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RESEARCH ARTICLE

Interrelationships among phosphorus and some soil properties in soils derived on cretaceous sediments, shale and quaternary alluvium in Edo state, Nigeria

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ABSTRACT

The interrelationships between phosphorus and a few soil parameters in soils produced from Cretaceous Sediments, Shale, and Quaternary Alluvium in Edo State, Nigeria, were investigated in order to better understand possible soil limits to increasing crop yields. Samples were reserved from the profile pits sunk for each parent material type. Clay had a significant negative association with total P, organic P, and available P in soils generated from cretaceous sediment, while clay had a substantial negative link with total P and accessible P in soils created from shale. Soil pH had a substantial positive connection with total P, indicating that in quaternary alluvium soils, soil pH had a higher influence on total P. In shale-derived soils, organic carbon displayed a substantial positive connection with total P, organic P, Ca-P, and accessible P. Corrective measures are taken to improve the productive capacity of these soils in order to achieve high yields of viable crops.

Keywords: Cretaceous sediments; Interrelationships; Phosphorus; Profile pits; Quaternary alluvium; Shale.

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INTRODUCTION

In terms of value for the growth of good and high yielding crops, management of phosphorous (P) is the second to nitrogen management. Supply of natural P in soils is limited, and the P available in the soil is little (Aduloju and Abdulmumini, 2014). "Parent material is defined as the material from which soil is presumed to have been derived" (Esu, 2010). "It is also defined as the unconsolidated, chemically weathered mineral or organic matter from which the A and B horizons (Solum) of soils may have developed by pedogenic processes" (Brady and Weil, 2008).

Westin and Buntley (1966) and Irmak et al. (2007) has investigated on the phosphorus and the potassium contents of the South Dakota of United States of America soils and has found that the soil phosphorus and potassium contents are significantly affected by the parent material. Robenhorst et al. (1982) has also revealed that soils rich in magnesium (Mg^{2+}) in Maryland of the United States of America are derived from parent material rich in magnesium (Mg^{2+}). Akamigbo and Asadu (1983) have also found that the most important soil properties soil have a significant relationship with parent material. Ojanuga and Awujooba (1981) have suggested in Jos Plateau of Northern Nigeria, the types of parent material of soils are associated with exchangeable cations, cations exchangeable capacity, and clay contents in the soil.

Natural resources such as soils can't be appropriately managed without appropriate knowledge of their characteristics (Idoga and Azagaku, 2005). The soils of Edo State are derived from different parent materials whose effect on soil properties must be studied for efficient management and for effective agricultural land use. Limited studies on soil properties have been conducted in Edo State; these include the report on the distribution and forms of P in Edo State (Omoregie and Oshineye, 1998; Orhue and John, 2015). These reports only deal with the forms, status and distribution of phosphorus in their various areas of study. There is paucity of information on the interrelationship among phosphorus and some properties in the area of study. Hence, the current research aims to evaluate the physicochemical properties of the soils of Edo State and assess their relationship with phosphorus due to varying parent materials, aiming to suggest suitable remedial measures to boost the crop production.

MATERIALS AND METHODS

The present investigation was conducted in soils representative of three parent materials, namely cretaceous sediments (Ekpoma), shale (Ozalla) and quaternary alluvium (Illushi) of Edo State. These sampling places were considered for the study due to agrarian activities of the area of study and its contribution to some of the food consumption in Edo State. Ekpoma situates in latitude 06° 45'N and longitude 06° 08'E, Ozalla lies in latitude 6° 48′N, and longitude 06° 01′E and Ilushi locates in 06° 40′N and longitudes 06° 37′E. Ekpoma is a forest-savannah transition with low plain landforms, and the soils are ultisols. The major food crops grown are cassava, yam and maize. Ozalla is predominantly rainforest with undulating landforms, and the soils are alfisols. The major food crops grown are yam and maize, while Illushi is guinea savannah with flat landforms and the soils are inceptisol. The major food crops grown are yam, maize and swamp rice. The sampled locations had no history of previous chemical fertilization.

Three profile pits measuring 1.5 m x 1.4 m (2 m depth) were dug in each location in the field. Horizons were delineated according to colour according to Anderson and Ingram (1993) and Okalebo et al. (2002). Soil samples were collected from the bottom horizon to the top horizon into an adequately labelled soil bag. Data analysis were done by according to (Harry and Steven, 1995).

RESULTS AND DISCUSSION

Table 1 shows the correlation coefficient (connection) between phosphorus forms and soil physicochemical parameters in cretaceous sediment-based soils. Percent clay had a substantial negative association with total P, organic P, and accessible P in soils produced on cretaceous sediment, but had a non-significant negative link with occluded Fe/Al-P. This means that the clay in these soils will effectively immobilise the P in the soils by chelating total, organic, and accessible P.

Total P, organic P, occluded Fe and Al-P, and accessible P all demonstrated a non-significant positive connection with soil pH. The findings were consistent with Osodeke and Kamalu's report from 1992. Saloid P, Ca-P, Al-P, and Fe-P all demonstrated a negative non-significant connection with it. Organic carbon and organic P revealed a substantial positive connection (r = 0.891*). This was also in line with Agboola and Oko's (1976) findings, which said that there is a "significant association between soil organic matter and organic P for soils of Western Nigeria," demonstrated a non-significant positive connection with calcium. This pattern was also noticed by Osodeke and Kamalu (1992).

Total P and organic P demonstrated a strong positive relationship with manganese. This could be owing to the synthesis of organic chelates with P in the parent materials' soils. This is an agreement of previous findings of Enwenzor et al. (1989), who found that accessible P is influenced by a variety of parameters including pH, Mn, free oxides of Fe and Al, and parent materials, among others.

Table 1. Correlation coefficient (relationship) among phosphorus forms and soil physico-chemical properties in soils formed on cretaceous sediment

	Total P	Organic P	Saloid P	Ca-P	Al-P	Fe-P	Occ. Fe & Al-P	Occluded P	Available P
Clay	-0.937*	-0.987**	0.419	0.283	0.436	0.644	-0.683	0.664	-0.934*
pH	0.585	0.553	-0.655	-0.506	-0.036	-0.282	0.061	-0.833	0.542
O.C	0.878	0.891*	-0.171	-0.225	-0.182	-0.432	0.688	-0.599	0.737
Ca	0.312	0.265	-0.435	-0.430	-0.366	-0.307	-0.227	-0.331	0.397
Mg	-0.646	-0.739	0.041	-0.095	0.172	0.421	-0.802	0.334	-0.594
K	-0.053	0.069	0.442	0.470	-0.706	-0.418	0.340	0.754	0.185
Mn	0.962*	0.943*	-0.377	-0.439	-0.321	-0.527	0.503	-0.734	0.861
Fe	-0.399	-0.748	0.677	-0.472	0.646	0.977**	-0.869	0.280	-0.861
Zn	0.948*	0.792	0.172	-0.564	-0.497	-0.385	-0.453	-0.715	-0.087
Cu	0.215	0.009	-0.329	-0.688	0.527	0.385	-0.453	-0.715	-0.087
ECEC	-0.101	-0.216	-0.300	-0.426	0.027	0.133	-0.607	-0.192	-0.100

Table 2 shows the link between phosphorus forms and soil physicochemical parameters in soils developed on shale parent material. Total P and accessible P demonstrated a substantial negative connection with percent clay (r = -0.869 and r = -0.830, respectively). This means that when the percent clay content rises, the total P and accessible P become fixed and unusable. This was consistent with Tening et al. (2013)'s findings, which found a negative significant connection and ascribed P-fixation to soil pH and clay concentration.

Total P, organic P, Ca-P, and accessible P all demonstrated a substantial positive connection with organic carbon. This implies that organic phosphorus and the total P content of the soil are heavily controlled by organic carbon. It also means that as the organic matter in the soil mineralizes, total P, organic P, and accessible P are released for plant use. The soil organic matter as a chief source of P in the parent materials' soils is highlighted by the fact that it had a strong and positive relationship with both organic and accessible P in this study. This pattern corresponded to previous findings by Agboola and Ayodele (1983); Akinrinde and Obigbesan (2000); Aduloju and Abdulmumini (2014), who found that organic P is a key predictor of P availability. Ohaeri and Eshett had also observed similar findings (2011). Morris et al. (1992) found a positive connection between millet phosphorus uptake and organic P in a Sri Lankan alfisol. Organic P was main P component released during the mineralization process and taken up by plants, according to Brady and Weil (2002). Total P, organic P, Ca-P, and accessible P all demonstrated a substantial positive connection. As a result, the connection is a predictor of the relative form of P availability in the soil due to the presence of macronutrients. Potassium exhibited a substantial positive association with total P, organic P, and accessible P (r = 0.887, r = 0.955, and r = 0.933), while magnesium had a significant positive link with organic P (r = 0.890).

Manganese had a positive correlation with total P, organic P, Ca-P, Al-P, and available P among the micronutrients, while iron had a negative association with Al-P and Fe-P. Zinc had a positive association with total P. This could possibly be related to the synthesis of organic chelates with P in the parent materials' soils. Enwenzor et al. (1989), found that accessible P is influenced by a variety of parameters including pH, Mn, free oxides of Fe and Al, and parent materials, among others. Copper demonstrated a substantial negative connection with occluded Fe and Al-P, implying that occluded Fe and Al-P in soils generated on this parent material may bind up Cu as chelates, rendering it inaccessible for plant use. Total P, organic P, Ca-P, and available P all had a significant positive relationship with ECEC.

Table 3 shows the link between phosphorus forms and soil physicochemical parameters in quaternary alluvium soils. ECEC had a substantial positive association with accessible P, but soil pH had a positive link with total P. The considerable positive association between soil pH and total P indicates that soil pH has a higher influence on total P, implying that when soil pH rises, the total P content of the soil rises as well. This finding is consistent with Ruhal and Ram (1979), who found a substantial positive connection between pH and total P.

Table 2. Correlation coefficient (relationship) between phosphorus forms and soil physicochemical properties in soils formed on shale

	Total P	Organic P	Saloid P	Ca-P	Al-P	Fe-P	Occ. Fe & Al-P	Occluded P	Available P
Clay	-0.869*	-0.775	-0.012	-0.689	-0.765	-0.626	-0.652	0.149	-0.830*
pH	0.562	0.245	-0.082	0.211	0.680	0.777	-0.006	0.646	0.297
O.C	0.913*	0.984**	-0.329	0.907*	0.803	0.480	0.187	-0.382	0.980**
Ca	0.874*	0.980**	-0.331	0.856*	0.740	0.377	0.241	-0.464	0.969**
Mg	0.674	0.890*	-0.388	0.804	0.543	0.117	0.208	-0.587	0.858
K	0.887*	0.955**	-0.461	0.781	0.803	0.420	0.056	-0.282	0.933**
Mn	0.959*	0.986**	-0.336	0.912*	0.875*	0.571	0.190	-0.271	0.989**
Fe	-0.803	-0.551	0.189	-0.490	-0.869*	-0.842*	-0.047	-0.434	-0.594
Zn	0.932*	0.994**	-0.367	0.906*	0.840*	0.495	0.207	-0.325	0.991**
Cu	-0.523	-0.632	-0.266	-0.530	-0.268	-0.125	-0.875*	0.728	-0.663
ECEC	0.818*	0.961**	-0.346	0.857*	0.682	0.304	0.214	-0.518	0.944**

Table 3. Correlation coefficient (relationship) between phosphorus forms and soil physico-chemical properties of soils formed on quaternary alluvium

	Total P	Organic P	Saloid P	Ca-P	Al-P	Fe-P	Occ. Fe & Al-P	Occluded P	Available P
Clay	-0.067	0.359	0.355	0.045	0.170	0.337	-0.289	0.301	0.448
pH	0.771*	-0.581	-0.048	0.015	0.186	-0.330	0.454	-0.278	-0.491
O.C	0.664	-0.686	0.168	-0.123	0.351	-0.533	0.415	-0.157	-0.422
Ca	0.490	-0.548	0.266	0.100	0.428	-0.239	1.000	0.054	-0.010
Mg	0.618	-0.544	0.094	0.008	0.230	-0.332	0.133	-0.002	-0.121
K	0.714	-0.553	-0.220	-0.045	-0.049	-0.538	0.698	-0.538	-0.697
Mn	0.575	-0.433	0.192	-0.025	0.237	-0.343	0.178	-0.025	-0.090
Fe	0.175	-0.346	-0.161	-0.149	0.068	-0.230	0.380	-0.214	-0.550
Zn	0.493	-0.471	0.320	-0.010	0.402	-0.271	0.012	0.132	0.036
Cu	0.396	-0.056	0.556	-0.275	0.546	0.097	0.015	0.427	0.071
ECEC	-0.290	-0.164	0.149	0.060	0.012	-0.189	-0.750	0.550	0.797*

CONCLUSION

Clay demonstrated a substantial negative connection with total P, organic P, and accessible P in soils produced on cretaceous substrate. Clay demonstrated a substantial negative connection with total P and available P in soils grown on shale, indicating that clay in these soils may bind total P, organic P, and available P as chelates, rendering them unavailable to crop plants. Organic manure, with or without inorganic P-fertilizer, would expand the accessibility of phosphorus to plant crops on these soils. Because the organic matter content of these soils has a significant impact on phosphorus availability, efforts should be made to conserve soil organic matter content. Overgrazing, bush burning, and tillage are examples of activities that expose the topsoil and speed up soil organic matter mineralization. Soil test-based fertilisation might be recommended to avoid nutrient toxicity or imbalance.

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