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Sulphate Sorption Characteristics of Some Soil of Abia State, Nigreia

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Abstract: Ten surface soil (0-15 cm) samples of different parent materials and physical and chemical properties were studied to relate sulphate sorption to soil properties. The results obtained showed that the soils are acidic with pH values rangeing from 4.30-6.20, they are sandy and generally of low nutrient content. The sorption capacity of the soils differs significantly and followed the order: Ntigha>Alayi>Owerrinta> Amaeke and Ohafia>Arochukwu>Isuikwuato>Bende> Umudike>Isiala-Ngwa Locations. Adsorption maximum ranged from 953.7μg g^{-1} in Isiala-Ngwa to 2065.7μg g^{-1}in Ntigha. The bonding energy K was highest in coastal plain sand and lowest in shale so also was Maximum Sulphur Buffering Capacity (MSBC). Some of the physical and chemical properties of the soil correlated significantly ($p<0.05$) with sulphate sorption parameters.

Key words: Sulphate, sorption, acid soils

INTRODUCTION

Sulphur is one of the sixteen elements for crop production. It is essential for nodule development in legumes and for fruiting in some other crops[1]. Its adsorption by plant is hindered by high S. adsorption by the highly weathered tropical soils, [2]. Sulphate sorption capacity is one criterion used to assess and predict effect of acidic deposition on soils and related terrestrial and aquatic ecosystems[3]. Factor affecting sulphate sorption include pH and the presence of complexing anions, extractable A1 and Fe, organic carbon and soil horizon type[3,4]. Sorption of sulphate ion ($S0_4$) can result in the release of 0H ion to the bulk soil solutions[5] and can increase cation exchange capacity[6]. Sulphate adsorption is an important process affecting the soil availability of suphur in acidic highly weathered soils[7]. The capacity of variable charge soil to absorb sulphate, buffers the supply of plant available sulphur against leaching losses[7]. Information on the sulphate sorption characteristics of soil of Abia State is lacking. Therefore, this study was under taken with the objective of determining the sulphate sorption characteristics of these soils.

MATERIALS AND METHODS

The study was conducted using soil samples collected from ten locations in Abia State Nigeria. The samples were collected to represent the different parent materials of the state. The locations are Isiala-Ngwa, Ntigha and Umudike (coastal plain sand), Bende, Arochukwu and Alayi (shale), Ohafia, Isiukwuato and Amaeke (sandstone) and Owerrinta (fresh water alluvium). The samples were collected from 0-15 cm depth, air dried and sieved through 2 mm sieve and used for the study. Particle size analysis was by the hydrometer method[8]. The soil pH was determined in 1: 2 soil/water suspension using the glass electrode pH meter[9] .

Exchangeable cations were determined by extracting the samples with neutral normal ammonium acetate. Exchangeable calcium and magnesium were determined by the EDTA titration method of [8], while potassium was read using flame photometer. The exchangeable acidity was determined by extracting 5 g of the soil with IN KCL and titrating with 0.5N Na0H using phenolphthalein indicator[10]. Available phosphorus was extracted by the Bray 1 method[11].

Sorption studies: Sulphate sorption was carried out by the method of Bhogal *et al.*, [12]. Five gram of soil were shaken for 4 hours with 50mL solution of H_2S0_4 varying in sulphur concentrations from 0 to 100 μg g^{-1}in 50mL volumetric flask. The suspensions were filtered through Whatman 42 filter paper and the amount of sulphur remaining in the solution determined turbidimetrically[13]. The amount of sulphur sorbed was estimated as the difference between equilibrium S concentration and initial

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Table 1: Some physical and chemical properties of the soils

Location	PH (H_2O)	Sand (%)	Silt (%)	Clay (%)	Org. C (%)	Total N (%)	Av. P. Mg kg^{-1}	Ex. Ac. (Cmol kg^{-1})	ECEC (Cmol kg^{-1})
Isiukwuato	5.5	87.5	11.6	0.8	1.4	0.3	30.2	2.6	6.9
Amaeke	6.2	65.0	8.0	27.6	1.2	0.1	10.3	0.5	3.5
Ohafia	5.1	87.5	7.6	4.8	0.2	0.2	1.4	2.0	6.2
Alayi	5.7	92.5	2.3	5.3	1.1	0.3	29.3	4.6	5.7
Ntigha	5.0	75.2	6.0	18.8	0.8	0.3	8.3	2.7	3.5
Bende	4.5	77.5	15.6	6.8	1.7	0.2	2.1	2.0	10.0
Umudike	4.7	71.5	19.6	8.8	1.6	0.1	14.7	2.6	8.2
Owerrinta	5.1	81.0	5.0	14.0	0.8	0.1	15.1	1.8	3.5
Arochukwu	6.0	79.0	7.0	14.0	1.1	0.1	12.5	0.5	3.8
Isiala-Ngwa	5.5	87.5	11.6	0.8	1.4	0.3	30.2	2.6	6.9

Table 2: Isotherms of sulphate adsorption in the different soils

Equilibrium	*S. concentration* in solution (C) µg g^{-1}					Amount of *S. sorbed* by the soils µg g^{-1}				
Location	20.0	40.0	60.0	80.0	100.0	20	40	60	80	100
Isiukwuato	1.0	4.0	6.0	7.4	9.8	160	330	510	696	872
Amaeke	2.0	4.4	4.9	6.4	9.3	153	329	524	709	880
Ohafia	0.1	1.7	5.2	6.7	8.6	179	363	529	713	894
Alayi	3.4	4.0	6.1	7.4	8.4	136	330	509	696	886
Ntigha	2.0	2.6	3.6	5.2	5.9	128	322	512	696	889
Bende	1.2	1.6	2.2	6.2	14.6	164	160	554	714	830
Umudike	0.8	1.2	3.2	8.0	11.6	184	380	560	712	876
Owerrinta	3.2	3.6	4.2	6.8	10.6	140	336	530	704	886
Arochukwu	2.4	2.8	6.4	7.2	7.4	140	336	500	692	890
Isiala-Ngwa	1.0	2.2	3.8	10.4	12.6	156	344	528	662	840

Table 3: Sulphate sorption parameters of the different soils

Location	Sulphate sorption Maximum (b) (µg g^{-1})	Bonding energy (K) (L µg^{-1})	Maximum buffering capacity (L kg^{-1})
Isiukwuato	1011.9	0.2463	249.23
Amaeke	1417.6	0.1165	165.15
Arochukwu	1375.1	0.1150	158.14
Alayi	1754.4	0.0650	114.04
Ntigha	2065.7	0.0819	169.18
Bende	966.0	0.4059	392.10
Umudike	957.2	0.5316	508.85
Owerrinta	1656.2	0.0786	130.18
Isiala-Ngwa	953.7	0.3361	320.54
Ohafia	1417.6	0.1165	165.15

Table 4: Relationship (r) between sulphate sorption parameters and some soil properties

	S. Sorption Maximum	MSBC	Bruding energy
pH	0.35	-0.53*	-0.52*
Sand	0.23	-0.28	-0.25
Silt	-0.82**	0.94**	0.97**
Clay	0.26	-0.31	-0.34
Org. C.	0.59	0.71**	0.73*
Av. P.	0.10	-0.06	-0.03
Total N.	0.24	-0.12	-0.12
Ex. Acidity	0.18	0.07	0.07
ECEC	-0.67*	0.79**	0.81*

S added. The isotherm data were interpreted in terms of Langmuir sorption equation. The sorption parameters (Adsorption maximum, maximum buffering capacity and bonding energy) were correlated with some of the soil physical and chemical properties as outlined by Wahua[14].

RESULTS AND DISCUSSION

The physical and chemical characteristics of the soil are show in Table 1. The soils are acidic and the pH varied from 4.3-6.2 with the soils of Isiukwuato having the lowest pH value indicating strongly acidity while the soils of Amaeke are slightly acidic. Particle size analysis showed that the soils varied from sandy loam to sand with clay values of 0.80 to 27.0% and sand 65.0 to 92%. This pattern is characteristics of the acid sand of southeast Nigeria, Enwezor *et al.*,[15]. The organic carbon of the soils varied from 0.2 mg kg^{-1}in Ohafia to 1.4 mg kg^{-1}in Isiala-Ngwa with a mean value of 1.1 mg kg^{-1}in the entire study area. Values of available P varied from 1.4 to 49.4 µg g^{-1} with a mean of 12.5 µg g^{-1}, with most of the soil having p-values below the critical level of 8 µg g^{-1}[16].

Sulphate sorption characteristics: The sulphate sorbed by the soil and sulphate remaining in equilibrium solution are presented in Table 1. Sulphate sorption in the soil increased with increasing levels of sulphate added to soil. The sulphate sorption isotherm curves are presented in Fig. 1. These curves are typical of all the soils studied. These curves related the amount of sulphur sorbed by the soil to the concentration of sulphur in equilibrium solution. The curves indicated that with continuous addition of sulphur and higher sulphur concentrations in equilibrium solution, each of the curves tend to flatten and approach a maximum indicating that the soil is saturated with S. Similar curves were reported by Osodeke[17] for phosphorus. The highest sulphur sorption capacity at the different levels of sulphur application followed the trend of Ohafia>Arochukwu> Ntigha>Alayi>Amaeke>Umudike>Isukwuato>Owerrinta> Isiala-Ngwa> Bende (Table 2). Some of these soils for example Ohafia and Bende (from shale) and Ntigha and Isiala-Ngwa (from coastal plain sand) are from the same parent material but had great disparity in their ability to sorb sulphur. This could be due to the organic matter content and past management practices[18]. It has been demonstrated that tropical soils have greater sulphur sorption potential than temperate soils[7,19]. This high sulphur adsorption capacity of tropical soils has been attributed to the intensity of weathered conditions of the soils of the regions, which has resulted in high concentrations of various oxides of iron and aluminum[20].

Application of Langmuir equation: The langmuir adsorption equation was applied to the sorption data. The equation is written as:

$$C/x/m = c/b + 1/kb$$

Where C = Equilibrium concentration of S in solution ($\mu g\ g^{-1}$)
X/m = Quantity of sulpur sorbed ($\mu g\ g^{-1}$)
b = Adsorption maximum ($\mu g\ g^{-1}$)
k = Constant, a measure of intensity of adsorption reflecting the strength of the bonding energy between sulphate ions and soil particles

The plot of c/x/m against c produced liner graph as shown in Fig. 2. These values fitted into the equation and are typical of the ten soils studied. The slope 1/kb was used for calculating for the adsorption maximum (b) and bonding energy (k) as shows in Table 3. They values varied from 953.7-2065.7 $\mu g\ g^{-1}$with a mean of 1325.5 $\mu g\ g^{-1}$ for coastal plain sand, 966-1754.4 $\mu g\ g^{-1}$with a mean of 1378.3 $\mu g\ g^{-1}$1 for shale, 1011.9-1417.6 $\mu g\ g^{-1}$1with a mean of 1214.8$\mu g\ g^{-1}$for sandstone and 1656.2 $\mu g\ g^{-1}$for freshwater alluvium. These values are high compared to the value obtained by Dolui *et al.*,[6] for inceptisols. Sulphate sorption maximum had the trend of Ntigha>Alayi>Owerrinta>Ohafia and Amaeke>Arochukwu> Isuikwuato>Bende>Umudike>Isiala-Ngwa. Sorption maximum had the trend of freshwater alluvium>shale>coastal plain sand>sandstone. Sulphur adsorption maximum correlated significantly but negatively with silt and ECEC and positively with organic matter (Table 4). The maximum buffering capacity (MSBC) was calculated. The values ranged form 114.04 to 508.85 $\mu g\ g^{-1}$with a mean 237.27 $\mu g\ g^{-1}$in the different soil parent materials. There was wide variation in MSBC among soils of different parent materials. Coastal plain sand had the highest MSBC while shale had the least. Maximum buffering capacity correlated significantly with silt, for organic carbon, magnesium and ECEC. When the coefficients derived from the langmuir sorption equation (Table 3) were compared for the different soil parent materials, it was observed that K (bonding energy) varied from 0.065 to 0.5316 with a mean of 0.211 in the different parent materials. The coefficient correlation between K and silt, organic carbon, magnesium and ECEC. This study indication that the soils have high sulphate adsorption. Therefore high application of sulphur would be needed for optimum crop yield in these soils.

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