Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.8, No.6, 2018
www.iiste.org

# Soil Quality Studies of a 22-Hectre Land Area at 'Ugwuonyeama' for Agricultural Purposes: Implications on Environmental Protection

Uzochukwu Cornelius Ugochukwu[1] Virginia Ugoyibo Okwu-Delunzu[2]
1.SHELL/UNN Centre for Environmental Management and Control, University of Nigeria, Enugu Campus
2.Department of Geography and Meteorology, Faculty of Environmental Sciences, Enugu State University of Science and Technology, Agbani, Nigeria

**Abstract**
The soil quality of a 22-hectre land area around 'Ugwuonyeama' was studied in order to understand the physico-chemical properties of the soil and the implications on environmental protection. The physico-chemical parameters studied were partcicle size distribution, bulk density, porosity, hydraulic conductivity, organic carbon, total nitrogen, available phosphorus, exchangeable bases and acidity. The obtained results indicate that the soil of the study area contained high proportion of sand and moderately high hydraulic conductivity. The soil was also acidic and contained low levels of nitrogen and phosphorus indicating that the soil would require liming and fertilization with respect to phosphorus and nitrogen to boost agricultural production. Owing to the fact that the soil has moderately high hydraulic conductivity, there is the potential adverse impact of groundwater contamination by fertilizer application. Improper fertilizer application could also lead to surface water contamination that would eventually cause eutrophication of surface waters. This therefore calls for proper soil management in order to boost production yield without compromising environmental sustainability.
**Keywords**: Soil quality, groundwater, fertilization, physico-chemistry properties, soil nutrients.

## 1. INTRODUCTION

The importance of the study of soil quality cannot be over-emphasized given that soil is the natural resource base of the biosphere's nutrients – essential micronutrients (chlorine, iron, boron, manganese, zinc, copper, molybdenum), non-essential micronutrients (bromine, cobalt, fluorine, iodine, nickel, rubidium, selenium, silicon, sodium, strontium, tungsten, vanadium) and macronutrients (nitrogen, phosphorous, potassium and sulphur, calcium, magnesium). Among the macro-nutrients, nitrogen, phosphorous and potassium are mostly needed by plants (Ayeni and Adeleye, 2014). These nutrients especially the macronutrients derivable from soils are made available for plant absorption through such processes as mineral weathering and the decomposition of organic matter into inorganic minerals (McLean and Watson, 1988; Brady, 1990; Durand et al., 2001; Barghouthi et al., 2012).

Soil quality studies also provide information that aids in the protection of the environment whilst the soil performs its functions (Kaweewong et al., 2013).

The ability or fitness of a given soil to function within its capacity and within natural or managed ecosystem boundaries to sustain the productivity of animals and plants, maintain or enhance water and air quality, and support human health and habitation has been defined as soil quality (Karlen *et al*., 1997; Arshad and Martin, 2002). Soil quality could therefore be said to be a measure of both the ability of soil to function and how well it functions relative to a given or specific use (Brady and Weil, 2002). Land use types could alter the properties used in characterizing a given soil for its quality classification. (Senjobi and Ogunkunle, 2010; Senjobi *et al*., 2013). In very simple terms soil quality is a measure of the condition of soil relative to the requirements of one or more biotic species and or to any human need or purpose (Johnson et al., 1997). Hence soil quality is the ability of a soil to perform functions that are essential to people and the environment. Soil quality reflects how well a soil performs the functions of maintaining biodiversity and productivity, partitioning water and solute flow, filtering and buffering, nutrient cycling, and providing support for plants and other structures. Soil management has a major impact on soil quality. Our understanding of soil quality leads us to assess and manage soil so that it functions optimally now and is not degraded for future use. Soil quality assessments focus on the dynamic, or management-affected, properties of soil, such as nutrient status, salinity, and water-holding capacity. These properties are assessed in the context of the inherent capability of a particular soil. Soils support plant growth, recycle dead material, regulate and filter water flows, support buildings and roads, and provide habitat for many plants and animals. Depending on the land use, many of these functions occur simultaneously. Soil functions provide private benefits such as crop production or structural support for buildings but these functions cannot be directly measured except through soil quality indicators. Simultaneously, the same soil may provide societal benefits such as carbon sequestration, water quality protection, or preservation of soil productivity for future generations. Measuring soil quality is an exercise in identifying soil properties that are responsive to management, affect or correlate with environmental outcomes, and are capable of being precisely measured within certain technical and economic constraints.

There are three main categories of soil quality indicators: physical, chemical and biological. Owing to the fact that soil quality cannot be measured directly, these three categories of soil quality indicators, soil biological and physico-chemical properties are used to monitor the quality of soil (Brejda *et al*., 2000).

Soil quality studies are able to identify areas with potential fertilization requirements and what kind of fertilization is required including sometimes the rates of application of the fertilizers. This has been demonstrated to boost agricultural productivity and revenue generation with huge economic benefits at no environmental expense (Kaweewong et al., 2013).

Due to variability in soil, weather and crop conditions, nutrient management for a specific site has been said to vary widely necessitating site specific nutrient management to avoid nutrient losses, low yield and adverse environmental impacts (Ferguson et al., 2002; Koch et al., 2004; Kaweewong et al., 2013).

The study site which is a 22-hectre land area up-stream Onyema Coal Mine is a proposed site for agricultural activities. However, the soil physico-chemical properties of this site or any adjoining soil area have not been reported hence it is not known yet whether the soil would require nutrient addition and to what extent. Also, there is no information on how the soil management of the area should be carried out in order to avoid groundwater pollution as a result of the land use for agricultural purposes.

The questions to be answered by this study therefore are:

- What are the physico-chemical properties of the soil of the study area and implications for agricultural purposes?
- Do the soil physico-chemical properties suggest potential threat to groundwater resources if used for agricultural purposes?

## 2. METHODOLOGY

### 2.1 Study area

The study area lies within the area defined by the geologic coordinates N06$^{0}$ 28' 25.7'' E007 26' 23.5'' which is part of the 'Ugwuonyeama' area of Ninth Mile, Udi Local Government Area in Enugu State, Nigeria. The study area is as presented in Figure 1.

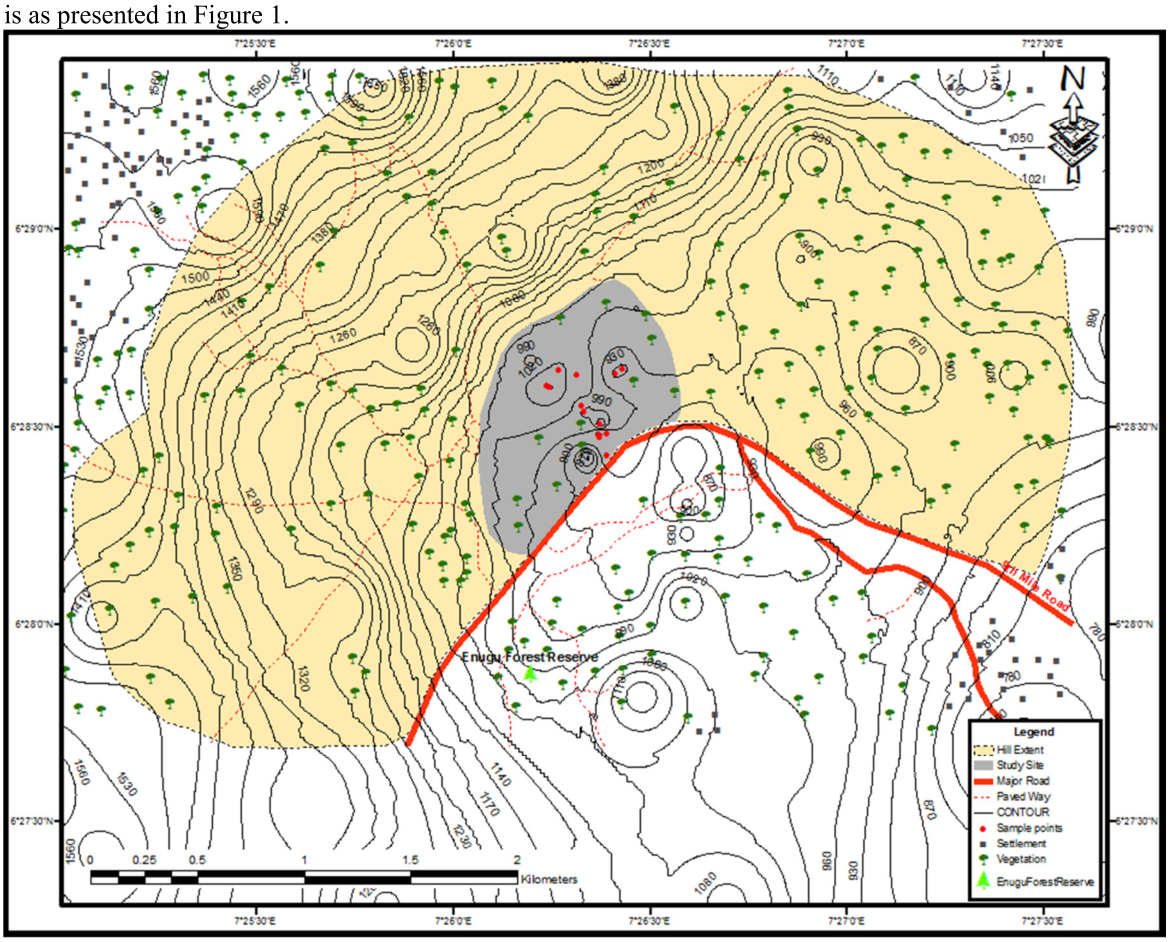


Figure 1: Map of the study area showing sampling points and topography.

The 3-D contour of the study area is as shown in Figure 2.

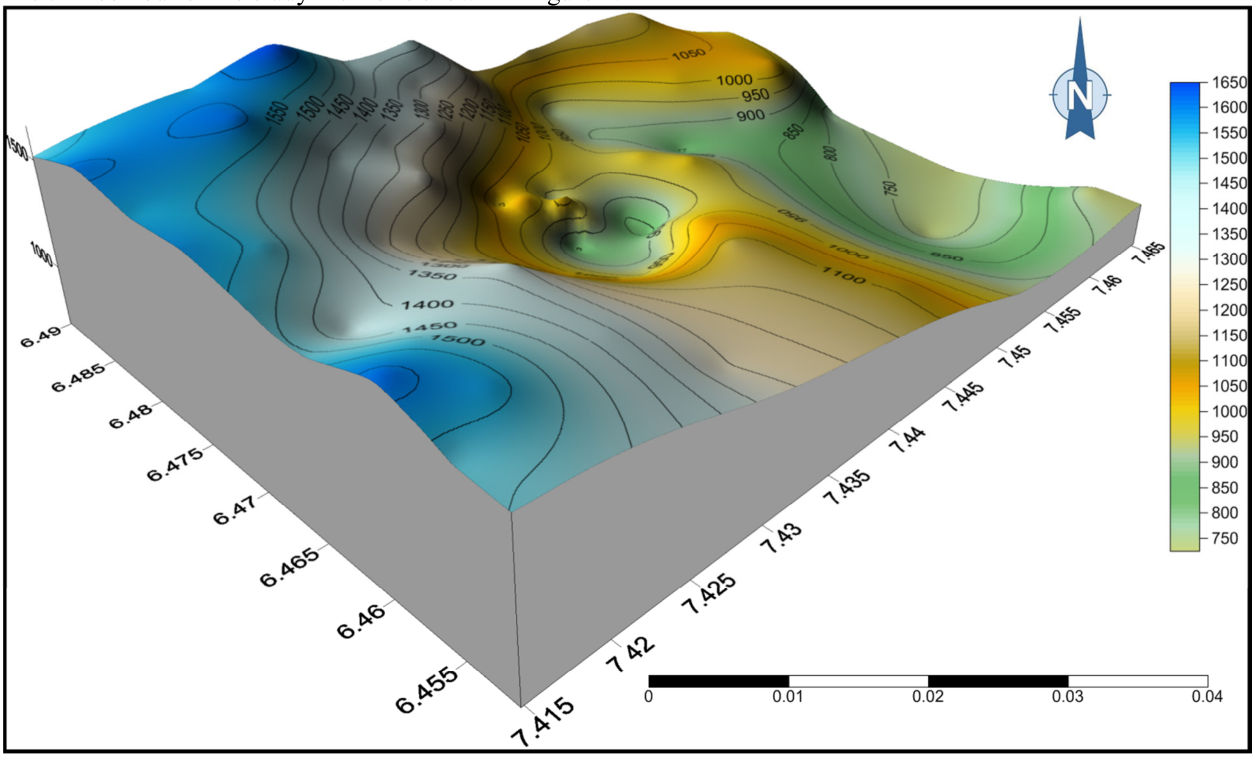


Figure 2: 3-D Contour of the study area

The climatic condition of the study area is generally sub-humid. Like many parts of Nigeria, the climatic conditions of the study area is influenced by the North-South movement of a zone or surface of discontinuity (SD) between Maritime (Atlantic) air masses and dry continental (Sahara) air masses.

The regular movement of these air masses creates two distinct climate seasons in the area. In the dry season, the SD moves to the south, occasionally almost as far as the coast, accompanied by warm, dry North-Easterly winds whereas in the wet season, the SD moves to the North as far as $20^0$ Latitude accompanied by Southerly and South-Westerly winds, transporting humid air inland. The following climate elements are characteristic of the study area (NIMET, 2010):

The mean maximum monthly temperature at the project area varies between $31^oC$ and $36^0C$ whereas the mean minimum monthly temperature varies between 19 and 23 $^0C$. Generally, the variation of monthly temperature is small.

The range of rainfall in the wet season (April-October) averages 157.99mm-296.16mm. Peak rainfall is 296.16mm around September. The dry season runs from November to mid February giving about 120 days of dry season

The main winds in the study area are the South-Westerly (SW) and Westerly winds. The winds are strongest between January and July (5.92 Knots-6.14 Knots).

The Relative Humidity as measured by NIMET at 9:00am over a ten year period (2000-2009) is between 61% and 89.4%, while at 3:00 pm is between 33.9% and 50.4%. July is the most humid whereas February is the least humid.

**2.2 Sample collection**

Soil samples (30, 3 from each sampling point) were collected along each transect at intervals of 25 m using auger borer. Core samples were also collected. Random samples were also collected from areas outside the sampling transects. Sampling was done by boring into a depth of 30cm. The samples were collected in appropriately labeled containers in accordance with environmental standards and guidelines. The sampling points for the purpose of the soil studies were B1, B2, B3, B4, B5, B6, B7, B8, B9 and B10. The geo-references are as shown in Table 1.

Table 1: Geo-references of the sampling points of study area

| S/N | Code | Geo-reference |
|---|---|---|
| 1. | B1 | N06$^0$ 28' 28.8'' E007 26' 22.2'' |
| 2. | B2 | N06$^0$ 28' 29.0'' E007 26' 23.4'' |
| 3. | B3 | N06$^0$ 28' 30.5'' E007 26' 23.9'' |
| 4. | B4 | N06$^0$ 28' 32.3'' E007 26' 20.1'' |
| 5. | B5 | N06$^0$ 28' 33.2'' E007 26' 19.6'' |
| 6. | B6 | N06$^0$ 28' 36.3'' E007 26' 14.4'' |
| 7. | B7 | N06$^0$ 28' 36.1'' E007 26' 14.7'' |
| 8. | B8 | N06$^0$ 28' 38.7'' E007 26' 16.2'' |
| 9. | B9 | N06$^0$ 28' 37.9'' E007 26' 18.9'' |
| 10. | B10 | N06$^0$ 28' 38.2'' E007 26' 24.8'' |

All samples were properly labeled and field notes taken with detailed information of the samples (reference number of sample, location, date, time, etc).

The following soil characteristics were determined for each soil sample: particle size distribution, pH, organic carbon, total Nitrogen, exchangeable cations (Na, K, Ca, Mg, Mn), available phosphorus. Physical properties such as bulk density, total porosity and hydraulic conductivity of the soil were also determined. Soil texture was also used to characterize the study area. Prior to analyses, the soil samples collected from the study area were air-dried and made to pass through a 2 mm sieve. The fine earth was then used for the laboratory analyses as follows:

***Particle size destribution***: The particle size distribution was determined using hydrometer method as described by Bouyoucos [1951]. This method is based on the differential sedimentation rates of the different sizes of particles in a uniform suspension. Approximately 50g of the soil samples were weighed into a metal dispersion cup. The dispersion cup was filled to 2/3 full with distilled water. 23ml of 10% sodium hexametaphosphate was then added and allowed to soak the soil before the dispersion cup was stirred for 25 minutes. The dispersion was then transferred from the dispersion cup to Bouyoucos Cylinder. Hydrometer was placed in the suspension and the volume was made up to 1130 mL mark using distilled water. The hydrometer was removed, and the cylinder was agitated thoroughly by placing No.13 rubber stopper over the mouth of the cylinder and turning the cylinder upside down and back several times. The cylinder was then placed on a table and the time was recorded. Hydrometer was quickly and carefully placed in the suspension, and the reading was recorded after 40 seconds. The temperature of the suspension was measured after removing the hydrometer. Second hydrometer and temperature readings were recorded after 2 hours. The percentage silt, clay and sand contents were then calculated.

***Soil pH***: The pH value of the soils and sediments in water and KCl were determined using Kent EIL 7020 pH meter. The ratio, 1:2.5 soil: water and 1:2.5 soil: KCl suspensions were prepared respectively and stirred for 20 minutes**.** The suspension was allowed to equilibrate before dipping the electrode of the pH meter into the suspension.

***Hydraulic conductivity***: The method of constant head permeability was employed in the determination of the hydraulic conductivity of the soil samples.

***Soil bulk density***: Soil bulk density on dry basis was determined for each sample by oven-drying the soil for 48 hr at 105 $^0$C and dividing the resultant mass by the volume of the core.

***Porosity***: Porosity was determined by measuring and dividing the pore space volume of the soil by the total volume of the soil and then multiplying by 100%.

***Organic Carbon***: The method of organic carbon determination as described by Walkley and Black [1934] was adopted for the determination organic carbon. In this method, the reducing material in the soil sample is oxidized by chromic acid, formed by adding Conc. $H_2SO_4$ to potassium dichromate solution. Approximately 1g of finely ground soil sample was weighed in duplicate and transferred into 400 mL beakers. Thereafter, 10 mL of $K_2Cr2O_7$ solution was pipetted into each beaker, and the beakers were gently rotated to wet the sample. A graduated cylinder was used to pour in 20 mL of Conc. $H_2SO_4$ rapidly into each beaker. The beakers were rotated to ensure complete oxidation and allowed to stand for 10 minutes. This was followed by dilution with distilled water to about 200 to 250 mL. Then, 10 mL of 85% phosphoric acid and 1 mL of diphenylamine indicator solution were added before titration with 1N ferrous sulphate solution.

***Total Nitrogen***: Total nitrogen content of the soil samples were determined by the semi-micro Kjeldahl Method (Bremner and Mulvaney, 1982). Soil samples of 5 g each were weighed into a digestion flask and digested with a mixture of Conc. $H_2SO_4$ with $Na_2SO_4$ and $CuSO_4$. The digest was washed with distilled water and made up to 100 mL in a volumetric flask. Thereafter, 10 mL
of digested solution was pipetted into Markharm Still, and the distillate was collected in 200 mL
of 25% Boric acid to a total of 50 mL. This was then titrated with 0.05N HCl.

***Exchangeable Acidity*:** Titration method as described by Mclean [1965] was used to determine the exchangeable acidity. This method involves extraction with KCl.

***Exchangeable Cations*:** 1N ammonium acetate solution was used as extractant in the exchangeable cation determination. 25mL of 1N ammonium acetate solution was added to 3g of finely ground soil sample and the mixture was agitated on a mechanical shaker for 1hour, before centrifuging at 2000 rpm for 10 minutes. A clear supernatant was decanted into a volumetric flask. The supernatant was used for the determination of potassium and sodium by flame photometry [Gallenkamp Flame Analsyer, FGA – 330 –3C] while Magnesium and Calcium were determined by Atomic absorption spectrophotometry.

***Cation Exchange Capacity (CEC)***

Five gram air dried soil sample was leached to 100 mL with 1N ammonium acetate (pH 7), then wash with methanol and allowed to dry. Further leaching with 0.1N KCl was undertaken in order to extract the adsorbed $NH_4^{+}$. After collecting 250 mL leachate, 50 mL aliquot of the leachate was treated with 20 mL neutral formaldehyde (pH 7). This was titrated with a solution of 0.1N NaOH using phenolphthalein indicator. CEC was computed accordingly using one litre.

***Available Phosphorus***:

Bray – 1 extracting solution [0.03N NH4F in 0.1N HCl] was used to determine the available phosphorus in the soil samples. One gram air dried soil sample was treated with 20 mL of the above extractant and shaken for 1 minute and filtered immediately using Whatman No. 42 filter paper equivalent. The filtrate was used for the development of molybdenum blue colour using 1 mL 2 % of ascorbic acid solution and ammonium molybdate-sulphuric acid reagent (mixture of 150 mL conc. $H_2SO_4$ and 150 mL deionized water and 100 mL of a solution of 10 g crystalline ammonium molybdate in 100 mL of deionized water ). The optical density of the developed blue colour was read at 660 nm using a VP 1012 Jowan, spectrophotometer and calculated after reference to a standard curve.

## 3. RESULTS AND DISCUSSION

### 3.1 Physical properties of the soil

Particle size distribution shows the relative proportion of sand, silt and clay in a soil based upon which soil textural classes are derived. The particle size determination also gives an indication of soil structure, water retention capacity (moisture content) and total porosity of a soil. The particle size distribution shows that the soils of the study area have varied texture (sandy loam, loamy sand, and sand). This implies that the soil has high proportion of sand particles, which is dominated by fine sand fraction, with values ranging from 31% - 78% (Table 2). The high proportion of sand at the site is indicative of high rate of water infiltration, suggesting that contamination of groundwater due to peculation of contaminant in soil water could pose a serious challenge.

Table: 2: Particle Size Distribution of the soils of the study area

| Sample code | Sampling depth (cm) | Clay (%) | Silt (%) | F.S (%) | C.S (%) | T. Class |
|---|---|---|---|---|---|---|
| B1 | 0-30 | 10 | 11 | 66 | 11 | SL |
| B2 | 0-30 | 10 | 7 | 78 | 5 | LS |
| B3 | 0-30 | 12 | 9 | 62 | 17 | SL |
| B4 | 0-30 | 8 | 7 | 61 | 24 | LS |
| B5 | 0-30 | 6 | 5 | 65 | 24 | S |
| B6 | 0-30 | 6 | 5 | 31 | 58 | S |
| B7 | 0-30 | 6 | 5 | 38 | 51 | S |
| B8 | 0-30 | 6 | 3 | 54 | 37 | S |
| B9 | 0-30 | 8 | 7 | 67 | 18 | LS |
| B10 | 0-30 | 8 | 7 | 73 | 12 | LS |

Where: SL = Sandy Loam; LS = Loamy Sand; S = Sand; F.S= Fine sand; C.S = Coarse sand; T = Textural.

Soil bulk density is the density of a volume of soil as it exists naturally. It includes the air space and organic materials in the soil. It is the mass of dry soil per unit bulk volume. Thus, bulk density gives an indication of soil compaction and total porosity. The bulk densities of the soils of the study area range from 1.39 to1.59 $gcm^{-3}$ (Table 3) with the mean value of 1.51 $gcm^{-3}$. This range of bulk density is normal where the soil is not compacted. Pore spaces in the soil consist of the portion of the soil volume not occupied by solids (minerals or organic). Air and water under field condition always occupy pore spaces. The size of the pore spaces depends upon the size and shape of the primary particles. Sands have large and continuous pores while clays, in contrast, although contain more total pore space because of the minute size of each clay particle, have very small pores, which transmit water slowly. The most rapid water and air movement occurs in sands and strongly aggregated soils. Therefore, low percentage total porosity is an indication of large pore size, (which occurs in sandy soil), and rapid water and air movement. The percentage total porosity of the soils at the study area ranges from 40.0 to 47.6 % with the mean as 43.2 %. This implies that the soils of the study area have moderately high porosity which would result to high hydraulic conductivity. Hydraulic conductivity refers to the movement of water in the soil through pore spaces. The water movement is mainly due to gravitational pull, matric and osmotic forces. Water infiltration is rapid into large, continuous pores in the soil. This movement is reduced by anything that reduces the size of pore spaces such as clogging by dislodged soil particle, structural breakdown and amount of pore spaces. The saturated hydraulic conductivity of the soils is moderately high due to high proportion of sand in the soil texture and low total porosity (which indicates high proportion of macro-pore spaces). Hence there is a compelling need for proper soil management in order to prevent the contamination of groundwater.

Table: 3: Physical Properties of the soils of the location

| Sample code | Sampling depth (cm) | Bulk density (g/cm3) | Total Porosity (%) | Hydraulic Conductivity (Kcm3/hr.) |
|---|---|---|---|---|
| B1 | 0-30 | 1.56 | 40 | 5.15 |
| B2 | 0-30 | 1.44 | 45.7 | 24.21 |
| B3 | 0-30 | 1.52 | 42.6 | 7.73 |
| B4 | 0-30 | 1.39 | 47.6 | 30.91 |
| B5 | 0-30 | 1.51 | 43.0 | 19.06 |
| B6 | 0-30 | 1.52 | 42.6 | 82.42 |
| B7 | 0-30 | 1.47 | 44.5 | 85 |
| B8 | 0-30 | 1.56 | 41.1 | 10.30 |
| B9 | 0-30 | 1.55 | 41.5 | 3.61 |
| B10 | 0-30 | 1.48 | 44.2 | 30.05 |

### 3.2 Chemical properties and fertility status of soils of the project location

#### 3.2.1 Soil Reaction and Exchangeable Acidity

The pH values show that the soils ranged from very strongly acid to slightly acid. The values obtained in water ranged from 4.9 to 6.0 in water, while the values obtained in KCl ranged from 4.1 to 4.8 (Table 4). Soil pH is a measure of hydrogen ion concentration in a soil and an indicator of other soil chemical and biological properties. It influences vegetative cover and plant growth by its effect on the activity of beneficial microorganisms. While fungi tolerate acidity, nitrogen-fixing bacteria and actinomycetes are not very active in acid soils (Zahran, 1999). The inhibition of nitrogen-fixation could lead to low nitrogen content of the soil. The majority of soil microorganisms grow best at pH 7. Most plants are best suited to pH of 5.5 on organic soil and a pH of 6.5 on mineral soils. Although the exchangeable acidity showed appreciable values of $Al^{3+}$, $H^+$ was the dominant acid-forming cation in the soil. The values of $Al^{3+}$ and $H^+$ ranged from 0.2 Cmol/kg to 1.4 Cmol/kg and 1.2 Cmol/kg to 2.4 Cmol/kg respectively. The acid property of the soils could be attributed to the $H^+$. The high rainfall observed at this region accounts for high leaching losses of base-forming cations (Ca, Mg, K and Na), thus giving rise to acid condition. The acidity of the soil can be managed by the employment of liming.

#### 3.2.2 Organic Carbon and Total Nitrogen

The organic carbon of the soils was very low moderate. The values ranged from 0.07 to 0.56% at the location. The generally very low level of organic carbon may be due to the very high rate of decomposition of organic matter occasioned by adequate aeration. Similarly, the values of nitrogen were low, with values ranging from 0.098 to 0.266 %. The implication is that the organic nitrogen reserve capability of undergoing mineralization was low. Total nitrogen content of 0.25% and above is considered moderate. The inhibition of the activities of nitrogen-fixing bacteria as a result of soil acidity could also account for low values of nitrogen in the soil. The soil would require nitrogen fertilization at controlled rate to avoid groundwater pollution.

Table 4: Values of the chemical properties of the soils at the project location

| SAMPLE CODE | SAMPLE Depth (cm) | pH | | OC (%) | OM (%) | N | $Na^+$ (Cmol/Kg) | $K^+$ | $Ca2^+$ | $Mg2^+$ | CEC (Cmol/Kg) | $H^+$ (Cmol/Kg) | $Al3^+$ | BS (%) | Av. P (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $H_2O$ | KCl | | | | | | | | | | | | |
| B1 | 0-30 | 5.5 | 4.2 | 0.35 | 0.61 | 0.098 | 0.19 | 0.14 | 0.80 | 1.80 | 17.20 | 2.00 | 0.60 | 17.03 | 2.80 |
| B2 | 0-30 | 5.5 | 4.2 | 0.46 | 0.79 | 0.266 | 0.19 | 0.14 | 0.80 | 1.20 | 27.20 | 1.20 | 1.00 | 8.57 | 10.26 |
| B3 | 0-30 | 5.4 | 4.1 | 0.56 | 0.97 | 0.182 | 0.19 | 0.07 | 2.20 | 0.001 | 19.60 | 1.60 | 1.40 | 12.55 | 0.00 |
| B4 | 0-30 | 4.9 | 4.1 | 0.25 | 0.42 | 0.140 | 0.19 | 0.07 | 1.00 | 1.00 | 23.60 | 2.40 | 0.80 | 9.58 | 0.93 |
| B5 | 0-30 | 5.7 | 4.2 | 0.28 | 0.48 | 0.196 | 0.19 | 0.14 | 1.20 | 0.80 | 16.80 | 1.60 | 0.60 | 13.87 | 2.80 |
| B6 | 0-30 | 5.9 | 4.7 | 0.39 | 0.67 | 0.140 | 0.19 | 0.14 | 1.40 | 1.20 | 19.60 | 1.80 | 0.20 | 14.95 | 2.80 |
| B7 | 0-30 | 6 | 4.7 | 0.21 | 0.36 | 0.168 | 0.19 | 0.11 | 1.00 | 1.00 | 21.60 | 1.60 | 0.20 | 10.65 | 3.73 |
| B8 | 0-30 | 5.9 | 4.8 | 0.07 | 0.12 | 0.182 | 0.19 | 0.07 | 1.20 | 1.00 | 15.60 | 1.80 | 0.20 | 15.77 | 3.73 |
| B9 | 0-30 | 5.6 | 4.2 | 0.21 | 0.36 | 0.182 | 0.19 | 0.14 | 1.00 | 0.80 | 15.60 | 1.40 | 0.80 | 13.65 | 3.73 |
| B10 | 0-30 | 6 | 4.7 | 0.25 | 0.42 | 0.196 | 0.19 | 0.07 | 0.60 | 1.40 | 21.60 | 1.60 | 0.60 | 10.46 | 2.80 |

#### 3.2.3 Exchangeable Cation and Cation Exchange Capacity

The cation exchange complexes of the soils of the project location are composed of predominantly divalent cations, mostly calcium. The exchangeable calcium and magnesium were mostly low. While $Ca^{2+}$ ranged from 0.60 – 2.20 Cmol/kg, $Mg^{2+}$ varied from 0.00 (nil) to 1.8 Cmol/kg. The dominance of $Ca^{2+}$ over the other basic cation is desirable as plant growth is adversely affected when exchangeable $Mg^{2+}$ exceeds the value of exchangeable $Ca^{2+}$. Similarly, the exchangeable sodium and potassium were low. While sodium was constant at 0.19 Cmol/kg, potassium ranged from 0.07 – 0.14 Cmol/kg at the study area. Sodium ion plays an important role in plant nutrient because it may partially substitute for $K^+$. In addition to having a depressing effect on crops when present in large amount in exchangeable form, $Na^+$ results in soil dispersion and degradation, a situation which hinders nutrient uptake by plants and water penetration. Thus, the soils of the study area are not only free from salinity problem but also suitable for plant and vegetative growth. Generally, the order of concentration of the base cations in the soil is as follows: Ca > Mg > Na > K. The dominance of Ca over the other basic cations stem from the fact that the release of base forming cations during weathering process in the humid tropical soil is in the order, Ca > Mg > Na > K. The energy of adsorption of basic cations by soil colloids approximates same order as: Ca > Mg > K > Na. The cation exchange capacity ranged from 15.60 to 27.20 Cmol/kg soil. These values are considered moderate. On the contrast, the percentage base saturation is very low, with values varying from 8 to 17.03 Cmol/kg soil. Percentage base saturation indicates the extent to which the cation exchange complexes are occupied by baseforming cation. Low base saturation implies high concentration of nutrient cations on the cation exchange site. The high value of percentage base saturation is desirable for adequate plant and vegetative growth.

### 3.2.4 Available Phosphorus

Phosphorus is a major plant nutrient. The amount of phosphorus in soils is influenced by the soil parent material. The concentration of available phosphorus in the studied soil ranged from 0.00 (nil) to 10.26 ppm. Thus, available P is deficient in the soils, and well below the critical value for tropical soil. The critical value of phosphorus required by plants for tropical soil has been reported to be in the range of 15-20 ppm (Bruce, 1972; Bruce and Bruce, 1972). This indicates that the soil would require phosphorus fertilization for optimum agricultural production.

## 4. CONCLUSION

This study was on the soil quality of a 22-hecter land area (around 'Ugwuonyeama') to be used for agricultural purposes. It is intended that the study would provide information that would lead to proper soil management that obviates groundwater and surface water contamination.

The soil physico-chemical properties indicate that the soil is acidic and would therefore require liming to raise the pH to a level of neutrality required by most plants. The saturated hydraulic conductivity of the soils is moderately high due to high proportion of sand in the soil texture and low total porosity (which indicates high proportion of macro-pore spaces). Hence there is a potential threat to groundwater resources indicating a compelling need for proper soil management in order to prevent the contamination of groundwater.

The levels of phosphorus and nitrogen in the soil are low necessitating addition of nitrogen and phosphorus fertilizers at controlled rates in order to avoid pollution of groundwater resources. Surface water could also be contaminated by uncontrolled application of phosphorous and nitrogen fertilizers leading to eutrophication.

## REFERENCES

Arshad, M.A., Martin, S. 2002. I dentifying critical limits for soil quality indicators in agroecosystems. Agriculture, ecosystems and environment, 88, 153-160.

Ayeni, L.S., Adeleye, O.E. (2014). Mineralization rates of soil forms of nitrogen, phosphorous, and potassium as affected by organomineral fertilizer in sandy loam. Advances in Agriculture. http://dx.doi.org/10.1155/2014/149209.

Barghouthi, Z., Amereih, S., Natsheh, B., & Salman, M. (2012) Analysis of Macro and Micronutrients in Soils from Palestine Using Ion Exchange Membrane Technology. Open J Soil Sci , 2, 44 – 49.

Bouyoucos, G.J., 1951. A Recalibration of the Hydrometer Method For Making Mechanical Analysis of Soils. *Agronomy Journal*, 43, 434-438.

Brady, N.C., Weil, R.R. 2002. The nature and properties of soil, 13th edition, Prentice Hall, New York, 486-490 pp.

Bremner, J.M. and Mulvaney, G.S. (1982) Nitrogen total: In Page et al (ed.) Methods of Soil Analysis. American Society of Agronomy No 9, Madison, W.I. pp. 595 – 624.

Brejda, J.J., Moorman, T.B., Karlen, D.L., Dao, T.H. 2000. Identification of regional soil quality factors and indicators: I. Central and southern high plains. Soil Science Society American Journal.

Bruce, R.C. 1972. The effect of topdressed superphosphate on the yield and botanical composition of a *Stylosanthes guyanensis* pasture. Tropical Grasslands,6, 135-141.

Bruce, R.C. and Bruce, I.J. 1972. The correlation of soil phosphorous analyses with response of tropical pastures to superphosphate on some north Queensland soils. Australian Journal of Experimental Agriculture and Animal Husbandry, 12, 188-194.

Durand, R., Bellon, N. &Jaillard, B. (2001) Determining the Net Flux of Charge Released by Maize Roots by

Directly Measuring Variations of the Alkalinity in the Nutrient Solution. Plant Soil, 229, (2), 305 – 318.

Ferguson, R.B., Hergert, G.W., Schepers, J.S., Gotway, C.A., Cahoon, J.E., Peterson, T.A. (2002). Site-specific nitrogen management of irrigated maize: Yield and soil residual nitrate effects. Soil Science Society of America Journal, 66, 544-553.

Johnson, P., Lamb, M., Saul, A.E. & Winter-Nelson (1997). Meaning of environmental terms. J Environ Qual 26: 581-589.

Karlen, D.L., Mauschbach, M.J., Doran, J.W., Cline, R.G. Harris, R.F. & Schuman, G.E. (1997). Soil Quality: A Concept, Definition and a Framework for Evaluation. Soil SciSoc Am J 4-10.

Kaweewong, J., Kongkeaw, T., Tawornprek, S., Yampracha, S., Yost, R. (2013). Nitrogen requirements of cassava in selected soils of Thailand. Journal of Agriculture and Rural Devlopment in the Tropics and Subtropics, 114 (1), 13-19.

Koch, B., Kholsa, R., Frasier, W.M., Westfall, D.G.; Inman, D. (2004). Economic feasibility of variable-rate nitrogen application utilizing site-specific management zones. Agronomy Journal, 96 (6), 1572-1580.

McLean, E.O. and Watson, M.E. (1988) Soil Measurements of Plant – Available Potassium, In: R.D Munson (Ed) Potassium in Agriculture, Soil SciSoc Am J, Madison, pp. 227 – 308.

Senjobi, B.A. &Ogunkunle, O.A. (2010) Effect of Land Use on Soil Degradation and Soil Productivity Decline on Alfisols and Ultisols in South Western Nigeria. Journal of Agriculturae Conspectus Scientificus, Faculty of Agriculture, University of Zagreb, Croatia, 75 (1): 9 -19.

Senjobi, B.A., Akinsete, S.J., Ande, O.T., Senjobi, C.T., Aluku, M. & Ogunkunle, O.A. 2013. An Assessment of Spatial Variations of some Soil Properties Under Different Land Uses in South – Western Nigeria. *American Journal of Experimental Agriculture.* 3(4): 896 – 903.

Walkley, A. & I.A. Black. I.A. 1934. An examination of the Degtjareff method for determining organic carbon in soils: Effect of variations in digestion conditions and of inorganic soil constituents. *Soil Science*. 63:251-263.

Zahran, H.H. (1999). Rhizobium-Legume Symbiosis and Nitrogen Fixation under severe Conditions and in an Arid Climate. Microbiology and Molecular Biology Reviews, 63, 968-989.