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PHOSPHORUS FRACTIONS IN RELATION TO THE GENESIS OF SOME OXISOLS IN KERALA

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The fractions of soil phosphorus have often been utilized as an indicator of intensity of soil weathering and development. Chang and Jackson (1958) postulated that in the course of chemical weathering and soil development, Ca-P would decrease considerably followed by Al-P resulting in an increase of Fe-P, occluded P and reductant soluble P. Walker and Syers (1976) reported that the transformation and loss of P during pedogenesis would be influenced by the nature of the phosphorus in the parent material. An attempt is made in this paper to summarise the findings of a study on the P fraction of laterite soils derived from different parent materials in Kerala and their relation to the genesis of the soils.

Materials and Methods

Six laterite soil series were identified for the study from soil maps on the basis of the parent rock. The particulars of samples collected are presented in Table 1. The air dried 2 mm sieved samples were used for the study. The particle size distribution was carried out by the international pipette method (Piper, 1942). Bulk density was determined by the core method outlined by Daskhinamurthi and Gupta (1968). Soil reaction was determined in 1:1 soil water using Systronic pH meter. Electrical conductivity was determined in 1:2 soil water suspension using a conductivity meter. Cation exchange capacity was determined by sum of bases method (NH_4OAc) and exchange acidity determined by $BaCl_2$-TFA (Soil Survey Staff, 1957). Free iron oxide was extracted using dithionite citrate bicarbonate method (Mehra and Jackson, 1960). Iron was determined by the o-phenanthroline method and fractionation of P was carried out using the modified procedure of Chang and Jackson as described by Hesse (1971).

Results and Discussion

Mechanical composition and bulk density of soils are given in Table 2 Sand formed the predominant size fraction. The soils from all the areas are developed from acid igneous rocks with quartz predominating the light mineral suite. Acid igneous rocks on weathering produce quartz rich infertile soils, the predominant sand fraction owes its origin to the parent material from which the soils are developed.

Among the size fraction, silt was the lowest. The intense weathering conditions of the tropics have been responsible for complete transformation of the feldspars to clay with insignificant proportions of silt (Radwanki and Olier, 1959). The clay fraction in all the soils showed migration to lower layers and is mainly the

Table 1

Details of soil samples collected

Profile No.	Rock type	Soil series	Location
I	* Tertiary sediments of Warkalli	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	Hornblenda-biotite gneiss	Nenmanda	Calicut (Iringal)

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

results of high rainfall conditions (> 2500 mm) of the study areas. Sandy clay loam surface textures followed by clay to sandy clay in the subsurface layers of the profiles were the typical sequence of textural class observed.

The bulk density values did not raveal appreciable differences between the soil series. The preponderance of coarse fraction in the soils has clearly reflected in the bulk density values as indicated by the higher values observed in sample No. 1 of Thonnackal series. The decreasing trend in the bulk density values of Kootala series and the slight increasing trend in Anjur also paralled the distribution of sand fraction.

Chemical properties of soils are given in Table 3. The soils from all the locations were in general acid (pH < 5.5) as was expected in highly weathered and leached soils of tropics. The acidic nature of the parent rocks, intense weathering and leaching of bases are the factors responsible for the acidity. The electrical conductivity values recorded were very low and showed little variation within the profile and between soils series. The soils from all locations were from mid-land regions of the state and practically nonsaline. The cation exchange capacity of the soils was low as was expected of highly weathered tropical soils. No appreciable differences within the profiles and between soil series were observed. The CEC of soils rich in kaolinite, halloysite, hydrated oxides of Fe and Al and other low activity clay is usually low (Coleman and Thomas, 1967). The soils under investigation have been developed through progressive stage of weathering under heavy

Table 2

Mechanical composition and bulk density of soils

Soil series, sample No. and depth (cm)		Size class (Per cent)				Textural class	Bulk density (g/cm³)
		Coarse sand	Fine sand	Silt	Clay		
Thonnackal							
1	0- 14	48.37	23.23	5.40	23.00	Sandy clay loam	1.74
2	14— 30	47.68	18.57	5.03	28.72	Sandy clay loam	1.51
3	30— 57	43.42	13.72	3.19	39.67	Sand clay	1.64
4	57- 90	37.80	11.90	3.84	46.43	Sandy clay	1.78
5	90-180 +	35.95	17.67	2.53	43 80	Sandy clay	1.46
Kootala							
6	0- 13	41.87	11.53	11 46	35.14	Clay	1.75
7	13— 53	32.10	10.40	8.17	49.33	Clay	1.47
8	53—110	29.87	5.26	10.15	54.72	Clay	1.41
9	110-180 +	27.57	5,07	12.10	55.26	Clay	1.22
Anjur							
10	0— 13	35.08	11.20	7.15	46.57	Clay	1.20
11	13—40	49.75	17.15	1.72	31.38	Sand clay	1.50
12	40 – 90	25.49	9.12	7.44	58.00	Clay	!.58
13	90—160 +	50.32	8.05	5.63	36.00	Clay	1.62
Kanjikulam							
14	0- 10	42 88	10.26	7.86	39.00	Clay	1.58
15	10- 48	41.59	7.52	6.20	44.69	Clay	1.57
16	48- 96	35.84	4.84	2.06	57.26	Clay	1.61
17	96—145 +	30.31	6.96	12.38	50.35	Clay	1.47
Mannur							
18	0— 10	48.17	3.18	1282	35.83	Clay	1.70
19	10- 21	27.78	8.54	10.98	52.70	Clay	1.41
20	21— 50	27.86	4.23	7.90	60.00	Clay	1.46
21	50-110	39.31	8.48	10.58	41.63	Clay	1.65
22	110—180 +	31.86	11.19	5.83	51 12	Clay	1.56
Nenmanda							
23	0— 14	50,84	11.87	6.77	30.52	Clay loam	1.20
24	14— 36	45.93	7.86	5.20	41.01	Clay	1.64
25	36- 98	45.07	4.38	5.20	45.35	Clay	1.57
25	98-150 +	56.79	6.26	2.30	36.65	Sandy clay	1.51

Table 3

Chemical properties of soils

Soil series, samples No. and depth (cm)		Soil reaction (1:1, H_2O)	Electrical conductivity mmho/cm (1:2, H_2O)	Cation exchange capacity me/100 g soil	Total iron (%)	Dithionite citrate extractable iron (%)
Thonnackal						
1	0— 14	4.70	0.085	5.88	1.66	1.04
2	14— 30	4.40	0.080	5.16	1.60	1.56
3	30— 57	4.60	0.045	6.46	1.86	0.85
4	57— 90	4.45	0.045	7.31	3.97	3.69
5	90—180+	4.40	0.045	7.61	2.94	1.84
Kootala						
6	0— 13	4.95	0.040	14.83	8.06	7.83
7	13— 53	4.70	0.020	17.69	10.88	6.44
8	53—110	4.85	0.019	15.91	9.98	9.22
.9	110—180+	4.60	0.030	13.30	9.40	9.22
Anjur						
10	0— 13	6.30	0.055	6.86	5.44	3.48
11	13— 40	4.85	0.025	9.42	6.72	6.44
12	40— 90	5.10	0.020	13.99	6.46	6.08
13	90—160+	5.20	0.020	10.03	5.95	5.73
Kanjikulam						
14	0— 10	4.55	0.033	10.38	5.82	5.39
15	10— 48	4.90	0.030	13.50	6.46	6.44
16	48— 96	4.90	0.030	11.50	6.40	6.26
17	96-145	5.05	0.018	10.42	11.46	10.87
Mannur						
18	0— 10	5.60	0.085	9.04	7.30	5.73
19	10- 21	5.25	0.035	12.07	6.34	5.56
20	21— 50	4.90	0.025	12.54	6.40	5.73
21	50—110	5.15	0.020	8.95	5.95	5.23
22	110—180+	4.80	0.010	12.53	6.59	5.73
Nenmanda						
23	0— 14	4.85	0.035	8.82	3.94	3.35
24	14- 36	4.60	0.025	8.71	5.25	4.61
25	36— 98	4.85	0.011	5.66	5.89	4.03
26	98-150+	5.30	0.010	6.19	6.02	3.75

Table 4 Phosphorus fractions in soil (ppm)

Soil series Sample No. and depth (cm)		Total P	Active inorganic P			Saloid P	Reductant P	Occluded P	Active fraction %		
			Fe-P	Al-P	Ca-P				Fe-P	Al-P	Ca-P
Thonnackal											
1	0— 14	214.0	14.5	2.1	30.3	4.99	18.1	9.2	30.8	4.4	64.6
2	14- 30	107.3	12.1	1.2	38.5	1.38	18.1	9.2	23.3	2.4	74.1
3	30— 57	160.9	8.4	2.3	6.2	0.69	18.1	14.4	495	13.7	36.7
4	57— 90	214.0	9.4	2.9	6.2	3.37	18.1	43.4	47.9	16.6	35.4
5	90—180+	107.3	9.3	1.0	25.0	6.41	18.1	70.9	26.3	2.8	70.7
Kootala											
6	0— 13	2768.5	541.4	230.2	41.8	3.77	437.4	218.0	66.5	28.3	5.1
7	13 — 53	3627.7	922.5	404.5	70.2	1.87	503.5	159.5	66.0	28.9	5.0
8	53—110	3048.7	541,4	278.6	60.9	0.92	496.8	184.5	61.4	31.6	6.9
9	110—180+	2978.0	1003.5	192.4	16.8	0.92	205.3	224.0	82.7	15.8	1.3
Anjur											
10	0- 13	378.0	112.1	23.4	16.8	3.77	85.7	48.5	73.5	15.3	11.0
11	13— 40	378.0	96.9	9.1	24.8	1.15	27.5	51.6	74.0	6.9	18.9
12	40— 90	431.7	136.9	26.4	21.3	1.38	143.5	29.8	74.1	14.3	11.5
13	90-145+	431.7	128.4	17.5	15.3	1.08	116.5	64.1	79.6	10.8	9.5
Kanjikulam											
14	0- 10	322.6	94.7	18.9	26.0	5.78	27.5	51.6	67.8	13.4	18.6
15	10— 48	322.6	73.2	14.6	15.2	1.38	70.6	65.9	71.0	14.2	14.7
16	48- 96	322.6	73.2	14.6	16.8	0.92	85.6	48.5	69.9	13.9	16.1
17	96—145+	431.7	87.5	17.5	15.7	2.80	217.5	78.8	72.4	14.4	13.0
Mannur											
18	0— 10	268.2	102.1	20.4	19.6	3.28	27.5	65.0	71.8	14.3	13.8
19	10— 21	213.9	73.2	14.6	20.2	2.32	46.3	52.4	67.7	13.5	18.7
20	21— 50	322.6	87.5	17.5	30.4	3.77	85.6	32.9	64.6	12.9	22.4
21	50—110	322.6	14.7	2.9	6.0	0.69	106.1	31.1	61.9	12.3	25.6
22	110—180+	268.2	15.6	3.1	8.5	0.69	107.0	22.9	57.2	11.4	31.2
Nenmanda											
23	0— 14	268.2	25.2	7.5	3.6	1.38	75.6	14.6	69.2	20.6	10.1
24	14— 36	322.6	19.7	37.2	2.7	7.91	75.6	19.7	33.0	62.3	4.6
25	36— 98	268.2	19.7	20.9	3.2	4.98	78.0	16.6	44.9	47.6	7.3
26	98—150+	431.7	17.6	23.4	1.8	5.66	75.6	92.0	41.1	54.5	4.2

rainfall and high temperature conditions and hence low CEC of soils can be attributed to the nature of the clay fraction. The dithionite citrate extractable from (Fe-d) ranged from 0.85 per cent of Thonnackal series to 10.87 per cent of Kanjikulam series. It constitutes the major portion of the total iron showing its highly weathered nature.

Various phosphorus fractions are given in Table 4. Fe-P formed the major part of total P and ranged from 8.4 ppm of Thonnackal series to 1003.5 ppm of Kootala series. According to Chang and Jackson (1958) as weathering intensifies Ca-P decreases and Fe-P increases forming the dominant fraction of highly weathered soil. The results of the present study showed the Fe-P to predominate the active inorganic fractions of all the soils except Thonnackal indicating their strongly weathered nature.

The Al-P ranged from 1.0 ppm of Thonnackal series to 404.5 ppm of Kootala series. With regard to Ca-P, it varied from 1.8 ppm in Nenmanda series to 70.2 ppm in Kootala series. Low levels of Ca-P would be taken as an index of advanced stages of weathering in soils (Chang and Jackson, 1958). All soils under investigation are acidic, have low CEC and exchangeable Ca and these factors would have contributed to the small levels of Ca-P fraction. Judged from the above, Nenmanda series with a minimum of Ca-P is highly weathered as compared to Thonnackal with slightly higher contents of this fraction. All the soils appeared to have relatively higher amount of occluded P. It varied from 9.26 ppm of Thonnackal series to 224.0 ppm of Kootala series. Syers *et al*. (1969) and Smeck (1973) have reported higher levels of occluded P at the expense of Ca-P and Al-P in intensely weathered soils.

Reductant P of soils shows higher levels than occluded P in all the series except Kanjikulam and ranged from 18.1 ppm of Thonnackal series to 503.9 ppm of Kootala series. All profiles have appreciable amounts of Fe-P and hence account for higher levels of this fraction (Swindale, 1966). The content of saloid P was low and ranged from 0.69 ppm of Thonnackal series to 7.91 ppm of Kootala series.

Highly weathered soils according to Chang and Jackson (1958) contain appreciable amounts of Fe-P with concomittant reduction in other fractions. Among the active inorganic phosphorus fractions, Fe-P formed the dominant fraction in all the series except for Thonnackal indicating their highly weathered nature. However, judged from the content of Ca-P, Nenmanda series with the minimum of Ca-P was highly weathered.

Summary

A study was made on phosphorus fractions from six profile collected from laterite soil (Oxisols) series identified in different regions in Kerala. Fe-P formed the predominant among the active fractions on all the soils investigated except Nenmanda and Thonnackal series indicating their highly weathered nature. This was followed by Ca-P and Al-P respectively in the case of Anjur, Kanjikulam and

Mannur series. In Kootala series, Fe-P was followed by Al-P and then Ca-P. Thonnackal series showed a predominance of Ca-P followed by Fe-P and then Al-P.

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