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INFILTRATION STUDIES IN SHER-BARUREWA DOAB IN NARMADA BASIN

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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 groundwater emphasizes its importance in hydrologic investigations.

Under 'Comprehensive Hydrological Studies in a River Basin' project of the National Institute of Hydrology, a study has been undertaken to determine the infiltration rates of the soils of the Sher-Barurewa river doab in the Bargi Left Bank Canal Command area of Narmada Basin. The area is bound by Sher river, Barurewa river and left bank canal of Bargi Dam (under construction) near Narsinghpur town, Narsinghpur District, Madhya Pradesh. It is hoped that this study will be of great use for users of different departments and organisations in their watershed management program.

This report is based on the field experiments carried out in October, 1995, in the Bargi Canal command area by the Hydrological Investigations Division. The report has been prepared by Sri B.P. Roy, Sc. E, and Sri Hukum Singh, S.R.A. Sri Mohar Singh Tech. Grade-II assisted in conducting field experiments. 'The report has been thouroughly edited and rewritten by Dr. Sudhir Kumar, Sc.C.

(S.M. Seth)
Director

CONTENTS

LIST OF FIGURES

LIST OF TABLES

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. Earlier, the term infiltration was used to denote the difference between rainfall and runoff in small areas. Hydrological importance of the infiltration process is to be seen from the fact that it marks the transition from fast moving surface water to slow moving soil moisture and groundwater.

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

Generally, infiltration has a high initial rate that diminishes during continued rainfall to a nearly constant lower rate. The rate at which water enters into the soil at a given moment is known as the '**Infiltration rate**'. Infiltration rate is of great interest to the hydrologists and water resources engineers, as it influences many of the hydrological parameters, such as, surface runoff, soil moisture, evaporation and evapotranspiration, groundwater recharge and spring flow rates. It is also of interest to the agriculturists, conservationist and environmentalists. The knowledge of infiltration properties can help agriculturists in developing integrated crop, soil and water management plan including adoption of proper irrigation methods and irrigation schedule. The conservationist and environmentalist can derive the information on soil erosion (as runoff depends on infiltration) and in turn the sedimentation rate in reservoirs using the infiltration data.

Quantitatively, infiltration rate is defined as the volume of water passing into the soil per unit time and has the dimension of velocity (L/T). This rate depends on a number of factors viz. physio-chemical properties of the soil, vegetation and landuse pattern, rainfall intensity and duration, and surface slope. Besides these factors, the depth to groundwater, climate and man's activity also affects the process of infiltration.

Under special circumstances wherein the rainfall exceeds the ability of the soil to absorb water, infiltration proceeds at a maximal rate called as soil's '**Infiltration capacity**' (Horton, 1940).

Keeping in view the importance of infiltration studies, infiltration studies have been initiated in the Bargi Left Bank Canal Command area. In the year 1995-96 tests were conducted in the Sher - Barurewa doab falling under the command area of Bergi Left Bank canal in Narsinghpur district of Madhaya Pradesh.

2.0 STUDY AREA

The Bargi multi-purpose project, renamed as Rani Avanti Bai Sagar Project, is one of the major river valley project on Narmada river. Two main canals i.e., Right Bank Canal and Left Bank Canal will carry water from the reservoir for irrigation of 203,000 hectare of land.

The study area is a part of the left bank canal command of Bargi Multi-purpose Project.

2.1 Location

The study area lies between latitude 22^0 50′ 30″ N to 23^0 0′ 30″0 N and longitude 79^0 6′ 30″ E to 79^0 23′ 15″ E and is located in the Narsinghpur district of Madhya Pradesh. This area is a doab, encompassed by Sher river in the east and the north, Barurewa river in the west and Bargi left bank canal in the south, having an area of 250 sq. km. The study area is a part of Bargi Dam left bank canal and is a part of Narmada Basin. Location of the area is shown in FIG.1.

The study area lies around Narsinghpur town, the headquarters of Narsinghpur district and is well connected by the National Highway No. 26 from Jhansi to Nagpur and State Highway No. 22 from Jabalpur to Hoshangabad. The main broadgauge railway line from Hawrah to Bombay also passes though the study area.

2.2 Topography

The elevation above mean sea level of the study area varies from 325m to 380m. The general topography of the area appears to be flat except in the vicinity of the rivers, where deep gullies and ravines have formed giving rise to undulating to rolling topography. As such, the entire area is a broad plain of low relief. Local difference in elevation is small due to adaptations of "Haveli system" of cultivation, which has checked the erosion. "The old Haveli" system of cultivation is practised in rabi. The preference to rabi cultivation is due to the high clay content of the soil which is difficult to work in rainy season. Broadly speaking, under Haveli system a large area is bunded and utilised for collecting rain water during the monsoon and is left fallow during Kharif season. The rain water stored as soil moisture helps

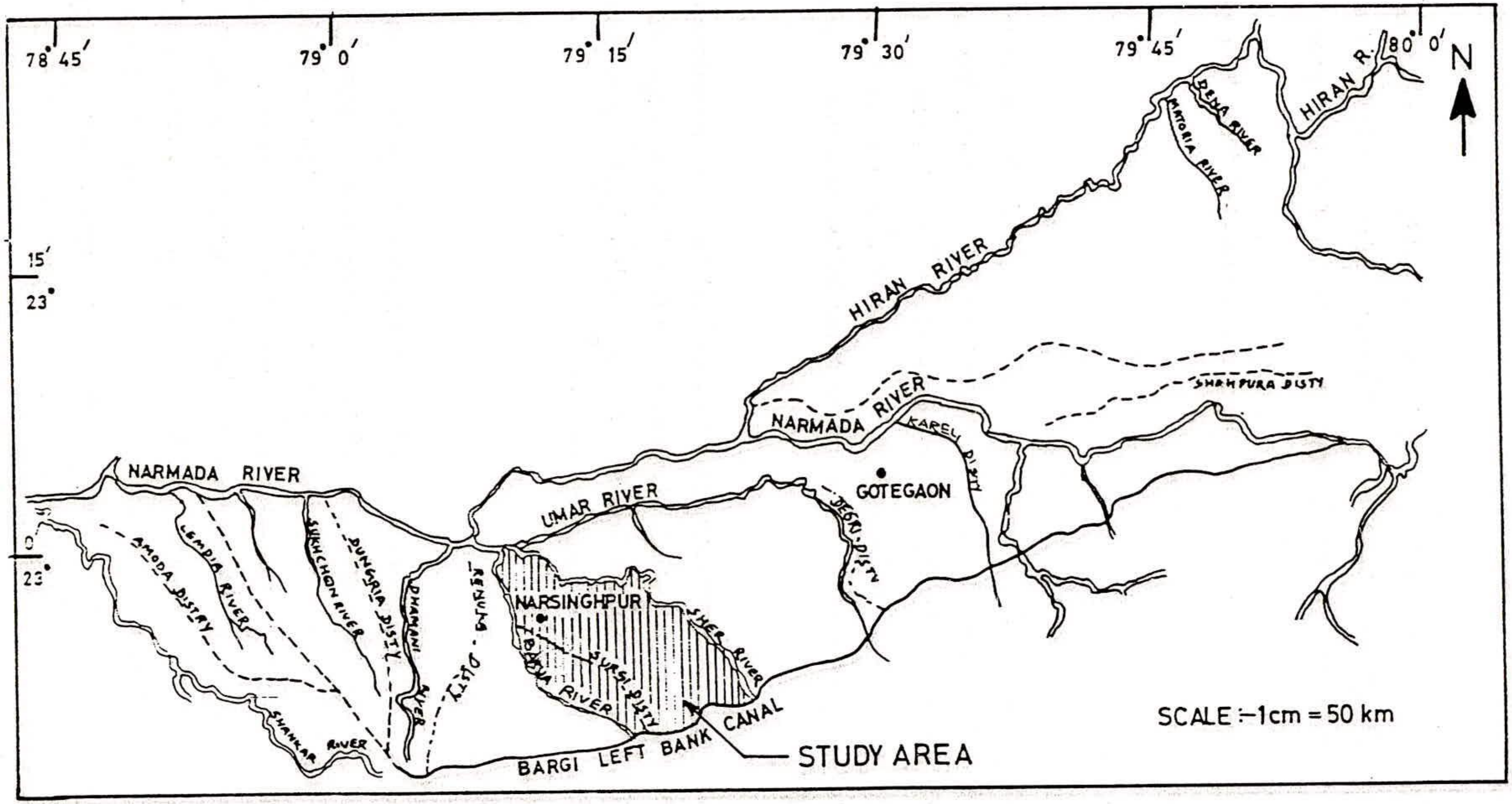

Fig.1 : Location map of the study area.

to grow rabi crops. In the plain area, the slope ranges from 0 to 3%, but in area having undulating topography, the steeper slopes even up to 15% are noticed.

The drainage in the area is dendritic in nature. Small rivulets are confined to the southern and northern part of the study area (FIG.2). In southern area, the drainage is mainly in the hilly area and in the northern part it is along the two major rivers, i.e., Sher and Barurewa. In the central part of the doab, the drainage is poor.

2.3 Climate

The study area broadly falls in sub-zone-2c based on hydrometeorological similarity of the country. The tract enjoys a sub-tropical climate. There are considerable variations in rainfall, temperature and humidity. The area has three distinct seasons in a year, (i) rainy season, (ii) winter season, and (iii) summer season.

The rainy season in area extends from June to October under the influence of south-west monsoon. The area also receives some rainfall during January and February from North-East monsoon. July and August are the heaviest rainy-months. Normally, the rainfall ceases by the end of September. However, inquiet a large number of years, October receives good rainfall. There is considerable variation in rainfall from year to year as well as month to month in a year. As per the rainfall data of Narsinghpur meterological station, annual rainfall varied from 563.3 mm (1965) to 1893.6 mm (1977), with average annual rainfall of 1162 mm (1965-89). Mean monthly rainfall of Narsinghpur meteorological station is given in TABLE-1.

The temperature begins to rise rapidly from about March till May which is generally hottest month. With the on-set of the monsoon in the second week of June, there is an appreciable drop in day temperature. From mid-November on-wards, both day and night temperature decreases rapidly. December and January are the coldest months of the year.

In winter, cold waves affect the area in the wake of western disturbances passing across North India. Normally, the annual temperature varies from 2^0C to 45^0C. On the whole, the days are warm and nights are cooler.

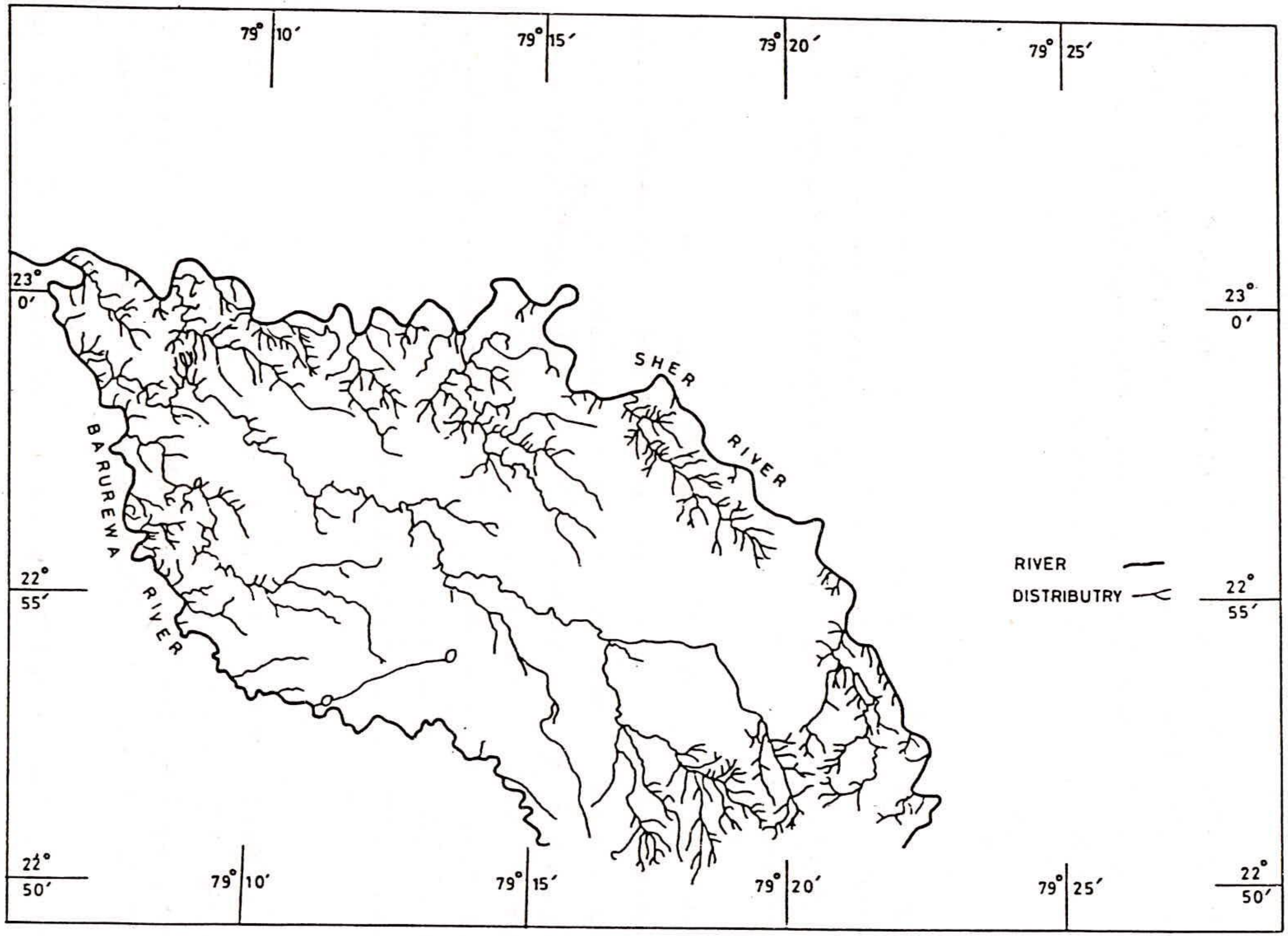

FIG. 2 : Drainage map of the Sher-Barurewa river doab.

Table-1 : Mean monthly rainfall at Narsinghpur meteorological station for the period 1965-89.

Sl. No.	Month	Mean monthly rainfall (mm)	Year 1989
1.	January	18.74	0.00
2.	February	19.40	0.00
3.	March	10.36	38.00
4.	April	1.68	0.00
5.	May	7.05	0.00
6.	June	166.70	231.80
7.	July	314.95	93.40
8.	August	422.50	603.60
9.	September	155.58	120.80
10.	October	22.30	0.00
11.	November	11.30	0.00
12.	December	11.40	0.00
	TOTAL	1161.96	1087.60

2.4 Soils

Broadly speaking, the soils of the area are in various shades of darkness and are derived from Deccan trap rocks. Generally, the soils are clayey in texture and its depth is more than 9 m. Mostly black soil constitute the top layer and is variable in thickness (about 1-2 meters). Below the dark brown soil, a yellowish layer is found. Towards the banks of river, the texture of the soil changes from heavier to lighter grade i,e from clay to clay loam, loam, sandy loam and finally sandy. The colour of the soil also changes from dark greyish brown to brown, yellowish brown and finally yellow grey.

In some places, the soils have been formed from sand stone parent material in which a lot of textural variation is found. It varies from sandy loam to clay. The soil crust is deep and has a fair amount of gravel or Kankar (impure form of nodular calcium carbonate) along the depth of profile.

The soil survey of the area had been carried out by Soil Survey Unit, Jabalpur under Department of Agriculture, Govt. of Madhya Pradesh. In study area, there are only four types of soil i.e. clay, clay loam, sandy clay loam and loam, in which clay and clay loam are predominant (FIG.3). Based on morphological and chemical characteristics of the soil profiles six soil series i.e. Beloda, Sanguraria, Sarol, Gopalpur, Amagaon and Kunda have been identified (FIG.4). The types of soil and soil series of area are enlisted in TABLE-2 and TABLE-3 respectively.

Table-2 : Soil texture in Sher-Barurewa doab area.

Sl. No.	Textural class	Grid No.	Total no. of Grids
1.	Clay	229, 230, 231, 232, 234, 242, 245, 248, 249, 250, 252, 253, 260, 261, 262, 263, 265, 267, 269, 270, 280, 281, 282, 283, 284.	25
2.	Clay loam	233, 244, 246, 251, 266, 268, 277, 278.	8
3.	Loam	264.	1
4.	Sandy Clay loam	243, 247, 258, 259, 275, 276, 279, 287, 288.	9

Table-3 : Soil Series in Sher-Barurewa doab area.

Sl. No.	Soil Series	Grid No.	Total No. of Grids
1.	Amgaon	229, 230, 231, 232, 233, 234, 245, 249, 250, 251, 260, 262, 263, 266, 269, 270, 282, 284.	18
2.	Beloda	244, 248, 252, 267.	4
3.	Gopalpur	243, 246, 247, 259, 264, 279.	6
4.	Kunda	242, 258, 268, 275, 276, 277, 287, 288.	8
5.	Sarol	265, 280, 281, 283.	4
6.	Songuraria	253, 261, 278.	3

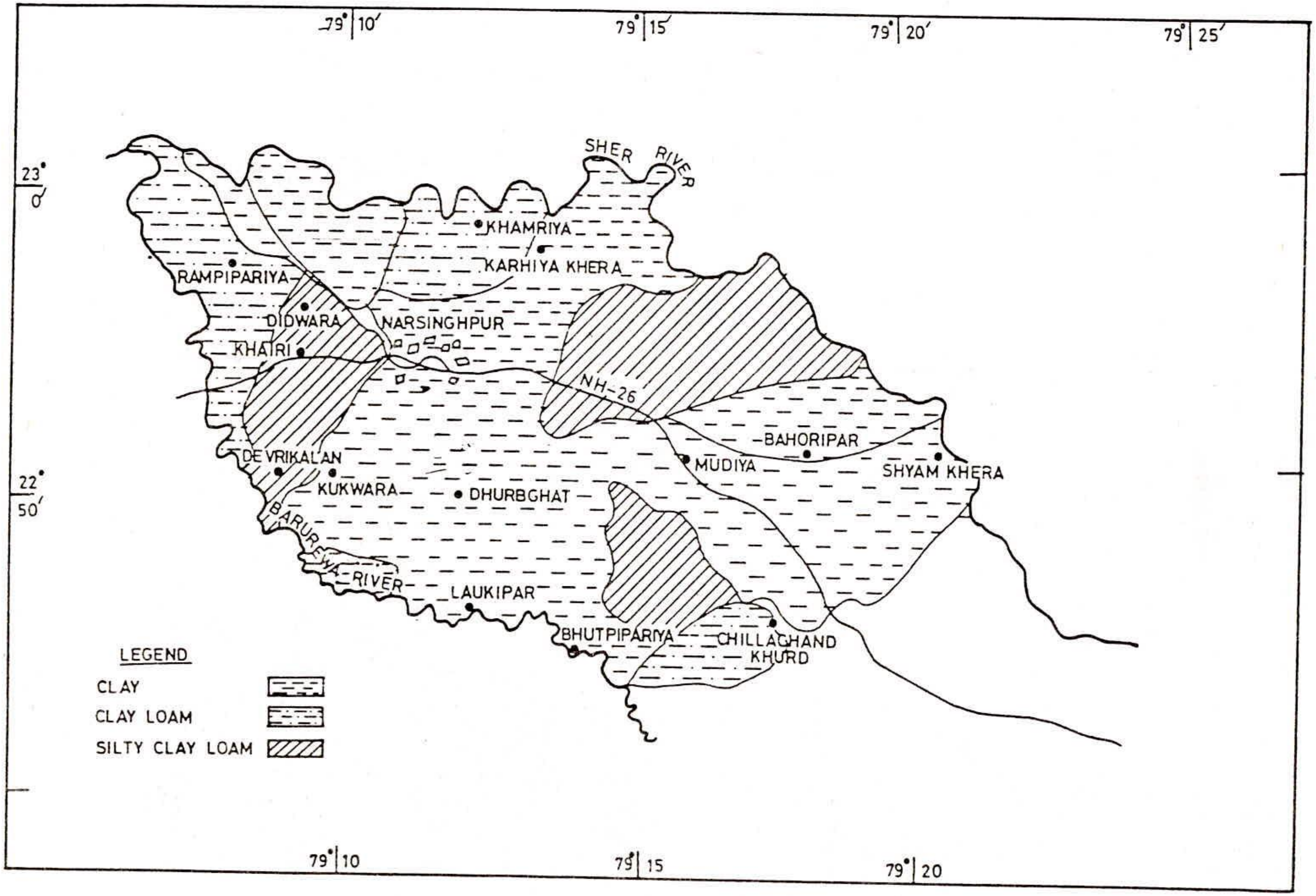

Fig. 3 : Soil type map of the Sher-Barurewa river doab

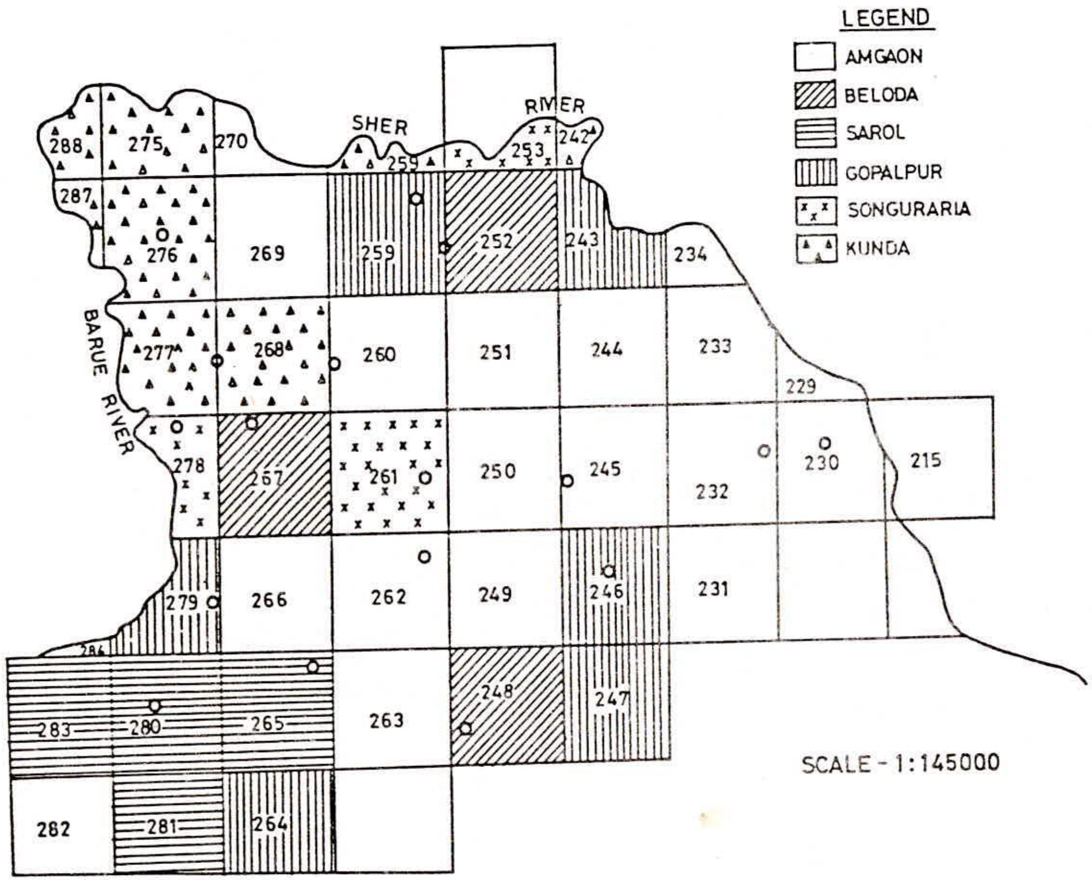

Fig. 4 : Soil series map of the Sher-Barurewa river doab

2.5 Groundwater

The entire study area is covered with alluvium of recent age. Alluvium consists mainly of clay and fine to medium grained sand. The thickness of alluvium varies from place to place ranging from 15 to 180m. Groundwater is mostly present under confined conditions and gives yield of 75-150 m^3/hr for 6m drawdown.

Water table is a guiding factor which controls the movement of water through soil, though by physical character, a soil may have different drainability. The water levels in different observation wells are given in TABLE-4.

Table-4 : Groundwater conditions in the study area in 1989.

S. No.	Village	Ground Level (m)	Pre-monsoon (m)	Post-Monsoon (m)
1.	Devakachh	340.00	322.00	323.85
2.	Nandwara	351.00	345.55	347.28
3.	Narsinghpur	352.50	338.28	343.52
4.	Singhpur	359.50	345.40	350.00
5.	Khamaria	341.50	335.70	337.95
6.	Dangidhan	369.90	359.40	365.15
7.	Bachai	385.00	378.40	381.55
8.	Mainawari	355.00	349.09	352.77
9.	Ghatpidar	363.20	356.25	357.60
10.	Rathotia	349.00	339.70	341.00
11.	Umaria	345.00	326.90	328.05
12.	Kalyanpur	375.00	368.90	372.15
13.	Niwari	349.00	349.45	353.65
14.	Navalgaon	366.70	361.05	365.15

(Source : Groundwater Survey Unit, Narsinghpur)

2.6 Landuse and vegetation

The study area is normally agricultural area with no forest land. Forested area lies beyond Bergi canal in the south. The main crops grown in the area are Soyabean, Gram, Arhar, Masoor, Moong, Jwar, Wheat and Sugar Cane. In some low lying areas, rice is also cultivated. Fruit bearing trees are Mango and Jamun.

2.7 Irrigation Practices

As the general topography of the area under study is somewhat irregular, soil is highly impermeable due to its high clay content, both surface/sub-surface method of irrigation are not efficient for the study area. Therefore, Sprinkler method of irrigation is in general practice to irrigate the fields located in the study area.

3.0 INFILTRATION PROCESS AND METHODS OF MEASUREMENT

Infiltration characteristics of a soil is an important parameter for hydrological modelling. It is essential to know the rates at which different soils will take in water under different conditions. Infiltration rates are affected by a number of factors of which soil moisture, soil texture and vegetal cover are most important. It is a basic parameter for developing an integrated crop, soil and water management plan. The knowledge of infiltration is of great importance to a hydrologist in estimating rate of runoff and peak flow with time, to a soil scientist / agronomist in estimating the availability of soil moisture, to irrigation and drainage engineer in planning and design of various water resources development projects.

3.1 Factors affecting infiltration rate

Once the importance of study of infiltration rate has been established, it is useful to understand the effect of various soil and climatic factors on the infiltration rate. Some of the most common factors affecting infiltration rate are :

a. Soil properties (including structure, texture and distribution, porosity and compactness of soil grains),
b. Soil moisture,
c. Landuse characteristics,
d. Rainfall (duration and intensity),
e. Surface slope, and
f. Climate.

Effect of soil properties

Musgrave and Horton (1964) have shown that infiltration , characteristics are effected by grain size and 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, whereas in silts and clays the soil aggregates breaks due to the impact of raindrops, causing the clay and silt particles to flow at and penetrate previously existing pores, thus clogging them and greatly reducing infiltration.

Rauzi and Fly (1968) found that the unfavourable surface soil conditions markedly reduce water intake rates. They found that soils with compact or blocky clay sub soils and clay have low intake rates. Clay soils with good structure take water at rates three or four times that of dense clay soils with poor structure i.e. the degree of surface soil compactness is a major factor affecting infiltration rate.

Many experiment have shown that pore sizes and pore-size distribution are greatly affected by the content of organic matter because both the sizes and soil aggregates and their stability in water are related to the amount of soil organic matter. The addition of organic matter or its removal changes the prevailing permeability.

Effect of Soil Moisture

Horton studied the maximum and minimum infiltration rates of a soil. The maximum infiltration rate for a given soil occur at the beginning of the rain. He has indicated that the infiltration rate decreases rapidly because of changes in the structures of the surface soil and increase in soil moisture and then gradually approaches to a somewhat stable minimum. Powell and Beasley have reasoned that when the soil is dry the high initial 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.

Effect of land use

Musgrave and Horton have stated 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 materials 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 parts 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).

Effect of Rainfall

Linsley, Kohler and Paulhus(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 application of water was sufficient to give runoff, a fairly definite amount of water entered the soil and any amount of application in 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.

Green (1962) has 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.

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 the greatest slope.

Effect of Climate

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 permeable as, or even more permeable than, frost-free soil. On the other hand, if the soil is frozen while saturated, concrete frost in the form of a very dense, nearly impermeable layer often results. Trimble et. al (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.

3.2 Infiltration Estimation And Measurement Techniques

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 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.

Maximum infiltration rates are measured in the field by applying water to the soil surface either by ponding or as natural or artificial rain at rates sufficient to cause some runoff. Maximum infiltration rates are very high in the beginning of water application, but diminishes in time to much lower, nearly constant values.

In India many type of infiltrometers (as discussed below) are used to determine the infiltration characteristics of the soils. Where infiltrometer data are not available, phi index or empirical formulae are used.

Infiltrometers can be grouped into two general groups; (i) Rainfall Simulators, with the water applied in the form and at the rate comparable with natural rainfall and (ii) 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, in the quantity of water that is required, and in the methods of measuring the water. In flooding type too, mainly double ring infiltrometers are used, but some times single ring infiltrometers are also used.

Single Ring Infiltrometer

It consists of a metal cylinder which is driven into the soil to a short distance (nearly 15 cm). The time pattern of infiltration is obtained by monitoring the change in supply to the surface. Refinements to the technique involve the introduction of an outer ring as a buffer and devices for monitoring a constant head of supply

Changes in the supply are monitored by recording the water levels in the graduated column above the infiltrometer at selected times.

Double ring infiltrometer or Concentric Ring Infiltrometer

The most common type consists of two shallow concentric rings of sheet metal, usually ranging from 22.5 to 90 cm diameter are placed with their lower edges a few centimetres below the ground surface and with the upper portion projecting above (FIG.5) :

Water is now applied in both apartments '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 must be added to the inner ring in order to maintain a constant level, the infiltration capacity and its manner of variation are determined. A plot of infiltration rate in cm/hr v/s time is shown in FIG.5.

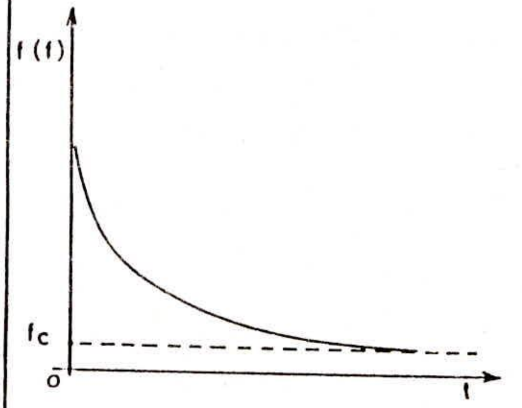

Fig. (a)- Typical Infiltration Curve.

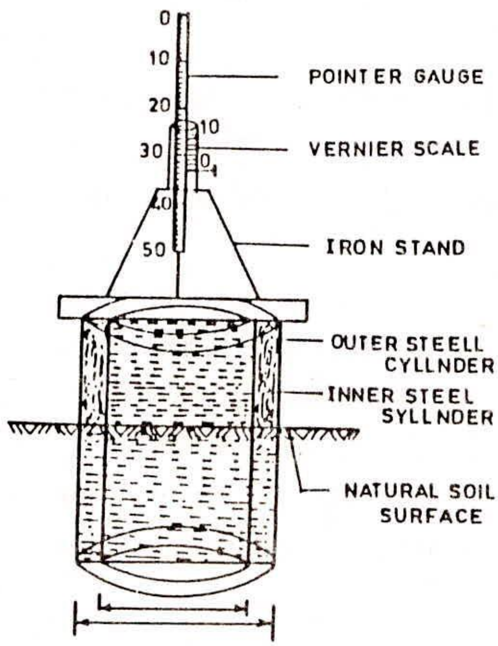

Fig. (b) Equipment Measuring. Infiltration Rate

FIG.5 : Double Ring Infiltrometer

4.0 METHODOLOGY

Normally, three steps are involved in any field investigation, i.e., pre-field preparations, field investigations and post-field analysis.

4.1 Pre-field preparations

Reconnaissance soil survey of the Bargi Left Bank Canal Command area has been carried out by the Soil Survey Unit, Department of Agriculture, Government of Madhaya Pradesh. The soil texture map and soil series map (based on soil characteristics) of the Narsinghpur District was collected from the Department of Agriculture, Narsinghpur (FIG.3). A base map, indicating road network of the area, was prepared using Survey of India Toposheets. The soil texture map was transferred on the base map for location of test sites. The sites were tentatively chosen in such a way that different type of soils found in the area are covered and the sites are easily approachable. Twelve sites were identified for the infiltration tests, well distributed all over the area (FIG. 6).

4.2 Field Investigations

Field work was carried out during the first and second week of October, 1995. During the field work, infiltration tests were carried out at twelve locations and soil samples were collected for soil texture analysis.

Infiltration tests were carried out using micro-processor based double ring infiltrometer. The inner and outer rings used for the test were of 22.5 cm and 35 cm diameter, respectively. The rings were inserted into the ground upto a depth of 25 - 30 cm. The tests were carried out using constant head method with a head of 10 cm. Each test was conducted for such a duration (2 to 4 hrs.) during which the infiltration rate became constant.

4.3 Post field analysis

After the field work was over, the samples were brought to the National Institute of Hydrology, Roorkee for laboratory analysis, i.e. particle size analysis and Saturated hydraulic conductivity etc.

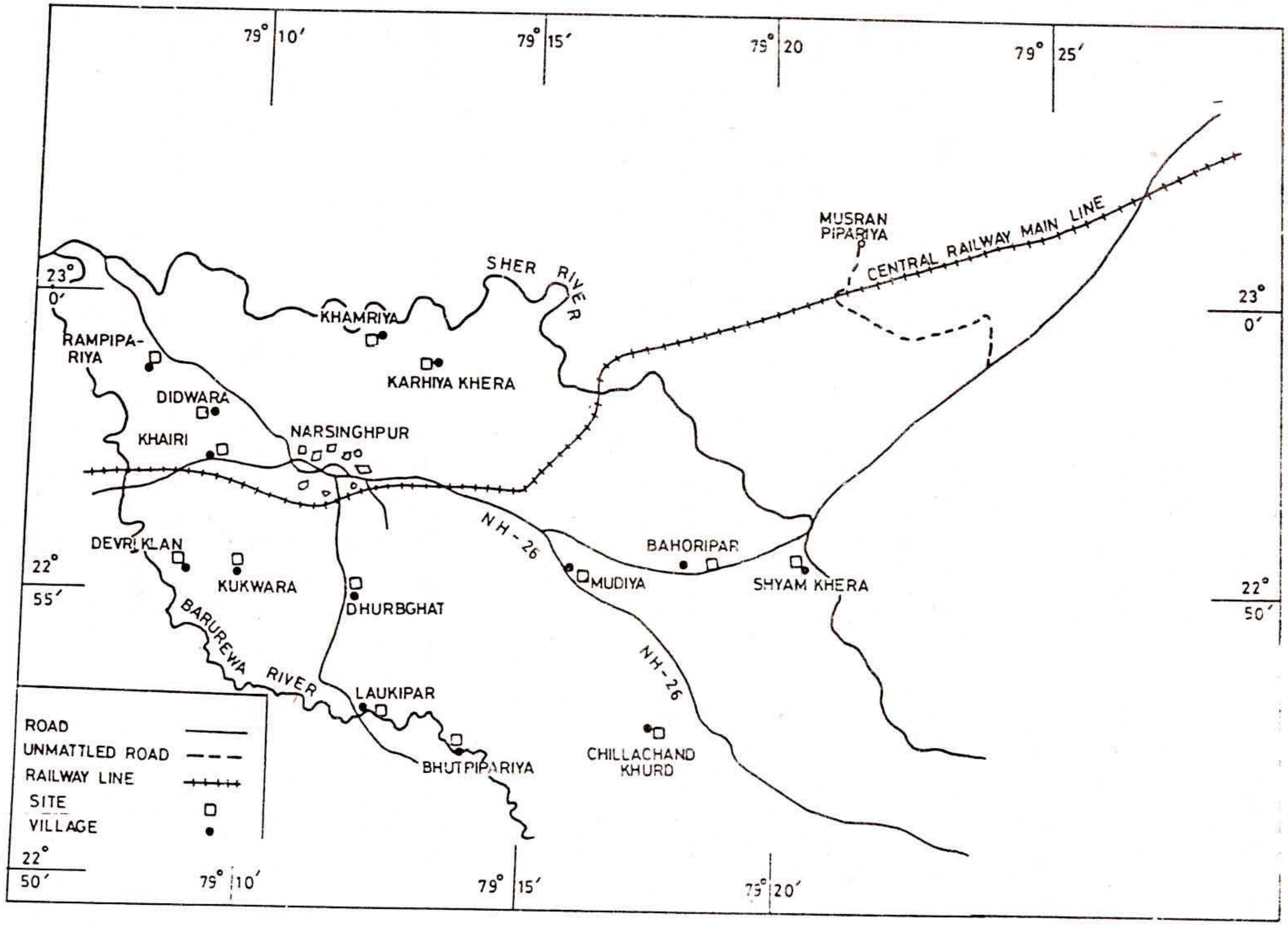

FIG.6 : Location of Infiltration test sites.

Textural analysis

The samples collected from the field were tested in the Soil Water Laboratory, Nation Institute of Hydrology, Roorkee, for the particle size distribution. Particle size distribution of the soils was by sieve and sedimentation analysis. Soil samples were washed with distilled water to remove the soluble salts. The washed samples were separated into two fractions i.e., +75 micron and -75 micron through wet sieving. Sieve analysis was performed for the fraction of soil retained on 75 micron sieve (+75 micron). The portion passing through the 75 micron sieve (-75 micron) was analysed by sedimentation analysis using hydrometers. The test results of the analysis are given in TABLE-5 .

Table-5 : Particle size distribution in soils of Sher-Barurewa river doab

Sl. No.	Name of village	Depth (cm)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Texture
1.	Chilichawk Khurd	10-35	0.50	27.00	15.50	57.00	Clay
2.	Karhiya khera	20-50	5.30	6.50	12.20	76.00	Clay
3.	Devri Kalan	25-50	5.20	11.30	13.50	70.00	Clay
4.	Kukwara	25-50	4.40	5.60	11.00	79.00	Clay
5.	Niwari	25-50	7.00	17.50	9.50	66.00	Clay
6.	Mudia	25-50	0.80	2.80	14.90	81.50	Clay
7.	Shyamkhera	20-40	0.10	5.40	11.50	83.00	Clay
8.	Khandhrapur	20-50	2.10	11.67	10.73	75.50	Clay
9.	Laukipar	20-50	0.10	36.31	14.59	49.00	Sandy clay
10.	Khamariya	25-50	2.60	34.65	10.75	52.00	Sandy clay
11.	Dhrubghat	15-50	1.10	2.60	11.30	85.00	Clay
12.	Didwara	25-50	2.20	7.70	12.60	77.50	Clay

The Table-5 shows that the soils are mostly clayey in texture, except at two places were sand percentage is a bit higher.

Preparation of Infiltration map

Raw data obtained from the field was processed to find the infiltration capacity of the soils. This soil infiltration capacity was transferred to soil series map of the area and infiltration capacity map was prepared (FIG.7).

Table-6 : Infiltration capacity of the soils of Sher-Barurewa river doab

S. No.	Name of village	Texture	Infiltration capacity (cm/hr)
1.	Chilichawk Khurd	Clay	0.6
2.	Karhiya Khera	Clay	0.4
3.	Devri Kalan	Clay	0.2
4.	Kukwara	Clay	0.3
5.	Niwari	Clay	0.24
6.	Mudia	Clay	0.6
7.	Shyamkhera	Clay	0.6
8.	Khandhrapur	Clay	0.8
9.	Laukipar	Sandy clay	1.2
10.	Khamariya	Sandy clay	0.3
11.	Dhrubghat	Clay	0.3
12.	Didwara	Clay	0.4

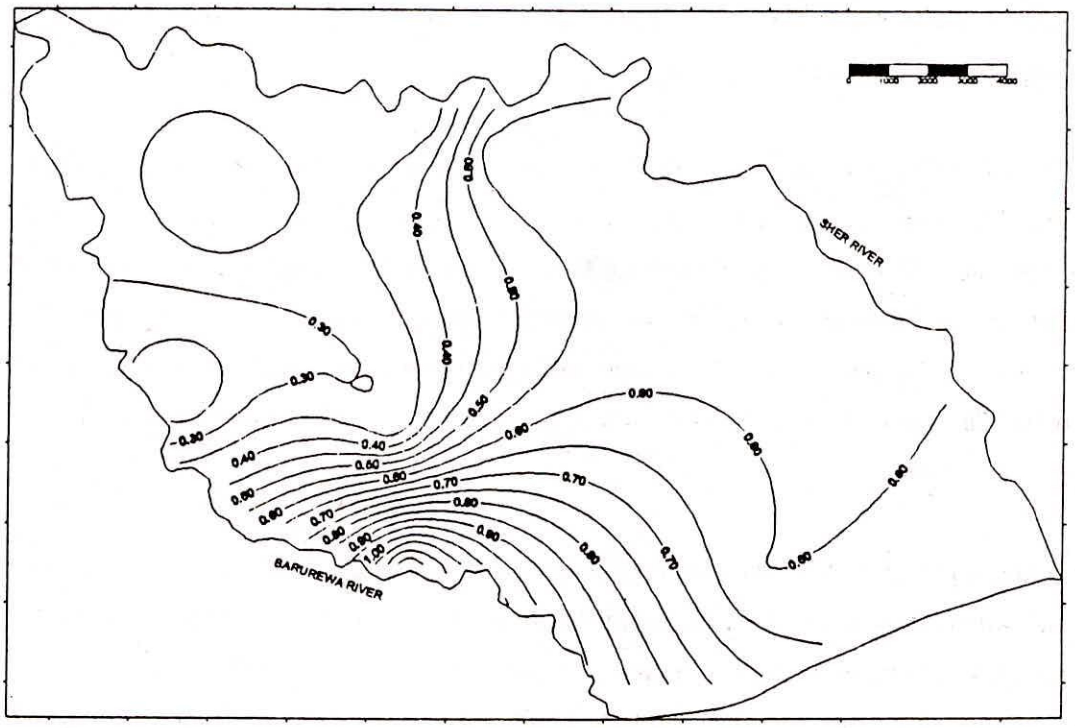

FIG.7 : Infiltration Map of the Sher-Barurewa Doab

5.0 RESULTS AND DISCUSSION

Infiltration tests were carried out at twelve locations in the Sher-Barurewa doab in Narmada basin during October, 1995 to assess the infiltration capacity of the soils in the area. Results of the infiltration tests are shown in FIG.8 to FIG.19.

The top soils of Sher-Barurewa doab area are mostly dark coloured and are clayey in texture. These soils normally form a layer of about 1-2 meter thickness. At few places, underlying coarse calcareous yellow coloured soil are also exposed. Black clayey soils have been derived from Deccan Trap rocks, which are abundant in the nearby areas. Both the black clayey soils and yellow calcareous soils have low infiltration rate, ranging from 0.24 cm/hr to 1.2 cm/hr. In the initial period of water application the infiltration rate is very high which reduces very rapidly with time.

The soils of Khamriya and Laukipar are sandy clay in texture and the infiltration rate varies from 0.3 cm/hr to 1.2 cm/hr. At Khamariya, it has been seen that initially, i.e. till 150 minutes, the rate is high (4.2 cm/hr) after that it drops rapidly to 0.3 cm/hr. This may be due to presence of low permeability layer (clay) present below sandy clay at shallow depth. At all other ten sites, the soil is clayey in texture and the infiltration rate varies from 0.24cm/hr to 0.8cm/hr. The variation in infiltration rate at these sites is small and and may be due to local heterogeneities.

Initial high infiltration rate may be because of the presence of cracks in the soils. As the time of water application increases, the infiltration rate reduces very quickly, may be. due to the presence of swelling clays. The soils derived from basic rocks (like Deccan Trap) generally contain clay minerals like montmorilonite. These clay minerals have the property of expanding in the presence of moisture. This expansion of minerals causes the reduction in pore space as well as the connectivity of pores and hence reduces the infiltration rate. The light coloured soils are rich in $CaCo_3$, as is evident from the presence of kankers in this layer of soils. The low rate infiltration rate may be due to cementation of mineral particles by the calcareous material present.

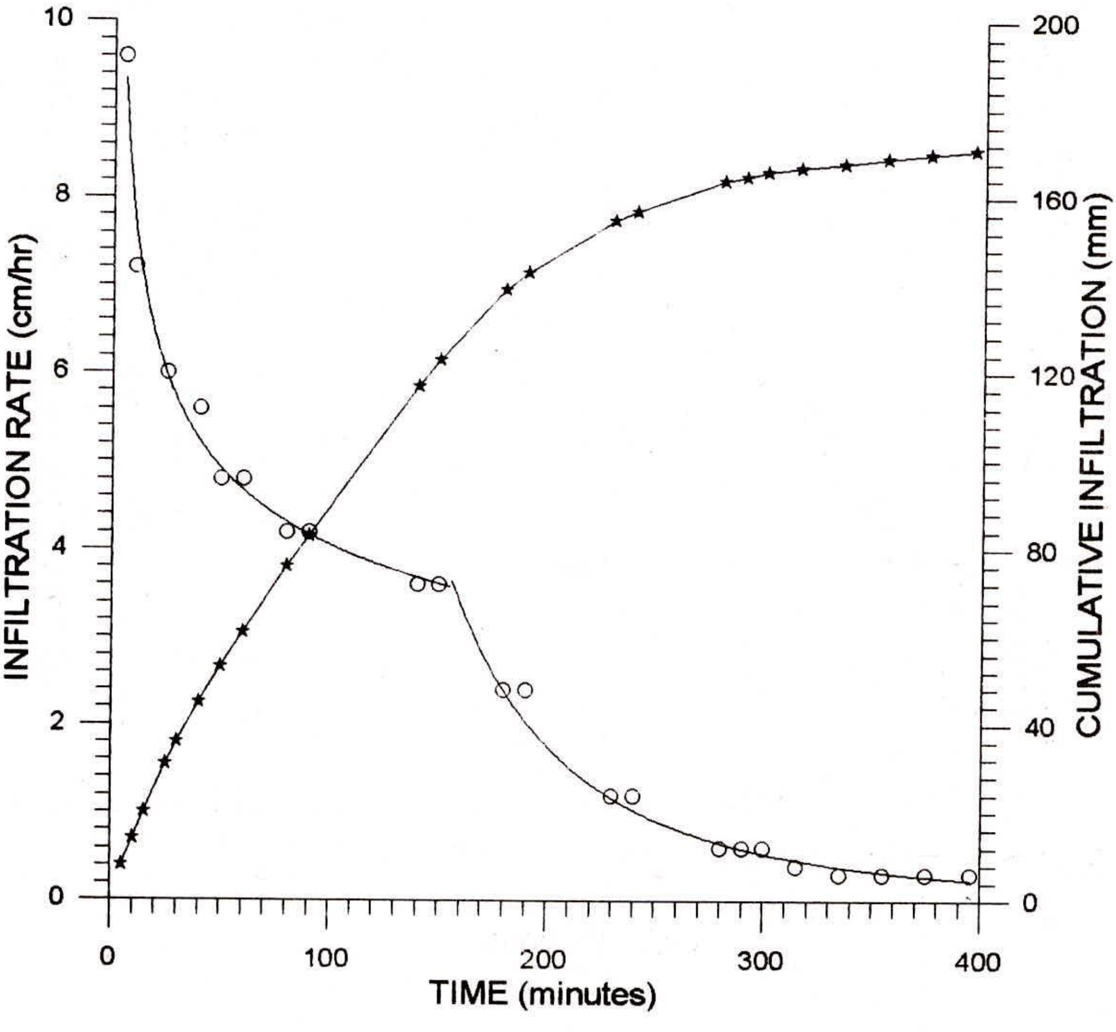

FIG.8 : Infiltration rate and Cumulative infiltration curves at Khamariya

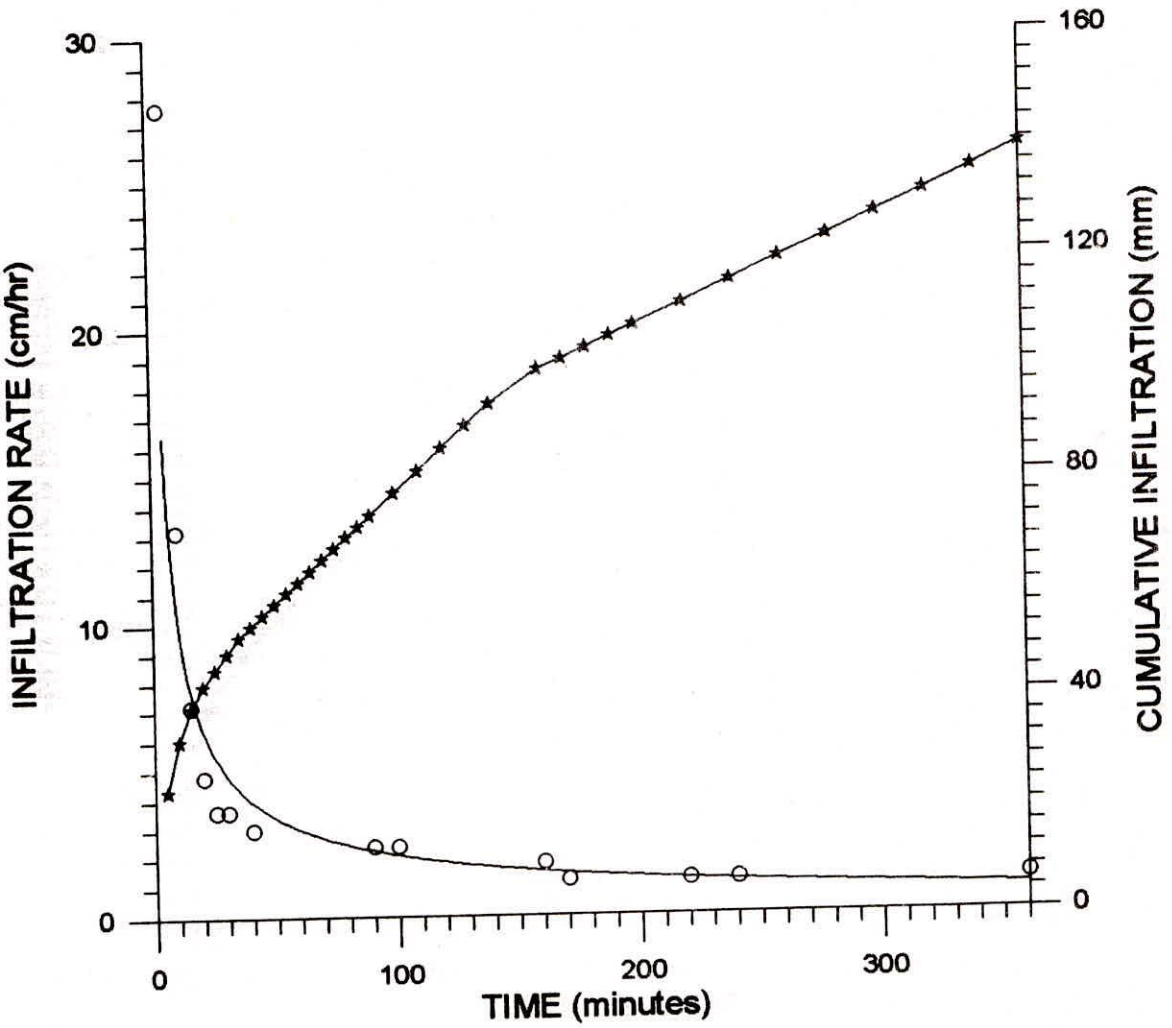

FIG. 9 : Infiltration rate and Cumulative infiltration curves at ChilichawKhurd.

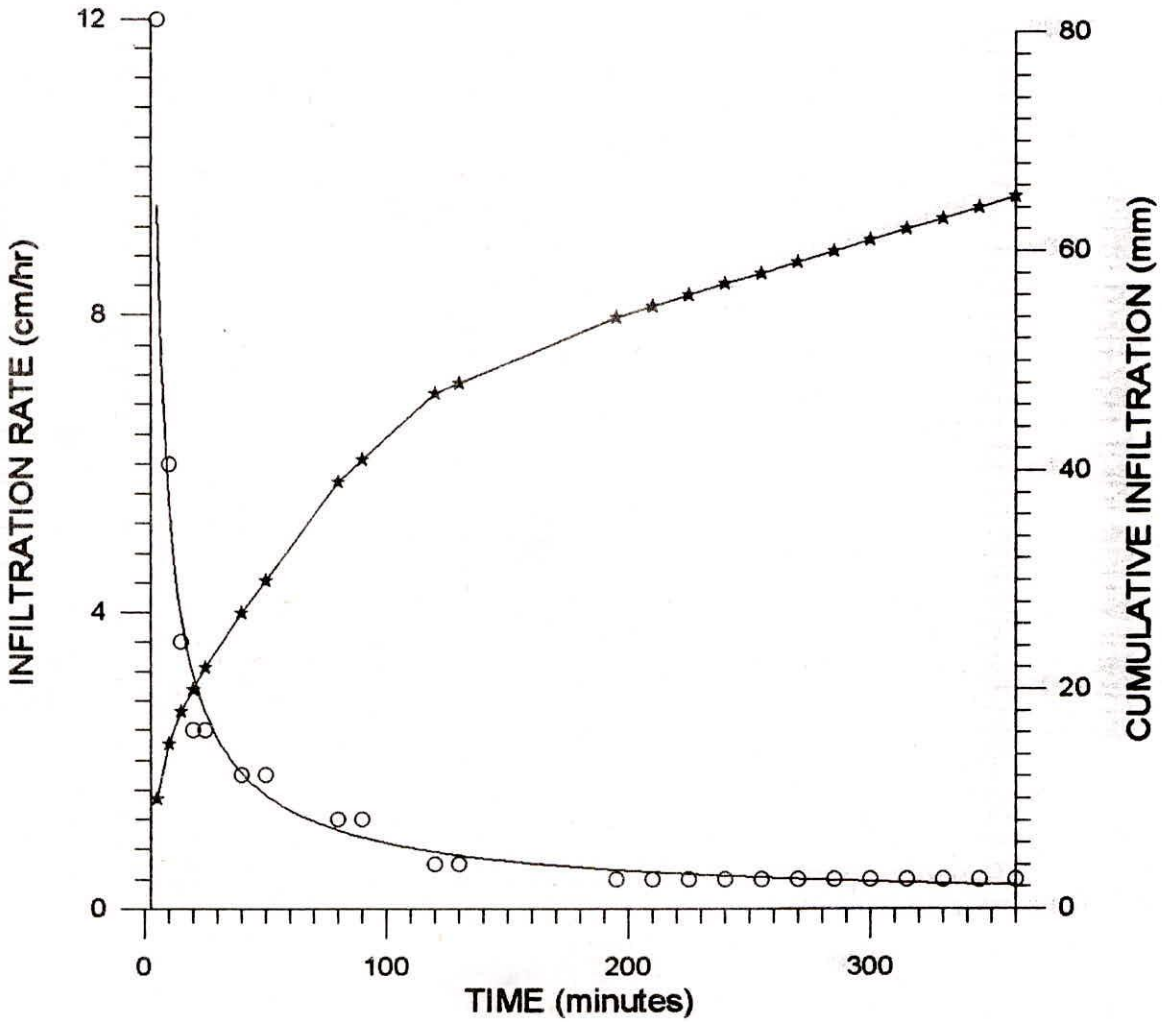

FIG.10: Infiltration rate and Cumulative infiltration curves at Karhiya Khera.

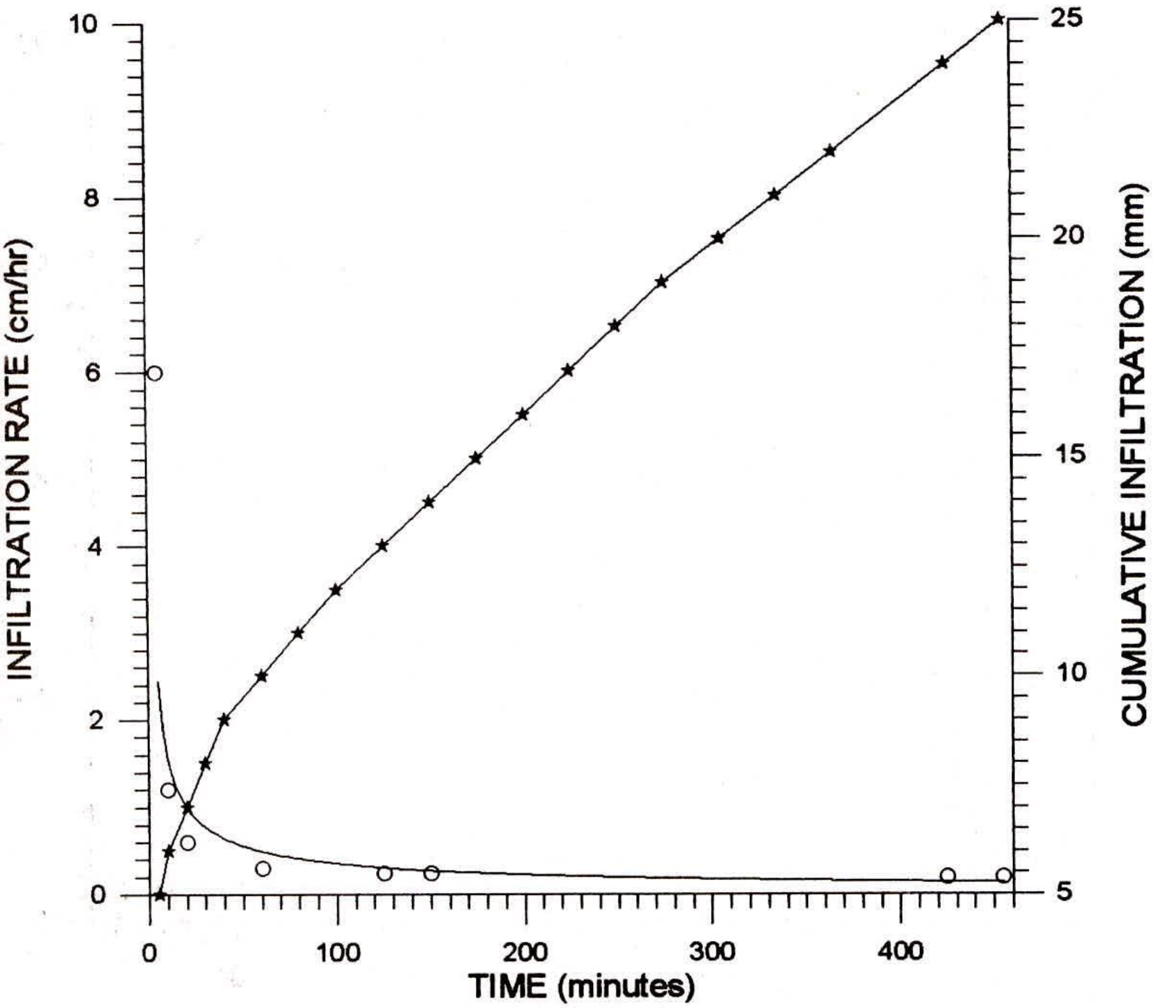

FIG.11 : Infiltration rate and Cumulative infiltration curves at Devrikalan.

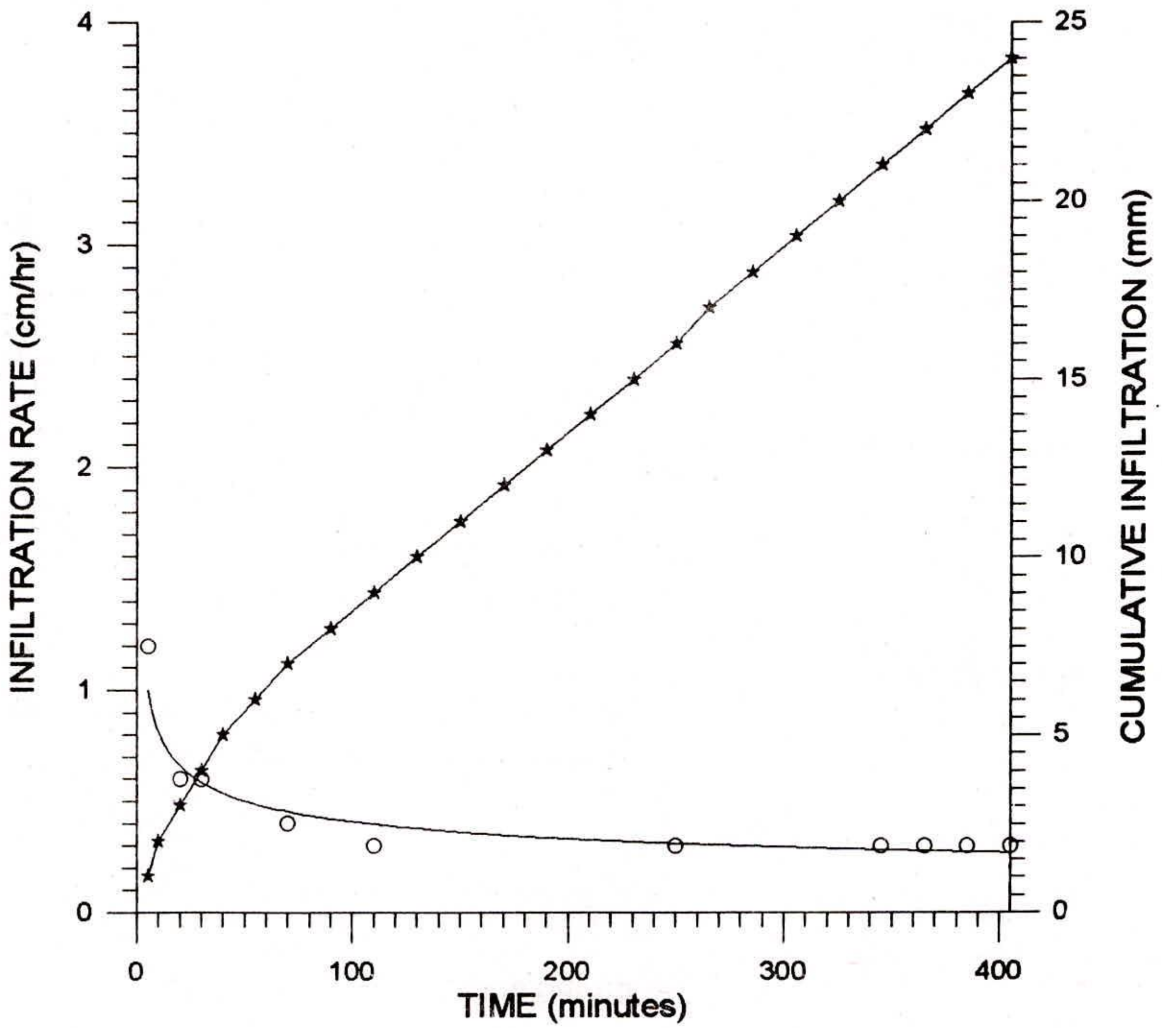

FIG.12 : Infiltration rate and Cumulative infiltration curves at Kukwara.

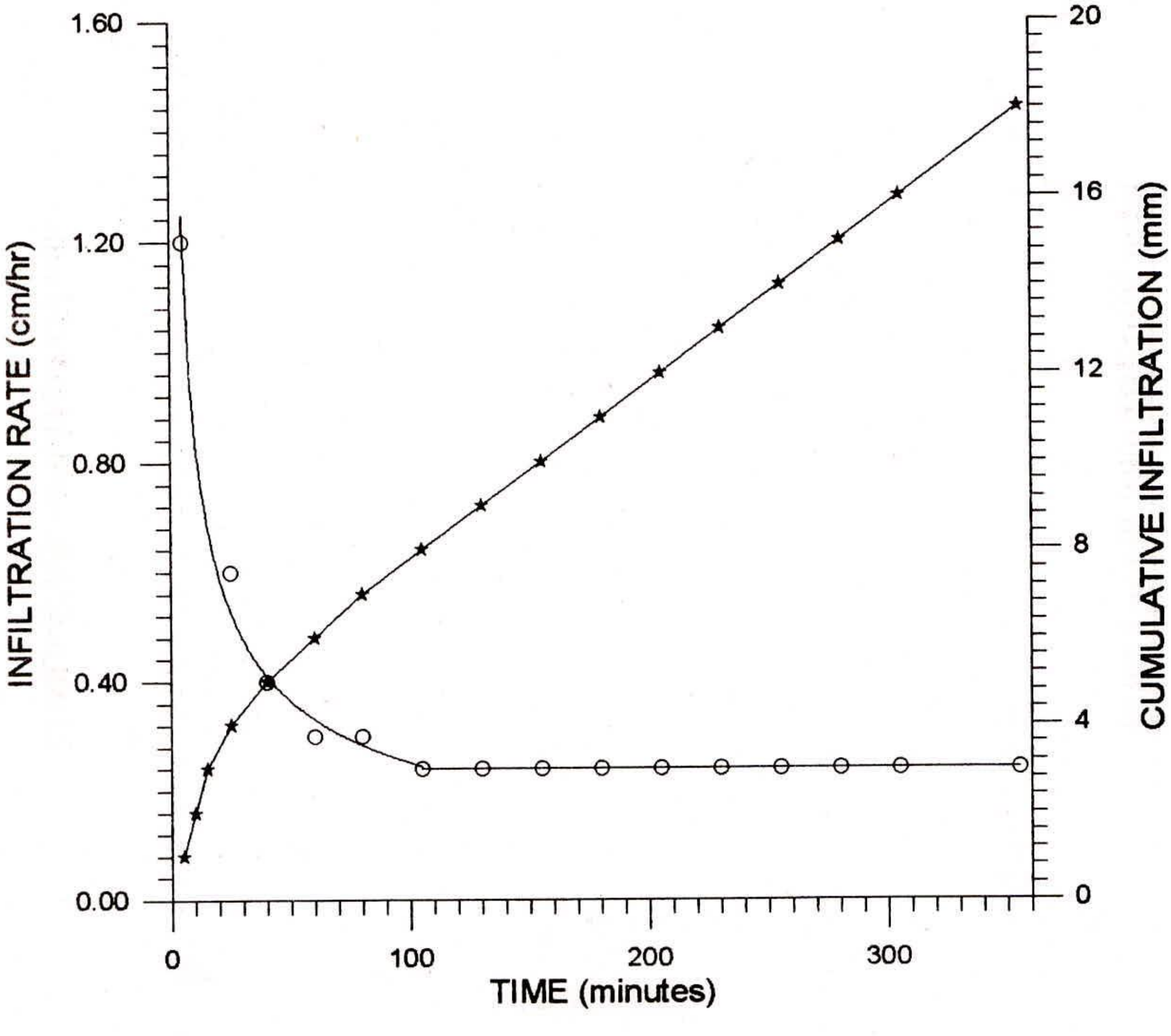

FIG.13 : Infiltration rate and Cumulative infiltration curves at Niwari.

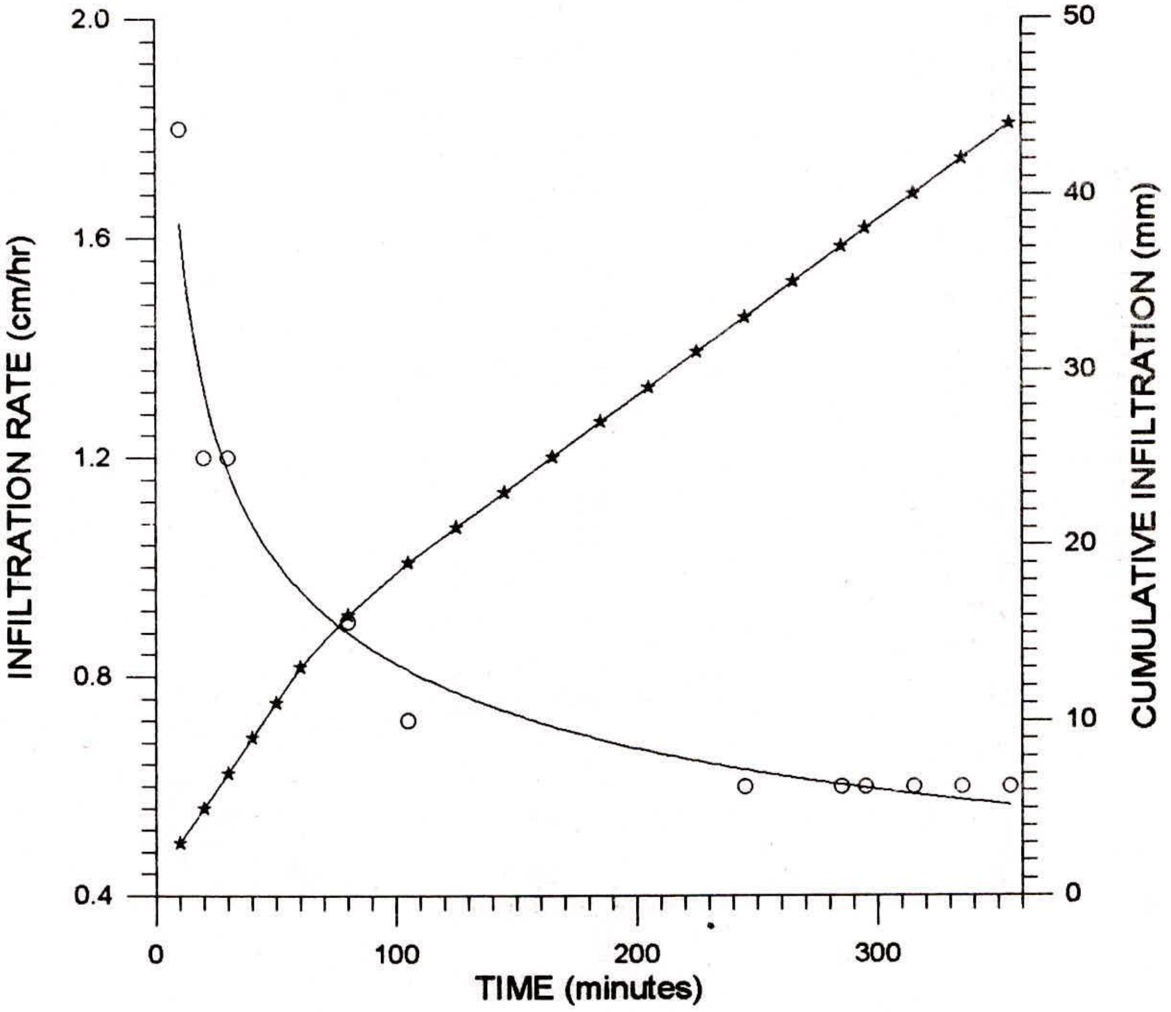

FIG.14 : Infiltration rate and Cumulative infiltration curves at Mudia.

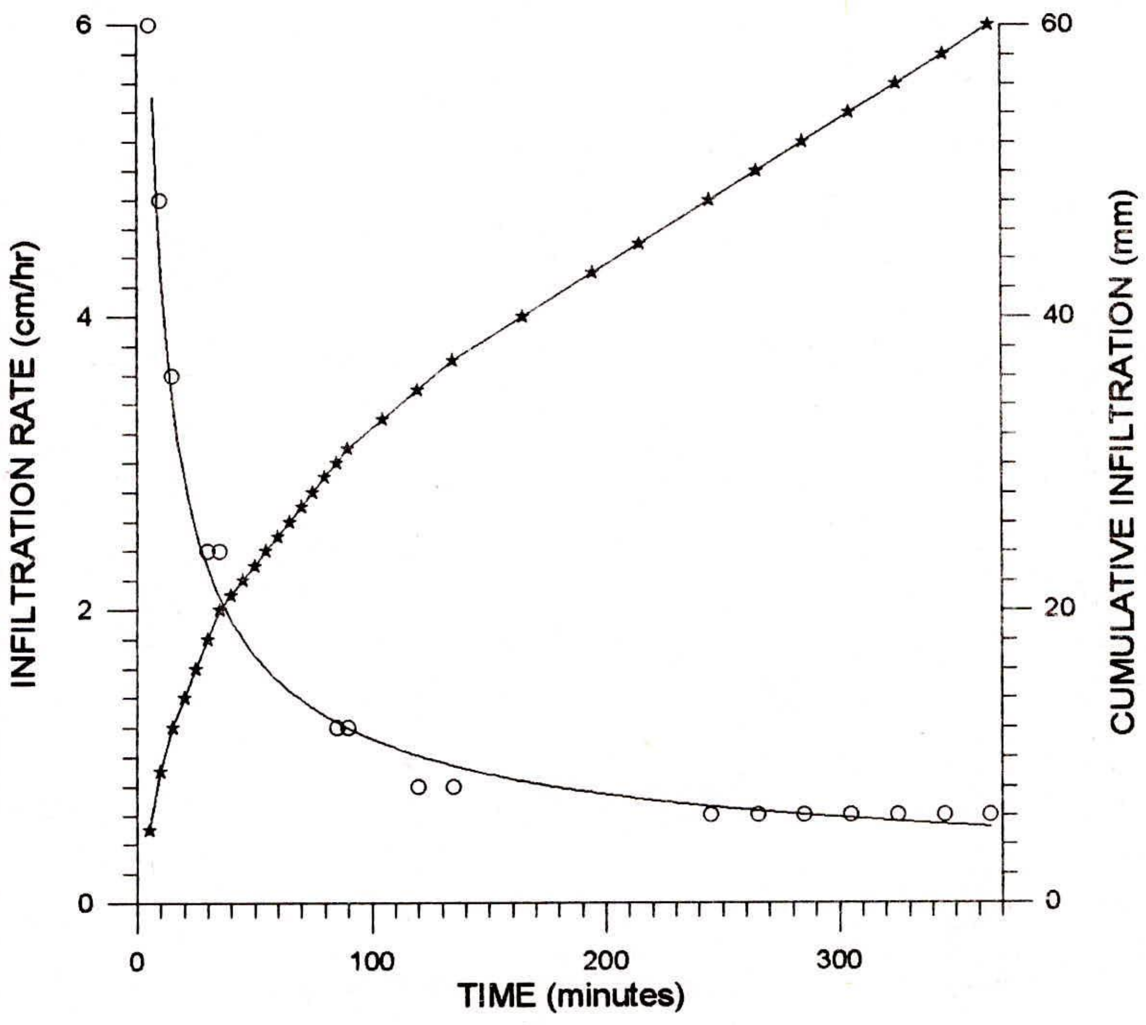

FIG.15 : Infiltration rate and Cumulative infiltration curves at Shyamkhera.

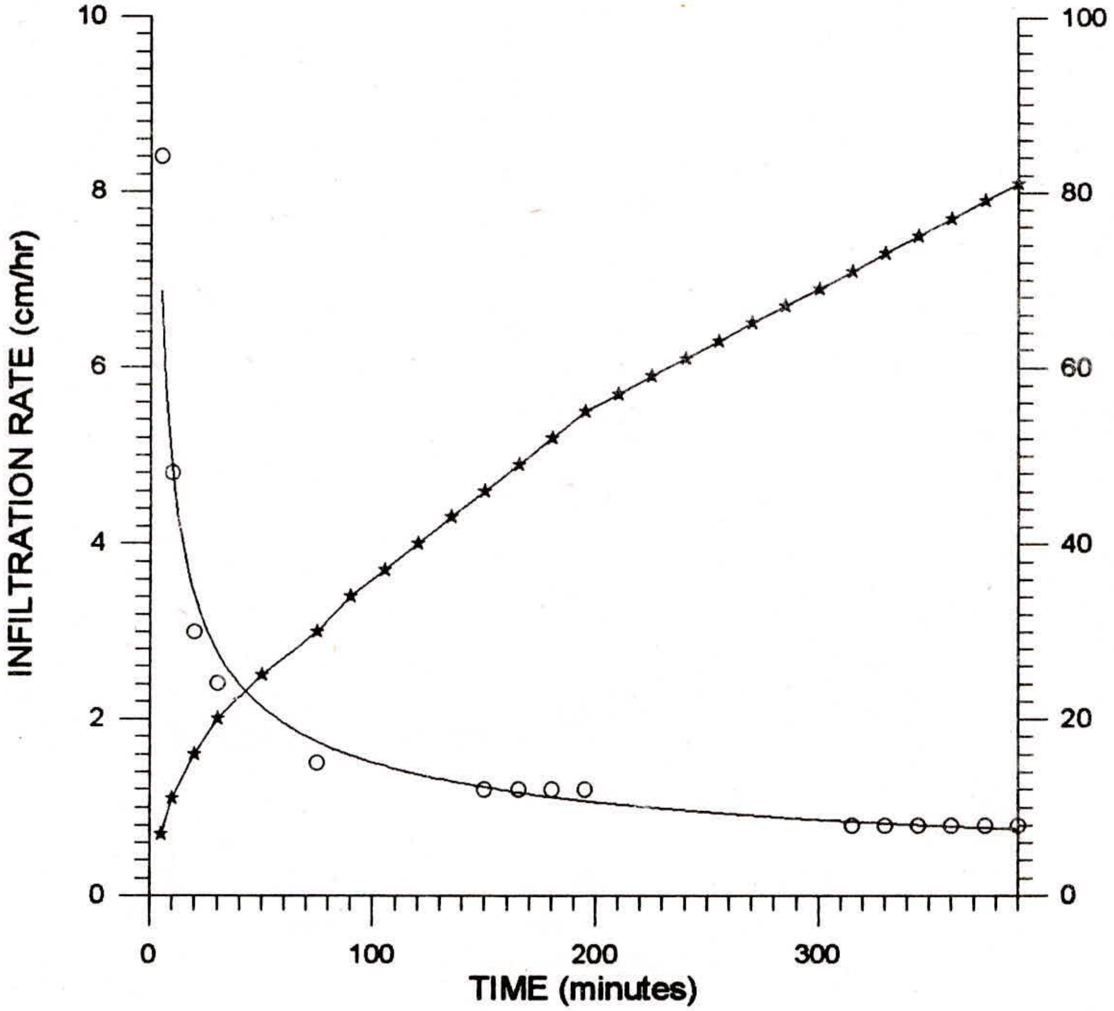

FIG.16 : Infiltration rate and Cumulative infiltration curves at Kandharapur.

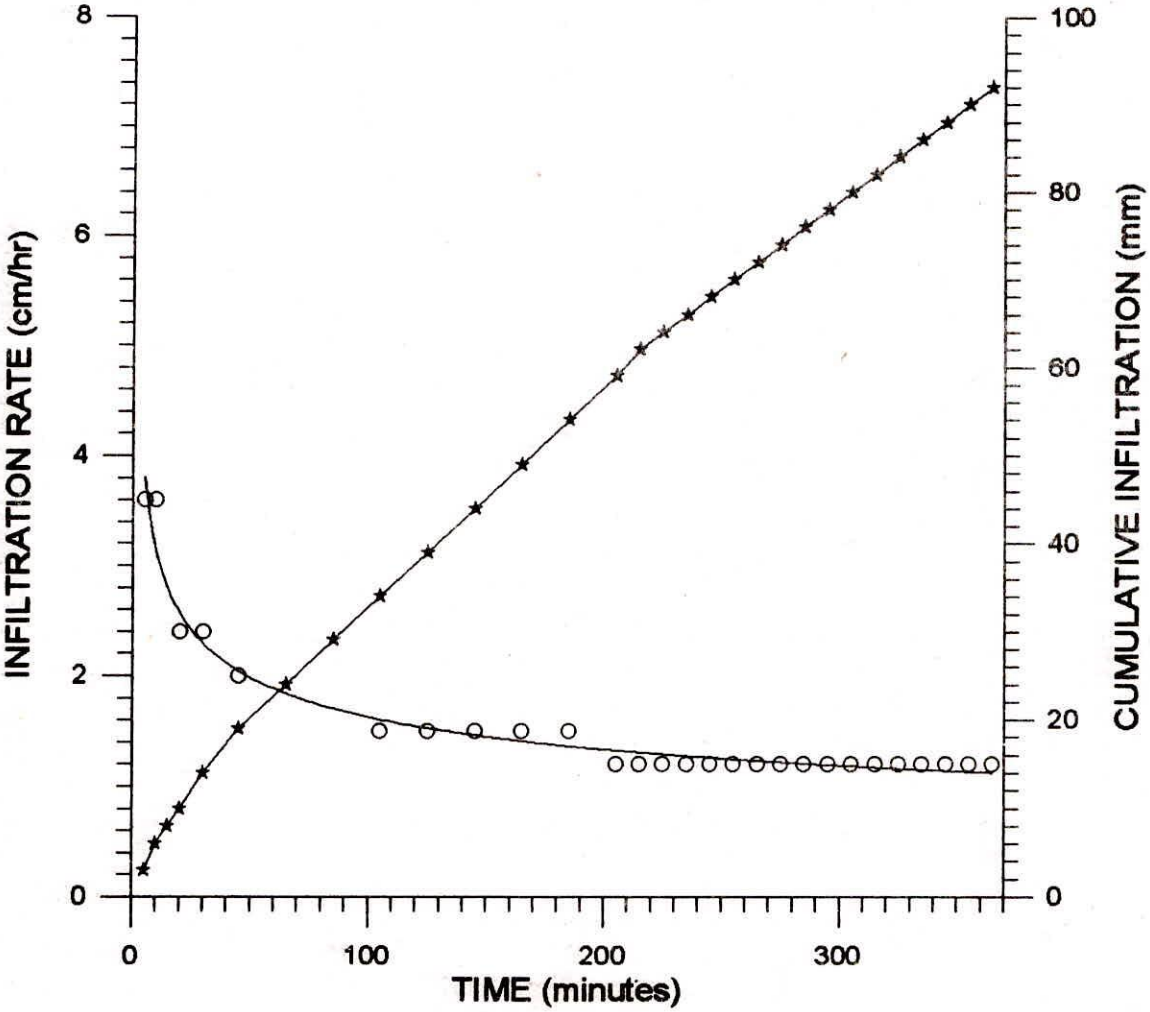

FIG.17 : Infiltration rate and Cumulative infiltration curves at Laukipar.

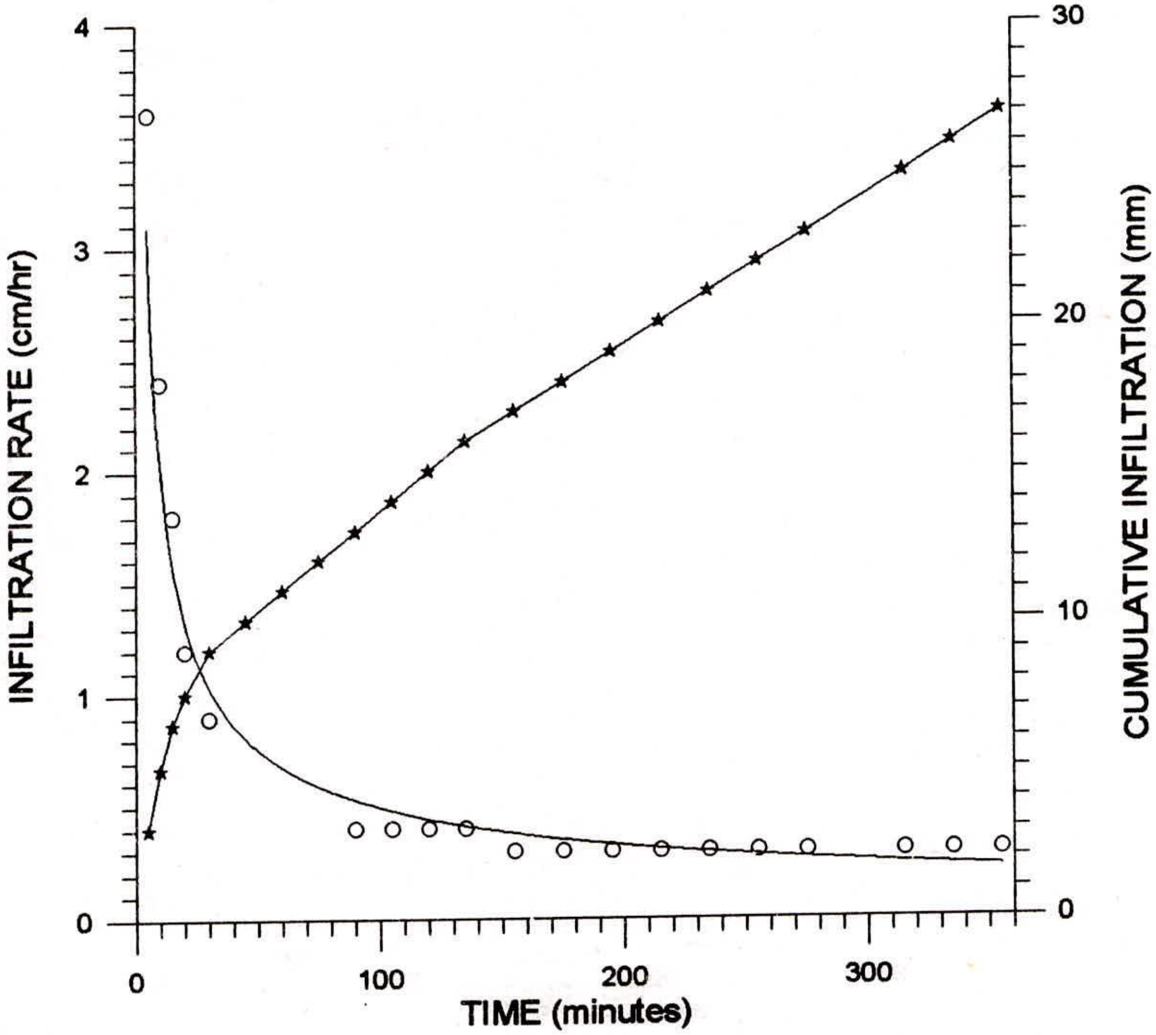

FIG. 18 : Infiltration rate and Cumulative infiltration curves at Dhrubghat.

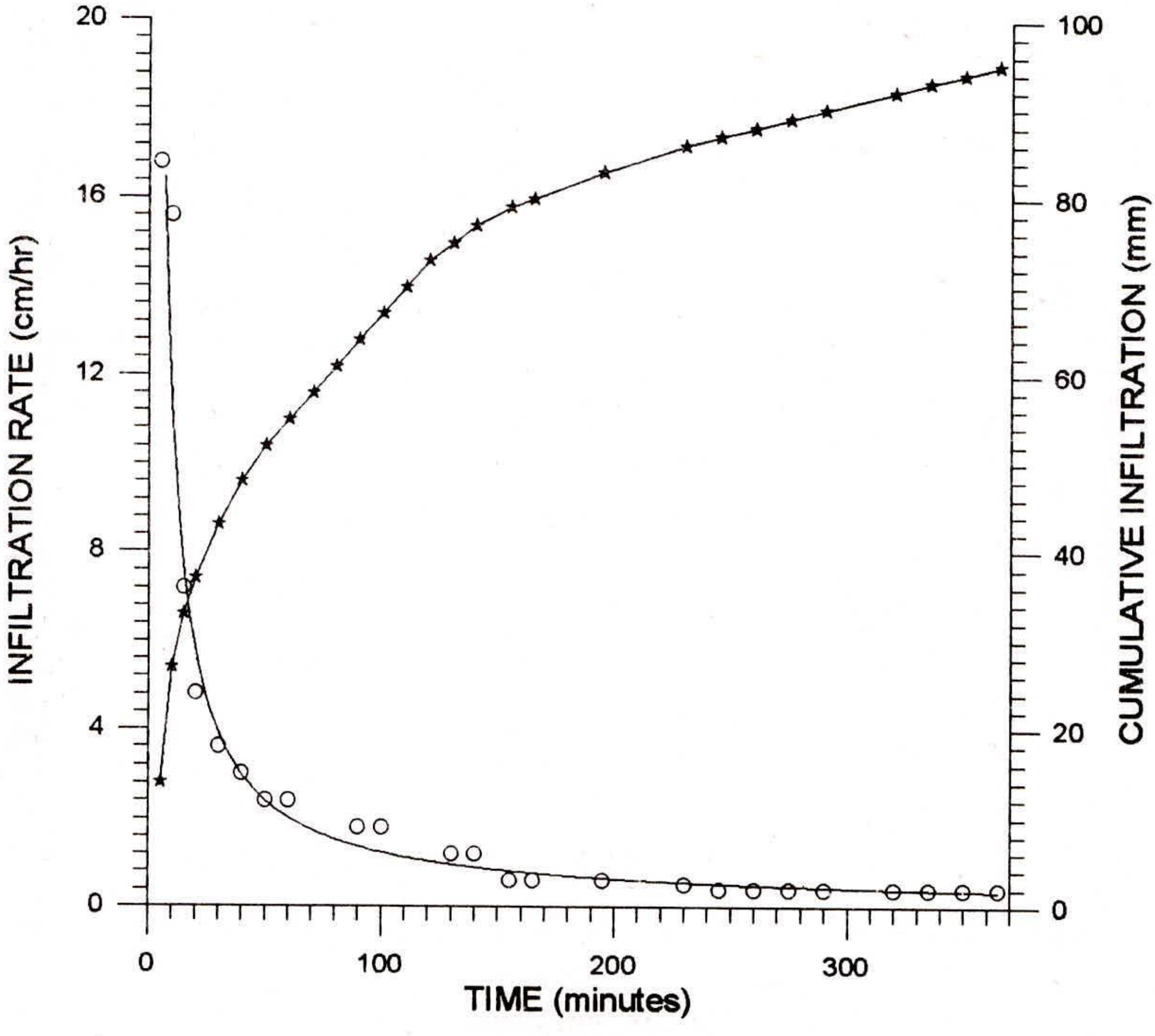

FIG. 19 : Infiltration rate and Cumulative infiltration curves at Didwara.

Till now, limited water is available for irrigation in the form of groundwater. There is no source of surface water except rain water. Therefore, agriculture in the area is mainly rainfed. In the irrigated field, water is applied through sprinklers, from the water derived from groundwater source. Ground water in the area is present mainly in confined conditions and very few dug wells are present.

During rainy season, in the areas having some slope, excess water runs away through small rivulets, but in flat areas or small/shallow depressions the water stands for long periods as the infiltration capacity of the soils is low. This renders the land waterlogged and thereby unusable for quit some time. Only way of removal of this water is through evaporation.

When the Bargi Left Bank Canal will be completed then abundant water will be available for irrigation. For irrigation of land in this area, the water will have to be applied carefully. Excess water will have to be removed through drainage or the water will have to be applied through sprinklers. Otherwise waterlogging or salinisation may occur causing degradation of land.

6.0 CONCLUSIONS

Based on the infiltration tests carried out in the Sher-Barurewa doab, following conclusions can be derived :

- The soils present in the Sher-Barurewa doab are mainly black clayey soil (black cotton soils) with very low infiltration capacity ranging from 0.24cm/hr to 1.2cm/hr.

- The variation in infiltration rate is mainly due to variation in texture.

- The soils are not suitable for flooding method of irrigation. If this practice of irrigation is used (after the completion of the Bargi Left Bank Canal), then proper drainage should be provided .

- Excess irrigation with canal water may lead to waterlogging and salinisation.

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APPENDIX -I

Location	:	Vill. Khamariya, District Narsinghpur
Latitude	:	22^0 59′ N
Longitude	:	79^0 12′ 30″ E
Landuse	:	Agricultural barren land
Irrigation	:	Sprinkler
Slope	:	Flat
Soil texture	:	Sandy Clay
Soil moisture	:	High
Soil Series	:	Gopalpur
Water Level	:	3.2m
Last rainfall	:	18.09.95
Date of test	:	06.10.95.

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
0	0	0
5	8	9.6
10	14	7.2
15	20	7.2
20	26	7.2
25	31	6.0
30	36	6.0
40	45	5.6
50	53	4.8
60	61	4.8
70	69	4.8
80	76	4.2
90	83	4.2
100	90	4.2
110	97	4.2
120	104	4.2
130	111	4.2

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
140	117	3.6
150	123	3.6
160	129	3.6
170	135	3.6
180	139	2.4
190	143	2.4
205	149	2.4
215	153	2.4
230	155	1.2
240	157	1.2
250	159	1.2
260	161	1.2
270	163	1.2
280	164	0.6
290	165	0.6
300	166	0.6
315	167	0.4
335	168	0.3
355	169	0.3
375	170	0.3
395	171	0.3

Location	:	Vill.Chilichawkhurd,Dist. Narsinghpur
Latitude	:	22^0 52′ 15″ N
Longitude	:	79^0 17′ E
Landuse	:	Agricultural barren land
Irrigation	:	Sprinkler
Slope	:	Flat
Soil texture	:	Clay
Soil moisture	:	High
Soil series	:	Gopalpur
Water level	:	2.5m
Last rainfall	:	18.09.95
Date of test	:	7.10.95.

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
0	0	0
5	23	27.6
10	32	13.2
15	38	7.2
20	42	4.8
25	45	3.6
30	48	3.6
40	53	2.4
45	55	2.4
50	57	2.4
55	59	2.4
60	61	2.4
65	63	2.4
70	65	2.4
80	69	2.4
90	73	2.4
100	77	2.4

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
110	81	2.4
120	85	2.4
130	89	2.4
140	93	2.4
150	97	2.4
160	99	1.2
170	101	1.2
180	103	1.2
190	105	1.2
200	107	1.2
220	109	0.6
240	111	0.6
260	113	0.6
280	115	0.6
300	117	0.6
320	119	0.6
340	121	0.6
360	123	0.6

Location	:	Vill.Karhiyakhera, Distt. Narsinghpur
Latitude	:	22^0 59′ N
Longitude	:	79^0 12′ 45″ E
Landuse	:	Agricultural barren land
Irrigation	:	Sprinkler
Slope	:	Flat
Soil texture	:	Clay
Soil moisture	:	High
Soil Series	:	Beloda
Water Level	:	6.5m
Last rainfall	:	18.09.95
Date of test	:	08.10.95.

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
0	0	0
5	10	12.0
10	15	6.0
15	18	3.6
20	20	2.4
25	22	2.4
30	24	2.4
40	27	1.8
50	30	1.8
60	33	1.8
70	36	1.8
80	39	1.2
90	41	1.2
100	43	1.2
110	45	1.2
120	47	0.6
130	48	0.6

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
140	49	0.6
150	50	0.6
160	51	0.6
170	52	0.6
180	53	0.6
195	54	0.4
210	55	0.4
225	56	0.4
240	57	0.4
255	58	0.4
270	59	0.4
285	60	0.4
300	61	0.4
315	62	0.4
330	63	0.4
345	64	0.4
360	65	0.4

Location : Vill. Devarikalan, Dist. Narsinghpur

Latitude : 22^0 55′ 15″ N

Longitude : 79^0 9′ E

Landuse : Agricultural barren land

Irrigation : Sprinkler

Slope : Flat

Soil texture : Clay

Soil moisture : High

Soil series : Songuraria

Water Level : 8.2m

Last rainfall : 18.09.95

Date of test : 09.10.95.

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
0	0	0
5	5	6.0
10	6	1.2
20	7	0.6
30	8	0.6
40	9	0.6
60	10	0.3
80	11	0.3
100	12	0.3
125	13	0.24
150	14	0.24
175	15	0.24
200	16	0.24
225	17	0.24
250	18	0.24
275	19	0.24
305	20	0.2

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
335	21	0.2
365	22	0.2
395	23	0.2
425	24	0.2
455	25	0.2

Location	:	Vill. Kukwara, District Narsinghpur
Latitude	:	22^0 55′ 45″ N
Longitude	:	79^0 10′ E
Landuse	:	Agricultural barren land
Irrigation	:	Sprinkler
Slope	:	Flat
Soil texture	:	Clay
Soil moisture	:	High
Soil Series	:	Beloda
Water Level	:	7.7m
Last rainfall	:	18.09.95
Date of test	:	10.10.95.

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
0	0	0
5	1	1.2
10	2	1.2
20	3	0.6
30	4	0.6
40	5	0.6
55	6	0.4
70	7	0.4
90	8	0.3
110	9	0.3
130	10	0.3
150	11	0.3
170	12	0.3
190	13	0.3
210	14	0.3
230	15	0.3
250	16	0.3

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
265	17	0.4
285	18	0.3
305	19	0.3
325	20	0.3
345	21	0.3
365	22	0.3
385	23	0.3
405	24	0.3

Location	:	Vill. Niwari, District Narsinghpur
Latitude	:	22^0 52′ N
Longitude	:	79^0 8′ E
Landuse	:	Agricultural barren land
Irrigation	:	Sprinkler
Slope	:	Flat
Soil texture	:	Clay
Soil moisture	:	High
Soil Series	:	Sarol
Water Level	:	4.8m
Last rainfall	:	18.09.95
Date of test	:	11.10.95.

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
0	0	0
5	1	1.2
10	2	1.2
15	3	1.2
25	4	0.6
40	5	0.4
60	6	0.3
80	7	0.3
105	8	0.24
130	9	0.24
155	10	0.24
180	11	0.24
205	12	0.24
230	13	0.24
255	14	0.24

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
280	15	0.24
305	16	0.24
355	18	0.24

Location	:	Village Mudia, District Narsinghpur,
Latitude	:	22^0 55′ N
Longitude	:	79^0 16′ E
Landuse	:	Agricultural barren land
Irrigation	:	Sprinkler
Slope	:	Flat
Soil texture	:	Clay
Soil moisture	:	High
Soil Series	:	Amgaon
Water Level	:	4.9m
Last rainfall	:	18.09.95
Date of test	:	12.10.95.

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
0	0	0
5	2	2.4
10	3	1.2
20	5	1.2
30	7	1.2
40	9	1.2
50	11	1.2
60	13	1.2
80	16	0.9
105	19	0.72
125	21	0.6
145	23	0.6
165	25	0.6
185	27	0.6
205	29	0.6
225	31	0.6

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
245	33	0.6
265	35	0.6
285	37	0.6
295	38	0.6
315	40	0.6
335	42	0.6
355	44	0.6

Location	:	Vill. Shyamkhera, Distt. Narsinghpur
Latitude	:	22° 55′ 15″ N
Longitude	:	79° 20′ 15″ E
Landuse	:	Agricultural barren land
Irrigation	:	Sprinkler
Slope	:	Flat
Soil texture	:	Clay
Soil moisture	:	High
Soil Series	:	Amgaon
Water Level	:	4.6m
Last rainfall	:	18.09.95
Date of test	:	13.10.95.

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
0	0	0
5	5	6.0
10	9	4.8
15	12	3.6
20	14	2.4
25	16	2.4
30	18	2.4
35	20	2.4
40	21	1.2
45	22	1.2
50	23	1.2
55	24	1.2
60	25	1.2
65	26	1.2
70	27	1.2
75	28	1.2
80	29	1.2

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
85	30	1.2
90	31	1.2
105	33	0.8
120	35	0.8
135	37	0.8
165	40	0.6
195	43	0.6
215	45	0.6
245	48	0.6
265	50	0.6
285	52	0.6
305	54	0.6
325	56	0.6
345	58	0.6
365	60	0.6

Location	:	Vill. Kandharapur, Distt. Narsinghpur
Latitude	:	22⁰ 52′ 30″ N
Longitude	:	79⁰ 9′ E
Landuse	:	Agricultural barren land
Irrigation	:	Sprinkler
Slope	:	Flat
Soil texture	:	Clay
Soil moisture	:	High
Soil Series	:	Gopalpur
Water Level	:	2.25m
Last rainfall	:	18.09.95
Date of test	:	14.10.95.

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
0	0	0
5	7	8.4
10	11	4.8
15	16	3.0
30	20	2.4
50	25	1.5
75	30	1.5
90	34	1.2
105	37	1.2
120	40	1.2
135	43	1.2
150	46	1.2
165	49	1.2
180	52	1.2
195	55	1.2
210	57	0.8
225	59	0.8

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
240	61	0.8
255	63	0.8
270	65	0.8
285	67	0.8
300	69	0.8
315	71	0.8
330	73	0.8
345	75	0.8
360	77	0.8
375	79	0.8
390	81	0.8

Location	:	Village Laukipar, District Narsinghpur
Latitude	:	22^0 52′ 45″N
Longitude	:	79^0 12′ 30″E
Landuse	:	Agricultural barren land
Irrigation	:	Sprinkler
Slope	:	Flat
Soil texture	:	Sandy Clay
Soil moisture	:	High
Soil Series	:	Amgaon
Water Level	:	4.2m
Last rainfall	:	18.09.95
Date of test	:	15.10.95.

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
0	0	0
5	3	3.6
10	6	3.6
15	8	2.4
20	10	2.4
30	14	2.0
45	19	1.5
65	24	1.5
85	29	1.5
105	34	1.5
125	39	1.5
145	44	1.5
165	49	1.5
185	54	1.5
205	59	1.5
215	62	1.2
225	64	1.2

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
235	66	1.2
245	68	1.2
255	70	1.2
265	72	1.2
275	74	1.2
285	76	1.2
295	78	1.2
305	80	1.2
315	82	1.2
325	84	1.2
335	86	1.2
345	88	1.2
355	90	1.2
365	92	1.2

Location	:	Vill. Dhrubghat, District Narsinghpur
Latitude	:	22^0 55′ N
Longitude	:	79^0 12′ E
Landuse	:	Agricultural barren land
Irrigation	:	Sprinkler
Slope	:	Flat
Soil texture		Clay
Soil moisture	:	High
Soil Series	:	Sonuguraria
Water Level	:	7.1m
Last rainfall	:	18.09.95
Date of test	:	16.10.95.

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
0	0	0
5	3	3.6
10	5	2.4
15	6.5	1.8
20	7.5	1.2
30	9	0.9
45	10	0.4
60	11	0.4
75	12	0.4
90	13	0.4
105	14	0.4
120	15	0.4
135	16	0.4
155	17	0.3
175	18	0.3
195	19	0.3
215	20	0.3

Time(min)	Cumulative Infiltration (mm)	Infiltration rate (cm/hr)
235	21	0.3
255	22	0.3
275	23	0.3
295	24	0.3
315	25	0.3
335	26	0.3
355	27	0.3

Location	:	Vill. Didwara, District Narsinghpur
Latitude	:	22^0 58′ N
Longitude	:	$79^0$9′30″E
Landuse	:	Agricultural barren land
Irrigation	:	Sprinkler
Slope	:	Flat
Soil texture		Clay
Soil moisture	:	High
Soil Series	:	Amgaon
Water Level	:	4.4m
Last rainfall	:	18.09.95
Date of test	:	17.10.95.

Time(min)	Cummulative Infiltration (mm)	Infiltration rate (cm/hr)
0	0	0
5	14	16.8
10	27	15.6
15	33	7.2
20	37	4.8
30	43	3.6
40	48	3.0
50	52	2.4
60	55	2.4
70	58	1.8
80	61	1.8
90	64	1.8
100	67	1.8
110	70	1.8
120	73	1.8
130	75	1.2
140	77	1.2

Time(min)	Cummulative Infiltration (mm)	Infiltration rate (cm/hr)
155	79	0.6
165	80	0.6
195	83	0.6
230	86	0.5
245	87	0.4
260	88	0.4
275	89	0.4
290	90	0.4
320	92	0.4
335	93	0.4
350	94	0.4
365	95	0.4

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