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INFLUENCE OF POULTRY MANURE ON PHOSPHORUS SORPTION CHARACTERISTICS IN SELECTED ALFISOLS OF BENUE STATE, NIGERIA

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ABSTRACT

Phosphate sorption studies was carried out at the University of Agriculture Makurdi to determine the influence of poultry manure on Phosphorus sorption in some Alfisols of Benue State. Surface soil samples (0 - 20 cm) were collected from three different locations in Benue State (Daudu, TseKough and Ayange) and Poultry manure sourced from the University of Agriculture Makurdi Livestock Teaching and Research Farm. The physical and chemical properties of the soils and poultry manure were determined using standard procedures. Phosphate sorption characteristics of the soils and the influence of poultry manure was determined by equilibrating 5 g sub samples of 2 mm sieved soils from each location in two sets of 60 cm^3sample bottles. Volumes of 40 $cm^3$of 0.01 M $CaCl_2$ solution containing 0, 15, 25, 40, 100, 200, 400, and 800 mg l^{-1}P as K_2HPO_4 were distributed to each set of the sample bottles. Poultry Manure was added to one set at the rate of 6 t ha^{-1}(11.85 g) and the other set left without poultry manure and the soils incubated for 6 weeks after which the samples were equilibrated. The supernatant was filtered and P in the solution analyzed by the modified method of Murphy and Riley. The Freundlich adsorption equation was used to evaluate the adsorption data. Results indicate that the adsorption capacities of the soils were 35.58 mg kg^{-1} for Daudu, 35.43 mg kg^{-1} for TseKough and 33.12 mg kg^{-1} for Ayange. Addition of poultry manure however, reduced the adsorption capacities of the soils to 33.10 mg kg^{-1}, 34.26 mg kg^{-1} and 33.00 mg kg^{-1} representing 6.97 % decrease for Daudu soil, 3.36 % for TseKough and 0.36 % for Ayange. The phosphorus buffering capacities (PBC) of the soils ranged from 115.26 mg kg^{-1} at Tse-Kough, 126.33 mg kg^{-1} at Ayange to 130.28 mg kg^{-1} at Daudu. Upon addition of Poultry manure, PBC increased to 126.28 $mgkg^{-1}$,137.85 mg kg^{-1} and 133.65 mg kg^{-1} for Tse-kough Ayange and Daudu respectively. It was concluded that addition of poultry manure would increase the phosphate buffering and reduce the adsorption capacities of the soils.

Keywords: Sorption, Poultry Manure, Alfisols, Buffering Capacity, Adsorption Capacity

1. INTRODUCTION

Phosphorus (P) is a macronutrient that plays a number of important roles in plant. Adequate phosphorus results in higher grain production, improved crop quality, greater stalk strength, increased root growth and earlier crop maturity. Warren (1992) stated that phosphorus deficiency is one of the largest constraints to food production in tropical African soils due to low native P and high fixation by iron and aluminum oxides. This leads to the need for large applications of fertilizer P to achieve high yields of arable crops (Warren, 1994; Agbenin and Tiessen, 1995). However, for most smallholder farmers with limited resources, high P deficiency is a factor most limiting to crop productivity because of its high cost and scarcity (Warren, 1994; Nziguheba*et al.*, 1998).

Greater dependence on chemical fertilizers for nutrients' supply to plants, consequent growing concern for degrading soil health coupled with escalating fertilizer prices has renewed interest in the use of manures for recycling of plant nutrients. Organic waste can be a valuable and inexpensive fertilizer and source of plant nutrients. Positive effects of organic waste on soil have been reported in several studies (Hue *et al.*, 1994; Nziguheba*et al.*, 1998). Poultry litter is one of such manure rich in mineralizable phosphorus (Sims and Wolf, 1994). However, their solitary application can hardly meet the nutrient (phosphorus) requirement of high yielding crop cultivars.

Therefore Information on the availability of phosphorus following organic waste addition to soil may help for better management of P fertilization of crops with respect to plant growth and environment protection (Scherer, 2004).Based on this information, the present study was carried out

- To determine the phosphorus sorption characteristics of the soils under study.
- To determine the influence of poultry manure on Phosphorus sorption characteristics of the soils under study.

2.0 MATERIALS AND METHODS

The study involved laboratory studies and sorption experiments which were carried out at the Advanced Analytical Soil Laboratory of the Department of Soil Science, University of Agriculture Makurdi. Surface soil samples (0 - 20 cm) were collected from three different locations in Benue State (Daudu, TseKough and Ayange); these soils were earlier classified as Alfisols(Table 1). Poultry manure was sourced from the University of Agriculture Makurdi Livestock Teaching and Research Farm.

2.1 Routine Soil Analysis

The collected soil samples were air-dried and ground to pass 2 mm sieve. Soil pH was determined in a 1:1 soil-water suspension by the glass electrode method, particle size analysis by the hydrometer method of Bouyoucos (1951) in which sodium hexametaphosphate (Calgon) was used as dispersing agent. Total organic carbon by the chromic acid oxidation procedure of Walkley and Black (1934), exchangeable bases by the neutral ammonium acetate saturation. Na and K in the extracts were determined by the flame photometer while Ca and Mg were determined with the Atomic Absorption Spectrophotometer (AAS), exchange acidity by the 1 M KCl extraction and 0.01M NaOH titration. Nitrogen in the samples was determined by the Marco Kjeldahl method, Free Fe and Al oxides (Total oxides) were extracted by the citrate dithionate – bicarbonate method (Mebra and Jackson, 1960). Iron and Aluminum oxides in the extracts were determined with an Atomic Absorption Spectrophotometer (AAS) at 248.3 nm and 396.1nm wavelengths respectively.

Table 1:Soil Classification of the Study Sites

S/N	Location	GPS Coordinates	Soil Class
1	Daudu	N 7^0 55.06’, E 8^0 35.74’	TypicPaleustalf (USDA) OrthicLuvisol (FAO)
2	Tsekough	N 7^0 28.83’, E 8^0 37.35’	TypicHaplustalf (USDA) OrthicLuvisol (FAO)
3	Ayange	N 7^0 20.00’, E 8^0 34.00’	Aquichaplustalf (USDA) Orthicluvisol (FAO)

Source: FDALR, 1990

2.2 Poultry Manure Analysis

Cured poultry manure that was used in the experiment was air dried and ground to pass 2 mm sieve. The ground poultry manure sample was analysed for pH in a 1:1 manure-water suspension using a pH meter, N using the Marco Kjeldal method of Isaac and Johnson (1985), Total organic carbon by the chromic acid oxidation procedure of Walkley and Black (1934) and total P by the H_2SO_4 digestion method (Mehra*et al.*, 1954). Ca and Mg were determined using Atomic Absorption Spectrophotometer (AAS) while K and Na was determined using flame photometer.

2.3 Phosphorus Sorption Studies

Phosphate sorption characteristics of the soils and the influence of poultry manure on them was determined by placing 5 g sub samples of the 2 mm sieved soils from each location in two sets of 60 cm^3 sample bottles. Volumes of 40 cm^3 of 0.01 M $CaCl_2$ solution containing 0, 15, 25, 40, 100, 200, 400, and 800 mg l^{-1} P as K_2HPO_4 were distributed to each set of the sample bottles as described by Dear *et al.*(1992).

Poultry Manure was added to one set at the rate of 6 t ha^{-1} (11.85 g) and the other set left without poultry manure addition. Two drops of toluene was added to avoid microbial growth and the soils were incubated for 6 weeks. After the incubation period, the samples were equilibrated by shaking for 24 hours and then centrifuged for 10 minutes at 2000 rpm at 4^0 C in a refrigerated centrifuge. Thereafter the supernatant was filtered through a Whatman’s number 42 filter paper and P in the solution analyzed by the modified method of Murphy and Riley (Watanabe and Olsen, 1965) as reported by Page *et al.*, (1982).

Phosphate sorbed was calculated as the difference between the concentration of added P and P in solution. The Freundlich adsorption equation which expresses an empirical relation between the amount of a substance adsorbed (K) per unit mass of the adsorbent (Q) and the aqueous concentration (C) was used to evaluate the adsorption data. The Freundlich equation is given by

Log Q = Log K + 1/n Log C (Russel and Prescott, 1916)

Where

Q is the amount of P adsorbed in $mgkg^{-1}$

C is the equilibrium concentration in mg l^{-1}

K and n are empirical constants, as K is a measure of the adsorption capacity

Phosphorus Buffering Capacity (PBC) was calculated from sorption curves as the slope of the regression equation relating P sorbed to the logarithm of the P concentration of the supernatant solution (Moody *et al.*, 1990)

3.0 RESULTS

3.1 Properties of the Experimental Soils

Some selected properties of the experimental soils are shown on Table 2. pH (H_2O) values ranged from 5.00 at Daudu to 5.98 at TseKoughindicating that the soils are acidic. Clay content varied from 139 g kg^{-1} at TseKough to 173.2 g kg^{-1} at Daudu. The threeexperimental soils were all sandy loam in texture. Organic matter content varied from 15.6 g kg^{-1}at Ayange to 16.4 g kg^{-1} at Daudu which had the highest organic matter content. Fe_2O_3 ranged from 8.0 g kg^{-1}at Ayange to 19.0 g kg^{-1} at Daudu. TseKough had the least Al_2O_3 content (10.0 g kg^{-1}) while Ayange soils had the highest value (12.0 g kg^{-1}). Available P values ranged from 5.20 mg kg^{-1} at TseKough to 7.21 mg kg^{-1} at Ayange. Results also showed that cation exchange capacity (CEC) varied from 6.20cmol kg^{-1} at TseKough to 6.52 cmol kg^{-1}at Ayannge. The three soils all had high base saturation (> 80 %)

3.2 Properties of Poultry Manure

Selected properties of the poultry manure used in the experiment are as shown on Table 3. Results indicate that the pH of the manure is near neutral and has appreciable amount of organic carbon content with Calcium been the most abundant (7.40 cmol kg^{-1}) of the exchangeable cations.

Table 2: Physical and Chemical Properties of the Experimental Soils

Soil property	Daudu	TseKough	Ayange
pH (1:1)	5.00	5.98	5.68
Sand (g kg^{-1})	695	730	726
Silt (g kg^{-1})	131.8	131	124
Clay (g kg^{-1})	173.2	139	150
Textural class	SL	SL	SL
Organic C (g kg^{-1})	9.5	9.3	9.0
Org matter (g kg^{-1})	16.4	16.1	15.6
N (%)	0.09	0.10	0.09

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Available P (mg kg^{-1})	6.01	5.20	7.21
Ca (cmol kg^{-1})	3.75	3.57	3.85
Mg (cmol kg^{-1})	1.50	1.54	1.40
K (cmol kg^{-1})	0.27	0.29	0.26
Na (cmol kg^{-1})	0.69	0.58	0.60
CEC (cmol kg^{-1})	6.22	6.20	6.52
B.S (%)	99.84	96.45	93.71
Exch A.	0.02	0.02	0.02
Fe_2O_3(g kg^{-1})	19.0	12.0	8.0
Al_2O_3(g kg^{-1})	11.0	10.0	12.0

*SL = Sandy Loam

Table 3: Properties of the Poultry Manure used in the Experiment

Parameter	Value
pH (1:1)	6.80
N (g kg^{-1})	50.2
P (mg kg^{-1})	5.00
K (cmol kg^{-1})	0.90
Ca (cmol kg^{-1})	7.40
Mg (cmol kg^{-1})	0.52
Na (cmol kg^{-1})	0.98
Org C. (g kg^{-1})	121.0

3.3 Phosphorus Sorption Study

The sorption characteristic of Daudu soil indicates that the soil has some capacity to sorb P. The quantity of P sorbed increased with the concentration of added P. However, the percentage of P sorbed decreased as the concentration of added P was increased. The percentages of added P adsorbed were 95.38%, 93%, 82.05% 79.10% 75.25% 56.87 % and 52.42 % when 15, 25, 40, 100, 200, 400 and 800 mg P kg $^{-1}$ were added respectively. The set of soils with poultry manure addition gave lower percentages of P sorbed at all the levels of P added. The percentages were 91.55 %, 87.90 %, 79.50 % 75.10 %, 70.82 % 53.40 % and 48.20 %. The percentage decrease in adsorption of P upon poultry manure addition to 15, 25, 40, 100, 200, 400 and 800 mg P kg $^{-1}$ were 4.05 %, 5.46 %, 3.11 %, 5.10 %, 5.89 %, 6.10 % and 8.05 % respectively with an average of 5.39 %. The P sorption isotherm for the Daudu soil is presented on Figure 1.

The TseKough soils demonstrated some capacity to hold P. the quantity of P sorbed increased with increasing concentration of P in solution while the percentages of P sorbed decreased as the concentration of added P was increased just like the Daudu soil. The percentages of P sorbed were 98.40 %, 88.21 %, 82.47%, 73.58%, 72 %, 62.12% and 52 % when 15, 25, 40, 100, 200, 400 and 800 mg P kg $^{-1}$ were added respectively. However, the percentages of P sorbed of the samples with poultry manure addition were lower. These percentages were 96 %, 87.1 %, 80.45 %, 70.56 %, 69.98 %, 60.10 % and 49.50 % when 15, 25, 40, 100, 200, 400 and 800 mg P kg $^{-1}$ were added respectively. The percentage decrease in the amount of P adsorbed when poultry manure was added to 15, 25, 40, 100, 200, 400 and 800 mg P kg $^{-1}$ were 2.44 %, 1.22 %, 2.46 %, 4.10 %, 2.81 %, 3.25 %, and 4.81 % respectively with an average value of 3.01 %.The P sorption isotherm for the TseKough soil is shown on Figure 2.

The Ayange soilalso demonstrated some capacity of P adsorption. 98.43%, 91.50 %, 88.21%, 80.40 %, 76.50 %, 60.59 % and 58.50 % of P were adsorbed when 15, 25, 40, 100, 200, 400 and 800 mg P kg $^{-1}$ were added respectively. However, the set of samples with poultry manure addition had 95.46 %, 88.40 %, 85.50 %, 78.10%, 73.20 %, 58.50 %, and 54 % when 15, 25, 40, 100, 200, 400 and 800 mg P kg $^{-1}$ were added respectively. Percentage decrease observed upon addition of poultry manure to 15, 25, 40, 100, 200, 400 and 800 mg P kg $^{-1}$ were 2.98 %, 3.41 %, 3.06 %, 2.86 %, 4.31 %, 3.45 %, 7.69 % respectively with an average of 3.97 %. The P sorption isotherm for Ayange soil is presented on Figure 3.

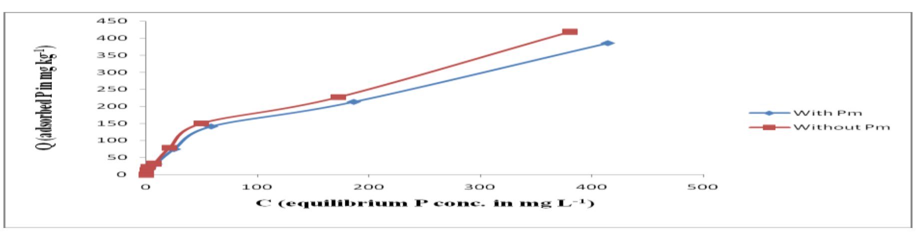

Figure 1: Sorption Isotherm for Daudu Soil

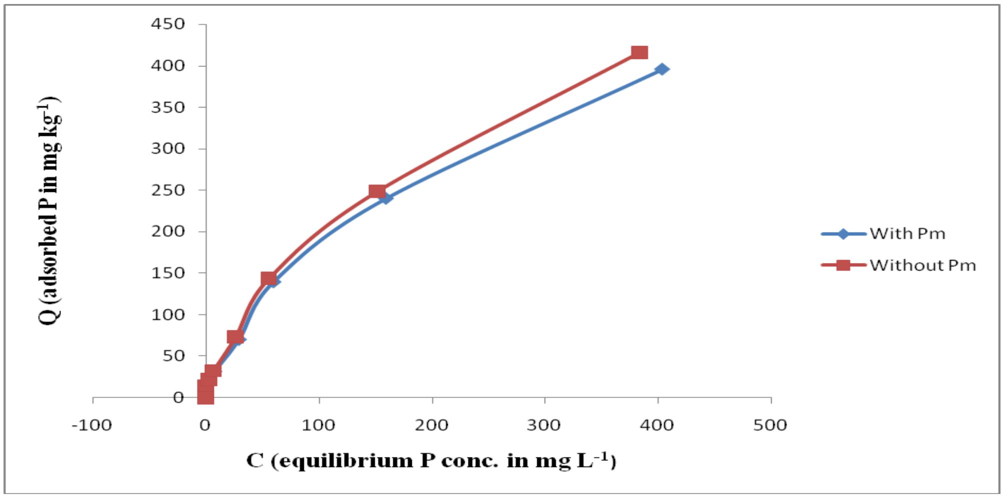

Figure 2: Sorption Isotherm for TseKough Soil

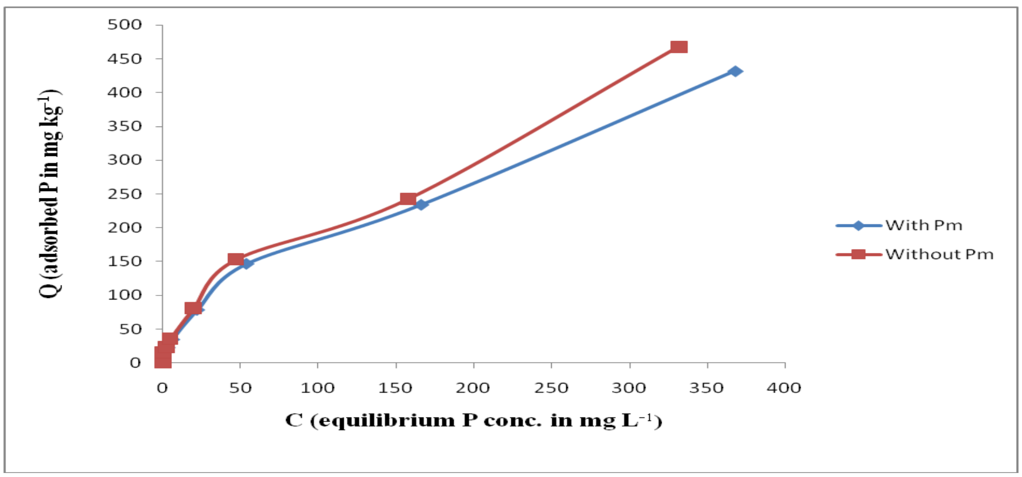

Figure 3: Sorption isotherm for Ayange soil

3.4 Phosphorus Buffering Capacity of the Soils

The phosphorus buffering capacities of the soils calculated from the sorption curves as the slope of the regression equation relating P sorbed to the logarithm of the P concentration in the supernatant solution are presented on Table 4. The P buffering capacities of the soils ranged from 115.26 mg kg^{-1} at Tse-Koughto 130.28 mg kg^{-1} at Daudu. Ayange had 126.33 mg kg^{-1}, Upon Poultry manure addition, increase in the PBC values of the soils was observed. The PBC of the Daudu soil increased to 133.65 mg kg^{-1}, Tse-Kough to 126.28 $mgkg^{-1}$ and Ayange to 137.85 mg kg^{-1}.

3.5 Phosphorus Adsorption Capacity of the Experimental Soils

The phosphorus adsorption capacities of the soils under study are shown on Table 5. P adsorption values for these soils ranged from 33.12 mg kg^{-1}at Ayange to 35.58 mg kg^{-1} at Daudu.

TseKough had 35.45 mg kg^{-1}. For soil samples with poultry manure addition, the P adsorption capacity of the soils decreased narrowly ranging from 33.00 mg kg^{-1} at Ayange to 34.26 mg kg^{-1} at TseKough. Daudu soil had 33.10 mg kg^{-1}. The percentage decrease in the adsorption capacity of the soils upon poultry manure addition were 6.97 % for Daudu soil, 3.36 % for TseKough and 0.36 % for Ayange.

Table 4: Phosphorus Buffering Capacity of the Soils

Location	PBC (mg kg^{-1})	PBC (mg kg^{-1}) With Pm Addition
Daudu	130.28	133.65
TseKough	115.26	126.28
Ayange	126.33	137.85

*Pm = Poultry manure, PBC = Phosphorus buffering capacity

Table 5: Phosphorus Adsorption Capacity (K) of the Experimental Soils

Location	K (mg kg^{-1})	K (mg kg^{-1}) (With Pm addition)
Daudu	35.58	33.10
TseKough	35.45	34.26
Ayange	33.12	33.00

*Pm = Poultry manure, K = Adsorption capacity

4.0 DISCUSSION

The properties of the soils indicate that the soils are acidic and this confers on these soils the tendency to sorb P. The soils were generally low in potassium, organic carbon content and total Nitrogen content this may be due to the practice of slash and burn which is still very common in the state and the seasonal indiscriminate burning of vegetation by wild fires (Anjembe, 2004) which prevents the formation of organic matter which is also the store house of most nutrients. The results agrees with the observation of Aduayi*et al.*, (2002) that most Nigerian soils are deficient in nitrogen, phosphorus and potassium, where for these elements less than 1.5 g kg^{-1} Total N, less than 8 mg kg^{-1} (Bray- 1 P) and less than 0.20 C molkg^{-1} K are considered respectively to be below critical levels. Available P in the soils was low (5.20 – 7.21 mg kg^{-1}).

The differences in clay, Fe_2O_3, and Al_2O_3 content of the soils may have been responsible for the differences observed in their sorption behaviour.

The phosphorus sorption isotherms of the three soils were similar (concave shape) indicating similarity in the nature of adsorption reaction, but differed in the intrinsic characteristics such as the slopes of the isotherms and adsorption capacity. The slopes of the sorption curves showed that the amount of P sorbed by the soils differed. P-sorption and equilibrium P-concentrations tended to increase with increasing levels of added P in all the soils. The possible major factors affecting the P-sorption of these soils can be ascribed to some properties of the soils such as clay content, initial P content and the presence of oxides of Iron and Aluminium. This result was in conformity with the reports of Anjembe*et al.* (2014) who ascribed sorption behaviour of some Benue soils to factors such as organic matter content; initial P content and clay content which could have provided active sites for P sorption.

In all the soils, the adsorption isotherms obtained could be conveniently divided into three regions corresponding to distinct stages in soil soil phosphate interaction as suggested by Olsen and Khasawneh (1980). The first region corresponding to low phosphate additions resulting in practically complete adsorption or a negligible fraction of the added P remaining in solution causing the isotherm to rise steeply. The second region is the strongly curved portion of the isotherm. Bache (1964) showed that adsorption in this region varies logarithmically with the equilibrium phosphate concentration. The third portion approaches linearity and occurs at medium to high phosphate concentration. Here the adsorption varies linearly with the amount of phosphate in the equilibrium solution.

The Phosphorus buffering capacity of the soils shows that the soils exhibited different buffering capacities with the Daudu soil having the highest value (130.28 mg kg^{-1})this means that the Daudu soil have greater ability to maintain and sustain a relatively stable P concentration in the soil solution throughout the growing period. In other words they have the ability to maintain a balance between the solid phase P and P in solution. With the addition of poultry manure the soils Phosphorus buffering capacities increased probably due to the solubilizing effects of decomposing products of the manure which releases P that has been fixed in the soil for long as well as a result of the P that is been added as the poultry manure decomposes (Staunton and Leprince, 1996).

The phosphorus adsorption capacity of the soils showed that the soils had different sorption capacities with the Daudu soil having the highest adsorption capacity (35.58 mg kg^{-1}) and Ayange the least (33.12 mg kg^{-1}). The implication of this is that the Ayange soil will require less P fertilization to achieve optimum level of production while more Phosphate fertilization will be required for the Daudusoils. This is in conformity with earlier reports by Hakim (2002) and Udo (1985).There are inconsistent reports on the effects of organic matter on P adsorption as it could be increased, decreased or not affected at all (Zhao *et al*., 2006). However, for the soils under study, poultry manure addition decreased the sorption capacity of these soils with the sorption curves lying below the sorption curves of samples with no poultry manure addition. This may be due to interactions generated by decomposition products from the poultry manure such as humic and citrate acids which have been reported to have great affinity for Al and Fe oxides than for phosphates (Violante and Huang, 1989; Staunton and Leprince, 1996). Other studies have shown that when poultry manure, cattle and goat manure are applied to highly weathered tropical soils, the P adsorption efficiency and P buffering capacity decreased with an increasing incubation period (Azeez and Averbeke, 2011). However, in the present study, the addition of poultry manure brought a drop in adsorption capacity of the soils and an increase in the P buffering capacity. The higher the buffering capacity, the larger the proportion of P in the solid phase relative to solution phase; increasing buffering capacity also lowers the rate of dissolution of P and vice – versa (Holford, 1989).

CONCLUSION AND RECOMMENDATIONS

Conclusion

- The soils varied in their P adsorption capacities with Daudu soilsshowing relatively higher P adsorption compared to the other soils and would therefore react differently to applied P.
- The addition of Poultry manure reduced P adsorption capacities of all the soils by varying percentages and increased the phosphorus buffering capacities of the soils.
- The Daudu soilwith the highest adsorption capacity (35.58 mg kg^{-1}) will require more P fertilization than the Ayange soils which had the least (33.12 mg kg^{-1}).

Recommendations

- Sorption indices of soils should be taken into consideration for an efficient fertilizer P management program.
- The use of poultry manure for fertilizer P management program is encouraged as poultry manure which would have constituted environmental problems could be used to supply P to crops and as well reduce the adsorption capacity of soils.

REFERENCES

Aduayi, E. A,V. O. Chude, B. A. Adebusuyi and S.O. Olayiwola eds.(2002). Fertilizer use and management practices for crops in Nigeria. 3rd ed. S.B.Garko international limited. 67-70.

Agbenin, J. O., Tiessen, H. (1995). Phosphorus forms in particle-size fractions of a toposequence from northeast Brazil. *Soil Science Society of America Journal* 59, 1687–1693.

Anjembe, B. C. (2004). Evaluation of Sulphur status for groundnut production in some selected soils of Benue state, Nigeria. M.Sc Thesis.University of Agriculture, Abeokuta, Nigeria.70 pp.

Anjembe, B., Adejuyigbe C.O and Ibrahim F. (2014) Influence of Soil Properties on P Sorption Characteristics and Yield of Soybean (Glycine Max (L) Merr.) in Some Alfisols in Benue State, Nigeria. *International Journal of Innovative Research and Development.* 3 (5):224-230

Azeez, J.O. & Van Averbeke, W. (2011).Effect of manure types and period of incubation on phosphorus-sorption indices of a weathered tropical soil.*Communications in Soil Science and Plant Analysis*. 42: 2200-2218.

Bache, B.W (1964). Aluminum and iron phosphate studies relating to soils. II. Reactions between phosphate and hydrous oxides. *Journal of Soil Science*. 15:110-116.

Bouyoucos G.H (1951) A recalibration of the hydrometer method for making mechanical analysis of soils.*Agronomy journal*. 43:434-438

Dear B.S., Helyar, K.R., Muller, W.J and Loveland, B (1992). The P fertilizer requirements of subterranean clover, and the soil P status, sorption and buffering capacities from two P analyses, *Australian Journal of Soil Research*. 30: 27-44

Federal Department of Agricultural Land Resources (1990). Soils report IV: 76 – 132

Hakim, N. (2002). Organic matter for increasing P fertilizer use efficiency of maize ultisol by using 32P technique. Symposium No. 59, paper No. 229.*World Congress on Soil Science Bangkok, Thailand, 14 -21 August, 2002.*

Holford, I. C. R. (1989).Phosphorus behavior in soils.*Agricultural Science*. 12: 15- 20.

Hue N.V, Kawa H., Silvia J.A (1994).Increasing plant available phosphorus in an ultisol with yard waste compost.*Communications in Soil Science and Plant Analysis 25: 3292-3303*

Isaac, R. A. and W. A. Johnson (1985). Elemental analysis of plant tissue by plasma emission spectroscopy: Journal of Association of official Analytical Chemists. 68 (3): 499.

Iyamuremye, F., Dick R. P. (1996).Organic amendments and phosphorus sorption bysoils.*Advances in Agronomy* 56: 139–185

Mebra, O.P and M.I Jackson (1960). Iron oxide removal from soils and clays by a dithionate-citrate system buffered with sodium bicarbonate. Proceedings of 7th National Conference on clays and clay minerals.Paragon press, New York.Pp 317 – 327.

Mehra N.O Legg, J.C, Goring CAI & Black CA (1954). Determination of organic phosphorus insoil: 1. Extraction methods. *Soil science society of America proceedings* 18: 443-449.

Moody P.W, Dickson T, Dwyer J.C and Compton B.L (1990).Predicting yield responsiveness and phosphorus fertilizer requirement of soybeans from soil tests.*Australian Journal of Soil Research* 28: 399-406.

Nziguheba, G., Palm, C. A., Buresh, R. J., Smithson, P. A. (1998). Soil phosphorus fractions and adsorption as affected by organic and inorganic sources.*Plant and Soil* 198: 159-168.

Olsen, S. R. and Khasawneh, F. E. (1980). Use and limitations of physical-chemical criteria for assessing the status of phosphorus in soils In: The Role of phosphorus in Agriculture. ASA-CSSA-SSSA, 677 South Segoe Road. Madison. WI 53711,USA.

Page A.L, R.H Miller, and D.R Keeney (eds) (1982) methods of soil analysis part 2, chemical and microbiological properties 2nd edition, agronomy 9: *Soil Science Society of America*. Madison, USA. (9): 539 – 579.

Russel, E. J. and Prescott, J. A. (1916).The reaction between dilute acid and the phosphorus compound of the soil.*The Journal of Agricultural Science-Cambridge*. 8:65-110.

Scherer, H.W. (2004). Influence of compost application on growth and phosphorus exploitation of ryegrass (*LoliumperenneL*.). *Plant Soil and Environment*, 50 (12): 518−524.

Sims, J.T., Wolf, D.C., (1994). Poultry waste management: agricultural and environmental issues. *Advances in Agronomy* 52: 1–83.

Staunton S. and Leprince F. (1996). Effect of pH and some organic anions on the solubility of soil phosphate : implications for P bioavailability. *European Journal of Soil Science* 47: 231 – 239

Udo E. J. (1985). Phosphorus status of Major Nigerian soils. In soil fertility, Soil tilth and post clearing land degradation in the humid tropics. *Proceedings of the International Society of Soil Science Commission iv – vi*. Pp, 243 – 251

Violante, A and Huang, P.M. (1989). Influence of oxidation treatment on surface properties and reactivities of short-range ordered precipitates of aluminium. *Soil Science Society of America Journal*. 53: 1402-1407.

Walkley, A., and I. A. Black. (1934). An examination of Degtjareff method for determining soil organic matter and proposed modification of the chromic acid in soil analysis.1. *Experimental soil science* 79: 459-465.

Warren G.P. (1992). Fertilizer phosphorus: Sorption and residual value in Tropical African Soils. NRI Bulletin 37, Chatham, UK: Natural Research Institute.P 37.

Warren, G. P. (1994). Influence of soil properties on the response to phosphorus in sometropical soils: I. Initial response to fertilizer. *European Journal of Soil Science* 45: 337-344.

Watanabe, F.S and S.R. Olsen (1965). Test of an ascorbic acid method for determination of phosphorus in water and $NaHCO_3$ extracts from soils. *Soil Science Society of America proceedings* 29: 677

Yusuf I.A and A.A Idowu (2001).NPK requirement for soybean production in the Southern Guinea Savannah.*Tropical Oil Seeds Journal* 6:50-56.

Zhao, X., Zhong, X., Li, G. (2006).The evaluation of phosphorus leaching risk of 23 Chinese soils II.The relationships between soils properties, P adsorption characteristics and the leaching criterion.*ActaEcologicaSinica*. 26: 3011-3017.