# WORLD ENVIRONMENTAL CONSERVATION CONFERENCE
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# CLIMATE CHANGE PARTNERSHIP ACTIONS FOR SUSTAINABLE FUTURE AND RESTORING LIFE ON EARTH

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## PREFACE

There is a growing concern on the adverse impacts of climate on biodiversity. This phenomenon is greatly manifested in form of shifting weather patterns threatening global food security, health and species existence. Humanity is at the receiving end of the consequences of climate change hence there is a need to step up actions on all fronts- overtime, everywhere all at once.

This calls for collaboration, partnership and networking to strengthening synergy among relevant stakeholders in a bid to tackling climate change menace. This forms the basis for the theme of this year world Environmental conservation conference: **CLIMATE CHANGE PARTNERSHIP ACTIONS FOR SUSTAINABLE FUTURE AND RESTORING LIFE ON EARTH.** The theme is conceived with a view to create an interface for information sharing and offer opportunities for participants to refine their commitments and pledges in the quest to achieving Sustainability in the face of climate change.

This year World Environmental Conservation Conference is memorable in the sense that it received overwhelming funding from the host - West African Science Service on Climate Change and Adapted Land use). WASCAL is posed to provide information and knowledge at the local, national and regional level to cope with the adverse impacts of climate change. Thus, this conference will offer opportunities for participants to learn from good practices demonstrated and showcase by WASCAL during the course of the conference. It will also strengthen staff-student exchange and provide prospect for Doctorate Research Doctoral Research in West Africa Climate System Programme (DRP WACS) – WASCAL among others.

Special appreciation goes to the management of The Federal University of Technology, Akure the host institution, National Park Service and African Regional Center for Space Science and Technology Education-English (ARCSSTE-E) that co-host this conference. We equally acknowledge other private, individual and corporate organizations that have contributed towards the success recorded in this event.

All the submitted articles were subjected to strict double blind peer-review process by the reviewers that are experts in the area of the particular submitted manuscript. The accepted manuscripts are published in WECC 2023 proceedings and also available for download on the organization website (www.necorng.org).

The accepted manuscripts fall within the underlisted subthemes:

- Climate change adaptation strategies in Agriculture, Forestry and Other Land Use (AFOLU)
- Climate smart city and architectural landscape design
- Retrofitting and decarbonization in tourism and hospitality industry
- Indigenous knowledge and local innovation in climate change adaptation
- Climate risk management, health, safety and hygiene
- Carbon credit-offset marketing/circular economy
- ICT development in environmental conservation (image processing and acquisition, computer vision, graphics, speed, interface technology, HMD devices, GIS: Body Tracking, AI and IOT, VRT, IVE).

We commend our keynote speaker Prof. Douda Kone Director Capacity Building Department, WASCAL Headquarter, Ghana and other guest speakers Prof. Babatunde Rabiu, Director General, Chief Executive Office, African Regional Centre for Space Science and Technology Education-English (ARCSSTE-E) and Dr. Goni I. M., Conservator General National Park Service.

*It is hoped that researchers, students and policy makers will find the papers in this book very useful. Even though all the papers were reviewed and edited, the content and option expressed remain essentially that of the authors and not necessarily that of Netlink Environmental Conservation Organization.*

**Dr. Oladeji S. O.**

*President Netlink Environmental Conservation Organization*

*Convener World Environmental Conservation Conference*

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**PHYSICAL AND CHEMICAL PROPERTIES OF SOILSOF SELECTED FOREST RESERVES. OYO STATE, NIGERIA.**

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***ABSTRACT***

*Inadequate information on current soil properties is a major factor limiting agricultural production in Nigeria. Soils were sampled from within three forest reserves in Nigeria which are Ijaye, Osho and Onigambari forest reserves. In each location, three soils samples were collected diagonally at the edges from each sample plot at three fixed depths of 0-10 cm, 10-20 cm, and 20-30 cm using soil auger. The soil samples were subjected to standard laboratory analytical methods to determine the physical and chemical properties. Data collected were subjected to descriptive statistics ($p \leq 0.05$) and ANOVA using SPSS version 26.0. The results established that, values of chemical and physical properties across the three forest reserves varied with depth. The soils ofthe study area were dominantly loamy sand in texture and the soils range from 72.63 to 72.70% in Ijaye, 72.63 to 72.73% in Osho while 62.67 to 70.60% for sand particles were obtained at Onigambari forest reserve. Higher soil physical properties were recorded at Ijaye and Osho forest reserve than Onigambari forest reserve. The magnesium, organic carbon, organic matter, nitrogen, calcium and cation exchange capacity increases with soil depth at 0-10, 10-20 and 20-30cm respectively, however, Cation exchange capacity had the highest mean value of 154.43% at 0-10cm soil depth. Sodium, Phosphorus decreased with increasing soil depth while pH and Potassium has irregular mean value with soil depth. Since soil depth has significant effect on physical properties, atOsho forest reserve, physical properties and its interaction with soil may significantly influence the response variables. To sustain continuous tree planting and reduce the rate of soil nutrient decline in the region, Government and farmers are encouraged to adoptimprovedsoil fertility management practices, which may be based on combined use of crop residues (organic inputs), livestock manure, inorganic fertilizers, crop rotation, legume-based intercropping.*

**Key words:** *Soils, forest reserves, physical, chemical, properties, Oyo State.*

## INTRODUCTION

The major ecological role of soils in forests and the natural environment cannot be overemphasized. Soils are significantly affected by geologic and geomorphologic factors (water, wind, temperature change, and gravity chemical interaction. topography, vegetation, living organism, and pressure differences) (Opeyemi*et al*., 2020). Different characteristics of soil such as depth, consistency, temperature, nutrient contents, moisture content, permeability, porosity, etc., can greatly influence the nature of vegetation that grows on them (Boyle and Powers, 2013). The physical, chemical and biological processes sustained by soil make it a dynamic zone, consisting of inorganic (rocks) and organic particles (plant and animal remains), liquid (water and chemicals in solution), and gaseous substances (Isah*et al*., 2014).The relationship between trees and soil is important since they are dependent on each other and the environment as a whole (FAO, 2015). The support, nutrients, and water needed by trees to grow are provided by soil; while trees and other plants are important factors in the formation and enrichment of soil (FAO, 2015). The biological nitrogen fixation, phosphorus solubilization, and decomposition of organic matter in the rhizosphere and non-rhizosphere zones of plants increase soil organic matter, improving soil structure and nutrient cycling of soils (Meena, 2016). Likewise, the gathering of nutrients by different tree species as well as their potential to return these nutrients to the soil can cause variations in soil properties (Rawat, 2019). The regular removal of vegetation through deforestation for farming and other human activities decreases the vegetation cover thereby leading to soil degradation by erosion processes, especially in areas with hilly topography (Amonum*et al*., 2019). It may also result in water logging which may in turn cause the leaching of nutrients under the plant's root zone and volatilization, making the soil deficient in some nutrients (Olujobi, 2016). Therefore, the sustainability of natural forest and the environment depend largely on consistent monitoring of soil quality. Thus, this study investigated the physical and chemical properties of soil within the natural forest ecosystem to elucidate the fertility and productivity status of the soil in Oyo forest reserves.

## METHODOLOGY

### Sampling Procedure

Line transects were employed for the laying of temporary sample plots in the selected study sites. Two-line transects of 1000 m each in length with a distance of at least 1000 m from each other were laid approximately at the middle of each site. Temporary sample plots of 40 m × 20 m were laid at alternate sides along each transect after every 250m interval, giving 4 plots per transect, and 8 plots per site.

### Soil Sample Collection

A 5 m × 5 m quadrant was laid within the sample plot for soil sample collection. Based on soil profile classification, three soils samples were collected diagonally at the edges from each sample plot at three fixed depths of 0-10 cm, 10-20 cm, and 20-30 cm using soil auger (Onyekwelu *et al*., 2008). Soils from the same depths within each sample plot were bulked to form a composite sample for the site. Analysis of the soil samples was carried out at the wet laboratory of the Department of Forestry and Wood Technology, Federal University of Technology, Akure, Ondo State.

### Data Analysis

The soil samples were air dried after which the big lumps were broken up with the aid of a mortar and pestle. The samples were then mixed thoroughly and sieved through a 2 mm sieve and then stored in polythene bags ready for analysis. The laboratory analyses consisted of detailed routine analyses of the soil samples for required plant nutrients.

### Particles Size Analysis

The analysis was carried out using Bouyoucos hydrometer method. 50g (< 2mm) of each air-dried soil samples were treated with 50ml of 5% calgon (sodium hexametaphosphate) along with 100ml of distilled water in clean plastic bottles. The samples were stirred with multi-mix machine for 15minutes. The suspension was transferred from the plastic bottles to the glass cylinders and topped with distilled water to 100ml mark. The top of the cylinder was covered with hand and inverted several times to ensure complete suspension. The cylinder was placed on a table and the hydrometer was inserted immediately and the reading was taken after 40seconds. After the hydrometer reading, the temperature was taken using a thermometer. The second reading was taken after 3 hours. Also, the temperature of the suspension was taken after the second hydrometer reading. The first reading measured the percentage of silt and clay in suspension. The second reading indicated the percentage of total clay in the suspension. Thus, the percentage composition of sand, silt and clay were calculated using the formula below.

$$(\text{clay} + \text{silt})\% = \frac{\text{5mins hydrometer reading} - \text{correction for temperature} \times 100}{\text{Oven dry mass of sample}} \quad \ldots\ldots (1)$$

$$(\text{clay})\% = \frac{\text{5hours hydrometer reading} - \text{correction for temperature} \times 100}{\text{Oven dry mass of sample}} \quad \ldots\ldots (2)$$

$$(\text{Silt})\% = (1) - (2) \quad \ldots\ldots (3)$$

$$(\text{Sand})\% = \frac{\text{oven dry weight of particles retained on 45μm sieve} \times 100}{\text{Oven dry mass of sample}} \quad \ldots\ldots (4)$$

### pH of the Soil

The method that was used in the determination of pH of the soil was the potentiometer method. The pH of the soil samples was determined using a glass electrode pH meter. A 1:1 soil to water ratio suspension was prepared by measuring 20g (< 2mm) of air dried soil into a beaker followed by adding 20ml of distilled water and stirred with a glass rod occasionally. The electrode was inserted in the partly settled solution after allowing the suspension to stand for 30 seconds and the pH was measured (Black, 1965).

### Organic Carbon Determination

The determination was carried out using dichromate oxidation method (Beltrame *et al*., 2016). Each representative sample were crushed with pestle and mortar and then passed through 0.5mm mesh sieve. 1g was weighed into a flask and 10ml of 1N potassium dichromate ($K2Cr2O_7$) was added and swirled gently to disperse the soil. 20ml of concentrated sulphuric acid was added and left to cool for 30 minutes before 100ml distilled water was added. Three drops of phenonthroline indicators was added and titrated against 0.5N FeSO4. As the end point approached, the solution took on a greenish cast and then changed to a dark green. At this point, the ferrous sulphate was added drop by drop until the color changed sharply from blue to red (Maroon color).

**Cation Exchange Capacity (CEC)**

25g (<2mm) of air-dry soil was weighed into 250ml Erlenmeyer flask and 50ml ammonium acetate (NH4OAC) solution was added and stopped. The content were shaken for 30 minutes and allowed to stand overnight. It was filtered into volumetric flask and 150ml NH4OAC added and filtered made up to 200ml. 95% Ethanol was added to ammonium-saturated soil on the funnel and leached. The leachate was discarded and the soils together with the filter paper were transferred to Kjeldahl flask. 400ml of water about 10g NaCl and 5 drops of antifoam mixture would be added to this. 2g granular zinc and 40ml of 1N of NaOH was added. 200ml of mixture in the Kjeldahl flask was distilled into 50ml of 40% Boric acid solution in a conical flask. The distillate was titrated to the first color of purple with 0.2 NH4Cl using 10 drops of mixed indicators and 2 drops bromocresol green. The tire of cation exchange capacity $Na^+$ and $K^+$ were calculated using the formula by Jackson, M.L, (1954). 1000mg/l = KCl g/K or NaCl/Na

Calcium mMol/100g = T1 x=X M (EDTA) x $\frac{V1}{V2}$ X$\frac{100}{W}$

Magnesium mMol/100g = (T-$T_m$) x M (EDTA) x $\frac{V1}{V2}$ X$\frac{100}{W}$

Where: T1=Titre value for calcium alone,Tm = Titre value for magnesium, V1 = Volume of extracted solution,V2 = Volume of extracted sample used in titration andW = Weight of sample used for extraction. $Mg^{2+} = (Ca^{2+} + Mg^{2+}) – Ca^{2+}$ (Olofinkuade, 2002).

Available $N_a$ and K was determined using digital flame photometer.

**Available Phosphorus**

This was determined using Ammonium Fluoride (NH4F) and HCL extracting solution. 5g of each soil sample passed through a 2mm sieve was weighed into a plastic bottle and 35ml of the extracting (NH4F/HCL) was added. The content was shaken for 5 minutes on the mechanical shaker. The suspension were gently decanted through filter paper and then transferred to 50ml volumetric flask and made up to the mark with distilled water. 5ml of the filtrate was measured into a test tube and 25ml of ascorbic acid (color developer was added. The color was allowed to develop for 15minutes and phosphorus was determined using colorimeter (spectrophotometer 20). Average results of 5 determinations for each level were given in the table of results.

**Statistical Analysis**

Soil data was subjected to analysis of variance (ANOVA) using Randomized Complete Block Design (RCBD). One way analysis of variance was used to determine whether there is difference in the soil properties of the soil from different depths, for statistically different parameters ($p < 0.05$), means would be separated using Least Significant Difference (LSD).

**RESULTS**

The mean soil depth and physical properties obtained at Ijaye forest reserve were presented in Table 1 showing sand, clay, and silt content in Ijaye forest reserve for three soil depths: 0-10 cm, 10-20 cm, and 20-30 cm. For sand content, 20-30cm depth obtained the highest mean value with 72.7% followed by 72.66% and 72.63% representing 10-20 and 0-10cm depth respectively. Clay content at 0-10cm depth recorded the highest mean value of 24.51%, followed by 22.62% and 22.61% representing 20-30cm and 10-20cm depth respectively. Soil depth of 10-20cm recorded the highest men value of 4.72%, while 4.68% and 2.85% representing soil depth of 20-30cm and 0-10cm respectively for silt content.

**Table 3: Mean Physical Properties Soil depth for at Ijaye Forest Reserve**

| Soil Depth (cm) | Sand (%) | Clay (%) | Silt (%) |
|---|---|---|---|
| 0-10 | $72.63 \pm 0.15^a$ | $24.51 \pm 0.19^b$ | $2.85 \pm 0.3^c$ |
| 10-20 | $72.66 \pm 0.15^a$ | $22.61 \pm 0.03^b$ | $4.72 \pm 0.18^c$ |
| 20-30 | $72.7 \pm 0.1^a$ | $22.62 \pm 0.03^b$ | $4.68 \pm 0.10^c$ |

*Means within the same row and followed by different letter are significantly different (P<0.05).*

**Physical Properties of Soil at Osho Forest Reserve**

The result of physical properties obtained along different soil depth at Osho forest reserve were presented in Table 2 showing the result of sand, clay, and silt content in the forest reserve for three soil depths: 0-10 cm, 10-20 cm, and 20-30 cm respectively. Sand soil content at 20-30cm depth obtained the highest mean value with 72.73% while 72.63% representing 10-20 and 0-10cm depth respectively. Also, clay content at 20-30cm depth recorded the highest mean value of 24.62%, followed by 24.61% and 22.6% representing 10-20cm and 0-10cm depth respectively. Soil depth of 0-10cm recorded the highest men value of 4.76%, while 2.67% and 2.64% representing soil depth of 10-20cm and 20-30cm respectively for silt content.

**Table 4: Mean Soil depth for Physical Properties at Osho Forest Reserve**

| Soil depth (cm) | Sand (%) | Clay (%) | Silt (%) |
|---|---|---|---|
| 0-10 | 72.63 ± 0.20[a] | 22.60± 0.03[b] | 4.76 ± 0.24[c] |
| 10-20 | 72.63 ± 0.15[a] | 24.61 ± 0.30[b] | 2.67 ± 0.17[c] |
| 20-30 | 72.73 ± 0.11[a] | 24.62 ± 0.15[b] | 2.64 ± 0.13[c] |

*Means within the same row and followed by different letter are significantly different (P<0.05).*

**Physical Properties of Soil at Onigambari Forest Reserve**

The mean soil depth and physical properties obtained at Onigambari forest reserve were presented in Table 3 showing sand, clay, and silt content in Onigambari forest reserve for three soil depths: 0-10 cm, 10-20 cm, and 20-30 cm. For sand content, 0-10cm depth obtained the highest mean value with 70.6% while 64.63% and 62.67% representing 10-20 and 20-30cm depth respectively. For clay content, 0-10cm and 10-20cm depth recorded the highest mean value of 26.62%, while 22.61% representing 20-130cm depth recorded the lowest. Soil depth of 10-20cm recorded the highest men value of 10.70%, while 8.74% and 2.77% representing soil depth of 20-30cm and 0-10cm respectively for silt content.

**Table 5: Mean Soil depth for Physical Properties at Onigambari Forest Reserve**

| Soil depth (cm) | Sand (%) | Clay (%) | Silt (%) |
|---|---|---|---|
| 0-10 | 70.6 ± 0.20[a] | 26.62 ± 0.01[b] | 2.77 ± 0.21[c] |
| 10-20 | 62.67 ± 0.15[a] | 26.62 ± 0.05[b] | 10.70 ± 0.16[c] |
| 20-30 | 64.63 ± 0.15[a] | 26.61 ± 0.15[b] | 8.74 ± 0.16[c] |

*Means within the same row and followed by different letter are significantly different (P<0.05).*

**Chemical properties of soil at Selected Forests Reserves**

The mean values of different chemical properties of soils at three different forests (Ijaye, Osho, and Onigambari) were presented in Table 4. The chemical properties include Calcium, Magnesium, Organic Carbon, Organic Matter, PH, Sodium, Potassium, Phosphorus, Cation Exchange Capacity, and Nitrogen. The values of various chemical properties were presented for three different soil depths considered for the study and they era; 0-10cm, 10-20cm, and 20-30cm.

At Ijaye forest reserve, the highest mean values of Magnesium, Organic carbon, Organic matter, pH, Potassium, Calcium and Cation exchange capacity were obtained at 20-30cm soil depth respectively. Sodium recorded highest mean value at 0-10cm depth while Phosphorus and Nitrogen obtained higher soil depth at 0-10cm and 10-20cm respectively. The result of this study shows that at Osho forest reserve, the highest mean values of magnesium, organic carbon, organic matter and potassium obtained higher mean value at soil depth of 10-20cm respectively, while Sodium, calcium and cation exchange capacity were obtained at 20-30cm soil depth respectively, while PH recorded highest soil depth at 0-10cm.

Result on table 4 shows the result of soil chemical properties at Onigambari forest reserve, the highest mean values of magnesium, organic carbon, organic matter, calcium and cation exchange capacity were obtained at 20-30cm soil depth respectively. Sodium and potassium obtained higher at depth of 0-10cm respectively while nitrogen had higher depth at 10-20cm as pH had the same mean value across different depth. The results indicate that the chemical properties of the soils vary with depth and forest location. These variations could have implications for the growth of plants in these forests and may require different management practices to optimize plant growth.

**Table 6: Mean of Soil depth for Chemical Properties at Ijaye, Osho and Onigambari Forest Reserves**

| **Soil**depth (cm) | Mg (cmolkg$^{1}$) | OC (%) | OM (%) | pH | Na (cmolkg$^{1}$) | K (cmolkg$^{1}$) | P(cmolkg$^{1}$) | N(%) | Ca(cmolkg$^{1}$) | CEC(cmolkg$^{1}$) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Ijaye** | | | | | | | | | | |
| **0-10** | 11.23 ± 0.2$^{c}$ | 14.1 ± 0.9$^{b}$ | 14.23 ±0.5$^{a}$ | 5.19 ± 1.2$^{a}$ | 73.0 ± 0.6$^{a}$ | 36.0 ± 0.3$^{c}$ | 0.12 ± 0.4$^{a}$ | 2.10 ± 0.4$^{a}$ | 15.6 ± 0.7$^{c}$ | 135.83 ± 2$^{b}$ |
| **10-20** | 15.7 ± 0.7$^{b}$ | 21.23 ± 1.5$^{ab}$ | 21.26 ±0.2$^{ab}$ | 4.71 ± 0.7$^{b}$ | 67.66± 0.2$^{b}$ | 31.33 ± 1.1$^{b}$ | 0.12 ± 0.3$^{a}$ | 2.11 ± 1.2$^{a}$ | 22.266 ± 1$^{b}$ | 138.96 ± 3$^{ab}$ |
| **20-30** | 20.56 ± 1.1$^{a}$ | 25.26 ± 0.5$^{a}$ | 25.26 ±0.4$^{a}$ | 5.51 ± 1.5$^{a}$ | 63.66 ± 0.1$^{c}$ | 41.33 ± 0.3$^{a}$ | 0.06 ± 0.1$^{a}$ | 2.1 ± 1$^{a}$ | 29.23 ± 1$^{a}$ | 154.80 ± 1$^{a}$ |
| | **Mg(cmolkg$^{1}$)** | **OC(%)** | **OM(%)** | **pH(cmolkg$^{1}$)** | **Na(cmolkg$^{1}$)** | **K(cmolkg$^{1}$)** | **P(cmolkg$^{1}$)** | **N(%)** | **Ca(cmolkg$^{1}$)** | **CEC(cmolkg$^{1}$)** |
| **Osho** | | | | | | | | | | |
| **0-10** | 0.06 ± 0.1$^{b}$ | 3.7 ± 0.1$^{c}$ | 3.7 ± 0.25$^{b}$ | 5.10± 0.2$^{a}$ | 75.3 ± 1.5$^{c}$ | 39 ± 1.0$^{b}$ | 0.04 ± 01$^{a}$ | 2.10 ± 1.0$^{a}$ | 15.6 ± 0.2$^{a}$ | 135.8 ± 3.2$^{b}$ |
| **10-20** | 5.43 ± 0.1$^{a}$ | 9.63 ± 0.2$^{a}$ | 9.70 ± 0.2$^{a}$ | 4.42 ± 0.1$^{a}$ | 80 ± 1.0$^{b}$ | 43.6 ± 1.5$^{a}$ | 0.03 ± 01$^{a}$ | 2.10 ± 1.0$^{a}$ | 22.26 ± 0.2$^{b}$ | 138.9 ± 5.1$^{ab}$ |
| **20-30** | 0.4 ± 0.1$^{b}$ | 6.2 ± 0.1$^{b}$ | 6.36 ± 0.1$^{b}$ | 4.93 ± 0.1$^{a}$ | 83.3 ± 2$^{a}$ | 42.6 ± 3.0$^{a}$ | 0.04 ± 04$^{a}$ | 2.10 ± 1.0$^{a}$ | 29.2 ± 0.2$^{a}$ | 154.8 ± 0.2$^{a}$ |
| **Onigambari** | **Mg(cmolkg$^{1}$)** | **OC**(%) | **OM**(%) | **pH** | **Na(cmolkg$^{1}$)** | **K(cmolkg$^{1}$)** | **P(cmolkg$^{1}$)** | **N**(%) | **Ca(cmolkg$^{1}$)** | **CEC(cmolkg$^{1}$)** |
| **0-15** | 11.16 ± 0.2$^{c}$ | 15.13 ± 0.5$^{c}$ | 15.13 ± 0.5$^{c}$ | 5.0 ± 0.1$^{a}$ | 92.0 ± 1.0$^{a}$ | 81.3 ± 1.5$^{a}$ | 0.12 ± 0.1$^{a}$ | 2.06 ± 0.1$^{b}$ | 18.5 ± 0.2$^{c}$ | 203.03 ± 2.6$^{b}$ |
| **15-30** | 29.2 ± 0.1$^{b}$ | 31.23 ± 0.2$^{b}$ | 31.23 ± 0.2$^{b}$ | 5.0 ± 0.1$^{a}$ | 81.0 ±1.0$^{c}$ | 52.0 ± 0.4$^{c}$ | 0.17 ± 0.2$^{a}$ | 8.0 ± 1.0$^{a}$ | 37.5 ± 0.1$^{b}$ | 199.76 ± 2.7$^{c}$ |
| **30-45** | 34.5 ± 0.1$^{a}$ | 43.26 ± 0.1$^{a}$ | 36.3 ± 0.2$^{a}$ | 5.0 ± 0.1$^{a}$ | 83.0 ± 0.5$^{b}$ | 55.3 ± 03$^{b}$ | 0.17 ± 0.5$^{a}$ | 2.60 ± 0.1$^{b}$ | 40.26 ± 0.2$^{a}$ | 213.10 ± 2.3$^{a}$ |

*Alphabets with different letters show that there is a significant difference along the same column for Calcium (Ca), Magnesium (Mg), Organic Carbon (Org. Carbon), Organic Matter (Org. Matter), PH (Ph), Sodium (Na), Potassium (K), Phosphorus (P), Cation Exchange Capacity (C.E.C), and Nitrogen (N).*

**DISCUSSION**

Table 1-3 contains vital information regarding the physical properties of soil at various depths representingIjaye, Osho and Onigambari forest reserves. It was observed that, sand content tends to be higher at Osho forest reserve, followed by Ijaye and Onigambari. Clay content were higher at Onigambari than Osho and Ijaye forest reserves while silt contents were relatively higher at Onigambari, followed by Ijaye and Osho forest reserves. The different variation in sand, clay and silt content across the three forest reserves could be attributed to numerous factors which affect soils regionally, the most influential factors include the parent material (the rocks from which the soil has come), the climate and terrain of the region, as well as the type of plant life and vegetation present, and, of course, human influence (Knight *et al*., 2014; Akbas *et al*., 2017). The soil content obtained in this study across the three forest reserves ranges from 62.67% to 72.73%, clay ranges from 22.60% and 26.62% while silt content ranges from 2.64% to10.70%. This corroborated with the findings of Alabi*et al*., (2019) who had sand content ranged from 35% to 89.5%, while the clay content ranged from 7.3% to 50%. The soil content obtained in this study, is also higher than the soil content reported by Onyekwelu*et al*., (2008) who recorded 59.2% in primary (Queen's) and degraded (Elephant and Oluwa) rainforests in South-Western Nigeria. However, lower the value reported by Isienyib*et al*., (2021) who had 83% at Onigambari forest reserve. It was observed that soil content has irregular pattern as the value decreased with increasing in soil depth, this could result as a factors affecting soil depth such as parent material, soil texture etc, Akbas*et al*., (2017). Deforestation or degradation of rainforest soils results in soil structure deterioration, reduces soil nutrients, and soil compaction (Nesper*et al*., 2015).

The results in table 4 indicated that, the levels of Mg, OC, OM, and Ca tend to increase with depth, while pH, Na, K, P, N, and CEC tend to decrease with depth across the three locations. These findings are consistent with previous research that has shown a general trend of increasing soil organic matter and nutrient content with increasing depth, while soil acidity tends to decrease with depth. This is in conformity with Fagwalawa*et al*., (2014) who said, moderate levels of organic carbon are usually expected at the top layers due to accumulation and decomposition of organic debris accumulates at the top of the soil. Similarly, a study by Baldock*et al*., (2013) found that soil organic carbon and nitrogen levels tend to increase with soil depth in Australian grassland. It was observed that magnesium content obtained in this study relatively lower at Osho forest reserve and comparably higher at Ijaye and Onigambari forest reserves. Higher than 1.86 ± 0.28 recorded by Onyekwelu*et al*., (2008) in primary (Queen's) and degraded (Elephant and Oluwa) rainforests in south-western Nigeria. However, Oyetola*et al*., (2021) also had lower magnesium content in Southern Guinea Savanna Zone of Nigeria. Magnesium attracts more water than calcium and hence has a larger hydrated radius, as a result, soil particles become farther apart and more spread. As a result, soils with higher magnesium levels have fewer water stable aggregates and lower pore integrity (Ajwa and Trout, 2006). It was observed that, organic carbon content recorded in this study increased in increasing soil depth at Ijaye and Onigambari forest reserves, this is in conformity with Fagwalawa*et al*., (2014) who said, moderate levels of organic carbon are usually expected at the top layers due to accumulation and decomposition of organic debris accumulates at the top of the soil. Soil pH tends to have higher mean values at the top soil across all the locations as investigated. The PH of the soil studied ranges from 4.42% to 5.51% and it falls within the neutral to very acidic class (Oyebiyi*et al*., 2018). Acidity could be caused by the leaching of significant amounts of exchangeable base-forming cations (Ca, Mg, K, and Na) from the soil's surface layers, as well as the soil's high buffering capacity. Sodium (Na) in this study tends to increase in increasing depth across different locations except at Osho Forest reserve. Mean value obtained for sodium in this study is higher than 0.23 reported by Ogunkunle, (2013) in forested area Lagos, also higher than 0.31 reported by Ajon, and Ajembe, (2018) at Gboko, Benue State, Nigeria. High levels of sodium can destroy the aggregate structure of fine- and medium-textured soils (Gathala*et al*., 2011). This decreases porosity and prevents soil from holding sufficient air and water needed for plant growth (Johan *et al*., 2021). Nitrogen is a macronutrient in soil that serves to regulate the consumption of potassium, phosphorus, and other soil elements by most plants (Mesfin, 1998). It was observed that nitrogen content was higher at the depth of 10-20 across all the location, soil nitrogen content obtained in this study ranges from 2.10% to 8.0% which is higher than 1.8% previously reported by Yusufu and Abenu, (2019), also higher than 0.32% reported Ajon, and Ajembe, (2018) at Gboko, Benue State, Nigeria. It was observed that nitrogen content increased with increasing in depth. The calcium content investigated in this study ranges from 15.6% to 40.26% across all the locations, which is higher than 0.59 reported by Ogunkunle, (2013) in forested area Lagos. Because organic matter is what makes exchangeable cations available to plants, the high calcium values may be related to the highest organic matter values observed for this study. According to Landon (Landon, 1991) cation exchange capacityis used to estimate the potential fertility of the soil, the possible response to fertilizer application and as a rough guide to the types of clay minerals present. According to this study, the values of cation exchange capacity(CEC)ranges from 0.67 Cmol/kg to 1.07 Cmol/kg in the top soils and sub soils, respectively across all the locations. This is lower than 5.11 previously recorded by Mustapha *et al*., (2021) in Savannah Region of Northern Nigeria. Also lower than 6.54 reported by Ajon, and Ajembe, (2018) at Gboko, Benue State, Nigeria. The low cation exchange capacitymay be due to reflection of the intensity of weathering that produced the soils or as a result of continuous mining through cultivation (Odunze, 2003; Shehu*et al*., 2015).Jimoh*et al*., (2011) proposed that high value of CEC indicates good nutrient retention, release and buffering capacity of the soil.Cation exchange capacity (CEC) of the soil affects its capacity to supply nutrient cations for plant growth (Brady and Weil, 2002).

## CONCLUSIONS

The determination of the physical and chemical properties of the Ijaye, Osho and Onigambari forest reserve was the principal objective of this study.The results showed that, the soils of the area of study were mainly sandy loam, according to the USDA Textural Class (USDA, 2001); and that the soils have suitable pH, sodium, potassium, nitrogen, organic carbon, organic matter, exchangeable calcium and magnesium cation exchange capacity across the three forest reserves. However, the soils are deficient in available phosphorus and nitrogen. Inadequate phosphorus in soil can limit the crop growth while deficiency of soil nitrogen and CEC can lead to limiting supply of nutrient cations needed for plant growth. To sustain continuous farming and reduce the rate of soil nutrients decline, Government and farmers in thestudy area are encouraged to adopt soil fertility management practices involving the combined use of crop residues (organic inputs), inorganic fertilizers.

### Recommendations

It is recommended that the forest be protected and fenced if possible to reduce soil degradation and encroachment by human activities into the forest and this will help the soil to retain its fertility. Human activities, such as deforestation and logging, can have a significant impact on the soil and vegetation in the forest reserves. Therefore, monitoring and managing these activities can help to ensure the sustainable management of these forest reserves.

There is overwhelming evidence that anthropogenic activities are causing the earth's climate to change through inputs of $CO_2$ and other greenhouse gases (GHGs) into the atmosphere. To promote the adoption of measures that maximize the sequestration and stabilization of SOC within climate mitigationagenda, it is necessary to establish or identify policy alternatives relevant to soil conservation, carbon sequestration and GHGs emission reduction. It is important to constantly assess how soil processes its nutrients that boost soil organic carbon that have an impact on land and soil management.This can help to develop more effective management strategies that will protect and enhance the soil and vegetation components of these reserves.

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