CASE STUDY

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INFILTRATION STUDY OF A SUB-BASIN

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PREFACE

The Infiltration Process Plays a conspicuous role in hydrology and thus in watershed management, and management of water resources for agricultural purposes. It functions in generating runoff from rainfall, losses in stream channels and irrigation, and ground water recharge. In watershed management studies, infiltration indices obtained from soils under various types of plant cover and land use are helpful in providing a basis for judgment so as to optimize watershed conditions for water yield and soil erosion. Infiltration is also considered to be the basic criterion in the design of Surface Irrigation as well as Ground Water Irrigation.

The National Institute of Hydrology proposed to carryout infiltration studies and to prepare a thematic map under comprehensive hydrological studies of Narmada basin. In first phase, a doab area of Sher river, Berurewa river and left bank canal of Bargi dam near Narsinghpur, is selected for model study. It is expected that results of this study will be useful to Scientists, Planners and local water use organizations in their watershed development programme.

The infiltration experiments were conducted by automatic infiltrometer,developed in the Institute by Dr.Bhisma Kumar,Sc.-E. The report has been prepared by Sh. B.P. Roy, Scientist-E and Sri Hukam Singh, Senior Research Assistant. Sri Mohar Singh, Technician Gr.-II assisted in conducting field experiments and in analysis, Sri S.K. Yadav Tech. Gr-II also assisted.

(S. M. SETH)
DIRECTOR

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1.0 INTRODUCTION:

Infiltration is defined as the process of the entry into the soil of water made available (under appropriately defined conditions) at its surface. This "Surface" may be the natural more or less horizontal Upper Surface of the soil or it may be the bed of a natural or artificial furrow or stream, or the walls of a natural or artificial tunnel or cavity. Quantitatively, infiltration rate is defined as the volume of water passing into the soil per unit area per unit time and has the dimension of velocity.

This is an important parameter for hydrologists and watershed managers. Knowledge of infiltration characteristics of the basin helps in estimating the quantity of rainfall excess resulting from a stream. Infiltration is one of the basic parameters for developing an integrated crop, soil and water management practices. Hydrologic importance of the process is to be seen from the fact that it marks the transition from fast moving surface water to slow moving soil and ground water.

Infiltration characteristics are very useful to the agronomists and ecologists who are concerned with the availability of soil moisture in the root zone of crops and plants. The plant growth may be affected in the conditions of water logging or moisture stress. Therefore, the infiltration is very important for assessing the soil moisture deficits and accordingly planning irrigation and drainage systems. The knowledge of infiltration is also useful to soil conservationist for planning devices to dissipate the energy of flowing water to minimize soil erosion.

He may suitably plan engineering and forestry measures to induce infiltration through the land surface depending upon the soil infiltration characteristics. A geomorphologist may be interested in the magnitude, frequency and spatial characteristics of infiltration related to rainfall intensity for preventing land slips due to overland flow. Keeping in view the importance of infiltration characteristics in hydrology of watershed management practices, the report attempts to determine infiltration characteristics of an area under comprehensive hydrological study of a basin with the help of field experiments since requisite data in required quantity were not available of the area.

2.0 STUDY AREA:

The proposed study area broadly falls in Sub-zone-2C based on hydrometeorological similarity of the country. At present, study will be confined in the command area of Bargi Dam. The index map of the project is FIG. 1. The model area of Study is a uoab one which is encompassed by Sher river in east, Berurewa river in west & Bargi left bank canal in south, having an area of 350 sq.km. located in Narsinghpur district of Madhya Pradesh between latitude 22^{o} 50' N to 23^{o}1' N and longitude 79^{o}8'E to 79^{o} 23" E. FIG. 2 is a specific map of study area.

2.1 Salient Features:

As already stated that study area is a part of left bank Bargi command a_ea of Bargi Dam. The salient features of the project are as follows:

2.1.1 Bargi Multipurpose Project:

Bargi Multipurpose Project on Narmada river envisages construction of a major dam, Power houses and canal systems on both banks. This project is included in the first phase Programme of Narmada valley Development and will be first one to be completed out of the 29 Major projects proposed to be constructed on the river Narmada. The main benefits from the Bargi Project are irrigation and power generation with a small portion of water being reserved for Urban Water Supply and industrial uses.

2.1.2 Bargi Dam and Reservoir:

The dam site is situated about 43 km from Jabalpur (Latitude 22^{o}-56'-30"N, Longitude 79^{o}-55'-30"E). It has a catchment area of 14,556 sq.km. with a gross storage of 3294 Mm^{3}. The dam is a composite type with a masonry central portion and earthen dam on either flank. The maximum height of the dam above the deepest foundation level is 69.80 m. The full reservoir level is at EL 422.76 m. The sill level of the Left Bank Canal (LBC) is EL 399.50 m and that of Right Bank Canal (RBC) is EL 405.98 m.

2.1.3 Right Bank Canal and the Diversion:

The Right Bank canal will be 95 km in Jabalpur district. The canal will be further extended to make a trans-basin diversion to Sone and Tons basins after cutting Sleemnabad ridge separating the Narmada and the other basins. Running over a distance of 24 km it will out fall into Katni river. A barrage is proposed to be constructed on the Katni river at Amkuhi village. The Amkuhi main canal takes off from this barrage and from its tail two canals branch off, one irrigating lands in Rewa district and the other in Satna district. The total volume of water proposed to be utilised annually from Bargi reservoir is 2012 Mm^3.

2.1.4 Left Bank Canal:

The Left Bank Canal will be 137.2 Km long. The design capacity of the canal is 124.65 m^3/s. The total volume of water to be utilised annually for irrigation is 1740 Mm^3. The command area of the canal covers parts of Jabalpur district on the right bank of the Narmada river. The Patan branch Canal which serves the right bank areas will cross the Narmada through a major aqueduct after off-taking at RD 31 Km. The justification for serving the part of right bank areas from the Left Bank canal with the costly aqueduct crossing is that the off-take level of the Right Bank Canal is very high (405.98 m) to permit supply of water to the whole right bank area at the end of the rabi season. The trans-basin diversion to the Sone and the Tons basins from the RBC and the topographical constraints of crossing of a ridge require the high elevation of RBC take-off at the dam. The Left Bank Canal will irrigate an area of 0.157 million ha which comprises 62,000 ha in Jabalpur and 95,000 ha in Narsinghpur districts.

2.1.5 Power Generation:

There will be two power generating units of 45 MW each which will be installed in the river bed. In addition, there will be two power generating units of 7.5 MW each to be installed on the Left Bank Canal. The power generated would be fed into the main grid of Madhya Pradesh.

2.2 Topography:

The elevation above mean sea level of the command area varies from 313 m to 380 m in Narsinghpur district. At some places deep gullies and ravines are also formed. The general topography of Narsinghpur district appears to be flat and as such, the entire area is a broad plain of low relief. Due to heavy system of cultivation. Which is prominent in study area, local differences in elevation are small. In plain area, the slope ranges from 0 to 3 percent.

2.3 Soil:

Topography, parent material, climate and vegetation have played an important role in the formation of Soils in the area. The soils are alluvium in nature. In general, the soils of Narsinghpur district have been classified as deep black under broad classification of Indian soils. Based on the morphological and chemical analysis of the profiles of the command area of Narsinghpur district, six soil series were identified and they are Baloda, Songuraria, Sarol, Gopalpur, Amgaon, and Kunda. Mostly the depth of the soil goes from more than 9 m and depth of dark soil is only 1.5 m to 3 m after which a yellowish layer is found. Mostly the land is occupied by cultivation and orchard. The types of soil of command area is enlisted as TABLE-1.

In study area, there are only four types of soil. They are clay, clay loam, sandy clay loam and loam in which clay and clay loam are predominant. At five different places in different soils, the depth of dark soil is only 1.00 m to 1.50 m and after that a yellowish layer is encountered.

2.4 Rainfall:

The rainy-season in command area extends from June to October under the influence of South-West monsoon. The command area also receicves some rainfall during January and February from the North-East monsoon. July and August are the heaviest rainy months. Normally, the rainfall ceases by the end of September. However, inquite a large number of years, October receives good rainfall. The rainfall data reveals that there is considerable variation in rainfall from year to year as well as month to month in a year.

In Narsinghpur district, the raingauges are located at Narsinghpur, Gategaon and Mahapani. The present study area is near to Narsinghpur. The average annual rainfall of Narsinghpur rain gauge station for 31 year period (1948-78) is 1246 mm. The annual rainfall ranged between 623 mm and 1993 mm. From rainfall records it is observed that Narsinghpur raingauge receives about 95 percent of annual rainfall in monsoon months. The monthly rainfalls for Narsinghpur raingauge station is tabulated in TABLE-2.

The table also shows the average monthly, monsoon, non-monsoon and annual rainfall magnitudes.

2.5 Temperature:

The command area lies in the hot region of the country. The temperature begins to rise rapidly from about March till May which is generally the 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 onwards 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. On such occasions the minimum temperature drops to about the freezing point. The maximum, minimum and mean monthly temperature are shown in TABLE-3.

2.6 Humidity:

As the Project areas lies in hot zone, the variation in humidity in quite large. The mean monthly relative relative humidity at Narsinghpur is shown in TABLE-3.

2.7 Ground Water Levels:

The Narsinghpur district has got mainly black cotton soil which is supposed to be highly productive. The major crops of the district are gram, arhar, wheat and Jowar. During Kharif season Paddy, Jowar and Arhar are the main crops. Recently Kharif soyabean is gradually becoming popular among the farmers. Narsinghpur district is almost "a mono-crop" area because rabi crops are cultivated on high scale in comparison to the kharif crop.

From the study of recorded data for the period 1975-83 carried out by WAPCOS, the average depth of water table below the surface of ground in the beginning of monsoon season varies from 2.3 m to 21.6 m. In general, depth of water below the ground surface is more near the Narmada river. In the rainy season water table rises appreciably and remains between 1.1 m and 19.1 m below in ground level.

Due to maximum ground water exploitation for rabi crops, ground water table has considerably depleted. The ground water tables in village Kheri, Rampipariya, Jallapur, Bhootpipariya and Bahoripar were 7.35 m, 19.15m, 15.15 m, 5.53 m and 9.06 m respectively during 1st-2nd week of Feburary 1995.

3.0 SELECTION OF TESTING POINTS:

A rapid reconnaissance Survey of the Bargi left bank Canal project was carried out earlier in the year 1963-64. The grids adopted were too large to represent the area. The study was not based on morphological description and the information about the soil was limited. Hence a fresh reconnaissance Survey of the entire Bargi left bank canal command was carriedout by the Soil Survey Unit Jabalpur, Department of Agriculture, Government of Madhya Pradesh in 1974-75. This survey of command area was conducted on 1:126,720 scale tehsil and village maps as the base maps. The whole area was divided into 350 grids and normally a grid represents 1025 hectare.

As our study area is a part of this command area, a grid map of doab area was prepared having the same scale and assigning same grid no. as that of soil survey conducted in 1974-75. In each grid, type of soil was marked which is at FIG. 3. After marking the soils, it is observed that there are four types of soil i.e., clay, clay loam, sandy clay loam and loam, out of these, Clay and clay loam are predominant. But loam is lying in a small pocket in south-west part of the study area.

Keeping view the type of soils, five places were selected for carrying out point infiltration tests in Narsinghpur district of M.P. State. The types of soil covered are clay, clay loam and sandy clay loam. The infiltration test in fourth type of soil i.e. loam which is found in a small patch of area nearly 1025 hectare could not be conducted due to inaccessible approach to the area during 1st-2nd week of February 1995. The pictures of the experimental sites are shown in PLATE-1 to PLATE-6.

4.0 INFILTROMETER USED:

Measuring infiltration and infiltration capacities are difficult, since both are influenced by rate of application and several other factors associated with the phases through which the infiltrating water passes. That is why we are interested to know the basic rate of infiltration which is gained in saturation condition. Hydrologists, soil scientists and Irrigation engineers have developed several equipment and techniques for the determination of infiltration rate of soil. Though much development have taken place for automation of flooding type ring infiltrometer and rainfall simulator for keeping constant head and losses accordingly.

Infiltrometers may be considered in two groups - (i) flooding type with the water applied in a thin sheet upon on enclosed area and usually in a manner to obtain constant head, and (ii) rainfall simulators, with the water applied in the form and at the rate comparable with natural rainfall. Various kinds of equipment are in use for both types. They vary in size, in quantity of water that is required, and in methods of measuring the water level. For the present study, an electronic infiltrometer developed at National Institute of Hydrology, Roorkee, was used considering to eliminate the human errors associated in taking the observations and controlling the constant head of water.

The brief description of this infiltrometer is given below.

4.1 Automatic Electronic Infiltrometer:

The automatic electronic infiltrometer is a microprocessor based recently developed equipment equipment to conduct infiltration studies in situ under controlled conditions. Normally, people use double ring infiltrometer with some device to measure drop in water level and to supply the water, to keep the water level constant, either manually or automatically.

This complete system of automatic infiltrometer consists the following components:

1) Two G.I. rings of appropriate dimensions
2) Two G.I. containers of appropriate diameter filled with water
3) Two solenoid valves, one each fitted with the water container
4) Two sets of adjustable electrodes, one each fitted with G.I. infiltrometer ring.er ring.
5) One sensor (capacitance type) to be installed of the water container from which the water will be supplied to

the inner ring.

6) Microcontroller based programmable water level measuring device with digital display and memory module alongwith electronic circuitry to control the constant water level in the rings.

7) Two 12 V maintenance free batteries for the operation of solenoid valve and microcontroller based water level measuring device.

The electronic device can be programmed for storing the water level readings automatically from 1 minute to 99 minutes with the help of key pad fitted at the front panel. The digital display shows two values i.e. W.L. reading in the left side part in mm while the right side part indicate the time in minutes and hours.

There is a provision to set the initial reading at zero and system can also be calibrated if the water quality changed, with the help of two keys provided at the front panel which make the suitable changes in software. The sensor which is a ordinary hollow rod with copper wire fitted at the centre, connecting the both ends, works as a water level sensor. It is placed in one of the container whose water level is to be sensed. The drop in water level in the container, decrease the capacitance value of the sensor which is utilized as input signal. As the sensor is connected to an electronic circuit which generate pules of varied frequency according to the capacitance value, therefore, the change in capacitance value effectively encountered and accordingly the drop in water level is sensed by the sensor circuit. The analog signal generated due to the change in capacitance value on account of drop in water level is converted into the digital value using a analog to digital converter circuit. This value is then converted into the suitable units i.e. corresponding to the drop in water level in mm and then stored in the memory module at the preselected time intervals. The water level value in mm and corresponding time reading, both are stored simultaneously.

In order to save the power, the provision is made to switch off the display be pressing the key designated to 'run' the device. However, a sound beep will be given by the equipment whenever the water level reading will be stored in the memory according to the preselected time-interval. At the time of beep, the display will automatically be switched on for three seconds so that one can note down the W.L. reading manually. Also the key next to 'run' has been defined to switch on the display at any time to watch the functioning of the equipment and to see the water level and time readings.

The data can be retrieved on PC by connecting an interface with PC from the equipment. Maximum 1000 of W.L. and time can be stored in the memory module.

The detailed diagram of the set-up is shown in FIG. 4 alongwith the connections of the different items.

5.0 TEST RESULTS:

As stated earlier that tests were conducted on the basis of type of soil without considering the effect of slope for test point. Those test points are located at village Kheri, Rampipariya, Jallapur, Bhootpipariya and Bahoripar having clay loam, sandy clay loam and at last three places clay respectively. The infiltration with elapsed time and infiltration rate at each site are given in FIG. 5 to FIG. 14. For each site, the graph between cumulative infiltration with elapsed time has been drawn with the help of GRAPHER Package. The infiltration rates have been determined by taking the field observation value of infiltration. The field observation values are written to each site in TABLE-4 to TABALE-8.

The constant infiltration rate in clay loam is 0.32 cm per hour from FIG. 6. Similarly in sandy clay loam in saturated conditions it is observed 0.28 cm/hour from FIG.8. While in clay, it is varying from 0.12 - 0.14 cm/hour referring FIG. 10, & 12. The infiltration tests were also carried using different infiltration measurement methods, but the details of these methods and results are not being described as it will be reported else where. At site Bahoripar, the initial high infiltration rate was observed and the water tank was filled up three times. After analysing the infiltration curve and infiltration rate from FIG.13 & 14, the third filling of container was taken as start of infiltration rate considering the situation to be normal. As the infiltration rate is abnormal after lapsed of so much time in clay soil, the result is abondoned.

6.0 CONCLUSION:

i) The placement of infiltrometer is an important factor which governs the test result. In Bahoripar we observed that infiltration test result was abondoned as the placement of infiltrometer must be on crack which was not visible at top of soil where soil was clay.

ii) The constant rates of infiltration at Jallapur and Bhootpipariya are 0.12 cm/hr. and 0.14 cm/hr respectively having same type of soil as clay. The minor difference in the constant infiltration rate may be due to the different soil cover as at Jallapur, the soil was bared one, while at Bhootpipariya, it was having grass cover and also lithological variation in soil strata may also be the cause of variation though at top, soil was same.

iii) The constant infiltration rate at sites Kheri and Rampipariya are 0.32 cm/hr and 0.28 cm/hour though the soil at Kheri and Rampipariya were clay loam and sandy clay loam respectively. The rate should be reversed one. This may be due to soil cover which was grass at Kheri but bared one at Rampipariya.

iv) During the survey of study area for the selection of site for conducting field experiments, it was observed that at many sites, the top soil was physically seen similar type but when the soil sample were collected, the different type of soils were found at different sites with respect to depths. Therefore, it can be concluded eaily, that the selection of experimental sites for conducted infiltration tests should not be based on the reconnaissance survey but strictly, it should be selected on the basis of soil serieses, is order to save the time provided both type of information are availabale for the area to be investigated for infiltration rate.

v) Sufficient infiltration test in a grid pattern are required for deterministic approch to be followed for ascertaining infiltration rate in a sub-basin. Keeping this inview, it has been decided to carryout more infiltration test in the same area as discuss above. Therefore, further studies will be continued a doab area of Sher river, Berurewa river and left bank canal of Bargi dam near Narsinghpur during the year 1995-96 and therefore, infiltration rates result will be reported in the next publication with thematic map.

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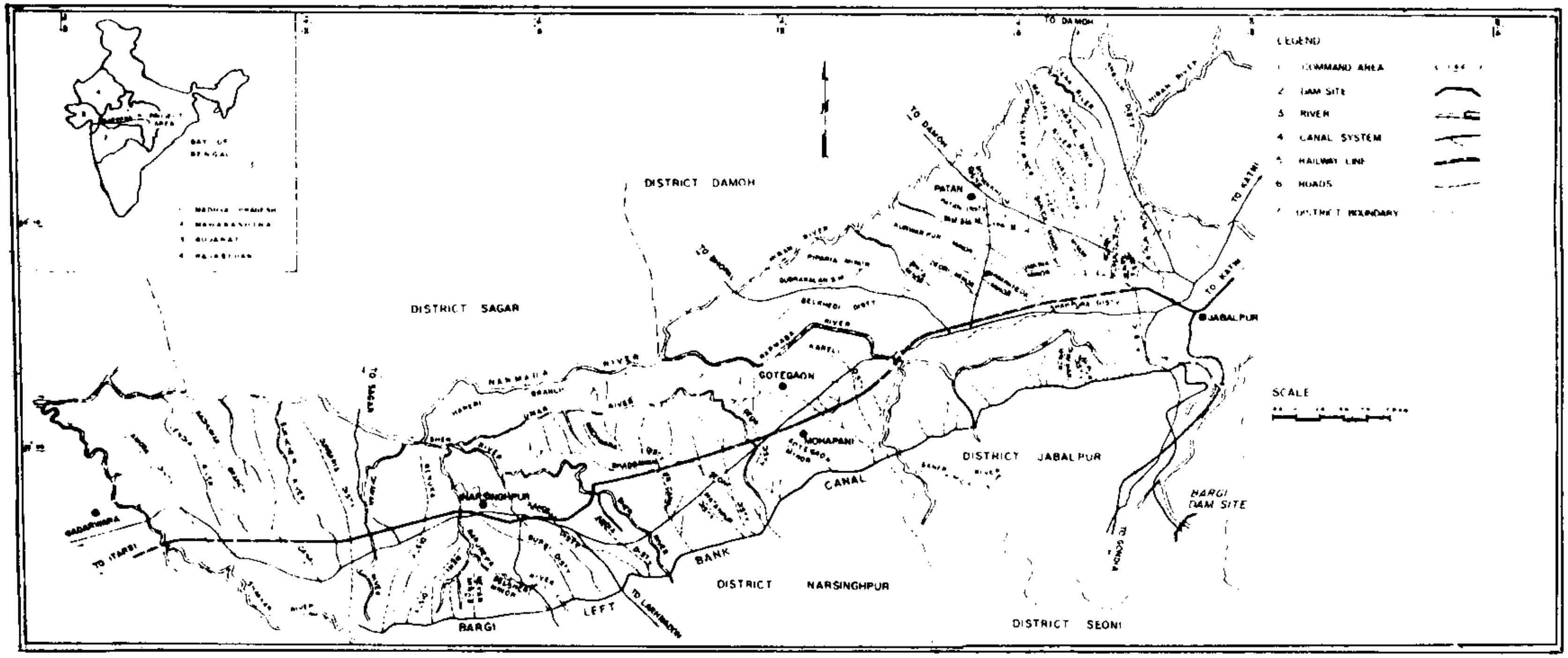

FIG.1 — INDEX MAP OF BARGI MULTIPURPOSE PROJECT

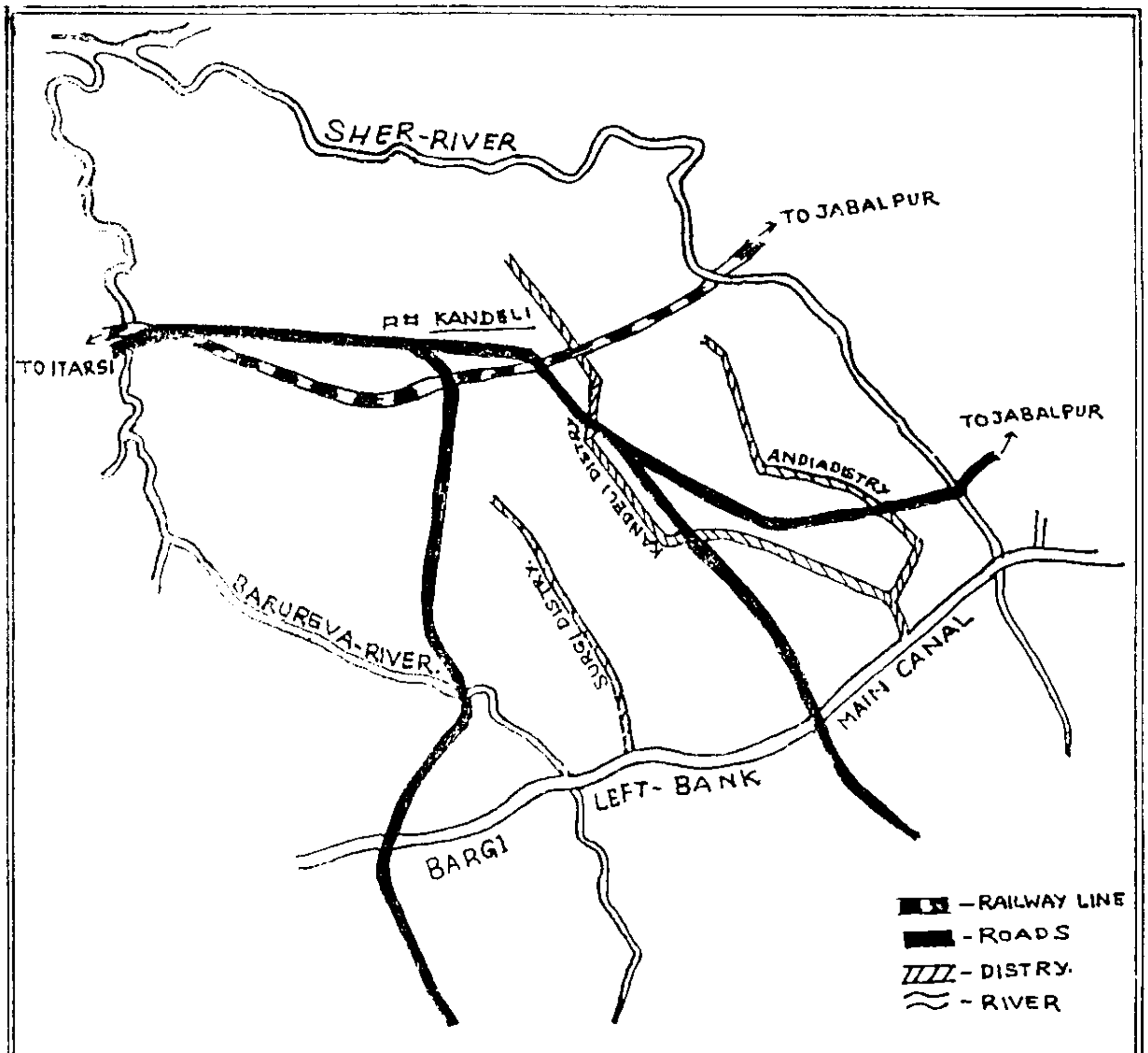

FIG. 2 — MAP OF STUDY AREA

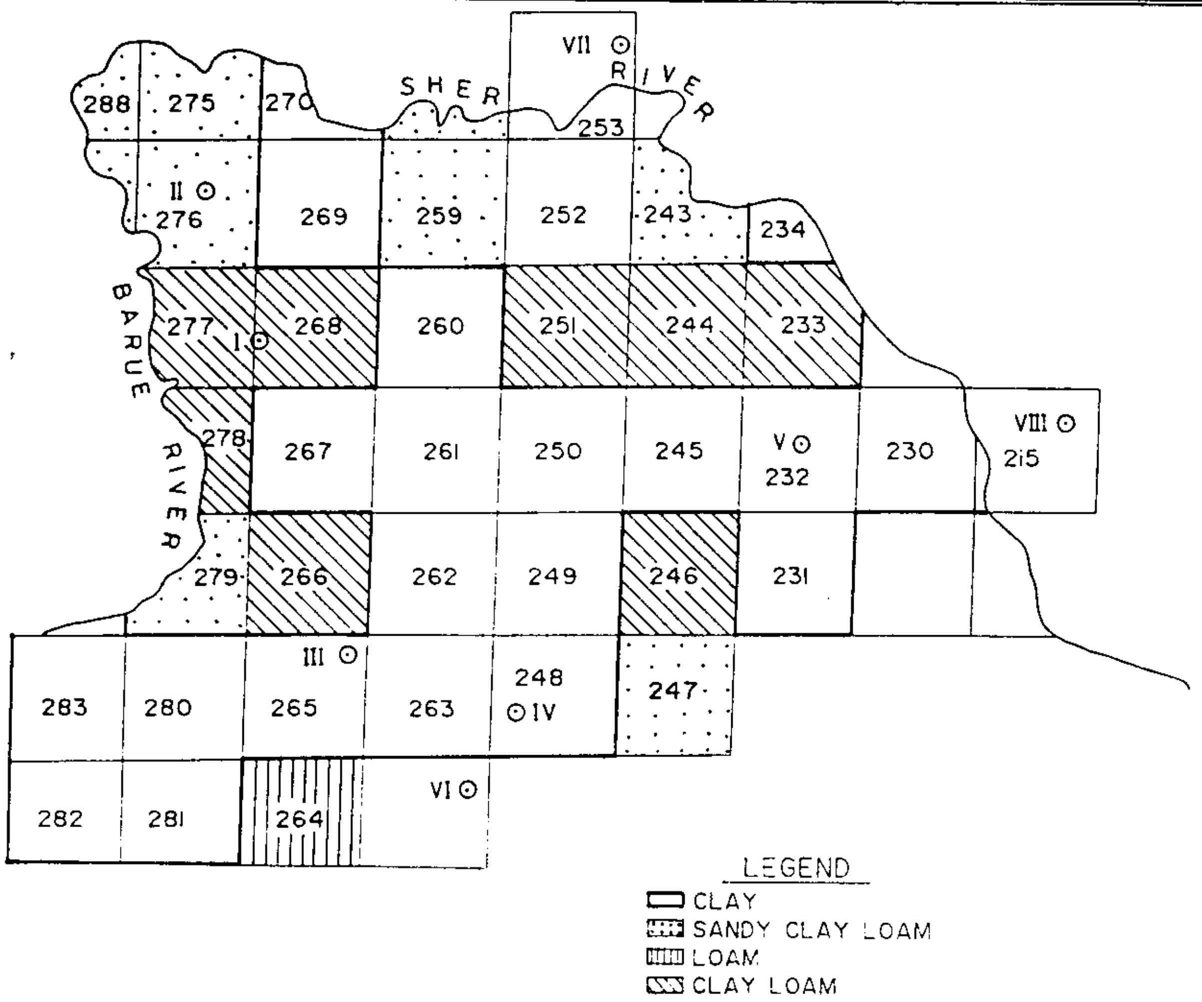

FIG.3 — TYPES OF SOIL IN STUDY AREA

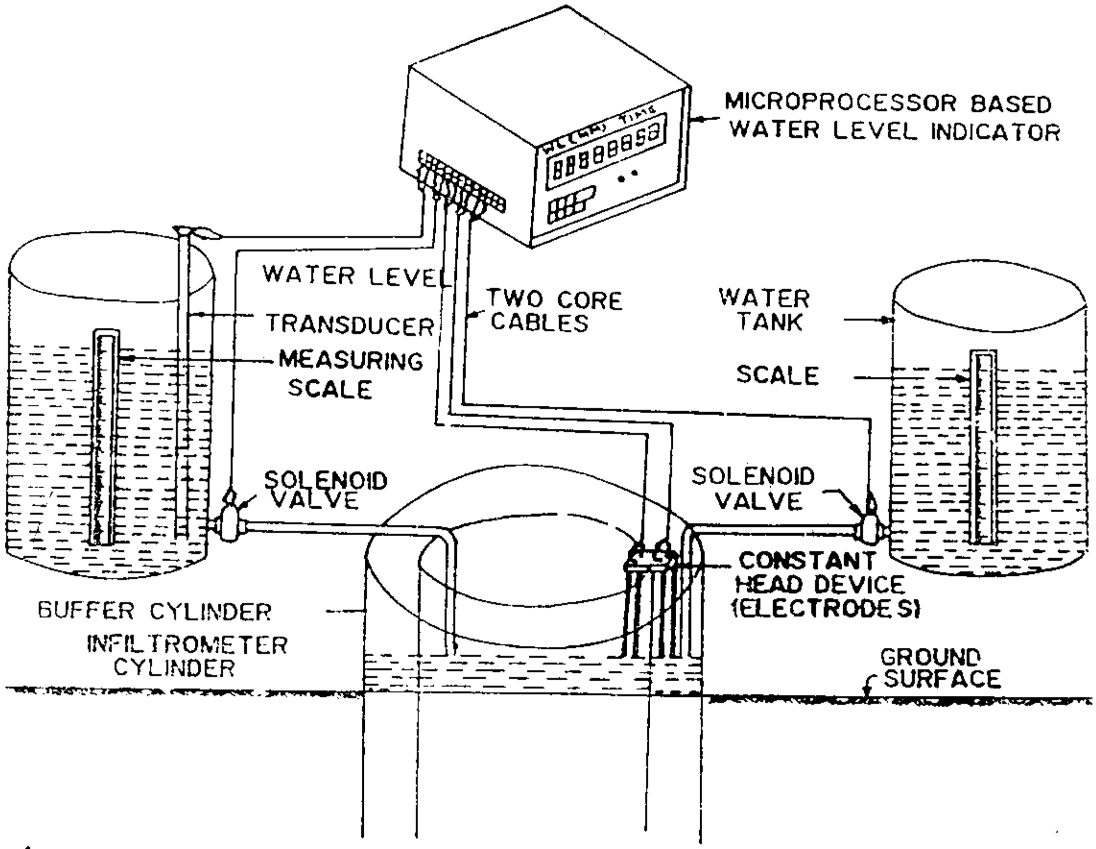

FIG.-4 — MICROPROCESSOR BASED DOUBLE RING INFILTROMETER WITH CONSTANT HEAD DEVICE
(AUTOMATIC ELECTRONIC INFILTROMETER)

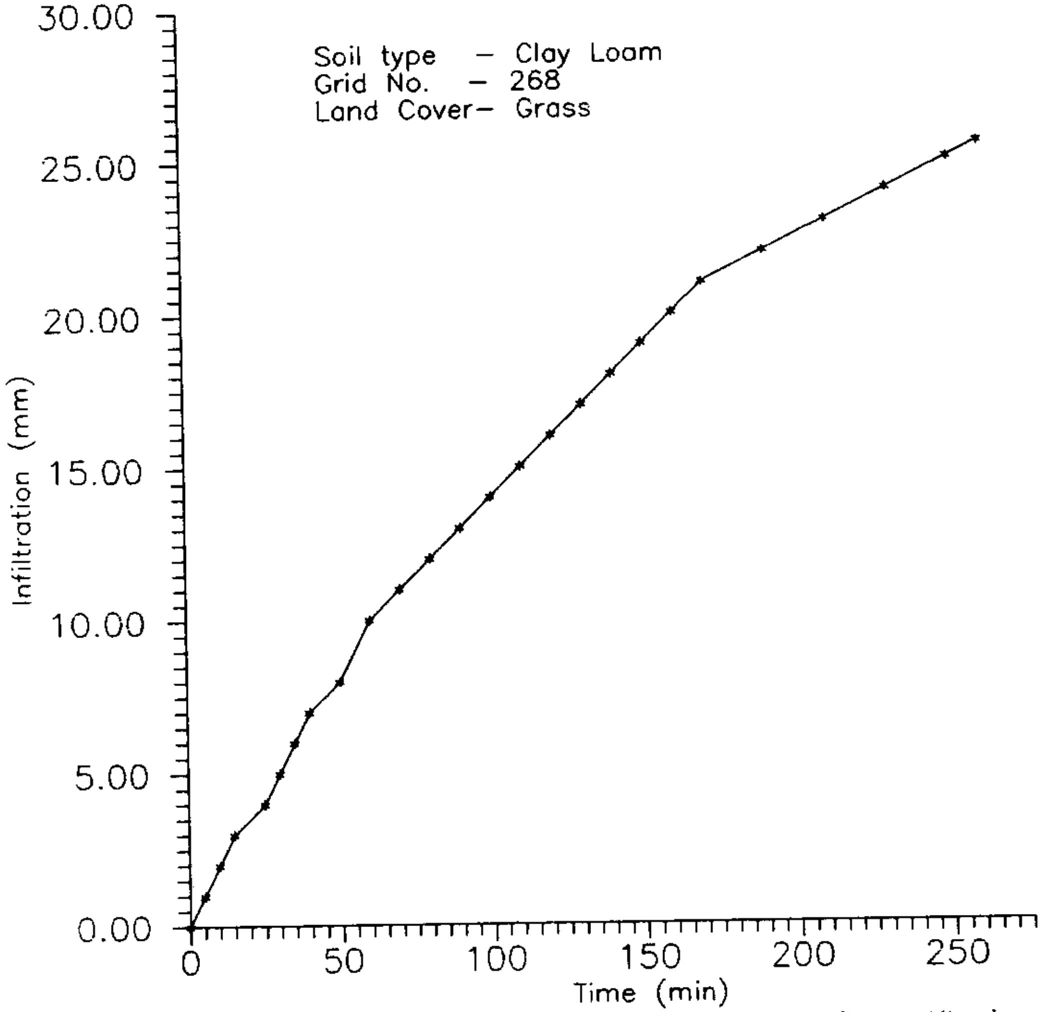

FIG. 5 Cumulative Infiltration at Village Kheri

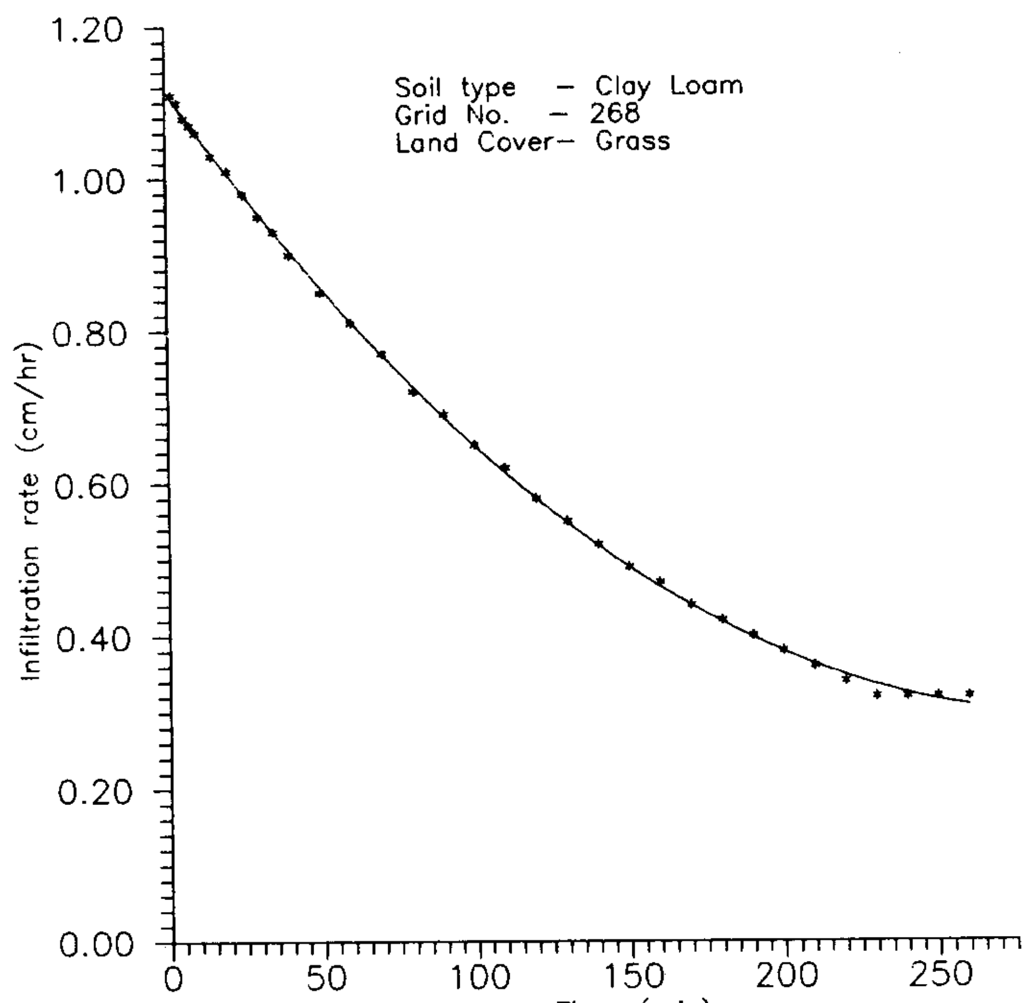

FIG. 6 Infiltration rate at Village Kheri

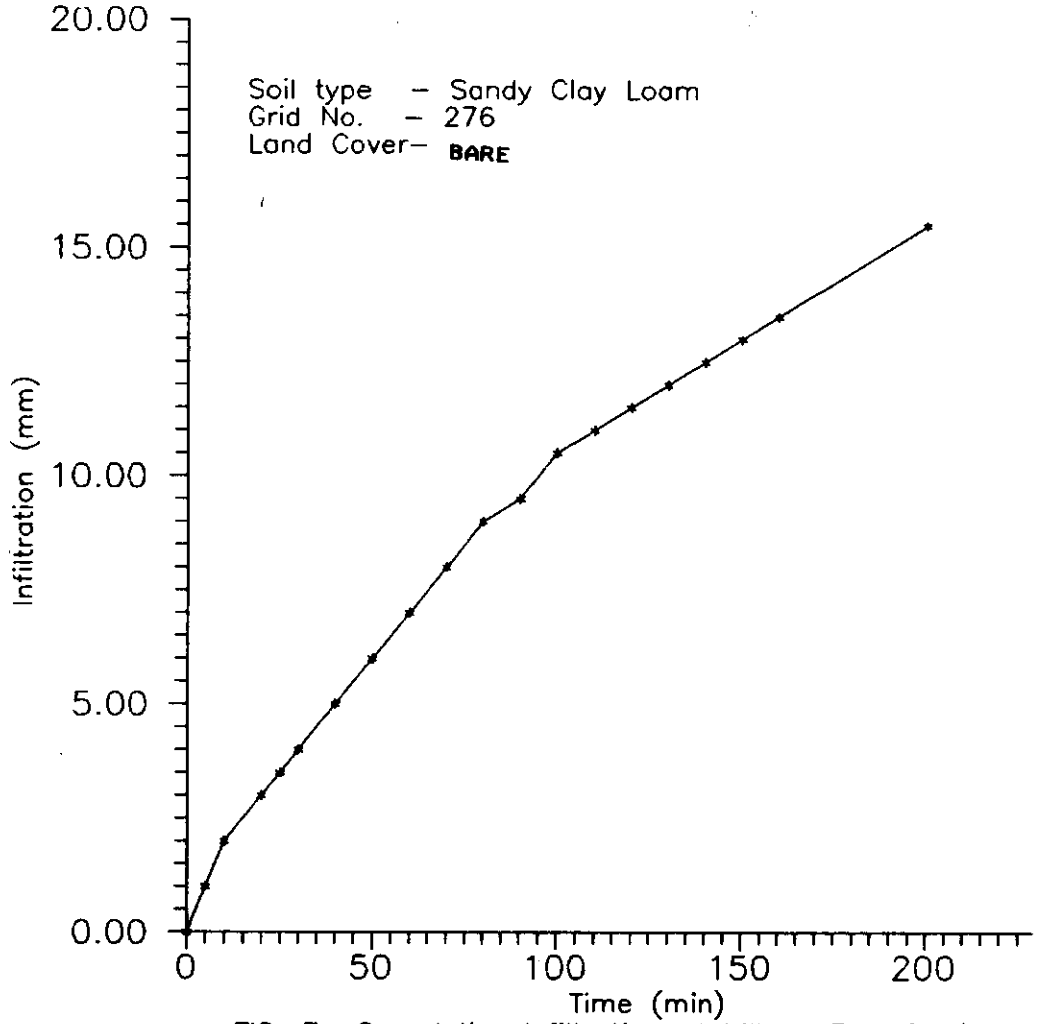

FIG. 7 Cumulative Infiltration at Village Rampipariya

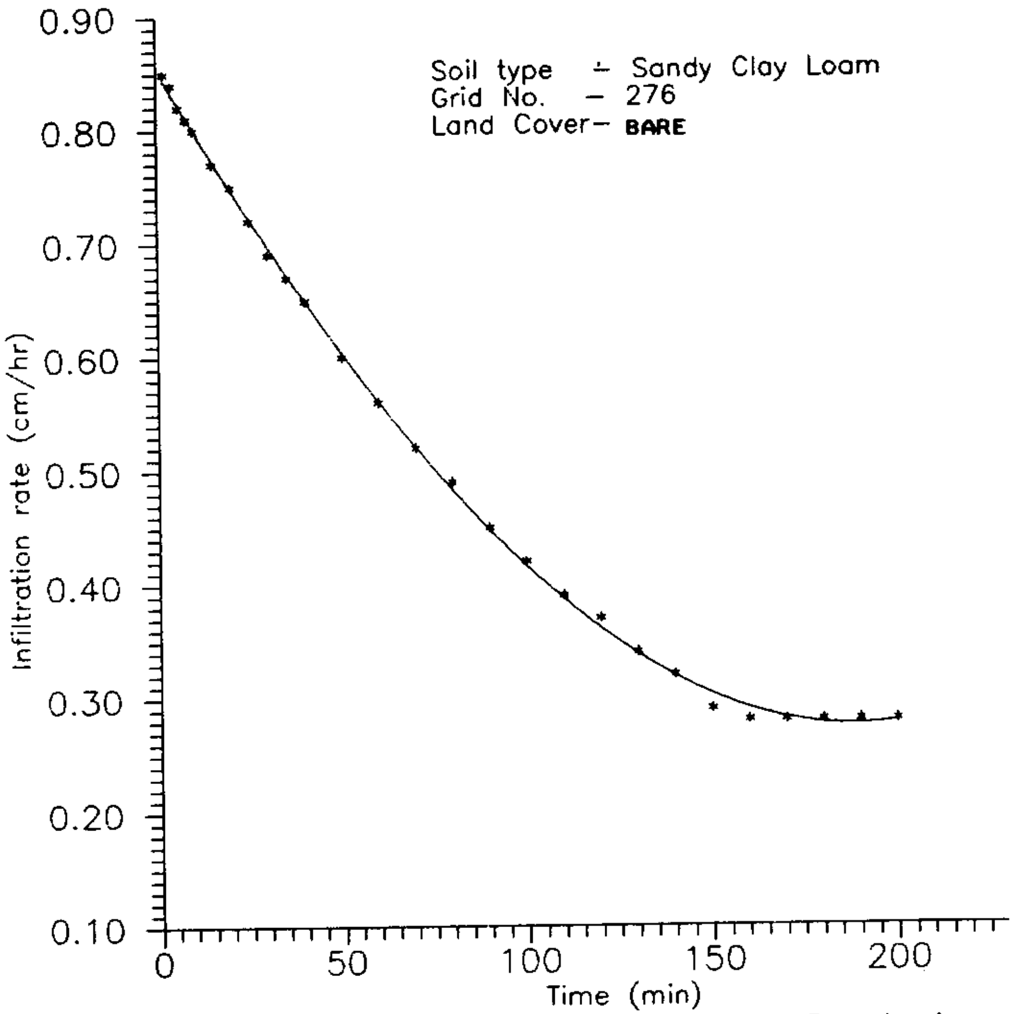

FIG. 8 Infiltration rate at Village Rampipariya

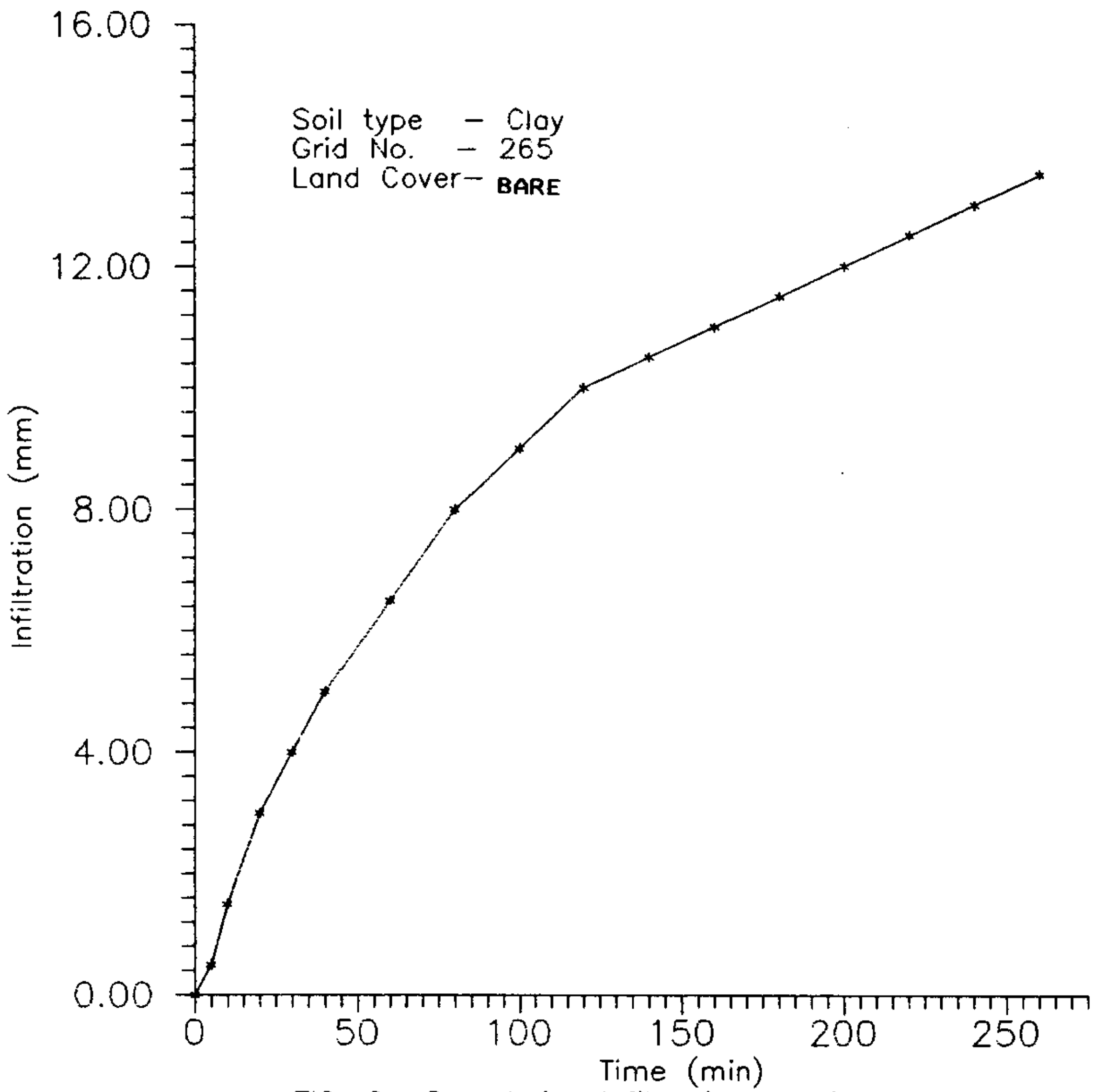

FIG. 9 Cumulative Infiltration at Village Jallapur

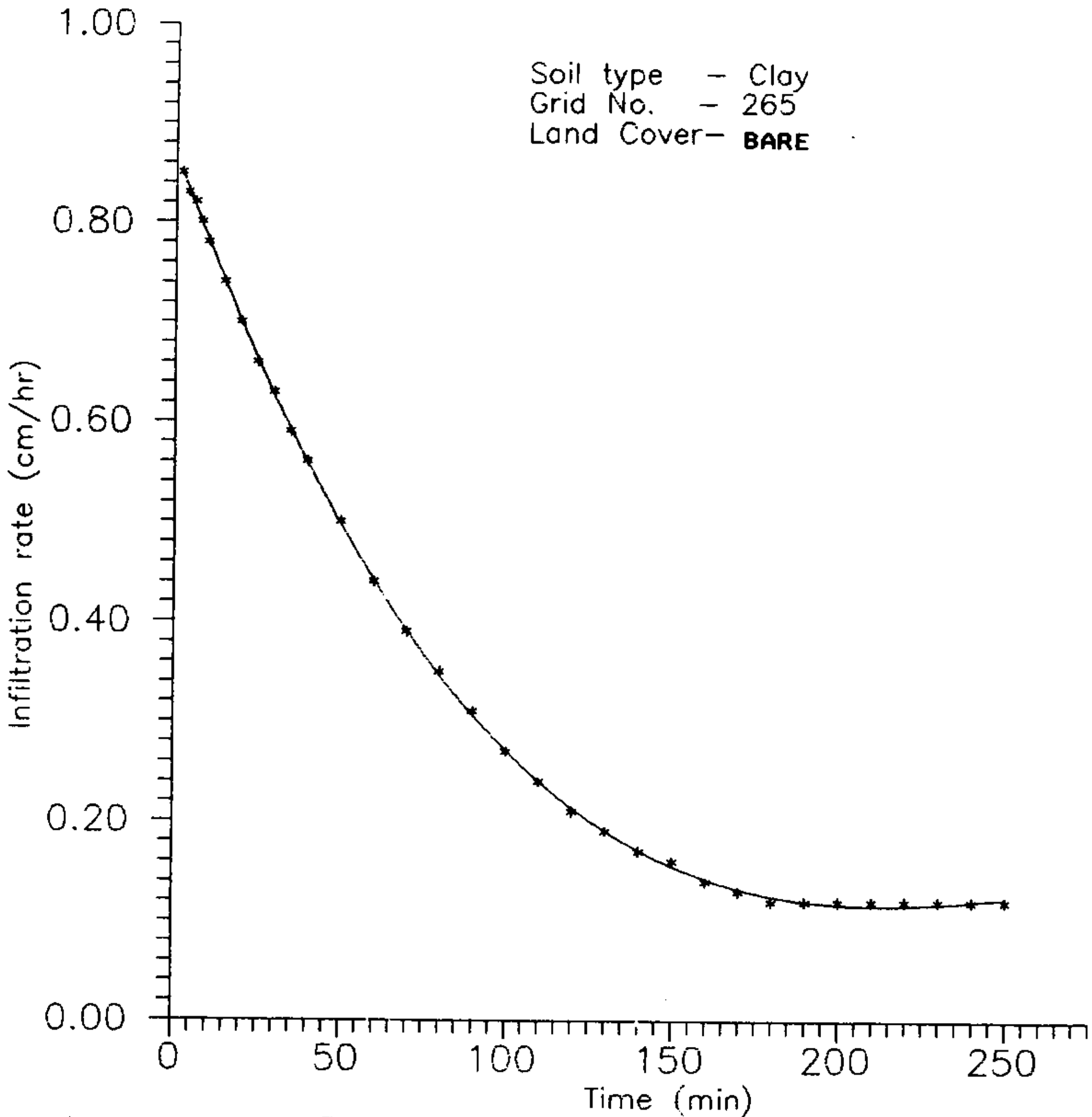

FIG.10 Infiltration rate at Village Jallapur

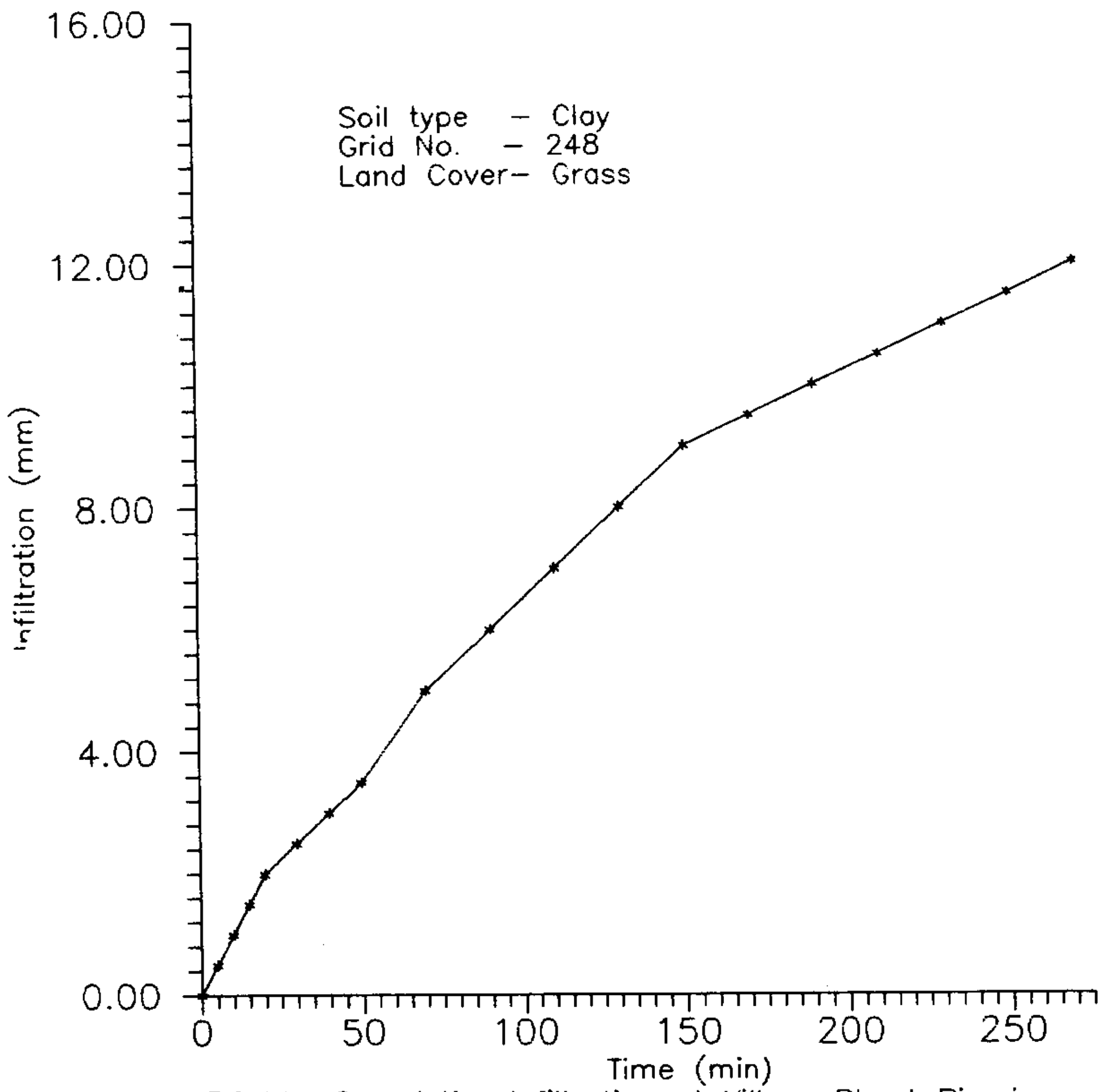

FIG.11 Cumulative Infiltration at Village Bhoot Piperiya

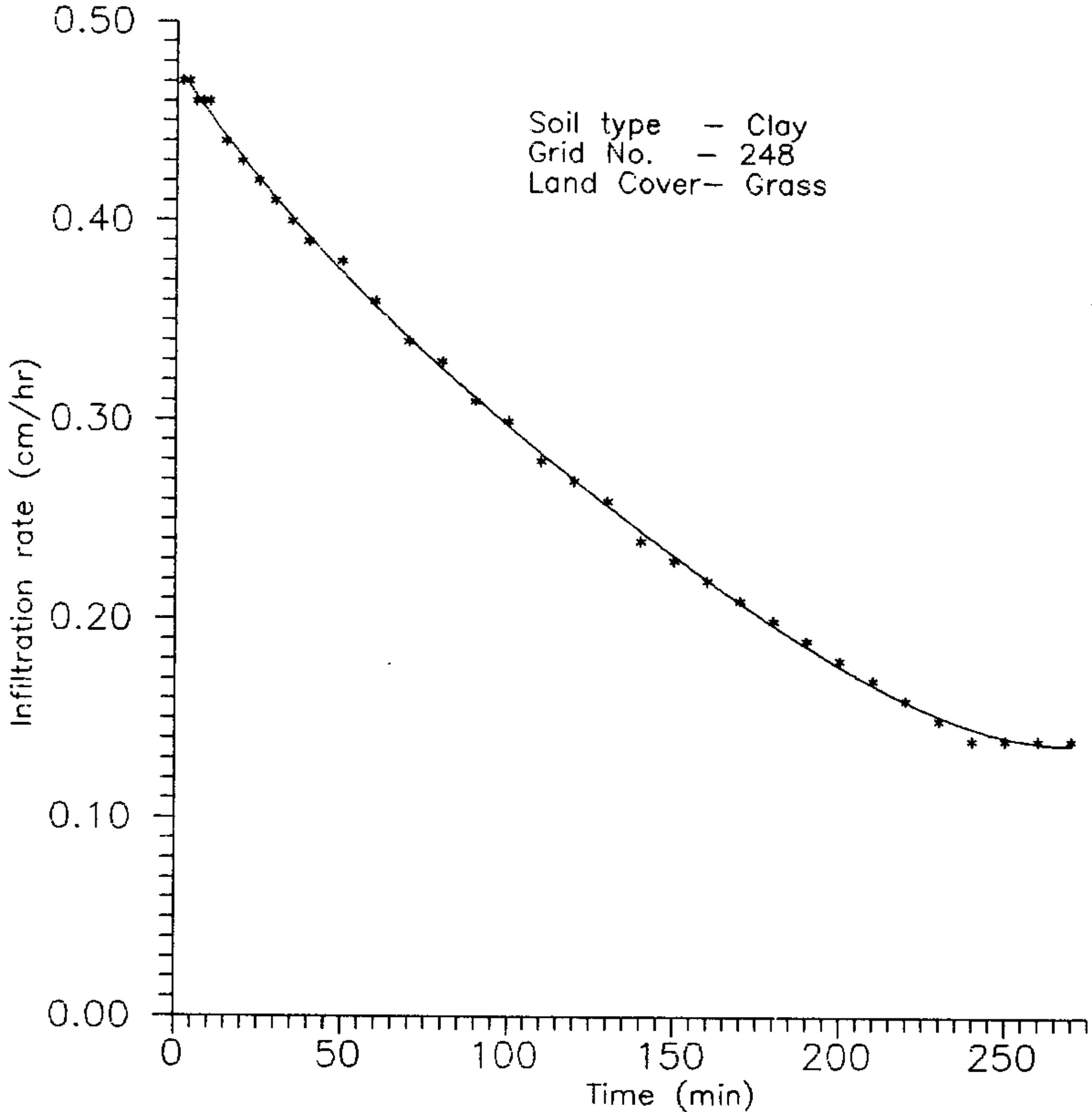

FIG. 12 Infiltration rate at Village Bhoot Piperiya

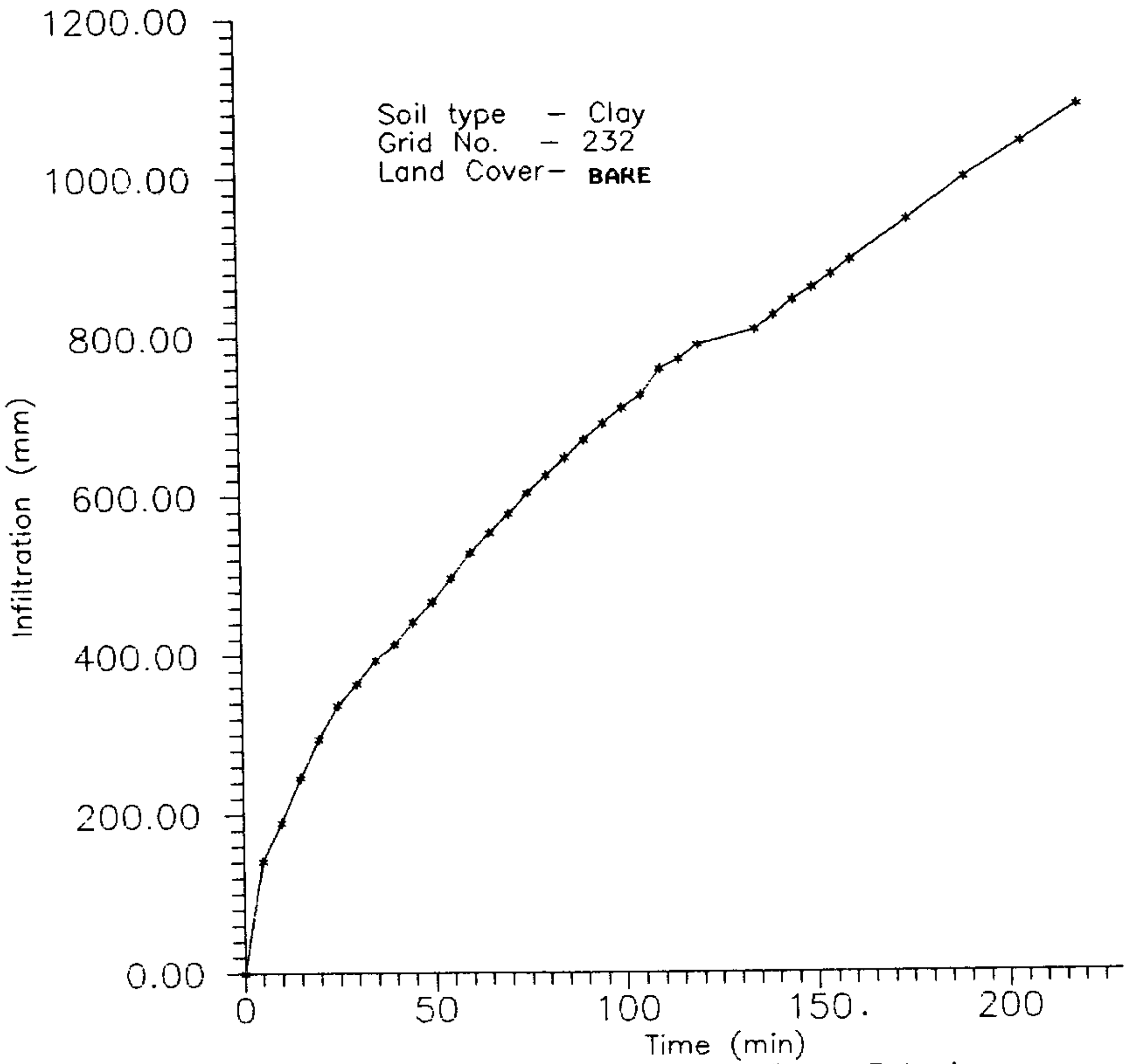

FIG.13 Cumulative Infiltration at Village Bahoripar

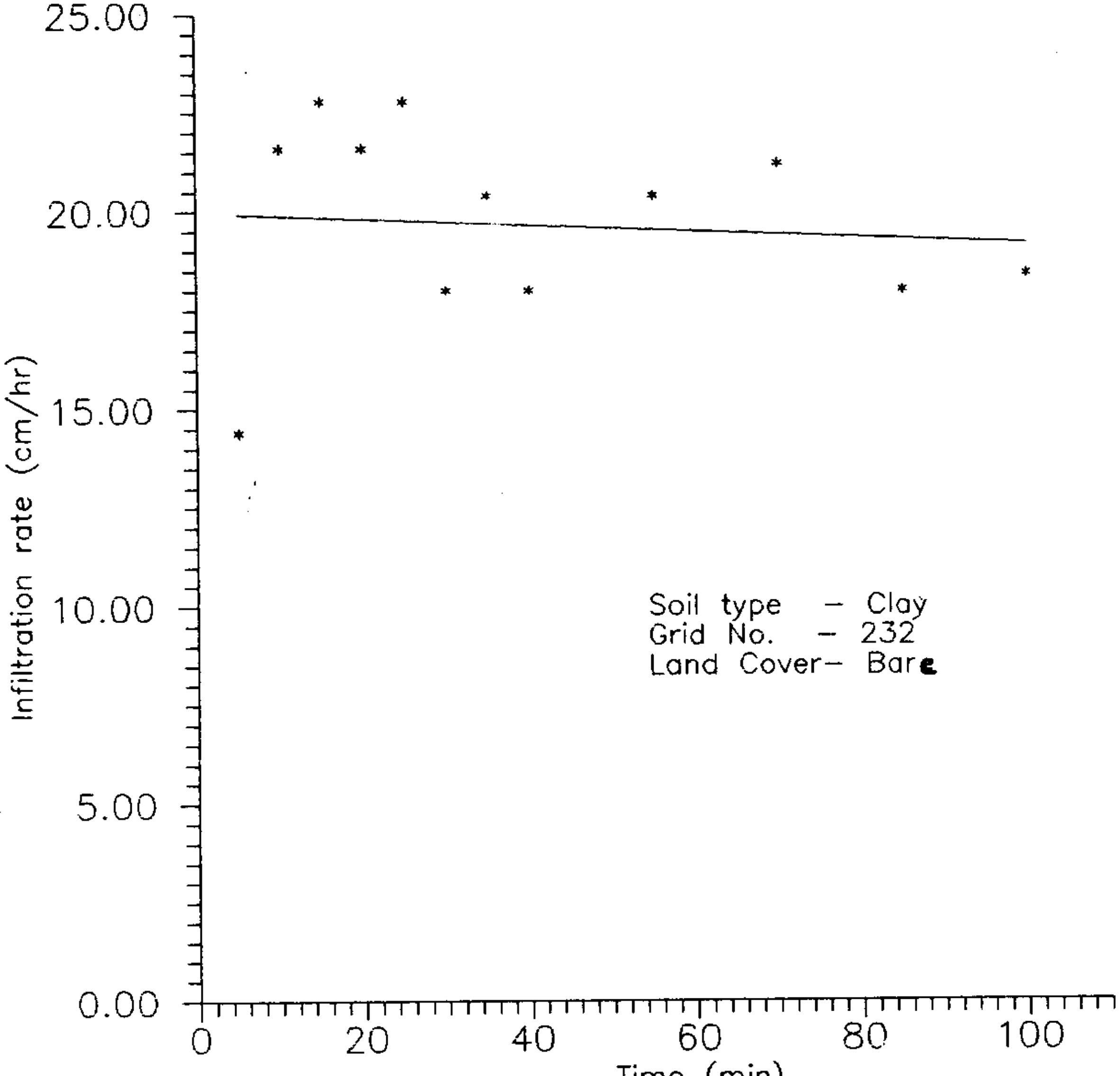

FIG.14 Infiltration rate at Village Bahoripar

PLATE 1 — INFILTRATION TEST AT VILLAGE KHERI

PLATE 2 —INFILTRATION TEST AT VILLAGE RAMPIPARIYA

PLATE 3 —INFILTRATION TEST AT VILLAGE JALLAPUR

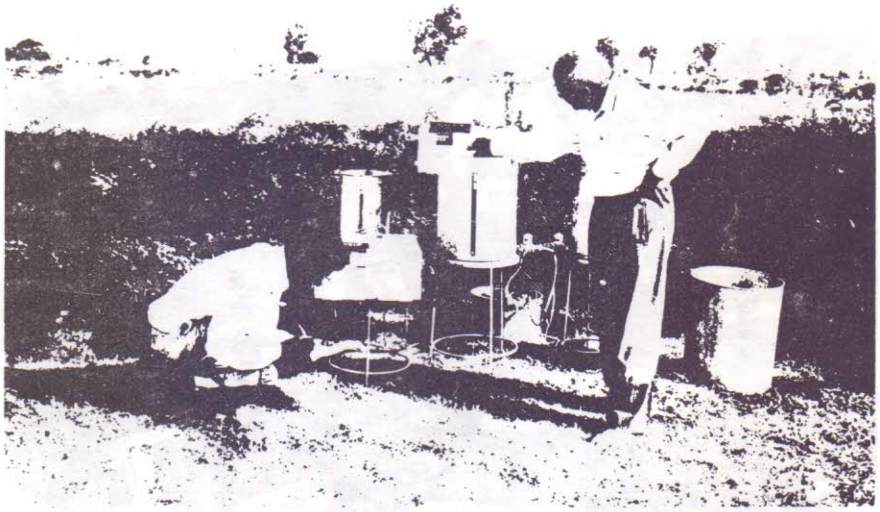

PLATE 4 —INFILTRATION TEST AT VILLAGE BHOOTPIPARIYA

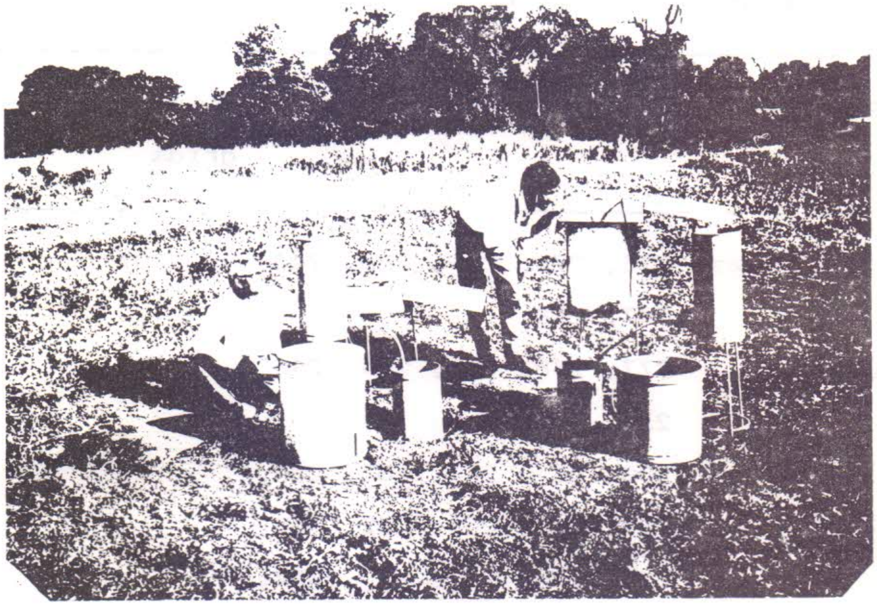

PLATE 5 —INFILTRATION TEST AT VILLAGE BAHORIPAR

PLATE 6 — VIEW OF HYDROLOGIC TESTS AT VILLAGE BHOOTPIPARIYA

TABLE 1 : Type of Soil in Study Area

Sl. No.	Textural Class	Grid No.	Total No. of grids	Area acres
1.	Sandy Clay Loam	275, 276, 279, 288, 243, 247, 258,	07	
2.	Clay Loam	277, 278, 233, 244, 246, 251.	06	
3.	Clay	280, 281, 282, 283, 284, 229, 230, 231, 232, 234, 245, 248, 249, 250, 252, 253, 260, 261, 262, 263, 269, 270, 265, 267,	24	
4.	Loam	264	01	

TABLE 2 : Monthly Rainfall of Narsinghpur
(JANUARY TO JULY)

(Unit:mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July
1948	13.0	-	-	-	-	174.0	339.0
1949	-	-	-	-	3.0	43.0	372.0
1950	-	-	4.0	-	-	71.0	353.0
1951	33.0	15.0	-	-	-	50.0	248.0
1952	-	68.0	-	-	-	234.0	274.0
1953	4.0	-	-	4.0	-	132.0	364.0
1954	17.0	14.0	18.0	-	-	69.0	186.0
1955	6.0	-	-	-	-	183.0	246.0
1956	-	-	-	-	58.0	185.0	962.0
1957	15.0	-	99.0	29.0	-	90.0	250.0
1958	20.0	-	-	-	-	81.0	372.0
1959	21.0	3.0	-	-	35.0	186.0	474.0
1960	40.0	-	24.0	-	-	129.0	487.0
1961	8.0	11.0	-	10.0	2.0	80.0	465.0
1962	5.0	51.0	11.0	17.0	13.0	54.0	219.0
1963	3.0	6.0	2.0	33.0	-	153.0	209.0
1964	38.0	-	39.0	-	-	142.0	297.0
1965	-	5.0	13.0	6.0	-	96.0	121.0
1966	-	-	-	-	-	66.0	282.0
1967	-	-	38.0	-	-	97.0	297.0
1968	-	-	-	-	-	137.0	282.0
1969	1.0	1.0	-	-	-	24.0	600.0
1970	46.0	9.0	24.0	-	9.0	316.0	411.0
1971	43.0	13.0	24.0	-	23.0	354.0	417.0
1972	-	-	-	-	-	72.0	341.0
1973	-	94.0	-	20.0	-	72.0	567.0
1974	-	39.0	-	-	-	169.0	320.0
1975	10.0	-	-	-	-	238.0	441.0
1976	-	-	-	-	-	59.0	469.0
1977	-	1.0	21.0	-	17.0	433.0	280.0
1978	21.0	69.0	22.0	4.0	-	NA	NA
1979	26.0	30.0	NA	-			
AVERAGE	11.0	14.0	11.0	4.0	5.0	140.0	365.0

Contd...(Aug. to December)

TABLE 2 : Monthly Rainfall of Narsinghpur
(AUGUST TO DECEMBER)

Year	Aug.	Sept	Oct.	Nov.	Dec.	M	NM	Annual
1948	392.0	291.0	21.0	85.0	--	1217	98	1315
1949	235.0	582.0	179.0	--	--	1411	3	1414
1950	279.0	226.0	6.0	--	51.0	935	55	990
1951	344.0	273.0	19.0	--	--	934	48	982
1952	366.0	158.0	8.0	--	3.0	1040	71	1111
1953	251.0	114.0	97.0	--	--	958	8	966
1954	297.0	540.0	11.0	--	--	1103	49	1152
1955	603.0	528.0	184.0	--	--	1744	44	1750
1956	522.0	137.0	44.0	85.0	--	1850	143	1993
1957	403.0	224.0	70.0	--	--	1037	143	1180
1958	276.0	252.0	90.0	4.0	--	1071	24	1095
1959	319.0	224.0	31.0	--	--	1234	59	1293
1960	475.0	46.0	65.0	--	--	1202	64	1266
1961	405.0	450.0	64.0	--	--	1464	31	1495
1962	308.0	320.0	--	--	35.0	901	132	1033
1963	347.0	264.0	13.0	3.0	--	986	47	1033
1964	368.0	90.0	8.0	--	--	905	77	982
1965	182.0	213.0	--	2.0	8.0	612	34	646
1966	189.0	71.0	--	15.0	--	608	15	623
1967	474.0	259.0	2.0	--	130.0	1129	168	1297
1968	394.0	89.0	8.0	--	--	910	--	910
1969	442.0	183.0	--	1.0	--	1249	3	1252
1970	606.0	286.0	2.0	--	--	1621	88	1709
1971	249.0	129.0	--	--	--	1149	103	1252
1972	774.0	NA	--	16.0	--	1187	16	1203
1973	530.0	278.0	35.0	5.0	--	1482	119	1601
1974	552.0	35.0	66.0	--	NA	1142	39	1181
1975	478.0	--	70.0	--	--	1227	10	1237
1976	257.0	249.0	--	67.0	--	1034	67	1101
1977	728.0	190.0	168.0	121.0	5.0	1799	165	1964
1978	NA	NA	--	3.0	35.0	NA	156	156
AVERAGE	402.0	231.0	41.0	13.0	9.0	1179	67	1246

M = Monsoon, NM= Non-monsoon
NA= Npt available

TABLE 3 : Monthly Temperature and Humidity of Narsinghpur. (1962–69)

Monthly Temperature °C				% Relative Humidity
Month	Max.	Min	Mean	Mean
Jan.	32.0	1.4	16.7	53.1
Feb.	36.6	2.8	19.7	44.4
Mar.	41.0	6.0	23.5	39.2
Apr.	45.4	10.0	27.7	34.5
May	45.6	17.0	31.3	35.1
June	46.6	20.4	33.5	54.9
July	40.2	19.9	30.1	78.2
August	35.4	17.1	36.3	84.1
Sept.	36.2	16.4	26.3	74.8
Oct.	38.2	9.6	23.9	51.8
Nov.	35.2	4.0	19.6	51.8
Dec.	33.0	1.0	17.0	57.7

TABLE 4 : Data of Infiltration Test at Kheri.

Time in Minutes	Cumulative Drop in mm	Infiltration rate in cm/hr
0	0	--
5	1.0	1.09
10	2.0	1.06
15	3.0	1.03
25	4.0	0.98
30	5.0	0.95
60	10.0	0.81
90	13.0	0.69
120	16.0	0.58
150	19.0	0.49
190	22.0	0.40
250	25.0	0.32
260	25.5	0.32

TABLE 5 : Data of Infiltration Test at Rampipariya.

Time in Minutes	Cumulative Drop in mm	Infiltration rate in cm/hr
0	0	--
5	1.0	0.83
10	2.0	0.80
20	3.0	0.75
25	4.0	3.50
30	5.0	0.65
60	7.0	0.56
90	9.5	0.45
120	11.5	0.37
150	13.0	0.29
160	13.5	0.28
200	15.5	0.28

TABLE 6 : Data of Infiltration Test at Jallapur.

Time in Minutes	Cumulative Drop in mm	Infiltration rate in cm/hr
0	0	...
5	0.5	0.83
10	1.5	0.78
20	3.0	0.70
30	4.0	0.63
40	5.0	0.56
60	6.5	0.44
100	9.0	0.27
140	10.5	0.17
180	11.5	0.12
220	12.5	0.12
240	13.0	0.12
260	13.5	0.12

TABLE 7 : Data of Infiltration Test at Bhootpipariya.

Time in Minutes	Cumulative Drop in mm	Infiltration rate in cm/hr
0	0	...
5	0.5	0.47
10	1.0	0.46
15	1.5	0.44
20	2.0	0.43
30	2.5	0.41
40	3.0	0.39
50	3.5	0.38
90	6.0	0.31
150	9.0	0.23
210	10.5	0.17
250	11.5	0.14
270	12.0	0.14

TABLE 8 : Data of Infiltration Test at Bahoripar.

Time in Minutes	Cumulative Drop in mm	Infiltration rate in cm/hr
0	0	
5	141	
10	190	
15	246	
20	295	
25	337	
30	364	
35	394	
40	413	
45	442	
50	468	
55	497	
60	529	
65	554	
70	578	
75	604	
80	626	
85	648	
90	670	
95	691	
100	710	
105	727	
110	760	0
115	772	14.4
120	790	21.6
125	809	22.8
130	827	21.6
135	846	22.8
140	861	18.0
145	878	20.4
150	896	18.0
165	947	20.4
180	1000	21.2
195	1045	18.0
210	1091	18.4

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