ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 8, Issue 11, November 2021

Comparative studies of infiltration at Coastal Districts for better management practices

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***Abstract*—In the hydrological cycle, infiltration is one of the ways which precipitation reaching the earth's surface is disposed of. In recent times the groundwater is getting depleted due to various reasons. This research work aims at augmenting the groundwater recharge in Puttur. Groundwater recharge mainly depend upon infiltration capacity of the soil. Infiltration is the movement of water into the soil from the surface. The water is driven into the porous soil by force of gravity and capillary attraction.**

The objectives were to analyse the infiltration rates at two districts of coastal Karnataka (in Puttur Dakshina Kannada and Bhatkal in Uttara Kannada) to get overall picture of typical soil infiltration capacity.

Even though different models are available for finding infiltration capacity Horton's model is used in the present analysis and infiltration value are compared with 26 tests. General infiltration capacities are proposed for both the stations.

The paper presents results of infiltration tests carried out at 10 sites in Bhatkal regions of Uttar Kannada District, Karnataka and 16 sites of Puttur regions of Dakshina Kannada District, Karnataka state. The double ring infiltrometer method was used for measurement of infiltration rates. The study aimed to determine constant infiltration rate at different places in Puttur & Bhatkal and comparing it with infiltration model obtained by Horton's model. The results shown that the infiltration rate depends upon soil type, Porosity, Bulk density, Temperature and Antecedent moisture content. The infiltration equations help to find the groundwater recharge method.

***Index Terms*— Infiltration, Groundwater Recharge, Horton's model**

I. INTRODUCTION

Water is the most essential part of life; clean and safe water for daily use is the basic need of human being. Government and other organisation giving emphasis in supply of portable water to everyone, but it is not yet achieved. Increasing demand of water due to rapid urbanisation has shown extensive use of groundwater. Natural replenishment of groundwater is terribly slow. The amount of exploitation is more than replenishment, this causes decline in groundwater table. This rate is not corrected eventually leads to mining of deep water from the sub surface. Artificial recharging increases the water in aquifer [1].

Water is constantly evaporated from the earth and is returned to earth in the form of precipitation mainly in the form of rainfall. One part of this rainfall sinks into the ground, forming groundwater reservoir, second major part flows as runoff in the form of rivers, and the rest is the evaporation and transpiration.

The rate of infiltration is governed by soil characteristics. The process of infiltration can only happen if the space for additional water at surface of soil. The available excess volume of water in the soil depends upon porosity, rate of infiltration, density of soil, texture of soil and type of soil. The maximum rate that water can enter a soil in each condition is the infiltration capacity [6], [9]. Typical rate of infiltration for different type of soil is given in Table-1 and Figure-1.

Table 1-Typical Infiltration rates [7]

Soils	f(cm/hr)
High (Sandy soil)	1.25-2.54
Intermediate(Loom/clay/ silt)	0.25-1.25
Low (Clay- Clay Loom)	0.025-0.25

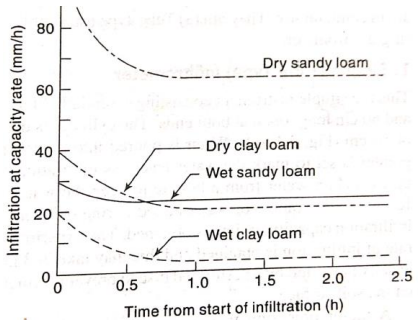

Fig. 1: Variation on infiltration capacity

II. METHODOLOGY

Puttur is a town in Dakshina Kannada district in Karnataka state of India. It features a Tropical Monsoon Climate. The average annual rainfall in Puttur is about 4300 mm (170inches). The average humidity is 75 percent and peaks in July at 89 percent [10]. The soil in this area is generally lateritic soil which is high in iron and aluminium.

Bhatkal is a small city situated in the coastal region of Karnataka state. Although the region receives more than 3500-4000 mm of rain fall every year, people face acute shortage of water in the months of February to may because

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 8, Issue 11, November 2021

rainfall to only four months. The region is comprised of well drained laterite soil formation which prevent storage of water in surface bodies.

Infiltration tests using double ring infiltrometer are conducted in 16 sites at Puttur taluk of Dakshina Kannada and 10 sites in Bhatkal of Uttara Kannada. Both the location is the coastal region of Karnataka.

Double ring infiltrometer method was used for measurement of infiltration rates at all the sites. In these two concentric rings were used. The diameter of the inner ring is 300mm + 10mm and the outer ring diameter is 600mm + 10mm. Rings are 250 mm deep and were made from 6 mm thick steel plate with sharpened bottom edge (figure 2). The rings were driven at about 15cm deep in soil by using falling weight type hammer [11].

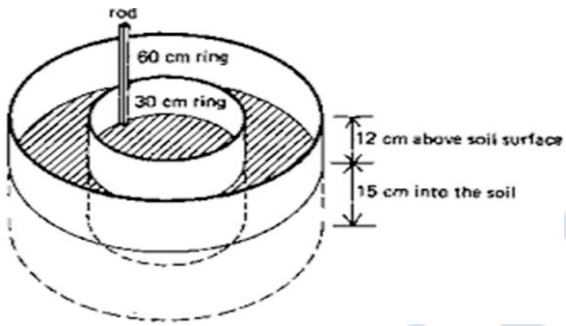

Fig. 2. Double ring Infiltrometer

Estimation of the infiltration rate uses the Model Horton [2]. The Horton Model is an empirical model that says the infiltration capacity as a function of time, so the infiltration rate is determined by the initial conditions of soil moisture at the time of soil infiltration is started to happen [3]. Horton Model suitable for field experiments conducted at various land uses[(1).]

Data analysis for estimating the capacity of soil infiltration uses the Horton Infiltration Model:

$f = f_c + (f_o - f_c)\, e^{-kt}$

f = infiltration capacity (cm/hr);

f_c = infiltration capacity at the time of constant infiltration.

f_o = initial infiltration capacity (at t = 0);

k = constant for a certain soil.

t = time.

The f_c value is estimated from plotting of the relationship between the infiltration rate and time. The K values for subsequent points can be done in the same manner [4], [5].

III. Results and Discussion

Conduction of Double ring infiltrometer test is based on division of Puttur taluk into 16 grids Nelyadi ,Nekkilady, Kadaba, Uppinangady, Kaniyoor, Ramakunja, Kolthige, Kowkradi, Charvaka, Icchlampady, Savanoor, Konaje, Kodipady, Kombaru, Bannur, Aithoor.

Table 2 Infiltration equations of Puttur Taluk

Location	Infiltration Equation
Nekkilady	$f = 58+132e^{-4.55t}$
Uppinangady	$f = 5.9+18.2e^{-6.06t}$
Kowkradi	$f = 8.4+28.4e^{-3.59t}$
Nelyadi	$f = 8.4+37.2e^{-6.526t}$
Kaniyoor	$f = 6.7+32.1e^{-3.821t}$
Kadaba	$f = 2.5+18.6e^{-4.769t}$
Aithoor	$f = 5.1+15.6e^{-4.216t}$
Kombaru	$f = 4.2+13.8e^{-6t}$
Konaje	$f = 2.5+13.7e^{-4.567t}$
Kolthige	$f = 3.8+16.7e^{-3.442t}$
Ichhlampady	$f = 1.2+20.2e^{-4.391t}$
Bannur	$f = 1.35+20.25e^{-4.402t}$
Kodipady	$f = 2.5+16.75e^{-3.101t}$
Ramakunja	$f = 2+17.9e^{-3.509t}$
Charvaka	$f = 5.8+24.8e^{-3.179t}$
Savanoor	$f = 3.5+23.1e^{-3.725t}$

The infiltration equation for all sixteen regions is merged to form one general equation, representing the entire Puttur Tq, and is as follows $\mathbf{f = 7.61+28.08e^{-4.364t}}$

Conduction of Double ring infiltrometer test is based on division of Bhatkal taluk into 10 grids Near Anjuman College, Daranda, Kaduvinakatte, Pump house, Belke, Muda Bhatkal, Haneefbad, Hurulisal, Renginakatte, Sagar road.

Table 3 Infiltration equation of Bhatkal Taluk

Location	Infiltration equation
Anjuman College	$f = 1.5+67e^{-3.97t}$
Daranda	$f = 5.9+18.2e^{-6.06t}$
Kaduvinakatte	$f = 5.8+16.5e^{-1.65t}$
Pump house	$f = 8.4+37.2e^{-6.526t}$
Belke	$f = 4.8+17e^{-1.21t}$
Muda Bhatkal	$f = 4.8+48.2e^{-1.12t}$
Haneefbad	$f = 3.8+47.7e^{-1.01t}$
Hurulisal	$f = 3.75+23.05e^{-1.88t}$
Renginakatte	$f = 4.38+37.92e^{-1.50t}$
Sagar road	$f = 4.83+37.04e^{-1.70t}$

The infiltration equation for all ten regions is merged to form one general equation, representing the entire Bhatkal Tq, and is as follows $\mathbf{f = 4.396+33.421e^{-1.913t}}$

ISSN (Online) 2456-1290

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Table 4. Summary of results of Infiltration tests in Puttur and Bhatkal.

Statistical parameters	Initial rate of infiltration f_o (cm/hr)		Final rate of infiltration f_c (cm/hr)		k value		No: of tests	
	Puttur	Bhatkal	Puttur	Bhatkal	Puttur	Bhatkal	Puttur	Bhatkal
Maximum	190	68.5	58	5.8	6.526	3.97	16	10
Minimum	16.2	19.5	1.2	1.5	3.101	1.01		
Range	173.8	49	56.8	4.3	3.425	2.96		
Mean	47.56	34.02	7.61	4.396	4.35	1.913		
Median	21.5	36.235	4	4.8	4.25	1.69		

Based on Table 4 we can say that the rate of infiltration is high in Puttur taluk compared to Bhatkal. This may be due to soil condition and vegetation cover.

IV. CONCLUSION

From the studies conducted on infiltration tests at Bhatkal in Uttar Kannada district and Puttur in Dakshina Kannada districts, the following conclusions can be drawn [8]

1. Mean infiltration value in Puttur is 47.56 cm/hr where as in Bhatkal it is 34.02cm/hr. Minimum infiltration rate in Puttur is 16.2cm/hr and Bhatkal is 19.5 cm/hr. From (Table 1) it can be concluded that the soil in the region is high sandy soil (f>1.25cm/hr) [6]
2. Constant k value in Horton Infiltration Model which depends upon vegetation cover and soil characteristics 4.35 in Puttur and 1.913 in Bhatkal.
3. Low value of infiltration found in Puttur is 1.2 cm/hr particularly Ichhlampady in Puttur and 1,5cm/hr in Anjuman college campus Bhatkal may be due to soil texture, surface conditions (like compaction, surface storage, soil shape) and temperature [9].

Though the basin receives heavy rainfall during monsoon season of about 3500-4000mm, it is confined to four months only and then severe freshwater scarcity during summer months. Most of these wells in the region will dry up in the may month, because of rapid fall of water table. Artificial recharging through check dams or subsurface dikes is also helpful in maintaining water table.

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