



Soil Exchangeable Cations and Aluminium in of Mangrove Soil of Akwa Ibom State

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Abstract

This study is to determine the soil exchangeable cations and Al^{3+} in mangrove swamp soil of Akwa Ibom State. Exchangeable cations and Al^{3+} will be measure by ammonium acetate and potassium chloride. Three soil samples is randomly take at Ikot Abasi Local Government Area to determine organic carbon %, PH, Electrical conductivity, total Nitrogen, exchangeable bases, % Al saturation, and particle size. Results show Kcl extracted more Al^{3+} , and Mg than Ammonium acetate. The soil is high in % base saturation whose values ranged from 70.55-88.16% in surface and 51.82-81.16% in sub-surface layers. The soil is saline in nature because its electrical conductivity value is above 1ds/m. These soils have more than 50% sand on the average are classified as loamy sand.

Keywords: Exchangeable, Cations, Aluminium, Mangrove, Soil.

Introduction

Soil exchangeable cations are positively charged ions which have been adsorbed on the soil miscelle and be easily exchanged by any added cation. Because they are easily replaced they are regarded by as

exchangeable cations. Thus they are those that can be exchanged by cation of an added salt solution (Index cation). Soil cations comprises of bases and exchangeable acidity. The bases are Ca^{2+} , Mg^{2+} , K^+ and Na^+ while exchangeable acidity are Al^{3+} and H^+

Many factors affect soil exchangeable cations. These include nature of soil content and soil reaction. Thus amount of exchangeable cations present in the soil is not affected by a single factor for example; ions in the soil can be buffered by addition of organic matters. Another important aspect of the role of organic matter in the soils is its complexing of Ions such as Al (Ahmed and Tan, 1986). Moorman and Pons (1974) also found that organic matter played an important role in soil acidity by forming complexes with AL Ions. They reported that hydrolysis of organo-metallic complexes contributed to acidity and organic matter influence availability of Al by complexing the Al thereby reducing soluble and exchangeable Al.

There is no doubt that soil activities, soil temperature, soil transformation processes, soil effective cations exchange capacity, availability of moisture and soil oxygen are greatly affected by organic matter content of soil (Naidoo, 1980, Ukpong, 1991, 1992a, Clarke and Hannon 1967, Botto and Wellington 1984). The need to study soil exchangeable cations need not be overemphasis. On agricultural view point, these exchangeable cations are basic plant nutrients. In the soil these exist also anions which are negatively charged ions. According to Hesse (1963) Cations in solution engage in a reversible reaction. That is when cations are absorbed by the by the soil from the solution the solution receives an equivalent amount of another cation from the soil e.g $\text{Ca}^{2+} + 2\text{KCl} \leftrightarrow (\text{soil})_{\text{K}^+} + \text{CaCl}_2$. These exchange reactions are necessary for the adsorption of nutrients by plants roots. Cation exchanged (Plants nutrients) find their way to plant roots or leached away be solidified to form rocks.

Exchangeable bases Ca^{2+} , Mg^{2+} , K^+ and Na^+ commonly occur in the soils in the order listed (Thomas 1977). But it is common in some situation to have the reverse, example in marine soils where we have marine live (corals) and dissolution of clay minerals under acid condition Mg^{2+} may be more than Ca^{2+} is low because these is no continuing source of it in the soil. Much $\text{Al}^{3+} + \text{H}^+$ on exchange complex result in soil acidity.

The principles of replacement of exchangeable cations is usually employed in the determining bases (Ca, Mg, K, and Na) while the principle for determining

acidity ($H^+ + Al^{3+}$) in the soil is by KCl extraction and titration with O. Im Naoh using phenolphthalein Indicator.

To determine soil exchangeable cations, the exchangeable cation can be replaced with saturating salt solution and the exchangeable cations taken as equivalent to cations present at the exchangeable leachate. Many methods for exchangeable cations determination are provided by using different combination of soil pretreatment, saturation, washing and extraction procedures, and replacing cations, washing solvents and P^H control. Issues involves in selection a suitable method are given in the reviews by Kelley (1968), and Thomas (1977).

Originally, exchangeable cations were measured as the quantity of ammonium held in exchangeable form after leaching a soil with ammonium chloride (Rhoades, 1982). Later ammonium acetate (NH_4OAC) was generally used. This was due to the recognition that ammonium so determined using ammonium chloride was not always equal the sum of individually measured cations in the leachate owing to extraction of soluble as distinct from exchangeable cations (Scholenberger and Simon 1945).

There has been a doubt as to whether or not Al^{3+} is exchangeable cations. A summary of work done by Barnhisel and Bertsch (1982) concluded that aluminum is not much involved in the exchange reaction but that it is ionized and brought into solution from acid clays by mineral salts. Thus, it is preferable to refer to as “extractable” aluminum rather than “exchangeable” aluminum. However, recent studies reveal hydroxyl nature of Al salts which are involved in exchange processes and in some instance, preferential adsorption of these species has been demonstrated. However to what degree these materials are involved in actual surface exchange reaction is difficult to estimate. (Bache and Sharp 196a) Exchangeable acidity (Al^{3+}) can be measured as water soluble Al, though the usual procedure is to take available form.

However as found by Gillman (1978) the availability of extractable Al is dependent upon the method of extraction and pH M'clean (1965) used NH_4OAC buffered to pH 4.8 and other co-workers have attempted to extract Al in the prevailing soil P^H by buffering the NH_4OAC , accordingly they found out that if the pH of the soil exceeded 4.8 the NH_4OAC extracted more AL than unbuffered solutions whereas if the pH was less than 4.8 the unbuffered solution extracted most of AL.

Thus the extraction is a continue function of pH. Solution pH of the extraction should be standardized whereas with unbuffered neutral salt and solution pH of soil control the extraction. Peech (1965) modified method of determining soil acidity using pH 8.3. This has since 1972 adopted by soil conservation it to distinguish between soil group due to the fact that many soil acids are weak enough that they are not fully neutralized at pH.

Thus pH that is meaningful in solution of AL salt or in suspension of clays or organic matter may not meaningful in other soil solution (Moorman and Pons 1974). In the mangrove, it is possible for the soil pH to change on being air dried from 7 to below 2. In this case AL so determined is referred to as extractable whereas in freshly collected Wet Soil 0.02% of the AL removed might be considered as exchangeable (Botto and Wellington, 1984).

Note should be taken that if the soil or extractant is acidic other forms of AL may be dissolved – it can that released from clay mineral structures, it can be that released from discrete non-crystalline Al phases.

Previously, it was popularly believed that the ability of the soil to hold cations in exchangeable forms is a properly believed that it fine mineral particles and its humus component. In mineral soil clay mineral fraction was largely believed to be responsible for the cation exchange properties until 1930's when the x-ray measurement revealed the crystalline nature of clay minerals was it realized that different clay mineral affected the cation exchange caspacity of the soils (Kelly 1968). Analysis of concise different clay minerals, Effect on exchangeable cations and exchange capacities of the soil has been done and given by Kelly (1968). Thus nature of clay considered it ability to hold water and exchangeable cations.

During treatment not all the acidity ($Al^{3+} + H^+$) are replaced when the soil is treated with solution of neutral salt because of hydrolysis of Al and subsequent dissolution of more aluminum as extraction proceeds Peech (1965). Though Kcl is suitable for estimating truly exchangeable Al to be more accurate exchange site most be completely saturated with saturating cations and soil sample combine with excess NH_4OAC to complete washing otherwise exchangeable cations will be underestimated. Finally, kcl could not be used to determine exchangeable K as this will amount to adding more K to extracts (Shuman and Duncan, 1990).

The need to study soil exchangeable cations is based on the fact that the determination of individual exchangeable cations and cations exchange

capacity not only helps to evaluate the soil fertility, but also classify it, it also provides one of the most efficient way of assess the exchangeable the lime requirements of the soil (Russel 1973).

The main objective of this study was to assess the Exchangeable bases of mangrove swamp soil of Akwa Ibom State using ammonium acetate and Potassium Chloride extractants.

MATERIALS AND METHODS

Experimental Sites

Three soil samples were taken from Mangrove Swamp soils of Akwa Ibom State to examine exchangeable bases of the soil. Akwa Ibom State falls within the tropical rain forest zone of Nigeria located in 05°02' North, longitude 07°55E and at attitude 38.1 above mean sea level. The State experiences two distinct seasons – wet and dry seasons. The wet season starts from April and lasts till October with a relative brief period of dryness called “August Break. The rainfall is heavy and annual range may vary from 2000mm to 4000mm.

Temperatures are generally very high during the dry season. The highest temperatures are experienced during the months of February through March and this according to Enwezor *et al.*, (1990) coincides with overhead passage of the sun. Rainfall pattern is bimodal with peaks in June and September (Ukpong, 1995a and Uniuyo Agromet, 1997).

Vegetation of the area was described by Chapman (1976) as salt-water wetland dominated by Mangroves which are evergreen plants tall or shrubby, belonging to several unrelated families that share common habitat preferences, functional and structural adaptations halophytic wood seed bearing plants.

Soil Sampling

Auger method was used in collecting the soil samples. Samples were collected at 0-15cm, depts. The samples were air dried, crushed and sieved through 2mm sieve and for the following analyses.

Laboratry Analysis

- PH was determined in water and in Kcl using PH meter with glass electrodes.
- Organic matter was determined by Nelson and Sommers (1982).

- Total Nitrogen determination was done using Macro – Kjeldahl digestion and distillation method of Jackson, (1970).
- Exchangeable bases were extracted with molar ammonium acetate and molar potassium chloride.
- K and Na in the extracts were determined by flame photometry Mg and Ca by titration (Jackson, 1970).
- Exchange acidity ($Al^{3+} + H^{+}$) was extracted with molar KCl and the acidity determined by titration.
- Effective cation exchange capacity (ECEC) was taken as the sum of individual exchangeable bases plus exchangeable acidity (Kamprath, 1970)
- Electrical conductivity (EC) was measured with electrical conductivity meter.
- Mechanical analysis was carried out by hydrometer procedure as desired by Day (1953).
- Physiochemical properties and exchangeable bases are presented in tables 1 and 2.

Results and Discussion

Soil samples were taken at three sites in Mangrove Swamp soils of Akwa Ibom State in Ikot Abasi to determine the levels of exchangeable cations and exchangeable Al using ammonium acetate and potassium chloride extractants.

Physiochemical Characteristics of Mangrove Swamp Soil

The physical and chemical characteristics of Mangrove Swamp Soils are presented in tables 1 and 2.

pH, Total N and Organic Matter

The soil is generally acidic with P^H values ranging from 3.29 to 3.70 in the three sites. Udo (1989) attributes the high acidic nature of the soil (dry season) to production of sulphuric acid by oxidation.

Though the pH is low, percent Al saturation values are moderate than could cause Al toxicity in these soils. The soil is poor in total nitrogen probably due to incomplete decomposition of extensive fibrous roots associated with *Raphia hookeri* and *Acrostichum aureum*.

This poor N content in the soil gives rise to C/N ratio of 23 to 59 in the top soil and 32 to 47 in the sub-surface soil. Organic carbon content is relatively higher in the surface layers.

As shown in Tables 1, organic carbon values ranged from 2.67 to 3.95% in the surface layer to 1.89 to 3.52% in the sub-surface layer. High organic carbon content in the soil is attributed to water borne residues including leaf litter (Ukpong 1997).

Exchangeable bases

The soils are relatively high in carbon exchange capacity (CEC). The values are high in the surface than sub-surface (Tables 1 x 2). Surface values ranged from 15.62 cmol/kg to 21.96 cmol/kg while sub-surface values ranged from 11.60 to 14.83 cmol/kg¹ respectively.

Mg and Ca, were the prominent cations Na and K values were comparatively lower. Of the two extractants (ammonium acetate and potassium chloride) KCl extracted more Ca and Mg than NH₄OAC as presented in figure 2. Values of Ca extracted with NH₄OAC ranged from 4.20 – 7.40 cmol/kg¹ for the surface layer and 3.00 – 6.30 cmol/kg for sub-surface layer.

However, no K was extracted with potassium chloride in that soil. Mg values ranged from 5.60 -8.80 and 2.00 – 5.20 cmol/kg in the surface Ca and Mg were 3.80 and 2.80 to 7.80 cmol/kg⁻¹ ca and 5.80 to 8.80 and 13.40 cmol/kg⁻¹ Mg for surface and sub-surface layers respectively.

Particle Size Analysis

Particle size analysis results shows that the soils loamy sand because they content more than 50% sand (Esu 1999).

Relationship between other Exchangeable bases and AL³⁺

Results on Tables 1 and 2 show that as exchangeable bases (Ca, Mg, Na) increase exchangeable AL³⁺ decreases. This is greatly due to replacement of Al by basic cations. As organic reaction occur Al³⁺ and H⁺ is generated which invade the exchange complex and replaces most other cations (Ahmed and Tan 1986).

Table I Physiochemical Properties of Mangrove Swamp Soils

Sample No.	L2		L4		L9	
	0-15	15-30	0-15	15-30	0-15	15-30
Dept. (cm)						
P ^H in water (Ratio 1:2.5)	3.20	3.00	3.70	3.40	3.70	3.50
P ^H (Kcl) 1:2.5	2.9	2.65	3.40	3.20	3.30	3.20
E _c (dslm)	1.20	1.20	1.30	1.10	1.30	1.10
%org. C.	3.52	3.52	3.95	3.23	2.67	1.89
Total N	0.06	0.11	0.17	0.09	0.07	0.04
C/N Raatio	59.00	32.00	23.00	36.00	38.00	47.00
Exchangeable Acidity (cmol/kg ⁻¹)	2.80	3.60	0.60	1.60	2.00	3.40
AL ³⁺	1.80	2.90	2.00	1.20	2.00	1.00
H ⁺						
ECCEC (cmol/kg ⁻¹)	15.62	13.30	21.96	14.83	19.44	11.60
%AL saturation	19.93	27.07	2.73	10.79	10.28	29.28
BB/S	70.55	51.82	88.16	81.11	79.42	62.06
% Sand	81	79	77	79	81	81
% Silt		16		18	20	14
% Clay		35		5	1	5
Textural class	Loamy Sand	Loamy Sand	Loamy Sand	Loamy Sand	Loamy Sand	Sand

Table 2 Exchangeable Bases Extracted with NH₄OAC and Kcl

	(M. NH ₄ OAC)		(M. KCL)	
	0 -15cm	15 - 30cm	0 - 15cm	15 - 30cm
L ₂	K 1.30	0.13	K N/E	N/E
	Na 0.19	0.17	Na 0.31	0.32
	Ca 4.20	4.00	Ca 3.80	2.80
(cmol)	Mg 5.60	2.60	Mg 5.80	1.70
L ₄	K 1.00	0.38	K N/E	N/E
	Na 0.16	0.15	Na 0.28	0.34
	Ca 9.40	6.30	Ca 8.60	5.40

(cmol) Mg	8.80	5.20	Mg	8.80	13.40
Lg	K 2.30	2.05	K	N/E	N/E
	Na 0.14	0.15	Na	0.34	0.34
	Ca 7.00	3.00	Ca	7.40	7.80
(cmol) Mg	6.00	2.00	Mg	6.00	6.20

CONCLUSION

Though the soil nutrient is relatively high, except N, the soil need additional fertilization to be able to produce a sustained yield of agricultural crops.

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