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Measurement of Salinity and Electrical Conductivity of Land Forms in Akwa Ibom State, Nigeria

Okechukwu.E. Agbasi[1], Godfery .T. Akpabio[2]
[1, 2] Department Of Physics, University Of Uyo, Uyo, Akwa Ibom State, Nigeria

Abstract: *The electrical conductivity (EC) Resistively (calculated) and salinity of some selected soil samples collected from three landforms, namely Beach Ridge Sand (BRS), coastal plain sand (CPS), sandstone/shale Hill ridges (SHR) from Akwa Ibom State of the Federal Republic of Nigeria were measured the obtained data were subjected to spearman rank order statistics and result shows that there were positive correlation of 0.20 between soil EC and salinity. The electrical conductivity of the area under study falls within the range of 0.031 ds/m for SHR 3A t0 0.200ds/m for SHR 2A while the salinities are between 0.6mg/l for BRS 3B and 0.9mg/l for SHA 2A soil samples. Soil sample SHR 3A has the highest resistivity measurement of 32.Ωm, while SHR 2A soil sample has the lowest of 6. Ωm. from the EC data the signal strength of EC measurements decreases with soil depth and most of the EC values falls within the range of 20 – 80 (µs/cm) which is the optimum level for most plants, usually indicates well – fertilized soils and salt sensitive plants may be insured.*
Key words*: Salinity, Electrical conductivity, Resistivity, soil and samples.*

I. Introduction

The study of soil properties is very important and useful to determine the salinity content of a particular land before cultivation can be done. This is so because various crops have different salt tolerance for good yielding and plant growth. If the salt tolerance level of a crop is known, the types of crop to be cultivated on that land will as well be known and this will increase crop yields in a situation whereby the salt concentration of a land is too high. By knowing the electrical conductivity of their soils, farmers can make more precise management decisions about fertilization applications, irrigation use of infanticides and other pesticides applications.

Similar studies of soil properties in recent times include: measurement of salinity and electrical conductivity of some soil samples of Uruan local government area of Akwa Ibom State. (Akpan et al, 2001), measuring the electrical properties of soil using a calibrated ground – coupled GPR system (Oden at al 2008) and characteristics wet and land soils of Akwa Ibom State. (Stephen 1997).Soil electrical conductivity (EC) is a property of soil that is determine by standardized measures of soil conductance (resistance-^{1}) by the distance and cross sectional area through which a current travels (Rhoades, 1996). Salinity is the level of salt content in a medium. Soil salinity results from the accumulated soluble salts in the soils. Apart from water content in the soil, salt is major factors that determine electrical properties of the soil. A soil with high salt content exhibits a high electrical conductivity and vice versa. This study is therefore directed towards measuring salinity and electrical conductivity of soil samples in Akwa Ibom State, Nigeria.

II. Electrical Conductivity (EC)

Electrical conductivity is the ability of a material to transmit (conduct) an electrical current and is expressed in the units of deci Siemens per meter (ds/m) which is equal to the readings in µs/m divined by 100. (Barnwisel et al 1996).

A Siemens is a measurement of materials conductance, expressing the value in milli Siemens per meter (µs/m) removes the volume from the equation just as a material density in independent of its volume. An Ohm is a measurement of resistance while Siemens are a measure of conductance (Nycle, et at, 1999).
To convert µs/cm to µs/m.

$$\frac{\mu s}{cm} = \frac{10^{-6} s}{10^{-2} m} = \frac{10^{-4} s}{m} = \frac{1\left(s/m \right)}{10^{4}}$$

Electrical conductivity can be regarded as the product of two factors, namely charge density and mobility of electrons. There is no full proof conversion factor that can be used to compare electrical conductivities of different soil to the ratios of water contents in the soil, since even if the solubility of the salts may vary with increasing dilution. However, the following relationships (which are approximates) may be useful as a rough guide provided the samples do not contain significant amount of gypsum. (Huisman J. A. et at 2003) $EC_e = 2.2 \times EC_{1.1}$ and $EC_e = 6.4 \times EC_{1.5}$.

III. Salinity of Soil

The processes that result in the accumulation of neutral soluble salts are referred to as Stalinization (Nycle and Ray 1999). The salts are mainly chlorides and sulfates of sodium, calcium, magnesium and potassium. Saline soils contain a concentration of their salts sufficient to interfere with the growth of many plants. Some salt sensitive fruit and vegetable crops are adversely affected when the EC is lower than 4ds/m, leading some scientist to recommend that 2ds/m is the level above which a soil could be classified as saline.

The classification of salt affected soil is often made on the basis of chemical properties that convey certain information with regard to the salt problem. Major cationic constituents such as SO_4C and bicarbonates and minor cationic constituents such as KCO_3 and NO_3 enrich the salinity of the soil. Numerous ions occur in smaller quantities and among them is borate. The presences of these salts in soils in larger quantities interfere with growth of most plants. (Oden et al 2008)

IV. Experimentation

4.1 Sample Collection and Preparation

Soil samples used for the experiments were collected from three landforms in Akwa Ibom State. The landform are: Beach Ridge sand (BRS), sandstone/shale –hill Ridges (SHR) and coastal plain sand (CPS) the soil samples were collected using “soil ogre” from different depth which are 0 – 15cm denoted by A and 15cm – 30cm denoted by B, while 1,2 and 3 are denoted by first, second and third locations. For example 1A, 2B, 2A, 2B, 3A and 3B means first, second and third location at depth 0-15cm and 15-30cm.

Eighteen different soil samples were collected; locations and sources of collection are as shown in the table I.

4.2 Measurement of Electrical Conductivity.

The following were used during the analysis: weighing balance, 2.0mm sieve, distilled water, mortar and pestle, shaking cups, measuring cylinder, mechanical shaker and electrical conductivity meter.

The samples were taken to the laboratory in labeled polythene bags, they were air-dried and also dried in an oven to remove water molecules. They were then crushed and passed through a 2.0mm sieve before the analysis.

10g of each of the soil samples were weighed into 100ml polyethylene tube and 20ml of distilled water was added to each of the 100ml polyethylene tube. They were agitated on a mechanical shaker for 1.5 minutes, and then allowed to stand for at least an hour. They were returned to the mechanical shaker for 2 hours. Centrifuged (filtered) and carefully decant the supernatant solution. The electrical conductivity of each of the soil samples were measured using electrical conductivity meter (Conductometer) by taking reading directly from the meter.

4.3 Measurement of Salinity

The following were used during the experiment: weighing balance, 2.0mm sieve, 20m pipettes, mortar and pestle, plastic cups beaker, funnel, conical flask, distilled water, filter paper, (whitman’s), soil samples, mechanical shaker, measuring cylinder, 50cm burette, reagent (silver nitrate ($AgNO_3$) and potassium dichromate (K_2CrO_4).

10g of each of the sieved soil samples were measured into plastic cups and 40ml of distilled water was added to each of the samples and shake for 30 minutes using mechanical shaker. Filtration was carried out using Whitman’s filter paper; the extract was stored for about 1 hour. Silver nitrate ($AgN0_3$) and potassium dichromate (K_2CrO_4) were used as reagent. 20ml of the extract was pipetted into the conical flask then 1ml of K_2CrO_4 was added to the pipette extract. They were then titrated with sliver nitrate ($AgN0_3$) solution to an end point of red brow color, and the titer value was recorded.

Using the value of EC and salinity in table 2 and spearman rank correlation co-efficient.

$$\alpha = \frac{1-6\sum d^2}{n\left(n^2-1\right)} \text{ ----------------------------------(1)}$$

n = 18

$$d = EC_R - S_R$$

$$d^2 = (EC_R - S_R)^2 \text{ ---------------------------------(2)}$$

$EC_R - S_R$ are correlation coefficient of electrical conductivity and salinity read from correlation table respectively.

$$\alpha = \frac{1-6\times 806.5}{18\left(18-1\right)}$$

$$\alpha = \frac{1-4839}{5814}$$
$$\alpha = 1.67 \times 10^{-1}$$
$$\alpha = 0.20$$

Using analysis of variance (ANOVA) to determine whether the EC values for the three landforms where the soil samples were collected area the same.

Null hypothesis (H_O): $EC = S$ if $\alpha_{calculated} > \alpha_{table}$

Alternative hypothesis (H_A): $EC = S$ if $\alpha_{calculated} < \alpha_{table}$

Where $\alpha_{calculated}$ calculated value of α and α_{table} value of α from collection table with 10 degree of freedom

α_{table} at

Ɣ = 0.01, 95% is 0.0986 i.e.

α_{table}= 0.0986

$\alpha_{calculated}$ = 0.20

Hence $\alpha_{calculated} > \alpha_{table}$ and the null hypothesis is upheld that EC = S. the above is summarized in the table III.

V. Discussion

Using spearman's rank correction coefficient, the correlation between electrical conductivity and salinity of the soil samples was found to give a position relationship of 0.20. This implies that electrical conductivity of the soil is directly proportional to the salinity of soil samples, the higher the salinity of the values of conductivity of soil samples, the higher the salinity of the soil. From analysis of variance (ANOVA), the mean EC values for the three landforms (BRS, CPS, SHR) where the soil samples were collected are different. From the EC data, the signal strength of EC measurements decreases with soil depth. Most of the EC values fall with the range of 20 – 80 (µs/cm) which is the optimum level for most plants, which usually indicates well fertilized soils. Salt sensitive plants may be insured.

Considering the Histogram showing EC measurement of different soil samples of figure 1, 0.2 µs/m is the highest EC measurement while 0.031 µs/m is the lowest EC measurement. The proportionate increase in conductivity with the salinity is due to the presence of metallic ions in salt. The atoms of these metals are made up of the protons, the electrons and the neutrons. The movement of electrons results in the production of current. Therefore, it can be said that Electrical Conductivity of the soil increases with a corresponding increase in salinity or the amount of metallic ions present in soil and vice versa.

VI. Conclusion

From the result of measurement of salinity and Electrical conductivity of some soil samples from different landforms in Akwa Ibom State, Nigeria, it is a fact that Electrical Conductivity data were less that 2µs/m which indicates that the land where the soil samples were collected are suitable for cultivation and the signal strength of the Electrical Conductivity measurement decreases with that soil Electrical Conductivity is directly proportional.

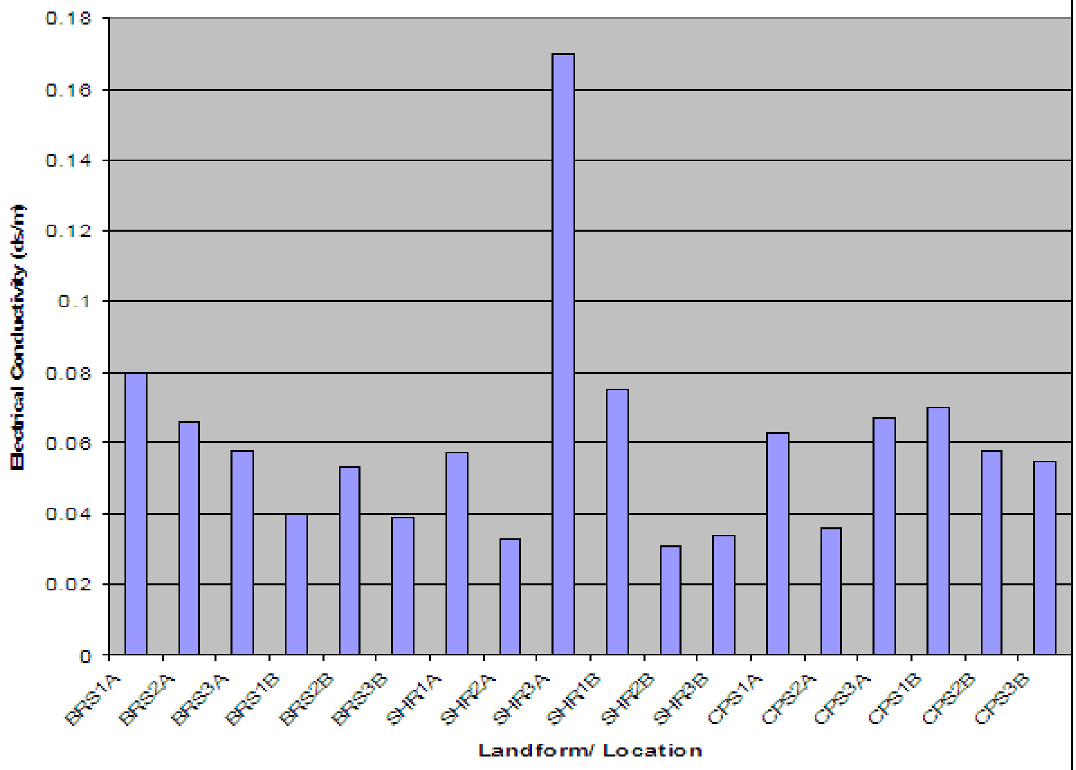

Figure 1 Electrical Conductivity of some soil samples

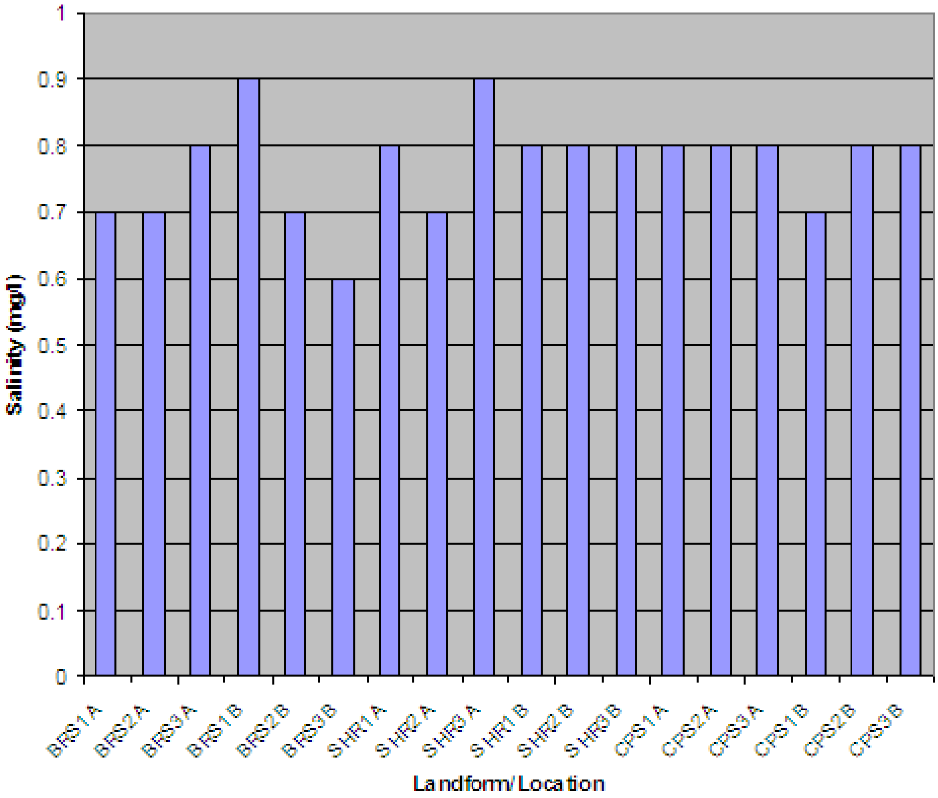

Figure 2 Measurement of Soil Salinity

Table I showing landform/location and sources of soil samples

S/N	LANDFORMS/LOCATIONS	SOURCES
1	BRS 1A	IKOT IBIOK (EKET L. G A)
2	BRS 1B	IKOT IBOIK (EKET L. G. A)
3	BRS 2A	IKOT AKPAN MKPE (ONNA L.G.A)
4	BRS 2B	IKOT AKPAN MKPE (ONNA L.G.A)
5	BRS 3A	IKOT AKPAN MKPE (ONNA L.G.A)
6	BRS 3B	IKOT AKPAN MKPE (ONNA L.G.A)
7	SHR 1A	IKPE IKOT NKON (INI L.G. A)
8	SHR 1B	IKPE IKOT NKON (INI L.G. A)
9	SHR 2A	IBIAKU NFOK OKPO (IKONO L. G. A)
10	SHR 2B	IBIAKU NFOK OKPO (IKONO L. G. A)
11	SHR 3A	NTAK INYANG (ITU L. G. A)
12	SHR 3B	NTAK INYANG (ITU L. G. A)
13	CPS 1A	IKOT AKAN (NSIT UBIUM L. G. A)
14	CPS 1B	IKOT AKAN (NSIT UBIUM L. G. A)
15	CPS 2A	IKOT AKAN (NSIT UBIUM L. G. A)
16	CPS 2B	IKOT AKAN (NSIT UBIUM L. G. A)
17	CPS 3A	UNIUYO ANNEX (UYO L. G. A.)
18	CPS 3B	UNIUYO ANNEX (UYO L. G. A.)

Table II Results showing values of electrical conductivity and salinity of soil samples

LANDFORMS/LOCATIONS	EC (µs/cm)	EC (µs/m)	SALINITY (mg/l)
BRS 1A	80. 000	0.080	0.700
BRS 1B	60. 000	0.066	0.700
BRS 2A	58. 000	0.058	0.800
BRS 2B	40. 000	0.040	0.900
BRS 3A	53. 000	0.053	0.700
BRS 3B	39. 000	0.039	0.600
SHR 1A	57. 000	0.057	0.800
SHR 1B	33. 000	0.033	0.700
SHR 2A	170. 000	0.170	0.900
SHR 2B	75. 000	0.075	0.800
SHR 3A	31. 000	0.031	0.800
SHR 3B	34. 000	0.034	0.800
CPS 1A	63. 000	0.063	0.800
CPS 1B	36. 000	0.036	0.800
CPS 2A	67. 000	0.067	0.800
CPS 2B	70. 000	0.070	0.700
CPS 3A	58.000	0.058	0.800
CPS 3B	55. 000	0.055	0.800

Table III of showing EC_R, S_R, $EC_R – S_R$ and $(EC_R – S_R)^2$

LANDFORMS/ LOCATIONS	EC (µs/m)	SALINITY (mg/l)	EC_R	S_R	EC_R-S_R=D	$(EC_RS_R)^2=D^2$
BRS 1A	0.080	0.7	2	15	-13	169
BRS 1B	0.066	0.7	6	15	-9	81
BRS 2A	0.058	0.8	8.5	7.5	1	1
BRS 2B	0.040	0.9	13	1.5	11.5	132.25
BRS 3A	0.053	0.7	12	15	-3	9
BRS 3B	0.039	0.6	14	16	-2	4
SHR 1A	0.057	0.8	10	7.5	2.5	6.25
SHR 1B	0.033	0.7	17	15	2	4
SHR 2A	0.170	0.9	1	1.5	-0.5	6.25
SHR2B	0.075	0.8	3	7.5	-4.5	20.25
SHR 3A	0.031	0.8	18	7.5	10.5	110.25
SHR 3B	0.034	0.8	16	7.5	8.5	75.25
CPS 1A	0.063	0.8	7	7.5	-0.5	0.25
CPS 1B	0.036	0.8	15	7.5	7.5	56.25
CPS 2A	0.067	0.8	5	7.5	-2.5	6.25
CPS 2B	0.070	0.7	4	15	-11	121
CPS 3A	0.058	0.8	8.5	7.5	1	1
CPS 3B	0.055	0.8	11	7.5	3.5	12.25
						$\sum d^2 = 806.5$

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