Assessment of Soil Infiltration Characteristics in Chikkaballapura taluk, Chikkaballapura district, Karnataka

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***Abstract*—Infiltration is a critical component of the hydrological cycle that regulates the movement of water from the land surface into the subsurface, thereby influencing surface runoff, soil moisture dynamics, and groundwater recharge. It is governed by multiple factors such as soil texture, antecedent moisture conditions, permeability, land use, and rainfall characteristics. In this context, infiltration tests were conducted in eight villages of Chikkaballapura Taluk under the National Aquifer Mapping Program 2.0 of Central Ground Water Board during 2025–26 to assess spatial and seasonal variability in infiltration behavior.**

Field infiltration tests were conducted during the monsoon (September 2025) and repeated the tests on the same location in non-monsoon (February 2026) seasons revealed a wide range of infiltration rates varying from 0.4 to 52.8 cm/hr in monsoon and 1.2 to 64.8 cm/hr in non-monsoon season. Clayey soils exhibited very low infiltration rate of 0.4 cm/hr in monsoon and 1.2 cm/hr in non-monsoon season reflecting their compact structure and low permeability rates, whereas sandy clay soils showed significantly higher infiltration rates of 52.8 and 64.8 cm/hr owing to their coarse texture and greater porosity. Moderate infiltration rates of 6 to 8.4 cm/hr and 1.6 to 2.4 cm/hr in monsoon and non-monsoon season were recorded in clay mixed soil types. Seasonal analysis indicated that infiltration rates are relatively lower during the monsoon season due to higher antecedent soil moisture, while higher initial infiltration rates were recorded during the non-monsoon season under dry soil conditions.

The analysis of cumulative infiltration and infiltration rate versus time curves demonstrated distinct seasonal patterns, with rapid stabilization of infiltration rates during monsoon and gradual decline during non-monsoon. The study highlights that soil texture is the dominant factor controlling infiltration characteristics, while seasonal moisture conditions play a secondary role. The findings provide valuable insights for groundwater recharge planning, watershed management, and sustainable water resource development in the study area.

***Index Terms*—Infiltration rate; Cumulative infiltration; Soil texture; Seasonal variation; Groundwater recharge**

I. INTRODUCTION

Infiltration is an important phase of the hydrological cycle that controls the movement of water on the land surface and through subsurface zones. It refers to the process by which water enters the soil from the ground surface. The rate at which water infiltrates into the soil depends on several soil and environmental characteristics such as soil type, soil moisture content, soil permeability, ground cover conditions, drainage characteristics, depth to the water table, and the intensity and volume of precipitation (Johson A.I, 1963 and Adeniji, F. A., et al., 2013, Kalola et al., 2025).

The soil type determines the size and number of capillary pores through which water can move into the ground, while the existing soil moisture content influences the capillary potential and relative hydraulic conductivity of the soil. These factors collectively govern the infiltration capacity of the soil (Richa Ojha et al., 2017, George Kargas et al.,, 2022). The study of infiltration characteristics of a basin under given conditions helps in estimating the quantity of rainfall excess likely to result from a storm event, which in turn assists in assessing potential runoff and flood generation. Infiltration is closely linked with other hydrological processes such as runoff, evapotranspiration, and groundwater recharge, as all these processes are influenced by soil moisture conditions. Therefore, simulation of infiltration is best achieved through hydrological models that incorporate these interrelated processes (Horton R.E, 1933 and Vereecken H., et al, 2008).

The present study has been carried out as part of the National Aquifer Mapping 2.0 (NAQUIM) studies of Central Ground Water Board (CGWB) under the Annual Action Plan (AAP) 2025–26 to understand the infiltration characteristics at different locations in Chikkaballapura Taluk.

II. STUDY AREA

The Chikkaballapura taluk covers 639 sq.km area with bounded by 13°20'10.7" to 13°39'59.4" North latitude and 77°36'04.7" to 77°52'20.2" East longitude. The study area is one of the over-exploited taluk of Chikkaballapura district with respect to groundwater resources (GWRA 2024, GWRA 2025). Agriculture is the main occupation and source of livelihood of the rural population of the taluk (Ashokan, 2017). A major part of Chikkaballapura Taluk is occupied by clayey soil, followed by clayey mixed and sandy clay soils. In addition, a considerable portion of the taluk is characterized by rocky outcrops and weathered granitic terrain, which significantly influence the soil properties and infiltration behavior of the area. Overall, the predominant soil cover in the taluk is red colored soil, which generally exhibits moderate infiltration characteristics depending on soil texture, structure, and moisture conditions.

III. OBJECTIVES OF THE STUDY

1. To determine the infiltration rate of soils at selected locations in Chikkaballapura Taluk.
2. To understand the spatial and seasonal variation of infiltration characteristics under different soil and land-use conditions.
3. To estimate the infiltration capacity of soils, which influences groundwater recharge potential.

IV. METHODOLOGY

The double ring infiltrometer field instrument is used for determining the infiltration capacity of soils. In this method, two concentric rings with diameters of 30 cm (inner ring) and 60 cm (outer ring) and rings length of 30 cm are used. The rings are partially driven into the soil to a suitable depth to prevent leakage along the sides. The procedure is as follows,

1. Two concentric rings of the infiltrometer were driven vertically into the soil to a depth of about 10–15 cm.
2. Water was poured simultaneously into both the inner and outer rings to maintain a constant head.
3. The drop in water level in the inner ring was measured at regular time intervals.
4. Water was added continuously in the outer ring to maintain a constant water level during the test.
5. Observations were recorded until the infiltration rate reached a nearly constant value, indicating the steady infiltration rate.

The schematic diagram of the double ring infiltrometer used in the study is shown in Fig. 1.

The observations were recorded in terms of time interval and depth of water infiltrated, from which cumulative infiltration and infiltration rate were calculated.

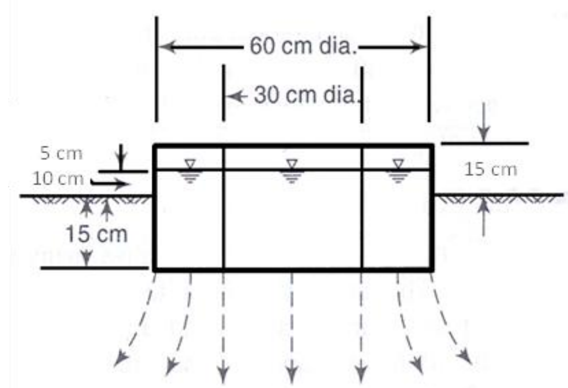


Fig. 1: Double ring infiltrometer

Classification of Infiltration Capacity

Soils can be broadly classified into different categories based on their infiltration capacity, which is an important parameter controlling surface runoff and groundwater recharge. Based on hydrological characteristics, soils are commonly grouped into hydrologic soil groups, where the steady-state infiltration capacity is one of the key parameters used for classification. The steady-state infiltration capacity is generally divided into four infiltration classes, ranging from very low to high infiltration potential. This classification helps in understanding the runoff behavior of soils and their ability to permit water to infiltrate into the subsurface. The standard classification of infiltration capacities as given by K. Subramanya (2015) is presented in Table 1.

Table 1: classification of soil based infiltration capacities		
Infiltration Class	Infiltration Capacity/rate (mm/hr)	Remarks
Very Low	< 2.5	Highly clayey soils
Low	2.5 – 12.5	Shallow soils, clay soils, soils low in organic matter
Medium	12.5 – 25.0	Sandy loam and silt soils
High	> 25	Deep sandy soils and well-drained aggregated soils

In the present study, infiltration tests were carried out at eight different locations across Chikkaballapura Taluk. The test sites were selected to represent different soil types and soil cover conditions, while also considering accessibility. Parameters such as soil moisture condition, soil texture, land cover and slope were taken into account during the selection of the sites to ensure that the observations covering the above mentioned parameters to ensure representative infiltration characteristics of the taluk and is shown in Fig. 2.

The infiltration tests were planned in such a way that experiments were conducted during the Monsoon season (September 2025) as well as during the non-monsoon season (February 2026), in order to determine and compare the infiltration capacities of the same locations under different seasonal conditions. The results obtained from the tests are summarized in Table 2.

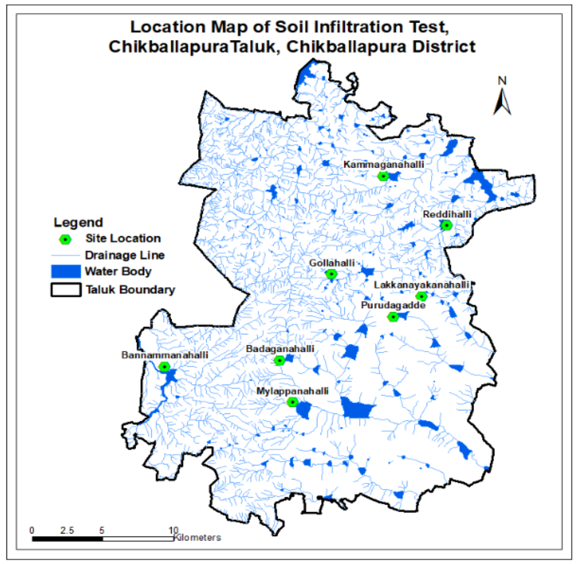


Fig. 2 : Location map of soil infiltration test

Table 2: Results of Soil infiltration test – Chikkaballapura taluk											
Sl. No.	Village	Latitude	Longitude	Location	Soil Type	Monsoon (September 2025)			Non-Monsoon (February 2026)		
						Duration (mins)	Cumulative depth (cm)	Infiltration rates (cm/hr)	Duration (mins)	Cumulative depth (cm)	Infiltration rates (cm/hr)
1	Mylappanahalli	13.428	77.711	Agriculture land adjacent to Kandavara Tank	Clayey	130	0.6	0.4	160	7.1	1.6
2	Badaganahalli	13.458	77.703	Open land near Rangadhama kere	Clayey	130	0.5	0.4	160	6.6	1.2
3	Bannammanahalli	13.454	77.627	Agriculture land adjacent to	Clayey	130	1.1	0.4	160	6	1.6

				Srinivasakere							
4	Purudagadde	13.487	77.778	Agriculture land adjacent to Dibbur Kere	Sandy Clay	100	92.5	52.8	100	119.5	64.8
5	Gollahalli	13.517	77.738	Open land near Gollahalli Kere	Clay Mixed	110	20.3	8.4	130	30.1	14.4
6	Kammaganahalli	13.585	77.773	Agriculture land adjacent to Peresandra Lake	Clay Mixed	115	25.6	6	130	56	17.2
7	Reddihalli	13.550	77.814	Open land near Reddihalli kere	Clayey	115	2.5	1.2	130	9.3	2.4
8	Lakkanayakanahalli	13.501	77.796	Agriculture land near Lakkanayanakahalli Kere	Clayey	115	5.8	1.2	145	49.7	14

V. RESULTS AND DISCUSSION

Infiltration tests were conducted at eight villages in Chikkaballapura Taluk, namely Mylappanahalli, Bodaganahalli, Bannammanahalli, Purudagadde, Gollahalli, Kammaganahalli, Reddihalli, and Lakkanayakanahalli under NAQUIM 2.0 during 2025–26. The infiltration tests were carried out during both monsoon (September 2025) and non-monsoon (February 2026) seasons.

1. Spatial variation of Infiltration rates

The study area comprises different soil types, including clayey, clay mixed and sandy clay soil. These variations in soil texture significantly influence the infiltration capacity.

Clayey soil observed in villages such as Mylappanahalli and Bodaganahalli falling under south west part of the taluk are recorded with very low infiltration rates in both the seasons due to their fine particle size and low permeability. The cumulative infiltration depths in these areas were minimal compared to other locations. The presence of compact soil structure reduces pore spaces, thereby limiting water movement into the soil profile.

In contrast, areas dominated by sandy clay soil, particularly Pudugadde village falling in north east part of the study area, exhibited very high infiltration rates and cumulative infiltration depths. The coarse texture and higher porosity of sandy soils allow water to percolate rapidly into deeper layers. Clay mixed soil found in Gollahalli and Kammaganahalli showed moderate infiltration rates, reflecting intermediate permeability characteristics.

2. Seasonal variation of Infiltration rates

2.1 Monsoon Season:

During Monsoon Season, the results obtained from the infiltration tests indicate considerable variation in infiltration rates across the study area. The infiltration rate varied from 0.4 cm/hr (Badaganahalli) to 52.8 cm/hr (Purudagadde). The cumulative depth of infiltration ranged from 0.5 cm (Badaganahalli) to 92.5 cm (Purudagadde) during the observation period. The lowest infiltration rates were recorded at Mylappanahalli, Bodaganahalli, and

Bannammanahalli, where clayey soil dominate. In contrast, the highest infiltration rate of about 52.8 cm/hr was observed at Purudagadde, which is characterized by coarse-textured sandy clay soil. Moderate infiltration rates ranging between 6 cm/hr and 8.4 cm/hr were observed in areas dominated by clay mixed soil types such as Gollahalli, Kammaganahalli, Lakkayanapalya, and Reddihalli.

2.2 Non-monsoon Season:

During Non-Monsoon Season, the tests were conducted in the same locations of Monsoon season to understand the seasonal variability of infiltration rates. The results obtained from the infiltration tests indicate considerable variation in infiltration rates across the study area. The infiltration rate varied from 1.2 cm/hr (Badaganahalli) to 64.8 (Purudagadde) cm/hr. The cumulative depth of infiltration ranged from 6 cm (Bannammanahalli) to 119.5 cm (Purudagadde) during the observation period. The lowest infiltration rates were recorded at Bannammanahalli.

In contrast, during non-monsoon, the highest infiltration rate of about 64.8 cm/hr was observed at Purudagadde, which is characterized by coarse-textured sandy clay soil. Moderate infiltration rates ranging between 1.6 cm/hr and 2.4 cm/hr were observed in areas dominated by mixed soil types such as Mylappanahalli, Bannammanahalli and Reddihalli.

2.3 Monsoon v/s non-monsoon comparison:

The infiltration capacity results obtained for Monsoon and Non-monsoon seasons for the same locations are compared to understand the variability of soil infiltration rates.

Based on the classification of infiltration capacities given in Table 1 (after K. Subramanya, 2015), the infiltration capacity in the study area ranges from low and high in monsoon season and low, medium and high in non-monsoon season (Table 3). The results clearly demonstrate that soil texture and land use conditions play an important role in controlling infiltration characteristics and groundwater recharge potential in the area. The non-monsoon results reflect the gradation in infiltration rates whereas, low infiltration rates in monsoon are depicting near to saturation conditions.

Table 3: Monsoon v/s non-monsoon infiltration rates comparison

Category	Infiltration rates (mm/hr)	Name of the Location	
		Monsoon	Non-monsoon
Low	2.5 to 12.5	Mylappanahalli, Badaganahalli, Bannammanahalli, Reddihalli, Lakkanayakanahalli	Badaganahalli,
Medium	12.5 to 25.0	-	Mylappanahalli, Bannammanahalli, Reddihalli
High	> 25	Purudagadde, Gollahalli, Kammaganahalli	Purudagadde, Gollahalli, Kammaganahalli, Lakkanayakanahalli

In comparison of monsoon and non-monsoon season, the results indicate that, the duration of the test to attain the saturation is more in non-monsoon season due to dry season effect bearing dry soil conditions. Attaining a saturation and final infiltration rate is shorter in time duration during Monsoon period.

Seasonal comparison of infiltration rates indicates that, infiltration behavior is influenced by soil moisture conditions. During the monsoon season, soils are relatively moist or partially saturated due to rainfall, which may reduce the infiltration capacity, particularly in clayey soils. During the non-monsoon season, relatively dry soil conditions increase the initial infiltration rates in permeable soils, although the overall infiltration behavior continues to depend largely on soil texture.

Horton (1933) established an exponential relation between the rate of infiltration and time. The infiltration rate is being maximum in start with falling off to a constant rate (Karanth, 1987). The plots of Cumulative infiltration (Fp) and Infiltration rate (fp) with time is plotted for both monsoon and non-monsoon season and it is observed that, during monsoon infiltration rates starts moderate to low because the soils are already moist/saturated during monsoon and decrease and stabilize quickly to low constant rate. Whereas, in Non-monsoon season, the infiltration rate starts high as the dry soil absorb the water quickly, decrease gradually over time and eventually reaches lower rate. The steep drop to flat lower infiltration rates is very well observed in plots Monsoon season with gentle linear rise in Cumulative infiltration (Fig.3a, 3b,4a,4b,5a,5b). Non-monsoon plots of *Fp* and *fp* verses time shows, smooth decay curve of infiltration rates and steep rise and flattening of the curve which clearly bifurcate the monsoon and non-monsoon seasonal behavior.

Fig.3a:Mylappanahalli, Chikkaballapura Taluk
Monsoon Season

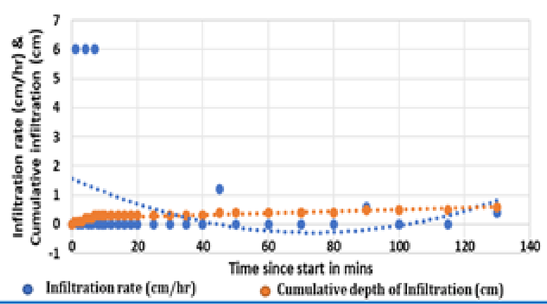


Fig.3b:Mylappanahalli, Chikkaballapura Taluk
Non Monsoon Season

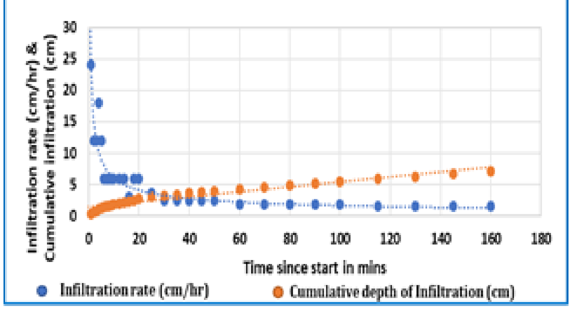


Fig.4a:Badaganahalli, Chikkaballapura Taluk
Monsoon Season

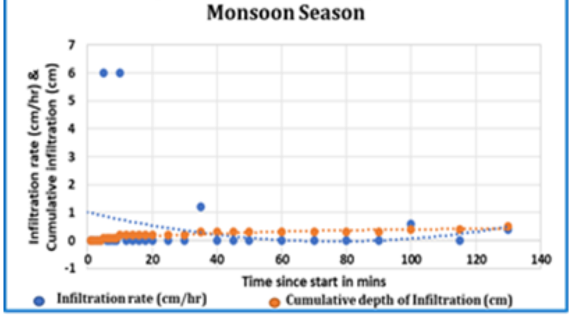


Fig.4b: Badaganahalli, Chikkaballapura Taluk
Non Monsoon Season

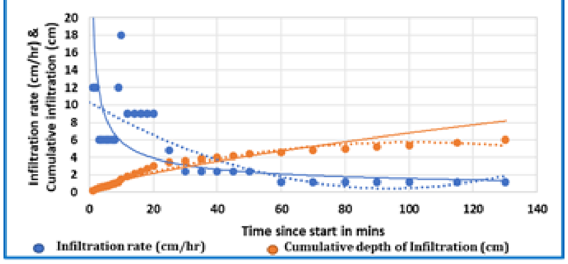


Fig.5a: Gollahalli, Chikkaballapura Taluk
Monsoon Season

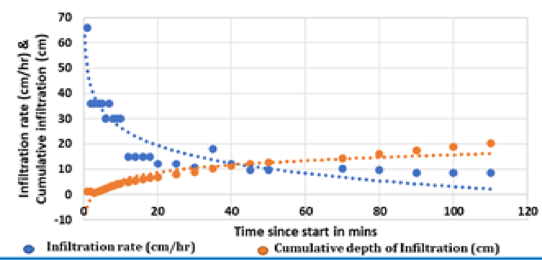
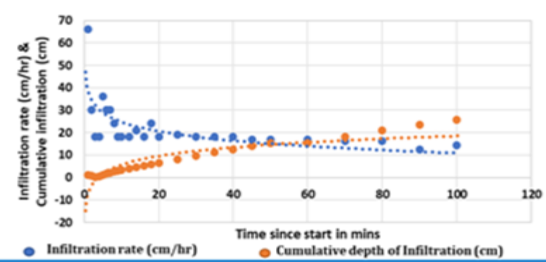


Fig.5b: Gollahalli, Chikkaballapura Taluk
Non Monsoon Season



VI. CONCLUSION

The soils in the study area are predominantly clayey, clayey mixed and sandy clayey soil, generally varying from pale red to red in colour. The results indicate significant variation in infiltration capacity depending on soil type and soil texture.

Clayey soils recorded the lowest infiltration rates of 0.4–1.2 cm/hr and 1.2 cm/hr in both the season due to their compact structure and low permeability. These areas exhibit limited groundwater recharge potential and are more prone to surface runoff during rainfall events. In contrast, sandy clay soils showed very high infiltration rates up to 52.8 cm/hr and 14 to 64.8 cm/hr in monsoon and non-monsoon season owing to their coarse texture and high permeability, allowing rapid percolation of water into deeper soil layers.

Moderate infiltration rates of 6 to 8.4 cm/hr and 1.6 to 2.4 cm/hr in both the season were observed in clay mixed soil types, indicating intermediate permeability and moderate groundwater recharge potential. Seasonal analysis indicates that soil moisture conditions influence infiltration behavior to some extent; however, soil texture remains the dominant controlling factor.

The high infiltration observed in Purudagadde indicates favorable conditions for artificial groundwater recharge structures such as recharge pits, percolation tanks, and check dams, subject to site-specific feasibility and hydrogeological suitability.

The duration of soil infiltration test varied in monsoon and non-monsoon season. The final infiltration in monsoon is observed in shorter times in monsoon season due to incidental soil moisture due to rainfall and saturation condition of the soil in monsoon season.

Overall, the study highlights that sandy clay soils possess the highest infiltration potential and are favorable locations for groundwater recharge structures, while clayey soils exhibit low infiltration capacity and relatively poor recharge potential. These findings provide valuable inputs for groundwater recharge planning, watershed management, and sustainable water resource development in Chikkaballapura Taluk.

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