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Determination of Surface Drainage Coefficient through Rainfall Analysis

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Abstract: **Drainage is removal of undesirable excess water from a region; crop land, city streets, dwelling place, playground, airport etc. The drainage need is expressed in terms of drainage coefficient. Drainage coefficient is expressed as the depth in centimetre of water drained off from a given area in 24 hours. Daily rainfall data was analysed to obtain one to four consecutive days maximum rainfall. One to four consecutive days maximum rainfall data were arranged in descending order. Accordingly ranks are given for each year 1991 to 2014. Then by lognormal, Weibull and Gumbel distributions probabilities corresponding to maximum rainfall were found out. Excepted values for one to four consecutive days were estimated by three most widely used probability functions namely Gumbel, lognormal and extreme value type-III distribution. One to four consecutive days rainfall valves were computed for R.I of 5,10,15 and 20 years. The drainage coefficients were calculated by subtracting basic infiltrations rate from consecutive days rainfall for RI of 5, 10, 15 and 20 years.**

Keywords**: Drainage coefficient , consecutive rainfall data**

I. INTRODUCTION

Rainfall is the most important factor influencing the value of drainage coefficient and large number of rainfall data is required for its depth duration frequency analysis. Higher the rainfall less often it occurs. Higher the recurrence interval, higher the design rainfall implying more costly project with less risk of failure. An average failure of 5 to 10 years is generally accepted for agricultural land drainage since cropping pattern in a particular area changes fast. Particularly, for flat lands with slopes ranging between 0-0.05% the design rate of removal of excess surface water is decided by the interaction of crop loss due to water logging. The design drainage rate for surface drainage rate is commonly taken as approximately 9.3 mm/day for agricultural watersheds of various command areas of the country, irrespective of the agro meteorological conditions such as type of crops grown, soils or rainfall pattern. Drainage is removal of undesirable excess water from a region; crop land, city streets, dwelling place, playground, airport etc. Drainage is needed in regions with flat topography, heavy soils, shallow water table, and presence of impermeable layer at shallow depth, requirement of leaching of harmful chemicals from soil surface and soil root zone profile and for water-sensitive crops. The drainage need is expressed in terms of drainage coefficient. Drainage coefficient is expressed as the depth in centimetre of water drained off from a given area in 24 hours. If the rate of drainage is not assessable by direct measurement, indirect method of its estimation such as analysis of rainfall is used.

The overall benefit of agricultural drainage is that it provides a healthy production base of land and water for enhancing agricultural production on a sustainable basis, subject to fulfilment of other input requirement for agricultural production. This implies that good agricultural land drainage by itself is not the necessary and sufficient condition for enhanced and sustainable crop growth and yield. Two methods to find out drainage coefficient are direct method and Indirect method The drainage coefficient for any region varies with the geographical location, land use, size of area, rainfall intensity, frequency and duration and other climatic factors. Bhattacharya et.al.,(1982) reported that for estimating drainage rate for agricultural crops one needs to know the total rainfall over a duration of crop tolerance period. It is possible to allow excess water condition to the crops for few days in agricultural drainage depending upon sensitivity of crop to excess water condition.

II. REVIEW OF LITERATURE

Mourya and Yadav (1992) reported crown root initiation & crop growth stage as most sensitive to excess water condition and one day period as permissible crop tolerance of wheat in clayey soils.

Sharma et al.,(1997) stated that soils of Tawa command having basic infiltration rate 1 to 3 mm/hr required surface drainage system for its existing major crop sequence soybean followed by wheat.

Determination of surface drainage coefficient through rain fall analysis

The drainage co efficient for agricultural watershed at CRS of PDKV Akola was estimated. For this purpose 25 years daily rainfall data was used for its depth-duration-frequency analysis to get one to 4 consecutive days rainfall values for 2,5,10 and 20 years recurrence interval. Computed DC indicated that the soils at CRS having basic infiltration rate

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above 3,5,7 and 8 mm/hour may not need surface drainage system for one day period rainfall of 2,5,10 and 20 years of R.I respectively. The corresponding value in case of two consecutive days rainfall are 2,3,3 and 4 mm/hr. For three consecutive days rainfall these values are 1,2,2 and 3 mm/hr respectively and for 4 days 1,1,2and 2 mm/hr. Study revels that at CRS having predominantly clayey soils with basic infiltration rate between 1 to 3 mm/hr and land at CRS may necessarily have to be provided with agricultural land drainage for its major existing crops.

III. MATERIALS AND METHODS

Location

Kumulur campus is located near Pallapuram village which is 25km away from Trichy. The area of Kumulur campus is around 280 acres. The latitude and longitude of Kumulur was found to be 10o55'29.34"N and 78o49'35.61"E. The average annual rainfall of this area was found to be 857.09mm. The mean rainfall of four seasons was found to be

Table 1. Availability of rainfall based on season

SEASON	RAINFALL(mm)
Winter	72.04
Summer	117.18
South west monsoon	292.28
North east mansoon	376.37

Soil type

In Kumulur campus there are mainly two major group of soil types were existing namely sandy loam and sandy clay loam. The soil types were identified based on infiltration rate test and textural classification. The two identified texture namely sandy loam and sandy clay loam were identified by plotting in textural triangular diagram.

The results obtained are

Table 2: Composition of the soil

S.No	Content (%)	Sandy loam	Sandy clay Loam
1	Sand	47	68
2	Silt	26	11
3	Clay	23	21

Thus the soil under the cental farm was sandy loam and soil under eastern farm was sandy clay loam.

Basic infiltration rate

The Basic infiltration rate was found by conducting double ring infiltrometer test. The basic infilteration rate was found as 1.8cm/hr for sandy clay loam soil.

Rainfall data

The daily rainfall data of 24 years (1991 - 2014) recorded from Agrl. Meteorological observatory situated within the agricultural watershed area.

From daily rainfall data, maximum one day rainfall per year was observed. Similarly maximum rainfall of two, three and four consecutive days were observed and data was used for both observed and expected values. Depth duration frequency analysis of one to four consecutive days maximum rainfall of 24 years worked out using log normal, Gumbel and weibull distributions. The expected values of maximum rainfall were found out by three well known probability distributions viz., Gumbel, Lognormal & extreme value type-III (Chow,1964). Among these three distribution methods the best fit distribution was decided by Chi-square test for their goodness of fit. The best probability function was determined by comparing Chi-square values obtained from each distribution and selecting the functions that gave smallest Chi-square value (Agrawal et. al, 1998). Lognormal distribution found to be best in predicting one to four consecutive days maximum rainfall. The drainage coefficient for agricultural watershed were estimated for 5,10,15 and 20 years R.I. by subtracting basic infiltration rate from estimated consecutive days rainfall. (Sharma et a1., 1997) Basic infiltration (Ib) rate values were found by conducting double cylindrical infiltrometer test. The drainage coefficient for different R.I were estimated by considering the fact that soils are saturated and evapotranspiration, surface retention and raindrop interception are negligible as far as land drainage in concerned.

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Table 3: Year wise one, two, three and four days maximum rainfall

S.No	One day (mm)	Two days (mm)	Three days (mm)	Four days (mm)	Probability (P) (%)	Recurrence Interval (years)
1	205.8	205.8	158	158	2.08	48.08
2	176	176	156.6	151	6.25	16.00
3	158	158	151	149	10.41	9.61
4	156.6	156.6	149	120	14.58	6.86
5	151	149	120	115.8	18.75	5.33
6	149	120	115.8	115.2	22.9	4.37
7	122.6	115.8	115.2	94.4	27.08	3.69
8	120	115.2	94.4	90.5	31.25	3.20
9	115.8	100	90.5	88	35.41	2.82
10	115.2	94.4	85.1	85.1	39.58	2.53
11	106.2	90.5	80.5	80.5	43.75	2.29
12	100	80.5	76	65	47.91	2.09
13	94.4	78.2	70.2	58.4	52.08	1.92
14	90.5	76	69.9	50.8	56.25	1.78
15	85.1	76	69.7	46.8	60.41	1.66
16	84	71.8	58.4	44.2	64.58	1.55
17	80.5	69.9	57.6	37.4	68.75	1.45
18	80	69.7	56	37	72.91	1.37
19	78.5	63.1	50.8	34.2	77.08	1.30
20	71.8	58.4	42	31.8	81.25	1.23
21	69.9	57.6	36	29	85.41	1.17
22	69.7	41.6	34.2	28.8	89.58	1.12
23	67	39.4	31.8	15	93.75	1.07
24	57.6	36	29	7.6	97.91	1.02

IV. RESULTS AND DISSCUSSION

Daily rainfall data was analysed to obtain one to four consecutive days maximum rainfall. One to four consecutive days maximum rainfall data were arranged in descending order. Accordingly ranks are given for each year 1991 to 2014. Then by lognormal, Weibull and Gumbel distributions probabilities corresponding to maximum rainfall were found out. Excepted values for one to four consecutive days were estimated by three most widely used probability functions namely Gumbel, lognormal and extreme value type-III distribution. One to four consecutive days rainfall valves were computed for R.I of 5,10,15 and 20 years. The drainage coefficients were calculated by subtracting basic infiltrations rate from consecutive days rainfall for RI of 5, 10, 15 and 20 years.

Table 4.Consecutive day rainfall values for different recurrence intervals

S.No	Recurrence Interval(years)	Rainfall for consecutive days(mm)			
		1	2	3	4
1	5	143.46	136.03	122.79	111.78
2	10	170.47	167.15	153.40	142.39
3	15	185.72	170.65	170.68	159.67
4	20	196.42	197.05	182.80	171.79

From Table 5,6,7 and 8, it is observed that for one day maximum rainfall, soils of agricultural watershed having basic infiltration rate above 8 mm/hr may not need drainage system for 5 years RI corresponding values for 5, 10 ,15 and 20 years R.L are 8,10,11 and 11mm/hr respectively. For two consecutive days maximum rainfall, soils having basic infiltration rate above 5,6,6 and 4mm/hr may not need drainage system for 5, 10,15 and 20 years RI respectively. For three consecutive days rainfall these values are 1, 2, 2 and 3 mm/hr respectively and for four days rainfall are 3, 4, 4 and 5 mm/hr for 5, 10,15 and 20 years R.I respectively. When one day period is considered as permissible crop tolerance, the one day maximum rainfall of 10 to 15 years is considered for estimation of drainage coefficient and in case of two, three and four days period, two, three and four consecutive days maximum rainfall is used. In case of one day period the estimated drainage coefficients varies between 44.47 mm/day to 170.47 mm/day for 10 years RI and between 59.72 to 185.72 mm/day for 15 years RI having basic infiltration rate between 1 to 8 mm/hr. However, in case of two consecutive days maximum rainfall the estimated values of drainage coefficient varies between 41.15 to 167.15 mm/day for 10 years RI and 44.65 to 170.65 mm/day for 15 years RL having same type soil with infiltration rate of 1 to 5 mm/day. In case of three consecutive days maximum rainfall the estimated values of drainage coefficients varies between 45.4 to 63.4 mm/day for 10 years RI and 62.68 to 80.68 mm/day having 15 years RI having basic infiltration rate between 1 to 2 mm/hr. In case of four consecutive days maximum rainfall the estimated drainage coefficient found to be 16.39 mm/day for 10 years RI having basic infiltration rate 2 mm/hr and it vary between 15.67 to 51.67 mm/day for 15 years RI having basic infiltration rate 1 to 4 mm/hr.

V. CONCLUSION

From the above discussion it is concluded that soil of agricultural watershed having predominantly clayey soils with clay percentage varying between 21-25% and having

basic infiltration rate between 1 to 8 mm/hr may necessarily have to be provided with agricultural land drainage for its major crops grown in the area.

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