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HYDRAULIC CONDUCTIVITY AND AGGREGATE ANALYSIS OF RED AND LATERITE SOILS OF KERALA

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Efficient management of irrigation water signifies the utilisation of every unit of water economically to obtain maximum returns. Soil is the storage reservoir for water from which plants obtain their requirements. Physical properties of soils affect the movement, retention and availability of water. Texture, structure and depth of the soil are the important physical properties of the soil that are important in irrigation. Hydraulic conductivity of a soil is the most important single parameter required for any drainage design. Very little field information exists on the patterns of soil water movement in the tropics. It is not yet possible to calculate the absolute value of the hydraulic conductivity of a porous body except in the case of certain idealized models.

The infiltration is the process whereby water enters into the soil through its surface (Horton, 1940). It is not necessary to hypothesize that the soil surface alone controls the process, more or less apart from conditions within the soil profile. Various factors, such as soil cover and vegetation, physiographic factors ,soil characteristics, climatological factors, water characteristics, time of water stagnation on the soil surface and cultural practices etc. modify the rate of water entry into soils.

Materials and Methods

Locations were selected at Vellayani and Thiruvallom in red loam group and Pazhayakunnummel, Varkala, Kudamalur, Pattambi and Koduvally in laterite group to collect the profile samples. The soil samples were collected representing the different horizons in each profile. Undisturbed samples were collected with the help of core sampler as designed by Dakshinamurti and Gupta (1968). The saturated hydraulic conductivity of the undisturbed and disturbed soil samples were measured by the method of Dakshinamurti and Gupta (1968). The infiltration rates of the soils were determined under field conditions, following the double ring infiltrometer method (Dakshinamurti and Gupta, 1968). For the aggregate analysis modified Yoder's method (1936) of wet sieving as suggested by Dakshinamurti and Gupta (1968) was followed.

Results and Discussion

The saturated hydraulic conductivity of the red loam soils varied from 40.93 to 52.41 cm/h indicating thereby the highly porous nature of these soils, whereas in case of laterite group of soils, the saturated hydraulic conductivity varied from 8.02 to 23.14 cm/h which indicates that these soils are also highly porous. Hence, the saturated hydraulic conductivity

Table 1
Volume-mass relationships of red and laterite soils

Soil group and location	Depth (cm)	Volume-mass relationships				
		Particle density (g/cm^3)	Bulk density (g/cm^3)	Total porosity (%)	Volume expansion (%)	Textural class
1	2	3	4	5	6	7
Red Loam (Alfisol)						
Vellayani	0-21	2.58	1.41	45.35.	1.43	Loam
	21-52	2.63	1.44	45.25	1.28	Loam
	52-180	2.70	1.45	46.30	2.05	Loam
Thiruvallom	0-22	2.48	1.39	43.95	1.40	Loam
	22-63	2.55	1.40	45.10	1.67	Loam
	63-175	2.71	1.47	45.76	1.78	Loam
Laterite (Oxisol)						
Pazhayakkunnummel	0-24	2.80	1.32	52.86	1.81	Clay loam
	24-45	2.84	1.28	54.93	1.99	Clay loam
	45-75	2.87	1.25	56.45	1.93	Clay loam
	75-150	2.77	1.24	55.23	2.24	Clay
Varkala	0-5	2.81	1.15	59.07	1.24	Loam
	15-45	2.85	1.22	57.19	1.47	Clay
	45-92	2.88	1.21	57.99	1.84	Clay
	92-120 +	2.28	1.20	58.33	2.29	Clay
Kudamalur	0-16	2.78	1.32	52.52	1.49	Sandy clay loam
	16-48	2.74	1.30	52.55	1.84	Clay loam
	48-103	2.70	1.25	53.70	2.08	Clay
	103-140	2.71	1.22	54.98	2.24	Clay
Pattambi	0-18	2.78	1.38	50.36	1.59	Sandy loam
	18-39	2.85	1.37	51.93	1-69	Sandy clay loam
	39-80	2.83	1.32	53.36	1.97	Clay
	80-142	2.74	1.30	52.55	2.02	Clay
Koduvally	0-12	2.78	1.32	52.52	1.83	Clay loam
	12-33	2.82	1.30	53.90	1.98	Clay loam
	33-70	2.76	1.31	52.54	1.98	Clay loam
	70-120	2.80	1.27	54.64	2.02	Clay loam
	120-150	2.69	1.24	53.90	2.01	Clay

Table 2

Quantitative index of water stability ot soil aggregates and saturated hydraulic conductivity of red and laterite soils

Soil group and location	Depth (cm)	Aggregate 0.25 mm (%)	Mean weight diameter	Aggregate stability (%)	Saturated hydraulic conductivity cm/h: Undisturbed samples	Saturated hydraulic conductivity cm/h: Disturbed samples	Infiltration cm/h
Redloam (Alfisol)							
Vellayani	0-21	84.10	1.55	74.02	51.86	44.80	13.30
	21-52	81.25	1.08	70.64	36.17	40.79	
	52-180	79.91	0.83	70.49	45.40	38.20	
Thiruvallom	0-22	69.96	1.00	48.06	52.41	47.30	12.90
	22-63	78.49	0.99	68.53	45.58	44.45	
	63-175	75.25	0.78	64.64	40.93	35.80	
Laterite (Oxisol)							
Pazhayakunnummel	0-21	91.59	3.24	81.10	51.71	14.01	9.80
	24-45	84.57	3.08	55.35	13.22	12.27	
	45-75	80.44	2.73	43.37	12.94	11.43	
	75-150	83.59	2.78	46.70	8.02	8.34	
Varkala	0-15	87.13	3.75	63.76	20.90	14.58	10.00
	15-45	81.48	3.57	36.07	17.57	14.44	
	45-92	83.99	3.14	50.63	16.02	9.14	
	92-120 +	78.23	2.49	33.14	12.36	5.17	
Kudamalur	0-16	88.34	3.63	58.97	22.22	21.27	10.90
	16-48	81.65	3.46	29.31	18.71	18.34	
	48-103	77.88	2.91	38.35	12.38	12.10	
	103-140	77.23	2.43	36.56	9.01	8.87	
Pattambi	0-18	88.38	3.79	68.36	23.14	21.83	11.00
	18-39	83.57	3.47	52.90	19.78	19.28	
	39-80	80.68	2.99	47.88	12.45	11.01	
	80-142	75.53	2.70	24.24	9.11	8.89	
Koduvally	0-12	88.07	3.84	68.25	18.34	17.69	10.40
	12-33	83.68	3.56	49.89	18.01	17.14	
	33-70	82.82	3.53	48.55	15.23	13.00	
	70-120	78.36	2.77	37.38	12.08	11.80	
	120-150	77.82	2.61	37.82	10.10	9.70	

Table 3

Aggregate size distribution in the soil samples

Soil group and location	Depth (cm)	0.1 mm	0.1-0.25 mm	0.25-0.5 mm	0.5-1.0 mm	1.0-2.0 mm	2.0-4.5 mm	4.5-8.0 mm
		Aggregate per cent						
Red Loam (Alfisol)								
Vellayani	0-21	5.29	10.61	15.84	19.98	28.97	10.59	8.72
	21-52	6.53	12.22	23.46	24.61	25.45	2.73	5.00
	52-180	2.00	18.09	26.62	26.56	22.27	3.78	0.68
Thiruvallom	0-22	17.60	12.44	21.75	20.26	17.20	6.32	4.43
	22-63	7.56	13.95	25.35	23.49	22.66	3.04	3.96
	63-175	6.05	18.70	33.11	18.76	18.85	2.72	1.81
Laterite (Oxisol)								
Pazhayakunnumal	0-24	1.06	7.35	10.45	9.69	14.84	21.69	34.92
	24-45	5.68	9.75	11.30	4.82	9.10	28.70	30.60
	45-75	6.89	12.67	14.75	7.26	8.90	21.11	28.42
	75-150	3.39	13.02	14.25	8.51	11.37	20.64	28.81
Varkala	0-15	5.52	7.35	7.15	7.09	5.61	21.29	45.99
	15-45	9.38	9.14	7.18	4.67	6.07	19.10	44.46
	45-92	5.08	10.93	10.57	9.71	8.70	18.69	36.32
	92-120+	6.92	14.85	13.68	8.42	10.26	22.40	23.47
Kudamalur	0-16	5.39	6.27	5.22	6.24	13.92	19.83	43.13
	16-48	10.00	8.35	8.03	3.71	9.20	18.24	42.47
	48-103	9.68	12.44	11.36	6.02	8.10	20.14	32.26
	103-140	8.17	14.60	13.23	8.21	11.66	21.34	22.79
Pattambi	0-18	5.53	6.09	4.67	4.35	9.13	26.77	43.46
	18-39	7.01	9.42	7.39	4.82	6.47	24.61	39.28
	39-80	6.47	12.85	10.46	7.23	6.97	24.46	31.56
	80-142	11.66	12.81	10.60	8.92	5.70	22.11	28.20
Koduvally	0-12	4.66	7.27	6.40	5.26	8.49	20.36	47.56
	12-33	6.20	10.12	8.69	5.29	6.85	18.76	44.19
	33-70	6-15	11.03	10.44	7.17	6.42	17.88	40.91
	70-120	9.37	12.27	12.11	10.42	7.39	17.24	31.20
	120-150	8.68	13.50	12.64	11.83	8.17	16.62	28.56

values were very high in both red and laterite soils under undisturbed and disturbed conditions. High saturated hydraulic conductivity observed for the Kerala soils is in conformity with the findings of Haridasan (1978), Lal and Cummings (1979) and Vamadevan (1980), all of whom have reported similar results for the soils developed under humid tropical conditions. It was also noted that the values of saturated hydraulic conductivity of the undisturbed soil was more than that of the disturbed samples, when the bulk density was maintained to be the same. This can be attributed to the fact that the undisturbed soils contained gravel and had continuous pores, whereas the disturbed soils were the sieved samples in which the continuity of pores had been broken. The necessity of determining the saturated hydraulic conductivity *in situ* has been stressed by Lal (1979) and the results of the present study also show that it is difficult to simulate field conditions in the laboratory perfectly.

Infiltration rates were observed to be very high in both the soil groups. In the red loam and laterite soils, it varied from 12.9 to 13.3 and 9.8 to 11.0 cm/h respectively.

The results of the infiitration rate show that clay tends to reduce the proportion of the larger pores in the soil and thereby reduce the infiltration rate. High rates of infiltration as observed in this study have been reported for other humid tropical soils by workers such as Wolf and Drosdoff (1976), and Lal and Cummings (1979).

The proportion of the macro-aggregates in the red loam and laterite soils were in the ranges of 69.96 to 84.10 and 75.53 to 91.56 per cent which speak for their excellent structural condition. The aggregate stability varied widely not only between soil groups but also within soils of the same group. The index varied from 48.06 to 74.02 per cent in red loams and from 24.24 to 81.10 per cent in the case of laterite soils.

The soil structure and its stability govern such soil water relationships as aeration, crusting, infiltration, peremeability, run off etc. and therefore also the production potential of a soil. The results of the aggregate analysis indicate a good state of aggregation in both groups of the soils studied. The degree to which the soil aggregates resist dispersion (stability index) was observed to be higher in the soils of the red loam and laterite soils. The variations in stability index may be attributed to differences in the content of such cementing agents as organic matter, clay, and Fe and Al oxides in the different horizons of each soil. Variations in aggregate stability with the above mentioned factors have also been reported by Uehara *et al* (1972).

The mean weight diameter varied from 0.78 to 1.55 mm in red loam soils. It was found to decrease with depth in this group. In the laterite group it varied from 2.43 to 3.84 mm indicating a better status of these soils in respect of their water stable aggregates. In these soils too, it was observed to decrease with soil depth.

The mean weight diameter which is a statistical index of aggregation gives an estimate of the average size were found to possess relatively longer values for mean weight diameter. The probable reason is the presence of large quantities of such cementing agents as organic matter, sesquioxides and clay in these soils. (Greenland, 1979).

Summary

In the study of the hydraulic conductivity and aggregate analysis of red and laterite soils of Kerala it was observed that the saturated hydraulic conductivities of both the soil groups were relatively very high. A trend of decrease in hydraulic conductivity was observed as the soil becomes finer in texture. The hydraulic conductivity of the undisturbed soils were found to be more than that of the disturbed samples even for the same bulk densities. The infiltration rates in both red and laterite soils were relatively high. The state of aggregation was excellent for both the soil groups studied. The soils contained more than 70% of the aggregates in the size range of diameter more than 0.25 mm. The stability index of the soils was also very high.

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