land under cultivation; surface soil having pebbles.	5.50	3.65	3.15	3.05
iv) Simlet: Good terraced land under regular crops, surface soil contains apparently moderate amount of pebbles and gravesl.	7.05	5.85	4.25	4.15
v) Tachla: Poorly terraced land	5.00	4.05	2.25	2.10

under monocropping;pebbles low in surface soil.				
Horticultural lands:				
i) Kathkore:Land with irregular slopes;surface soil extremely gravelly.	4.95	3.80	2.25	1.25
ii) Matas.Land with thin grass cover and excess of pebbles.	4.30	3.55	2.05	1.95
iii)Simlet:Land on irregular slopes and guly banks. Pebbles in excess in surface soil.	3.70	2.20	1.20	1.05
Grasslands:				
i) Malas:Land under moderate cover of miscellaneous grasses; bouldriness in surface soil.	4.25	3.40	2.25	2.15

It is evident from the values that at Kathkore the forest land shows moderate values of Infiltration rates i.e.5.20, 3.20, 2.05 and 2.00 cm/hr for I, II, III is apparently more than the Infiltration rate values for Malas, Bhagori and Tachla. These observations suggest that higher infiltration rates at Kathkore are probably due to preponderance of Pebbles, gravels and rock fragments on the surface soil which make it more porous and permeable to water. Bhardwaj et al (1974) have also noted that soils of Kathkore series are moderate to very gravelly, medium textured.

Prasad and Ali (1989) carried out studies on Infiltration characteristics of some soils of Kanhar catchment in Mirzapur district using double ring infiltrometer. The basic infiltration was determined by multiplying the average intake rate at 60 minutes of elapsed time by factor 0.6. Table 4.12.5 presents soil characteristics and infiltration data for some soils of Kanhar catchment.

Table 4.12.5 : Soil characteristics & infiltration data, Kanhar catchment, Mirzapur.

Soil series	Effective depth (cm)	Present landuse	Texture (a.Surface;b.subsurface)	Structure	Basic infil.rate (cm/hr)
Baralota(BL)	V.deep (150)	Double cropped	a.CL b.SCL to C	a.Sb b.Sb to Ab	0.69
Edala (ED)	V.deep (130)	-do-	a.L b.CL to C	-do-	3.36
Gangawar(GR)	V.deep (140)	-do-	-do-	-do-	0.48
Hurlong(HR)	V.deep (135)	Single cropped	a.CL b.CL	-do-	1.95
Matang(MG)	Mod.deep (50)	-do-	a.SL b.SCL	-do-	7.51
Sarma(SR)	V.deep (102)	Double cropped	a.SCL b.SCL to CL	-do-	6.0
Sukhra(SK)	Mod.deep	Single	a.SL b.SCL	-do-	16.65

Figure 8a explains the cumulative infiltration curves with elapsed time for different soils of the catchment as per Table 4.12.5. Figure 8b gives the curves of infiltration rates for different soils with elapsed time. All of the analysis for Kanhar catchment was carried out using the following empirical Kastikov's equations:

$Y = at$ ...(i) and

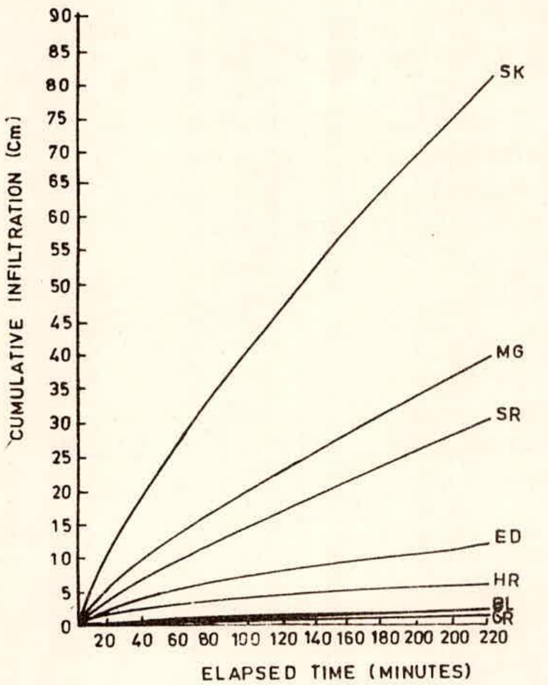
$Y = at + b$ ...(ii)

where $t \to o$ and

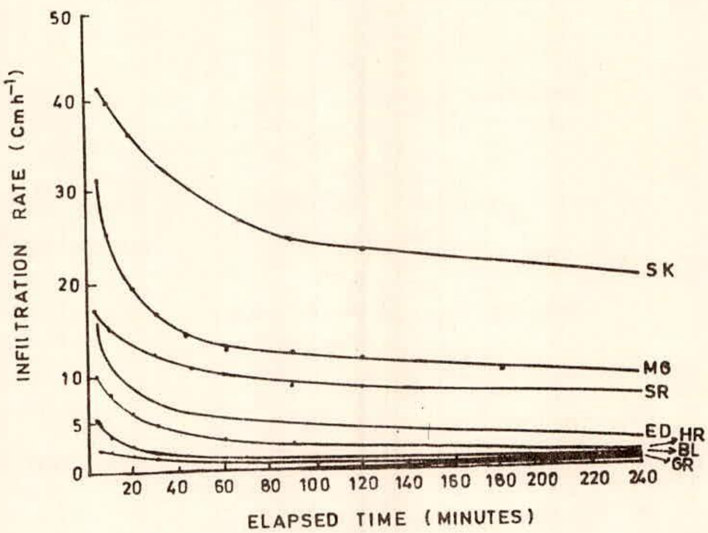
Y = accumulated infiltration in time t

t = elapsed time or infiltration opportunity time in minutes, a, and b are the characteristics of the soils and are constants.

The values of a, x and b constants in the above equation are



(a) CUMULATIVE INFILTRATION CURVES



(b) INFILTRATION RATE AS A FUNCTION OF TIME

Fig. 8. Infiltration Curve for Kanhar Catchment, Mirzapur U.P.

calculated for the soils of the catchment and the infiltration prediction equations for all the series are given as under:

1. Baratola : (Y - 0.165) = -0.955 + 0.559 logt

2. Edala : (Y - 0.411) = -0.465 + 655 logt

3. Gangawar : (Y + 0.323) = -0.539 + 0.342 logt

4. Huralong : (Y + 0.452) = -0.152 + 0.408 logt

5. Matnag : (Y - 0.887) = -268 + 0.770 logt

6. Sarma : (Y + 0.116) = -0.329 + 0.753 logt

7. Sukhara : (Y + 0.574) = 0.0758 + 0.770 logt

Infiltration measurements using cylinder infiltrometers were done in the watershed of river Asan, a tributary of river Yamuna, covering most of the western portion of Doon Valley. Suitable transects were chosen for the cultivated and forest lands on the Himalayan and the Siwalik uplands, as well as in the bottom lands of the valley sites. The mean readings of these six units of cylinder infiltrometers represented the average infiltration rate of the site (Table 4.12.6). The tests were run under almost a constant head of 5 cm (2 inches) maintained by simple float device. If any vegetation was found, it was cut and similarly the undecomposed litter within the cylinder was removed. The water intake rates were noted from a graduated reservoir feeding the cylinder at 5,10,15,30,60,120 and 180 minutes. From the cumulative value of water intake for each hour and cross section area of the cylinder, the rate of infiltration was estimated. One of the six cylinders with the soil core, after the field test, was lifted and examined in the laboratory. The profile details for each site were also taken.

Table 4.12.6: Infiltration rates in Doon valley, U.P.

Site	Soil cover	Elevation above MSL (meter)	Infiltration rates (cm/hr) 1st hr	2nd hr.	3rd hr
Group I : Cultivated valley area					
Dhulkot	Under Maize crop surface soils with no pebbles or stones	533	4.00	2.75	2.80
Sahaspur	Ploughed fallow with few stones or pebbles	478	3.55	1.95	1.80
Lakhanwala	Harvested rice field with some stones/pebbles	465	2.70	1.90	1.80
Tapkeshwar	Ploughed field with few stones or pebbles	610	4.50	2.25	2.30
Babugarh	Fodder sorghum harvested & no pebbles/stones	461	7.30	4.55	4.35
Bhurpur	Ploughed field with no stones or pebbles	541	3.75	0.85	0.85
Average			3.70	1.94	1.91
Group II : Cultivated Himalayan Upland area					
Sinola	Ploughed land with few stones or pebbles	983	7.90	4.20	4.30
Kidarwala	Ploughed with some pebbles/stones	533	7.50	4.40	4.50
Bakhtahar-pur	Ploughed with some pebbles/stones	679	7.10	6.65	4.55
Donga	Ploughed with some pebbles/stones	816	9.50	5.10	5.05
Rudarpur	Ploughed with some pebbles/stones	587	9.60	5.10	4.75
Khalagaon	Rice harvested, soil puddled, compact	1042	2.05	0.75	0.90
Average			8.32	4.69	4.69

Group III : Forest area in Himalayan upland (Foothills slopes)

Bidhauli	Sal forest with good leaf litter	838	8.95	5.90	5.85
Horawala	Sal forest with v.little leaf litter, compact	671	3.65	2.00	2.20
Mabari	Sal forest with little leaf litter, compact	567	4.55	2.45	2.50
Chandaur	Sal forest with little leaf litter	533	4.85	3.78	3.83
Dhulkot	Sal forest with good leaf litter	533	7.35	6.00	6.00
Average			5.87	3.78	3.83
Group IV: Forest area on Siwalik side slopes					
Karwapani Fireline	Sal forest with v.little leaf litter, compact	685	5.35	2.30	2.30
Karwapani R.F.	Sal forest compact eroded soil	610	2.80	1.15	2.30
Sabhawala Fireline	Sal forest, compact soil with little leaf litter	640	3.70	2.70	2.75
Sabhawala	Misc. forest with compact soil	499	4.15	2.00	1.95
Average			4.00	2.04	2.09

The average infiltration values in the above table for different groups clearly indicate that the soils on the slopes of Himalayan foothills have moderate rates when under cultivation (Group II); the infiltration rates gets appreciably reduced under forest cover (Group III). The soil profiles studied with their shallow depths preponderant with pebbles and rock fragments suggest high potential infiltration values. This is all the more so when top shallow mantle is disturbed by ploughing, thus giving high values under cultivation as in Group II; When undisturbed as under forest with trampling a surface sealing is anticipated giving comparatively reduced rates as found for Group III. The cultivated land in the valley in Group I gave moderate infiltration rates. The forest land on Siwalik slopes of the Valley under group IV gave slightly higher values than Group I but the different is not appreciable. The forest area on Siwaliks is without good leaf litter and is heavily grazed which may explain its reduced infiltration rates. The potential infiltration values are expected to be higher.

The infiltration curves in Fig. 9 show that the I st hour high value rapidly decreases in 2nd hour and becomes steady in 3rd hour onward in all the groups irrespective of the cover and other site factors or profile characters. Actual infiltration rates for each group of curves remain different. In general, the field observations show that Himalayan slopes, either cultivated or under forest give considerably higher infiltration values than the cultivated Valley or the Siwalik slopes under sal forests. The 3rd hour infiltration values for the Himalayan slopes of the Valley are observed to be almost double of those for the cultivated Valley as well as the Siwalik slopes under forest.

4.13. West Bengal

The All India Soil and Land Use Survey conducted Infiltration studies for 75 soil series covering River Valley Projects related data are presented below:

Table 4.10.5 Infiltration data for West Bengal

District	Taluk	Village	Soil series	Infit.rate (cm/hr)
Purulia	Arsha, Baghundi Balrampur	Hensla	Hensla	9.3
Purulia	-do-	Kanchanpur	Kanchanpur	1.1
Purulia	-do-	Salaidahar	Kultanr	6.1

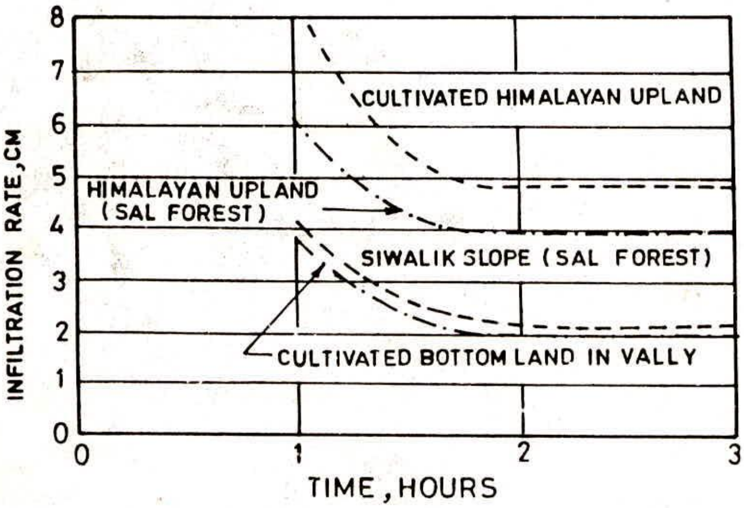


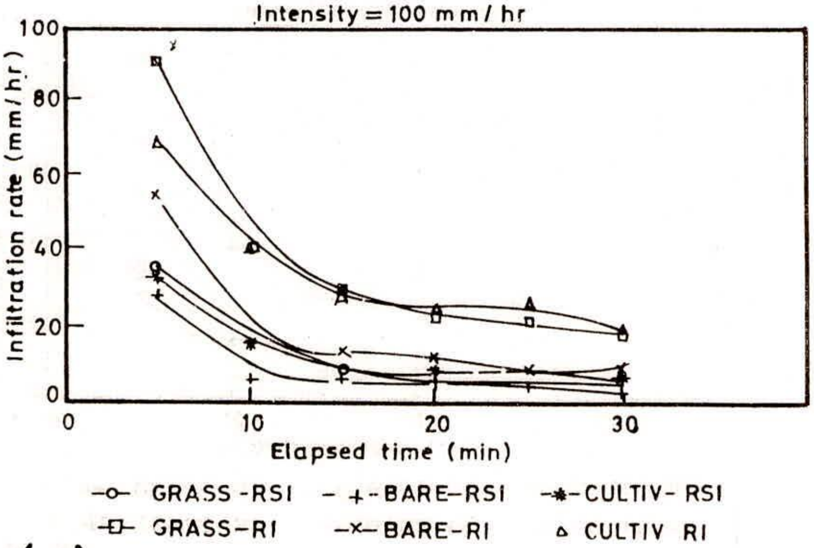
Fig. 9 - Hourly infiltration rate curve, for 4 graphs of softs Doon Valley.

Purulia	-do-	Palpal	Palpal	2.0
Purulia	-do-	Teyasi	Salaidhar	2.1
Purulia	-do-	Arsha	Sirkabad	8.5

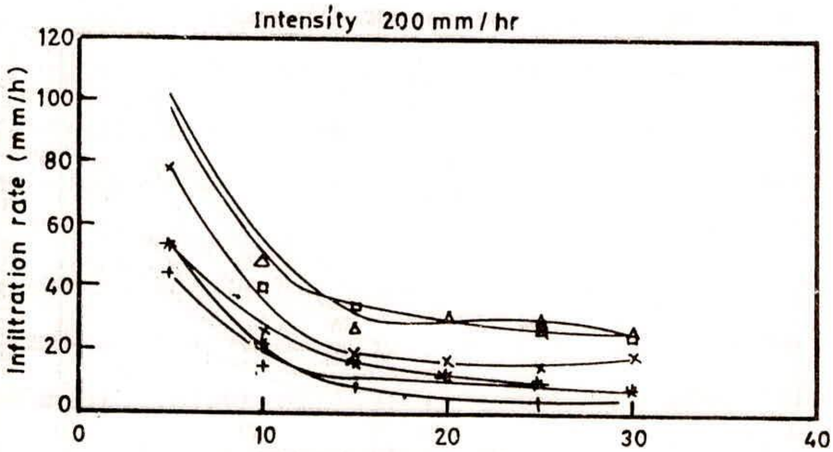
All the values from the West Bengal state are from Purulia district. The highest value of 9.3 cm/hr is recorded from Hensla village whereas the lowest value of 1.1 cm/hr is recorded from Kanchanpur village.

Bhardwaj and Singh (1992) conducted field tests in the IIT Kharagpur campus with rainfall simulator infiltrometer on grassed land, bare fallow land and cultivated land to determine infiltration, runoff and soil erosion, under two rainfall intensities of 100 mm/h and 200 mm/h. The soil studied was lateritic with a specific gravity of 2.65. To compare the infiltration results with those from the traditional flooding-type method double-ring infiltrometer, parallel measurements are made at adjacent locations.

The mean values of infiltration of soil measured by rainfall simulator infiltrometer and flooding-type double-ring infiltrometer are presented (Figs.10a and 10b). The summarized infiltration data is presented in Table 4.10.2. The infiltration rate is high for the initial 5 minutes and reduces gradually after each interval of 5 minutes with decreasing rate. This is true for all three cover conditions irrespective of the rainfall intensity and the method of measurement employed. Grassed and cultivated lands, under both rainfall intensities, have higher average infiltration rates than that of bare fallow land. This may be due to the fact that grass grown on the soil makes it more porous because of its root growth and increases the organic contents, facilitating the movement of water into the soil. The cultivated land, due to regular ploughing, is also more porous when compared to bare land which has been lying fallow for many years. Moreover, the bare soil having more fine soil particles



(a)



(b)

FIG. 10 : INFILTRATION CURVES FOR KHARAGPUR AREA WEST BENGAL

lying loose on the surface, gets easily mixed with water in case of rainfall simulator measurements, because of raindrop of raindrop impact, which makes it muddy, thereby sealing down the pores of the soil, reducing its infiltration rate.

Table 4.10.2 : Infiltration data from Deptt. of Engg. Campus, IIT, Kharagpur. West Bengal

Land use	Basic Infiltration Rate (cm/hr)			
	Intensity 100 mm/hr		Intensity 200 mm/hr	
	RI	RSI	RI	RSI
Grassland	1.8	0.6	2.3	0.6
Bareland	1.0	0.4	1.9	0.4
Cultivated	2.0	0.8	2.3	0.6

CONCLUDING REMARKS

The data presented in this report for different states of India are very scanty. Therefore, it has not been possible to produce any thematic map of the infiltration characteristics of soils of different states. Further, the data format is extremely variable and sometimes the details of additional physical characteristics of soils are not available without which it is difficult to draw inferences about spatial variations in infiltration characteristics. More infiltration tests must be carried out by the concerned organisations in the respective states and along with the infiltration data, information about the grain size distribution, soil carbonate distribution, landuse (soil cover) etc. should also be collected. Only then, the infiltration data will form an important input to the hydrologic modelling to derive information about the runoff potential of the area.

In conclusion, the following points are stressed :

1. There is an urgent need for conducting infiltration tests at different locations in each state. As this would be an stupendous task, the involvement of state governments would be necessary.
2. Infiltration data should be collected and recorded in standard format.
3. The automatic infiltration measuring equipment shall be developed and widely tested expeditiously.
4. A clear cut role of use of infiltration results for hydrologic modelling be defined.
5. The data on infiltrometer for each state shall be compiled in the form of books.

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