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STUDY ON INFILTRATION RATE AND RUNOFF OF DIFFERENT SOILS IN PULINCUNNU PANCHAYATH

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Abstract - - *Infiltration rate is the measure of temporal rate at which soil is able to absorb rainfall or irrigation. Less infiltration rate affects the magnitude and distribution of runoff. In 2018, Kerala was affected with severe floods, due to unusually high rainfall during the monsoon season. The work is aimed at determining the infiltration rate of soils in Pulincunnu panchayat using double ring infiltrometer. Also estimating the runoff at these sites using Soil Conservation Service Curve Number Method (SCS-CN). The site selected were Kannady and Ambanapaly and test were conducted. It was observed that soil at Kannady has more infiltration capacity and slightly lesser runoff compared to soil at the site Ambanapaly. The greater infiltration is due to the particle size, lesser field density, and water content.*

Keywords: Infiltration, Double ring infiltrometer, runoff, Curve Number method

1. INTRODUCTION

Infiltration is the process by which water on the ground surface enters the soil that in turn continuously affect the magnitude and distribution of surface runoff. Water seeps into the porous soil by force of gravity and capillary attraction. Infiltration rate is a measure of the rate at which soil is able to absorb rainfall or irrigation. The rate decreases as the soil becomes saturated and excess water can contribute to local and regional flooding of streams and rivers. Thus infiltration is crucial in modelling of surface runoff. In 2018, Kerala faced its second largest flood, by receiving an average rainfall of 2763mm. The study area, Pulincunnu region in Alappuzha district. Infiltration rate is related to the hydraulic conductivity of the near-surface soil. The rate of infiltration is high in the beginning. It decreases rapidly in the initial stages and then slowly till it approaches a nearly constant rate in about 30 to 90 minute depending upon the type of soil. Double ring infiltrometer method is used for measurement of infiltration rates.

1.1 Literature Review

Mangala S et.al(2016) conducted a study on factors affecting infiltration on different soils, estimated infiltration rate of different soils using single ring and double ring infiltrometers and compared the results with equation obtained from physical models such as by Kostiakov, Philip's, and Horton's and Green-Ampt infiltration models. Thus the soil testing enabled successful and effective storm water management design that incorporates a suitable infiltration rate for design calculations. Also helped to investigate the subsurface conditions below existing surfaces/pavement etc.

Bahar A et.al (2016) conducted a study about varying infiltration rates with varying soil types and cover in Kota Bharu- the capital of Kelantan state. From the soil classification map produced by Department of Agriculture (DOA), selected soils are tested using double ring method to identify the infiltration rate in the study area. From the analysis of infiltration conducted, it has been identified that most of the soil in the study area exhibit low permeability comprising about 70% of the soil. A few patches show moderate to high permeability comprising 15%, where as 5% of the soil is constituted of very high permeability. Any sizeable reduction in the infiltration of water will subsequently increase the chances of flood occurrences. This situation will become a disaster when the runoff is high and the soil's ability to infiltrate the water is low. The outcome of this study provided useful information to carry out mitigation operations and strategies for flood hazards. The study will be also help in agricultural field regarding the judicious and timely irrigation.

Abbulu Y et.al (2017) conducted a work to evaluate infiltration characteristics of soils at Andhra University campus using a single and double ring infiltrometer and comparing it with the infiltration rates obtained by Kostiakov, Philip's, and Horton's and Green-Ampt infiltration models. Experimentation work is carried out at five different points in the campus. To get best fitting model for a particular soil condition the results obtained from various infiltration models are compared with observed field data and graphs are drawn with correlation coefficient and standard error

as tools. The results showed that constant infiltration rates of selected five locations of the study area i.e. at NCC, CSE Dept., Samatha Hostel, Dispensary and Assembly hall are 2.68, 2.06, 17.43, 7.8 and 1.46 respectively. From the graphs of infiltration rates against time it is found that initially infiltration rates were high and decreased with time up to constant infiltration rate. To increase the infiltration rates of the area infiltration facilities such as Rain Gardens, Vegetated filter strips, Porous Pavements, Infiltration Planters, Grass Swales, Infiltration ponds etc. were adopted.

Gandhi H et.al conducted a work to understand the various method used for measurement of infiltration capacity and also the relation of infiltration capacity with the soil parameters like bulk density, water content, dry density. The result showed that there is some relation between these parameters. They concluded that urban compacted soils have low infiltration rate compared to the forest. The result have also shown that cultivated and grazed land compared to the forest infiltration rate and water content were 70% and 45% and bulk density to about 13-20% larger.

Matomela N et.al (2018) conducted their work on, Bojiang Lake for estimating runoff and establishing a proper watershed management using Soil Conservation Service Curve Number method (SCS-CN) coupled with Geographic Information System (GIS) and Remote Sensing (RS) techniques. ArcGIS 10.2 software was used to overlay different thematic layers and develop an attribute table and calculate a weighted curve number. The weighted curve number was applied to the SCS-CN equations to estimate daily, monthly, and yearly runoff. Correlation coefficient (r) was used to test for the relationship between rainfall and runoff, and verify the computation of the method. The results show an average runoff of 17.78 mm which is about 7.18% of the annual average rainfall for the years 2001-2016. The derived output maps can assist in identifying suitable areas for water recharge/abstraction. The study demonstrates that SCS-CN in conjunction with GIS and RS can be used to calculate runoff for ungagged watersheds and assist in watershed management strategies.

Gary C et.al **(2010)** investigated the runoff in a Mediterranean vineyard during the 2003–2007 period in order to identify the inter-seasonal modification of water storage due to intercropping. Great variations in soil refilling were observed over the years, for both the bare soil and intercrop treatments. The complete refilling occurred once and it was associated with a rise of the water table up to less than 2m from the soil surface in the low part of the field. During the other years, the wetting front was identified between 1m and 2.3m at spring in the bare soil treatment, deeper in the lowest part of the field. A higher infiltration was observed in the intercropped treatment. Runoff kinetics was compared to rainfall kinetics in a selection of three rain events differing by duration and intensity. The curve number method was used to perform the analysis. With this method, the time limitation of water balance studies for Mediterranean vineyards would be partially removed.

Amutha R et.al **(2012)** they conducted a work on Malattar sub watershed which lies in the region Gudiyattam Block, Vellore District, Tamil Nadu. The daily rainfall data of Gudiyattam rain gauge station (1971–2007) was collected and used to predict the daily runoff from the watershed using Soil Conservation Service-Curve Number (SCS-CN) method (USDA, 1972) and GIS. Monthly and annual runoff have been calculated from the monthly rainfall data for the years of 1971 to 2007 in the watershed area. The average minimum and maximum rainfall for the years of 1971 to 2007 is 35.30 mm and 111.61 mm respectively and average runoff for the year of 1971 to 2007 is 31.87 mm^3 and 47.04 mm^3 respectively. The developed rainfall-runoff model is used to understand the watershed and its runoff flow characteristics.

2. METHODOLOGY

The study area, Pulincunnu is an island village in the Kuttanad region of Alappuzha district in the Indian state of Kerala. It lies between latitude 9.412ºN and longitude 76.41ºE with an area of 460 acres and a varying elevation from 10 MSL to 62.5 MSL. Two sites are taken from study area: Site 1- Kannady and Site 2- Ambanapaly.

The amount of infiltration rate and incremental infiltration rate can be accomplished by using the apparatus double ring infiltrometer. Two stainless steel rings of diameter 30cm and 60cm and height of 60cm were used. Two cylinders will be inserted inside the soil where the measurement will be taken in the inner cylinder only and the outer cylinder will help to flow the water perpendicularly& not alongside. The metal plate will shield the soil surface of the inner cylinder so that it can reduce the force of water poured inside the cylinder. The cylinders are of height 30cm which are

been inserted to a height of 15cm inside the soil with the aid of wooden piece and hammer. Cylinder will be kept back 15cm above the ground surface in which the water will be poured and the measurement will be taken. The measurement was continued until and unless a fixed rate of infiltration was observed. Infiltration readings were taken continuously for 2 to 3 hours, so that the maximum infiltration capacity of that particular site can be taken. A double ring infiltrometer apparatus and test conducted on it is shown in figure 1 and 2.

Fig -1: Double ring Infiltrometer

Fig -2: Test conducted on Double ring Infiltrometer

The inner ring and outer ring was filled with water at the same time. An interval of 5mins and 10mins was taken to measure the drop of water level inside the inner ring only. A long scale was used to measure the depth of water infiltration. In this way the two site readings were taken so that a comparison can be made between the two places.

Soil Testing

Table -1: Index properties of the soil at the two sites

Sl No:	Descriptions	Site 1: Kannady	Site 2: Ambanapaly
1	Field Density	1.45g/cm^3	1.58 g/cm^3
2	Water Content	14.8%	47.9%
3	Void ratio	1.469	1.18
4	Specific Gravity	2.6	2.4
5	Liquid Limit	17%	14%
6	Shrinkage limit	2%	10%

Measurement of Runoff

The most commonly used empirical method is the Soil Conservation Service Curve Number (SCS-CN) method to estimate the direct runoff is based on a non-linear rainfall-runoff that include a parameter called curve number. The model involves relationship between land use, hydrological soil mass which is a function of soil type and antecedent moisture content. The infiltration losses are combined with surface storage by the relation of

$$Q = (P - Ia)^2 / (P - Ia + S)$$

Where, Q is the accumulated runoff or rainfall excess in mm, P is the rainfall depth in mm, Ia is the initial abstraction in mm. It includes surface storage, interception, and infiltration prior to runoff and empirical relation was developed for the term Ia and it is given by, Ia = 0.3S. For Indian condition, the form S in the potential maximum retention. The equation can be rewritten as,

$$Q = (P-0.3S)^2 / (p+0.7S)$$

3 RESULTS AND DISCUSSION

Infiltration Rate

The results of infiltration rate obtained from Site 1- Kannady and Site 2- Ambanapaly are shown in table below:

Table -2: Infiltration rate of selected sites

Time (min)	Site1: Kannady (cm)	Site 2: Ambanapaly(cm)
2	25.5	26.8
4	24.8	26.4
6	24.5	26.2
8	24.1	25.4
10	23.8	25
15	23.5	24.8
20	23	24.3
25	22.8	24
30	22.6	23.5
40	22.3	22.8
50	22	22.5

60	21.9	22.3
70	21.7	22.2
85	21.5	22
100	21.4	22
115	21.4	22
130	21.4	-

Sieve Analysis

It was found that sample collected from Site 1- Kannady contained 98% sand and that sample collected from Site 2- Ambanapaly contained 97% sand.

Daily rainfall recorded at RRS Moncompu during May-September, 2018

The record of Daily rainfall obtained in the selected sites Kannady and Ambanapaly is obtained by collecting the rainfall data from Rice Research Station (RRS), Moncompu. The daily rainfall data in each month is added to get the total rainfall obtained in each month. The following table shows the total rainfall in each month at RRS, Moncompu.

Table 3: Total rainfall recorded at RRS Moncompu during May-September, 2018

Year	Month	Rainfall(mm)
2018	May	303.8
	June	573.2
	July	683.3
	August	621.3
	September	108.8

Results of Runoff Estimation

The runoff in selected sites is obtained using an empirical method which is the Soil Conservation Service Curve Number (SCS-CN) method to estimate the direct runoff which is based on a non-linear rainfall-runoff data that include a parameter called curve number. The results of infiltration rate obtained from Site 1- Kannady and Site 2- Ambanapaly are shown in table below:

Table -4: Runoff Estimation of selected sites

Sl No	Month	Runoff in kannady (mm)	Runoff in Ambanapaly (mm)
1	May	212.32	217.59
2	June	473.07	479.37
3	July	581.45	587.96
4	August	520.35	526.75
5	September	40.76	43.63

4. CONCLUSION

1. The infiltration value decreases, and then decreases gradually and then a constant infiltration is obtained.
2. Site1 – Kannady is having more infiltration rate compared to Site 2 – Ambanapaly
3.
4. The greater infiltration is due to the higher void ratio, lesser field density, and lesser water content.
5.
6. In July and August 2018 Kerala got highest rainfall in the year. Site 2- Ambanapaly observed slightly higher runoff compared to Site 1- Kannady.
7.

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