A STUDY OF SOIL PROPERTIES IN MACHAERIUM LUNATUM ENVIRONMENT OF NIGER DELTA, NIGERIA

Ifeoma Gladys Ugiomoh & Donatus Ikechukwu Anyanwu
Department of Plant Science and Biotechnology, University of Port Harcourt
NIGERIA

ABSTRACT

Machaerium lunatum Linn F Ducke is a shrub of the Fabaceae family. It grows along river banks in fresh, brackish and salt water especially in marsh and tidal areas. A study of the soil properties of the plant was conducted in selected areas of the Niger Delta, Nigeria. These areas include Aluu, Choba, Emohua, Ogbia, Ogoni and Okrika and flank between 4º - 4º45´N and 6º - 6°20´E. Conductivity, pH, alkalinity, as well as the soil mineral elements (sulphate, phosphate and Nitrate) contents and total organic matter were the parameters evaluated. The study showed that the pH levels of these areas were of the weak acid range without any significant variation between the sites. Conductivity was higher in the wet season for surface soil. Alkalinity values were generally low for both the wet and dry season but the highest value was in Emohua. The sulphate content was low in both seasons especially at Emohua. Phosphate values varied significantly but there was no difference in Choba and Okrika in both seasons. Nitrate values were high in both seasons but Ogbia was higher in the wet season. The total organic matter showed higher values for surface soil in the wet season at all sites. Conclusively, despite variation in soil chemical properties observed of the different study locations, the plant was observed to thrive in the environment as long as the tidal action provides the moisture needed.

Keywords: *Machaerium lunatum*, mineral elements, soil physicochemical properties.

INTRODUCTION

Machaerium lunatum is an erect glabrous shrub of the Fabaceae family which belongs to the genus *Machaerium* Pers. It is distributed from Mexico in South America and the West Indies (Keay, 1985; Airy-Shaw, 1985) and coastal West Africa (Klitgaard and Lavin, 2005). In Africa, it grows along the tropical belt of the West African Coast from the Democratic Republic of Congo through Angola, Cameroon and Nigeria to the Gambia (Nyananyo, 2006). *M. lunatum* is amphiatlantic predominantly Neotropical from Mexico to Brazil and Argentina; the third largest Dalbegiod genus with approximately 125-130 species (Medonca-filho et al., 2011). One species, *M. isadelphum*, reaches Trinidad and Tobago while the other species, *M. lunatum*, extends to the West African coast (Klitgaard and Lavin, 2005). *M. lunatum* exhibits compound foliage with 5-7 oblong and elliptic leaflets, about 5cm long and 2cm wide. The inflorescence is a panicle with distinct individual flowers usually at the axial portion. The fruit is a sickle-shaped pod, green when unripe and brown when ripe. The most remarkable characteristic feature of this plant is the recurved stipules which occur in pairs (Keay, 1985; Airy-Shaw, 1985; Nyananyo, 2006). It fruits between the months of December and March (Hussaini and Gill, 1986). It is a perennial plant that grows along the river banks in fresh, brackish and salt waters especially marshes and tidal areas (Airy-Shaw, 1985; Nyananyo, 2006). The soil around these areas is usually water logged, consisting mostly of loamy, clay, sand, silt and debris. The growth rate of a plant depends solely on the characteristics of the soil around that plant. Inherent problems in the soil such as texture, structure, salinity, acidity, water logging or compaction will affect the plant's ability to extract water and nutrients for growth. In addition to its natural advantage as a legume, the people of the Niger Delta use this plant as fishing bait and hedge plant. It also has a myriad of medicinal uses; the different parts of the plant are used to treat different ailments. The leaves are used for heart palpation, malnutrition and debility (Burkill, 1995). The root is used to cure diarrhoea, dysentery, edema, gout and in the treatment of stomach ulcers, internal heat. This plant has been identified on the river banks of selected areas of the Niger Delta Nigeria. This study was designed to assess the chemical characteristics of the supporting soil medium around *Machaerium lunatum*.

MATERIALS AND METHODS

This study was carried out at six locations: Aluu, Choba, Emohua, Ogbia, Ogoni, and Okrika all in Niger Delta, Nigeria. These locations have high densities and support the survival of *Machaerium lunatum* as conspicuous components of its natural vegetation. Soil samples were collected at two soil depths: 0-15cm (surface soil) and 15-30cm (subsoil) with a soil auger from three sample plots at each study locations. The samples collected were immediately placed in polythene bags (Dana, Dana Plastics) and wrapped with paper tape (Euro Globe Tape, EURO), labeled according to their location of collection and taken to the Department of Plant Science and Biotechnology, University of Port Harcourt. Soil pH and conductivity were measured using pH meter (Jenway 3015 model) and conductivity meter (Jenway 4010 model) respectively from slurry of distilled water and soil sample. Final values displayed on instruments were read. Soil alkalinity was determined by titrating filtrate soil sample solution against 0.02N H_2SO_4 solution. Soil sulphate was obtained using turbidometric method. The turbidity of soil samples was obtained from its solution by measuring absorbance at 420nm using spectrophotometer (Genesys 20). Ascorbic acid, Brucine and Ashing methods were used to determine the Soil phosphate and nitrate contents and, total organic matter respectively. Data analyses were done using analysis of variance.

RESULTS AND DISCUSSION

The results of the parameter of the different location where this plant was found in the Niger Delta Area of Nigeria manifested a relationship both spatial and seasonal in their variation. There was spatial and seasonal variation in the result for hydrogen ion (pH) content of the soil. The surface soil was significantly higher in value at $p = 0.05$ level than the subsoil (Fig 1a). The site at Okrika was higher in pH value for sub soil in the wet season than all the other sites. The dry season was significantly higher at the $p = 0.05$ levels for the surface soil in four of the locations namely Emohua, Choba, Ogbia and Okrika. Aluu and Ogoni recorded low values for surface soil at the $p = 0.05$ level of significance. Aluu, Emohua and Choba had low values for sub soil while Ogbia and Ogoni were significantly higher in the dry season (Fig 1b). In Okrika the value for subsoil was high both for the wet and dry season. All the values on the scale fell within the optimum values which favoured plant growth. The high values of the surface soil may be due to human activities on the surface soil than in the subsoil.

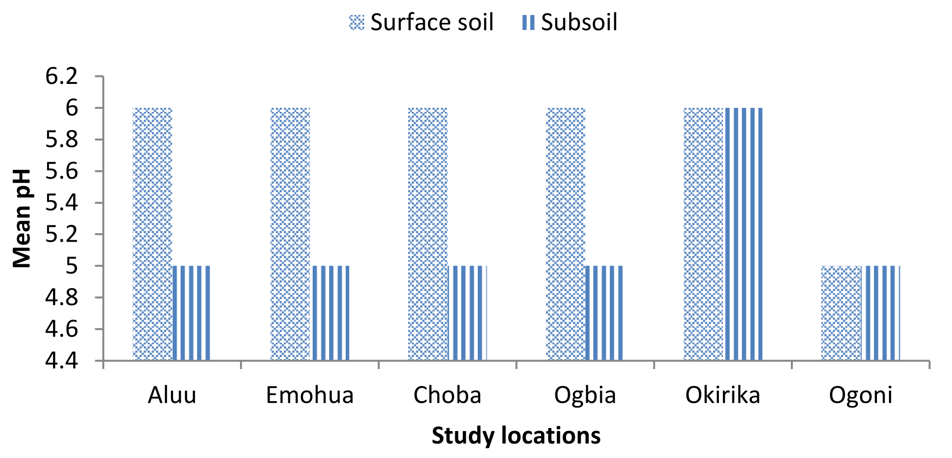

Fig. 1a: Soil pH of the study locations at wet season

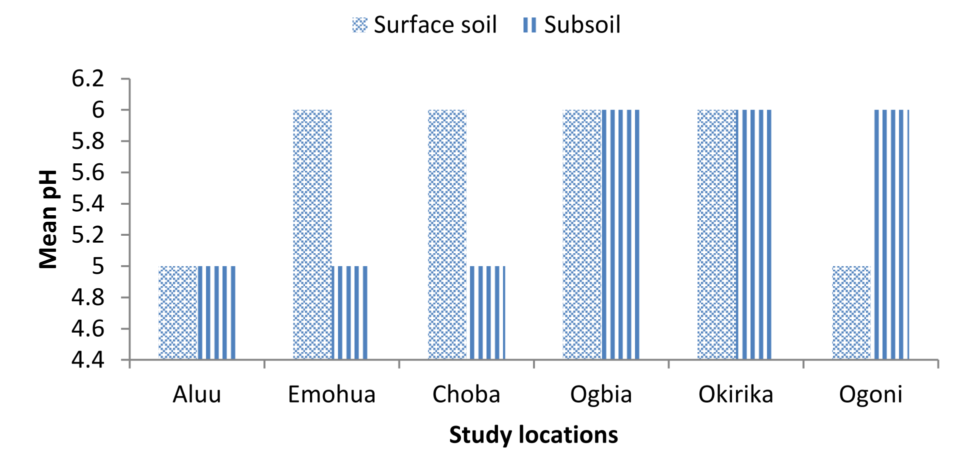

Fig. 1b: pH of the study locations at dry season

There were increased anthropogenic activities on the surface soil and effluents from different sources are dumped more on the surface soil. Otherwise every other value fell within the weak acid range in both the wet and dry seasons in the different locations. The values for conductivity varied both seasonally and spatially. Variation levels were higher in the surface soil than the subsoil in the wet season. The surface soil at sites Aluu and Ogbia were significantly higher in values at the p=0.05 levels than their sub soil (Fig 2a). There was no significant difference between surface soil Choba and Sub soil Choba. However in the dry season the values for Aluu, Emohua and Okrika were higher for surface soil while the other sites Choba, Ogbia and Ogoni had higher values for sub soil (Fig 2b). There was spatial variation in the alkalinity content of the soil. For the rainy season, Emohua was significantly higher than all the other sites for both the surface and the sub soil. The result was still same in the dry season (Fig 3a and b). The nutrients in the soil showed that SO_4 was significantly higher in the surface soil in the wet season. The site Aluu, Choba and Ogoni were significantly higher than the other sites for surface soil (Fig4a) but the highest was in Choba. The subsoil was significantly (p= 0.05) higher in Ogoni, and Okrika. The least values for both surface and subsoil were found in Emohua in both the wet and the dry seasons. Ogbia was significantly higher (p = 0.05) higher than all the other sites in the dry season. The phosphate content showed that Emohua, Choba, Ogbia and Okrika had the same Values and are significantly higher (p=0.05) for surface soil in the wet season while Choba and Okrika are higher at p = 0.05 levels for the subsoil in the wet season (Fig 5a). In Choba and Okrika the values for the surface soil and sub soil were the same and significantly higher than the other sites in the dry season (Fig 5b). In Aluu, Ogoni and Ogbia the values for the subsoil was higher than the surface soil. The soil NO_3 showed the highest content in wet season in Ogbia (Fig 6a) for surface soil. This value was significantly (p=0.05) higher than the others while the other values stayed very close to each other for both the surface and the sub soil. For the dry season the values for Ogbia was higher for both surface and sub soil (Fig 6b). The values for all the sites look like the values for wet season but only slightly lower. The organic matter content showed a significantly (p=0.05) higher value in the wet season (Fig 7a).The surface soil was higher in value than the subsoil in all the sites but the highest was in Ogbia closely followed by Okrika for both surface and sub soil. The highest value was still found in Ogbia for both surface and sub soil in the dry season (Fig 7b).

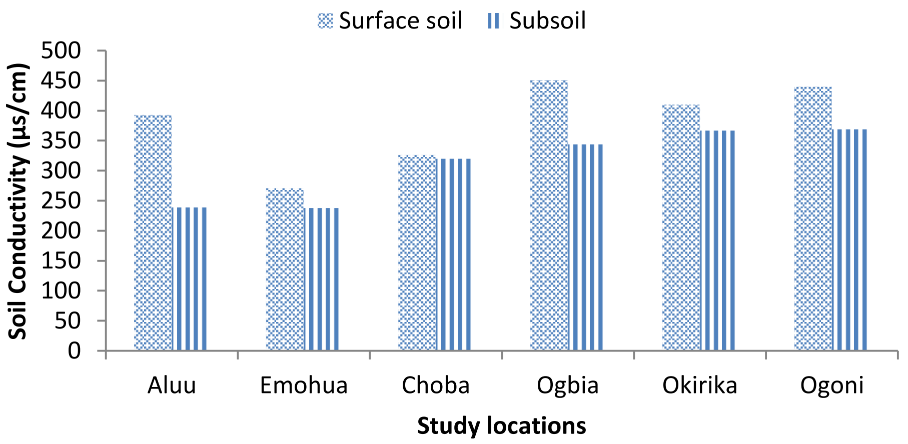

Fig. 2a: Soil conductivity of the study locations at wet season

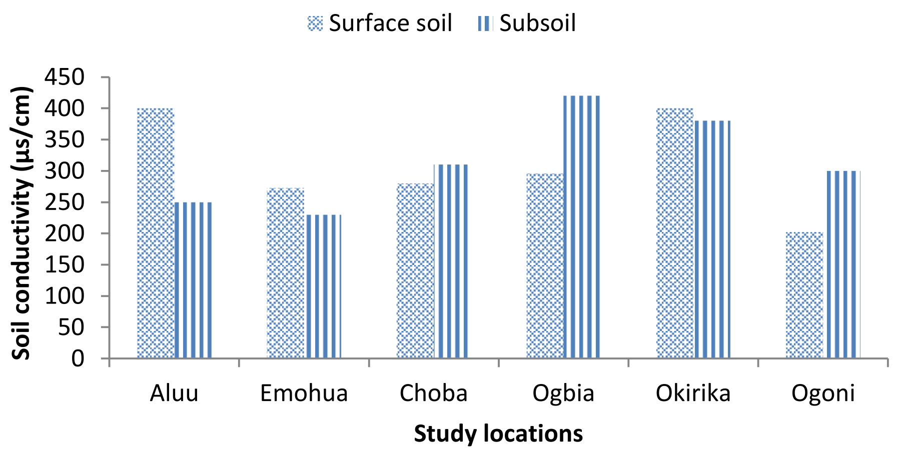

Fig. 2b: Soil conductivity of the study locations at dry season

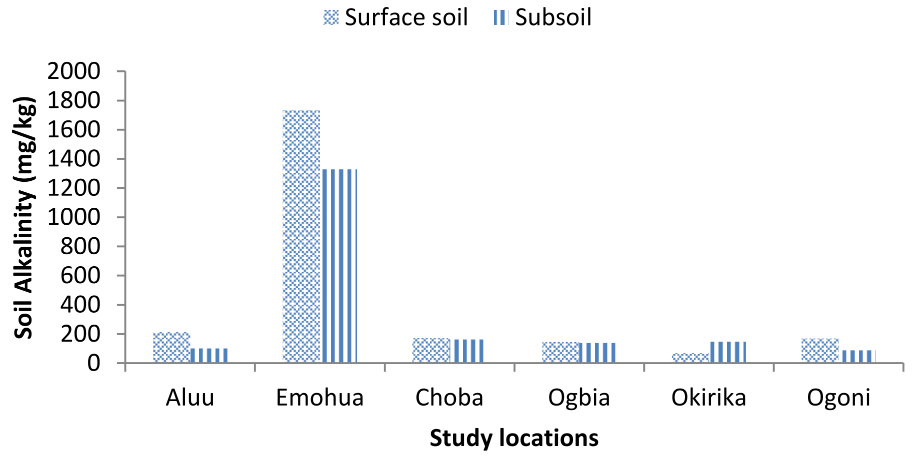

Fig. 3a: Soil Alkalinity of the study locations at wet season

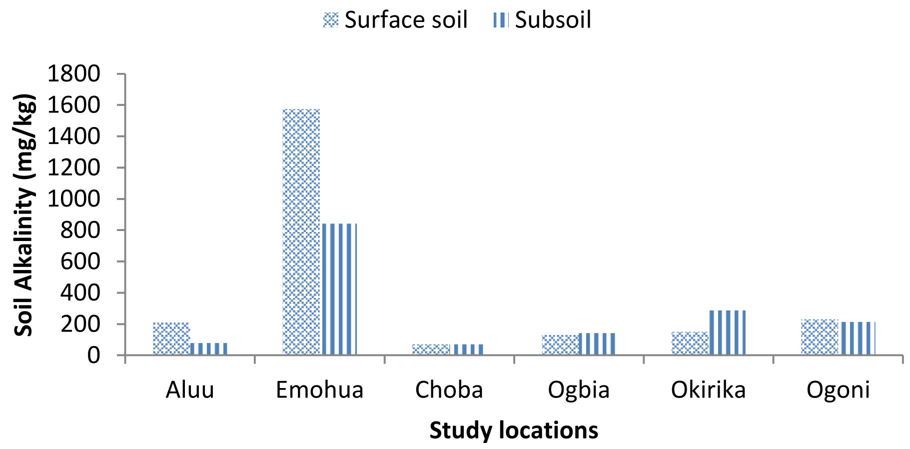

Fig. 3b: Soil Alkalinity of the study locations at dry season

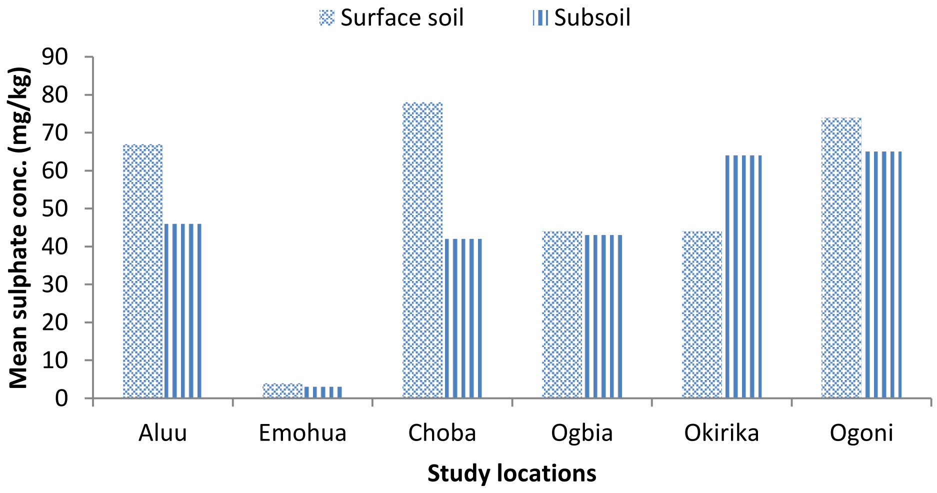

Fig. 4a: Soil sulphate concentrations of the study locations at wet season

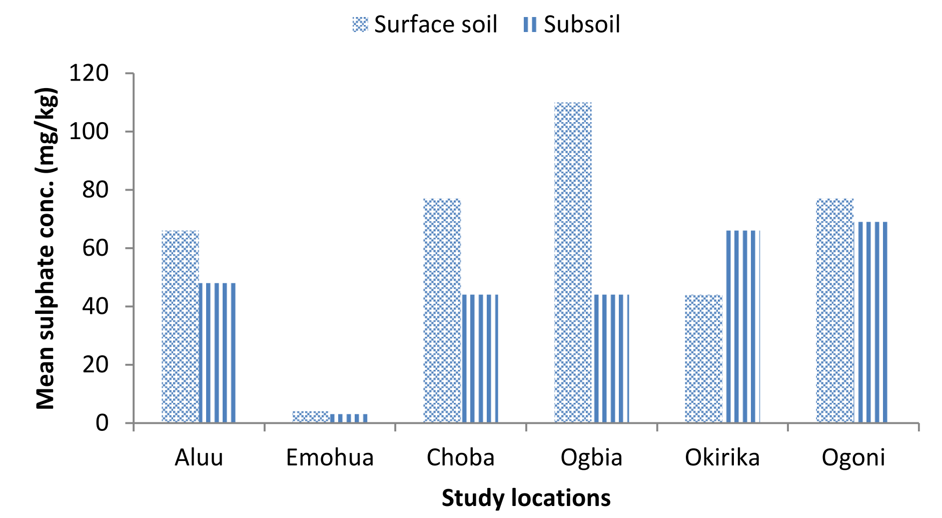

Fig. 4b: Soil sulphate concentrations of the study locations at dry season

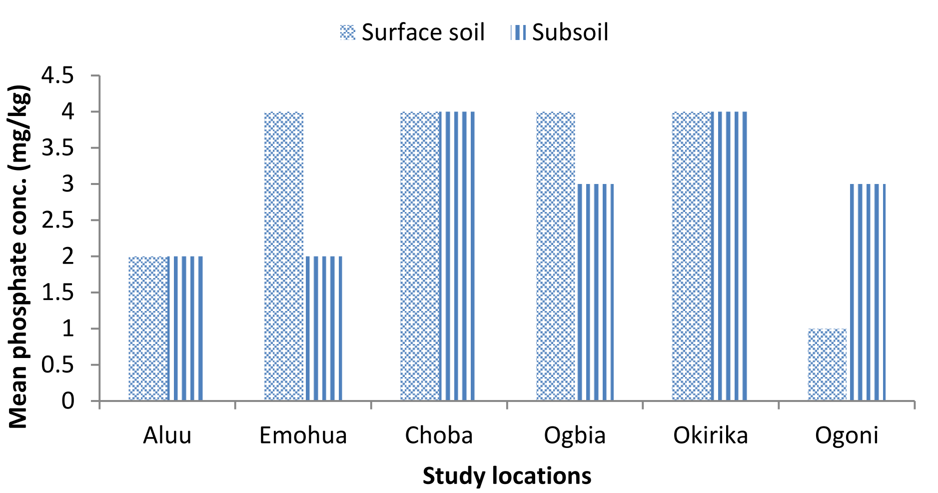

Fig. 5a: Soil phosphate concentrations of the study locations at wet season

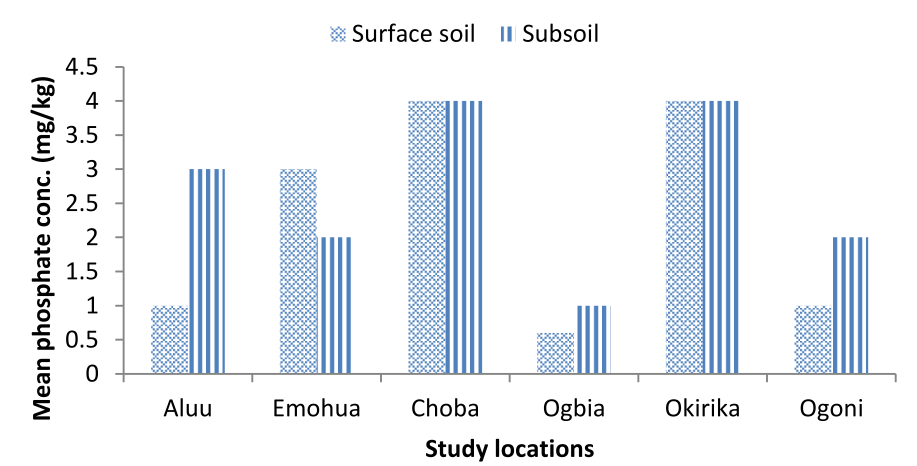

Fig. 5b: Soil phosphate concentrations of the study locations at dry season

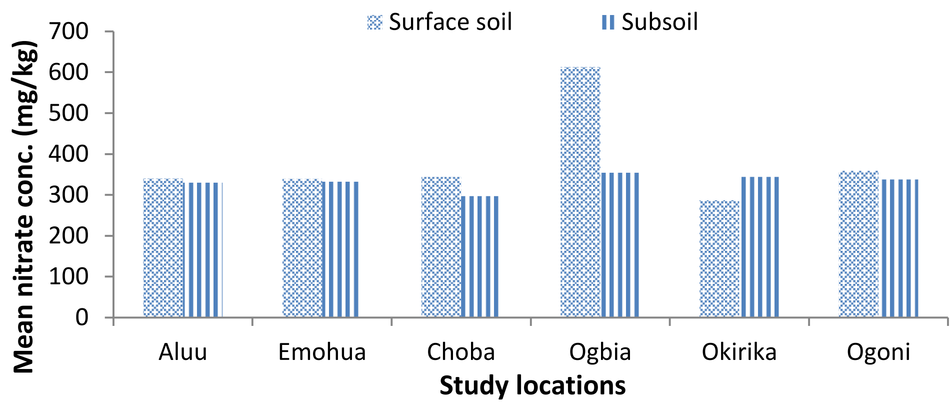

Fig. 6a: Soil nitrate concentrations of the study locations at wet season

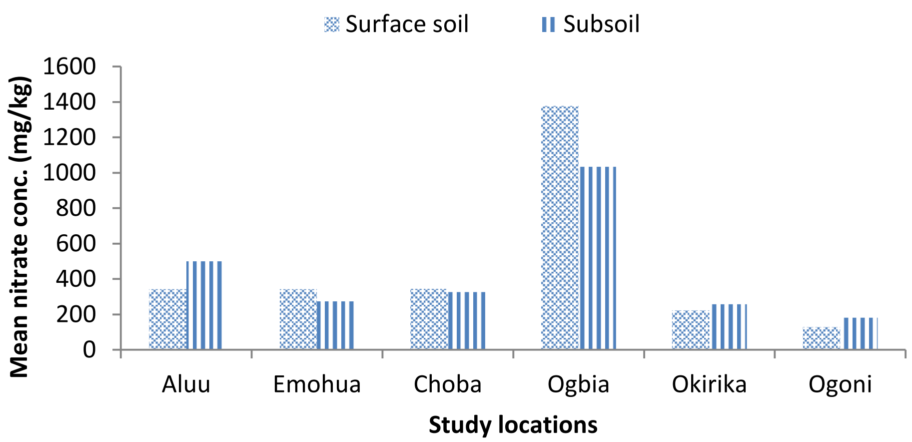

Fig. 6b: Soil nitrate concentrations of the study locations at dry season

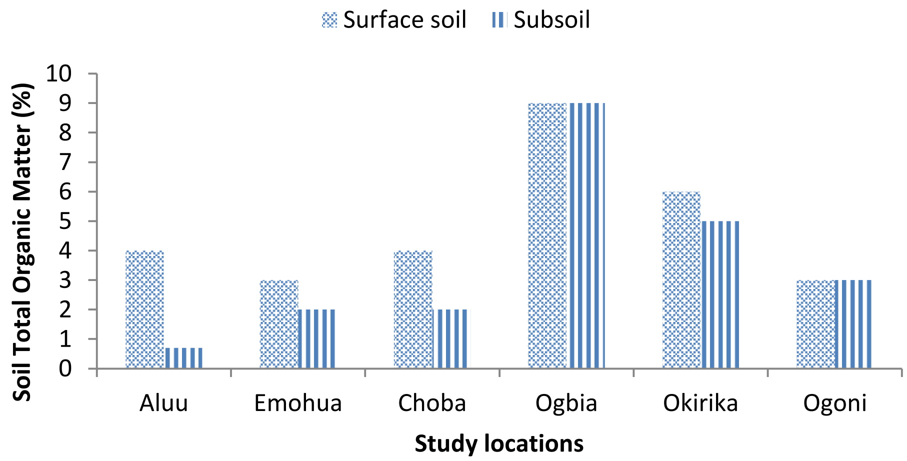

Fig. 7a: Soil Total Organic Matter of the study locations at wet season

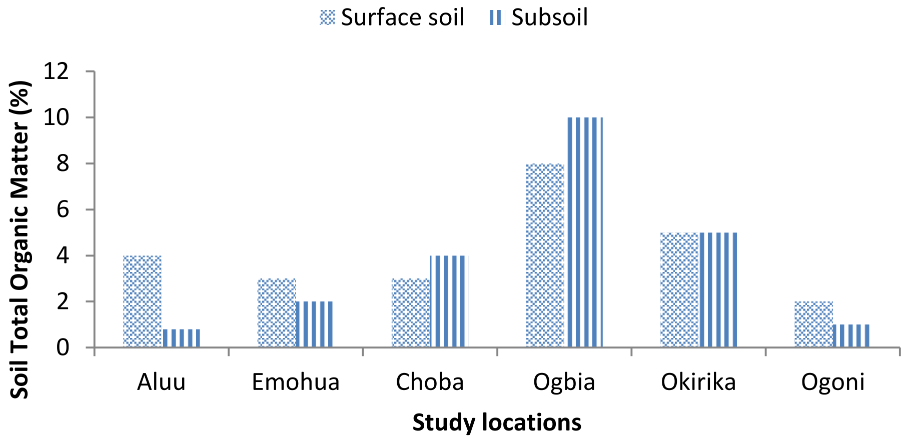

Fig. 7b: Soil Total Organic Matter of the study locations at dry season

M. lunatum thrives in the bank of fresh, brackish and salt water (Airy-shaw, 1985; Nyananyo, 2006). The water bodies here were confirmed as fresh, salt or brackish using local intelligence by the use of the presence of certain plants basically *Nypa fruiticans* (nypa palm) to indicate fresh water and *Pandamus* species to indicate brackish and salt water. Once nypa palm is present in an area it was obvious that *M. lunatum* will not be present and it is usually confirmed as fresh water. On the other hand *Pandamus* was used to indicate brackish or salt water as there was no better way of separating the two but invariably will yield *M. lunatum*, so *Pandamus* was used as an indicator of the most likely places where the plant can be found. *Pandamus* was present in all the sites used for this study.

The pH scale measures the degree of acidity and or alkalinity of the soil; it also affects the solubility of certain minerals and nutrient availability in the soil (Ololade et al., 2007). pH has been known to have maximum variability and spatial dependence (Bilal et al., 2007). The optimum range of pH for plants to grow is between 3-9 (Tanee, 2007). All the locations used for this study were of the weak acid range between 5-7. The Ogbia site was less acidic than the other sites, it also was a larger water body among all the sites sampled and had larger surface area than the other sites. The stands were only accessible through water and the stands are mainly anchored in the silty parts.

Conductivity, alkalinity and soil total organic matter

Soil conductivity determines the degree of free cations present and is a measure of the fertility of the soil. The concentration of ions in the solution is determined by the process of oxidation, reduction, adsorption, precipitation and desorption (Alloways, 1995). Conductivity decreases with years and with soil depth (Sequel et al., 1995). Conductivity levels of the site sampled were higher in wet season. Alkalinity decreases with soil depth this is because movement of elements is slow in the dry season and so the surface soil shows mean low alkalinity content than the sub soil. During the rainy season there is increase in salinity and decrease in alkalinity. The CEC even though not shown here was high. This could be because the plant is not cultivated rather it grows in the wild. This agrees with the work of Sharma et al. (2009) who found higher values in agroforestry system compared to an agro- horticultural system, pastoral system and arable land. Soil organic matter serves as an indispensable source of plant nutrients and enhances soil biological, chemical and physical properties. Organic matter contributes to

CEC, soil water holding capacity, aggregate stability, permeability and other desirable soil properties. Carbon is a major part of soil organic matter and holds a great proportion of nutrients, cations, and trace elements that are of importance to plant growth. It prevents nutrient leaching and is integral to organic acids that make minerals available to plants (Agbede, 2009). It buffers the soil from strong change in pH (Leu, 2007). The amount of organic matter in soil is dependent on the annual input of organic material, and the rate of decomposition. Decomposition is usually highest in hot, humid climatic regions (De Ridder & Van Keulen, 1990; Rowell, 1994). The organic matter content in these sites varied greatly and was generally low but was not a limiting factor in the establishment, growth and survival of *M. lunatum* in these areas. This agrees with the work of Ojeniyi (2012) which says that soils in sub Saharan Africa are generally inherently and spatially low in soil organic matter content. The alluvial nature of the soil and the inherent properties of the soil provided the requirements needed for it to thrive. Besides tidal action floods the area constantly invariably and may contribute a major part of the nutrient requirement. In the wet season the surface area had higher values while in the dry season the subsoil were higher in some sites, moisture may be a contributing factor since in the wet season the surface area is constantly moistened by rain in addition to the tidal action but in the dry season the subsoil does not dry out at the rate of the surface soil.

Phosphate, Sulphate and Nitrate

The basic components of fertilizer used in most agricultural ventures are Nitrogen, Phosphorus and Potassium in different ratios this property sets them apart as itinerant components in soil enhancement for a better performance for plants. Other major nutrients include Ca, mg and S while others still are needed in trace quantities. These nutrients are obtained from the breakdown of organic and inorganic materials to forms that are absorbable and available to plants. All legumes have nodules from which nitrogen fixing bacteria transform atmospheric nitrogen to the more plant appropriate nitrite from where it is reduced and incorporated into organic compounds. *M. lunatum* is a legume and so has the capacity of carrying out these processes. The nitrate content of the soil was found to be high but higher in the rainy season maybe because the soil has more moisture in the rainy season than the dry season. The location Ogbia had more nitrate content than the other sites and may account for the luxuriance of the leaves and the abundance of the stands in the area. This agrees with the work of Palmer et al (2001) and Giller, (2001). Legumes require phosphorus for growth and nitrogen fixation (Ae et al., 1990; Giller and Wilson, 1991). Soil phosphorus is an important factor in biomass accumulation (Enrique et al., 2015). The surface soil of the rainy season was higher in phosphate content than the subsoil in rainy season; this could also be attributed to the retention of moisture during the rains. Sulphate derived from sulphur is a constituent of amino acids in plant protein and is involved in every producing process in plants. The alkalinity values in Emohua were low while the sulphate content was invariably high; this shows the soil at Emohua was less acidic even though the water is salt water. These mineral elements have maximum variability and are measures of the soil fertility. The mean values of these parameters were high in the sites used for this study mostly at the river banks and tidal areas. The rate of absorption for these elements was not dependent on the type of water body the plant inhabits since on the long run the rate of survival, growth and production of fruits was not affected. Since this plant is an aquatic plant the seed floats on water until it finds a conducive substrate and begins its life cycle again when the roots are firmly anchored on the substrate. *M. lunatum* is a shrub that grows on water and has a high network of branching roots. This gives the root an increased surface area which also means more availability of nutrients and prevents it from being hindered by whatever edaphic factors that is at play in any particular environment. From the findings, it can therefore be concluded that mild acid pH (5 – 6 range), high soil phosphate and nitrate contents are some of the edaphic characteristics which support the survival of *M. lunatun*.

REFERENCES

Ae et al. (1990) Phosphorus uptake by pigeon pea and it's role in cropping systems of the Indian Subcontinent, Science 248: 477 - 480.

Agbede, O.O. (2009) *Understanding Soil and Plant Nutrition*. Salman Press and Co Nig Ltd Keffi Nassarawa State Nigeria.260 pp.

Alloway, A.B. (1995) *Chemical Principles of Environment Pollution.* New York.

Airy-Shaw, H. K. (1985) *A dictionary of the flowering plants and ferns.* 8th edition. Cambridge: University Press.

Bilal et al. (2007) Assessment of Spatial Variability in some soil Properties as related to soil salinity, alkalinity in Biafra plain in Northern Turkey. *Environ. Monit Asses* 124: 223 – 234.

Burkill, H. M. (1995) *The useful plants of West Tropical Africa.*Vol. 3. Surrey, England: Royal Botanic Gardens.

De Ridder, N. & Van Keulen, H. (1990) Some aspects of the role of organic matter in sustainable intensified arable farming system in the West African semi-arid tropics *Fert. Res.* 26: 299 – 310

Dike, B. U. & Nwachukwu, B.A. (2003) Analysis of Nigerian Hydrometeorological Data. *Nigerian Journal of Technology*, 22 (1):29-382.

Enrique et al. (2015) Changes in Soil Physical and Chemical Properties in Long Term Improved Natural and Traditional Agroforestry Management systems of Cacao Genotypes in Peruvian Amazon. National center for Biotechnology Information, National Library of Medicine 8600 Rockville Pike, Bethesda MD 20894 USA

Giller, K.E. (2001) *Nitrogen Fixation in Tropical Cropping Systems.*2nd ed. CAB International, Wallingford, 423 pp

Giller, K.E. & Wilson, K.J. (1991) *Nitrogen Fixation in Tropical Cropping Systems*, CAB International, Wallingford, UK, 313 pp.

Keay, R.W.J. (1985) *Flora of west tropical Africa.*Edition 2 volume I part2National Germplasm Resources laboratory Beltsville, Maryland.

Klitgaard, B.B & M. Lavin (2005) Dalbergieae pp. 307-335 in legumes of the world, eds. G.B. Lewis, B. Schirre, B. Mackinder, and M. Lock. Kew: Royal Botanic Gardens.

Leu, A. (2007) Organic and Soil Carbon: Increasing soil carbon, crop productivity and farm profitability in "managing the carbon cycle' Katanning Workshop 21-22 March 2007 www.Amazingcarbon.com

Mendonca-Filho et al. (2011) "Two new species of *Machaerium* (leguminosae) from Bahia and Southeastern Brazil". *Novon 21 (1): 73-77.*

Nyananyo B.L. (2006) *Plants from the Niger Delta.* Port-Harcourt: Onyoma publications.

Ololade et al. (2007) A study on effects of soil physico-chemical properties on cocoa production in Ondo State. *Modern Applied Science.* 2010; 4: 35–43.

Ojeniyi, S.O. (2012) *Tropical Soil Management and Agriculture in Nigeria.* Bash-Moses publishers Ososami, Ibadan, Oyo State. Pp.122

Rowell,D.L. (1994) *Soil Science: Methods and applications.* Longman – U.K. Pp. 266-276

Seguel et al. (2013) Physical properties of a fine textured haplocambid after three years of organic matter amendments management. *J Soil Sci and Plant Nutrition;* 13: 690–705.

Sharma et al. (2009) Soil fertility and quality assessment under tree-, crop-, and pasture-based land-use systems in a rain fed environment. *Comm in Soil Sci and Plant Anal*; 40: 1436–1461.

ISSN 2056-5879

Tamunobereton-Ari, I., Uko, E. D. & Davies, D. H. (2013) Prediction of Water Resource Potentials and Sustainable Supply of Water in Port Harcourt, Nigeria from Meteorological Data. *The International Journal of Engineering and Science*, 2(01): 222-231.

Tanee, F.G.B. (2007) The Performance of Two Cassava (*Mannihot esculenta*,Crantz) Varieties (Nr 8082 And Tms 30572) In A Crude Oil Polluted Following Remediation. Ph.D Thesis Department of Plant Science and Biotechnology, University of Port Harcourt.

Uko, E. D. & Tamunobereton-Ari, I. (2013) Variability of Climatic Parameters in Port Harcourt, Nigeria. *The International Journal of Engineering and Science*, 4(5):727-730.