



(RESEARCH ARTICLE)



A Qualitative Analysis on Physicochemical Parameters found in Swamp Soils, Mokonde Village, Kori Chiefdom, Moyamba District

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Abstract

The study of swamp soils is critical for understanding the complex interactions between soil properties and the unique ecosystems they support. This work presents a comprehensive qualitative analysis of the physicochemical parameters of swamp soils, focusing on their composition, structure, and environmental implications. The research was conducted in selected swamp regions, where soil samples were collected and analyzed for key physicochemical parameters, including pH, electrical conductivity, organic matter content, texture, and nutrient availability. This research explores the qualitative analysis of some of the physicochemical parameters of selected swamp soils found in Mokonde, Village, Kori Chiefdom, Moyamba District, Southern Sierra Leone. By employing standard analytical methods, the research will provide insights into the soil's fertility and ecological health, contributing to sustainable land management practices. The findings are expected to inform local agricultural practices and environmental conservation efforts, highlighting the significance of swamp ecosystems in the region's biodiversity and agricultural productivity. The findings reveal that swamp soils exhibit distinctive physicochemical characteristics compared to upland soils, with high organic matter content and unique mineral compositions. The acidic nature and high moisture retention capacity of these soils influence nutrient cycling and availability, which are critical for supporting the diverse flora and fauna typical of swamp ecosystems. Variations in these parameters were also observed across different swamp types and depths, highlighting the influence of hydrological and biological factors. This study provides valuable insights into the management and conservation of swamp ecosystems. By understanding the physicochemical properties of swamp soils, land managers and policymakers can make informed decisions to preserve these ecologically important areas. The research underscores the need for an on-going monitoring and tailored conservation strategies to mitigate the impacts of environmental changes and human activities on swamp environments.

Keywords: Physicochemical Parameters; Soil Sample; Acidic; Qualitative Analysis; Mokonde

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Graphical Abstract



A and B represent Fishpond, C and D represent Back of Winters; E and F represent NATC

1. Introduction

Swamp soils, often referred to as hydric soils, are unique environments characterized by their saturated conditions, which significantly influence their physical and chemical properties. These soils are crucial for maintaining wetland ecosystems, which provide essential services such as water filtration, flood regulation, and habitats for diverse flora and fauna. Understanding the physicochemical parameters of swamp soils is vital for wetland management, conservation, and restoration efforts. Soil is a critical component of the terrestrial ecosystem, supporting plant growth and influencing water and nutrient cycles. Soil is the unconsolidated mineral on the surface of the earth that serves as a natural medium for plant growth (Imran et al., 2010). It is the main reservoir of plant nutrients and water. The physical and chemical (physicochemical) properties of the soil vary drastically in time and space, depending on the texture, climate, organic matter content, soil biological activity and tillage practices (Alletto et al., 2010). Tillage is one of the main causes of spatial and temporal variability in soil physical properties, but its effects have not always been consistent depending on the location and soil type (Green et al., 2003). Soil plays an important role in the formation and heterogeneity of habitats that may result into changes in vegetation structure and plant diversity (Rodrigues et al., 2018). Therefore, the structure and diversity of vegetation are determined by the discontinuous distribution of biotic and abiotic factors in the habitat. Spatial variation in soil physicochemical properties occurs as the result of soil forming factors, including time, nature of parent material, topography, climate and organisms (Saglam et al., 2011).

Soil physicochemical properties have effects on plant growth and consequently plant morphology. Evaluation of soil spatial variation is important in agricultural and environmental researches, since the information on soil properties has agronomic applications (Sauer et al., 2006). Soil, as the main reservoir of plant nutrients and water is one of the key environmental factors that may affect plant morphological characters. Morphological variation among plant populations may be caused by either genetic factors or environmental factors (Crispo, 2008). Among the environmental factors, soil properties are the key factor that may influence plant morphological characters, hence morphological variation among populations or sites. There are several soil physical and chemical properties which play various roles in the soil, hence influencing the morphological characters of various plant species. For example, soil pH determines the acidity or alkalinity of the soil, which affects the chemical reactions between water and soil minerals (Imran et al., 2010).

There is a strong relationship between soil pH and nutrient availability because the uptake of various plant nutrients is pH dependent (Marschner, 1986). Moreover, most of the primary nutrients, such as nitrogen, phosphorus and potassium, as well as secondary nutrients, such as calcium, magnesium and sulphur are best utilized by plants at pH ranging from 5.5 to 7.9 (Imran et al., 2010). Likewise, several other soil physio-chemical properties of the soil play roles in the soil that may influence plant morphological characters at different levels. Understanding soil properties is essential for sustainable agriculture, as it directly impacts crop productivity, environmental health, and resource management. Swamps are very vital when it comes to the production of rice and other crops. swamps have been endowed with specific structural and functional attributes performing major ecological role in the biosphere (Mahajan et al., 1991). Swamps quality in wetland is of vital concern for mankind since it is directly linked with human welfare (Sultan et al., 2017).

Soil characteristics are studied on the basis of two properties: physical and chemical, and the nature of soil are determined according to the proportion and organization of these particles (Chinevu et al., 2013). Soil consists of four basic components: minerals, air, water and organic matter. In most soils, minerals represent around 45% of the total volume, water and air about 25% each, and from 2% to 5% organic matter (Retallack, 2008). Physical properties of soil include color, texture, structure, density, porosity, consistency, temperature, air and resistivity. Colors of soil vary widely and indicate properties as organic matter, water and redox conditions. Soil texture, structure, porosity, density and consistence are related with types of soil particles and their arrangement. There are two types of soil particles-primary and secondary. Sand, silt and clay are the primary particles which are categorized on the basis of their diameter. Their relative proportion in soil is called soil texture (Osman, 2012). Soil density, particularly bulk density, is a measure of soil compaction. Soil porosity consists of the part of the soil volume occupied by air and water. Soil consistency is the ability of soil to stick together. Soil temperature is self-defining. Resistivity refers to the resistance to conduction of electric currents and affects the rate of corrosion of metal and concrete structures (Santos et al., 2011).

The chemistry of soil determines the availability of nutrients, the health of microbial populations, and its physical properties. Soil chemistry also determines its corrosivity, stability and ability to absorb pollutants and to filter water. The surface chemistry of clay and humus colloids determines the chemical properties of soil. The high surface area of colloids gives soils its great ability to hold and release cations in what is referred to as cation exchange. Most soils contain organic colloidal particles as well as inorganic colloidal particles of clays (Li et al., 2021). There are about 72 mineral elements present in the soil which are referred to as plant nutrients and are classified as major and minor. They are very important for plant growth and development. The major elements include carbon, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, manganese, iron, zinc, copper, boron and molybdenum (Donahue et al., 1977). Carbon is one of the main elements in soil which have many origins and sources of occurrence. Each source may have its own specialty and capability in giving the soil better properties (Munghate et al., 2020). Soil inorganic carbon is a mineralized form of carbon, such as calcium carbonate, or caliche. It is more stable than most organic carbon because it does not provide food or fuel for microorganisms (Quilchano et al., 2008). Inorganic carbon, while it does not possess the water holding and soil enhancing properties of organic carbon, is nevertheless a significant store for atmospheric carbon (Liu et al., 2010). Soil nitrogen (N), phosphorus (P), and potassium are important sources of micronutrients for plant growth and productivity and they play an important role in terrestrial functions by influencing soil properties, plant growth and soil activities (Hati et al., 2008).

Physicochemical characteristics of soil vary in space and time due to variations in topography, climate, physical and chemical weathering processes, vegetation cover, microbial activities and several other biotic and abiotic variables. Vegetation plays an important role in soil formation (Chapman and Reiss, 1992) through decomposition of plant tissues for the main source of soil organic matter, which controls the physical and chemical properties of soil such as Ph, water holding capacity, texture and nutrient availability (Adams et al., 1986). Knowledge of physical properties of soil is important for determining soils suitability for agricultural, environmental and engineering uses. The supporting capability; movement, retention and availability of water and nutrients to plants; ease in penetration of roots, and flow of the heat and air are directly associated with physical properties of the soil. Physical properties also influence the chemical and biological properties of soil (Phogat et al., 2015). This research aims to analyse soil properties and composition to promote sustainable agricultural practices. The study will focus on the physical and chemical aspects of soil in various regions, correlating these properties with crop productivity and environmental impact. The goal is to provide actionable insights for farmers to optimize soil health and enhance crop yields while maintaining ecological balance. Heavy metals occur naturally in soil usually at low concentration because of weathering and other pathogenic processes acting on rock fragments from which the soil developed. Soil is a primary recipient of solid wastes (Nyles and Ray, 1999).

The study of soil physicochemical parameters is important to agricultural chemists for plants growth and soil management. Soil acts as a thin layer of earth's crust which serves as a natural medium for the growth of plants and it

is the unconsolidated mineral matter influenced by genetic and environmental factors (Manimegalai and Sukanya, 2014). It is a natural body consisting of layers (soil horizons) of mineral constituents of variable thicknesses, which differ from the parent materials in their morphological, physical, chemical and biological properties (Sumithra et al., 2013; Manimegalai and Sukanya, 2014). Soil is one of the most significant ecological factors, on which plants depend for their nutrients, water and mineral supply (Shaikh and Bhosle, 2013). Soil testing is the only way to determine the available nutrient status in soil and the only way we can develop specific fertilizer recommendations. Results of physical and chemical tests provide information about the capacity of soil to supply mineral nutrients (Ganorkar and Chinchmalatpure, 2013). Soil characterization in relation to evaluation of fertility status of the soils of an area or region is an important aspect in context of sustainable agricultural production. Nitrogen, phosphorus, potassium and sulphur are important soil elements that control its fertility and yields of crops (Singh and Mishra, 2012). Wetlands can be distinguished from uplands and other ecosystems by examining certain characteristics that relate to features such as water, soils, and biota, and to function such as hydrology, biogeochemical cycling, habitat and food webs. These characteristics and features are displayed in the layers (horizons) of the soil profile, and it develop because of the interaction between the five soil forming factors are the nature of the parent material, climate, organisms, topography, and time. Swamps or Wetland soils are formed as the result of periodic to continuous inundation and soil saturation leads to anaerobic soil conditions and reduced decomposition, which results in the build-up of organic matter. As organic matter content in soil increases, bulk density decreases due to reduced particle density of the organic material compared to mineral soil (Craft, 2000).

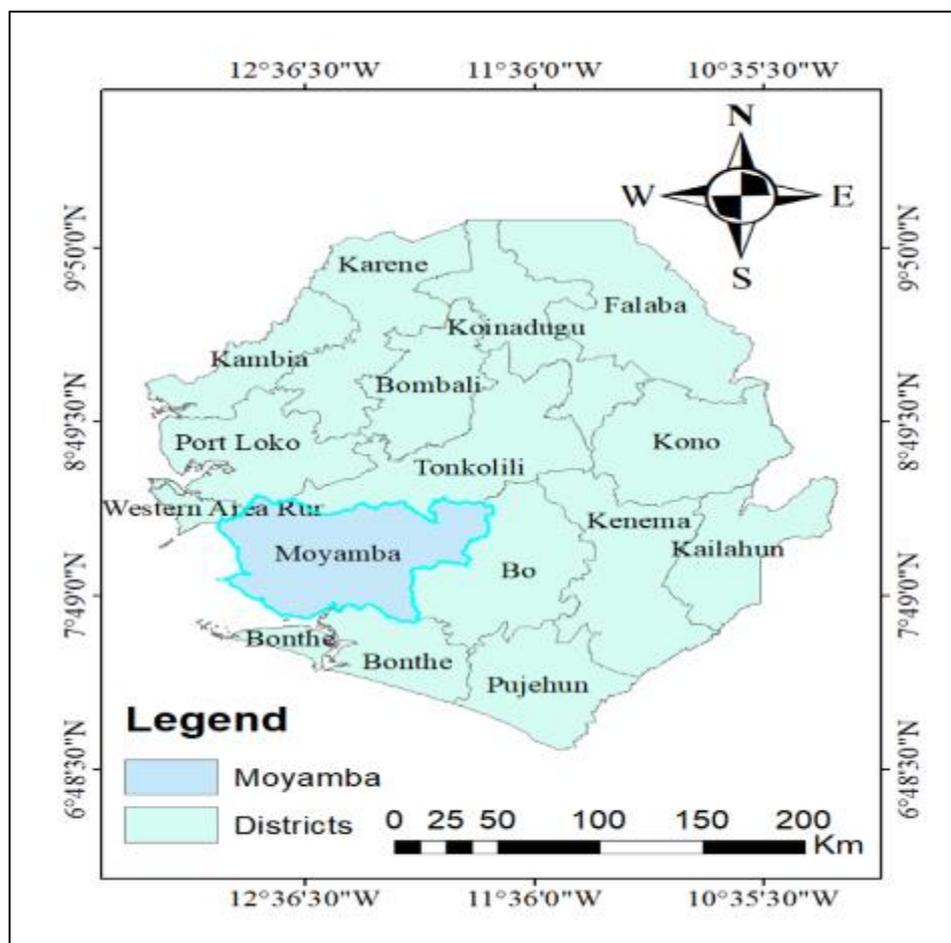
Despite the ecological significance of swamp soils, there is a limited qualitative understanding of their physio-chemical characteristics. The complexity and variability of swamp environments pose challenges for comprehensive soil analysis. This research focuses on a qualitative analysis of the physicochemical properties of swamp soils in Kori Chiefdom, Moyamba district, Southern Sierra Leone. Physicochemical parameters were investigated. Understanding these properties is crucial for assessing soil health and its capacity to support local ecosystems and agricultural practices. The findings will contribute to broader environmental management strategies and sustainable land use in the chiefdom, addressing potential impacts of anthropogenic activities on soil quality.

2. Materials and Methods

2.1. Study Area

Mokonde Village is in the Kori Chiefdom of Moyamba District in Sierra Leone, West Africa. The village is characterized by extensive swampy areas that are vital for local agriculture, particularly rice cultivation. The climate is tropical, with distinct wet and dry seasons. The soils in the area are primarily alluvial, influenced by seasonal flooding and sediment deposition. Kori Chiefdom is a chiefdom located in the Moyamba District of Sierra Leone. It serves as one of the administrative subdivisions within the Moyamba District. The capital of Kori Chiefdom is Taiama. The Chiefdom is an essential part of the Southern Region of Sierra Leone and contributes to the cultural and administrative landscape of the region (Sierra Leone Census, 2021).

The climate system of Mokonde Village, Kori Chiefdom, Moyamba District in Sierra Leone falls under the tropical monsoon climate zone, classified as Am in the Kappen Climate Classification system. This classification signifies that Moyamba experiences high temperatures throughout most of the year with significant rainfall concentrated in specific months. The district's average yearly temperature is 28.5°C (83.3°F), which is slightly higher than Sierra Leone's overall averages. The climate system of Kori Chiefdom in Moyamba District, Sierra Leone is characterized by a Tropical monsoon climate (Classification: Am). The area experiences a yearly temperature of 28.5 °C (83.3 °F), which is about 0.89% higher than the averages for Sierra Leone. The region typically receives approximately 269.04 millimeters (10.59 inches) of precipitation annually, with 257.21 rainy days occurring throughout the year, accounting for about 70.47% of the time. The district is situated at an elevation of 61 meters (200.13 feet) above sea level. (Sierra Leone Census, 2021):



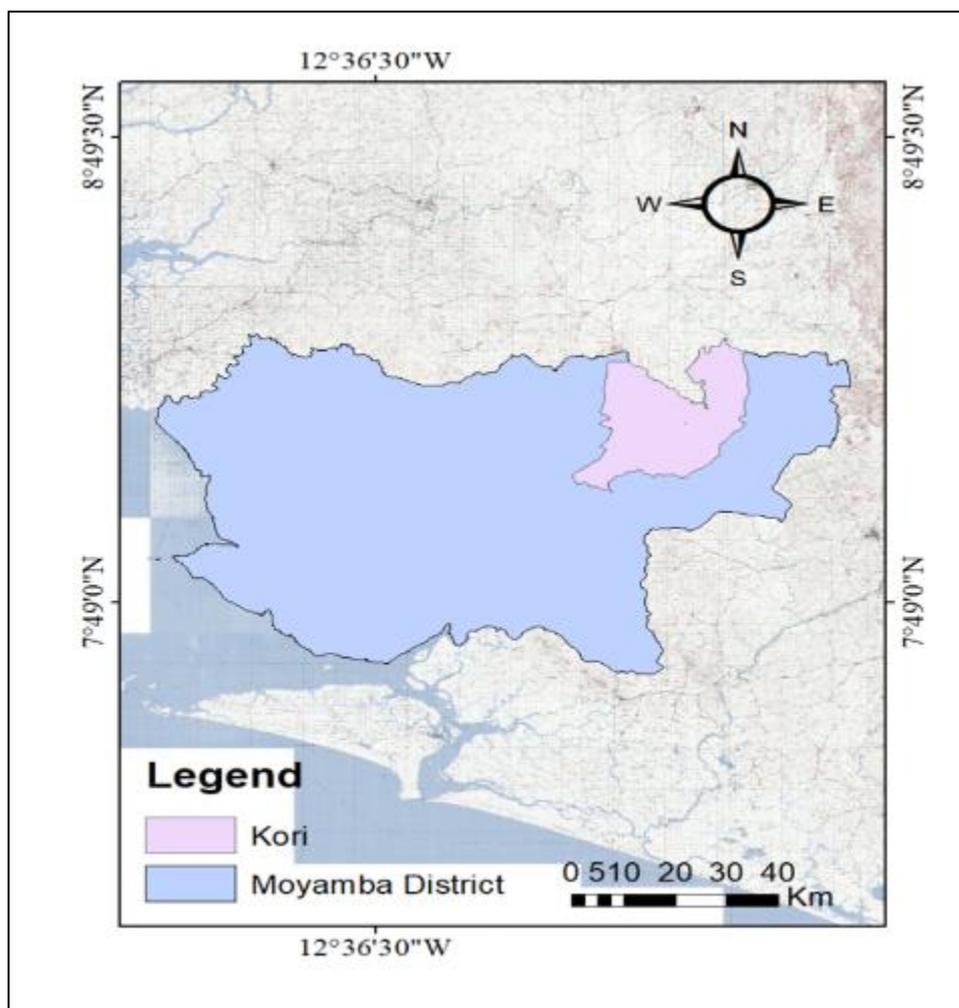
(Source: author, 2025)

Figure 1 Map of Sierra Leone showing Moyamba District

2.2. Vegetation and Economic Activities

The vegetation of Kori Chiefdom in Moyamba District, Sierra Leone is characterized by a diverse range of flora typical of the region. Kori Chiefdom, being part of the Moyamba District, which is known for its agricultural activities and natural resources, likely has a mix of vegetation types that support the livelihoods of the local population. Given that agriculture is the mainstay of the district's residents and the largest sector of the economy, it can be inferred that Kori Chiefdom also has fertile land suitable for cultivation. The vegetation in Kori Chiefdom may include various types of trees, shrubs, and plants commonly found in tropical regions. The presence of oil palm plantations in Moyamba District suggests that oil palms are likely part of the vegetation in Kori Chiefdom as well. Additionally, cereals such as maize, rice, sorghum, and millet are grown in the district, indicating that these crops may also contribute to the vegetation cover in Kori Chiefdom. According to the available information, the population of Kori Chiefdom in Moyamba District is not explicitly provided in the context. However, it is mentioned that the district had a population of 318,064 in the 2015 census (Mid-Term Census, 2015), and 346,771 in the 2021 Digital Mid-Term Census Population Results (Mid-Term Census, 2021).

Agriculture is the main economic activity in Kori Chiefdom, Moyamba District. The district's economy heavily relies on agriculture, with a focus on various crops such as oil palm, cereals (maize, rice, sorghum, and millet), as well as starchy food crops like yam, cassava, and cocoa. Additionally, other popular farm products in the region include cashew, black pepper, ginger, pineapple, and sugarcane. Despite having abundant land and water resources in the district, most farmers operate smallholdings ranging from 0.5 to 2 cropped hectares. Livestock activities in Kori Chiefdom are relatively small and underdeveloped compared to crop farming. Households typically own poultry, goats, and cattle at a basic subsistence level (Mid-Term Census, 2021).



(Source: author, 2025)

Figure 2 Map of study area

2.3. Soil Samples Preparation

Prior to air-drying, sub-samples were taken to determine the moisture content in the samples. This was to determine the moisture correction factors for each sample when weighing for analysis and calculation of results. Sample brought to the lab from the field were air-dried, sieved through the 2.0 mm screen. The samples were then transferred into sizeable laboratory nylon and given a distinct number as others have done in previous times (Mid-Term Census, 2021)..

2.4. Soil Sample and sample Analyses

In the mentioned locations, the soil profile sampling and description were systematically conducted following the methodology described in the Field Book for Describing and Sampling Soils (Schoeneberger et al. 2012). Excavation of the Soil samples were collected from different depths (0-15 cm and 15-30 cm) to capture variations in physicochemical properties within the soil profile. A soil auger was used to extract the samples. Three duplicates (undisturbed cylinders) were taken for physical analysis for each horizon, and two more samples (0.5 kg each) were taken for mineralogical, chemical, and textural investigations. After being carefully labelled, packaged, and delivered to the university soil and water laboratory, the soil samples were dried, ground, and prepared for later delivery to other Freetown labs for additional examination. At the EMQC laboratory, physical analyses of the soil were also carried out. For each analysis specific weight of soil was weighed in either an extracting vessel or a beaker for a general extraction. The methods below were used to analyze the result for the various nutrient contents.

2.5. pH

Sample pH (1:1) in water and potassium chloride were determined following the methods described by Anonymous, (1994) and Moore and Loeppert, (1987), respectively. Ten grams of air-dried (2.0 mm sieved) sample was weighed into a 25 mL beaker and 10 mL of water was added. The mixture was thoroughly stirred for 5 seconds with a glass rod. The sample water suspension was allowed to stand for 30 minutes and the pH was read using a pH meter. Sample pH was measured at 20 to 25°C stirring the sample water mixture with glass rod whilst the measurement was taken. The pH was immediately read after 30 to 60 seconds to the nearest 0.1 pH unit.

2.6. Electrical Conductivity

The EC was determined by using ten grams of air-dried (2.0 mm sieved) and the soil was weighed into a cup and 10 mL of deionized water was measured into the cup and mixed thoroughly for 5 seconds with a glass rod. The soil-water mixture was then allowed to stand for 20 minutes. The EC measurement was done at 20 to 25°C and the EC was immediately taken after 15 to 30 seconds.

2.7. Texture

The Hydrometer Method described by Benton-Jones (2001) was employed for the soil textural class determination. Briefly, 50 g of air-dried soil samples were treated with Sodium hexametaphosphate and allowed to stand overnight to enhance particle dispersion. The samples were later transferred into 1000 mL measuring cylinders and made to volume with distilled water. Hydrometer readings were taken after 20 seconds and 2 hours. Values obtained were used to calculate the percentages of sand, silt and clay in soil samples. With the use of the textural triangle, the textural class of each soil sample was determined.

2.8. Organic Carbon (C)

Briefly 0.5 g of air-dried (2 mm sieved) soil samples were placed into 500 mL conical flask. Potassium dichromate and sulphuric acid were added to digest the organic matter in the samples. Then, 50 mL of deionized water was added and allowed to cool before titrating with ferrous ammonium sulphate.

2.9. Total Nitrogen (N)

Into a Kjeldahl flask, 1.0 g of soil sample was placed and 10 mL distilled water was also added. This was followed by the addition of 0.7 g of copper sulphate, 1.5 g of K_2SO_4 and 30 mL of conc. H_2SO_4 . The mixture was heated gently at 150°C until frothing stopped and at 300°C until a clear colour is seen. The flask was removed and allowed to cool with 50 mL of deionized water. Then 30 mL of 10 M of NaOH, 0.2 g Devadas's alloy and 25 mL of 0.05 M of H_2SO_4 alloy were added to the distilling flask. The mixture was distilled for about 30 minutes and titrated with 0.1 M of NaOH.

2.10. Available Phosphorus (P)

Bray 1 Method (Bray and Kurtz, 1945) was followed in available P determination. Briefly, 2 g of soil sample was placed in a 125 mL flask and 14 mL of the extracting solution was added and allowed to filtrate. 3 mL of the filtrate sample was put into a test-tube and thereafter, 3ml of mixed solution was added. The solution was allowed to stand for about 30 minutes, and P was read and recorded using a spectrophotometer.

2.11. Exchangeable Potassium (K)

Available K was determined as described by Benton-Jones (2001). Five grams of air-dried (2-mm) soil was weighed into a 50 mL extraction vessel. Then, 25 mL of Extraction Reagent was added and shaken for 5 min at 150 rpm on a reciprocating shaker. The mixture was immediately filtered and collected for elemental determination.

2.12. Exchangeable Acidity and Aluminium (Al)

Ten grams of air-dried (2 mm sieved) soil was weighed into a 100 mL beaker and 25 mL 1.0 N KCl was added. The mixture was stirred and allowed to stand for 30 min and then filtered through filtration system. Ten aliquots of 10 mL KCl were added to the filtration system to give a total volume of 125 mL. The filtrate was titrated after adding 4 to 5 drops of phenolphthalein with 0.1M NaOH to the first permanent pink end point. The final titrated value was used to calculate exchangeable acidity and aluminium.

2.13. Exchangeable Calcium (Ca)

The ammonium acetate extraction method described by Benton-Jones (2001) was utilized in exchangeable cations determination. Five grams of air-dried (2-mm) soil was weighed into a 50 mL extraction vessel. Then, 25 mL of 1 M ammonium acetate extraction reagent was added and shaken for 5 minutes at 150 rpm on a reciprocating shaker. The samples were then centrifuged for 5 minutes and filtered. The filtrate was collected for elemental determination using a flame photometer.

2.14. Cation Exchange Capacity

The ammonium acetate extraction method was employed. Five grams of soil sample was weighed into 50 mL centrifuge tube and 25 mL of 1.0 M NH_4OAc solution was added. The mixture was centrifuged for 5 minutes at 2000 rpm until supernatant liquid is clear. The liquid was then decanted and process repeated three more times. Ethanol was also used to repeat the process until the EC of decants read less than 40 mS/cm. Finally, the decant was collected in a 100 mL volumetric flask fitted with a funnel and filter paper and made up the volume with 1 M NH_4OH . The cation exchange capacity was then determined by steam distillation.

2.15. Trace Elements (Fe, Cu and Zn)

The Ammonium Bicarbonate–DTPA Extraction Method described by Soltanpour, (1991) was used to determine the soil trace elements. (Fe, Cu & Zn). 10g of sieve air dried soil was weighed into extracting vessels with screw caps. 35 mL of the DTPA Solution was added to the sample and screwed. The electromagnetic shaker was used to shake the sample for ten (10) minutes and later centrifuged for 5 minutes. The centrifuged samples were sieved through Whatman filter papers and used for elemental determination by the AAS.

3. Results

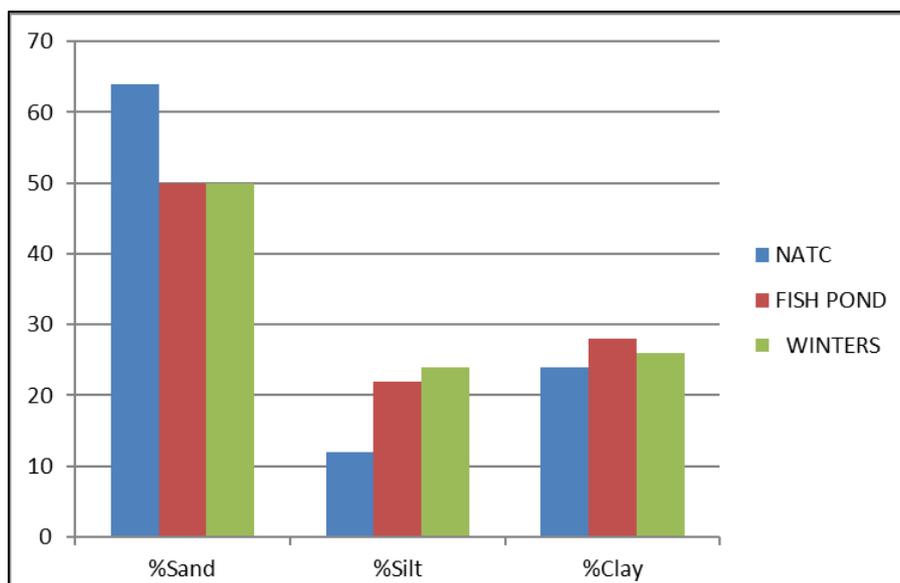
In our analysis, we not only calculate the mean values for each parameter but also explore the variances and standard deviations. These statistical measures provide crucial insights into the consistency and variability of the data, further enriching our understanding of the quality of swamp soils in the above-mentioned location. The findings presented will not only contribute to our understanding of the quality of these swamp soils samples but also will have broader implications for public health, agriculture, and policymaking. As we discuss these results, we will also review existing literatures to provide context and insights, ultimately facilitating a more comprehensive assessment of the situation and contributing to the global discourse on swamp soil quality.

3.1. Soil Texture

The study collected data from three different locations, including NATC, FISHPOND and WINTERS. The Mean, Variance and Standard Deviation for each swamp soil were calculated.

Table 1 Mean, Variance and Standard Deviation of Soil Texture for Soil samples

Location of swamps	Soil texture			Mean	Variance	Standard deviation
	Sand (%)	Silt (%)	Clay (%)			
NATC	64	12	24	33.3	741.335	27.2274
FISH POND	50	22	28	33.3	217.335	14.7422
WINTERS	50	24	26	33.3	209.335	14.4684



(Source: author, 2025)

Figure 3 A chart showing percentages of Soil Texture

The study found out that the soil sample collected from NATC has the highest number of Sand with 64% whiles FISHPOND and WINTERS both have 50% each. Also, the soil sample collected from WINTERS recorded the highest amount of Silt with 24% whiles the soil sample collected from NATC has the lowest Silt with 12%. The soil sample collected from FISHPOND has the highest amount of Clay with 28% whiles the soil sample collected from NATC has the lowest amount of Clay with 24%. The study's data analysis further revealed high variance and relatively low standard deviation in the soil texture readings across. The Mean for all the soil samples collected and analysed are relatively the same at 33.3.

3.2. Physical and Chemical Parameters

Table 2 Mean, Standard Deviation and Variance the physical and chemical parameters for NATC

LOCATION OF SWAMP	NATC				
	MONTH		MEAN	SD	VARIANCE
	JUNE	JULY			
PARAMETER					
pH	4.48	4.58	4.53	0.070711	0.005
EC(μ /cm)	50	54	52	2.828427	8
Total Carbon	1.97	2.07	2.02	0.070711	0.005
T. Nitrogen	0.02	0.01	0.015	0.007071	0.00005
T. Phosphorus	0.57	0.77	0.67	0.141421	0.02
T. Iron	2.01	4.06	3.035	1.449569	2.10125
T. Copper (mg)	0.36	1.55	0.955	0.841457	0.70805
T. Zinc (mg)	2	4.07	3.035	1.463711	2.14245
T. Potassium (Cmol/Kg)	0.035	0.021	0.028	0.009899	9.80E-05
T. Calcium (Cmol/Kg)	0.55	0.05	0.3	0.353553	0.125
Cation Exchange Capacity (Cmol/Kg)	0.12	0.28	0.2	0.113137	0.0128

Table 3 Mean, Standard Deviation and Variance the physical and chemical parameters for Fish Pond

LOCATION OF SWAMPS	FISHPOND				
	MONTH		MEAN	SD	VARIANCE
	JUNE	JULY			
PARAMETER					
pH	4.1	4.16	4.13	0.042426	0.0018
EC(μ /cm)	35	32	33.5	2.12132	4.5
Total Carbon	1.79	1.38	1.585	0.289914	0.08405
T. Nitrogen	0.05	0.03	0.04	0.014142	0.0002
T. Phosphorus	0.67	0.74	0.705	0.049497	0.00245
T. Iron	1.52	1.67	1.595	0.106066	0.01125
T. Copper (mg)	1.79	2.71	2.25	0.650538	0.4232
T. Zinc (mg)	32.24	69.83	51.035	26.58014	706.5041
T. Potassium (Cmol/Kg)	0.022	0.042	0.032	0.014142	0.0002
T. Calcium (Cmol/Kg)	0.612	0.011	0.3115	0.424971	0.180601
Cation Exchange Capacity (Cmol/Kg)	0.23	0.31	0.27	0.056569	0.0032

Table 4 Mean, Standard Deviation and Variance the physical and chemical parameters for Winter's Hostel

LOCATION OF SWAMPS	WINTER'S HOSTEL				
	MONTH		MEAN	SD	VARIANCE
	JUNE	JULY			
PARAMETER					
pH	4.78	4.88	4.83	0.070711	0.005
EC(μ /cm)	100	104	102	2.828427	8
Total Carbon	2.5	2.91	2.705	0.289914	0.08405
T. Nitrogen	0.04	0.01	0.025	0.021213	0.00045
T. Phosphorus	0.93	0.81	0.87	0.084853	0.0072
T. Iron	13.55	18.28	15.915	3.344615	11.18645
T. Copper (mg)	4.86	5.79	5.325	0.657609	0.43245
T. Zinc (mg)	650	841.98	745.99	135.7504	18428.16
T. Potassium (Cmol/Kg)	0.036	0.054	0.045	0.012728	0.000162
T. Calcium (Cmol/Kg)	0.74	0.04	0.39	0.494975	0.245
Cation Exchange Capacity (Cmol/Kg)	0.26	0.35	0.305	0.06364	0.00405

4. Discussions

4.1. pH

Sangita used a potentiometric pH meter to measure the soil's pH using a 1:2.5 soil water suspension ratio. pH measures the relative concentration of hydrogen ions in the solution. [Sangita C.D. 2020]. The mean, standard deviation and variance were calculated from the results obtained from soil sample at NATC Analysis of the result revealed a range of mean pH values across the examined samples, ranging from 4.48 to 4.58, with a mean and standard deviation of 4.53. Specifically, the sample from Fish Pond exhibited the lowest pH reading of 4.13, while the sample collected from Winters recorded the highest pH value of 4.83. These pH values fall within the mildly acidic to slightly alkaline range. The study further demonstrated that the variance and standard deviation of the pH readings were relatively low, signifying consistency in the pH measurements over the two-month observation period. This stability in pH readings suggests that the swamp soils maintained a relatively constant pH level during the study period. The observed pH values in this study align with what is commonly reported in various regions. The mildly acidic to slightly alkaline pH range reported here is consistent with studies conducted in other regions, as documented by authors like Kumar et al. (2018) and Appelo and Postma (2005).

4.2. Electrical Conductivity (EC)

One of the most crucial characteristics of soil is its electrical conductivity. It shows the total amount of soluble salts in the soil. The number of ions in the soil sample is measured by the conductivity value. The cations of the soil and salt solutions are traded in equal amounts with the cations of the clay and colloidal materials throughout this process. Cation exchange is the process of exchanging soil and salt solution cations. Anions like CO_3 , HCO_3 , and PO_4 and cations like Ca, Mg, Na, and K. The chemical characteristics of the soil can affect conductivity readings. Soil type is considered normal if EC is less than 4. [Sangita C.D. 2020]. The electrical conductivity (EC) of the soil samples collected ranged from 32 to 104 $\mu\text{S}/\text{cm}$ with mean and SD of 52 ± 2.82 , 32 to 35 $\mu\text{S}/\text{cm}$ with mean and SD of 33.5 ± 2.123 and 100 to 104 $\mu\text{S}/\text{cm}$ with mean and SD of 102 ± 2.82 for NATC, Fishpond and Winters respectively.

4.3. Total Carbon (C)

One significant component of the soil that affects soil fertility is the overall amount of organic matter. The foundation of soil fertility is soil organic carbon. Increasing soil organic carbon enhances soil fertility and health by releasing nutrients for plant growth. [Johnston AP et al., 2008]. The results found out that the mean total carbon of the soil samples ranged from 1.585% to 2.705%, with the sample from WINTERS recording the highest total carbon at 2.705% and while the sample collected from FISHPOND recorded the lowest total carbon at 1.585%. The study's data analysis further revealed relatively low variance and standard deviation in the total carbon readings across the two months.

4.4. Total Nitrogen (N)

Nitrogen Subbiah BV and Asija G. L (1956) used the alkaline per magnet approach to determine the amount of nitrogen that was accessible. For a plant's canopy to expand, nitrogen is a necessary nutrient. Nitrogen deficiency results in yellowish green leaves with stunted growth and lower yields and protein content. Analysis of the results for the mean total nitrogen of the soil samples ranges from 0.015% to 0.025%. The soil samples were collected from three different locations namely, NATC, FISHPOND and WINTERS. Specifically, the sample collected from FISHPOND recorded the highest total nitrogen at 0.04% while the sample collected from NATC respectively recorded the lowest value at 0.015%. And the results shows that the variance and standard deviation of the samples collected and tested are relatively low. Our result correlate with study done by Sangita [Sangita C.D. 2020]

4.5. Total Phosphorus (P)

In terms of soil quality, phosphorous is referred to as the master key ingredient. It is a vital component of all living cells. Growth, cell division, root growth, elongation, seed and fruity development, and early ripening are all dependent on it (Kachhave KG and More S. D, 1982). It also facilitates the transfer and storage of energy. According to analysis done from the soil samples collected from the three different locations namely: WINTERS, NATC and FISHPOND, the mean range for the total phosphorus are from 0.67 mg/kg to 0.87 mg/kg. Specifically, the sample collected from WINTERS recorded the highest phosphorus at 0.87 mg/kg while the sample collected from NATC recorded the lowest phosphorus at 0.67 mg/kg within the two months of collecting and analysing the data. Also, the Variance and Standard Deviation of all soil samples collected and analysed are relatively low just as study done by Sangita [Sangita C.D. 2020]

4.6. Total Iron (Fe)

The Mean range for total iron (Fe) of soil samples collected from the different locations is from 1.595 mg/kg to 15.915 mg/kg. The sample collected from WINTERS recorded the highest total iron (Fe) at 15.915 mg/kg while the sample collected from FISHPOND recorded the lowest total iron (Fe) at 1.595 mg/kg within the two months observation period. After the analysis, the result showed that WINTERS has the highest deposit of iron (Fe) content with a variance of 11.1864 mg/kg although their standard deviations are relatively low.

4.7. Total Copper (Cu)

The soil samples collected from the three different locations namely: (table 4) WINTERS, (table 2) NATC and (table 3) FISHPOND showed a mean range of Total Copper (Cu) from 0.955 mg/kg to 5.3 mg/kg. Also, soil sample collected from WINTERS recorded the highest deposit of Copper (Cu) at 5.3 mg/kg while sample collected from NATC recorded the lowest deposit Copper (Cu) at 0.955 mg/kg within the two months period. The results also showed that the Variance and Standard Deviation of the samples collected and tested are relatively low.

4.8. Total Zinc (Zn)

The mean range for Total Zinc (Zn) collected from three different locations namely: NATC, WINTERS and FISHPOND is from 3.035 mg/kg to 745.99 mg/kg. Also, the soil sample collected from WINTERS recorded the highest total deposit of Zinc (Zn) at 745.99 mg/kg while the sample collected from NATC recorded the lowest deposit of Zinc (Zn) at 3.035 mg/kg. Generally, the results showed that soil samples collected and tested significantly recorded high Variance and Standard Deviation.

4.9. Total Potassium (K)

Potassium is essential for a number of plant physiological functions. One of the most important nutrients for producing high-quality crops is potassium. [Miller RW and Donahue RL. 1992, Olsen SR et al., 1954, Piper CS. 1966, Richards LA. 1868 & Somwanshi RB et al., 1999] Its primary function is catalytic. The mean range for the Total Potassium (K) of soil samples collected from the three different locations namely: WINTERS, NATC and FISHPOND is 0.028 cmol/kg to 0.045 cmol/kg. The result shows that the soil sample collected from WINTERS has the highest amount of Potassium (K) present while sample collected from NATC has the lowest amount of Potassium (K) present. The Variance and Standard Deviation of soil samples collected are very low.

4.10. Total Calcium (Ca)

Calcium plays a vital role in nutrient availability, root development, and overall soil stability, all of which are necessary for preserving soil fertility, structure, and plant health. By flocculating clay particles, calcium enhances soil structure and aids in the formation of stable soil aggregates. In addition to decreasing erosion and runoff, these aggregates improve aeration, water infiltration, and root penetration. By interacting with negatively charged soil colloids, the divalent calcium ions (Ca^{2+}) enhance the micropore gaps where air and water exchange takes place and encourage soil flocculation (Sangita C.D. 2020).

The mean range for the Total Calcium (Ca) in all soil samples collected and tested is from 0.3 mg/kg to 0.39 mg/kg. The result also shows that the Variance and Standard Deviation of all soil samples are very low. Specifically, the soil sample collected from WINTERS recorded the highest Total Calcium (Ca) at 0.39 mg/kg while the soil sample collected from NATC recorded the lowest Total Calcium (Ca) at 0.3 mg/kg within the two months of observation period.

4.11. Cation Exchange Capacity (CEC)

The entire ability of soil to store and exchange positively charged ions (cations), such as potassium (K^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}), is known as Cation Exchange Capacity (CEC). It is a basic characteristic of soil that influences soil fertility and nutrient availability. Cation Exchange Capacity (CEC) is critical to soil health because it affects fertility and the sustainability of the ecosystem as a whole by determining the soil's capacity to hold and provide vital nutrients to plants (Sangita C.D. 2020).

Cation Exchange Capacity (CEC) was measured on the three different locations namely: WINTERS, NATC and FISHPOND. The mean range of soil samples is from 0.2 cmol/kg to 0.305 cmol/kg. WINTERS recorded the highest CEC at 0.305 cmol/kg while NATC recorded the lowest CEC at 0.2 cmol/kg. Also, the soil samples collected and tested recorded very low Variance and Standard Deviation values within the two months of observation period.

Abbreviations

- AAS: Atomic Absorption Spectroscopy;
- Al: Aluminium;
- C: Carbon;
- c/mol: Concentration per mole;
- Ca: Calcium;
- CEC: Cation Exchange Capacity;
- Cu: Copper;
- DPTA: Diethylenetriaminepentaacetic Acid;
- EC: Electrical Conductivity;
- Fe: Iron;
- H₂SO₄: Hydrogen Tetraoxosulfate;
- K: Potassium;
- K₂SO₄: Potassium Tetraoxosulfate;
- KCl: Potassium Chloride;
- Kg: Kilogram;
- NATC: National Agricultural Training Centre;
- N: Nitrogen;
- NaOH: Sodium Hydroxide;
- NH₄OAc: Ammonium Acetate;
- NH₄OH: Ammonium Hydroxide (Azanium hydrogen);
- P: Phosphorus;
- P: Potassium;
- pH: Potential Hydrogen;
- SD: Standard Deviation;
- T: Total;
- Zn: Zinc;

5. Conclusion

The comprehensive analysis of various parameters, ranging from soil pH, soil texture to total Zinc (Zn), total Iron (Fe), etc., has provided valuable insights into the current state of the soil which is mainly used for agricultural purposes to sustain the inhabitants living in that community. We have meticulously examined the data, scrutinized the findings, and now stood at a pivotal juncture from the realms of assessment to action. The study on the physicochemical parameters of swamp soils has provided valuable insights into the complex interactions between soil properties and environmental factors. The qualitative analysis revealed that swamp soils possess unique characteristics that distinguish them from other soil types, primarily due to their saturated conditions and organic matter content.

pH values ranged from 4.10 to 4.88, falling within the mildly acidic to slightly alkaline range. The stability in pH readings suggests consistent soil quality in terms of acidity or alkalinity. However, the soil pH alone does not provide a comprehensive indicator of soil quality. Electrical Conductivity levels ranged from 32.00 μ S/cm to 104.00 μ S/cm suggesting the presence of dissolved salts and minerals and the potential of these swamp soils to conduct and transport ions from one medium to another and for the presence of harmful contaminants. Total Iron concentrations were slightly low, but one soil sample had a notably high iron concentration (15.915 mg/L). The soil samples recorded low deposits of Total Copper (Cu), Potassium (K) and Calcium (Ca). Although, the soil samples possessed a high amount of Total Zinc (Zn) deposits present.

The findings obtained from this study further found out that Swamp soils are rich in organic matter, primarily derived from the decomposition of plant material. This high organic content influences the soil structure, making it more porous and less dense compared to mineral soils. The presence of organic acids can affect soil pH, often resulting in more acidic conditions.

Swamp soils generally exhibit acidic to neutral pH levels, which can be attributed to the accumulation of organic acids and the limited mineralization processes due to anaerobic conditions. The pH of swamp soils can significantly influence nutrient availability and microbial activity, impacting plant growth and soil health.

Swamp soils typically contain higher concentrations of certain nutrients, such as nitrogen and phosphorus, due to organic matter decomposition. However, the anaerobic conditions can lead to the formation of insoluble compounds, limiting the availability of these nutrients to plants.

The high organic matter content and porous structure of swamp soils enhance their water retention capacity. While this is beneficial for maintaining moisture in wetland ecosystems, it can also pose challenges for agricultural use, as poor drainage can lead to waterlogging and reduced oxygen availability for roots.

The anaerobic conditions in swamp soils support a unique microbial community adapted to low-oxygen environments. These microbes play a crucial role in nutrient cycling and organic matter decomposition, contributing to the overall fertility of swamp soils.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest regarding the publication of the paper, declared the author.

Statement of ethical approval

This study involved physicochemical parameters analysis of swamp soils, focusing on their composition, structure, and environmental implications. No human or animal subjects were used. Therefore, formal ethical approval was not required for this work, in accordance with the policy of Njala University, Sierra Leone. All laboratory safety protocols were strictly followed.

Author Contributions

- Issa Tura: Funding acquisition, Resources, Supervision, Validation, Writing – review & editing, Resources, Writing original draft
- Sahr Emmanuel Lebbie, Validation, Writing – review & editing, Resources, Writing original draft.
- David Conteh: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Visualization, Writing original draft

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