Augmentation of Groundwater Recharge through Infiltration Studies in Puttur of Dakshina Kannada District, Karnataka

Prashantha [1], Sandeep Nayak[2], Shridhar Yallurkar[3]

[1]Assistant Professor, Vivekananda college of Engineering and Technology, Puttur, 574 203, Dakshina Kannada, Karnataka, India
[2]Professor, Shri Madhwa Vadiraja Institute of Engineering and management, Bantakal, Udupi Karnataka, India- 574115.
[3]Associate Professor, Civil Engineering department, Anjuman Institute of Technology and Management Bhatkal Karnataka, India-581320.

---***---

Abstract - India is one of the few countries in the world endowed with abundant land and water resources. The average rainfall in the country is estimated to be over 4000 cubic km spread over the geographical area of 328 Mha of which 185 Mha is cultivable. Although India is home to 16% of the world's human population, only 2.4% of the total land and 4% of the total global water resource. Due to tropical climate conditions, India experiences vast spatial and temporal variation in the rainfall. The rate of infiltration is determined by soil characteristics including ease of entry, storage capacity, and transmission rate through the soil.

Infiltration studies plays vital role. In this study double ring infiltrometer was used to determine the constant infiltration rates. Groundwater recharge mainly depends upon infiltration capacity of the soil. The study aimed to determine constant infiltration rate at different places in Puttur taluk of Dakshina Kannada and infiltration equations are developed for each place using Horton's model. The equations developed in the study can be used at ungauged places having similar rainfall and climatic conditions as it simplifies conducting infiltration tests. Developed equations will be helpful for augment the natural groundwater as an economic reservoir.

***Key Words*: Infiltration, Groundwater Recharge, Horton's model. Augment.**

1. INTRODUCTION

Water is the most essential fuel of life; clean and safe water for daily use is the basic need of human being. Even after decade of hard work and struggle by the government bodies and other organization to supply ample amount of potable water to each & every human being in every corner of the world, is not yet achieved. Increasing demand for water, particularly in arid and semi-arid regions of the world, has shown that the extended groundwater reservoirs formed by aquifers are invaluable for water supply and storage. Natural replenishment of this vast supply of groundwater is terribly slow. (1) Therefore, exploiting groundwater at a rate greater than it can be replenished causes groundwater tables to decline and, if not corrected, eventually leads to mining of groundwater. Artificial recharge to boost the natural supply of groundwater aquifers is becoming increasingly important in groundwater management. Groundwater can have a wide range of beneficial uses. (2).

1.1 Study area

Puttur is a town in Dakshina Kannada district, in Karnataka state of India. Puttur is located at 12046'N 750 13'E. It has an average elevation of 87 meters (285 feet). It features a Tropical Monsoon Climate (Am) according to the Koppen climate classification. The average annual rainfall in Puttur is about 4329 millimeters. The average humidity is 75% and peaks in July at 89%. The soil is mostly lateritic type, characterized by high iron and aluminum content.

The main Objectives of this paper are as follows.

- To determine the infiltration capacity of soil in selected sites of Puttur taluk and obtain equations at each site using Horton's model.
- To have uniform equation for the region to compute Infiltration and better understanding of groundwater recharge process and rates in the study area.

2. METHODOLOGY

Double ring infiltrometer (Fig 1) 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. The rings were driven at about 15cm deep in soil by using falling weight type hammer striking on a wooden plank placed on top of ring uniformly without or undue disturbance to soil surface (3,4).

The rate of fall of water level was measured in the inner ring while a pool of water was maintained at approximately the same level in the outer ring to reduce the amount of lateral flow from the inner ring. Generally, the water level was kept at 50 mm depth; the difference in height between the inner and outer rings was kept to a minimum (8).

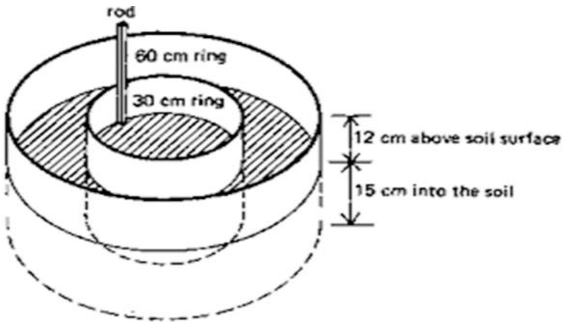

Fig1: Double ring Infiltrometer

Estimation of the infiltration rate uses the Model Horton. 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.

Data analysis for estimating the capacity of soil infiltration uses the Horton Infiltration Model: (7,9,10)

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

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 and vegetation.

t = time.

The fc value is estimated from plotting of the relationship between the infiltration rate and time. Infiltration tests were conducted in 16 grids representing entire taluk as shown in (Fig.2) to have uniformity.

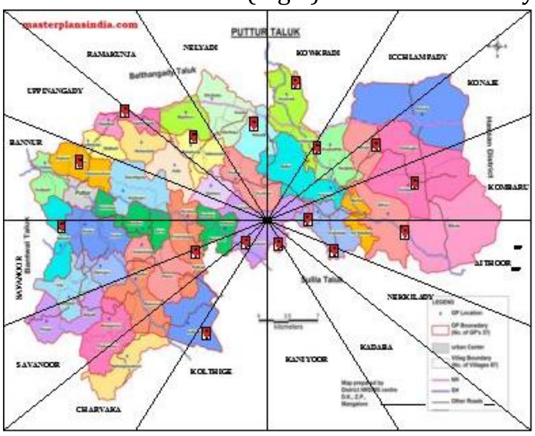

Fig2: Puttur map

The Infiltration tests were carried in these places.

Table-1: Locations of infiltration test at Puttur taluk

Location	Longitude & Latitude
Nekkilady	12°42'59.6"N 75°30'09.9"E
Uppinangady	12°50'16.8"N 75°14'57.7"E

Kowkradi	12°49'40.9"N 75°25'06.1"E
Nelyadi	12°50'12.2"N 75°24'14.1"E
Kaniyoor	12°43'05.7"N 75°22'05.0"E
Kadaba	12°43'36.0"N 75°28'22.1"E
Aithoor	12°43'54.2"N 75°31'53.7"E
Kumbra	12°41'32.3"N 75°14'56.7"E
Konaje	12°47'27.0"N 75°30'15.0"E
Kolthige	12°37'57.2"N 75°18'51.2"E
Ichhlampady	12°47'43.1"N 75°27'19.6"E
Bannur	12°46'45.6"N 75°11'40.2"E
Kodipady	12°46'07.1"N 75°10'02.5"E
Ramakunja	12°47'58.3"N 75°19'44.6"E
Charvaka	12°44'14.8"N 75°22'38.4"E
Savanoor	12°44'12.6"N 75°18'40.3"E

3. RESULTS AND DISCUSSION

After conducting infiltration tests, results are analyzed (Fig-3) and equations are obtained at 16 locations using Horton Model

1. Nekkilady $f = 58+132e^{-4.55t}$
2. Uppinangady $f = 5.9+18.2e^{-6.06t}$
3. Kowkradi $f = 8.4+28.4e^{-3.59t}$
4. Nelyadi $f = 8.4+37.2e^{-6.526t}$
5. Kaniyoor $f = 6.7+32.1e^{-3.821t}$
6. Kadaba $f = 2.5+18.6e^{-4.769t}$
7. Aithoor $f = 5.1+15.6e^{-4.216t}$
8. Kumbara $f = 4.2+13.8e^{-6t}$
9. Konaje $f = 2.5+13.7e^{-4.567t}$
10. Kolthige $f = 3.8+16.7e^{-3.442t}$
11. Ichhlampady $f = 1.2+20.2e^{-4.391t}$
12. Bannur $f = 1.35+20.25e^{-4.402t}$
13. Kodipady $f = 2.5+16.75e^{-3.101t}$
14. Ramakunja $f = 2+17.9e^{-3.509t}$
15. Charvaka $f = 5.8+24.8e^{-3.179t}$
16. Savanoor $f = 3.5+23.1e^{-3.725t}$

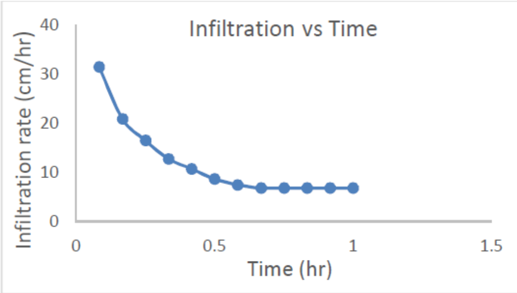

Fig-3: Typical Horton Model of Kaniyoor

Typical infiltration rates for different soils are shown in Table 2 (1,7).

Table-2: 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

The infiltration equation for all sixteen grids is merged to form one general equation, representing the entire Puttur taluk, and t this equation can be used in ungauged areas of Puttur where infiltration test cannot be conducted due to logistic reasons.

$$f = 7.61+28.08e-4.364t \quad (1.1)$$

The groundwater recharge depends on soil properties such as in situ density, permeability, gradation of soil etc. (8). Though the basin receives heavy rainfall during monsoon season of about 3500 to 4000 mm, it is confined to four months only and then there will be severe freshwater scarcity during summer months. Most of the wells in the Puttur region will dry up in the month of May, because of rapid fall in water table. Artificial recharging through check dams or subsurface dikes is helpful in maintaining the water table. Since the infiltration rate is moderate in almost all parts of Puttur Tq, adoption of artificial recharge by Basin and Percolation tank method and Stream Augmentation method will be effective, for increasing the groundwater potential recharge during non-monsoon season in Puttur.

Table-3: Summary of results of Infiltration tests in Puttur taluk

Statistical parameters	Initial rate of infiltration f_o (cm/hr)	Final rate of infiltration f_c (cm/hr)	k value	No: of tests
Maximum	190	58	6.526	16
Minimum	16.2	1.2	3.101	
Range	173.8	56.8	3.425	
Mean	47.56	7.61	4.35	
Median	21.5	4	4.25	

The result shows that the maximum initial infiltration rate (fo) is 190cm/hr and minimum is 16.2 cm/hr. Also, the maximum final rate of infiltration capacity (fc) is 58cm/hr and minimum are 1.2cm/hr. The maximum value of k is 6.526 and the minimum is 3.101.

4. CONCLUSIONS

Although there is high infiltration rate in some stations like Nekkilady, Kowkradi, Nelyadi, Kaniyoor, very low infiltration rates are also noticed in Ichhlampady, Bannur, Ramakunja because of variation in soil type ,moisture content and vegetation. From the test it is observed that Nekkilady has highest infiltration rate compared to other sites because of the thick vegetation cover which provides protection against rain drop impact and helps to increase infiltration.

Equation (1) can be used for computation of infiltration of nearby areas like Sullia, Bantwal and Vitla which are climatically homogeneous.Since the infiltration rate is moderate in almost all parts of Puttur taluk, adoption of artificial recharge by basin, percolation tank method and stream augmentation method will be effective, for increasing the groundwater potential recharge during non-monsoon season in Puttur. Moreover, rainwater harvesting techniques/ methods successfully adopted in other regions should not be blindly adopted in the coastal regions due to its specific soil conditions and rainfall intensity.

REFERENCES

[1] John, D., Thomas, S., "Infiltration rate assessment of some major soils", Journal of Irish Geography, vol. 36 (1), pp 32 – 46, 2003.
[2] Mailhol, Jean-Claude, "Validation of a predictive form of Horton infiltration for simulating furrow irrigation", Journal of Irrigation and Drainage Engineering, vol. 129, No. 6, pp 412 – 421, 2003.
[3] Singh, R. V., Bhaskar, S.R., "Comparison of different infiltration equations on different land covers", Journal of Indian water resource society, vol. 24, pp19 – 26, 2004.
[4] Mohan, S., Kumari, S.,"Recharge estimation using Infiltration models", Journal of Hydraulic Engg., vol. 11, pp 1- 10, 2005.
[5] Dubey, O. P., Sharma, D. C., Chhabra, S.S., "Determination of infiltration rate in Chitaurgarh dam command area", Hydrology journal, pp 17 – 24, 2005.
[6] H. M. Raghunath, "Engineering Hydrology", Mohinder Sing Setwal Forwilly Eastern publications, revised second edition 2008, pp 165-180.
[7] G.Ranganna, K.N.Lokesh, M.R,Gajendragad, G.Chandrakantha, K.Harshendra, M.M.Kori," Studies on infiltration Characteristics in soil of Pavanje river basin of Dakshina Kannada District", Journal of hydrology IAH, Vol 14,no 1,1991
[8] A.S.Patel, D. L Shah., "Water Management", New age International publishers, first edition, - 2008, pp 111 – 165.
[9] Jagdale Satyawan Dagadu, Nimbalkar P. T., "Infiltration Studies of Different Soils Under Different Soil Conditions And Comparison Of Infiltration Models With Field Data", International Journal of Advanced Engineering Technology, vol.3, pp52 – 63, 2012
[10] P. Jayarami Reddi, "Textbook of Hydrology", Laxmi publications, revised second edition, 2012, pp 251-272.