

Phosphorus forms and fixation capacity of representative soils in Akwa Ibom State of Nigeria

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ABSTRACT

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The P forms and fixation capacity of seven representative soils in Akwa Ibom State were evaluated. Total P varied widely from as low as 79 mg kg⁻¹ to as high as 1410 mg kg⁻¹ with the values decreasing with depth in some of the soils. Organic P also varied from 5 to 434 mg kg⁻¹ decreasing generally with depth and accounting on the average for 24.0% of the total P. The C/P ratios which influence the mineralization of organic P were generally low, being below 200 in most of the soils. The relative abundance of the active P fractions were in the order of Fe-P > Al-P > Ca-P > Sal-P in all the soils excepting those derived from shale and river alluvium where Ca-P was more abundant. Inactive P fractions or reverted P accounted for between 27 and 62% of total P. On the basis of the relative contents of reverted P in the soils, it has been inferred that soils derived from coastal plain sands and sandstone parent materials are more developed than others. Available P estimates indicated that the Bray P-2 method removed larger amounts of P than Bray P-1 and the soils differed markedly in their contents of available P, ranging from 2 to 112 mg kg⁻¹ using the Bray P-1 method.

The soils differed widely in their P adsorption capacity with a mean range of 0.4 to 44.9 expressed as an adsorption index ($X/\log C$). Soils derived from shale and river alluvium possessed the highest capacity to sorb P compared to those of coastal plain sand, sandstone and beach sand parent materials. The P sorption capacity was significantly correlated with both clay and silt contents and with oxalate-extractable Al₂O₃.

The significance of the adsorption tendencies of these soils is that those with very high sorption capacities may require larger P fertilizer dressings for optimum crop yield than others with low capacity. Routine soil testing before P fertilizer recommendations and adequate organic matter applications are management imperatives for these soils.

INTRODUCTION

Tropical soils are known to suffer from multiple nutrient deficiencies particularly that involving P. The availability to plants of P in soils is usually linked with the relative abundance of the various chemical forms of the ele-

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ment. Factors such as content of hydrous oxides and hydroxides of Fe and Al, pH, drainage conditions of the soil, types and amount of clay minerals and the degree of soil development are key determinants of the relative amounts of the various forms of P (Chang and Jackson, 1957; Juo and Ellis, 1968; Udo and Dambo, 1979; Loganathan and Sutton, 1987). The various forms of soil P are usually determined by the fractionation method of Chang and Jackson (1957) with various modifications (Peterson and Corey, 1966; IMPHOS, 1980).

Akwa Ibom State occupies the extreme southeast fringe of Nigeria and the soils are formed on a range of parent materials. Information on P characteristics of these soils is limited (Enwezor, 1977; Udo and Ogunwale, 1977; Udo and Dambo, 1979), and none of it has focussed on a wide range of soils. This paper was aimed at evaluating the various P forms and P fixation capacity using representative soil profiles to reflect the different soil groups based on parent materials in the Akwa Ibom State of Nigeria. The various parent materials are coastal plain sands, beach sand, river alluvium, sandstone and shale.

MATERIALS AND METHODS

Seven representative soil profiles were studied to cover five parent materials commonly encountered in this area. The soils were selected to exclude those which might have received P fertilizers previously. A summary of the profile location, parent material, vegetation and soil class is presented in Table 1. The locations of the soil profiles are shown in Fig. 1.

TABLE 1

Summary of profile location, parent materials, vegetation, and soil classification

Profile No.	Location	Vegetation	Parent material	Soil classification
B ₂₁	Ayadeghe	Mixed cropland	Alluvium	Aeric Tropaquept
C ₃	Idu Uruan	Fallow	Coastal plain sands	Oxic Dystropept
G ₆	Okosi-Udu	Fallow	Coastal Plain sands	Oxthoxic Tropudult
UK ₁₄	Ikot Afanga	Fallow	Coastal Plain sands	Oxic Dystropept
L ₁	Edebo	Fallow	Beach sand	Typic Tropopsamment
Y ₁₀	Nto Ndang	Fallow	Sandstone	Orthoxic Tropudult
Z ₂₆	Obotme	Fallow	Shale	Aeric Tropaquept

Source: Akwa Ibom State: Physical background, Soils and Land Use and Ecological Problems. Tech. Rep. of the Task Force on soils and land use survey of Akwa Ibom State (1989).

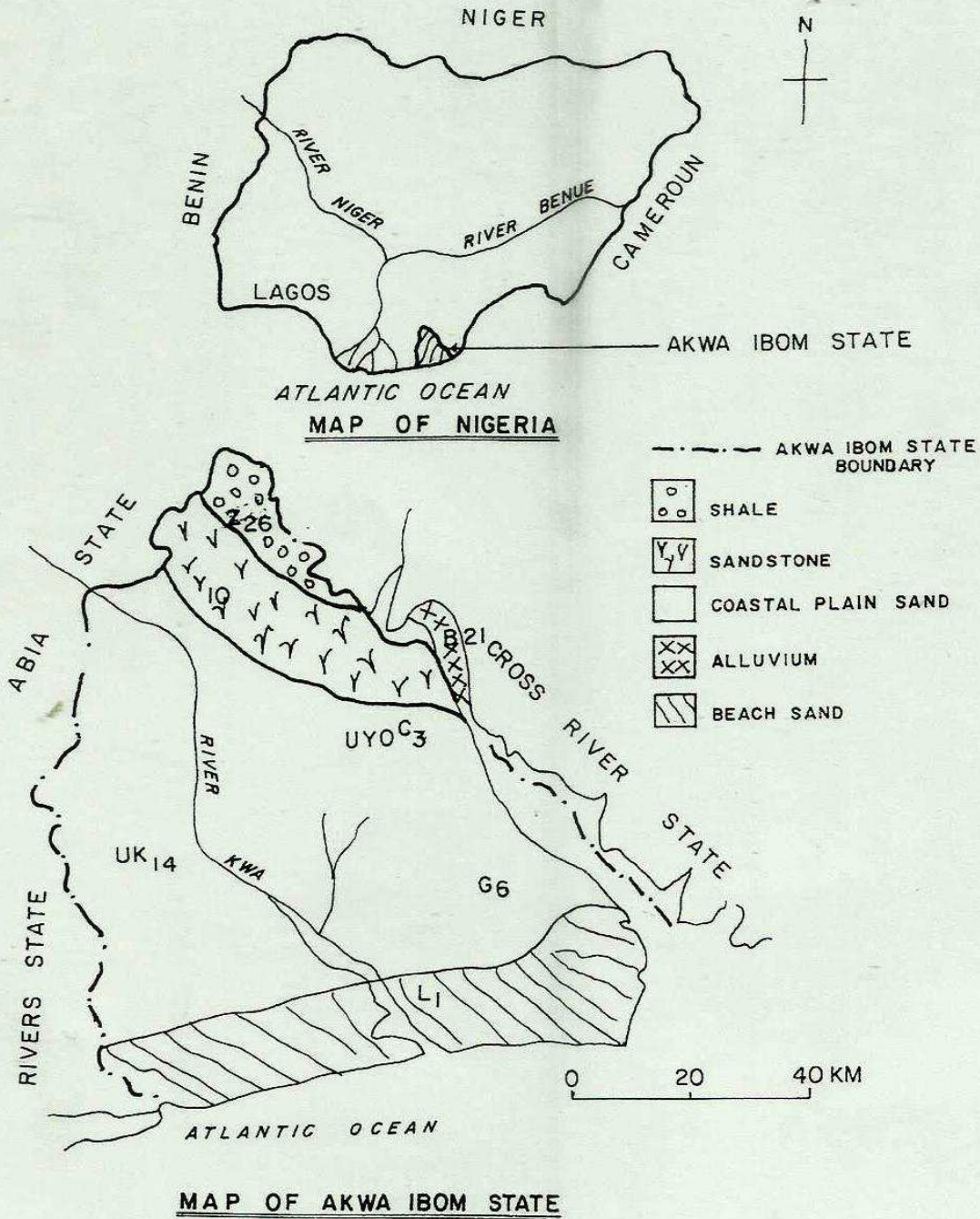


Fig. 1. Location of the soil profiles and geology of the study area.

Analytical procedures

The soil samples were air-dried, sieved through a 2 mm sieve and stored for analyses. Particle-size distribution was determined by the hydrometer method (Bouyoucos, 1951). Soil pH was measured at 1:2 soil:water ratio

using a glass electrode pH meter. Soil organic carbon was determined by the wet dichromic oxidation method described by Walkley and Black (1934). Exchangeable bases were extracted using 1M NH_4OAc . K and Na in the extracts were measured using flame photometry while Mg and Ca were determined by atomic absorption spectrophotometry. Exchangeable acidity was measured by the 1M KCl extraction procedure as described by McClean (1965). Effective cation exchange capacity (ECEC) was obtained by the summation method (IITA, 1979). Amorphous Fe and Al or oxalate-extractable Fe_2O_3 and Al_2O_3 were determined by the method outlined by McKeague and Day (1966) using an ammonium oxalate-oxalic acid buffer (Modified Tamm's Reagent).

Total P was extracted by the perchloric acid digestion method (Jackson, 1964) and the organic form by the ignition method as described by Legg and Black (1955). Inorganic P was sequentially fractionated using the procedure outlined by Chang and Jackson (1957) as modified by IMPHOS (1980) to exclude the occluded and reductant-soluble forms. Available P was extracted with acid fluoride using the Bray P-1 and Bray P-2 methods (Bray and Kurtz, 1945). Phosphorus in each extract was determined colorimetrically by the blue colour method of Murphy and Riley (1962).

P sorption study

The method of Bache and William (1971) was employed to determine the P sorption capacity of the soils. The soils were equilibrated in 50 ml centrifuge tubes for 6 days with 0.01M CaCl_2 containing 150 mg P per litre in a soil:solution ratio of 1:10 thus giving 150 mg P per 100 g of soil. Two to three drops of toluene were added to the soil to inhibit microbial growth and the soil was then shaken using a reciprocal mechanical shaker at a room temperature of 25°C. After equilibration, P in the supernatant was determined by the method of Murphy and Riley (1962) and the decrease in P concentration in the equilibrium solution was taken as the P adsorbed. From this, the absolute amount of P adsorbed and the adsorption index defined as $X/\log C$ (where X is P adsorbed measured in mg per 100 g of soil, C is P in solution measured in mol/l) were calculated.

RESULTS

Soils of the coastal plain sands, beach sand and sandstone were coarsely textured with textural class ranging from loamy sand in the surface horizons to sandy clay loam in the subsurface horizons (Table 2). Soils derived from shale and alluvial parent materials had a surface sandy clay loam and subsurface clay loam texture. The soils were generally moderately acidic with pH

TABLE 2

Some physical and chemical properties of the soils

Depth (cm)	pH (H ₂ O)	Org C (%)	EA ---(cmol ⁺ /kg)---	ECEC	BS (%)	Oxalate-extractable		Particles size		
						Fe ₂ O ₃	Al ₂ O ₃	Sand Silt Clay ------(%)-----		
<i>B₂₁: Ayadeghe</i>										
0-15	5.2	2.53	2.00	9.26	78	ND	ND	46.4	31.4	22.2
15-40	4.8	1.65	3.40	8.23	57	ND	ND	42.4	35.4	22.2
40-75	5.5	0.77	0.40	1.71	77	ND	ND	30.4	29.4	40.2
75-100	5.8	0.50	0.40	9.88	96	ND	ND	42.4	25.4	34.2
100-120	5.9	0.42	0.40	5.27	92	ND	ND	34.4	23.4	32.2
<i>C₃: Idu-Uruan</i>										
0-20	5.9	3.20	1.00	5.96	83	5.14	0.53	89.2	6.0	4.8
20-60	5.9	1.00	1.60	3.20	50	5.49	0.26	71.2	4.0	24.8
60-105	5.7	0.93	1.60	4.08	61	4.83	0.47	73.2	0.0	26.8
105-135	5.5	0.54	1.60	2.69	41	3.38	0.52	73.2	2.0	24.8
135-200	5.5	0.39	1.60	2.71	41	1.32	0.52	73.2	2.0	24.8
<i>C₆: Okosi-Udu</i>										
0-13	5.2	4.03	1.60	2.29	30	3.20	0.52	81.2	7.4	11.4
13-35	5.5	2.04	1.80	3.53	49	1.94	1.19	79.2	3.4	17.4
35-61	5.5	1.57	2.20	4.22	48	1.60	0.94	73.2	5.4	21.4
61-94	5.5	1.01	2.00	2.51	20	1.37	1.45	69.2	3.4	27.4
94-180	5.7	0.43	1.40	2.93	52	3.43	1.57	73.2	3.4	23.4
<i>UK₁₄: Ikot Afanga</i>										
0-16	5.4	3.95	1.00	2.00	50	1.00	0.57	85.2	5.4	9.4
16-50	5.5	1.85	1.20	2.04	41	1.20	0.89	85.2	3.4	11.4
50-100	5.6	1.43	1.20	2.00	40	1.14	1.45	85.2	3.4	11.4
100-157	5.6	0.85	1.00	2.34	57	2.03	1.30	81.2	1.4	17.4
157-200	5.7	0.50	1.00	3.90	74	1.69	1.10	83.2	1.4	15.4
<i>L₁: Edebo</i>										
0-8	5.6	2.96	1.40	1.93	27	1.03	1.25	95.2	0.0	4.8
8-22	5.7	1.09	1.20	2.65	54	0.91	1.81	93.2	1.4	5.4
22-58	5.8	0.86	1.00	2.11	53	1.03	2.02	89.2	1.4	9.4
58-115	5.9	0.54	1.00	2.11	53	0.77	0.94	89.2	0.0	10.8
115-170	5.8	0.31	0.80	1.25	36	0.27	1.15	85.2	5.4	11.4
<i>Y₁₀: Nto Ndang</i>										
0-14	5.0	5.11	1.80	4.59	61	0.49	1.30	79.2	7.4	13.4
14-28	5.2	2.92	2.00	3.12	36	0.72	1.40	73.2	7.4	19.4
28-105	5.4	0.73	1.40	1.99	30	0.69	1.57	61.2	1.4	31.4
105-136	5.3	0.73	1.60	4.82	67	0.69	0.77	69.2	3.4	27.4
136-192	5.4	0.35	1.40	3.75	63	0.59	1.03	67.2	1.4	31.4
<i>Z₂₆: Obotme</i>										
0-15	5.6	3.24	1.40	14.06	90	1.03	1.04	60.6	15.4	24.0
15-44	5.7	1.08	1.60	18.20	91	1.56	2.07	48.6	7.4	42.0
44-80	5.7	0.77	3.00	29.93	90	1.71	2.29	40.6	19.4	40.0

EA=Exchangeable Al; ECEC=Effective cation exchange capacity; BS=Base saturation; ND=Not determined.

values ranging from 5.0 to 5.9 in the surface. Organic carbon contents which decreased with depth ranged from 0.31 to 5.11% in the surface.

The effective cation exchange capacity (ECEC) was low in soils formed from coastal plain sands, beach sand and sandstone materials, with values ranging from 1.2 to 5.9 cmol^+/kg of soil. The soils formed from river alluvium and shale parent materials had values ranging from 1.7 to 29.2 cmol^+/kg . Base saturation was correspondingly low for most of the soils with the soil from Nto Ndang giving some inconsistent trends within the profile. The content of oxalate-extractable oxides varied considerably among the soils with extractable Fe_2O_3 ranging from 0.27 to 5.19% and extractable Al_2O_3 from 0.26 to 2.26%.

FORMS AND DISTRIBUTION OF PHOSPHORUS

Total P

As shown in Table 3, total P values varied between the soils and within the profiles. Two of the soils, namely C_3 and UK_{14} , derived from coastal plain sands and B_{21} and Y_{10} derived, respectively, from river alluvium and sandstone had high total P contents ranging from 598 to 1411 mg kg^{-1} . The third profile G_6 derived from coastal plain sands and those of L_1 and Z_{26} derived respectively from beach sand and shale had relatively low contents of total P with a range of 79 to 293 mg kg^{-1} indicating low P reserves in these soils.

There was a consistent decreasing trend with depth in the distribution of total P in four of the soils, namely UK_{14} , G_6 , L_1 and Z_{26} . Total P was significantly correlated with silt ($r=0.403^*$), oxalate-extractable Fe ($r=0.501^{**}$) and negatively correlated ($r=0.501^{**}$) with oxalate-extractable Al.

Organic P

Organic P contents in these soils also varied from a value of 5.0 mg kg^{-1} in the subsoil of G_6 to 434 mg kg^{-1} in the surface horizon of C_3 . There was a general decrease of organic P with depth in line with the trend in organic carbon distribution. As a fraction of total P, organic P varied from 6.3 to 50% giving a mean of 24% of total P. Organic P was positively correlated with organic C ($r=0.414^*$) and oxalate-extractable Fe_2O_3 ($r=0.547^{**}$) and negatively correlated with oxalate-extractable Al_2O_3 ($r=0.407^*$).

Inorganic P

As shown in Table 3, the order of abundance of the active inorganic P fractions was $\text{Sal-P} < \text{Ca-P} < \text{Al-P} < \text{Fe-P}$ in all the soils formed from coastal plain sand, beach and sandstone. The sequence in these highly weathered soils con-

TABLE 3

Profile distribution of various P forms in representative soils of Akwa Ibom State

Profile depth (cm)	Total P	Org. P	Active P				Inorg. P	Reverted P	Available P	
			Sal-P	Al-P	Fe-P	Ca-P			Bray P-1	Bray P-2
----- (mg kg ⁻¹) -----										
<i>B₂₁: Ayadeghe</i>										
0-15	819	130	1.6	18.2	310.0	114.0	689	245	17.7	33.3
15-40	683	135	1.4	18.0	300.0	109.0	548	120	17.4	35.0
40-75	645	130	1.6	17.4	250.0	65.0	515	181	11.7	30.4
75-100	720	127	2.0	20.1	295.5	80.4	593	195	12.5	24.4
100-120	747	100	1.8	21.8	316.0	84.4	647	223	14.3	20.4
<i>C₃: Idu Uruan</i>										
0-2	858	434	3.2	25.0	144.6	23.3	424	228	80.0	146.6
20-60	1035	328	3.8	22.2	291.3	24.2	705	364	166.7	185.6
50-105	911	250	6.4	27.2	320.0	20.0	661	287	180.0	199.9
105-135	921	201	4.0	29.4	363.0	19.4	720	304	113.3	147.5
135-200	878	140	1.0	26.8	301.0	22.0	738	307	140.0	200.0
<i>G₆: Okosi-Udu</i>										
0-13	124	51	1.0	1.4	10.2	1.8	73	59	10.0	36.6
13-35	117	21	1.2	1.8	10.1	1.9	96	81	31.7	49.7
35-61	111	16	1.3	2.0	11.4	1.0	94	78	6.3	32.9
61-94	94	12	1.0	2.2	9.0	1.0	82	69	Trace	6.4
94-180	79	5	Trace	2.4	9.3	1.8	74	60	Trace	6.0
<i>UK₁₄: Ikot Afanga</i>										
0-16	1411	300	3.2	77.6	248.0	50.4	111	731	111.7	174.8
36-50	1229	232	3.8	98.2	283.4	65.2	997	546	188.3	203.4
50-100	884	200	3.0	90.0	300.0	73.0	648	218	136.7	198.0
100-157	795	123	1.8	97.0	226.0	87.0	672	260	103.3	150.0
157-200	749	84	1.2	94.2	203.2	111.7	665	255	142.1	188.0
<i>L₁: Edebo</i>										
0-8	241	79	Trace	3.2	22.6	2.0	162	134	4.6	11.2
8-22	169	54	Trace	2.3	13.6	2.4	115	97	1.7	5.3
22-58	145	30	Trace	4.6	11.0	2.2	115	97	1.0	6.0
58-115	127	21	Trace	5.6	12.2	2.1	106	86	1.6	5.9
115-170	107	10	Trace	9.8	13.0	2.0	97	72	1.7	9.4
<i>Y₁₀: Nto Ndag</i>										
0-14	598	280	4.3	39.2	208.0	37.0	318	30	90.0	65.0
14-28	614	260	4.2	47.0	191.0	41.2	354	71	36.7	58.4
28-105	605	99	5.0	64.0	194.0	44.0	506	199	28.3	60.0
105-136	719	92	3.8	64.8	196.2	47.2	627	315	14.5	29.6
136-192	734	83	2.9	72.0	210.0	53.0	651	313	25.0	47.5
<i>Z₂₆: Obotme</i>										
0-15	293	120	Trace	10.0	14.0	15.4	173	133	1.7	6.3
15-44	221	108	Trace	6.0	7.0	9.0	113	91	1.0	2.6
44-80	187	84	Trace	3.4	5.6	20.0	103	74	1.0	2.0

TABLE 4

Correlation coefficient (r) relating P forms and soil properties

P forms	pH (H ₂ O)	Org. C	Silt	Clay	Oxalate Fe	Oxalate Al
Total P	-0.059	0.032	0.403*	-0.021	0.501**	-0.50**
Org. P	0.001	0.414*	0.261	-0.163	0.547**	-0.407*
Al-P	-0.109	-0.048	0.092	-0.135	0.054	-0.118
Fe-P	-0.143	-0.129	0.247	0.184	0.284	-0.522**
Ca-P	-0.230	-0.079	0.359*	0.163	0.062	-0.129

* $P < 0.05$, ** $P < 0.01$.

TABLE 5

Data on phosphorus adsorption of representative soils of Akwa Ibom State

Profile	Depth (cm)	Sorptions from addition of P at 150 mg/100 g soil		$X/\log C$
		(mg/100 g)	(% adsorbed)	
B ₂₁	0-15	115.5	77.0	37.9
Ayadeghe	15-40	121.5	81.0	41.0
	40-75	83.7	55.8	25.0
	75-100	73.0	48.6	21.5
	C ₃	0-20	10.0	6.7
Idu-Uruan	20-60	30.0	20.0	8.4
	60-105	20.0	13.3	4.9
	105-135	10.0	6.7	2.7
	G ₆	0-13	38.0	25.3
Okosi-Udu	12-35	55.0	36.7	15.8
	35-61	56.0	37.3	16.1
	61-94	55.0	36.6	15.8
	L ₁	0-8	56.0	37.4
Edebo	8-22	33.0	22.0	9.2
	22-58	47.0	21.6	13.4
	58-115	50.0	33.0	16.8
	115-170	12.0	8.0	3.3
	UK ₁	0-16	1.5	1.0
Ikot Afanga	16-50	9.0	6.0	2.5
	50-100	16.5	11.0	4.6
	100-157	15.0	10.0	4.1
	157-200	7.1	4.7	1.0
	Y ₁₀	0-14	13.5	9.0
Nto Ndang	14-26	21.0	14.0	5.8
	26-105	54.3	38.2	15.5
	105-136	55.5	37.0	15.4
	136-192	60.2	40.1	17.4
	Z ₂₆	0-15	62.2	41.5
Obotme	15-44	93.4	62.2	28.0
	11-80	128.1	85.4	44.9

 $X = P$ adsorbed; $C = P$ in solution.

forms to the sequence of Chang and Jackson (1957). For the soil derived from alluvial deposits, the order was Sal-P < Al-P < Ca-P < Fe-P and for that of shale, the order of abundance was Sal-P < Al-P < Fe-P < Ca-p. These two soils were relatively high in exchangeable Ca^{2+} due to their association with shale-rich parent material.

Only Fe-P gave a negative correlation with oxalate Al_2O_3 ($r = -0.522^{**}$) as shown in Table 4. Inactive P or reverted P when expressed as mean percentage of total P accounted for 46% in coastal plain sands, 27% in sandstone and alluvium, respectively, 62% in beach sand and 42% in shale derived soils.

Available P

Available P estimates showed that the Bray P-2 method removed larger amounts of P than the Bray P-1 method in all the soils. Soil test values estimated by the Bray P-1 method for surface soils ranged from as low as 2 mg kg^{-1} to as high as 112 mg kg^{-1} , whereas for Bray P-2 estimates, it ranged from 6 to 174 mg kg^{-1} depending on the soil.

Phosphorus sorption

As shown in Table 5, the absolute amount of P sorbed from the addition of 150 mg P/100 g of soil ranged from 1.5 to 128 mg with the corresponding percentage of sorbed P ranging from 1 to 85%. Over 50% of P added was retained by the soils derived from river alluvium and shale parent materials giving index values ranging from 18.0 to about 45.0. In others the index values ranged from 0.4 to 17.4 indicating their low capacity to retain P. The P adsorption capacity of the soils was significantly correlated (Table 6) with silt ($r = 0.72^{***}$), clay ($r = 0.62^{***}$), oxalate-extractable Al_2O_3 ($r = 0.53^{**}$) and Bray P-1 (-0.61^{***}).

TABLE 6

Correlation coefficients (r) relating percent P sorbed and some soil properties

Soil properties	Correlation coefficient (r)
pH (H_2O)	-0.244
Org. C (%)	-0.019
Silt (%)	0.721 ^{***}
Clay (%)	0.618 ^{***}
Oxalate Al_2O_3	0.538 ^{**}
Oxalate Fe_2O_3	-0.190
Total P	-0.337 [*]
Bray P-1	-0.613 ^{***}

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

DISCUSSION

The values of total P in the soils studied are within the limits previously obtained by some workers in Nigeria (Enwezor and Moore, 1966; Udo and Dambo, 1979; Uzu et al., 1975; Udo and Ogunwale, 1977) as well as in other areas of West Africa (Halm and Bampee-Addo, 1972). However, the low content of total P in the soil derived from shale-rich parent material contrasts markedly with the very high value obtained by Uzu et al. (1975) in Bende soils also derived from shale parent material.

The supply of P to plants in soils is particularly governed by the content of active inorganic P and organic P fractions. Organic P fractions contribute substantially to available P reserves following mineralization in tropical soils (Sare and Udo, 1988). This phenomenon is governed by C/P ratios and the established critical limit for tropical soils is 200 (Tisdale and Nelson, 1975). In the soil under study, the C/P ratios were generally low averaging 200 in most of the soils, suggesting easy release of substantial amounts of P in available forms to crops.

Inorganic P fractions consist of active and inactive forms, the former being saloid P, Al-P, Fe-P and Ca-P while the latter includes reverted P (IMPHOS, 1980), which Chang and Jackson (1957) designated as occluded P, reductant soluble P and residual P forms.

Under upland well-drained soil conditions, the active P forms are the fractions contributing most to plant nutrition (Thomas and Peaslee, 1973) with the availability increasing in the order of Ca-P, Fe-P and Al-P. The active P fractions have also been used to assess the degree of soil development (Westin and De Brito, 1969). As a result of increasing soil acidity during soil development, Ca-P tends to change to sesquioxide-bound P, and according to Chang and Jackson (1957) the degree of chemical weathering in soils is expressed by the sequence of inorganic phosphates being Ca-P \rightarrow Al-P \rightarrow Fe-P. Based on the absolute values of inactive P (reverted P) in these soils, it can be inferred that the soils derived from coastal plain sands and sandstone parent materials are more weathered than others.

Considering the critical value for P in soils of this zone, which is 15 mg kg⁻¹ (Enwezor et al., 1990), the variations in the content of available P in the soils imply that those which tested high, far above the critical level, namely C₃, UK₁₄, Y₁₀ and B₂₁ are well endowed with P. These soils may not require P fertilizer application for increased yield of most crops since crop response to P application is not likely, whereas the reverse would be the case for soils L₁, G₆ and Z₂₆ which tested low. However, routine soil testing before any fertilizer recommendations in this zone is imperative.

The range in the adsorption values is comparatively wide in comparison with 10.5 to 26.0 obtained by Udo and Dambo (1979) for soils derived only from coastal plain sands or values of 10.0 to 23.4 obtained by Sare and Udo

(1988) in some soils of the Republic of Benin. However, Rhodes (1977) obtained a wider range of 12.56 to 59.43 for some Sierra Leone soils while a range of 5 to 64 was obtained by Bache and Williams (1971) in a wide range of British soils.

The non-significant and negative relationship between the adsorption capacity and organic carbon suggests the negative or small role of organic matter in the retention of P in these soils. This kind of relationship is important in the soil fertility management of the soils because since the soils are generally low in organic matter and inherent fertility, adequate application of organic matter is a soil management imperative. Organic matter produces the bulk of the negative charges in many of the highly weathered soils and the maintenance of a high level of organic matter in these soils constitutes one of the principal means of improving the cation exchange capacity and fertility status of the soils with attendant decrease in P fixation. Sare and Udo (1988) attributed the negative correlation between P sorption and organic C in the soils they studied to the blocking of the P adsorption sites by the relatively large organic molecules. These organic molecules are thought to compete with phosphate ions for adsorption sites. The soils derived from alluvial parent material (B_{21}) with relatively high content of total P showed a high adsorption capacity compared to those formed from coastal plain sands and sandstone parent materials with high total P contents but relatively low adsorption capacities. This soil (B_{21}), in spite of its total P content, may require some P fertilizer applications to satisfy its P adsorption and crop requirements. The soils formed from beach sand and shale parent materials with very low contents of total P and available P values tended to exhibit relatively higher P adsorption capacities. The implication is that the two soils, namely L_1 and Z_{26} , will require a larger application of P fertilizers to meet the P requirements of crops compared to the fertilizer P requirements, if any, in soils derived from coastal plain sands or sandstone which have generally lower P fixing ability but high values of available and total P.

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