Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.2, 2015

Physico-Chemical Analysis of Otuoke Soils

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ABSTRACT

The study sternly examined the physico-chemical status of Otuoke soils by direct contact with the physical environment and collection of soil samples at eight (8) sites, which were analyzed in the laboratory. The study discovered a high nutrient level of soils in the study area which were simplified in three (3) descriptive tables of physical parameters, chemical parameters, and a summarized nutrient status. Finally, the study recommended for the high nutrient status of soils of the study area never to be abandoned instead, application of a suitable Land use zoning method to enable the effective existence of urbanization, industrialization and agricultural development in the area is necessary.

Key Words: 1. Physical Parameters 2. Chemical Parameters 3. Soil Analysis 4. Soil Taxonomy 5. Nutrient Status.

INTRODUCTION

Soil, as a natural phenomenon on the earth's surface is as vital as air and water for human survival and continuity of life in general. This has been an innate understanding in man, noticed in the sitting of ancient settlements and migration of ancient people which were in accordance with areas of fertile soils (Robinson, 1977 and Allison-Oguru etal, 1999). Soil survey staff of the United States Department of Agriculture attempted a broad definition of soil as the natural medium for the growth of plants, whether with or without horizons. They stressed further that, people all over the world have attached so much importance to soil for its support for a variety of highly significant features on earth such as food supply, production of fibers and drugs, infiltration of surface water, purification of groundwater, recycling of solid wastes (especially, organic wastes), and other human wants (Eli, 2012).

The rapid increase in human population across the globe has called for responses from various categories of persons touching various spheres of living in the world. These include structural adjustments in terms of number of births per nuclear family, urban and housing policy formulation and implementation, transport planning and management, planning and management of water, food supply, shelter and job opportunities etc. While all these are seriously under consideration, the need for a more serious attention on the three basic features for human survival (air, water and soil) is emphasized for significant results. (Collinson, 1977; and Garg, 2010). The importance of soils which cannot be over-emphasized can be seen in human survival, as well as plant and animal survival including micro-biological organisms. On this basis, there have been various dimensional studies of soil, i.e. both in regional (large) scale and unit (small) scale.

The significance for an in-depth study of the physical components and processes of soils has been greatly highlighted by Ukpong (2009). He discovered the inevitability of high soil quality for human survival in his work on perspectives on environmental management. A more emphasis has been stressed by Ogban (2009) in his work on Air, Soil and Water quality.Whether regional or non-regional and whether comprehensive or specific, soils are studied in terms of identification of types, climatic regions, physical parameters, chemical parameters, biological parameters, specific use, vertical horizons, local influence, and mode of formation (Waugh, 1995; Allison-Oguru, etal, 1999; Mayhew, 2009 and Eli, 2012). The first Scientist to attempt a classification of soils in a modern perspective was one Russian Soil Scientist called V. V. Dikuchaiev in 1900, placing soils in accordance to latitudinal zones (Kormondy, 2012). In 1938, the United States Department of Agriculture (USDA) developed a famous soil taxonomy which has stood the test of time as follows. Alfisols, Andisols Aridisols, Entisols, gelisols, histisols, inceptisols, mollisols, oxisols, spodosols, utisols and vertisols (Eli, 2012; and Kormondy, 2012). In 1978, Bridges (in Kormondy, 2012) advanced a zonal classification of soils in terms of latitudinal zone, bio-climatic zone and zonal soils.

Studies have revealed that soil is not static. Climato-fluvial and environmental factors are constantly working on the physical and chemical characteristics of soils of places that changes are often noticed from time to time, and from place to place (Olubiyo, 2003 and Ogidiolu, 2003). In a special purposed research carried out by Allison-Oguru, Zoufa and Berepubo (1999) on the Agricultural practices of people of Bayelsa State in the Niger Delta region of Nigeria, discovered that various places within Bayelsa State practice different methods of agriculture

resulting from difference in individual river characteristics and difference in soil nutrient status and cultural practices. They also discovered that rivers in the state drain differently and flood differently. To affirm this assertion is a study carried out by Abua et al (2009) on flooding effects on crop production along the Taylor Creek in Gbarain-Clan in Bayelsa State, discovered differences in effects on the various communities making up the Gbarain area due to differences in river characteristics, crops and cultural practices.

The study area is located in the midst of four famous creeks in the Niger Delta (Otuoke Creek, Kolo Creek, Akoloman Creek and Ekole Creek). Each of these rivers drains severely, its own catchment area. Carrying out an assessment of the nutrient status of soils of the study area is very necessary. Understanding the physico-chemical staltus of the soils of the study area, and bringing it to the fore will go a long way in solving a lot of problems afflicting the area and equally, it will help in directing agricultural activities in the area.

STATEMENT OF THE PROBLEM

Otuoke community from the beginning had been agriculture-based settlement with subsistence system in the major (amidst petty trading and a few civil service opportunities vis-à-vis teaching). Resulting from its privileged position as the home-town of Nigeria's current president, the study area stands out as the fastest growing rural settlement in Bayelsa State. The presence of Federal University, hospitals and other development prone institutions have enhanced this opportunity. Consequently, there is observable increase in population in-flux and physical expansion of settlement size on daily basis. From this development, there is high demand for food and accommodation, and scarcity of available land is beginning to be experienced. Meanwhile, the absence of a balancing effect to cushion the emerging consequences is quite obvious.

It is high-time; Otuoke community owns a documentary on some significant spheres of life, such as socio-cultural and environmental factors including soils in its nutrient status, importance and management. Establishing a comprehensive data-base for the study area is very necessary. This work is concerned with the absence of such vital accounts. This study goes a long way in opening many windows for further research on various aspects of the area's physical and socio-economic environment especially, as it concerns soils. Its findings will assist policy makers and developers to make a good and successful plan for the young and fast-growing rural settlement.

AIM AND OBJECTIVES OF THE STUDY

The main aim of this study is to make analysis of the physico-chemical properties of Otuoke soils.

The specific objectives include the following:

i. To have a direct contact with the soils and physical environment of the study area and description of its soil nutrient.
ii. To draw a descriptive table showing a general textural status of Otuoke soils in terms of sand, silt and clay
iii. To draw a descriptive table showing the chemical parameters of Otuoke soils in terms of pH, electrical conductivity, organic- carbon, total nitrogen, available phosphorus, calcium, Magnesium, Potassium and Sodium; and,
iv. To unveil the potentialities of soils of the study area.

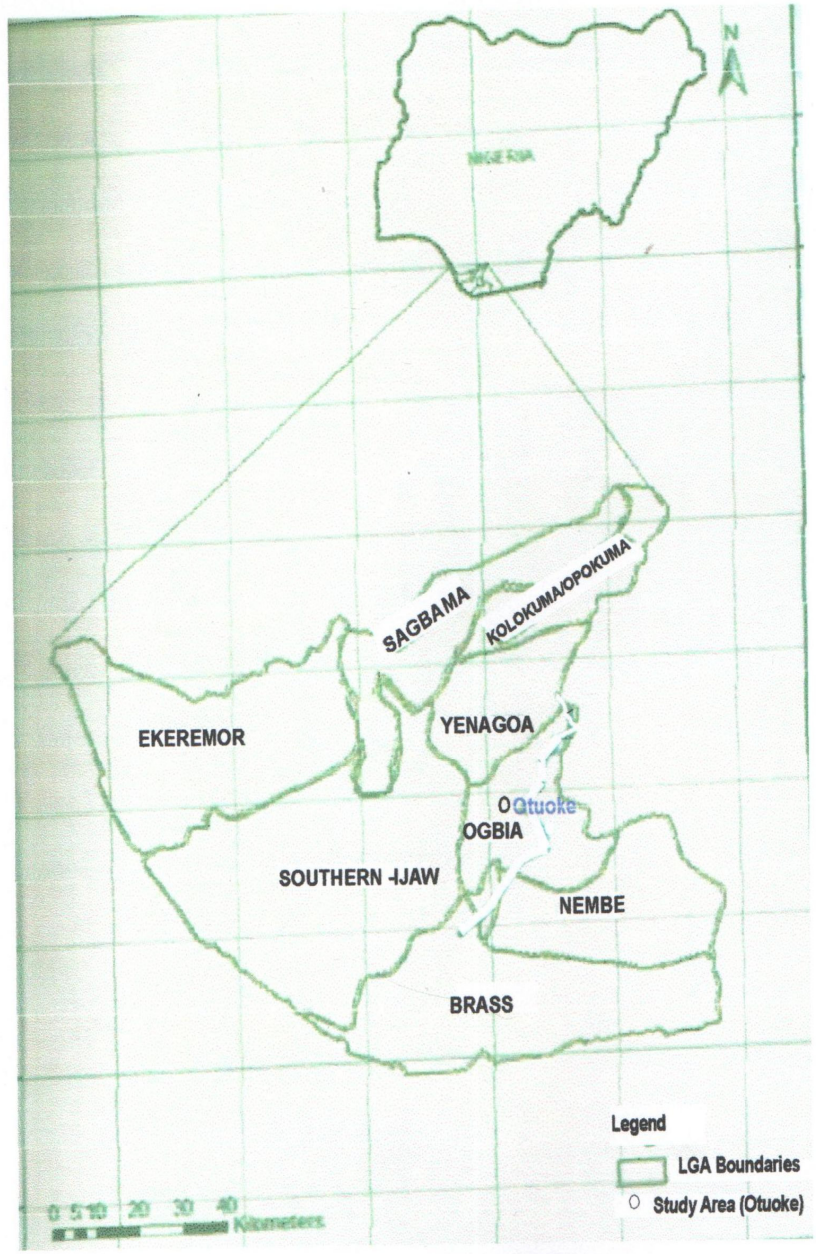
THE STUDY AREA

The study area (Otuoke) is located in Ogbia Local Government Area of Bayelsa State of Nigeria. Its point location is approximately at Lat 4^{o} 49^{1} North and Long 6^{o} 20^{1} East. It is bounded to the North by Elebele Community, to the East by Emeyal I and Kolo, to the West by Onuebum and Otuogori, and to the South by Otuaba and Ewoi Communities; all in Ogbia Local Government Area of Bayelsa State.

Otuoke, occupies a central position in the Niger Delta region of Nigeria. The surface is majorly drained by Otuoke Creek-Drainage System, cutting through the community from Elebele in the North, to Otuaba in the South, and emptying into Kolo Creek at Otuogidi/Ogbia – Town in the down South. By extension, its farmlands and extended territories are drained by Ekole Creek in the West through Atubu sub – creek and swamp drainage system; in the East by Kolo Creek drainage system, and South East by Akoloman Creek drainage system. The

area's climate being equatorial, and the reaches of the creeks draining the study area being fresh water reaches that are not obviously tidal, the vegetation is predominated by a peculiar freshwater swamp vegetation observed to have a mix of little freshwater vegetation and equatorial high forest, which we call High Equatorial Swamp forest.

With a high in-flux of human population on daily basis due to development projects and educational and medical institutions present, the study area has a complex socio-economic system. Its main livelihood patterns include sub-commercial cropping and swamp-fishing, trading, civil service jobs, transportation and apprenticeship trades such as bricklaying, welding, painting, carpentering, etc. The study area is mainly communicated by road. The water routes which are blocked by water hyacinths are mostly utilized by farmers who have their farms located along or near the water courses.



Map of Bayelsa State Showing the Study Area

Fig. 1.

Source:Calligraphic Unit,
Dept. Of Geography & Environmental Management,
Niger Delta University, Bayelsa State

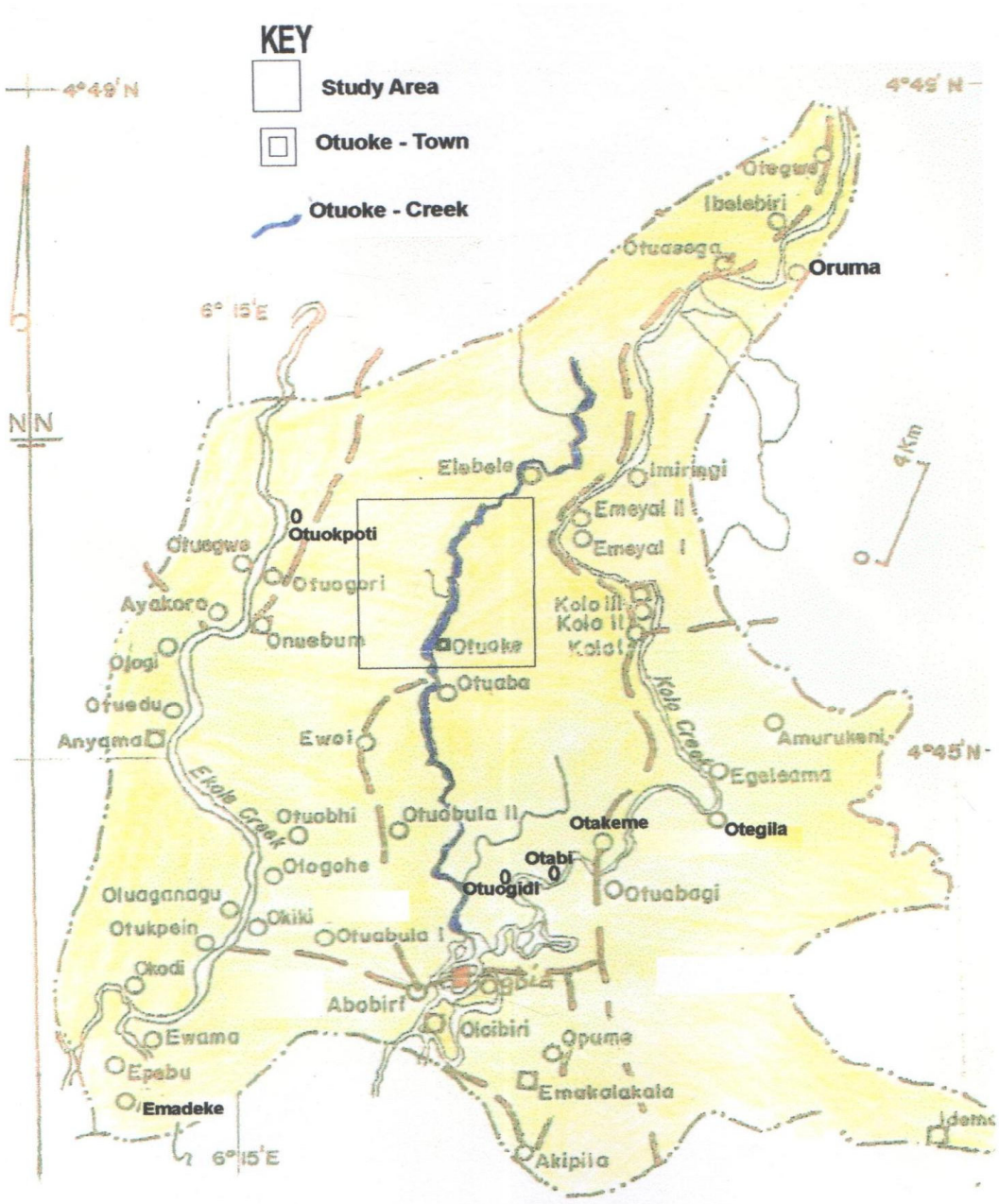


Fig. 2. **Map of Ogbia Local Government Area Showing the Study Area (Otuoke)**

MATERIALS AND METHODS

To effect an appropriate physico-chemical analysis of Otuoke soils, three (3) basic materials were taken to the field, viz; eight black polythene bags for the collection of soil samples; a GPS for recording of coordinates of the soil sample sites and a soil auger for collection of soil samples.

With the use of soil auger, composite soil samples were taken at two depths i.e. 0-15cm (surface soils) and 15-30cm (sub-surface soils) at eight sites, spread over the study area in consonant with the four drainage systems influencing the area. i.e. two sample sites in the North, two in the East, two in the West and two in the South. The collected samples were transported to the laboratory in labeled black polythene bags for the analysis of physico-chemical parameters.

The physico-chemical parameters analyzed include the following;

a. Physical Parameters;
   i. Sand
   ii. Silt
   iii. Clay
   iv. General textural status

b. Chemical Parameters
   i. pH
   ii. Electrical Conductivity (EC)
   iii. Organic Carbon (C)
   iv. Total Nitrogen
   v. Available Phosphorus (P)
   vi. Calcium (Ca)
   vii. Magnesium (Mg)
   viii. Potassium (K)
   ix. Sodium (Na)

Table 1: Soil Sample Sites and their Coordinates

S/NO	Sample Site	Coordinate
1	N1- North 1	**N** $4^0 48^1 20.536^{11}$ E $6^0 15^1 49.213^{11}$
2	N2- North 2	**N** $4^0 48^1 15.073^{11}$ E $6^0 16^1 37.882^{11}$
3	E1- East 1	**N** $4^0 47^1 30.541^{11}$ E $6^0 16_1 44.404^{11}$
4	E2- East 2	**N** $4^0 47^1 30.541^{11}$ E $6^0 17^1 24.593^{11}$
5	W1-West 1	N $4^0 47^1 50.517^{11}$ E $6^0 14^1 31.075^{11}$
6	W2-West 2	**N** $4^0 47^1 34.358^{11}$ E $6^0 14^1 57.93^{11}$
7	S1- South 1	**N** $4^0 46^1 50.455^{11}$ E $6^0 14^1 44.711^{11}$
8	S2- South 2	**N** $4^0 46^1 53.674^{11}$ E $6^0 16^1 21.989^{11}$

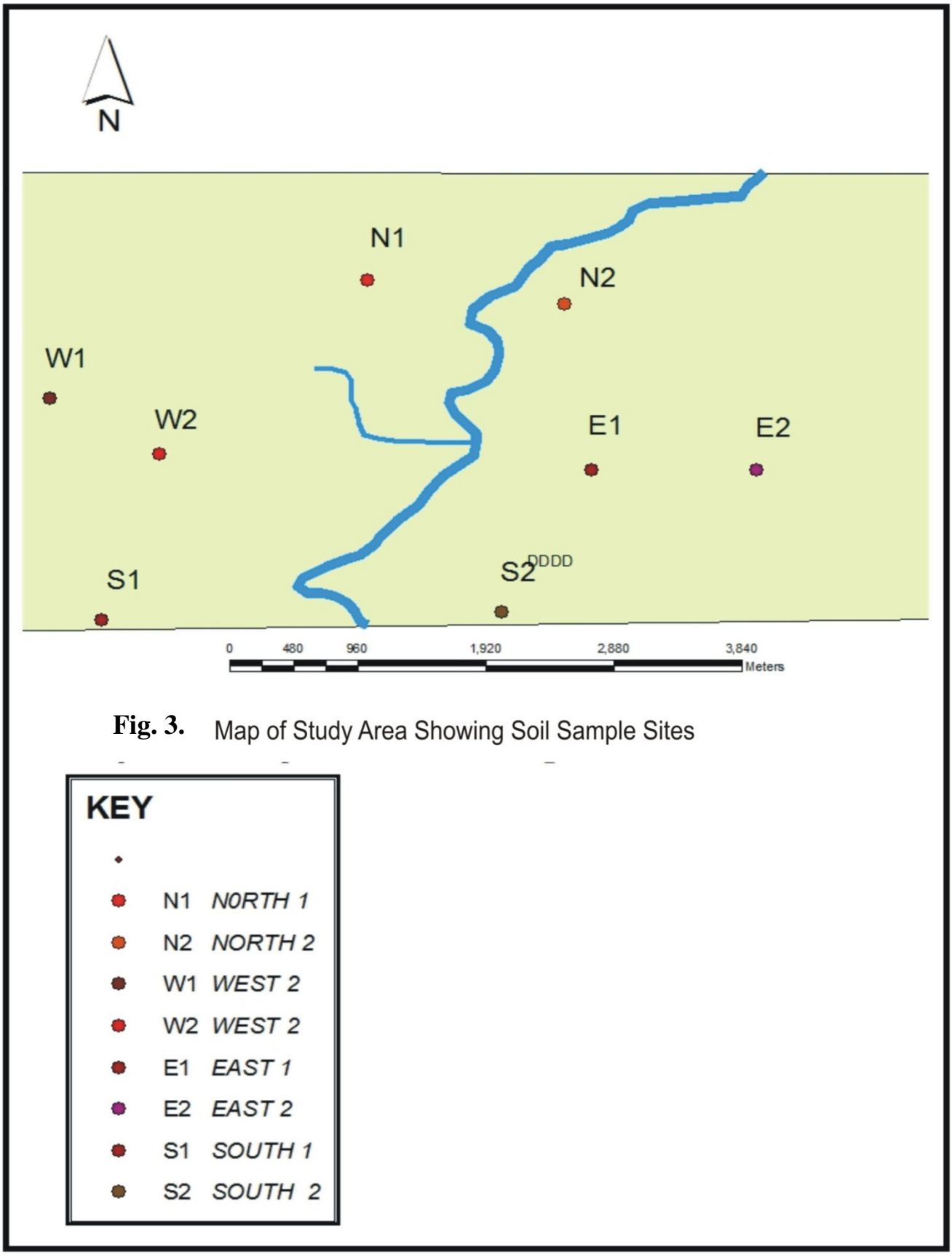


Fig. 3. Map of Study Area Showing Soil Sample Sites

The Soil Samples collected were air-dried at room temperature, ground with wooden roller and sieved via 2mm mesh. Particle size distribution was determined by Bouyoucos hydrometer method, using sodium hexa – metaphosphate as a dispersant, and the textural classes were determined by using the textural triangle chart.
The chemical parameters were determined, using the following procedures;
Soil pH was determined in 1:2.5 soil, and water suspension using calomel glass electrode pH meter. Organic carbon was determined by the application of walkley and Black method as outlined by Juo (1979) and the available phosphorus was determined by the application of Bray and Kurtz (1945) No. 1 method. Total Nitrogen was determined by the micro-Kjeldahl digestion method. Exchangeable bases of calcium and magnesium was determined in the extract by Versenate EDTA titration method, while the exchangeable bases of potassium and sodium was determined by flame photometry.

FINDINGS AND DISCUSSION

Table 2: Physical Parameters of Otuoke Soils

S/NO	Soil Samples site	Physical Parameters			Textural Class	%
		Sand	Silt	Clay		
1	North 1	84.76	4.52	10.72	Loamy silt (ls)	
2	North 2	84.74	4.54	10.72	,,	
3	East 1	84.76	4.54	10.70	,,	
4	East 2	84.78	4.58	10.64	,,	75%
5	West 1	84.70	4.54	10.76	,,	
6	West 2	84.70	4.52	10.78	,,	
7	South 1	82.76	4.52	12.72	silty loam	
8	South 2	82.74	4.50	12.76	silty loam	25%
	Average	**84.24**	**4.53**	**11.23**	**loamy silt**	**100%**

Table 3: Chemical Parameters of Otuoke Soils

S/N	Soil Samples Site	Chemical Parameters									
		pH	EC	C %	N %	P	Ca	Mg	K	Na	Nutrient Level
1	North 1	4.3	0.004	3.05	0.13	12	3.68	6.52	1.69	0.26	High
2	North 2	4.3	0.004	2.95	0.14	12	3.67	6.52	1.69	0.25	,,
3	East 1	4.4	0.005	2.45	0.13	13	3.65	3.20	1.73	0.24	,,
4	East 2	4.5	0.006	2.97	0.12	13	3.67	3.55	1.74	0.41	,,
5	West 1	4.4	0.004	2.94	0.12	12	3.79	4.69	1.70	1.25	,,
6	West 2	4.4	0.003	2.93	0.13	14	3.76	4.67	1.70	1.30	,,
7	South 1	4.3	0.008	2.95	0.11	14	3.60	4.07	2.06	1.67	,,
8	South 2	4.4	0.009	2.95	0.11	13	3.61	4.09	2.04	1.68	,,
	Average	4.4	0.005	2.95	0.12	13	3.68	4.66	1.79	0.88	

Table 2, shows the status of physical parameters of Otuoke soils, sampled from eight units within the study area. The sand, silt and clay fractions did not vary much with site. The texture of the soils sampled don't vary significantly within six of the sampling units (i.e. North 1, North 2, East 1. East 2, West 1 and West 2), showing texture status of loamy-silt; while only two of the stations in the South (i.e. South 1 and South 2) show a texture status of silty loam. Comprehensively, the table reveals a seventy-five percent (75%) of loamy silt, and a twenty-five (25%) of silty loam. On the average, each textural fraction is shown in the table vis-à-vis sand (84.24%), silt (4.53%) and clay (11.23%) showing the soils in the area as loamy silt. Such soils have the absorptive capacity for basic plant nutrient and water, because the soils are characterized as fine texture with low sand contents.

The chemical parameters of soils of the study area are shown in table 3. pH average value is 4.4. Soil pH shows whether the soil is acidic, neutral or alkalinic. This provides information on the availabilities of the exchangeable cations. Soil pH controls plants nutrient availability and microbial reactions in soil. The low pH indicates that the soils may contain pyritic materials (FeS_2) which undergo oxidation and could leach out basic cation from the soil

solum in the study area. Such acidic soil condition can induce phosphate fixation, and reduce the ability of microbes to fix atmospheric nitrogen. Electrical conductivity (EC) results of the various sampled units show a range between 0.003-0.009 dsm^{1}. The lowest being at site West 2 (0.003 dsm^{1}) and the highest at site South 2 (0.009 dsm^{1}), the average is 0.005 dsm^{1}. This means that, the soils in the study area do not have salinity problem. Therefore, it would not cause any adverse effect on crop production in the area. The presence of organic carbon in any soil forms the foundation of life in that soil. The laboratory results on organic carbon in the soils of Otuoke reveal an average of 2.95% (showing a range between 2.93% and 3.05%). Generally, it shows that the soils are inherently fertile in nutrient contents, and would not require the application of organic or inorganic fertilizers for optimum crop yields.

The available nitrogen in the soil is ammonium or nitrate ion. On the average, the soils of the study area show a nitrogen content of 0.12 percent (the lowest being 0.11% and the highest 0.14 percent). If compared with the medium range of 0.10 to 0.45 percent as rated by Holland et al (1989) the nitrogen content in soils of Otuoke is quite low; but the fact that nitrogen in the form of protein is present in the protoplasm of every cell of the area's soil, these values can support crop production in the area.

The average value of available phosphorus in the area is 13 mgkg. Phosphorus is an essential part of nucleoprotein in the cells nuclei, which control cell division and growth. Thus, the phosphorus content in the soils of Otuoke demonstrates a high fertility status. Furthermore, the average values of Calcium (3.68 $cmolkg^{1}$), Magnesium (4.66 $cmolkg^{1}$), Potassium (1.79 $cmolkg^{1}$) and Sodium (0.88 $cmolkg^{1}$) show a high nutrient status of soils in the area. Calcium (ca), Magnesium (mg), Potassium (K) and Sodium (Na) are positively charged ions which are generally absorbed by electrostatic attraction to soil surface colloids. The values are moderate, indicating that the soils could have the absorptive capacity for nutrients. See table 4 for more details.

Table 4: Nutrient Importance of Otuoke Soils

S/No	Parameters	Nutrient Importance
1	General Textural Class	The soils are loamy-silt on the average, indicating high absorptive capacity for basic plant nutrients and water
2	pH	The low pH indicates that the soils are acidic i.e may contain pyritic materials (feS_2) and can induce phosphate fixation and reduce the ability of microbes to fix atmospheric Nitrogen
3	EC	The electrical conductivity in the soils being so low shows that there is no salinity problem in the soil
4	Organic Carbon (C)	The high level of Organic carbon in the soils indicates that Otuoke soils are inherently fertile in organic content i.e they are fertile
5	Total Nitrogen	Nitrogen content in soils of the area is low; but the presence of nitrogen in the form of protein in the protoplasm of every soil cell makes its nutrients high.
6	Available Phosphorus	Phosphorus level is high in the soils, demonstrating also a high fertility status.
7	Calcium	The values show a high nutrient status i.e the soils have absorptive capacity for nutrients
8	Magnesium	-do-
9	Potassium	-do-
10	Sodium	-do-

CONCLUSION AND RECOMMENDATIONS

From all indications as revealed in tables 2, 3 and 4, the soils of Otuoke have high fertility status. Therefore, the study is sternly recommending that

i. The nutrient level of the soils should not be neglected. It has to be catered for and optimally utilized.
ii. Available space for crop production should be considered by government and traditional authorities in the study area while siting projects within the study area.

iii. The fact that Otuoke occupies a significant position in the Country and therefore may attract a reasonable attention, the application of zoning method is very necessary to avoid arbitrations and conflicts in land use location and development.

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