# EVALUATION OF FERTILITY STATUS OF SOILS OF DIFFERENT PARENT MATERIALS USED FOR ARABLE CROP PRODUCTION IN ENUGU STATE, NIGERIA

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## ABSTRACT
This study was carried out to evaluate the chemical and fertility status of soils of different parent materials used for arable crop production in Enugu State. The soil samples were collected from four different local government areas in Enugu State, which include Nkanu East (shale), Nkanu West (sand stone), Enugu south (alluvium), Enugu East (alluvium) and Enugu south (Sandstone). It was found that majority of the soils in Enugu State have low to medium fertility levels. This is evidenced by the low levels of organic matter and nitrogen found in the soil samples. The mean organic matter content of the soils was 1.09% while the mean total nitrogen is about 0.06%. It was also found that the pH of soils in the study area was mostly alkaline and slightly acidic, which could favour the growth and development of some crops in the area. High calcium, potassium and magnesium was found in the soil of the study area. The soils in the study area have a high ECEC and BS of 91.72% which means that they can hold onto a lot of nutrients and are well supplied with basic cations. It is therefore recommended to add Organic matter to the soil so as to increase the nutrient level and to ensure optimum productivity. Mulching is recommended to reduce the impact of raindrop on the soil surface and also add organic matter to the soil when it decomposes. Due to low nitrogen level in all the soils studied, crop rotation with leguminous crop should be adopted. This will help to add nitrogen to the soil naturally through nitrogen fixation.
**Keyword**: fertility status, parent materials, arable crop production.

## INTRODUCTION
Soil fertility refers to the ability of soil to provide essential nutrients to plants in adequate quantities and in a form that can be readily taken up by plant roots. Evaluating soil fertility is important for sustainable agriculture as it determines the productivity and health of crops. Several factors are considered when evaluating soil fertility, including soil pH, nutrient content, organic matter, and microbial activity (Brady, *et al.,* 2016). Evaluating the nutrient content of the soil is crucial in understanding its fertility. Key nutrients include nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and micronutrients like iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), and boron (B). Soil testing laboratories can provide analysis of nutrient levels and recommend appropriate fertilization strategies (Dawson, 2011).
Enugu State is located in Southeastern Nigeria and it is divided into six agricultural zones (Agbani, Agwu, Enugu, Enugu-Ezike, Nsukka and Udi). Agriculture plays important role in the state's economy because a large portion of its rural dwellers are arable crop farmers. Soil fertility evaluation plays a significant role in understanding the nutrient composition and availability of essential elements for optimal crop production. In Enugu State, Nigeria, the fertility status of soils may vary due to the diverse parent materials giving rise to different soil types. The soils of Enugu state are derived from varied parent materials, such as sedimentary rocks, volcanic ash, alluvium deposits, shell, sandstone, etc. These parent materials directly influence the chemical, physical, and biological properties of the soil, resulting in distinct soil types. Understanding the fertility status of these soils is crucial for successful arable crop production, as it allows farmers to implement tailored management practices based on specific nutrient deficiencies or excesses. The major arable crops grown in Enugu include cassava, maize, bambara beans, okra, yam etc.
Studies have been conducted in Enugu State to evaluate soil fertility status of soils and their suitability for different crops but very few researches had been tailored toward understanding the fertility status of soils of different parent materials used for arable crop production in the State. Understanding the impact of the various parent materials on the levels of major and micro nutrients, pH, organic matter content, and cation exchange capacity (CEC) will add to the bank of knowledge and help provide specific solution for the improvement of the fertility of soils used for arable crop production in Enugu State; thus, providing sustainable and increased crop production.

## MATERIALS AND METHODS
### DESCRIPTION OF THE STUDY AREA
The study was conducted on some soils of Enugu state in South Eastern Nigeria. Enugu state is situated within latitude $06^0 21^0$N and $06^0 30^0$N and longitudes $07^0 26^0$E and $07^0 37^0$E. Presently Enugu State consists of 17 local Government Areas(LGAs). It is bordered to the north by Benue state and to the west by Anambra state, to the east by Ebonyi state, and Abia State to the south. Soils were collected from Enugu East from soils formed under Alluvium, Nkanu East

from soils under shale parent materials, Enugu South from soils of Sandstone, and Nkanu West from soils formed on sandstone parent materials.

Enugu South Local Government Area lies between $6.42^0$N and $7.49^0$E with land area of about 73.1km square and population of 361,644. Nkanu East Local Government Area lies between $6^0$20N and $7^0$39E with a land area of about 441.2km$^2$. Vegetation is predominantly savannah grassland with pockets of rainforest. Nkanu West Local Government Area is between $6^0$18N and$7^0$33E with land area of about 202.3 km². Enugu East lies between $6.51^0$N and $7.51^0$E with estimated population of 160000 people.

**CLIMATE AND VEGETATION**

Enugu state experiences a tropical climate, characterized by two distinct seasons - the rainy season and the dry season. The rainy season usually starts in April and lasts until October, with the highest rainfall occurring between July and September. The dry season, on the other hand, lasts from November to March, with relatively low rainfall. The average annual temperature in the LGA is around 28°C (82°F). The mean annual rainfall of Enugu ranges from 2000-3000mm.

Enugu is dominated by tropical rainforest with derived savannah. The vegetation is rich with trees shrubs and grasses. The tree species include oil palm, oil bean, breadfruit, pear, kola, etc. The major farming system is the mixed cropping. The major arable crops grown include yam, maize, rice, cowpea, cassava and vegetables.

**FIELD STUDY**

The soil samples for the study were collected from depth of 0-20cm from soils of different parent materials used for arable crop production in Enugu state using soil auger. Soils formed on Alluvium were collected from Enugu East while soils formed on shale parent materials were collected from Nkanu East and soils formed on sandstone parent materials were collected from Enugu South and Nkanu West, respectively.

**SAMPLE PREPARATION**

The soil samples were air dried at room temperature and gently crushed to pass through a 2mm. The sieved samples were placed in neat polybags and properly label before taken to the laboratory for analysis.

**METHODOLOGY**

There are several methods used in determining the physical and chemical properties of soil:

**Particle size**

Particle size distribution was determined by the hydrometer method of Bouyoucos (1962), and modified by Udo *et al*., (2009).

**Soil pH ($H_20$)**

The pH of the soil sample was determined using a 1:2.5 soil water ratio using glass electrode (Udo *et al*.,2009).

**Organic carbon and organic matter**

Organic carbon was determined by dichromate-oxidation method of Walkley and Black wet oxidation method as outlined by Udo *et al*., (2009).

**Available phosphorus**

This was determined using Bray 2 method as described by Bray and Kurtz (1945).

**Total nitrogen**

Total nitrogen in the soil sample was determined by the Macro- Kjeldahl method by Bremner (1996) and modified by Udo *et al.,* (2009).

**Effective Cation Exchange Capacity (ECEC)**

This was calculated by summation of exchangeable cation and the exchangeable acidity. (Exchangeable Ca + Mg + Na + K) + Exchangeable acidity.

CEC= TEB + EA

**% Base saturation**

It was calculated using

TEB/ECEC × 100/1

Where TEB = total exchangeable bases

ECEC = effective cation exchange capacity

**RESULTS AND DISCUSSION**

**PARTICLE SIZE DISTRIBUTION**

Table 4.1 shows the particle size of the soils studied. According to the table, Alluvium E/south had 91.3% sand content, 4.9% silt content, and 3.8% clay content, with a textural class of sand. On the other hand, Shale Nkanu East had 24.3% sand content, 41.1% silt content, and 34.6% clay content, with a textural class of clay.

For Sandstone Enugu South, the sand content was (50.3), silt content (16.1) and clay content was (33.6). The textural class for Sand Stone Enugu south was Sandy clay loam. For Alluvium E/East, the Sand content (90.3), silt content (2.3) and clay content (7.4) were recorded. The textural class for Alluvium E/East was recorded as Sand. With reference to Sand Stone Nkanu West, the Sand content (52.3), silt content (17.1) and clay content (30.6) were recorded. Sand Stone Nkanu West had Sandy clay loam as the textural class.

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**CHEMICAL PROPERTIES**

Table 4.2 shows the chemical properties of soils studied. The table showed that Shale Nkanu East with the value (18.4) had the highest available phosphorus while Alluvium E/south with the value (14.4) had the lowest value on available phosphorus. This indicates that soils in this environment have enough phosphorus which could support the growth and development of plants. On total nitrogen (TN), Shale Nkanu East with the value (0.093) was the highest while Alluvium E/south with the value (0.032) had the lowest TN. This means that Nitrogen was almost scarce in Shale Nkanu East which could possibly affect the growth of plants in that environment. This is in line with the findings of Onweremadu, (2016), that most soils in Enugu state are deficient in total nitrogen.

In the case of Calcium (Ca), Shale Nkanu East with the value (6.40) had the highest value, while Alluvium E/south with the value (4.40) had the lowest value. For the Magnesium Mg content, Shale Nkanu East with the value (2.20) had the highest, while Alluvium E/East with the value (0.80) was the lowest. In terms of potassium (K), Shale Nkanu East with the value (0.220) had the highest, while Alluvium E/East with the value (0.088) was the lowest. Under sodium (Na), Shale Nkanu East with the value (0.176) was the highest, while Alluvium E/East with the value (0.080) had the lowest. Sandstone Nkanu West recorded the highest Exchangeable acidity (EA) with the value (1.32), while Alluvium E/East recorded the lowest value (0.18).

Shale Nkanu East recorded the highest in ECEC with the value (10.24), while Alluvium E/East recorded the lowest value (5.75). For Base saturation (BS), Alluvium E/East had the highest value (98.60), while Sandstone Nkanu West recorded the lowest value (83.49). For the Aluminum (Al) content, Sandstone Nkanu West had the highest value (0.46), while Sandstone Nkanu East had the lowest value (0.34).

The table shows that the soils in the study area have a high level of phosphorus, but a low level of nitrogen. This means that the soils are fertile and can support the growth of plants. However, nitrogen is an essential nutrient for plant growth, so it is important to add nitrogen to the soil in order to maximize crop yields.

The table also shows that the soils in the study area have a high level of calcium, magnesium, potassium, and sodium. These are all essential nutrients for plant growth, so the soils are well-supplied with these nutrients.

The effective cation exchange capacity (ECEC) of the soil is a measure of the soil's ability to hold onto nutrients. A high ECEC indicates that the soil can hold onto a lot of nutrients, while a low ECEC indicates that the soil can only hold onto a small amount of nutrients. The soils in the study area have a high ECEC, which means that they can hold onto a lot of nutrients. This is good for plant growth, as it means that the plants will have access to the nutrients they need even if the soil is not fertilized regularly.

Base saturation (BS) is a measure of the percentage of cation exchange sites in the soil that are occupied by basic cations, such as calcium, magnesium, and potassium. A high BS indicates that the soil is well-supplied with basic cations, while a low BS indicates that the soil is not well-supplied with basic cations. The soils in the study area have a high BS, which means that they are well-supplied with basic cations. This is a good thing for plant growth, as it means that the plants will have access to the nutrients they need.

Overall, the soils in the study area are fertile and well-suited for crop production. However, it is important to add nitrogen to the soil in order to maximize crop yields.

**Table 4.1 Physical and chemical properties of the soils studied**

| Sample | Sand % | Silt % | Clay % | Texture | pH $H_2O$ | pH kcl | Av.P mg/kg | TN % | OC % | OM % | Ca | Mg | K | Na | EA | ECEC | BS % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | ← cmol $kg^{-1}$ → | | | | | | |
| **Alluvium E/south** | 91.3 | 4.9 | 3.8 | Sand | 7.6 | 6.4 | 14.4 | 0.032 | 0.34 | 0.59 | 4.40 | 1.00 | 0.092 | 0.086 | 0.22 | 5.80 | 96.21 |
| **Shale Nkanu East** | 24.3 | 41.1 | 34.6 | CL | 6.6 | 5.8 | 18.4 | 0.093 | 1.02 | 1.76 | 6.40 | 2.20 | 0.220 | 0.176 | 1.24 | 10.24 | 87.79 |
| **Sand stone E/south** | 50.3 | 16.1 | 33.6 | SCL | 6.9 | 6.0 | 16.2 | 0.048 | 0.54 | 0.93 | 5.60 | 1.60 | 0.186 | 0.142 | 1.08 | 8.61 | 87.45 |
| **Alluvium E/East** | 90.3 | 2.3 | 7.4 | Sand | 8.5 | 7.3 | 15.2 | 0.042 | 0.46 | 0.79 | 4.60 | 0.80 | 0.088 | 0.080 | 0.18 | 5.75 | 98.60 |
| **Sand sto ne Nkanu west** | 52.3 | 17.1 | 30.6 | SCL | 6.8 | 5.9 | 16.6 | 0.068 | 0.76 | 1.31 | 5.20 | 1.40 | 0.180 | 0.150 | 1.32 | 8.30 | 83.49 |
| **Mean** | **62.39** | **16.48** | **22.2** | | **7.36** | **6.35** | **16.34** | **0.06** | **0.63** | **1.09** | **5.30** | **1.42** | **0.15** | **0.13** | **0.82** | **7.83** | **91.72** |
| **LSD (0.05)** | 22.33 | 7.12 | 8.62 | | NS | NS | NS | 0.02 | 0.22 | 0.39 | NS | 0.50 | 0.05 | 0.04 | 0.32 | 2.65 | NS |

**OM =organic matter, Av.p =Available phosphorus, TN=Total nitrogen, OC=Organic carbon, EA = Exchangeable acidity, ECEC=Effective cation exchange capacity**

**4.3 ORGANIC MATTER AND pH**

The Table showed that Organic matter in Alluvium E/south with the value (0.59) was very low, it has a pH in water with the value (7.6) and pH of (6.4) in KCl This shows that pH of 7.6 is slightly more alkaline than neutral. On the other hand, KCl (potassium chloride) with the pH of 6.4 would be considered slightly acidic. In the case of Shale Nkanu East, the organic matter OM content was (1.76) with the pH in water (6.6), and pH in KCl(5.8). This indicates that the pH of 6.6 in water is slightly acidic, while KCl (potassium chloride) at a pH of 5.8 would be considered moderately acidic. Under Sand Stone E/south, the organic matter OM is (0.93), with pH in water (6.9) and pH in KCl (6.0). This means that the pH in water is slightly acidic and pH in KCl is also slightly acidic. Alluvium E/East recorded (0.79) of Organic matter with pH of (8.5) in water and pH of (7.3) in KCl The pH in Alluvium E/East was more alkaline in nature than Alluvium E/south which is slightly acidic. In Sand Stone Nkanu West, the Organic matter is (1.31), pH of (6.8) in water and pH of (5.9) in KCl.

Organic matter provides essential nutrients, improves soil structure and water-holding capacity, and promotes the growth of beneficial microorganisms (Njoku *et al.*, 2017). It's worth noting that slight variations in pH can have significant effects on chemical reactions and biological processes which depend on specific levels of acidity or basicity. The result showed that low organic matter OM level in the study area and addition of organic matter is needed to improve soil fertility of the area.

The table you provided shows the organic matter content and pH (in water and KCl of soils from four different locations: Alluvium E/south, Shale Nkanu East, Sand Stone E/south, and Sandstone Nkanu West. Organic matter is a vital component of healthy soil. It provides essential nutrients for plants, improves soil structure and water-holding capacity, and promotes the growth of beneficial microorganisms. The table shows that all four soils have relatively low organic matter content, with the

lowest value being 0.59% in Alluvium E/south. A pH of 7 is neutral, a pH below 7 is acidic, and a pH above 7 is alkaline. The table shows that all four soils are slightly acidic, with pH values ranging from 6.4 to 6.9 in water and 5.8 to 6.0 in KCl. KCl (potassium chloride) is a salt that is sometimes used to measure soil pH. KCl extracts more hydrogen ions from the soil than water, which results in a lower pH reading. This difference in pH is known as the pH shift.

The results of this study suggest that the soils in the study area are low in organic matter and slightly acidic. This indicates that the soils would benefit from the addition of organic matter, such as compost or manure. Organic matter would help to improve soil fertility and structure, and it would also help to raise the soil pH.

## CONCLUSION AND RECOMMENDATIONS

The majority of the soils in Enugu State have low to medium fertility levels. This is evidenced by the low levels of organic matter, nitrogen, phosphorus, and potassium found in the soil samples. The pH levels of the soils ranged from acidic to slightly acidic, which is not ideal for many crops. Proper liming practices should be implemented to adjust the pH levels and improve soil fertility. High levels of sand in the soil samples indicate poor water and nutrient holding capacity. This can lead to leaching of nutrients and reduced crop productivity.,

Low levels of available phosphorus were discovered in the soils which indicate a need for phosphorus fertilizer application. This nutrient is essential for plant growth and development, and its deficiency can limit crop yield.

From the study, the low organic matter content was one the major factor that predisposed the some of the soils to low fertility, therefore the use of organic manure should be encouraged. Mulching is also recommended as it will reduce the impact of raindrop on the soil surface and also add organic matter to the soil when it decomposes. Due to low nitrogen level in all the soils studied, crop rotation with leguminous crop should be adopted. This will help to add nitrogen to the soil naturally through nitrogen fixation. Discreet application of nitrogen fertilizer will also help to make up for the nitrogen deficiency in the soil. Further soil test should also be carried out in the study areas to determine the level of micronutrients in the soils. This will give more insight on the fertility status of these soils and enhanced better soil management.

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