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A Study of Hydrological Parameters in Krishna District, and Hrapradesh

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***Abstract*:**
Groundwater percolation is an important aspect with regard to recharge of groundwater. Infiltration of native soil plays an important role in this regard. It depends on nature of soil, catchment area, topography, soil properties etc. Information on the infiltration trends at a given location will help in understanding the rate of infiltration at any time. Further, the groundwater depth and its quality are dependent on season of the year. The present study is carried out during Dec 2018 to March 2019 and aims to (i) determine infiltration of open wells at two locations in Nuzividu and Tiruvuru of Krishna district and develop empirical models for assessment of infiltration rates at these locations based on double ring infiltration tests (ii) determine the type of soil and correlate with the infiltration obtained from filed studies (iii) determine the depth of groundwater, its seasonal fluctuations and the corresponding variations of water quality. The study revealed that (i) the soil is silty clay (ii) minimum infiltration rate is < 5mm/hr at each of the locations (iii) seasonal variation of groundwater quality is ascertained (iv) the infiltration trends can be assessed using the empirical models developed for this purpose at these locations.

Keywords: Infiltration, fluctuation of groundwater quality, fluctuation of groundwater depth, empirical model, soil classification

INTRODUCTION

Water availability and unseasonal rains is a major global problem. The percolation of rainfall into subsurface and its availability as ground water depends on several aspects such as type of soil, infiltration, porosity, specific yield etc. (Jayaramireddy, 2011). The different soil types that are naturally available are boulders, gravel, sand, silt and clay that are based on size of the particle while the classification of native soil is based on the texture of the soil where combinations of the above categories are present in the soil (Punmia et al, 2005). The boulders or gravel are more permeable while clays are least permeable (Arora, 2009). Further, the rainfall incident at any location is dependent on intensity of rainfall and storm duration while the infiltration rate of water into the subsoil depends on the soil texture and structure, condition at soil surface, soil moisture content, soil temperature, catchment area, human activities on the soil surface, vegetation cover etc. (Subramanya, 2008). Infiltration is the rate at which soil can absorb rainfall

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and is measured in millimetres per hour (Jayaramireddy, 2011). The rate at which soil absorbs the water at a given time is called infiltration rate. For example, an infiltration rate of 10 mm/hour implies that a water layer of 10 mm on the soil surface will take one hour to infiltrate. A single ring or double ring infiltrometer is used in determining the infiltration rates in soil.

The quality of ground water in a well varies with the season of the year, i.e., low in rainy season due to dilution occurring in groundwater flow while it is poor in dry or summer season. A study leading to infiltration of water in a sub soil, fluctuation in the groundwater depth based on season of the year, variations of the quality of the water in open wells and analyzing all these information for the similarities will be interesting.

The infiltration rate of soil is determined in Udupi district Karnataka (Poojashree and Bhavya, 2016). The tests are conducted in three different locations and noted that the infiltration is not same throughout but varying from location to location. Jagdale and Nimbalkar (2012) conducted infiltration studies of different soils under different soil conditions in Sangola village of Maharashtra and compared them with the infiltration models. They concluded that the values obtained using Horton Model are more in agreement with the values obtained from field studies. Infiltration rates of different soils under different conditions are analyzed in Guwahati (Gayatri and Mimi, 2016) and classified the native soils of the region. Rede (2012) studied the seasonal variation and groundwater level fluctuations in 15 villages of Marathwada region in Jalna district, Maharashtra. Heavy depression is noticed in the study region due to the drought prevailing in that region during the study. Sarvamangala et al., (2016) discussed the various infiltration models that are used and the importance of infiltration in field applications. Marcelo and Rocio (2014) analyzed the temporal variation of specific yield from a University area using water table fluctuation method. The available groundwater quality in Nuzividu is studied (Srikanth et al., 2018). Physico-chemical parameters of groundwater samples are determined. It is concluded that, the dug wells are contaminated with sewage and sullage from nearby areas. They noticed that, the quality of water is dependent on depth of groundwater in the well. The concentration of minerals and chlorides is reducing with increase in depth. Groundwater quality is not suitable for drinking and is having excess hardness and chlorides in the region surrounding Mylavaram (Ramakrishna et al., 2017, 2018).

Proposed study:

The available studies are focusing on (i) determining infiltration rate using ring infiltrometers (ii) comparison of data obtained using field studies with those obtained using mathematical models for the purpose (iii) studies on quality of groundwater of a specific region and (iv) assessment of groundwater fluctuations using water table fluctuation method.

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However, studies are not available for (i) determining trends of season wise variation of ground water quality (ii) assessment of groundwater fluctuations using field measurement of groundwater depth in a region and (iii) trends of infiltration rate in a locality. The proposed study is aimed at determining these aspects with the following objectives:

- To determine and analyze the temporal fluctuations of water table in open wells in selected areas
- To determine the infiltration of soil near the open wells, correlate with the soil classification and develop trends for infiltration pattern at the sampling locations
- To study the soil classification and correlate with standard infiltration rates
- To study the water quality variation of the groundwater wells in different periods and compare with the permissible standards

Study region:

Two open wells in two towns Nuzividu and Tiruvuru in Krishna district are selected for this purpose. Nuzividu, is located 45 kms from the Vijayawada and is famous for seasonal mango fruits. Tiruvuru is located 87 kms from the Vijayawada and is located close to the border between Andhra Pradesh and Telengana states. The dimensions of the two open wells are given in Table-1.

Table-1: Dimensions of the sampling open wells at Nuzividu and Tiruvuru

S No	Dimensions of the open well	Nuzividu	Tiruvuru
1	Thickness	220mm	150mm
2	Inner diameter	1150mm	1440mm
3	Outer diameter	1370mm	1590mm
4	Depth of the open well above the ground level	1210mm	1360mm

RESULTS AND DISCUSSION

Experimental setup

The infiltration test is carried out using a double ring infiltrometer. It consists of two concentric cylinders (Jayaramireddy, 2011). The diameters of the inner and outer rings are 20cm and 40cm respectively with a height of 30cm each. The two cylinders are dug into the soil at the sampling location to half the depth of the rings (Refer Fig. 1). The water is filled in the inner and outer rings for the same depth. The water will try to flow vertically downward and due to the saturated soil below the outer ring, no lateral movement takes place (Jayaramireddy, 2011). When water is initially poured inside the rings, the fall is rapid due to initial dry condition of soil but slowly as the surrounding soil becomes wet and saturated, the infiltration rate decreases and attains a steady-state after a long time. The decrease in water levels with respect to time is noted. A graph is plotted with respect to these data points and a standard infiltration curve (Refer Fig. 2) is obtained (Subramanya, 2008).

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Fig.1 Double ring Infiltrometer

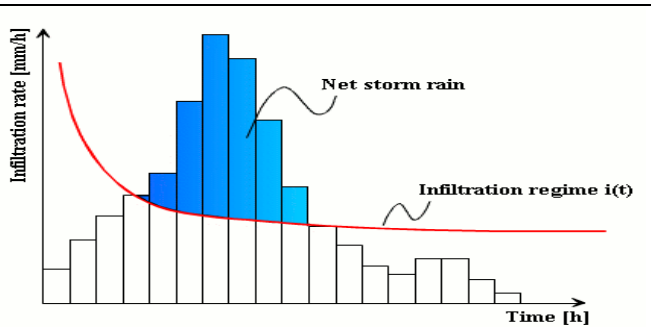

Fig. 2 Typical Infiltration curve

The infiltration rates of different soils vary (Brouwer et al., 2001) based on their texture and composition of the soil and are given in Table-2.

Table-2: Infiltration rate for different type of soils

S No	Type of soil	Range of Infiltration rate
1	Sands	>20mm/hr.
2	Sandy loams	10-20mm/hr.
3	Loams fine sands	5-10mm/hr.
4	Clay loams, silty clays, clays	1-5mm/hr.
5	Sodium clay loams	<1mm/hr.

Infiltration Tests in study region:

The study region is experiencing North-East monsoon during October-November and South-West monsoon during June-July. The sampling is conducted during Jan 2019 (Post Monsoon) and March 2019 (Pre Monsoon) for finding out the variation of infiltration rates during these periods. Sample output of Infiltration trends in the study region is shown in Fig 3 & 4. The trend line equations of infiltration pattern are also given in the Figs. 3 &4. The summary of the results for the both sampling wells along with corresponding trend line equations are given in Table-3. The trends reveal the standard pattern of decreasing infiltration in the native soil as shown in Fig.2. The minimum infiltration rate is identified from the Figure (Jayaramireddy, 2011), and the corresponding type of soil for the region (Brouwer et al., 2001) is determined. The soil in the region is identified as predominantly *silty clay*. The infiltration rate increased in Nuzividu in pre monsoon compared to that in post monsoon due to dry condition of soil in March. Similar trends are noticed in Tiruvuru also.

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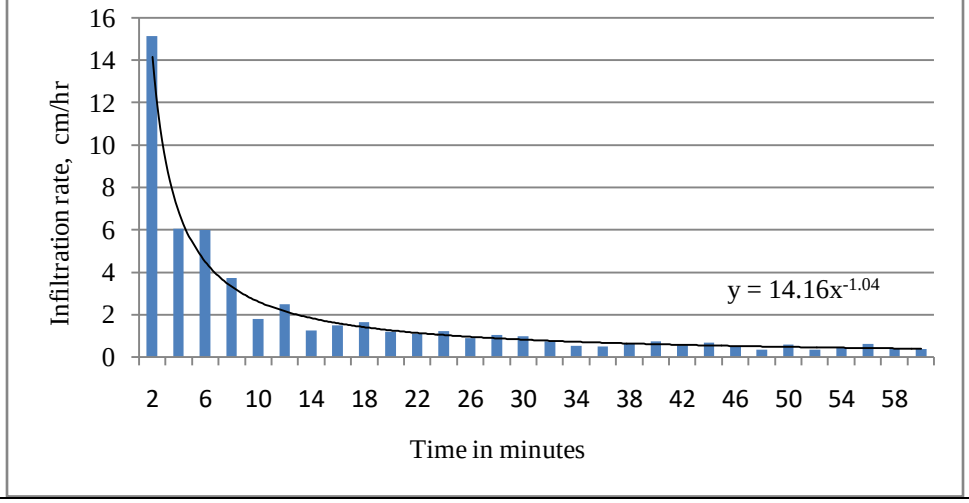

Fig.3: Infiltration trends at Nuzividu open well during Post Monsoon Jan 2019

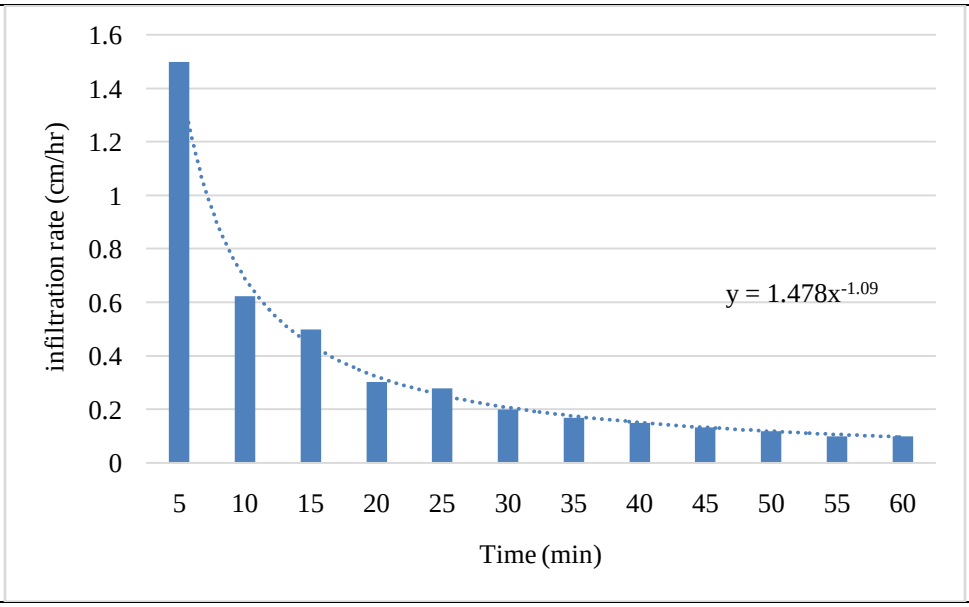

Fig.4: Infiltration trends at Tiruvuru open well during Post Monsoon Jan 2019

Table-3: Infiltration rate trends and classification of soil based on Infiltration rate at sampling locations

S No	Location	Sampling Period	Trend line Equation	Minimum Infiltration rate, mm/hr	Classification of soil
1	Nuzividu	Post-Monsoon (January, 2019)	$Y = 14.16 x^{-1.04}$	3.48	Silty clay loams
2		Pre-Monsoon (March, 2019)	$Y = 28.15x^{-0.94}$	4.55	Sandy/silty clay
3	Tiruvuru	Post-Monsoon (January, 2019)	$Y = 1.478x^{-1.09}$	1.00	Silty clay
4		Pre-Monsoon (March, 2019)	$Y = 11.948x^{-1.113}$	2.00	Silty clay/sandy clay

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Grain size analysis

Soil samples are collected at these two sampling wells and are subjected to grain size analysis. A graph is drawn to determine the D10 and D90 size of the soil samples and the details are given in Fig. 5 and 6. The grain size distribution of the soil samples is similar. The soil is analyzed for soil classification based on these parameters and soil texture (Arora, 2009) and is identified as *Silty clay* (Refer Table-4). It is to be noted that, the soil classification obtained based on infiltration rate and grain size distribution is similar.

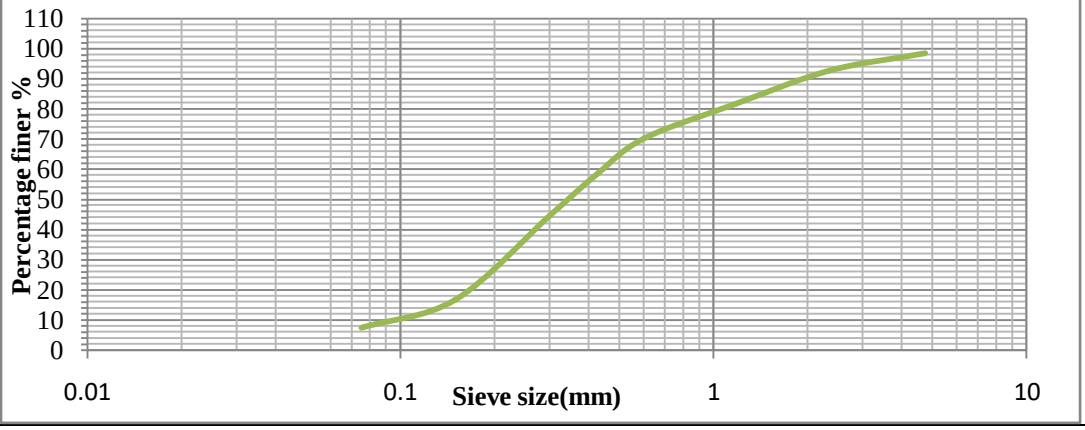

Fig.5: Grain size distribution of soil sample at Nuzividu

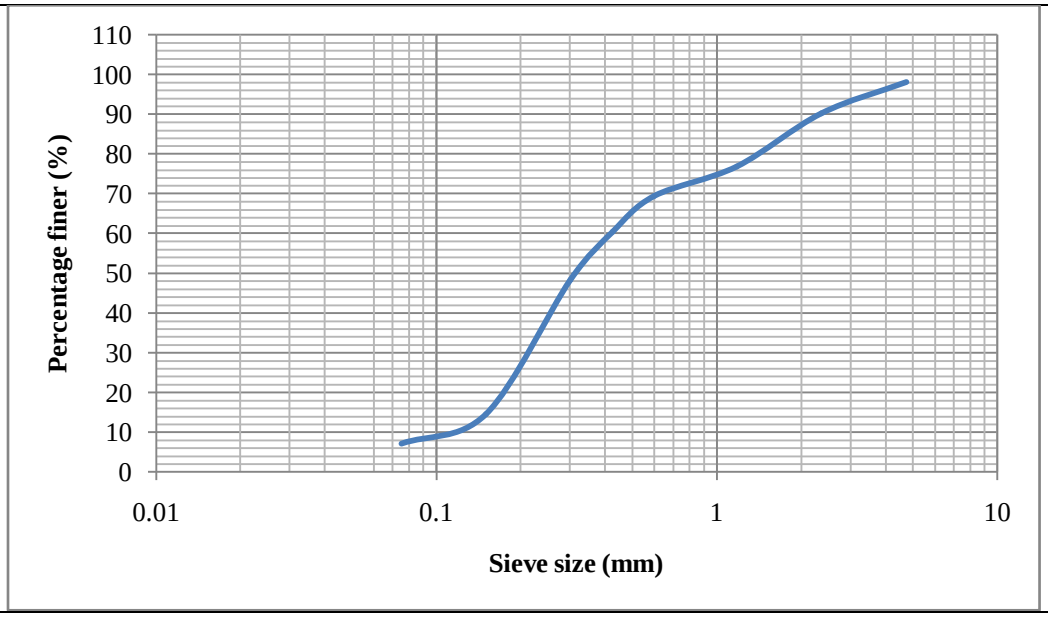

Fig.6: Grain size distribution of soil sample at Tiruvuru

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Table-4: Analysis of Grain size distribution of soil at sampling locations

S No	Location	D10, mm	D90, mm	Classification of soil
1	Nuzividu	0.1 mm	1.2 mm	Silty clay
3	Tiruvuru	0.1 mm	2.0 mm	Silty clay

Water level fluctuations

The water level in the two open wells at the two locations is recorded during three months: Jan, Feb and March 2019. The details are summarized in Table-5. It can be noted that, water level kept falling during these three months indicating the progress of dry periods (Refer Fig. 7). The maximum fluctuations of water in the sampling well are noticed above the average water level which reflects the fall of water level. The recharge to the open wells is negligible and hence large depths are noticed in these wells. Similar trends are noticed in Tiruvuru also.

Table-5: Water level fluctuations due to seasonal variations at Nuzvidu and Tiruvuru

S No	Location	Sampling Period	Highest depth below GL to WL (mm)	Lowest depth below GL to WL (mm)	Fall in water level in open well (mm)
1	Nuzividu	Jan 2019	2035	1650	385
		Feb 2019	2035	1590	445
		March 2019	2310	1510	800
2	Tiruvuru	Jan 2019	2480	2053	427
		Feb 2019	2663	2053	610
		March 2019	2757	2015	743

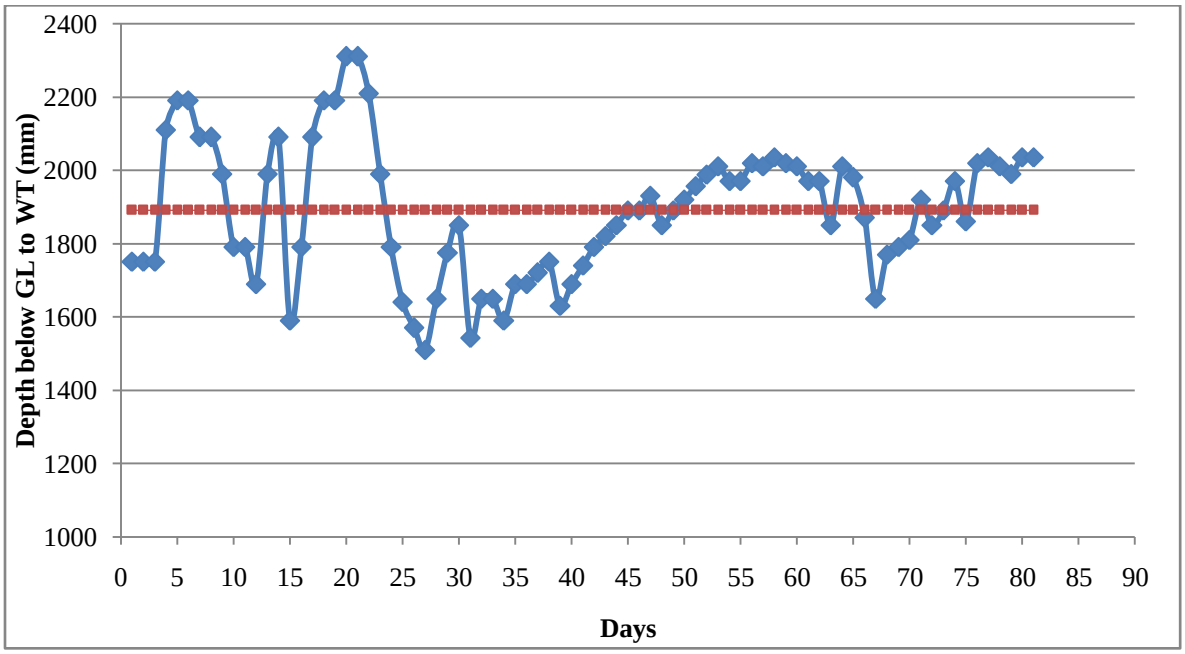

Fig. 7: Overall water level fluctuations data in Nuzvidu

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Water quality fluctuations

The groundwater quality is monitored during Dec 2018, Jan-, Feb-, and March-2019. Occasional rains are noticed during Feb 2019 otherwise it was a dry period from the Dec 2018 onwards. The summary of water quality parameters is given in Tables 6 & 7 for Nuzividu and Tiruvuru respectively. The average values for the dry period and wet periods are computed separately and compared with that of acceptable limits prescribed under IS 10500 for drinking purposes.

Table-6: Comparison of water quality parameters with dry period and rainy period in Nuzvidu

Location	Sampling period	pH	TDS (mg/L)	Total hardness (mg/L)	Alkalinity (mg/L)	Chlorides (mg/L)	Remarks
Nuzividu	Dec 2018	7.31	1740	552	533	451	Dry period
	Jan 2019	7.56	1660	658	450	423	Dry period
	Feb 2019	7.58	1450	596	418	385	Rainy period
	March 2019	7.37	1550	605	374	429	Dry period
	Avg. value	7.41	1650	605	452	434	Dry period
	Avg. value	7.58	1450	596	418	385	Rainy period
		6.5	**500**	**200**	**200**	**250**	Acceptable limits
		8.5	**2000**	**600**	**600**	**1000**	Permissible limits

Table-7: Comparison of water quality parameters with dry period and rainy period in Tiruvuru

Location	Sampling period	pH	TDS (mg/L)	Total hardness (mg/L)	Alkalinity (mg/L)	Chlorides (mg/L)	Remarks
Tiruvuru	Dec 2018	7.28	1080	838	342	351	Dry period
	Jan 2019	7.46	1080	776	334	331	Dry period
	Feb 2019	7.58	860	730	277	349	Rainy period
	March 2019	7.37	1030	806	262	302	Dry period
	Avg. value	7.41	1970	806	312	328	Dry period
	Avg. value	7.35	1630	730	288	349	Rainy period
		6.5	**500**	**200**	**200**	**250**	Acceptable limits
		8.5	**2000**	**600**	**600**	**1000**	Permissible limits

It is observed from Table-6 & 7 that in dry period the water quality was decreased because of low dilution and in rainy period the water quality was increased due to the dilution of water in open well. The alkalinity and chlorides are very slightly deviating from this pattern and this could be due to local interferences and dilutions during those periods. However, it is clearly evident that, the water quality is not acceptable for drinking purposes based on the parameters determined whereas the groundwater can be classified suitable for drinking only based on the upper limits for rejection when there is

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no other source available for drinking. Hence caution should be exercised for using the groundwater from these underground wells for drinking purpose.

SUMMARY AND CONCLUSIONS

The water level fluctuations of two open wells in Nuzividu and Tiruvuru are studied from Dec 2018 to March 2019. The water level dropped due to the dry season prevailed during this period. Correspondingly, selected water quality parameters are determined for the water samples from these wells and analyzed with respect to the seasonal fluctuations. Dilution in water quality levels is noticed and hence it is proved that the rainwater falling in the region is percolating to the subsoil and is leading to dilution in groundwater quality. In order to understand the nature of the soil surrounding the sampling locations, double ring infiltration tests are conducted. The trends are compatible with the standard patterns at both the locations. The trend line patterns are empirically modelled for future needs. The soil type is assessed using the infiltration rates and is ascertained using the grain size analysis of the soil sample in the region. Similar results are obtained. The present study revealed the following: (i) groundwater depth and quality is affected due to dry and wet periods of the season (ii) the hydrological movement of rainwater depends upon the infiltration and soil properties and the obtained values are consistent irrespective of approaches used for the purpose.

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