Infiltration model calibration using double ring infiltrometer- To Find infiltration rate of soil.

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Abstract: The constant infiltration rates of different soils under different soil conditions were calculated at near uben river. Experimentation work was carried out on black cotton, clay, and sandy soil. The double ring infiltrometer method was used for measurement of infiltration rate. The study aimed to determine constant infiltration rates of those soils under different soil condition and comparing it with the infiltration rates obtained by kostiakov, Horton's and Green-Ampt infiltration models. For getting best fitting model for particular soil and soil condition the results obtained from various infiltration models were compared with observed field data and graphs were drawn. The parameter considered for best fitting of model were correlation coefficient and standard error. The result shown that, The Horton's model and Green-Ampt model were best fitting to observed field data to estimate infiltration rates at any given time with high degree of correlation coefficient and minimum degree of standard error. In this project we are find out different types of soil in infiltration to use as double ring infiltrometer equipment.

***Index Terms* - Infiltration, Infiltration rate, soil condition.**

I. INTRODUCTION

Infiltration is the process of water enter the soil through the earth's surface. The w0ater at the soil surface originate from rain. The infiltration depends on the availability of water at the soil surface and on soil characteristics. The movement of water in to the soil is caused by gravitational and is affected by forces of soil particles on the water. As these forced depend mostly on the soil water content. To find the rate of infiltration in this project we will used double ring infiltrometer. The double ring infiltrometer is a simple instrument used for determining water infiltration of the soil. The ring is partially inserted into the soil and filled with water. After which the speed of infiltration is measured. Infiltration is the process of water penetrating the ground surface. The Intensity of this process is called the infiltration rate. The infiltration rate is expressed in terms of the volume of water per ground surface and per unit of time. The double ring infiltrometer is suitable for almost any type of soil and is applied in irrigation and drainage projects and groundwater. The infiltration capacity of a soil decrease rapidly over time during infiltration. The initial infiltration capacity in dry grounds is high.

II. TERMINOLOGIES

Soil structure: - The clumping of the soil textural components of sand, silt and clay forms aggregates and the further association of those aggregates into larger units forms soil structures called pads. The soil structure affects aeration, water movement, conduction of heat, plant root growth and resistance to erosion. Water has the strongest effect on soil structure due to its solution and precipitation of minerals and its effect on plant growth

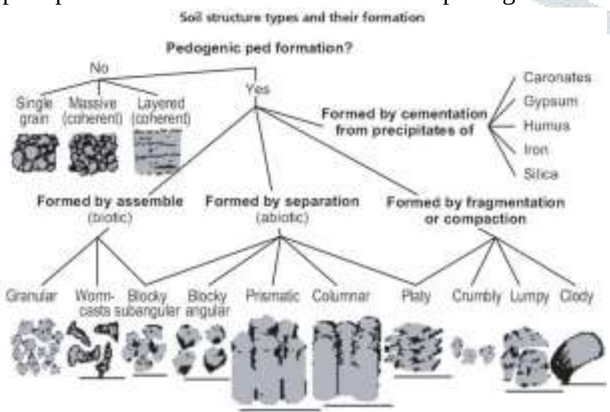


Figure: - Soil Structure

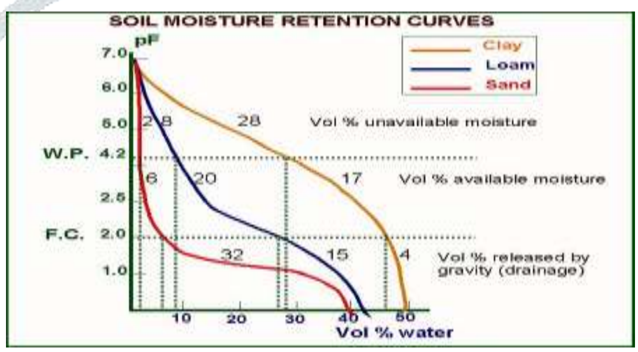


Figure: - Availability of water

Soil Water characteristics: -The moisture stored in or flowing through the soil affects soil formation, structure, stability and erosion and is of primary concern with respect to plant growth.

Available soil water: -When a field is flooded, the air space is displaced by water. The field will drain under the force of gravity until it reaches what is called field capacity, at which point the smallest pores are filled with water and the largest with water and air. Field capacity corresponds with a suction equivalent of 1/3 bar. Plants that use the water must produce increasingly higher suction, finally up to 15 bar. At 15 bar suction, the soil water amount is called wilting point. The amount of water remaining in a soil drained to field capacity and the amount that is the available are functions of mainly soil texture. The available soil moisture can be determined in the laboratory.

Soil Texture: - The mineral component of soil, sand, silt, clay, determine a soil's texture. Soil texture affects soil behaviour, in particular its retention capacity for nutrients and water. Soil components larger than 2 mm are considered as rock and gravel and can be included in texture class. For example, a sandy loam soil with 20% gravel would be called a gravelly sandy loam. When the organic component of a soil is substantial, the soil is called organic soil rather than mineral soil.

Figure: - Soil Texture

Color: - Soil colour is determined by organic matter content, drainage condition, and the degree of oxidation. Soil colour, while easily discerned, has little use in predicting soil characteristics it is of use in distinguishing boundaries within a soil profile, determine the organic of a soil's parent material, as an indication of wetness and waterlogged conditions, and as a qualitative means of measuring organic, salt and carbonate contents of soil.

Consistency: - Consistency is the ability of soil to stick together and resist fragmentation. It is of use in pre directing cultivation problem and the engineering of foundation. Consistency is measured at three moisture condition: air-dry, moist and wet. More precise measure of soil strength is required prior to construction.

Porosity: - Pore space is that part of the bulk volume that is not occupied by their mineral or organic matter but is open space occupied by either air or water. ideally, the total pore space should be 50% of the soil volume. The air space is needed to supply oxygen to organisms decomposing organic matter, humus, and plant roots. pore space also allows the movement and storage of water and dissolved nutrients.

Density: - Density is the weight per unit volume of an object. Particle density is the density of the mineral particle that make up a soil; i.e. It excludes pore space and organic material. particle density averages approx. 2.65g/cc.e. A high bulk density indicates either compaction of the soil or high sand content. A lower bulk density by itself does not necessarily indicate higher suitability for plant growth.

Water flows: -Water moves through soil due to the force of gravity, osmosis and capillarity. At zero to 1/3 bar suction, water moves through soil due to gravity this called Saturated flow. At higher suction, water movement is called unsaturated flow. Water flows can be measured in the field.

III. ABOUT OF INFILTRATION

Infiltration rate in soil surface is a measure of the rate at which soil is able to absorbed rainfall of irrigation. It is measured in inches per hour or millimeters per hour. The rate decrease as the soil becomes saturated, if the precipitation rate exceeds the infiltration rate, runoff will usually occur unless there is some physical barrier. It is related to the saturated hydraulic conductivity of the near surface soil. The rate of infiltration can be measured using an infiltrometer. Infiltration is caused by two forces: Gravity and capillary action. While smaller pores offer greater resistance gravity, very small pores pull water through capillary action in addition to and even against the force of gravity. The rate of infiltration is determined by soil characteristics including easy of entry, storage capacity, and transmission rate through the soil, soil temperature and rainfall intensity all play a role in controlling infiltration rate and capacity.

IV. PROCESS OF INFILTRATION

The process of infiltration can continue only if there is room available for additional water at the soil surface. The available volume for additional water in the soil depends on the porosity of the soil and the rate at which previously infiltrated water can move away from the surface through the soil. The maximum rate that water can enter a soil in a given condition is the infiltration capacity. If the arrival of the water at the soil surface is less than the infiltration capacity, it is sometimes analyzed using hydrology transport models, mathematical models that considered infiltration, runoff and channel flow to predirect river flow rates and stream water quality

V. TYPES OF SOIL

Some examples of constant infiltration rates (or near-saturated hydraulic conductivity) for different soil type.

1. **Sandy soil**
   Sandy: >30mm/hr.

2. **Sandy loam**
   Sandy loam: 20 to 30 mm/hr.

3. **Loam**
   Loam: 10 to 20 mm/hr

4. **Clayey loam**
   Clayey loam: 5 to 10 mm/hr

5. **Clayey**
   Clayey: <5 mm/hr.

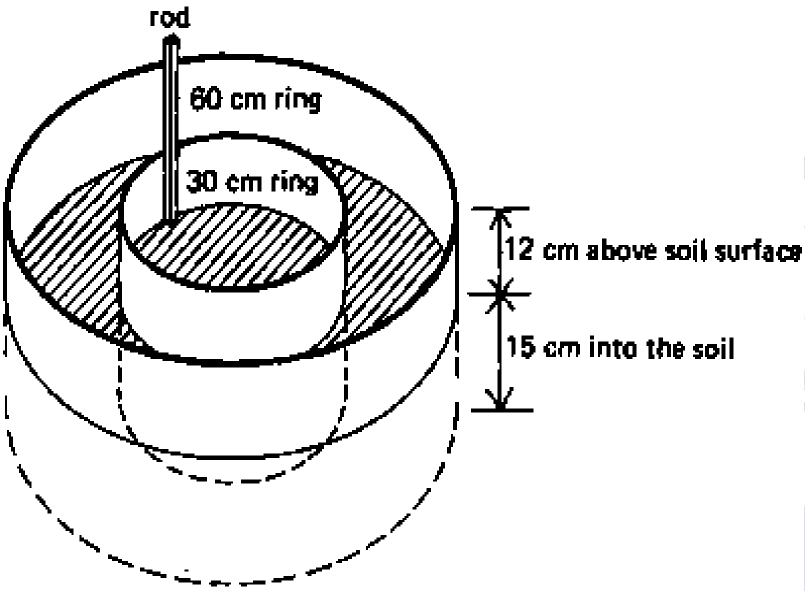
VI. DOUBLE RING INFILTRATION PROCEDURE

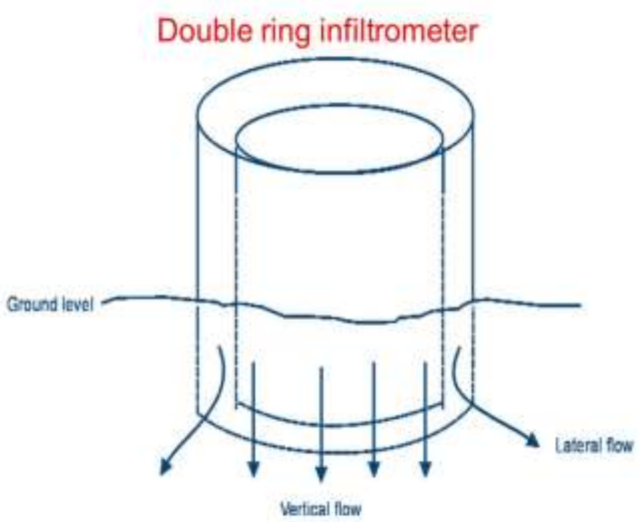
Infiltration is the process by which water arriving at the soil surface enters the soil. This process affects surface runoff, soil erosion and groundwater recharge. Being able to measure the surface infiltration rate is necessary in many disciplines. The double-ring infiltrometer if often used for measuring infiltration rates. Ring infiltrometers consist of a single metal cylinder that is driven partially into the soil. The ring is fitted with water, and the rate at which the water moves in to the soil is measured. The rate becomes constant when the saturated infiltration rate for the particular soil has been reached. The size of the cylinder in these devices is one source of error. A 15 cm diameter ring produces measurement error of approximately 30%, while a 50 cm diameter ring produces measurement error of approximately 20% compared to the infiltration rate that would be measured with a ring of an infinite diameter. It has been suggested that a diameter of at least 100 cm should be used for accurate result. Cylinders of this size become very difficult to use in particle on light soils, because large volumes of water are required to conduct tests on sandy soils with high infiltration rate. The double- ring infiltrometer test is a well-recognized and documented technique for directly measuring soil infiltration rates. The double-ring infiltrometer as often being constructed from thin walled steel pipe with the inner and outer cylinder diameter being 20 and 30 cm, respectively: however, other diameter may be used. There are two operational technique used with the double-ring infiltrometer for measuring the flow of water in to the ground. In the constant head test, the water level in the inner ring is maintained at a fixed level and the volume of water used to maintain this level is measured. In the falling head test, the time that the water level takes to decrease in the inner ring is maintained at a constant level to prevent leakage between rings and to force vertical infiltration from the inner ring. Numerical modeling has shown that falling head and constant head method give very similar results for fine textured soil, but the falling head test underestimates infiltration rates for coarse textured soil.

PROCEDURE

Double ring infiltrometer is the modified form of simple infiltrometer, used to increase the accuracy of the results. It consist of two cylinders, called ring. The inner ring is 22.5 cm is diameter and the outer ring is 35 cm diameter. The inner tube is used to determine the infiltration rate as in the simple infiltrometer. The water level in the annular space between the two rings is at the same level as that in the inner ring to reduce the border effect due to water coming out of the inner tube. Thus the outer ring provides a sort of water jacket to the inner ring and water in the inner ring infiltrates vertically downward without spreading. The water volume being added to the inner ring at different time intervals are noted.The experiment is continned till a uniform rate of infiltration is achieved.

$$\text{Infiltration capacity} = \frac{\text{volume of water added}}{\text{Area of inner ring} * \text{time interval}}$$





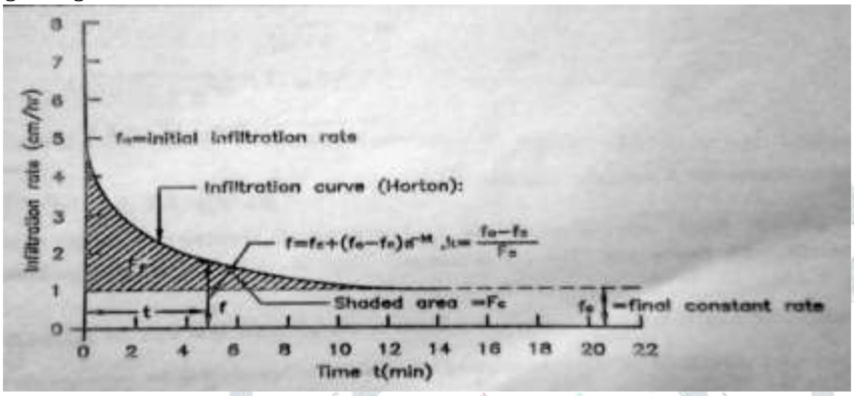
VII. INFILTRATION MODEL

HORTON'S EQUATION

The maximum rate at which the soil in any given condition is capable of obserbing water is called its infiltration capacity (fp). Infiltration (f) often begins at a high rate (20 to 25 cm/hr) and decreases to a fairly steady state rate (fc) as the rain continues, called the ultimate fp (1.25 to 2 cm/hr).The infiltration rate (f) at any time t is given by Horton's equation as,

$$f = fc + (fo – fc)\ e\text{-}kt$$

Where,
fo = initial rate of infiltration capacity
fc = final constant rate of infiltration at saturation
k = a constant depending primarily upon soil and vegetation
Fc = shaded area below infiltration curve
e = base of the Napierian logarithm
t = time from beginning of the storm.



GREEN – AMPT MODEL

Green and Ampt proposed a model for infiltration capacity based on Darcy's law as,

$$fp = K\ (\ 1 + (n^*Sc\ /\ Fp))$$

Where,
fp = infiltration capacity
n = porosity of soil
Sc = capillary suction at the wetting front
K = Darcy's hydraulic conductivity

VIII. METHODOLOGY

In this project we are find to Infiltration rate of soil. We are going to the different places and experiment are carried out double ring infiltrometer. All the places different different infiltration rate results are note down. Above the infiltration data of different soil infiltration model will be chosen.

Select a location: - (1) Makhiyala, (2) Majevadi, (3) Toraniya, (4) Bhesan.

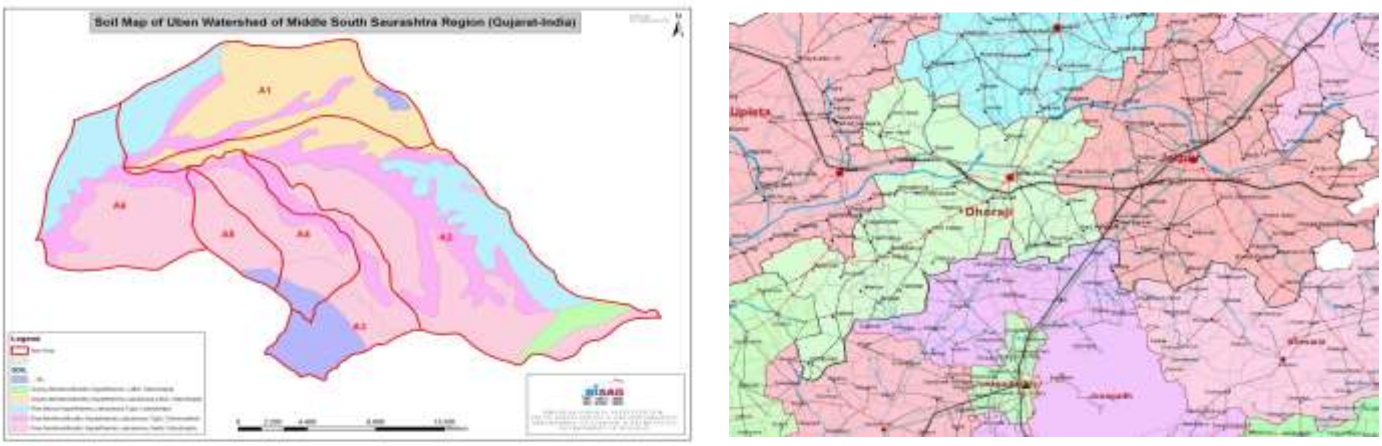


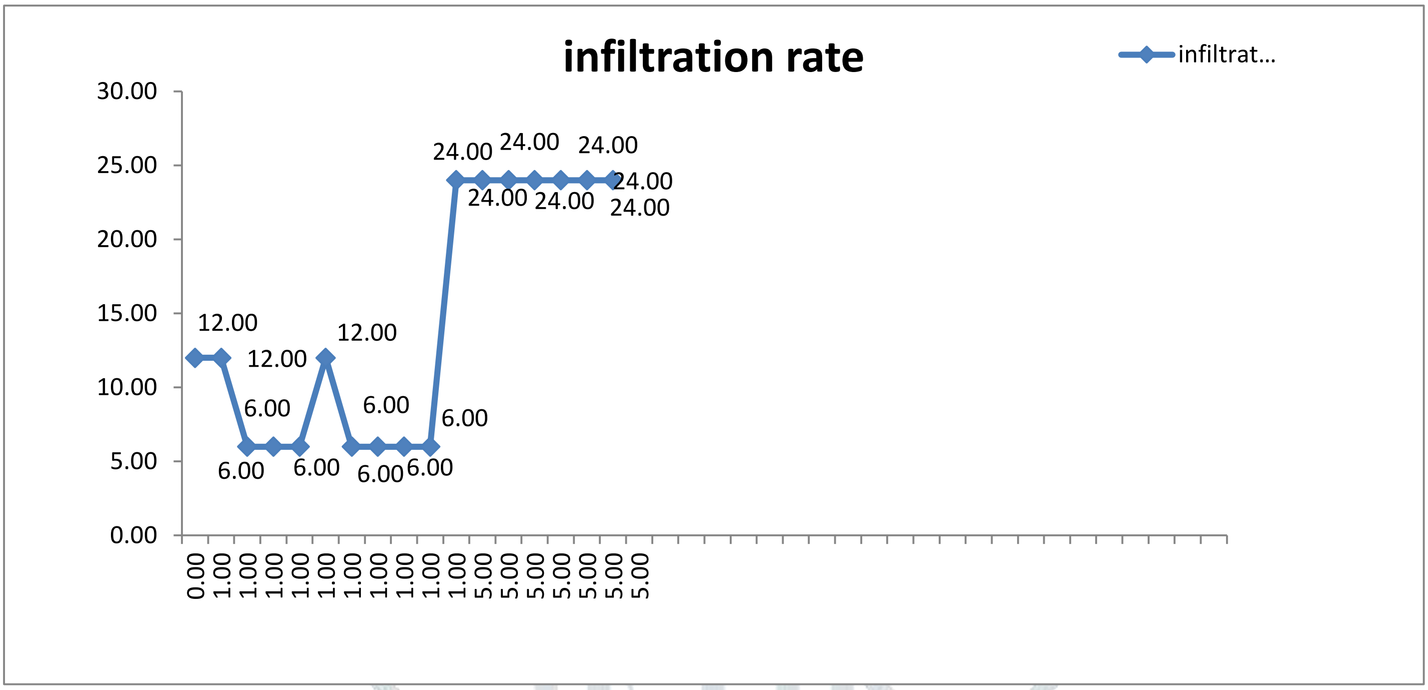
Figure: - Soil map of uben watershed

First of in this project Combined the revenue map of Junagadh district and Rajkot district. The combination of both map is used to the select the region when the experiment of soil. The Both map are combined in the AUTOCADD. After the near uben watershed region are selected.

IX. RESULT AND DISCUSSION

BHESAN: -

INFILTRATION MESUREMENT DATA SHEET						
LOCATION :Bhesan				DATE :1/03/2018		
SRNO.	time sec	time minitue	time in hr	infiltration in mm	infiltration in cm	rate of infiltration (cm/hr)
	0	0.00	0.00	0	0	0
1	60	1.00	0.02	2	0.2	12.00
2	60	1.00	0.02	2	0.2	12.00
3	60	1.00	0.02	1	0.1	6.00
4	60	1.00	0.02	1	0.1	6.00
5	60	1.00	0.02	1	0.1	6.00
6	60	1.00	0.02	2	0.2	12.00
7	60	1.00	0.02	1	0.1	6.00
8	60	1.00	0.02	1	0.1	6.00
9	60	1.00	0.02	1	0.1	6.00
10	60	1.00	0.02	1	0.1	6.00
11	300	5.00	0.08	4	0.4	24.00
12	300	5.00	0.08	4	0.4	24.00
13	300	5.00	0.08	4	0.4	24.00
14	300	5.00	0.08	4	0.4	24.00
15	300	5.00	0.08	4	0.4	24.00
16	300	5.00	0.08	4	0.4	24.00
17	300	5.00	0.08	4	0.4	24.00
				total infiltration cm	11	

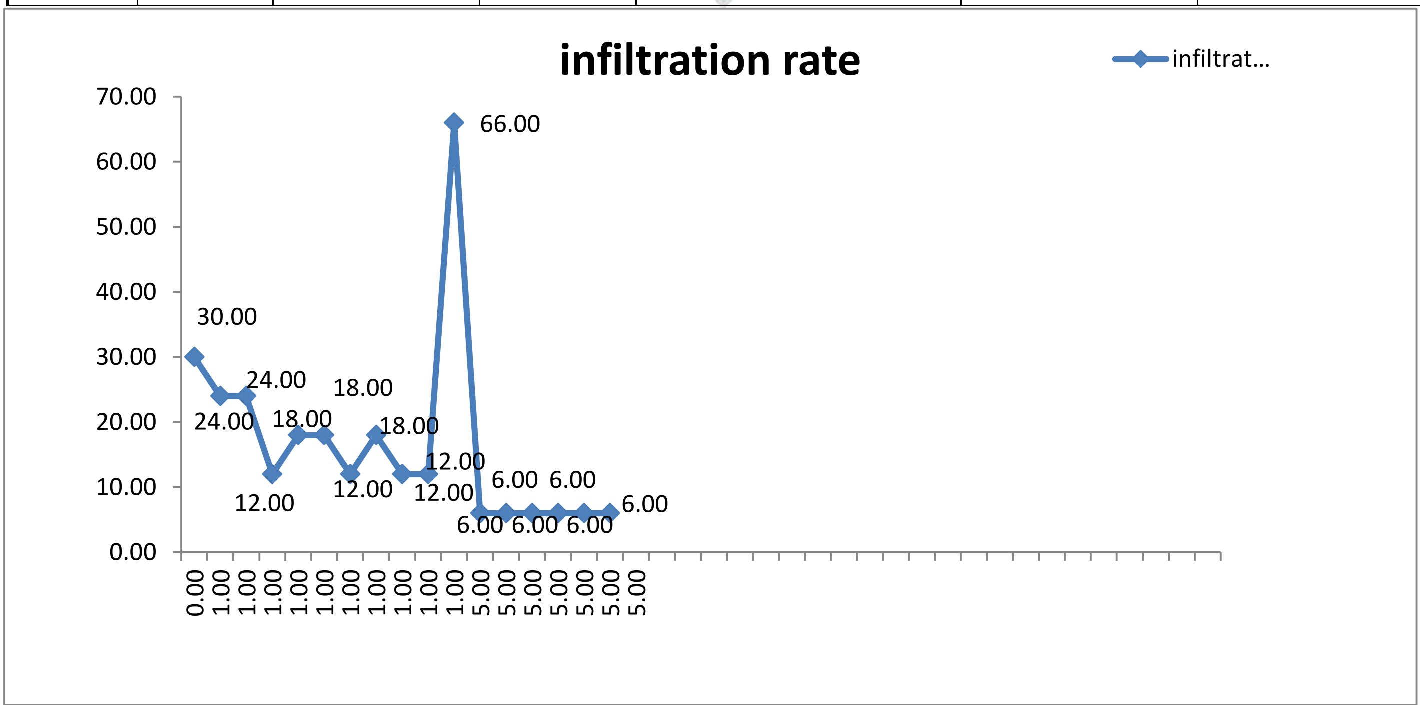


MAJEVADI:-

INFILTRATION MESUREMENT DATA SHEET

LOCATION :Majevadi **DATE :15/03/2018**

SRNO.	time sec	time minitue	time in hr	infiltration in mm	infiltration in cm	rate of infiltration (cm/hr)
	0	0.00	0.00	0	0	0
1	60	1.00	0.02	5	0.5	30.00
2	60	1.00	0.02	4	0.4	24.00
3	60	1.00	0.02	4	0.4	24.00
4	60	1.00	0.02	2	0.2	12.00
5	60	1.00	0.02	3	0.3	18.00

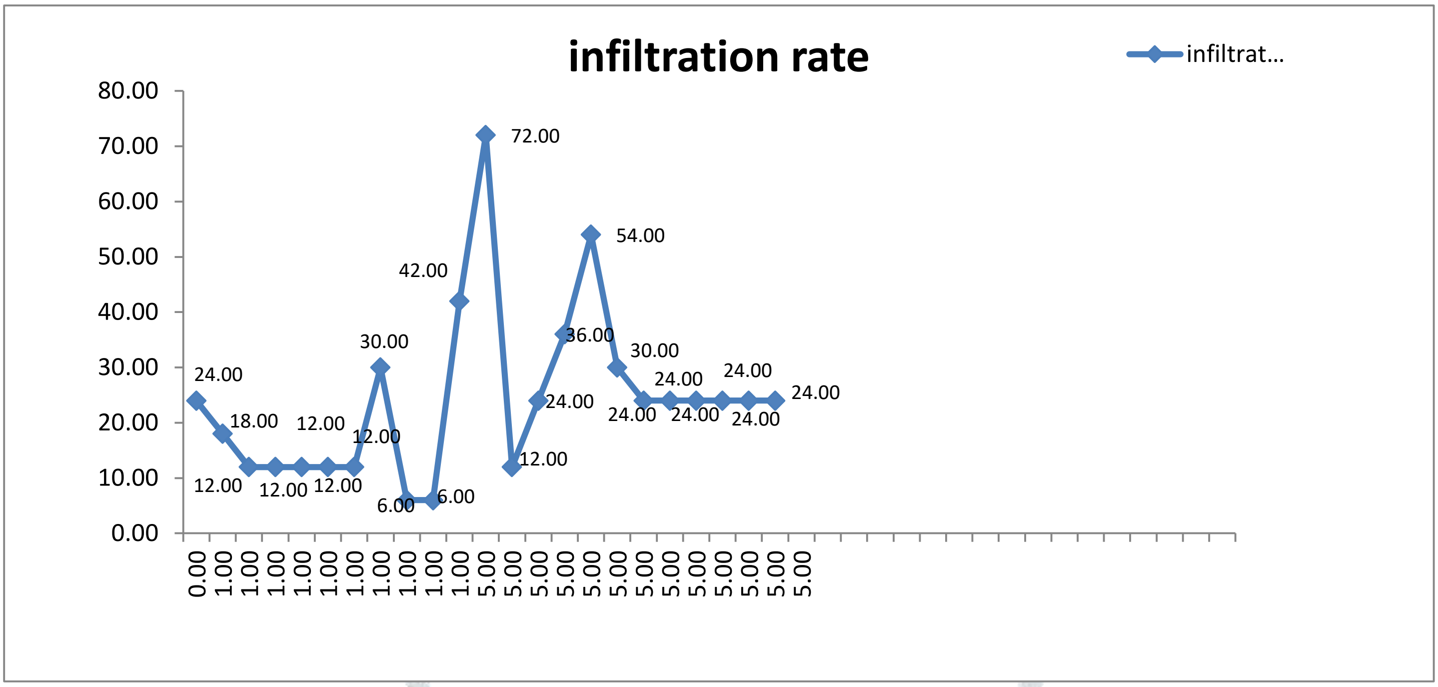


6	60	1.00	0.02	3	0.3	18.00
7	60	1.00	0.02	2	0.2	12.00
8	60	1.00	0.02	3	0.3	18.00
9	60	1.00	0.02	2	0.2	12.00
10	60	1.00	0.02	2	0.2	12.00
11	300	5.00	0.08	11	1.1	66.00
12	300	5.00	0.08	1	0.1	6.00
13	300	5.00	0.08	1	0.1	6.00
14	300	5.00	0.08	1	0.1	6.00
15	300	5.00	0.08	1	0.1	6.00
16	300	5.00	0.08	1	0.1	6.00
17	300	5.00	0.08	1	0.1	6.00
				total infiltration cm	11	

MAKHIYALA:-

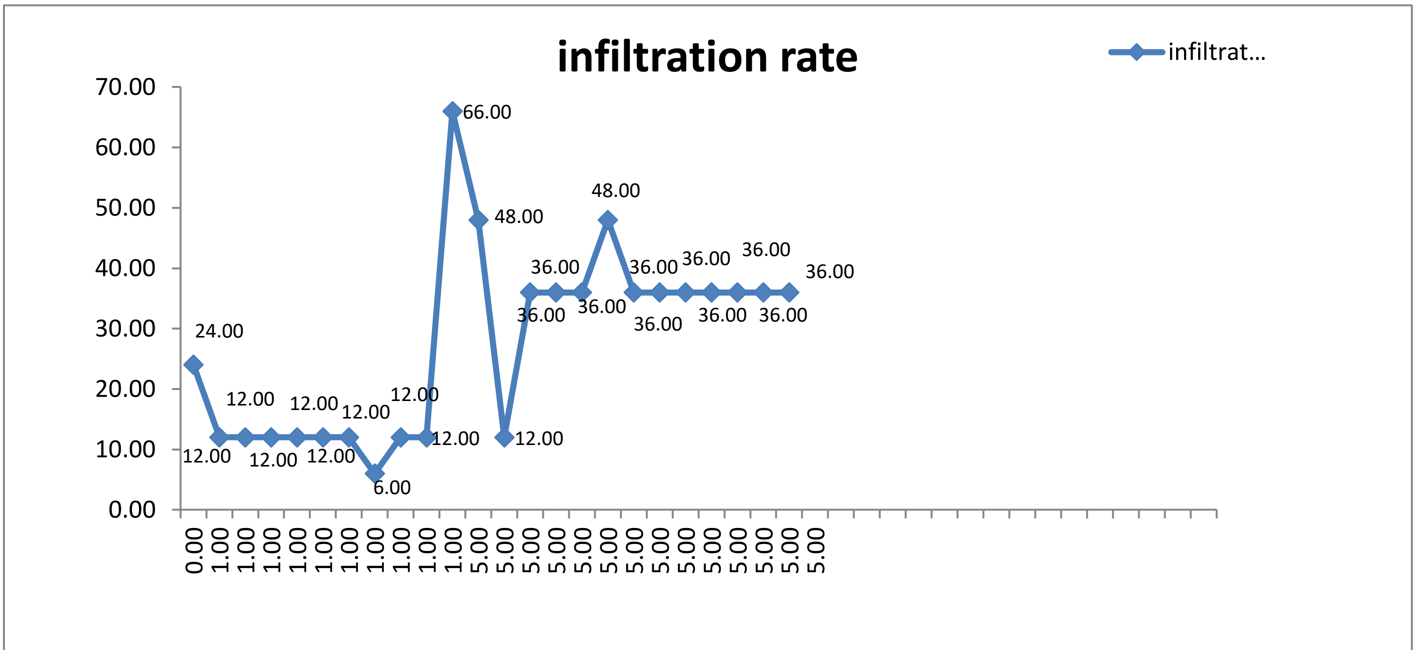
INFILTRATION MESUREMENT DATA SHEET						
LOCATION :Bhesan				DATE :1/03/2018		
SRNO.	time sec	time minitue	time in hr	infiltration in mm	infiltration in cm	rate of infiltration (cm/hr)
	0	0.00	0.00	0	0	0
1	60	1.00	0.02	4	0.4	24.00
2	60	1.00	0.02	3	0.3	18.00
3	60	1.00	0.02	2	0.2	12.00
4	60	1.00	0.02	2	0.2	12.00
5	60	1.00	0.02	2	0.2	12.00
6	60	1.00	0.02	2	0.2	12.00
7	60	1.00	0.02	2	0.2	12.00
8	60	1.00	0.02	5	0.5	30.00
9	60	1.00	0.02	1	0.1	6.00
10	60	1.00	0.02	1	0.1	6.00
11	300	5.00	0.08	7	0.7	42.00
12	300	5.00	0.08	12	1.2	72.00
13	300	5.00	0.08	2	0.2	12.00
14	300	5.00	0.08	4	0.4	24.00
15	300	5.00	0.08	6	0.6	36.00
16	300	5.00	0.08	9	0.9	54.00
17	300	5.00	0.08	5	0.5	30.00
18	300	5.00	0.08	4	0.4	24.00
19	300	5.00	0.08	4	0.4	24.00
20	300	5.00	0.08	4	0.4	24.00
21	300	5.00	0.08	4	0.4	24.00
22	300	5.00	0.08	4	0.4	24.00
23	300	5.00	0.08	4	0.4	24.00

				total infiltration cm	11	



TORANIYA:-

INFILTRATION MESUREMENT DATA SHEET						
LOCATION :Mtoraniya			DATE :20/03/2018			
SRNO.	time sec	time minitue	time in hr	infiltration in mm	infiltration in cm	rate of infiltration (cm/hr)
	0	0.00	0.00	0	0	0
1	60	1.00	0.02	4	0.4	24.00
2	60	1.00	0.02	2	0.2	12.00
3	60	1.00	0.02	2	0.2	12.00
4	60	1.00	0.02	2	0.2	12.00
5	60	1.00	0.02	2	0.2	12.00
6	60	1.00	0.02	2	0.2	12.00
7	60	1.00	0.02	2	0.2	12.00
8	60	1.00	0.02	1	0.1	6.00



9	60	1.00	0.02	2	0.2	12.00
10	60	1.00	0.02	2	0.2	12.00
11	300	5.00	0.08	11	1.1	66.00
12	300	5.00	0.08	8	0.8	48.00
13	300	5.00	0.08	2	0.2	12.00
14	300	5.00	0.08	6	0.6	36.00
15	300	5.00	0.08	6	0.6	36.00
16	300	5.00	0.08	6	0.6	36.00
17	300	5.00	0.08	8	0.8	48.00
18	300	5.00	0.08	6	0.6	36.00
19	300	5.00	0.08	6	0.6	36.00
20	300	5.00	0.08	6	0.6	36.00
21	300	5.00	0.08	6	0.6	36.00
22	300	5.00	0.08	6	0.6	36.00
23	300	5.00	0.08	6	0.6	36.00
24	300	5.00	0.08	6	0.6	36.00
				total infiltration cm	11	

X. CONCLUSION

We have in this project using DOUBLE RING INFILTROMETER method, different different places soil experiment. In our project 4 places, 1) Bhesan, 2) Majevadi, 3) Makhiyala, and 4) Toraniya. All the places on the site double ring infiltrometer practical do and data collected of soil infiltration. All the soil infiltration data result in horton's model is best.

XI. ACKNOWLEDGMENT

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