# MORPHOLOGICAL CHARACTERISTICS AND CLASSIFICATION OF INCEPTISOLS OF OHAJI / EGBEMA IN IMO STATE SOUTHEASTERN, NIGERIA

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## ABSTRACT

Soil morphology is the branch of soil science that deals with the technical description of soil, especially; texture, colour, structure, and consistence. Soil morphology offers general idea to the evolution in the soil body through description and interpretation of soil profile properties as initial information in classifying soil. The purpose of this research was to determine the morphological characteristics and soil classification of Inceptisols in Ohaji / Egbema Local Government Area of Imo State Southeastern, Nigeria. The research method used was free survey in the field and soil analysis in the laboratory. The soil samples was first of all air dried and crushed gently in order to reduce the effect of clods. Two (2) millimeter sieves were used to sieve the soil for routine analysis. The soil samples were subjected to various physical and chemical laboratory analyses. The results showed that the dominant texture was loamy sand, sandy loam and clay in all soil profiles with a low silt / clay ratio. Other Soil properties of bulk density, total porosity, gravimetric moisture content, pH, organic carbon, total nitrogen, available phosphorus, cation exchange capacity, base saturation, and exchangeable bases (Ca, Mg, K, Na) were estimated as well using the standard analytical methods. The results showed that they are generally low with a relatively constant distribution pattern with increasing depth. Soils are classified into the order of inceptisols in all soil profiles because they have a cambic sub-horizon resulting from physical alteration and chemical transformation. The humidity regime of hicks gave the sub-order category name; udepts. The temperature regime includes: Isohyperthermic which made it to be categorized into the Great Group Dystrudepts and the Typic Dystrudepts sub-group for pedon 1 and 2, while pedon 3 is Fluvaquentic Dystrudepts as a result of its clayey textural class.

**Keywords:** Morphology, characterization, classification, inceptisols, Ohaji-Egbema.

## INTRODUCTION.

Soil morphology is soil properties that can be observed and studied directly in the field (Hardjowigeno, 1993). Soil morphology offers general idea to the evolution in the soil body through description and interpretation of soil profile properties as initial information in classifying soil (Suryani *et al.*, 2021).

Soil characterization study is a major building block for understanding the soil, classifying it, and getting the best understanding of the environment (Esu, 2005). Soil taxonomy provides hierarchical grouping of natural soil bodies and it is based on soil properties that can objectively be observed or measured (Brady and Weil, 2002).

There is an increasing demand for information on soils, as a means to produce food. Lack of detailed information on soil and land characteristics and the need to classify and characterize soils has become necessary to know the prospects and unravel some unique soil problems in the ecosystem (Fasina *et al.*, 2007).

Soil taxonomy by USDA is used to classify soils based on the similarity of soil properties from the Order category to the important family for agriculture in detail.

Inceptisol is a young soil that is starting to develop. Horizon formation in the profile is rather slow as a result of alteration of the parent material. The horizons did not show the results of extreme destruction. Utilization of Inceptisol in Ohaji / Egbema Imo State Southeastern Nigeria can still be developed with appropriate cultivation techniques to obtain maximum productivity (Okereafor *et al.*, 2020).

## MATERIALS AND METHODS:

### Study Location

The research was conducted in Ohaji / Egbema Local Government Area of Imo State Southeastern, Nigeria. Etekuru: latitude 5°28' 6" N and longitude 6° 47' 19" E), Abacheke: latitude 5° 30' 20" N and longitude 6° 43' 58" E and Obiakpu: latitude 5° 30' 46" N and longitude 6°45'22"E.

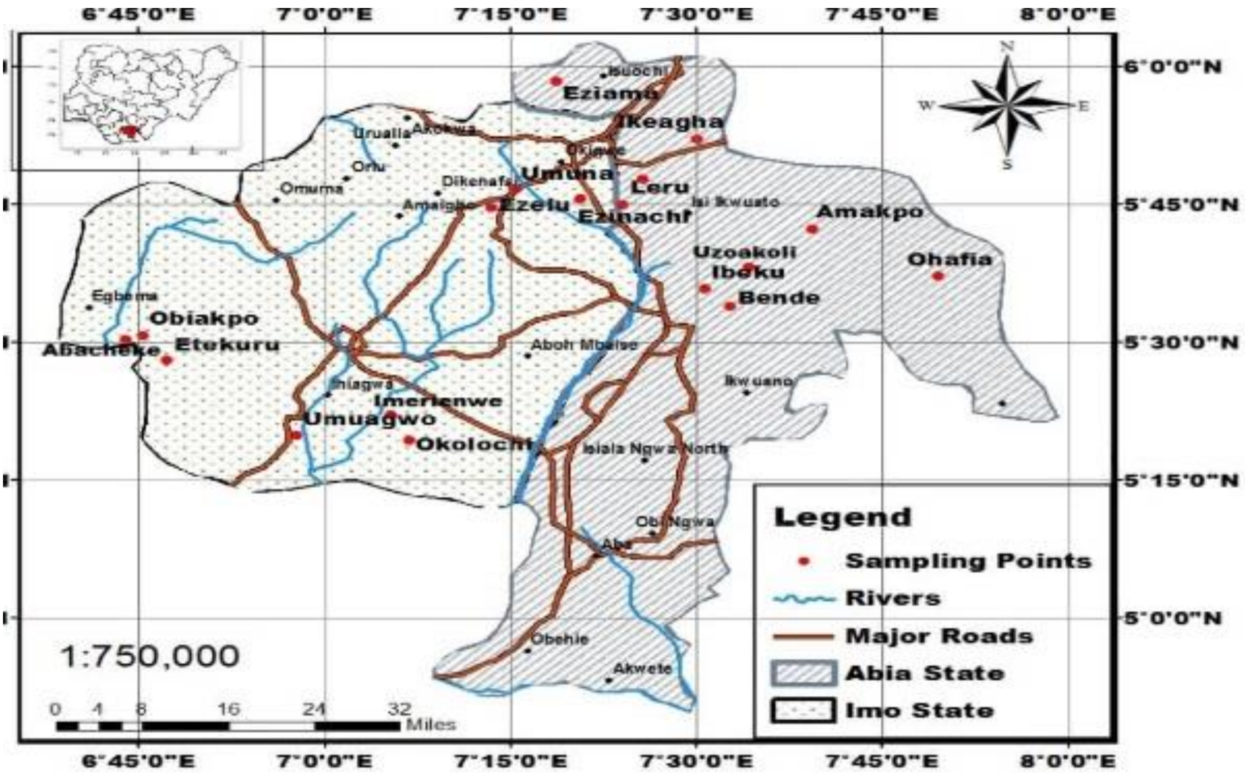


Figure 1: Soil sampling locations in Southeastern Nigeria.

Source: Created from Arc GIS, 10.2

### Geology and Geomorphology

The major geological formation of the study area is Alluvium. The topography of the study area ranges from lowlands to sloping grounds.

### Climate

These areas belong to the humid tropics with total mean annual rainfall ranging from 1500-3000 mm and total mean annual temperature ranging from 21-35$^0$C. The relative humidity of the area is high (above 75 %) throughout the year, especially during the rainy season (Ahukaemere, 2018).

### Vegetation/Land Use

The vegetation stretches from the mangrove swamp in the coast through to the derived savanna in the interior (Chukwu *et al*., 2009), but the region lies in the lowland rainforest natural vegetation belt with evergreen trees in the south and gradually gives way northward to rainfall-savanna forest characterized by trees interspersed with grass. This vegetation has been drastically altered by anthropogenic activities with variety of plant types like cassava *(Manihot spp)*, plantain *(Musa paradisiaca)*, oil palm (*Eleais guineesis*), maize (*Zea mays*), yam *(Dioscorea species)*, Ogbono tree *(Irvingia gabonensis)*,ube (*Dacryodes edulis*), mango (*Mangifera indica.)*.

## HYDROLOGY AND DRAINAGE

Ohaji-Egbema has a natural depression within the extended east bank flood plain of the River Niger downstream of Onitsha. Surface water and ground water forms the type of hydrology of the area. Infiltration, evapotranspiration, condensation and precipitation forms the hydrological processes in the study area. This gave rise to alluvial soils of the area. The alluvium underlying the area is a good aquifer that is annually recharged by rainfall and flood waters.

### Socioeconomic Activities

In Southeastern Nigeria, agriculture, cottage industries, trading, sand and stone mining and other activities are major socio-economic activities in the area. About 50% of the total area is used as cultivated land. Slash and burn technique has been the major method of land clearing, whereas bush fallow is a soil fertility regeneration practice that has prevailed over the decades, whose length has been drastically reduced due to demographic pressure on land (Onweremadu, 2008).

## FIELD WORK AND SOIL SAMPLING

A reconnaissance field study was carried out at Ohaji / Egbema in Imo State Southeastern Nigeria for the purpose of having a fore-knowledge of the site of study. Alluvium parent material was identified and studied at the following locations; Etekuru (pedon1), Abacheke (pedon 2) and Obiakpu (pedon 3) in Ohaji-Egbema Imo State Southeastern, Nigeria. Three (3) soil profile pits were dug and described according to FAO guidelines for soil description (FAO, 2006) and sampled according to the genetic horizons from the deepest horizon to the topmost horizon using free survey sampling. All sites were geo-referenced using hand held GPS receiver. Fifteen (15) Soil samples, five (5) from each profile pit were taken for routine physical and chemical analysis while morphological studies was done in-situ. Soils of Ohaji / Egbema in Imo State Southeastern Nigeria were classified based on the criteria of USDA soil taxonomy (SSS, 2022).

### Physical Properties

**Particle Size Determination;** Particle size distribution was determined using hydrometer method according to Gee and Or (2002), Calgon or sodium hexametaphosphate $(NaPO3)_6$ solution was used as dispersant.

**Bulk Density;** This was determined by the core method as described by Grossman and Reinsch, (2002).

**Gravimetric Moisture Content;** Moisture content was described gravimetrically (Gardner, 1986).

**Porosity;** Total porosity was calculated from the results of the bulk density (Vomocil, 1965).

### Chemical properties analyzed include

**Soil pH** was measured in 1:2.5 soil/water suspensions (Hendershot *et al.,* 1993).

**Soil Organic Carbon and Organic Matter;** Soil organic carbon (SOC) was analyzed by Walkey and Black method as described by Nelson and Sommers, (1982). Soil organic matter was derived by multiplying the value of soil organic carbon by a Van Bemmelen'scorrection factor of 1.724.

**Total Nitrogen;** was measured by micro-kjeldahl digestion method (Bremner and Mulvaney, 1982).

**Available Phosphorus;** was determined calorimetrically using Bray (11) method (Olsen and Sommers, 1982)**.**

**Exchangeable bases;** (Sodium, Potassium, Calcium and Magnesium). Exchangeable sodium and potassium was extracted using 1N NH4OAc in flame photometry (Jackson, 1964).While Exchangeable Magnesium and Calcium were evaluated by ethylene diamine tetra acetic acid (EDTA) titration method (Thomas, 1988).

**Exchangeable acidity** was evaluated titrimetrically (Mclean, 1982).

**Effective Cation Exchange Capacity** was calculated from the summation of all exchangeable bases and exchangeable acidity (IITA, 1982).

**Base Saturation** was computed. Base Saturation (%)= (Base cations / CEC ) × 100

**Statistical Analyses**
Data collected from the study sites were subjected to basic statistical analysis. The basic statistics include Coefficient of Variation (CV) which was used to measure the variability among the soils studied. The CV was ranked as follows: < 15 % low variation, 16-35% moderate variation, and > 35 % high variation (Wilding *et al.,*1994).While Pearson correlation analysis was implemented to determine the relationship between the soil properties.

**RESULTS AND DISCUSSIONS**

Morphological properties of the studied soils were shown in Table 1, the physiographic mapping units have different colour matrix range and all the horizons are well drained characterized by loose topsoil. Macromorphological properties of soils of Etekuru (Pedon 1) showed soil colour notation that ranged from dark brown (7.5 YR 3/2) moist to red (2.5 YR 5/6) moist. Pedon 2, soils of Abacheke showed colour notation that ranged from dark brown (7.5YR 3/3) to redish yellow (7.5 YR 6/8) moist. While Pedon 3, soils of Obiakpu had a colour notation that ranged from very dark gray (10 YR 3/1) moist to gray (5 YR 5/1) moist. Variation in soil colour of the studied pedons indicates difference in soil moisture and drainage conditions.

Soil texture ranged from loamy sand to clay loam at pedon 1, silt loam to silt clay loam at pedon 2, while pedon 3 had clay textural class in its horizons. The structure of the studied pedons was weak and moderate grade, with a fine and very fine structural class. The structural type is granular at the top soil and sub-angular blocky at the subsoil, which is attributed to the density of the compaction of the soil. Root presence was observed to be common at the epipedon and few as the depth decreases, following increase in soil moisture content. The inadequate root at the sub-surface horizons can be attributed to anaerobic condition of the soil. This is in line with the findings of ( Hammermark, *et al*., 2011), who stated that submersion of soil suppressed air, gives room for anaerobic condition. They also noted that vegetation influences scour and deposition in high energy flood plain environment. An inclusion of krotovina was observed at the sub-surface of pedon1 and pedon 3 as a result of the movement of foreign bodies in the pedons.

**Table: 1: Morphological Properties of Ohaji / Egbema soils in Imo State Southeastern, Nigeria**

| Horizon | Depth(Cm) | Colour (Moist) | Mottles | TC | Str (C) | Str (C) | Str (T) | Con (M) | Roots | inclusion | Boundary Distinctives | Boundary Topography |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Etekuru (Pedon 1)** | | | | | | | | | | | | |
| A | 0-13 | DB(7.5YR3/2) | - | LS | 1 | F | gr | very friable | cf | | C | w |
| AB | 13-22 | B(7.5YR4/2) | - | SL | 1 | F | gr | friable | mf | | G | s |
| BA | 22-25 | RB(5YR4/3) | - | SL | 2 | M | sbk | firm | ff | krotovina/ecofact | G | s |
| $Bt_1$ | 25-80 | R(2.5YR4/6) | - | CL | 2 | M | sbk | firm | ff | | G | s |
| Bt2 | 80-135 | R(2.5YR5/6) | - | CL | 3 | M | sbk | firm | r | | | |
| **Abacheke (Pedon 2)** | | | | | | | | | | | | |
| A | 0-17 | DB(7.5YR3/3) | - | SL | 1 | Vf | gr | friable | mm | | C | s |
| AB | 17-28 | YR(5YR4/6) | - | SCL | 2 | Vf | sbk | friable | mf/m | | G | s |
| $Bt_1$ | 28-79 | DYB(10YR5/4) | - | SL | 2 | F | sbk | friable | ff/m | | G | s |
| Bt2 | 79-110 | RY(7.5YR6/6) | - | SL | 2 | M | sbk | friable | ff | | G | s |
| BC | 110-188 | RY(7.5YR6/8) | - | SL | 2 | M | sbk | firm | r | | | |
| **Obiakpu (Pedon 3)** | | | | | | | | | | | | |
| A | 0—12 | VDG(10YR3/1) | | C | 2 | F | gr | friable | fm | | C | w |
| AB | 12—25 | DG(10YR4/1) | distinct red(2.5YR4/8) | C | 2 | F | gr | firm | mf/m | krotovina | G | s |
| $Bt_1$ | 25-61 | DG(5YR4/1) | distinct red(2.5YR4/8) | C | 2 | M | sbk | firm | ff | | G | s |
| Bt2g | 61-101 | RG(5YR5/2) | light red(2.5YR4/6) | C | 3 | C | sbk | very firm | v/ff | krotovina | G | s |
| Bt3g | 101-160 | G(5YR5/1) | light red(2.5YR6/6) | C | 3 | C | sbk | very firm | r | | | |

Horizonation: A=Master horizon, AB=Transitional horizon of two master horizon with Horizon A dominant over B, Bts=Argillic horizons. Colour: DB=dark blown. SB=slight brown, RB=red brown, WR=weak red, R=red,LR=light red,DG=dark gray,B=brown,RB=reddish brown, R=red.TC=Texture: S=Sand, LS=Loamy Sand. Str.(G)=Structure Grade:1=weak, 2=moderate, 3=strong. Str.(C)=Structure Class: F=fine, M=medium, VF=very fine. Str.(T)=Structure Type: gr=granular, sbk=subangular blocky. Roots: cf=common fine, mf=medium fine, ff/m=few fine/medium, r=rare, ff=few fine, vff=very few fine. Boundaries: c=clear, w=wavy, Con.(M)=concentration in moist condition.

**Source: Field Data (2023).**

**Physical Properties of Ohaji / Egbema soils in Imo State Southeastern, Nigeria**

The studied soil physical properties are presented in Table 2. The Sand Contents were high in all pedons and had a mean range of 412 g/kg to 764 g/kg with low coefficient of variation (CV) > 25%. Which indicates that the studied area is dominated by sand and the sand content decreases with depth.

The soil textural class ranged from loamy sand to clay at the epipedon and Sandy Loam to clay at the subsurface horizons. Irregular distribution of sand and clay was observed in the profile horizons, which suggest different periods of deposition of Sediments. Obi, (1984) had observed similar result in the Niger Delta, noted that soils of the flood plain had such textural pattern because of the parent materials and mode of deposition of sediments.

The silt content of the soils was moderate with values ranging from 46 gkg to 186 g/kg. The silt content of the studied pedons had high coefficient of variation (CV) > 35%. This indicates that the soil will support arable crops.

The clay contents of the studied soils ranged from 190 g/kg to 402 g/kg., with high coefficient of variation (CV =46%) at pedon 1; CV=38 % at pedon 2 and moderate coefficient of variation CV = 31 % at pedon 3. The irregular distribution of the clay content down the soil profile at pedon 1 and 2 is attributed to clay migration by lessivage to produce the process of illuviation, same was observed by Essoka and Esu, (2006).

Bulk density of the studied soils ranged from 1:44 mg/m$^3$ to 1.55mg/m$^3$ with low coefficient of variation (CV) >25 % in all the pedons studied. The bulk density had an inverse relationship with total porosity, indicating that as bulk density is increasing with depth, total porosity is decreasing with depth and vice versa. The increase in bulk density observed in the subsurface horizons is an indication of low soil porosity and soil compaction which may cause restrictions to root growth and poor movement of air and water through the soil. Higher bulk densities show restriction of root penetration. This may lead to poor plant growth, lower crop yield and reduce vegetation cover available to protect the soil from erosion (Arshad *et al.,* 1996). According to Akamigbo, (2001), low soil organic matter was responsible for increased bulk density in cultivated soils of Southeastern Nigeria.

The average total porosity of the studied soils ranged from 41.58 % to 45.81 % with low coefficient of variation (CV) > 25 % among the pedons studied, indicates good soils for maximum plant growth. The percentage total porosity was high in the top soil of all pedons due to decomposed leaf litter which helped to improve soil structure. Percentage of soil porosity decreased as depth increases due to compaction and sealing. Porosity is inversely proportional to bulk density. The higher the bulk density, the lower the soil porosity.

Gravimetric moisture content of the studied pedons ranged from 5.10 % to 6.32 % with low coefficient of variation (CV) < 25 %, indicating that the parent materials affected the moisture content of the studied soils.

**Table 2: Physical Properties of Ohaji / Egbema soils in Imo State Southeastern, Nigeria**

| Horizon | Depth(Cm) | Sand (g/kg) | Silt | Clay | TC | SCR | BD (Mg/m$^3$) | TP (%) | Ѳm (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | **Etekuru (pedon 1)** | | | | |
| A | 0-13 | 860 | 40 | 100 | LS | 0.40 | 1.3 | 50.94 | 4.96 |
| AB | 13-22 | 770 | 60 | 170 | SL | 0.35 | 1.33 | 49.81 | 5.1 |
| BA | 22-25 | 750 | 60 | 190 | SL | 0.32 | 1.42 | 46.42 | 5.12 |
| $Bt_1$ | 25-80 | 610 | 40 | 350 | SCL | 0.11 | 1.5 | 43.40 | 5.16 |
| Bt2 | 80-135 | 590 | 100 | 310 | SCL | 0.32 | 1.63 | 38.49 | 5.14 |
| **Mean** | | **716** | **60** | **224** | | **0.30** | **1.44** | **45.81** | **5.10** |
| **CV(%)** | | **15.91** | **40.82** | **46.14** | | **36.4** | **9.325** | **11.03** | **1.555** |
| | | | | | **Abacheke (pedon 2)** | | | | |
| A | 0-17 | 810 | 50 | 140 | CL | 0.36 | 1.23 | 53.58 | 5.12 |
| AB | 17-28 | 660 | 30 | 310 | SL | 0.10 | 1.35 | 49.06 | 5.16 |
| $Bt_1$ | 28-79 | 800 | 40 | 160 | SCL | 0.25 | 1.42 | 46.42 | 5.14 |
| Bt2 | 79-110 | 810 | 50 | 140 | SL | 0.36 | 1.58 | 40.38 | 5.12 |
| BC | 110-188 | 740 | 60 | 200 | SL | 0.30 | 1.65 | 37.74 | 5.16 |
| **Mean** | | **764** | **46** | **190** | | **0.27** | **1.45** | **45.43** | **5.14** |
| **CV(%)** | | **8.513** | **24.79** | **37.59** | | **39.6** | **11.78** | **14.15** | **0.389** |
| | | | | | **Obiakpu (pedon 3)** | | | | |
| A | 0—12 | 510 | 50 | 440 | C | 0.11 | 1.35 | 49.06 | 6.16 |
| AB | 12—25 | 410 | 140 | 450 | C | 0.31 | 1.44 | 45.66 | 6.14 |
| $Bt_1$ | 25-61 | 390 | 230 | 380 | C | 0.61 | 1.62 | 38.87 | 6.18 |
| Bt2g | 61-101 | 370 | 250 | 380 | C | 0.66 | 1.65 | 37.74 | 6.46 |
| Bt3g | 101-160 | 380 | 260 | 360 | C | 0.72 | 1.68 | 36.60 | 6.66 |
| **Mean** | | **412** | **186** | **402** | | **0.48** | **1.55** | **41.58** | **6.32** |
| **CV(%)** | | **13.77** | **48.18** | **10.01** | | **53.77** | **9.355** | **13.14** | **3.65** |
| **Overall CV(%)** | | **12.73** | **37.93** | **31.25** | | **43.26** | **10.15** | **12.77** | **1.86** |

TC=Textural Class, SCR=Silt Clay Ratio, BD=Bulk Density, TP=Total Porosity, Ѳm=Gravimetric Moisture Content, CV=Coefficent of Variation.

**Source**: **Field Data (2023).**

**Chemical Properties of Ohaji / Egbema soils in Imo State Southeastern, Nigeria**

The chemical properties of the soils of Etekuru, Abacheke, and Obiakpu in Ohaji-Egbema Imo State are shown in Table 3. The soils are slightly acidic with low variability as a result of its associated parent materials. The mean values of pH of the studied soils ranged from 5.82 to 6.44 in water and 4.84 to 5.46 in 1NKCl. While the coefficient of variation (CV) of all the pedons were less than = 25% indicating low variation. The pH values in water suspension was higher than the corresponding values in INKCl solution. This is an indication that all soils at natural pH are negatively charged, (Villabodo and Graetz, 2001). This implies that Delta pH (pH in water – pH in 1N KCl) was positive in all pedons studied. The recorded Low pH values could be due to the dominance of $Al^{3+}$ and $H^{+}$ in soil exchange complex (Soil Survey Staff, 2003). However, higher pH values observed in the upper soil layer could be attributed to litter accumulation leading to higher organic matter concentration.

The mean values of organic carbon, total Nitrogen and available phosphorous were 25.98 g/kg, 0.68 % and 8.08 g/kg respectively for pedon 1. These values were low using the rating of (Soil Survey Staff, 2006). This could be as result of litter fall. Phosphate is considered low and thus explains the reasons for high P fixation in wet land soils. Ogbodo *et al.* (2012), made similar finding of low available P, which was as a result of low organic matter, acidity, nutrient mining by plants and perhaps due to the nature of parent material. Exchangeable calcium, magnesium, potassium and sodium were low for the studied soils with mean values of (2.13, 0.79, 0.16, 0.04) Cmol/kg respectively. Effective cation exchange capacity values was also low according to the rating of (Esu, 1991) with mean values of (9.24, 4.33 and 7.39) Cmol/kg respectively for the pedons. Also, low base saturation was recorded with mean values of (33.81, 32.59 and 59.96) % respectively for the pedons. There was moderate to high variability recorded for exchangeable cations with the over all CV of 118%, 113%, 58%, 69%, 54%, 27%, 61%, 29%, 47% and 40% respectively for OC, TN, Avial. P, Ca, Mg, K, Na, TEB, TEA, and CEC. While base saturation recorded low variability with overall CV = 12.34%. This may be due to illuviation of the basic cations in the lower horizons. The low contents of the basic cations may be due to intense leaching weathering and ferrolysis, hence low inherent fertility status. This agreed with the findings of Olaleye, (1998); Fasina (2005); Fasina *et al.* (2007). The general low ECEC could also be due to the presence of low activity clays. According to Babalola *et al.* (2011), high sand content as well as intense rainfall may have resulted in the exchangeable cations being leached out of the soil profile. Low total exchangeable bases in the study site suggest that sustained crop production without adequate fertilizer may not be feasible.

**Table 3: Chemical Properties ofOhaji / Egbema soils in Imo State Southeastern, Nigeria**

| Horizon | Depth (Cm) | pH water | pH KCl | OC (g/kg) | TN (%) | Av.P (Mg/kg) | $Ca^{2+}$ | $Mg^{2+}$ | $K^{+}$ | $Na^{+}$ | TEB | $H^{+}$ | $Al^{3+}$ | TEA | ECEC | CEC | Bsat (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | ← | | | | Cmol/kg | | | | | → | |
| | | | | | | | **Etekuru (pedon1)** | | | | | | | | | | |
| A | 0-13 | 6.2 | 5.3 | 68 | 2.12 | 19.8 | 1.86 | 0.7 | 0.11 | 0.03 | 2.7 | 1.88 | 3.63 | 5.51 | 8.21 | 9.13 | 32.89 |
| AB | 13-22 | 5.9 | 4.8 | 45.2 | 0.70 | 10.1 | 1.9 | 0.72 | 0.15 | 0.03 | 2.8 | 1.57 | 3.88 | 5.45 | 8.25 | 9.21 | 33.94 |
| BA | 22-25 | 6.5 | 5.5 | 9 | 0.30 | 1.7 | 2.02 | 0.8 | 0.17 | 0.03 | 3.02 | 2.91 | 3.21 | 6.12 | 9.14 | 9.88 | 33.04 |
| $Bt_1$ | 25-80 | 6.6 | 5.5 | 6.4 | 0.20 | 4.66 | 2.43 | 0.83 | 0.19 | 0.04 | 3.49 | 3.12 | 3.37 | 6.49 | 9.98 | 10.51 | 34.97 |
| Bt2 | 80-135 | 6.5 | 5.5 | 1.3 | 0.08 | 4.12 | 2.46 | 0.92 | 0.2 | 0.05 | 3.63 | 2.89 | 4.09 | 6.98 | 10.61 | 10.92 | 34.21 |
| **Mean** | | **6.34** | **5.32** | **25.98** | **0.68** | **8.08** | **2.13** | **0.79** | **0.16** | **0.04** | **3.13** | **2.47** | **3.64** | **6.11** | **9.24** | **9.93** | **33.81** |
| **CV (%)** | | **4.544** | **5.701** | **112.5** | **123.20** | **89.62** | **13.6** | **11.18** | **21.82** | **24.85** | **13.23** | **28.23** | **9.896** | **10.66** | **11.45** | **7.925** | **2.55** |
| | | | | | | | **Abacheke (pedon 2)** | | | | | | | | | | |
| A | 0-17 | 5.8 | 4.9 | 50.2 | 1.08 | 8.6 | 0.11 | 0.31 | 0.07 | 0.02 | 0.51 | 0.19 | 0.96 | 1.15 | 1.66 | 3.83 | 30.72 |
| AB | 17-28 | 5.6 | 4.6 | 13 | 0.56 | 5.76 | 0.7 | 0.33 | 0.09 | 0.02 | 1.14 | 0.96 | 1.5 | 2.46 | 3.6 | 4.15 | 31.67 |
| $Bt_1$ | 28-79 | 5.9 | 4.8 | 8.8 | 0.20 | 7.96 | 0.9 | 0.4 | 0.11 | 0.03 | 1.44 | 1.16 | 1.93 | 3.09 | 4.53 | 5.02 | 31.79 |
| Bt2 | 79-110 | 6 | 5 | 7.1 | 0.11 | 4.3 | 1.08 | 0.48 | 0.13 | 0.04 | 1.73 | 1.12 | 2.11 | 3.23 | 4.96 | 5.53 | 34.88 |
| BC | 110-188 | 5.8 | 4.9 | 1.4 | 0.06 | 3.6 | 1.66 | 0.5 | 0.14 | 0.04 | 2.34 | 1.79 | 2.77 | 4.56 | 6.9 | 7.15 | 33.91 |
| **Mean** | | **5.82** | **4.84** | **16.10** | **0.40** | **6.04** | **0.89** | **0.40** | **0.11** | **0.03** | **1.43** | **1.04** | **1.85** | **2.90** | **4.33** | **5.14** | **32.59** |
| **CV (%)** | | **2.549** | **3.133** | **121.2** | **106.10** | **36.34** | **63.4** | **21.19** | **26.51** | **33.33** | **47.47** | **54.86** | **36.53** | **42.81** | **44.28** | **25.58** | **5.31** |
| | | | | | | | **Obiakpu (pedon3)** | | | | | | | | | | |
| A | 0—12 | 6.4 | 5.4 | 65.5 | 2.06 | 13.2 | 12.16 | 4.12 | 0.39 | 0.12 | 16.79 | 0.51 | 1.18 | 1.69 | 18.48 | 20.36 | 90.85 |
| AB | 12—25 | 6 | 5.1 | 20.4 | 1.04 | 11.13 | 1.11 | 0.33 | 0.19 | 0.07 | 1.7 | 0.63 | 0.98 | 1.61 | 3.31 | 3.96 | 51.36 |
| $Bt_1$ | 25-61 | 6.5 | 5.5 | 9.4 | 0.31 | 11.77 | 2.08 | 0.68 | 0.23 | 0.08 | 3.07 | 1.51 | 1.71 | 3.22 | 6.29 | 6.22 | 48.81 |
| Bt2g | 61-101 | 6.6 | 5.6 | 6.8 | 0.22 | 5.11 | 1.98 | 0.68 | 0.26 | 0.09 | 3.01 | 1.07 | 1.26 | 2.33 | 5.34 | 5.88 | 56.37 |
| Bt3g | 101-160 | 6.7 | 5.7 | 3.6 | 0.09 | 3.03 | 1.16 | 0.39 | 0.2 | 0.11 | 1.86 | 0.71 | 0.98 | 1.69 | 3.55 | 4.2 | 52.39 |
| **Mean** | | **6.44** | **5.46** | **21.14** | **0.74** | **8.85** | **3.70** | **1.24** | **0.25** | **0.09** | **5.29** | **0.89** | **1.22** | **2.11** | **7.39** | **8.12** | **59.96** |
| **CV (%)** | | **4.195** | **4.216** | **121.1** | **110.60** | **50.7** | **128.5** | **130.5** | **31.81** | **22.06** | **122.2** | **45.89** | **24.5** | **32.55** | **85.48** | **85.08** | **29.16** |
| **Overall CV (%)** | | **3.76** | **4.35** | **118.27** | **113.30** | **58.89** | **68.5** | **54.29** | **26.71** | **26.75** | **60.96** | **42.99** | **23.64** | **28.67** | **47.07** | **39.53** | **12.34** |

OC=Organic Carbon, TN=Total Nitrogen, Av.P=Avialable Phosphorous, Ca=Calcium,Mg=Magnesium, K=Potassium, Na=Sodium, TEB=Total Exchangeable Base, H=Hydrogen, Al=Aliminum, TEA=Total Exchangeable Acidity, ECEC=Effective Cation Exchange Capacity, CEC=Cation Exchange Capacity, Bsat=Base Saturation, CV=Coefficient of Variation.
**Source**: **Field Data, (2023).**

### Correlation among soil physico-chemical properties of soils of Ohaji / Egbema Imo State Southeastern, Nigeria.

The correlation among soil physico-chemical properties of soils of Ohaji / Egbema Imo State Southeastern, Nigeria is shown in Table 4. pH in water had a positive Significant correlation with silt (r = 0.54*). Which indicates that percentage silt content contributed positively to the acidic nature of the soils. Organic Carbon had a negative significant correlation with clay (r = -0.56*), which means that there is an inverse relationship between clay and organic carbon in the studied soils. Total exchangeable bases had a negative significant correlation with Clay (r= -0.54*), this indicates that increase in clay content will lead to increase in the exchangeable bases in the studied pedons. Effective Cation exchange capacity had a negative significant correlation with clay (r = -0.60*) at 5% probability level, and a high positive significant correlation with total exchangeable base (r = 0.99**) at 10% probability level, and with cation exchange capacity (r = 0.86**) this indicates that clay content is a determinant factor of the fertility status of the soil. This is in line with the findings of Essoka and Esu, (2006) which states that clay migrates by lessivage to produce the process of illuviation that contributes to soil fertility. Base saturation had a high positive significant correlation with total exchangeable base (r =0.91**) and a positive significant correlation with cation exchange Capacity (r = 0.62*) indicating that increase in base saturation will lead to increase cation exchange capacity.

**Table 4: Correlation among soil physico-chemical properties of soils of Ohaji / Egbema Imo State Southeastern, Nigeria.**

| | Silt | Clay | BD | Ɵm | pHw | OC | TEB | CEC |
|---|---|---|---|---|---|---|---|---|
| **Silt** | - | - | - | - | - | - | - | - |
| **Clay** | 0.56* | - | - | - | - | - | - | - |
| **BD** | 0.65** | 0.36 | - | - | - | - | - | - |
| **Ɵm** | -0.19 | -0.40 | -0.33 | - | - | - | - | - |
| **pHw** | 0.59* | 0.47 | 0.51 | 0.00 | - | - | - | - |
| **OC** | -0.36 | -0.20 | -0.78** | 0.55* | -0.20 | - | - | - |
| **TEB** | -0.11 | 0.43 | -0.13 | -0.04 | 0.31 | 0.46 | - | - |
| **CEC** | -0.30 | 0.22 | -0.17 | 0.09 | 0.36 | 0.44 | 0.91** | - |
| **Sand** | -0.83** | -0.92** | -0.54* | 0.35 | -0.59* | 0.30 | -0.24 | -0.01 |
| **SCR** | 0.86** | 0.07 | 0.53* | 0.07 | 0.45 | -0.21 | -0.32 | -0.42 |
| **TP** | -0.65** | -0.36 | -1.00** | 0.33 | -0.51 | 0.78** | 0.13 | 0.17 |
| **pHk** | 0.614* | 0.47 | 0.50 | 0.07 | 0.98** | -0.16 | 0.30 | 0.33 |
| **TN** | -0.31 | -0.01 | -0.70** | 0.61* | -0.13 | 0.94** | 0.53* | 0.47 |
| **AvP** | -0.13 | -0.05 | -0.5* | 0.69** | -0.14 | 0.81** | 0.30 | 0.25 |
| **Ca** | -0.11 | 0.43 | -0.13 | -0.04 | 0.30 | 0.46 | 1.00** | 0.91** |
| **Mg** | -0.15 | 0.38 | -0.18 | -0.03 | 0.28 | 0.50 | 0.99** | 0.91** |
| **K** | 0.40 | 0.74** | 0.30 | -0.23 | 0.64** | 0.10 | 0.83** | 0.69** |
| **Na** | 0.69** | 0.76** | 0.45 | -0.20 | 0.63* | 0.00 | 0.60* | 0.33 |
| **H** | -0.21 | -0.15 | 0.23 | 0.13 | 0.39 | -0.34 | -0.10 | 0.28 |
| **TEA** | -0.34 | -0.33 | 0.10 | 0.25 | 0.23 | -0.16 | -0.10 | 0.32 |
| **ECEC** | -0.26 | 0.25 | -0.07 | 0.08 | 0.40 | 0.35 | 0.88** | 0.99** |
| **Bsat** | 0.37 | 0.711** | 0.10 | -0.16 | 0.42 | 0.30 | 0.84** | 0.57* |

*=significant at 1% probability level, **=significant at 5% probability level,BD=Bulk Density,Ɵm=Gravimetric moisture content, pHw=pH in water, OC=Organic Carbon, TEB=Total Exchangeable Bases, CEC=Cation Exchange Capacity, SCR=Silt Clay Ratio, TP=Total Porosity, pHk=pH in IN KCl, TN=Total Nitrogen, AvP. =Avialable Phosphorus, Ca=Calcium, Mg=Magnesium, K=Potassium, Na=Sodium, H=Hydrogen, TEA=Total Exchangeable Acidity, ECEC=Effective Cation Exchange Capacity, Bsat.=Base Saturation.

**Source**: **Field Data (2023).**

## SOIL CLASSIFICATION

Soil classification result is presented in Table 5. In the studied three (3) pedons, soil is classified into the order of Inceptisols because they have a cambic sub-horizon resulting from physical alteration and chemical transformation, or a combination of these processes. The soils meet the requirement of the hicks humidity regime, which qualified it into the suborder udepts. The temperature regime includes isohyperthermic, which made the soil to belong to great group Dystrudepts and the Typic Dystrudents sub-group for pedon1 and 2, while pedon 3 is Fluvaquentic Dystrudepts this could be as a result of clay content that dominate the soils of this very pedon 3.

**TABLE 5: Classification of soils of Ohaji/Egbema in Imo State Southeastern Nigeria**

| Pedon No. | The soil classification | | | | |
|---|---|---|---|---|---|
| | Location | Order | suborder | Great group | Sub group |
| 1 | Etekuru | Inceptisols | udepts | Dystrudepts | Typic Dystrudepts |
| 2 | Abacheke | Inceptisols | udepts | Dystrudepts | Typic Dystrudepts |
| 3 | Obiakpu | Inceptisols | udepts | Dystrudepts | Fluvaquentic Dystrudepts |

## CONCLUSION

Based on the research results, it shows that most of the study profiles have lost all or part of the A horizon. The studied soil properties such as pH, total nitrogen, cation exchange capacity, base saturation, exchangeable bases (Ca, Mg, K, Na) and available P are generally low with a relatively constant distribution pattern with increasing depth.

The soils are classified into the order Inceptisol because it has a cambic sub-horizon resulting from physical alteration, and chemical transformation or a combination of these processes. The humidity regime qualified the soils to sub-order category of udepts. The temperature regime of Isohyperthermic made the soil to be categorized into Great Group Dystrudepts and sub-group Typic Dystrudepts for pedon 1 and 2. While pedon 3 is identified as Fluvaquentic Dystrudepts.

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