European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 07, Issue 07, 2020

Comparative Infiltration Characteristic Of Agriculture Land Use Over Other Land Uses Of Selected Area In Konkan Region.

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Abstract: The present research was carried out to study the infiltration characteristic of different land uses in selected watershed area of Konkan region Maharashtra. A grid survey was conducted in selected watershed area to access the infiltration characteristics of land uses viz. plantation land, agricultural land, pasture land and terrace land. The infiltration data collected for selected land use/cover were correlated by Kostiakov's, Kostiakov Lewis and Philip's infiltration equations. The infiltration rate for various grids ranges from 2.04 to 11.15 cm/hr with the cumulative infiltration ranges from 315.9 to 1277.16 cm. The average infiltration rate for agricultural land ranges from 2.04 to 5.09 cm/hr and the cumulative infiltration was 315.9 to 603.06 cm while the cumulative infiltration ranges from 382.23 cm to 1084.05 cm and average infiltration was 3.30 cm/hr to 7.80 cm/hr for pasture land. For plantation land the average infiltration rate ranges from 3.59 cm/hr to 11.15 cm/hr and cumulative infiltration was 549.48 cm to 1277.16 cm. The average infiltration rate for terrace land ranges from 6.47 cm/hr to 9.83 cm/hr and cumulative infiltration was 654.57 cm to 1084.05 cm. It was found that the Kostiakov's model gives almost perfect fits for the infiltration data.

Keywords : infiltration rate, empirical formula, agriculture, pasture land

1. INTRODUCTION

Kokan is the hilly costal region of Maharashtra and constitutes 10% of the geographical area of the state. The soils in this region are mostly lateritic soil characterized by high infiltration rates and low water holding capacity. Due to permeable substrata, infiltrated water flows laterally at high rates and cannot hold water in to the soil which reduces the storage capacity of soil at surface as well as in soil profile (Mahale, el al 2004). Infiltration encourages accumulation of water in the form of surface runoff and subsurface runoff characterized as the major hydrological components. It is essential that the infiltration data on which they are based should be reasonably stable over decades. (John Diamond and Thomas Shanley, 2003). Infiltration plays the key role for controlling the water budget and water transport in the soil profile. Estimation of infiltration will decides the proportions of the water moving beyond the root zone which stored in the form of subsurface runoff in the (Serrano, 1990). Basic data of Infiltration utilized for planning and management of soil and water conservation structure, irrigation scheduling and water management, removal of excess water as well as input information for execution of most hydrological models. The variability

of infiltration was observed under different land use systems. The infiltration rate values for different land use/land cover for five hours duration were decreasing order i.e. land under plantation > agriculture land > grass land > dense vegetation / forest > barren land was observed by Tamhankar and Ambetkar, (2006). The research was done in central soil and water conservation by Saha et al.(1995) investigated the soil infiltrability. Difference in infiltration characteristics among treatments were reflected in soil water sorptivity (S) computed on the basis of Philips model. Philip model described the infiltration process better than kostiakov's model. Cumulative infiltration, sorptivity and initial moisture of subsurface layer appeared to be important discriminator of different land use systems but had some exception.

The hydrological behavior of any watershed changes with time due to cumulative effect of soil conservation measures and changes in vegetation pattern and soil properties. (Yadav et al., 2005). In view of the above the present investigation was undertaken to study the infiltration characteristics of agricultural land compared with different land use/cover.

2. MATERIAL AND METHODS

The experiments were conducted on the research field of Dr. Budhajirao Mulik College of Engineering and Technology Mandki-Palvan, Chiplun, Ratnagiri district. The research farm is located at latitude 16º30' to 18º04' N and longitude 73º08' to 73º54' E and altitude of 250m from mean sea level. The total area of research farm has the 30 hectare. The climatic conditions for the watershed were typically hot and humid. The annual rainfall of this region ranges between 2500 to 3000 mm and temperature varies from 21ºC to 36 º C. The relative humidity nearly equals to 80%. It has hilly undulating topography and shallow and stony lateritic soils.

Experimental design and infiltration test

Infiltration test were conducted in selected watershed area which was divided into systematic square grids of size 25 X 25m. Four grid in each land use cover had been selected randomly and the infiltration characteristics and soil texture were studied in these selected grid only. The infiltration test with double ring Infiltrometer was performed at selected grids as per the land use pattern viz. Plantation land, Agricultural land, Pasture land, Terrace Land. The soil samples were taken from selected grids at 15cm and 30cm depths for determination of soil texture.

Infiltration Model

The criteria for choosing a suitable model is mainly based on the model input parameters. There are various models are available for infiltration measurement and its parameters such as empirical, homogeneous, Ponding, Wetting, etc. These models used to estimates of infiltration rate and cumulative infiltration rates. In the present study Koatiakov's, Koatiakov's – Lewis and Phillip's infiltration model has been used

1. *Kostiakov Model :* Kostiakov (1932) proposed the following model estimating infiltration rate.

$$I = at^{\alpha} \quad \ldots\ldots (1)$$

Rewritten as,

$$\log (I) = \log (a) + \alpha \log (t) \quad \ldots\ldots (2)$$

Where I = Cumulative infiltration (cm) and t = Elapsed time (min) where a and α = Model parameters (constant).

So, that simple regression between log (I) and log (t) could be used to estimate 'a' and 'α'. By using the values of 'a' and 'α' for given elapsed time 't', the cumulative infiltration

was determined and these parameters of infiltration model was compared with measured data.

2. Kostiakov – Lewis model

$I = at^{\alpha} + b$ …….(3)

Where b is basic infiltration rate. As the above empirical infiltration model is developed entirely from the field data and have little or no physical basis. This basic approach of empirical model is to develop a field equation consist of mathematical function whose shape, as a function of time, matches the observed features of the infiltration rate, and then attempting a physical explanation of the process. (Jury et al 1991).

3. Philips Model

Philip's model was proposed by Philip (1957)

$$I = st^{-½} + At \quad \ldots\ldots (4)$$

Rewritten as,

$$(I/t) = S(1/t^{-1/2}) + A \quad \ldots\ldots (5)$$

Where;

I = Cumulative infiltration (cm).
t = Elapsed time (min).
s = Sorptivity ($cm/hr^{½}$).
A = Model parameter (constant).

The linear regression between (I/t) and ($1/ t^{-½}$) was used to estimate 's' and 'A'. The value of sorptivity 's' was taken from Bharambe (1987) and the value of 'A' depends on ability of soil to transmit water. A comparison was made between computed infiltration parameters and measured field data.

3. RESULT AND DISCUSSIONS

The measured infiltration characteristics from different grid were tested in different land uses and infiltration models to suggest the most suitable equation for the grids as well as for watershed.

Land use/Land cover

1. Plantation land

The plantation land comprises of the tree plantation including fruit crops like mango, blue berry in addition to some of the wild tree. Plantation land was having undulating topography including flat topography to hilly area. The maximum infiltration rate was recorded for grid T-4 was 30 cm/hr, while the minimum infiltration rate for grid M-14 was 1.8 cm/hr. The maximum average infiltration rate was 11.15 cm/hr, while minimum average infiltration rate was 3.59 cm/hr. The maximum cumulative infiltration was 1277.16 cm for a grid X-9 and minimum of 549.48 cm for grid V-5 was observed during test. The highest infiltration rate was observed in some grids of plantation land due to the presence of macro pores and rodent holes. Due to the compaction of soil and clogging of pore spaces by clay particles at lower layers, low infiltration rates were recorded. Kostiakov model is best suited for plantation land and it gives maximum value of 'r'= 0.99 for grid M-14.

2. Agricultural land

In agricultural land, mostly area was under the paddy cultivation and small area was under vegetable cultivation. The soil type of agricultural land was found to be mostly clay soil texture. As per the infiltration characteristic of agricultural land, cumulative infiltration was ranges from 315.9 cm to 603.06 cm. The maximum average infiltration rate was 5.09 cm/hr for grid Y-24 was observed, while minimum average infiltration rate was 2.04 cm/hr for grid D1-26. Kostiakov model is best suited for agricultural land and it gives maximum

value of 'r'= 0.99 for grid D1-26. The maximum infiltration rate recorded for grid T-20 was 28.2 cm/hr while the minimum infiltration rate for grid D1-26 was 0.24 cm/hr. Due to the clay texture of soil profile compaction of soil and clogging of pore spaces takes place by clay particles, which results in low infiltration rates.

3. Pasture land

The maximum average infiltration rate recorded for grid K-17 was 7.80 cm/hr while the minimum average infiltration rate for grid J-4 was 3.3 cm/hr. The maximum infiltration rate recorded was 24 cm/hr while the minimum infiltration rate was 1.26cm/hr. The maximum cumulative infiltration was 1084.05 cm and minimum infiltration was 382.23 cm. The compact structure of soil results in low infiltration. The change in soil profile results variations in infiltration rates. Kostiakov model is best suited for pasture land with correlation coefficient 'r'= 0.98 for grid G-13.

4. Terrace land

The Terrace land was area of selected watershed which having the slope from 6 to 10 percent in which terraces had been prepared. The soil type of terraces land was varied from sandy loam to loamy land. The maximum average infiltration rate recorded for grid G-25 was 9.83 cm/hr while the minimum average infiltration rate for grid F1-27 was 6.47 cm/hr. The maximum infiltration rate recorded was 45 cm/hr while the minimum infiltration rate was 2.2 cm/hr. Kostiakov model is best suited for terrace land with correlation coefficient 'r'= 0.99 for grid G-25. The maximum cumulative infiltration was 1084.05 cm and minimum cumulative infiltration was 654.57 cm. The minimum infiltration is due to sloppy nature of the land.

Table 1. The soil texture of the selected land uses

Sr. No	**Land Use**	**Grid**	**Soil type**
1	Plantation land	M-14	Sandy loam
2		V-5	Sandy clay loam
3		X-9	Sandy loam
4		T-4	Sandy loam
1	Agriculture Land	U-11	Clay
2		T-20	Clay
3		Y-24	Clay
4		D1-26	Clay
1	Pasture Land	J-4	Sandy clay loam
2		G-10	clay loam
3		G-13	Sandy clay loam
4		K-17	Sandy clay loam
1	Terrace land	D1-30	Sandy loam
2		F1-27	Sandy loam

3		G-25	Loam Sandy
4		H1-24	Sandy loam

Infiltration Equation/Model

The field measured data were compared with different infiltration equation/models for calculating different parameters for different equation/models and these parameters are enlisted in table and the explanation about it is given below.

Plantation land : For Grid M-14 in plantation land ,the Kostiakov- Lewis and Philips model gave with correlation coefficient r = 0.98. The correlation coefficient for Kostiakov model was perfect fit with correlation coefficient r = 0.99. In Grid V-5 For this grid with correlation coefficient r = 0.98, Kostiakov model and r = 0.97 for Philips model and r = 0.95 for Kostiakov-Lewis model. The Kostiakov model gave almost perfect fit with correlation coefficient r = 0.98. For the Grid X-9, the Kostiakov model was best suited with correlation coefficient r = 0.98 The correlation coefficient r = 0.97 for Philips model and Kostiakov-Lewis model. In Grid T-4, With correlation coefficient r = 0.95, Kostiakov-Lewis model and Philips model over observed data. Kostiakov model was perfect fit with the correlation coefficient r= 0.97.

Agriculture land : The result reveled in Grid U-11 that correlation coefficient r = 0.99, Kostiakov model and Kostiakov- Lewis model gave best fit over observed data. The correlation coefficient r = 0.98 for Philips model. In Grid T-20, the Kostiakov model, Kostiakov- Lewis model and Philips model with correlation coefficient 'r' is 0.99, 0.98, 0.82 respectively. For Grid Y-24, the correlation coefficient r = 0.99 for Kostiakov model gave best fit over observed data and in Grid D1-26 the Kostiakov-Lewis model and Philips model gave the correlation coefficient r=0.98. The correlation coefficient r = 0.99 for Kostiakov model gave best fit over observed data.

Pasture land: In Grid J-4, With correlation coefficient r = 0.963, Kostiakov model and Philip model gave best fit over observed data. For Grid G-10 with correlation coefficient r = 0.97, Kostiakov model correlates very well whereas the correlation coefficient for Kostiakov – Lewis model was r= 0.95 and for Philip model r = 0.96. if we see for the Grid G-13, it has been observed that with correlation coefficient r = 0.98, Kostiakov model gave best fit over observed data. In the Grid K-17 The Kostiakov model gave almost perfect fit with correlation coefficient r = 0.97. A Similar observations were reported by Mbagwul J. S. C. (1994).

Terraced land : In terrace land in Grid D1-30 and Grid F1-27, The Kostiakov model gave almost perfect fit with correlation coefficient r = 0.98 and 0.96 respectively. The correlation coefficient r = 0.95 for Kostiakov-Lewis model and r = 0.97 for Philips model. The same result has been observed in Grid G-25, where The Kostiakov model gave almost perfect fit with correlation coefficient r = 0.99. The correlation coefficient r = 0.96 for Kostiakov-Lewis model and r = 0.98 for Philips model. In the Grid H1-24 The Kostiakov model gave almost perfect fit with correlation coefficient r = 0.97. The correlation coefficient r = 0.93 for Kostiakov-Lewis model and r = 0.96 for Philips model.

Table 2. Infiltration parameters for different infiltration models.

Type of land	**Grid No.**	**Kostiakov model**		**Kostiakov-Lewis model**			**Philips model**		**Correlation coefficient (r)**		
		a	**α**	**a**	**α**	**b**	**A**	**S**	**Kos**	**Kos-Lewis**	**Philip**
Plantation Land	**M-14**	0.55	0.72	0.39	0.86	0.75	0.03	0.34	0.99	0.98	0.98
	V-5	0.52	0.82	0.56	1.02	0.88	0.07	0.29	0.98	0.95	0.97

	X-9	0.75	0.80	0.56	0.92	1.50	0.14	0.63	0.98	0.97	0.97
	T-4	0.84	0.69	0.56	0.85	0.82	0.10	0.62	0.97	0.95	0.95
Agriculture Land	**U-11**	0.86	0.45	0.62	0.57	1.09	0.01	0.71	0.99	0.99	0.98
	T-20	0.80	0.52	1.09	0.41	1.42	0.07	0.69	0.99	0.98	0.82
	Y-24	0.64	0.72	0.53	0.80	0.60	0.05	0.44	0.99	0.98	0.98
	D1-26	0.47	0.67	0.40	0.74	0.19	0.01	0.22	0.99	0.98	0.98
Pasture Land	**J-4**	0.50	0.74	0.20	1.7	1.02	0.02	0.40	0.96	0.96	0.96
	G-10	0.62	0.76	0.44	0.90	1.05	0.07	0.44	0.97	0.95	0.96
	G-13	0.62	0.77	0.41	0.93	1.36	0.11	0.23	0.98	0.96	0.96
	K-17	0.28	0.84	0.38	1.02	0.72	0.11	0.20	0.97	0.94	0.95
Terrace Land	**D1-30**	0.81	0.72	0.44	0.97	2.73	0.08	0.86	0.98	0.95	0.97
	F1-27	0.50	0.85	0.21	1.23	2.01	0.08	0.33	0.96	0.89	0.95
	G-25	0.84	0.72	0.46	0.97	2.99	0.09	0.94	0.99	0.96	0.98
	H1-24	0.67	0.78	0.34	1.06	2.46	0.08	0.61	0.97	0.93	0.96

Comparison of Infiltration Characteristics between Selected Land Use / Cover

For selected land use and land cover the comparison of infiltration characteristics was carried out by taking into account the maximum value of correlation coefficient 'r' of a grid in a given land use.

Agricultural and Plantation Land

For plantation land grid M-14 was selected with correlation coefficient r = 0.99 and for agricultural land grid D1-26 with correlation coefficient r = 0.99 was selected. The maximum infiltration rate observed for plantation land was 18 cm/hr while for agricultural land it is 6.6 cm/hr. The average infiltration rate for plantation land and agricultural land was 3.59 cm/hr and 2.04 cm/hr respectively. The cumulative infiltration observed in agricultural land was 374.5 cm and for plantation land cumulative infiltration was 829.93 cm. It was observed that the average infiltration of all the grids in plantation land use was 7.21 cm/hr which is greater than average infiltration rate of all grids in agricultural land use i.e., 3.21 cm/hr but the average infiltration rate for grid D1-26 is less than grid M-14 due to its compact soil structure.

Agricultural and Pasture land

For Agricultural land grid D1- 26 was selected with correlation coefficient r = 0.99 and for pasture land grid G-13 with correlation coefficient r = 0.98 was selected. The cumulative infiltration for grid D1-26 of agricultural land use was 374.5 cm. and cumulative infiltration for grid G-13 of pasture land use was 1084.05 cm. The maximum and minimum value of infiltration rate for agricultural land was 6.6 cm/hr and 0.24 cm/hr respectively while for pasture land was 24 cm/hr and 5.2 cm/hr respectively. The average infiltration rate for agricultural land in grid D1-26 was 2.04 cm/hr which is less than average infiltration rate 7.45 cm/hr for grid G-13 of pasture land.

Agricultural and Terrace land

For terrace land grid G-25 was selected with correlation coefficient r = 0.99 and for agricultural land grid D1-26 with correlation coefficient r = 0.99 was selected (Table 2.). The maximum and minimum value of infiltration rate for terrace land was 45 cm/hr and 6.18 cm/hr respectively while for agricultural land was 6.6 cm/hr and 0.24 cm/hr respectively. The

cumulative infiltration observed for terrace land in grid G-25 was 1084.05 cm while for agriculture land in grid D1-26 was 374.5 cm. The average infiltration rate for agriculture land in grid D1-26 was 2.04 cm/hr due to the compact structure of soil which is less than average infiltration 9.83 cm/hr of terrace land in grid G-25 but it was observed that the average infiltration rate of all grids in terrace land was 8.34 cm/hr which is greater than average infiltration rate 3.21 cm/hr of all grids in agricultural land.

4. CONCLUSION

There was high variability in infiltration characteristics such as infiltration rate, cumulative infiltration and basic infiltration rate in land use/cover of selected watershed area. Among Kostiakov, Kostiakov-Lewis and Philip model, Kostiakov model gives almost perfect fits for the measured data. For agricultural land the average infiltration rate in selected watershed area ranges from 2.04 cm/hr to 5.09 cm/hr and the cumulative infiltration was 315.9 cm to 603.06 cm.

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