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COMPARATIVE CHEMICAL COMPOSITION OF SOIL AND GRAVEL IN SOME OXISOLS

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The coarse fragments (>2 mm) form a predominant part of the laterite soils and are of importance in water relations especially available water capacity, permeability etc. It is also a deciding factor on the extent of root volume exposed to the soil which is important as far as nutrition of the crop is concerned. The coarse fragments according to Mohr and Van Baren (1954) have been considered to be disintegration products of fossilised laterite. Accumulation of chemical constituents in these gravel has been reported by early workers. The present investigation was taken up with a view to compare the chemical composition of soil, and gravel and relative accumulation of the different constituents in these fractions.

Materials and Methods

Six laterite soil series of Kerala were identified for the study from soil maps on the basis of the parent rock. The particulars of the soil samples collected are presented in Table 1.

The air dried 2mm sieved soil samples and the powdered gravel were used for total elemental analysis. Total SiO_2, Al_2O_3, Fe_2O_3, TiO_2, MnO_2, P_2O_5, K_2O, CaO and MgO were determined in perchloric-nitric acid (1:2) extracts. Silica was determined gravimetrically. Iron and aluminium were estimated by o-phenanthroline and xylenol orange methods respectively, while CaO and MgO were estimated by EDTA method as outlined by Hesse (1971). The content of P_2O_5 was estimated by vanadophosphoric yellow colour method, potassium by flame photometry and MnO_2 by atomic absorption spectrophotometry (Jackson, 1958).

Results and Discussion

The total elemental composition of soils is given in Table 2. The SiO_2 content of all the soils recorded high values ranging from 39.30 per cent of Kootala and Kanjikulam series to 89.40 per cent of Thonnackal series. The particle size analysis of soils showed a predominance of sand in all the soils investigated. The Thonnackal series which is having the highest mean content of sand showed the highest content of silica. Close relationship between silica content and sand fraction of soils was observed by Agarwal *et al.* (1957) on catenary soils of Indian plateau. Quartz being the predominant mineral of the fine sand fraction of red and laterite soils of Kerala, the higher values of silica observed in the present investigation are expected.

The Al_2O_3 content varied from 2.94 per cent in Thonnackal series to 30.10 per cent in Mannur series. A steady increase in the content of Fe_2O_3 with depth was noted in Thonnackal, Kootala, Kanjikulam and Anjur series while other soils showed no definite pattern of variation in. the profile. In the case of Fe_2O_3 the range observed was from 1.60 per cent in Thonnackal series to 11.46 per cent in Kanjikulam series. Increase in the content of iron with depth was observed in Nenmanda soil, while others showed irregular distribution with depth. There was a significant positive correlation for clay content with total Al_2O_3 ($r = 0.469^*$) and total Fe_2O_3 ($r = 0.527^{**}$).

The content of Al_2O_3 in all the soils dominated over Fe_2O_3 except in the case of Anjur and Kanjikulam series. The distribution of Fe_2O_3 and Al_2O_3 closely followed the variation in the clay content. Positive and significant correlation was obtained between clay and these constituents. The above pattern of variation observed is suggestive of the capacity of clay to retain these oxides. The laterite soils being rich in kaolinite and hydrous oxides account for the high content of sesquioxides in the soils.

The total reserves of P_2O_5, CaO, MgO, K_2O and Na_2O were very low in all the soils investigated. This was in accordance with the findings of Venugopal (1980) in laterite soils of Kerala and Bastin (1985) in red soils of Kerala. The total reserve

Table 1

Details of soil samples collected

Profile No.	Rock type	Soil series	Location
I	*Tertiary sediments of Warkalli formation	Thonnackal	Trivandrum (Pallipuram)
II	Hornblende-biotite-diopside granulite	Kootala	Trichur (Alur)
III	Intermediate charnockite	Anjur	Trichur (Vellattanjur)
IV	Biotite gneiss	Kanjikulam	Palghat (Mundur)
V	Diopside granulite	Mannur	Palghat (Mannur)
VI	Hornblende-biotite gneiss	Nenmanda	Calicut (Iringal)

* Tha Warkalli formation refers to the geological formation described by King (1882) in the type locality in Varkala in Trivandrum district. Varkala was spelt as 'Warkalli' in the original paper.

Table 2 Gravel content and total chemical analysis of soils

Soil series sample No. and depth (cm)	Gravel (%)	Chemical analysis of soil									
		SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	MnO_2 (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	TiO_2 (ppm)
Thonnackal											
1 0- 14	7.97	89.40	2.94	1.66	0.008	0.05	0.11	0.20	0.24	0 049	3.79
2 14— 30	20.64	62.40	5.80	1.60	0.006	0.05	0.12	0.20	0.24	0.025	4.64
3 30— 57	59.10	62.40	12.14	1.86	0.006	0.14	0.10	0.10	0.96	0.037	7.88
4 57— 90	47.22	63.00	15.43	3.97	0.010	0.23	0.16	0.30	0.60	0.049	13.67
5 90-180 +	42.98	52.70	17.81	2.94	0.016	0.16	0.13	0.20	0.36	0.025	7.28
Kootala											
6 0— 13	62.71	44.20	19.44	8 06	4.046	0.44	0.13	0.30	0.36	0.634	21.53
7 13— 53	54.97	53.00	20.92	10.88	0.068	0.42	0.13	0.20	0.72	0.831	22.14
8 53—110	58.30	45.00	27.42	9.98	0.044	0.37	0.18	0.25	0.24	0.698	24.17
9 110—180 +	43.03	39.30	28.40	9.40	0.038	0.28	0.13	0.15	1.38	0.682	25.83
Anjur											
10 0— 13	24.92	71.50	8.76	5.44	0.070	0.28	0.14	0 20	0.54	0.087	11.02
11 13— 40	29.39	68.50	19.68	6.72	0.125	0.51	0.12	0.15	0.72	0.087	13.33
12 40- 90	39.97	56.50	19.74	6.46	0.092	0.26	0.10	0.10	0.48	0.099	9.12
13 90-160+	56.02	53.40	23.65	5.95	0.60	0.26	0.13	0.10	0.48	0.099	13.67
Kanjikulam											
14 0- 10	45.90	44.90	13.18	5.82	0.047	0.21	0.12	0.10	0.36	0.074	9.43
15 10— 48	54.09	55.00	18.54	6.46	0.002	0.12	0.11	0.10	0.54	0.074	10.38
16 48— 96	63.88	58.30	23.20	6.40	0.076	0.19	0.12	0.30	0.72	0.074	8.50
17 96—145 +	49.06	39.30	29 34	11.46	0.022	0.21	0.09	0.10	0.60	0.099	14.36
Mannur											
18 0— 10	50.00	59.50	30.10	7.30	0.060	0.28	0.13	0.10	0.48	0.061	21.34
19 10— 21	52.40	40.60	18.06	6.34	0.063	0.23	0.12	0.30	0.48	0.049	13 67
20 21 - 50	48.78	43.90	24.20	6.40	0.044	0.23	0.15	0.10	0.15	0.074	9.43
21 50-110	58.19	47.00	26.85	5.95	0.028	0.19	0.13	010	0.48	0.074	12.66
22 110—180 +	61.14	40.00	23.81	6.59	0.019	0.09	0.13	0.20	0.84	0.061	11.68
Nenmanda											
23 0- 14	58.46	60.00	18.46	3.94	0.024	0.14	0.14	0.20	0.48	0.061	6.40
24 14— 36	69.68	49 40	25.75	5.25	0.033	0.14	0.13	0.30	0.20	0.074	8.02
25 36— 98	75.51	40.00	26.91	5.89	0.019	0.21	0.10	0.15	1.80	0.061	8.82
26 98—150 +	43.54	40.00	25.18	6.02	0.017	0.12	0.11	0.25	0.60	0.99	9.76

Table 3 Total chemical analysis of coarse fragment (gravel)

Soil series sample No. and depth (cm)	Per cent									TiO_2 ppm
	SiO_2	Al_2O_3	Fe_2O_3	MnO_2	CaO	MgO	K_2O	Na_2O	P_2O_5	
Thonnackal										
1 0- 14	48.8	24.00	9.60	0.017	0.12	0.28	0.20	0.14	0.062	17.56
2 14— 30	48.5	28.84	8.96	0.016	0.13	0.14	0.11	067	0.085	23.75
3 30— 57	48.5	22.04	8.96	0.021	0.18	0.21	0.14	0.34	0.101	9.43
4 57— 90	64.6	5.68	24.32	0.013	0.14	0.19	0.45	0.47	0.62	8.02
5 90— 180+	57.0	21.00	9.60	0.022	0.16	0.14	0.80	0.18	0.051	8.19
Kootala										
6 0— 13	34.6	28.42	19.58	0.016	0.12	0.12	0.30	0.14	1.329	16.47
7 13— 53	38.5	21.96	23.04	0.016	0.13	0.21	0.20	0.40	1.391	16.47
8 53— 110	26.7	36.80	16.00	0.024	0.10	0.14	0.20	0.14	1.088	21.34
9 110—180+	33.3	24.46	23.04	0.036	0.11	0.16	0.30	0.54	0 370	17.19
Anjur										
10 0— 13	53.5	11.44	12.16	0.033	0.12	035	0.50	0.14	0 230	14.71
11 13— 40	30.8	12 56	23.04	0.033	0.10	0.20	0.20	0.14	0.191	11.02
12 40- 90	46.5	17.12	17.28	0.117	0.15	0.50	0.75	0.14	0.219	13.00
13 90—160+	40.0	8.72	20.48	0 047	0.14	0.50	0.20	014	0.179	21.34
Kanjikulam										
14 0— 10	38.5	17.84	21.76	0.030	0.10	0.25	0.15	0.14	0.651	21.34
15 10— 48	38.5	17.84	21.54	0.030	0.05	0.45	0.50	0.14	0.483	21.34
16 48— 96	31.9	21.24	21.76	0.040	0.05	0.45	0.75	0.18	0.191	20 94
17 96—145+	48.5	11.20	12.40	0.014	0.16	0.35	0.30	0.18	0.074	17.18
Mannur										
18 0— 10	37.0	20.80	22 40	0.092	0.10	0.35	0.25	0.14	0.315	19.00
19 10- 21	32.7	19.00	19.20	0.106	012	0.30	0.30	0.20	0.285	15.05
20 21- 50	38.5	25.16	16.64	0.057	0.14	0.25	0.30	0.40	0.279	18.29
21 50—110	33.9	25.00	16.00	0.019	0.13	0.40	0.30	0.67	0.179	18.65
22 110—180+	35.6	25.04	18.56	0.016	0.12	0.33	0.20	0.14	0.258	13.49
Nenmanda										
23 0- 14	38.5	26.20	19.20	0.016	0.15	0.02	0.20	0.14	0.191	14.39
24 14— 36	22.3	35.56	23.04	0.016	0.13	0.23	0,20	0.14	0.191	19 00
25 36- 98	32.3	27.52	26.88	0022	0.10	0.16	0.10	0.14	0.151	4.36
26 98—150+	27.2	39.60	69.20	0.016	0.16	0.26	0.20	0.14	0.123	297

Table 4 Relative accumulation of constituents in gravel and fine earth

Soil series sample No. and depth (cm)	Ratio of element in gravel/element in fine earth									
	SiO_2	Al_2O_3	Fe_2O_3	MnO_2	MgO	CaO	Na_2O	K_2O	P_2O_5	TiO_2
Thonnackal										
1 0- 14	0.546	8.16	5.78	2.13	5.60	1.06	0.70	0.83	1.27	4.63
2 14— 30	0.777	4.97	5.60	2.67	2.80	1.09	3.35	0.46	3.45	5.12
3 30- 57	0.777	1.82	4.82	3.50	1.50	1.79	3.40	0.15	2.70	1.20
4 57— 90	1.025	0.37	6.12	1.30	083	0.84	1.57	0.75	1.27	0.59
5 90—180+	1.082	1.18	3.27	1.38	0.88	1.31	0.90	2.22	2.04	1.13
Kootala										
6 0— 13	0.783	1.46	2.43	0.35	0.27	0.92	0.47	0.83	2.08	0.76
7 13— 53	0.726	1.05	2.12	0.24	0.50	0.93	2.00	0.28	1.67	0.74
8 53—110	0.568	1.34	1.60	0.55	0.38	0.56	0.56	0.83	1.56	0.88
9 110—180+	0.847	0.86	2.45	0.95	0.57	0.86	0.60	0.22	0.54	0.66
Anjur										
10 0— 13	0.748	1.31	2.24	0.47	1.25	0.82	0.70	0.93	2.53	1.33
11 13— 40	0.450	0.64	3.43	0.26	0.39	0.79	0.93	0.28	2.17	0.83
12 40— 90	0.823	0.87	2.67	1.27	1.92	1.57	1.40	1.56	2.22	1.43
13 90—160+	0.749	0.37	3.44	0.78	1.92	1.15	1.40	0.42	1.82	1.55
Kanjikulam										
14 0— 10	0.857	1.35	3.74	0.64	1.19	0.81	1.40	0.42	9.09	2.26
15 10— 48	0.700	0.96	3.33	0.57	3.75	0.50	1.40	1.39	6.67	2.05
16 48— 96	0.547	0.92	3.40	0.53	2.37	0.47	0.60	1.04	2.56	2.46
17 96—145+	1.234	0.38	1.08	0.64	1.67	1.85	1.80	0.50	0.75	1.20
Mannur										
18 0— 10	0.622	0.69	3.06	1.53	1.25	0.70	1.40	0.52	5.26	0.89
19 10— 21	0.805	1.05	3.03	1.68	1.30	0.98	0.67	0.63	5.88	1.10
20 21— 50	0.877	1.04	2 60	1.30	1.09	0.94	400	2.00	294	1.94
21 50—110	0.721	1.20	2.69	0.68	2.11	1.05	6.70	063	2.44	1.47
22 110-180+	0.890	1.05	2.82	0.84	3.67	0.88	0.70	0.24	4.17	1.15
Nenmanda										
23 0— 14	0.642	1.42	4.87	0.67	0.14	1.01	0.70	0.42	313	2.24
24 14— 36	0.451	1.38	4.39	0.48	1.64	0.95	0.47	1.00	2.56	2.37
25 36— 98	0.808	1.02	4.56	1.16	0.76	0.97	0.93	0.06	2.50	0.49
26 98—150+	0.680	1.57	3.19	0.94	0.13	1.45	0.56	0.33	1.25	0.30

of plant nutrients is mainly a function of the sand fraction (Hughes, 1981). The fine sand fractions of red and laterite soils in the present study showed quartz as the dominant mineral with few weatherable minerals. The soils of Kerala are derived mainly from acid crystalline rocks which are again poor in bases. Thus low reserves of major nutrients in the soil are the reflection of parent geology of the soils as revealed by the present study.

The chemical composition of gravel and gravel/soil ratios of constituents are presented in Table 3 and 4. The chemical composition of gravel showed a depletion of SiO_2 and accumulation of constituents especially Fe_2O_3 and Al_2O_3. Between the sesquioxides, accumulation of Fe_2O_3 appeared to be more compared to Al_2O_3. The mean values for the profile showed the highest accumulation of Fe_2O_3 in Thonnackal series followed by Nenmanda, Anjur, Kanjikulam, Mannur and Kootala. The coarse fragments observed in most of the soils included pisolithic laterite and quartz gravel. The ferrugenous laterite gravels clearly show accumulation of most of the constituents as compared to soils. High gravel/fine earth ratios of the constituents have been observed for Fe_2O_3, Al_2O_3, MgO, P_2O_5 and Na_2O. Accumulation of Fe, Mo, Ga, V and P_2O_5 in gravel relative to fine earth was reported by Turton *et al.* (1962) in gravelly laterites of Australia. Thonnackal series showed the highest order of accumulation among the various soils investigated for Al_2O_3, Fe_2O_3, MnO_2, MgO, CaO and TiO_2. Enrichment of constituents in the gravel from different depth did not show any pattern, but gravel from the upper layers of the soil profile, appeared to accumulate the elements to a greater extent. This can be attributed to the alternate wet and dry conditons and consequent well oxidised nature of upper layers of the soil profile. The concentration of iron and other elements in the form of concentric skins making them more harder and rounded is the result of the above processes.

Summary

A study was made on the comparative chemical composition of soil and coarse fragment gravel in some Oxisol series identified in different regions in Kerala. The chemical composition of gravel showed a depletion of SiO_2 and accumulation of constituents especially Fe_2O_3 and Al_2O_3. Between sesquioxides, accumulation of Fe_2O_3 appeared to be more compared to Al_2O_3. The mean values for the profiles showed the highest accumulation of Fe_2O_3 in Thonnackal series followed by Anjur, Kanjikulam, Mannur and Kootala. High gravel/fine earth ratios of the constituents have been observed for Fe_2O_3, Al_2O_3, MgO, P_2O_5 and Na_2O. The gravel from the upper layers of the profile showed accumulation of constituents to a greater extent than the lower layers.

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