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Investigating the Physical and Chemical Characteristics of Latosols Soil and its Influence on Plant Growth in Suakoko, Bong County

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Abstract

In recent times, the evaluation of the fertility status in the Liberian soils has mostly focused on determining soil to plant nutrients characteristics and leaving the Chemical and Physical properties unknown to farmers in the Country. Soil chemical and physical characteristics are important in agriculture crop production, as it gives detailed information on the type of soil to farm on for optimum yield and income generation for farmers. Many farmers in Liberia do not know the require soil property when growing their crops; as a result, there are low yield in many famer's field in the region.

The Soils of Liberia are marked by intense surface leaching, strong acidity, low soil organic matter (SOM) content, and low nutrients status, which are limiting factors to crop production in the Suakoko belt where the tested Soils were collected. These factors have adverse effects on crop production, thus increasing food insecurity in the region. The objective of this current study was to investigate the Physical and Chemical Characteristics of Latosol/Utisols and its influence on plant growth in Suakoko, Bong County, and Central Liberia.

Composite surface (0-25 cm depth) samples of four Latosols at different locations in Suakoko District label as (N001, Harris Farm; N002, CARI (Cacao seed garden); N003, CARI (Rice Field); N004, CARI (Root and Tuber crops Gene Bank)) were collected and analyzed for Physical and Chemical parameters and factors by standard laboratory procedures. The results from these current studies shows that**,** the studied soils are sandy clayey; very acidic with poor (SOC).

Keywords: Soil Characteristics, Suakoko, Latosols, Liberia

Introduction

The soil, which is a crucial component of crop development in agriculture, serves as a storage area for nutrients and air necessary for plant growth in addition to water. This condition is known as "Soil Fertility" and is necessary for the best plant growth and yield. The available nutrient elements and water must be available in their appropriate amounts and optimal conditions. It is necessary to identify a soil's physical, chemical, and biological features in order to assess its fertility condition. This information describes the soil's original fertility state and suggests corrective actions that might be taken in the future to raise or preserve that status.

It is also crucial to comprehend how water and nutrients are moved through the soil, changed there, and then taken up by plant roots. This is crucial, especially in locations where the predominant soil texture is coarse sand, which has a low capacity to hold water and nutrients (Saka and Chilimba, 2001) [1]. The following physical and chemical properties of soils must be known and understood in order to evaluate the transport process in soils: (i) bulk density; (ii) soil moisture content; (iii) texture; (iv) \electrical conductivity; and (v) soil pH.

But in Liberia, there hasn't been any use of the criteria for assessing soil fertility and land suitability based on soil characteristics.

Additionally, no research has been done to attempt to characterize the physical and chemical properties of the soil in the area, including its bulk density, bulk moisture content, texture, macro- and micronutrients, electrical conductivity, and pH. Researchers' focus has been clearly called to the significance of soil-water-plant relationships as a result of the global experience of climate change, particularly given the precarious smallholder farming conditions in Liberia. Data on soil properties are essentially nonexistent; for instance, the soils of Liberia do not have any known physical, biological, or chemical features. In order to inform farmers, NGOs, and the government of Liberia, it is necessary to characterize the soil attributes in this area that are not available for Liberia's agricultural soils. This study will provide data on the physical and chemical properties of soils in Liberia that can be used for (i) assessing the soil fertility status of various soil types (ii), determining the relationship between soil, water, and plants (iii), determining the soil pH (iv), determining soil texture, and (V), determining macro- and micronutrients, electrical conductivity, and determining the bulk density and color of the soil.

Porosity

The soil's ability to allow unhindered flow of gases, including air, water, and gases; this attribute also serves as a structural element of the soil. As a result, identifying its classification is essential for evaluating the results of adding organic matter to a soil system. Reduced porosity results from the loss of larger pores and the expansion of small holes (Güneyisi *et al*. 2008) [8].

The soil's pore size distribution is based on how much of the pore space is not occupied by solid material (Güneyisi *et al*. 2008) [8]. Pores are significant because they regulate fundamental elements of almost everything that occurs in the soil, such as the flow of water, air, and other fluids, as well as the transport and movement of minerals. By convention, fluid pockets that are completely enclosed within solid material are not included in the concept of pore space (Almendro-Candel *et al*., 2018). As a result, the porous space is seen as a single, continuous space within the soil body. According to Nimmo, J. R., *et al*. (2004) [9], it generally has fluid channels that are convoluted, occasionally restricted, and frequently strongly linked.

In soils with porosity, there is an obvious and essential link between the movement and storage of water. On the other hand, the form, size, and distribution of the pores—and frequently even more so than the overall number—define the soil's ability to move water (Nimmo, J. R., *et al*., 2004) [9]. From an agronomic perspective, the size distribution controls how much water the soil can contain as well as how much energy is maintained and how much of it moves toward the plant, the atmosphere, and other soil zones (Mara Belén *et al*. 2018).

Bulk Density

Dry bulk density (BD), one of the most noticeable markers of soil structure, may be determined by sampling undisturbed soil and doesn't call for specialized knowledge or expensive equipment. The dry mass of solids divided by the volume of the soil yields the bulk density (BD). To determine soil porosity, the values of bulk and particle densities are required. Once the particle density value is known or approximated, porosity can then be calculated from BD.

Water Holding Capacity

The capacity of a soil to hold water is its capacity to do so. Thus, the ability to provide plants with water year-round is a key benefit of this storage. The ability of a soil to hold water is influenced by environmental factors including rain, temperature, and isolation as well as soil qualities like organic content, texture, and structure. The ability of the soil to hold onto water is crucial to the growth of crops in rainfed agriculture in arid and semiarid areas. The two main processes that impact how much water is stored in the soil are infiltration and evaporation. The infiltration and evaporation rates of water in the soil are significantly influenced by surface conditions. The best results come through tillage.

Another characteristic of soil that affects the balance of water is its surface roughness, which improves the capacity of soil depressions to store water. In agricultural soils, tillage, vegetation, soil type, and rainfall intensity all affect how rough the surface is.

Waste can be used as a surface cover to prevent water from evaporating from bare soil, increasing the amount of water that is potentially available to plants.

This decrease is brought on by the soil's protection from the sun's rays, the air's temperature, and the increased barrier to water vapor passage caused by a decrease in wind speed.

Determining the impact on water movement in the soil profile is also necessary, though. It is crucial to the effective operation of agricultural soils in the arable layer.

Because of this, knowing the hydraulic conductivity of a system is crucial information for predicting how water will behave in relation to infiltration and soil storage and loss.

Soil Composition

According to Maria Belén *et al*. (2018), one of the most significant physical aspects of soil that controls or modulates the flow and retention of water, solutes, gases, and biota in agricultural and natural ecosystems is soil structure. Crop output is constrained by soil structure, which is crucial for soil productivity (Mara Belén *et al*., 2018). Numerous processes in soils are governed by soil structure. According to Maria Belén *et al*. (2018), it controls root penetration, erosion susceptibility, gaseous exchanges, soil organic matter (SOM), nutrient dynamics, and water retention and infiltration. Due to its significant impact on edaphic conditions and the environment, soil structure stands out among the other physical characteristics of soil. A granular medium's "structure" is the spatial configuration of its solid particles (texture) and empty areas. The majority of soils typically have a hierarchical structure. In other words, primary mineral particles cluster together to create "first order aggregates," frequently in conjunction with organic molecules. These group together to create larger clusters, or "second-order aggregates" (Mara Belén *et al*., 2018).

Increasing aggregate size with each subsequent level is a reflection of the aggregate hierarchy in soils. However, in addition to the geometrical arrangement of particles, the term "structure" in soil science typically refers to bonding mechanisms (Mara Belén *et al*., 2018). By acting as cement, organic matter can aid in the development of aggregates and, in turn, the structure of the soil.

Objectives of the Study

The objectives of this study are therefore, to determine soil physical (particle size analysis, bulk density, moisture content), and chemical (soil pH and electrical conductivity) characteristics that are important in characterizing nutrient leaching and uptake of the roots in the study soil.

Materials and Methods

Study Sites Description and Fieldwork

The study was carried out in Liberia's Suakoko District in Bong County. According to Report *et al*. (2019), Suakoko is situated at 7.03 north latitude and 9.55 west longitude, 187.5 kilometers from Monrovia and 16 kilometers from Gbarnga. Latosols (Utisols), which are heavily weathered soils with evergreen flora, including mangrove swamps, are present on the relatively level terrain. According to the country and city elevation maps for the places, the area experiences average temperatures and rainfall ranges of 650F to 850F and 70in to 80in, respectively. There are roughly 25,000 people living in Suakoko, and 35% of them produce rice and tuber crops for subsistence (Report *et al*., 2019).

Sample Collections

Each area in Suakoko had fifteen (15) disturbed topsoil samples taken, which were then combined to create a composite sample. The researched locations generally have tropical climates, and Table 1's summary of the specifics provides more information. Gneiss is the parent substance of the soils under study. The soil samples for the study were taken from the topsoil (0–25 cm depth) and were classed as Latosol by the USDA's soil taxonomy.

The examined parameters, including (i) soil bulk density (Pb. g/cm3), (ii) soil moisture content, (iii), soil texture, (iv), soil pH, and (v) electrical conductivity, were determined using the obtained soil samples. Utilizing the core procedures described by Blake and Hertege (1986), soil bulk density was calculated.

Laboratory Procedures

The soil that was gathered from these places was dried in an oven at 150°C in the laboratory of the College of Agriculture and Sustainable Development (CASD), and then it was ground into a mortar and pestle and sieved to remove unwanted material like roots and other plant parts. Particle size analysis (also known as soil texture), soil pH, soil moisture content, bulk density, electrical conductivity, both macro- and micronutrients, and soil color were all examined. The amount of silt, clay, and sand in the study soil was determined using the sieve method.

A pH meter was used to measure the soil pH (1:1 soil to water ratio), a dissolved oxygen meter to measure electrical conductivity, and a moisture meter to measure moisture content. The soil mussel color charts were also used to determine the soil's hue.

Table 1: Characteristics of the studied sites in Suakoko

Sample	Sites	Location	Soil Type	Land Use	Temperature	Rainfall(mm)/year	Parent Material
N001	Harris Farm	Suakoko	Latosols	Cassava	30.2°C	1992.0 mm	Gneiss
N002	CARI	Suakoko	Latosols	Cacao	31.9°C	1992.0 mm	Gneiss
N003	CARI	Suakoko	Latosols	Rice	31.9°C	1992.0 mm	Gneiss
N004	CARI	Suakoko	Latosols	Cassava	31.9°C	1992.0 mm	Gneiss

Data Analysis

Data analysis was performed using SPSS17.0 and origin 9 Pro.

Results and Discussion

The goal of the study was to look at the physical and chemical characteristics of soil and the state of the soil as it relates to crop development, with a focus on the production of cereal, root crops, tree crops, and vegetables. Make suggestions for improving the soil to increase agricultural productivity over the long and short durations. Four (4) farming locations were picked during the sample collection in each region where the sample was being taken for soil physical and chemical investigation. Please see below the results of our investigation's physical and wet chemical analyses as well as a recommendation in favor of the suggested farming of the chosen farmland.

Soil Physical Analytical Data

Soil pH and EC

With a soil and water suspension ratio of 1:5, the pH of the soil was measured using a pH meter (H1 9017 Microprocessor). 50 cc of distilled water was added to plastic beakers after 20 grams of soil had been weighed in. After continual stirring, the suspension was allowed to stand for 30 minutes. The pH and EC meters were calibrated using buffer solutions with pH values of 4.0 and 7.0, and then the soil's pH and EC were read by dipping the electrodes into the upper portion of the suspension and recording the reading on a digital display.

Soil Organic Carbon Determination

The Walkley and Black modified technique, as reported by Nelson and Sommers (1982) [6], was used to analyze the soil organic carbon. One gram of air-dried dirt was put into an Erlenmeyer flask. Also included were blank samples to serve as a reference. The samples and blank flasks received ten milliliters of 1 N (0.1667 M) potassium dichromate. Two milliliters of concentrated sulfuric acid were carefully poured to the soil using a measuring cylinder, stirred, and left to stand for 30 minutes in a fume cupboard. Then, 250 milliliters of distilled water and 10 milliliters of concentrated ortho-phosphoric acid were added. The reaction mixture was then titrated with 1.0 M ferrous sulphate solution after the addition of 1 ml of diphenylamine indicator.

Exchangeable Cations

Leaching 5g of soil with 100 ml of buffered 1.0 N ammonium acetate solution at pH 7 allowed researchers to determine the exchangeable cations in the soil. The soil's exchangeable sodium, potassium, calcium, and magnesium were then identified using the method outlined by Black (1986) [2].

Calcium and Magnesium Determination

By transferring a 25 ml aliquot of the extract into an algon yer flask, 2% potassium cyanide, 2% potassium ferrocyanide, hydroxylamine hydrochloride, 10 ml ethanolamine buffer, and 0.2 ml Eriochrome Black T solution were added, followed by the analysis of Ca and Mg. To titrate the solution to a pure turquoise color, 0.01 M EDTA (Ethylene Diamine Tetraacetic Acid) was utilized.

Soil Particle Size Distribution

To determine soil texture, Boyoucos' (1962) hydrometer method was applied. To perform this, 50 g of air-dried soil were weighed into a measuring cylinder, and then 50 ml of sodium hexamethaphosphate were added. The remedy was shaken and given time to suspend. At 40 seconds and 5 hours, corrected hydrometer readings were recorded.

Table 2: Representation of parameter discussed above

Sample Label	pH(1:1-Soil:Water)	EC (µS/cm)	Sand (%)	Silt (%)	Clay (%)	Texture	BD(g/cm^3)
N001	5.6	37	71.36	18	10.64	Sandy Loam	1.45g/ **cm^3**
N002	5.2	46	71.36	18	10.64	Sandy Loam	1.2g/ **cm^3**
N003	5.9	47	77.36	12	10.64	Sandy Loam	1.06g/ **cm^3**
N004	5.8	33	79.36	10	10.64	Loamy sand	0.9g/ **cm^3**

Interpretation of Soil Physical Properties

Result from the soil physical properties is seen in table1. The soil bulk density of the study sites is 0.9g/ cm^3 to 1.45g/cm^3. The critical value of bulk density for restricting root growth varies with soil type (Hunt and Gilkes, 1992) [4] but in general bulk densities greater than 1.6 g/cm^3 tend to restrict root growth (McKenzie *et al.*, 2004) [5]. In addition, Sandy soils usually have higher bulk densities (1.3–1.7 g/cm^3) than fine silts and clays (1.1–1.6 g/cm^3) because they have larger, but fewer, pore spaces. In clay soils with good soil structure, there is a greater amount of pore space because the particles are very small, and many small pore spaces fit between them. Soils rich in organic matter (e.g., peaty soils) can have densities of less than 0.5 g/cm^3. This range is ideal for drainage and aeration at the site. Even smooth penetration is possible for plants root to access soil available nutrients. The dark brown soil color ranged from 0-30 cm depth in most of the soil profile and from soil sample collected at 0-15 cm. The dark color reveals the presence of humus. Humus contains the elements necessary for plant growth: nitrogen, phosphorus, potassium sulphur, calcium and magnesium. Depending on the original plant and animal materials of the soil, the chemical composition of humus varies. Soils at 0-30 cm depth in most study areas reveal dark brown and brownish black.

Table 3: Soil Macro Nutrients

Sample Label	N (%)	P(mg/kg)	K(cmol/kg)	C (%)	Ca (cmol/kg)	Mg (cmol/kg)	Na (ppm)
N001	0.3	40.12	0.21	11.4	2.78	3.87	0.1
N002	0.3	20.21	0.55	9.2	4.59	3.69	0.2
N003	0.5	31.91	0.53	4.7	2.64	3.54	0.3
N004	0.5	42.85	0.57	6.0	3.66	4.68	0.1

Table 4: Ratings for Cation Exchange Capacity and Exchangeable Cations

Rating	CEC (cmol/kg)	Base Saturation %	Exchangeable Ca	Mg cmol/kg	K	Na
Very high	> 40	80-100	>20	> 7	>1.2	> 2
High	5-40	60-80	10-20	3 - 7	0.6 - 1.2	0.7 - 2
Medium	15-25	30-60	2-10	1 - 3	0. 3 - 0.6	0.3 - 0.7
Low	10-15	20-30	1-2	0.5 - 1	0.1 - 0.3	0.1 - 0.3
Very low	<10	< 20	< 1	< 0.5	< 0.1	< 0.1

Interpretation of Macronutrients Results

The results show the present of various macronutrients in the soil at various sites where sample were collected as soil carbon, nitrogen phosphorus, potassium, calcium, magnesium and sodium. Percent nitrogen levels were at medium and satisfactory at all study sites (N001, N002, N003 and N004) respectively. A range below medium point was not observed. Furthermore, the soil organic carbon was also satisfactory at the range of all the study sites. This result actually shows the underutilization and less pressure on soils in said areas or probably the constant use of soil organic matter. However, phosphorus levels significant at all site observed and high at site N004 (42.85mg/kg) followed by N001 (40.12mg/kg) and N003 (31.91mg/kg) respectively. The exchangeable cations were Ca, Mg, Na and K. The soil at all sample sites indicates a considerable cations exchange capacity. This is manifested because of the presence of continuous use of organic materials and virgin soil at various sites; however, said soils could be would need just suitable land use management such as land preparation and crop, site specific. Said crop management system would provide crops optimum utilization of soil available nutrients and improve crop performance. The soils from the Na and EC readings indicate that the soils are not saline.

Table 5: Soil Micro Nutrients

Sample Label	Li (ppm)	Cu (ppm)	Mn (ppm)	Zn (ppm)	Fe (ppm)	B (ppm)
N001	0.02	1.8	0.18	1.6	0.25	1.6
N002	0.02	2.1	0.23	1.2	0.32	2.8
N003	0.01	2.4	0.25	1.3	0.25	1.6
N004	0.02	1.5	0.13	1.4	0.25	2.6

Interpretation of Soil Micronutrients

From the table Boron and Zinc showed an accepted concentration in all areas tested with SS2, SS5 and SS9 showing the minimum for zinc concentration. A zinc soil test at and above 1.5 ppm using is sufficient for most crops. Corn, beans, onions, and deciduous fruit trees are especially sensitive to low levels of soil test Zn.

Results also indicates that Fe and Cupper concentration in soils at all survey location are ideal for crops performance as most plants produce well at a 0.6 ppm and above Cu level in soil.

Adequate soil test Mn varies with crop. Soil test values between 1 and 5 ppm are usually sufficient. Manganese deficiencies generally occur only when soil pH is 8.0 or above. From the above table, the results show that Mn is very low at all sampling sites.

The Concentration of Lithium was also measured to determine the level of sorption to soil. All areas studies, soil concentrations of Li were shown to range from 0.01 ppm to 0.03 ppm, and to be positively correlated with clay content in various soils. Under such condition, Li is less of contaminant to plant soil system. Compared to other cations in soil, Li is mobile and may leach into receiving waters, be taken up by plants, or have other biological impacts which all sites examined are exceptional to.

Implication of the Results

Farmers making farms in the studied sites continue to face the problem of low crop yield due to land degradation and the current climate change, a situation that is exacerbated by lack of nutrients and other factors for crop production in the study sites. Agricultural productivity is caused by so many factors, including the use of poor crop husbandry and agronomic practices, poor soil and management practices, and poor soil fertility conditions. Under smallholder farming conditions, the main constraint is poor soil fertility. The first step is to characterize the soil physical and chemical characteristics of all major agricultural soils so as to determine the inherent fertility status of the soils and to propose remedial measures for their proper management.

The results from this study have important implications on the leaching of soluble nutrient elements in the soil in Suakoko. However, studies conducted on many highly weathered tropical soils have clearly demonstrated the presence of variable surface charge clay minerals on most tropical soils as reported by (balasubramanian *et al*, 1973).

Conclusion

The present studies investigated the physical and chemical characteristics of some Liberian Latosols. Thus, all four studied Latosols were acidic, with low SOC.

However, there is a need to make a systematic characterization of soil physical and chemical characteristics that are important for describing nutrient leaching in agricultural soil at the studied sites in Suakoko. From the results obtained from this study, it can be concluded that, soils at the studied site can be characterize as not having much disturbing characteristics other than the study parameters. Therefore, concerted efforts are required to improve soil fertility status in an integrated and holistic manner through the judicious use of both organic and inorganic fertilizers. Therefore, further studies are requires to be conducted to focus attention on Characterizing the Biological properties that are equally important in describing transport phenomena in agricultural soils. Although there is an urgent need to fully characterize all major arable soil in Suakoko and Liberia, initial attention should be pay to the coarse-textured sandy soils that are dominant on the studied sites.

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