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Experimental evaluation of soil petrophysical attributes: Implications for sustainable agriculture

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Abstract. Agriculture is man's major supplier of his needs, particularly his primary need which is food. Soil is a major component for sustainable agriculture production needs to be studied and understood. Soil's characteristics determine the type of crop that would grow and the nature of the yield of the crop. The area of study is Covenant University farmland, where twenty soil samples from the farm were collected and petrophysical parameters such as conductivity and salinity were analysed on each soil sample.

1. Introduction

Soil is an important component of agriculture. The reason why the human civilization has thrived over centuries is because of the ability of man to use the resources around him to sustain his livelihood using different means among which agriculture is one of them. Agriculture does not only provide man with food, but also provides man with other resources that have made his environment conducive and comfortable. It has provided man with raw materials for production other materials useful to him. Agriculture has also served as income provider for man both of the individual and community scale. With numerous benefits of agriculture, there is need for the practice to be sustained. Agriculture as a science requires the systematic study of all factors that affect its sustainability. These factors can be categorized into two which are economic factors and environmental factors. The environmental factors include climate, soil type, soil texture, soil salinity, soil conductivity, moisture content and topography among others. Soil conductivity, soil salinity and soil water holding capacity and soil hydraulic characteristics are significant in the design and operation of irrigation agriculture system. The level of salt content in soil affect crop yield, as the high level of salt content might reduce or hinder crop yield. Salt tolerance refers to the relative capacity of plants to grow or thrive when subjected to saline soils. Excess accumulation of salt in the soils moves into the plant's transpiration stream from plant roots, thereby causing damage to the plant cells and facilitate further reduction in growth. Examples of physical signs of high salt salinity of soil in crops are stunted growth, brown or yellow leaves and dying leaves.



Most soil minerals like feldspar, quartz, clay minerals, iron oxide, are not conductors of electricity. However, most soils exhibit some level of electrical conductivity depending on the amount of dissolved salts present in the water within the pores. Sources of salinity in the soil include rainfall, build-up of salts over a period of time (due to geogenic processes) which are environmental or human induced methods such as irrigation, poor drainage, alteration of plant cultivation methods. The degree of soil salinity in an area has varying effects on the biotic components in the biosphere. The degree of soil salinity in West Africa has increased over time as a result of irrigated agricultural practices in farmlands [1]. Several researches have been conducted to proffer solutions to soil contamination characterization, environmental contamination groundwater, agriculture (salinity) and soil geo-engineering problems using geophysical GIS and remote sensing techniques [2-11]. The focus of this research is to assess the level of salt concentration in the soil of a farm within the Covenant University, Nigeria using electrical conductivity method.

2. Methodology

2.1 Study Area

The area of study is a farmland within the Covenant University campus, Sango-Ota, Ogun state, southwestern Nigeria (Figure 1). Figure 2 shows that the area lies geologically within the Eastern section of the Dahomey basin with east-westward trend sediments deposition and six lithostratigraphic units comprising Benin, Ilaro, Oshosun, Akinbo, Ewekoro and Abeokuta Formations from youngest to the oldest geological formation. Abeokuta Formation denoted as Cretaceous has been classified as a Group divided into Ise, Afowo and Araromi Formations. Abeokuta Formation is of sequence of poorly sorted grits and pebbly sands with intercallations of siltstones, mudstones and shaly clay. Ewekoro Formation is known to be a Paleocene shallow marine deposit of non-crystalline and non-fossiliferous limestone strata. Akinbo shale units are of late Paleocene to Early Eocene overlaid by Eocene Shale of Oshosun Formation. Coarse sequences of estuarine, deltaic and continental sandy unit of Ilaro Formation overlies Oshosun Formation. Coastal plain sands and Tertiary alluvium deposits of Benin Formation is the youngest overlying the Ilaro Formation.

2.2 Samples Collections and Preparation

Twenty (20) soil samples were obtained within the farmland for laboratory analysis. The samples were sieved with the intention of removing pebbles and other irrelevant materials that could cause error in the final output of the analysis. The samples were prepared by drying them properly in order to ensure that they are air tight. Approximately 5g of 20 dissimilar soil samples were weighed and placed in 20 beakers which were correctly labelled. 100 ml of distilled water was filled into each beaker sample with the mixture of the distilled water and soil samples mixed with spatula. The beakers filled with the solutions were kept away and covered with aluminium foil paper. The mixture was allowed to dissolve over a time frame of 48 hours and tested using the JENWAY 4510 to test for conductivity, temperature and salinity.

3. Results and Discussion

The results of the laboratory experimental analyses for conductivity, salinity and temperatures of the soil samples as well as the weight of each sample are presented in charts (Figure 3). It is revealed that soil conductivity ranges 0.04 to 0.37 dS/m with mean 0.152 dS/m, soil salinity ranges 0.03 to 0.18 percent with mean value of 0.08 percent and soil temperature measured ranges from 29.0 to 30.0 °C with mean temperature value of 29.4 °C. The level of the soil conductivity is optimal and the measured soil salinity is adjudged relatively low. Figure 4 equally revealed high correlation coefficient of 94.4 percent for both soil petrophysical parameters, implying their close relationship. The strong

correlation of both attributes equally showed their geogenic source and the fact that there is no anthropogenic influence on the soil quality within the farmland.

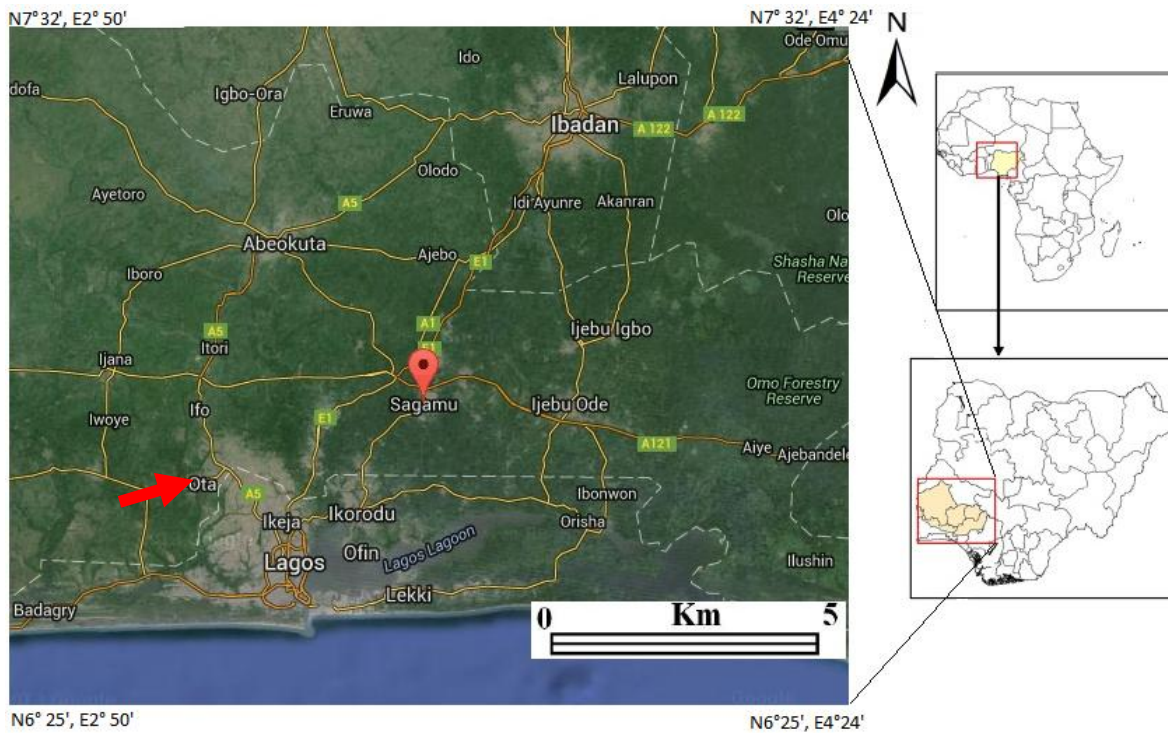


Figure. 1: Topographical map of the study area showing relief and accessibility. Inset: the position of the study area on the map of Nigeria and Africa. ©Google earth image downloaded 17.30 GMT 02.10.2015.

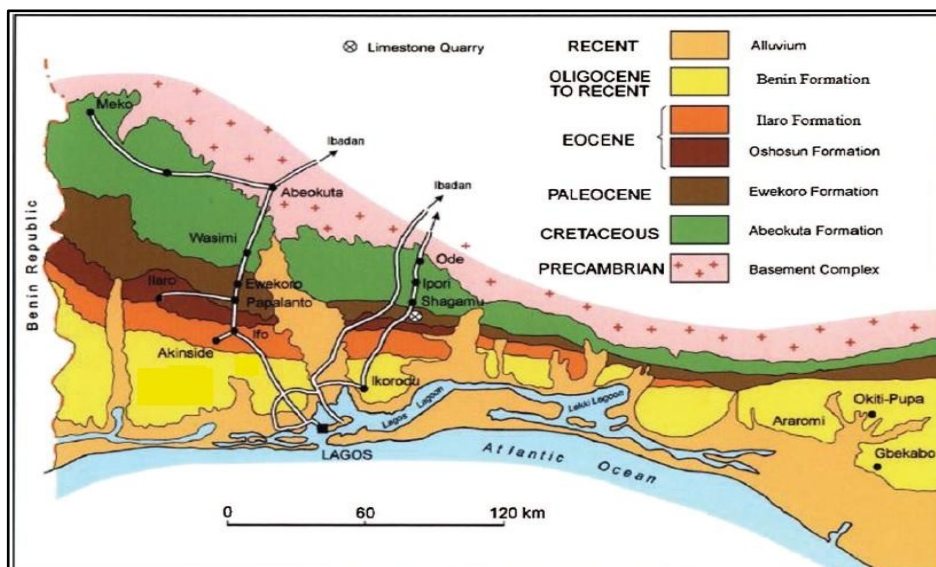


Figure. 2: Generalized geological map of Eastern Dahomey Basin (modified after[12]).

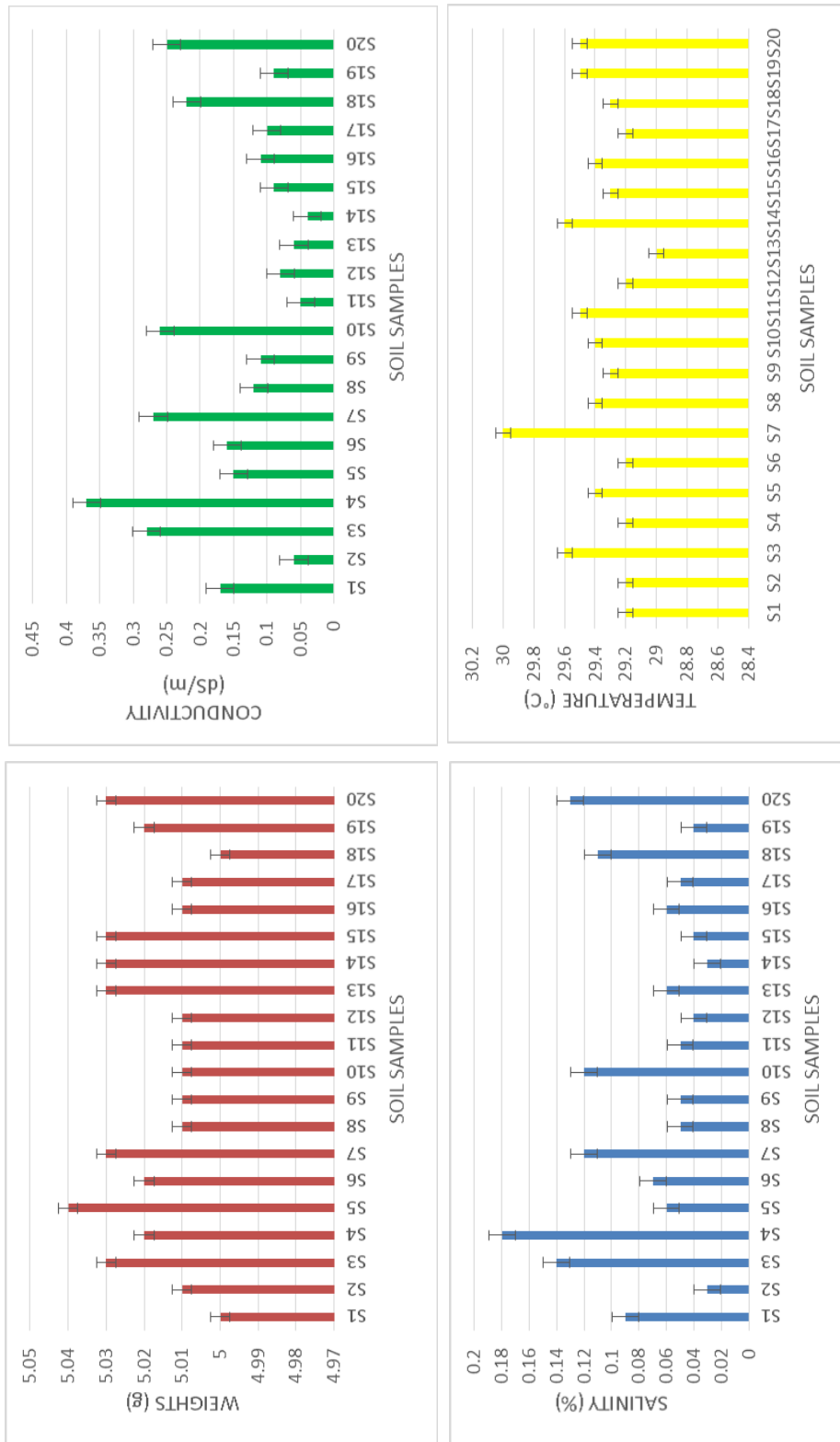


Figure 3: Charts showing the soil weights, soil conductivity, soil salinity and soil temperature in the farmland.

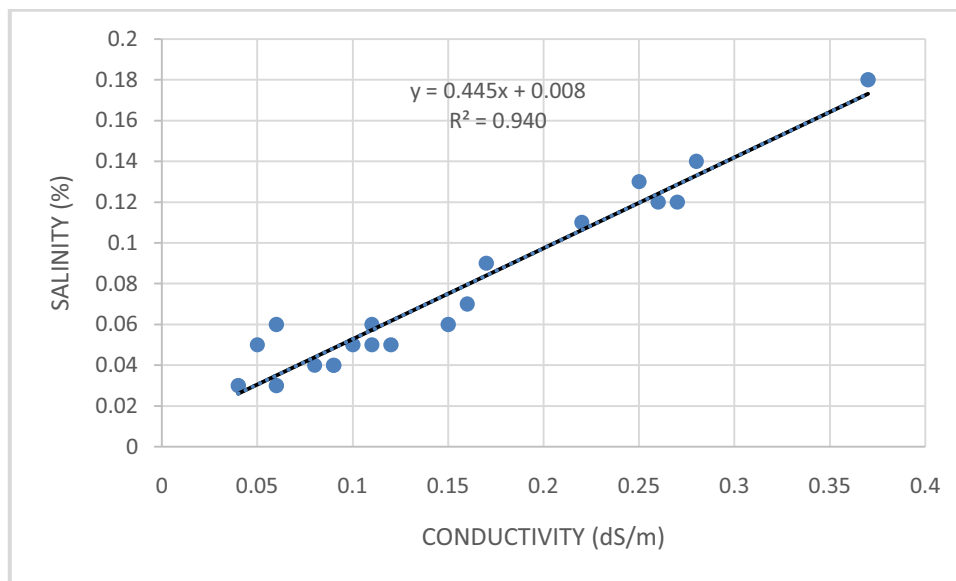


Figure 4: Correlation plot between measured soil conductivity and soil salinity.

4. Conclusions

In this study, soil conductivity, salinity and temperature were investigated in a farmland within the covenant University Nigeria campus. The aim of the research is to assess the level of salt concentration in the soil using electrical method. The study is essential as the salinization of soil is challenge worldwide and the knowledge of soil properties are important for farmers so as to know the crop type to be cultivated for a particular farmland. The results of the laboratory experimental analyses shows that measured petrophysical parameters are within the standard regulatory level and the level of salinization is relatively normal within the farmland making it suitable for plant growth. It is however recommended that routine check on the salinity test should be done for adequate monitoring.

Acknowledgments

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