GOLD COAST DEPARTMENT OF SOIL AND LAND-USE SURVEY

CONFERENCE PAPER

TOTAL PHOSPHORUS IN GOLD COAST SOILS

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TOTAL PHOSPHORUS IN GOLD COAST SOILS

Although the opinion has been expressed that total phosphorus has but little value in assessing fertility of soils (1), it is still a useful quantity in the study of translocations of phosphorus in the geochemical sense. As very little of this basic information is available with respect to Gold Coast soils, a country-wide survey was carried out to obtain data for the total phosphorus content. The survey comprises nearly all the major soils occurring in the country, but it may be mentioned that the number of profiles examined of each soil is not necessarily proportionate to the area the soil covers.

Analytical.- Literature data (2) and preliminary experiments indicated that all phosphorus can be extracted from the soils examined by heating with perchloric acid. 5 g. soil was heated on the sand bath with 30 ml. of 60 per cent. perchloric acid, until most of the excess acid was removed, the resulting solution filled up to 100 ml., centrifuged and 10 ml. = .5 g. soil of the extract used for the determination of phosphorus by the vanadomolybdate method (3). In the extraction procedure, all organic matter is completely oxidised and it was found that neither iron nor aluminium, although present in high concentrations, interfere with the determination of phosphorus. Chromium, occurring in considerable quantities in some of the soils, interferes, but this can be easily eliminated by suitable blank measurements. The Spekker photometer was used with the mercury arc lamp and the 4360 Å filter, employing 4 cm. cells. The range covers 30 to 3000 ppm. P_2O_5 in the soil, with more phosphorus a smaller aliquot was used. Reproducibility corresponds to $\pm$ 20 ppm. P_2O_5 in the soil, using a 10 ml. aliquot. Cr was determined by the procedure given by Sandell (4).

Results.- The first four morphological horizons of sixty selected profiles were examined. The overall depth of the four horizons averages about 3 ft. The results are shown in Table 1, with the corresponding amounts of organic matter for each horizon. Some profiles were examined in

Soil	Number of profiles	Depth of 4th hor. in inches	Total P_2O_5 p.p.m. Horizon 1	Horizon 2	Horizon 3	Horizon 4	organic matter% Horizon 1	Horizon 2	Horizon 3	Horizon 4
A. SAVANNAH ZONE										
Upland savannah soils, Northern Territories	8	32.9	269	234	220	208	1.45	.76	.46	.25
Red upland savannah soils, Accra Plains	3	43.3	353	273	346	358	1.96	.97	.75	.62
Black Earths, Accra Plains	5	45.6	435	365	320	348	2.40	1.67	1.06	.63
Grey Plonosols, Accra Plains	4	41.3	111	86	174	141	.96	.50	1.03	-
Vlei soils, Accra Plains	2	35.0	1702	553	491	476	4.16	1.65	1.71	-
Groundwater laterite, Northern Territories	3	35.0	853	958	1008	844	1.99	1.75	.66	.42
Alluvium, Accra Plains	1	36.0	796	727	461	598	3.10	1.70	1.00	-
TOTAL	26									
Weighted averages		38.36	484	368	368	351	1.95	1.14	.84	.44
Weighted averages, p.p.m. P			211	161	161	153				
B. FOREST ZONE										
Average forest soil	17	34.9	942	634	546	549	9.59	2.51	1.12	.90
Average forest soil, Togoland	4	33.0	880	544	525	539	6.60	1.39	.96	.67
High organic, ferruginous forest soils	11	37.6	1820	1468	1139	1059	15.26	5.56	2.42	1.45
Alluvium	2	20.0	640	303	283	233	6.33	1.40	.50	.45
TOTAL	34									
Weighted averages		33.51	1226	874	720	640	10.88	3.30	1.49	1.02
Weighted averages, p.p.m. P			535	371	314	279				

Notes: Hor.1 and Hor.2 represent the humous topsoil, Hor.3 and Hor.4 the subsoil.

Table 1.

Soil	Hor. depth in inches	pH	Org. matter %	Total P_2O_5 p.p.m.	Cr p.p.m.	$CaCO_3$ per cent.
AB 105 Swedru series: Sedentary soil over biotite gneiss. Average forest soil ('ochrosol').	0-2	7.4	9.37	1554	<200	.28
	2-5	7.3	3.84	1023	"	.07
	5-12	6.4	1.39	714	"	.01
	12-29	6.1	1.00	672	"	NIL
	29-59	5.2	.62	558	"	"
	59-78	5.4	.55	482	"	"
	78-115	5.3	.43	449	"	"
	115-128	5.2	.26	451	"	"
DBA 261 Dompim series: Drift soil, well developed ironpan ('oxysol').	0-3	4.1	10.25	1086	390	NIL
	3-8	4.4	3.29	859	407	"
	8-15	4.8	2.20	790	434	"
	15-37	5.0	1.46	962	427	"
	37-69	5.0	1.14	1108	607	"
	69-70	5.1	.52	1127	1019	"
APA 168 Akuse series: Developed over basic gneiss, semi-sedentary (Black Earth).	0-6	6.4	2.61	397	<200	.09
	6-18	6.9	1.44	299	"	.11
	18-32	8.0	.91	301	"	3.5
	32-42	8.2	.58	250	"	17.1
	42-66	8.4	.10	230	"	41.9
	66-88	8.5	NIL	739	"	15.9

Table 2.

more detail and these results are listed in Table 2. It is necessary to emphasise that individual variations within the averages of each soil group are considerable, as is the case with any soil characteristic, but the differences between groups are significant, where applicable. The Togoland forest soils, although belonging to the average forest soils, are deliberately listed separately to show the uniformity within one group. The group of highly organic, ferruginous forest soils is not only characterised by a high phosphorus content, but also by an increase of total phosphorus in the lower horizons towards the ironpan, after a minimum, and by a noteworthy accumulation of Cr.

Discussion.- The data of Table 1 leave no doubt about the dependence of phosphorus accumulation on depletion of organic matter. In the surface horizons this relation is nearly quantitative. Towards depth the amount of free iron oxides seems to have a considerable influence. The conspicuous accumulation of the mobile constituents in the upper part of the profile, so characteristic for the soils of the tropical forest, can be seen clearly also in the case of total phosphorus, and this accumulation depends little upon the reaction within the profile. Parent material, unless it represents extremes, e.g. quartzite or ultrabasic rock, has little influence upon the general pattern. The second maximum occurring in the deeper layers of the profile is unquestionably linked with the accumulation of the iron oxides, retaining a part of the phosphorus which in a normal profile would be lost by leaching. This effect of iron accumulation is well known(5).

In the normal upland soils of the savannah zone, the accumulation in the upper horizons is less conspicuous due to the lesser amount of organic matter. The general level of total phosphorus is also much lower in these soils. However, accumulation of phosphorus occurs in the groundwater laterites of this zone, showing the scavenging action of iron oxides.

Somewhat different from the general pattern are two groups of soils in the Accra Plains: the Black Earths(6) and the Grey Earths(7). Although the general trend following the distribution of the organic matter is still present, the

Black Earths are rather low on phosphorus, considering the basic igneous parent material and the favourable conditions for phosphorus retention created by the high reaction and prevalence of Ca and Mg in the exchange complex. The Grey Earths are conspicuously low on phosphorus, apparently due to the lack of primary phosphates in the parent material.

The alluvial soils of both the forest and the savannah zones do not differ from the general pattern. In the colluvial vlei soils related to the Black Earths, however, a conspicuous accumulation of phosphorus can be observed in the surface horizon, evidently linked with the accumulation of active organic matter.

The general level of total phosphorus in the soils of the forest zone corresponds to the findings of Kellogg (8) in similar soils in the Belgian Congo.

As to the question of phosphorus fertility, the number of field experiments concerning this point is small (9). Most of the experiments were carried out in the savannah zone or on the southern fringe of the forest region, thus the findings refer only to the soils of these regions. The experiments, on the whole, indicate a response to superphosphate, in agreement with the low total phosphorus content of these soils. Recent experiments on the Tropical Grey Earths showed striking responses to superphosphate (7), again in agreement with the low total phosphorus content and, in this particular case, with low Truog values. Thus it appears that in the savannah zone it may be satisfactory to correlate Truog values with field experiments as a basis for forecasting fertilizer requirements. The situation is less favourable in the forest zone. Field experiments are generally not available and in the few cases studied the responses are confusing. There is generally no or little response, particularly in case of tree crops (cocoa), and the Truog values studied on a large number of soils do not reflect the phosphorus fertility of the soil, as judged by the natural vegetation and cocoa yields. The correlation between the amount of total phosphorus and organic matter gives a strong indication that phosphorus nutrition in the soils of the forest zone is mainly linked with organic phosphorus. In this Department some preliminary investigations were carried out in past years concerning the organic phosphorus content

of the soils of the forest zone, but the results were not too conclusive because of the bad reproducibility of the results, due to the method employed. It is expected shortly to re-investigate the question in the light of the recent information available (10).

The accumulation of Cr in the ferruginous soils is in agreement with observations in other tropical regions. It is remarkable that Cr accumulates also in the groundwater laterites of the Northern Territories where no visible primary source of Cr occurs in the vicinity of the soils.

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Summary

A regional survey of the total phosphorus content of Gold Coast soils revealed a relative accumulation of phosphorus in the humus surface horizon. This is quite general, irrespective of the annual rainfall of the area. A second accumulation horizon occurs in highly ferruginous soils and in groundwater laterites. The accumulation of phosphorus in the ironpan of ferruginous soils is accompanied by the accumulation of chromium.