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Assessment of Nutrient Availability in Soil Textural Constituent as Influenced by Land Use

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ABSTRACT

Investigating the nutrient composition in soil textural constituent as influenced by land use is a necessity towards a good soil conservative and management measure. In view of this, a laboratory experiment was conducted; soil samples were collected from different locations within and outside the Federal University of Technology, Akure and analyzed for basic chemical elements. The soil sampling was based on land use and six different soil samples were collected at a depth of 0-15cm. These samples included bare soil (BS), waterlogged soil (WS), maize cultivated soil (MS), cassava cultivated soil (CS), cassava-maize intercrop (CM), and mixed cropping of cassava, maize and cowpea (MC). The waterlogged soil was cultivated to rice while the bare soil was not cultivated. The soil samples were air-dried and crushed after which fractionation was carried out using a three-layer sieve to separate the soil particles into different size of 2mm to 0.5mm (Sand), 0.5mm-0.05mm (Silt) and <0.002mm (Clay). Each separate was considered as a treatment and analyzed for basic chemical elements. The textural analysis was carried out using the hydrometer method while soil pH was determined using a pH meter. Other parameters determined included organic carbon, Total Nitrogen, Available Phosphorus and Exchangeable cations. The finding revealed that the clay fraction contains the highest organic carbon as well as chemical elements while the sand separates had the lowest values. It was concluded that land use has an effect on the retention of nutrients in the soil as a whole. Land use system that causes heavy disturbance to the soil can lead to the reduction of clay and silt content of the soil which in turn can lead to loss of a large amount of soil organic carbon as well as chemical elements in the soil.

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Introduction

Soil is formed from the influence of climate, relief (elevation and slope of terrain), organisms, and parent materials interacting over time (Silver et al., 2008). It continually undergoes development by way of numerous physical, chemical and biological processes, which include weathering with associated erosion (Chesworth et al., 2008). Many factors are responsible for soil and land degradation or loss of fertility which include erosion, leaching, bush burning, continuous cropping etc. This loss of fertility however has been investigated by researched and plausible solutions have been suggested which include green manuring (Akingbola and Dayo-Olagbende, 2017, Ambayeba, 2019), using of poultry manure (Dayo-Olagbende et al., 2018, Natasha et al., 2018) as well as organic residues from plant like tithonia (Amodu et al., 2019; Dayo-Olagbende et al., 2019). Continuous use of inorganic fertilizer has also been found to leave a residual acidity in the soil causing degradation (Serpil 2012), hence a split application of inorganic fertilizer has been found to reduce the occurrence of acidity in the soil (Dayo-Olagbende, 2019) or in combination with amendments from organic sources (Dayo-Olagbende et al., 2019). Conventional tillage is another major issue that has been found to propel degradation of soil; however, a research by Akingbola et al., (2020) pointed out that tillage in combination with organic manuring can ameliorate degradation caused by conventional tillage. One major issue however that has not been fully considered in relation to soil fertility and productivity is the issue of land use. A soil is made up of the mineral component, organic matter, air and water. Organic matter content is usually much lower than 5% in tropical soils (Troeh and Louis, 2005).

The mineral components of soil are sand, silt and clay, and their relative proportions determine a soil's texture (Silver et al., 2008) which influences porosity, permeability, infiltration, shrink-swell rate, water-holding capacity, and susceptibility to erosion (Haynes et al., 1998), which consequently influences the presence of nutrients in soil. Land use causes a degree of disturbance to a soil, thereby altering the proportion of these separates, making them susceptible to nutrient loss and degradation. This research therefore sets out to investigate the relationship between soil carbon and nutrients present in individual separates of soil as affected by different land use.

Materials and Methods

Study Location

The experiment was conducted at the Crop, Soil and Pest Management Analytical and Research Laboratory, Oba-Nla, Federal University of Technology, Akure, Ondo State, Nigeria. The site is located in the tropical rain forest zone of Nigeria with a temperature ranging from 21.8 °C to 32.3 °C respectively. Annual rainfall varied from 1,900mm – 2,700mm, mean annual evaporation is 2.1mm. The relative humidity ranges between 85% during the rainy season and less than 60% during the dry season.

Soil Sampling

Six (6) soil samples were collected from different sites within the university premises. The soil samples were collected based on agronomic land use at a depth of 0–15cm. the different land use considered and their acronyms is presented in Table 1.

Fractionation was carried out using a three-layer sieve to separate the soil particles into different size, each fraction after sieving was considered a treatment and analyzed for basic chemical elements. Table 2 shows the different soil separates of different land use and their acronyms.

Laboratory Analysis

The soil samples were air-dried and crushed to pass through 2mm sieve utilizing those that are less than 2mm for laboratory analysis. The sieved samples were analyzed for pH in 1:2 soil to water ratio using the Electrode pH meter. Nitrogen (N) was determined using the Kjeldahl procedure while organic carbon was determined by Walkey-Black dichromate wet oxidation method (Nelson and Sommer, 1982). Determination of particle size distribution was done by hydrometer method (Gee and Bauder, 1986).

Statistical Analysis

Data collected were subjected to analysis of variance using SPSS 17.00 version and means were separated using Duncan multiple range test at >0.05 level of significance.

Results and Discussion

Textural Class Analysis

Table 3 presents the percentage sand, silt and clay as well as the textural class of composite soil samples collected from different sites on the basis of land use. The soil texture of all the soil fall within the sandy clay loam textural class; however, they vary in sand, silt and clay content. The percentage sand ranges from 62.98% to 68.62% with WS (waterlogged soil) having the lowest sand content while CM (cassava × maize) has the highest sand content. The silt content ranges from 11.22% to 16.10% with WS (waterlogged) having the highest silt content and BS (bare soil) having the lowest silt content. Clay contents vary from 18.87% to 22.10% with CM (cassava x maize) recording the lowest and BS (bare soil) recording the highest.

Figures 1 to 5 present the distribution of Organic Carbon, N, P, K and CEC of the different soil samples respectively. As shown in Figure 1, the organic carbon content for the whole soil samples ranges from 0.05% to 3.73% with WS (waterlogged) having the highest and BS (bare soil) having the lowest OC content. WS has the highest OC on the sand fraction while BS has the lowest. On both the silt and clay fraction, land use MC had the highest OC while BS had the lowest. Figure 2 showed that total Nitrogen ranges from 0.02 % to 0.35 % with WS (waterlogged) having the highest value and BS (bare soil) having the lowest value for the whole soil.

Table 1. Agronomic Land Use and their Acronyms

Acronyms	Meaning
BS	Bare soil
WS	Waterlogged soil (rice cultivated)
MS	Sole maize
CS	Sole cassava
CM	Cassava-maize intercrop
MC	Mixed cropping (cassava, maize and cowpea)

Table 2. Soil Separates of Agronomic Land Use and their Acronyms

Acronyms	Meaning
BS1	Sand Separate of Bare Soils
BS2	Silt Separate of Bare Soil
BS3	Clay Separate of Bare Soil
WS1	Sand Separate of Waterlogged Soil
WS2	Silt Separate of Waterlogged Soil
WS3	Clay Separate of Waterlogged Soil
MS1	Sand Separate of Sole Maize Soil
MS2	Silt Separate of Sole Maize Soil
MS3	Clay Separate of Sole Maize Soil
CS1	Sand Separate of Sole Cassava Soil
CS2	Silt Separate of Sole Cassava Soil
CS3	Clay Separate of Sole Cassava Soil
CM1	Sand Separate of Cassava Maize Intercrop
CM2	Silt Separate of Cassava Maize Intercrop
CM3	Clay Separate of Cassava Maize Intercrop
MC1	Sand Separate of Mixed Cropping (Cassava, Maize and Cowpea)
MC2	Silt Separate of Mixed Cropping (Cassava, Maize and Cowpea)
MC3	Clay Separate of Mixed Cropping (Cassava, Maize and Cowpea)

Table 3. Percentage Sand, Silt and Clay of soils of Study Areas

Treatment	Sand %	Clay %	Silt %	Texture
BS	66.94^{b}	21.84^{b}	11.22^{f}	SCL
WS	62.98^{f}	20.92^{d}	16.10^{a}	SCL
MS	65.55^{d}	21.43c	13.02^{d}	SCL
CS	65.70^{c}	20.28^{f}	14.02^{b}	SCL
CM	68.62^{a}	18.87^{e}	12.51^{e}	SCL
MC	64.75^{e}	22.10^{a}	13.51^{c}	SCL

SCL: Sandy clay loam

On the sand and silt fraction of the soil, BS had the highest Nitrogen content while WS, MS and CM recorded the lowest on sand and WS on silt fraction. On the clay fraction, WS recorded the highest while CM had the lowest nitrogen content. Figure 3 presents the available Phosphorus which ranged from 0.99 mg/kg to 12.30 mg/kg, MC (maize x cassava x cowpea) recorded lowest while WS (waterlogged) has the highest P content for the whole soil. On the sand fraction, MS had the highest phosphorus content but was lowest on CM and MC. On the silt and clay fractions, WS had the highest while BS had the lowest. Figure 4 showed that WS had the highest potassium content in the whole soil as well as individual fractions (sand, silt and clay) while BS recorded the lowest in the whole and in individual soil fractions. Figure 5 presents the CEC values of whole soil and individual fractions. WS had the highest CEC values for both whole soil and individual fractions while BS recorded the lowest values at all instances.

For all the chemical components, the clay fraction had the highest value followed by the silt and lastly the sand fraction.

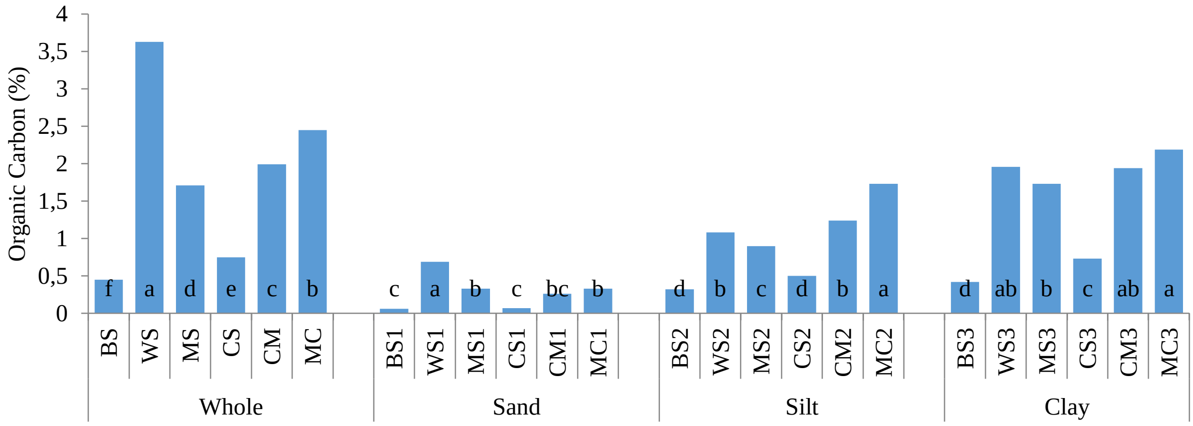

Figure 1. Organic Carbon Content of Each Soil Separates of Different Land Use

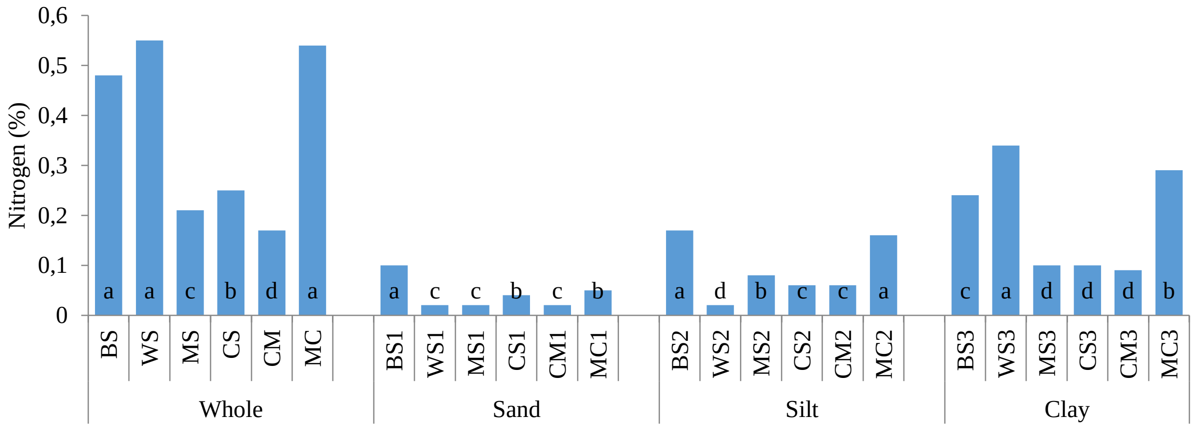

Figure 2. Nitrogen Content of Each Soil Separates of Different Land Use

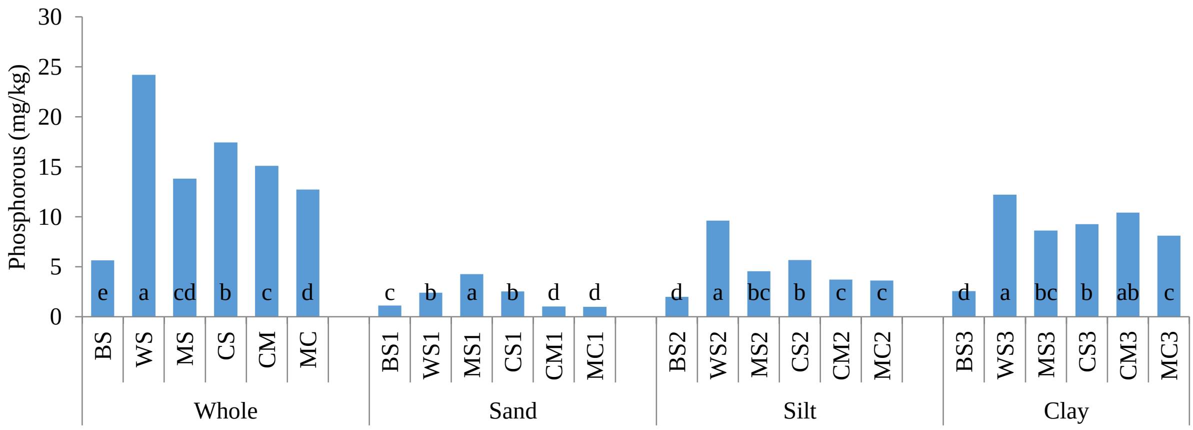

Figure 3. Phosphorus Content of Each Soil Separates of Different Land Use

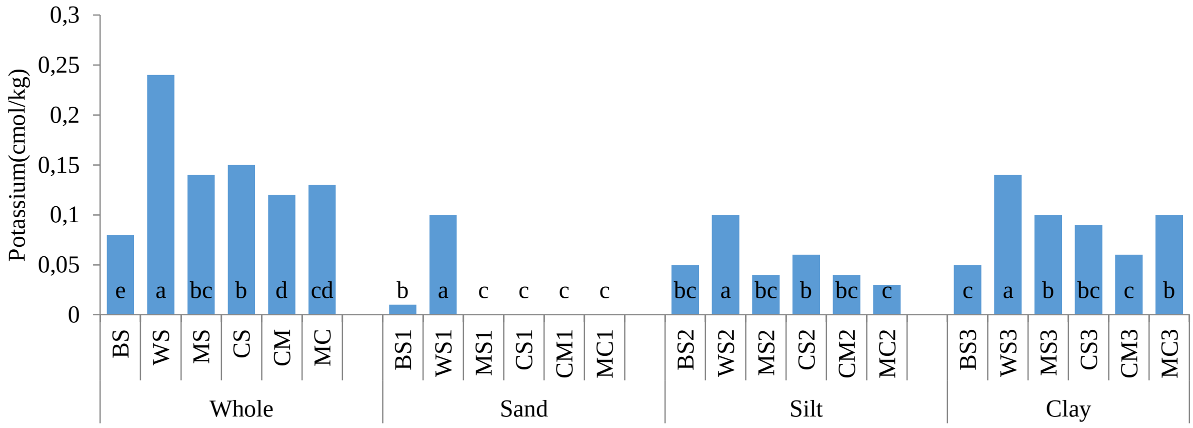

Figure 4. Potassium Content of Each Soil Separates of Different Land Use

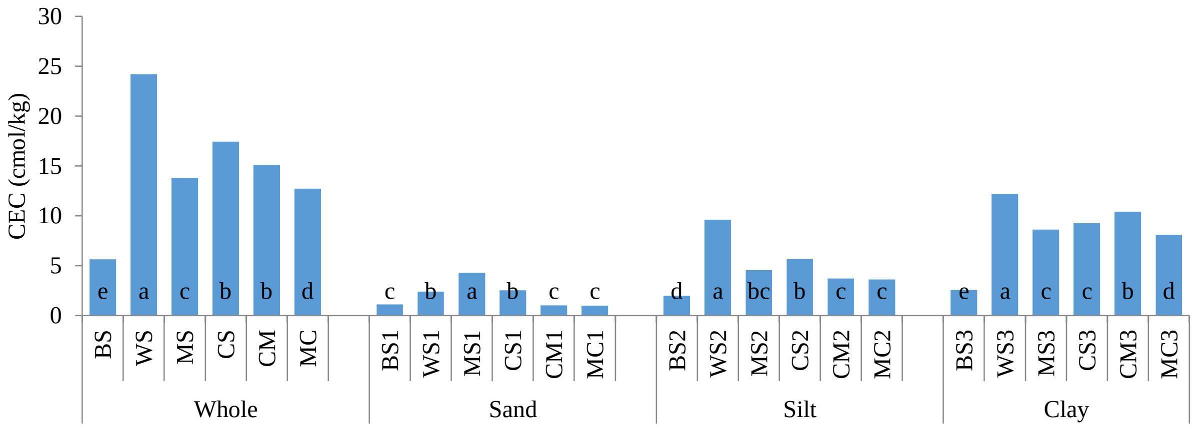

Figure 5. Cation Exchange Capacity of Each Soil Separates of Different Land Use

Percentage Sand, Silt and Clay Based on Agronomic Use

From table 3, it can be deduced that although all the soil samples fell within the same textural class, they all have different percentage of sand, silt and clay contents, this could be attributed to the different agronomic land use system the soil is subjected to. Waterlogged soil (WS) with the lowest amount of sand and highest silt content could be as a result of minimal disturbance to the soil as it could mostly likely be cultivated to only rice particularly in Nigeria. This corroborates the findings of Awdenegest et al., 2013 who stated that soil textural fractions (sand, silt and clay) varied with land use and soil depth. The most disturbed among the soil with little remediation is the cassava maize intercrop and it has the lowest values for clay and silt. Among the treatments, the waterlogged soil has the highest pH value of 7.20 (neutral) (table 2), this is due to the fact that Fe, Al in waterlogged soil displaces cations on the soil colloidal surface which is in line with the work of Hemati and Jalali, 2017. Also, WS recorded the highest OC due to the saturation of the vadose zone, decomposition activities was slowed down thereby OC didn't degrade quickly compared to when the soil is unsaturated, this agrees with the work of Kanwar, 2004 who stated that decomposition of *organic matter in the* absence of oxygen is *slow*, incomplete, and inefficient. The high content of OC could also account for the high value recorded for N, P, K and exchangeable cations (Jiang et al., 2008).

Organic matter distribution as well as nutrient content of the different soil separates followed the same trend (figure 1-5). The clay content held the highest OC and chemical elements and the sand particle gave the lowest. This could be attributed to the colloidal attribute of the clay particles which makes it attract easily with ions. Among the different soils sampled too, the waterlogged soil and the mixed cropping had the highest OC content on the clay particle as well as cation exchange capacity (CEC). This agrees with the statement of Nathan, 2017 that Soil texture affects CEC, the more clay, the higher the CEC. Nitrogen content was highest on both WS and MS on the clay particles while MC has the highest on silt. This could be because of the cowpea included in the mixture. All other nutrient elements followed the same trend as OC and N.

Conclusion and Recommendation

Conclusion

The result of this research shows that clay and silt are most important in terms of nutrient holding capacity. Clay particles hold the highest amount of N, P, OC as well as exchangeable cations followed by silt. Although the sand particles have some amount of these elements in them, it still recorded the lowest. The study also revealed that land use systems that does not cause much disturbance to the soil tend to have higher clay and silt content as seen in MC and WS while those that exert a great degree of disturbance to the soil has lower clay content as seen in SC. This is because during the planting of cassava from cultivation to harvest, the soil is constantly undergoing disturbance that is tillage practices are required during planting, as the tuber grows in the soil, the soil is disturbed and during harvesting, the uprooting of the tuber also disturb the soil. These processes make the clay and silt content be easily eroded by moving water. Soils with mixed cropping systems particularly with a legume crop tend to have higher silt and clay as seen in MC; this is because the soil has high degree of surface covering which in turn will reduce the impact of rain droplet as well as erosion. Also, the legumes can later die, decay and form part of the organic matter.

Recommendation

This study recommends that agronomic land use practices that can lead to loss of clay and silt separate of the soil should be reduced. Minimal disturbance should be done to the soil as much as possible. This is to keep the most active parts of the soil alive. Furthermore soil should be kept covered as much as possible to avoid clay and silt loss either through cover cropping, mixed cropping with legumes or mulching.

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