Impact of *Cannabis sativa* cultivation on soil physicochemical properties in Akure Forest Reserve, Ondo State, Nigeria

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ABSTRACT

The conversion of forest estates to other land use, particularly cannabis plantations, could have a detrimental effect on soil health and production. However, the impact of this practice on the physical and chemical properties of soil in this forest reserve is not known. This study was carried out in Akure Forest Reserve, Ondo State. Soil samples were collected at four depths and from four distinct areas of this forest: the undisturbed area, the degraded area without hemp, the degraded area with hemp in 2020, and the degraded area with hemp in 2023. Determination of soil physical and chemical characteristics was done using the Bouyoucos hydrometer, Walkley-Black net oxidation and potentiometer methods. Soil physical properties in this forest varied with depth and among the forest classes. In the undisturbed area of the forest, the study revealed that sand content decreased with depth, clay content increased with depth, while the silt content was the same with depth. Both soil physical and chemical properties were adjudged poor in all the degraded classes, revealing the potential of anthropogenic activities, particularly activities related to hemp planting, to destroy soil structure and health. These activities could lead to the destruction of the soil seed bank, resulting in poor regeneration and deficient tree growth. To avert deforestation and other negative consequences that may be occasioned by hemp planting activities, government should discourage forest destruction for Hemp planting and implement sustainable forest management practices.

INTRODUCTION

The tropical rainforest ecosystem is one of the principal natural formations that are very rich in plant and animal diversity (Lawal and Adekunle, 2013). Asides from the richness of tropical rainforest, it provides ecosystem services, such as stocks and flows of carbon, nutrients and water (Aloy, 2017). The goods and service functions of rainforest ecosystems are mostly provided by the tree component that depends on soil for healthy growth and development.According to Binkley (2013), soils are a crucial factor in the productivity of forests.

Forest soil has unique physical and chemical characteristics. It is a soil developed under a very long-term continuous vegetation cover with high activity of microbes, resulting in high humus contents and continuity of the soil pore system compared with other land use types (Sokołowska *et al.*, 2020). Nave *et al.* (2024) opined that forest soil has a very high organic matter (OM) content and suitable structure. Padbhushan *et al.* (2022) reported that soils under natural forests had 36.1% higher soil organic matter compared to converted croplands. Forest soil is a major component in the global carbon cycle, and the amount of carbon stored in the top 1 m depth of soil (1206 Pg OC) exceeded the atmospheric carbon store (800 Pg) (Zdruli *et al.*, 2017).

Soil organic carbon (SOC) is a major component of soil quality and health (Heidari and Feizian, 2025).Ramesh *et al.*, (2019) estimated that 60% of SOC is stored in the first 20 cm of soil surface. Converting atmospheric CO_2 into stabilized SOC for a long time in soil (carbon sequestration) is one of the best options for mitigating climate change (Benslama *etal*., 2024).According to Basheer *et al*., (2024), a minor increase in soil carbon stores has a significant impact on decreasing greenhouse gas emissions into the environment. Destruction of forest ecosystem has made forest soil a carbon source rather than a carbon sink, leading to an increase in atmospheric greenhouse gas concentrations and global warming (Lawal and Adekunle, 2013).

Before, the major cause of environmental degradation and global climate change all over the world was the conversion of forests to rangelands or agricultural lands (Barati *et al*., 2023). But today, it is the climate change that is impacting the vegetation and species composition by modifying soil moisture and temperature regimes, as well as nutrient cycles, and changes in biomass that have an impact on organic carbon (OC) storage (Yang *et al.*, 2024), affecting the soil's physical and chemical qualities (Nadal-Romero *et al.*, 2023) and forest productivity (Lawal and Adekunle, 2013).

Despite several government efforts to reverse the trend of deforestation in Nigeria, Queen’s plot in Akure Forest Reserve is still under severe pressure from hemp planters. Numerous researchers have investigated the effect of replacing natural and degraded forests with artificial forests on carbon sequestration and have highlighted the relevance of such studies (Liu *et al*., 2024; Wang *et al.*, 2021). However, study on the impact of hemp planting on soil physical and chemical properties is hard to come by. Therefore this study was designed to evaluate the impact of hemp planting on the physical and chemical properties of forest soil vis-a-vis the implication tree regeneration and growth.

MATERIALS AND METHOD

Study Area

This study was carried out in Strict Nature Reserve 2(SNR2) located within Akure Forest Reserve, Ondo State, Nigeria (Fig. 1). The SNR lies between latitude 06.59718° N and longitude 004.49199º E in Akure Forest Reserve, Ondo State, Nigeria. It was constituted by the federal government of Nigeria in 1948 and the Forestry Research Institute of Nigeria (FRIN) was saddled with the responsibility of maintaining this forest. The forest covers an area of about 32 hectares (Adeduntan and Olusola, 2013). The area is gently undulating and lies on a general altitude of 229 m above sea level (Jones 1948). The climate is humid tropical with seasonal variation (Lawal and Adekunle 2013). The mean annual rainfall is about 4000 mm with double maxima in the months of July and September and a short relatively dry period in August. December through to February constitutes the major dry season (Ola-Adams and Hall, 1987). The monthly mean temperature is about 27◦C, a condition that is conducive to the development of tropical rainforest.

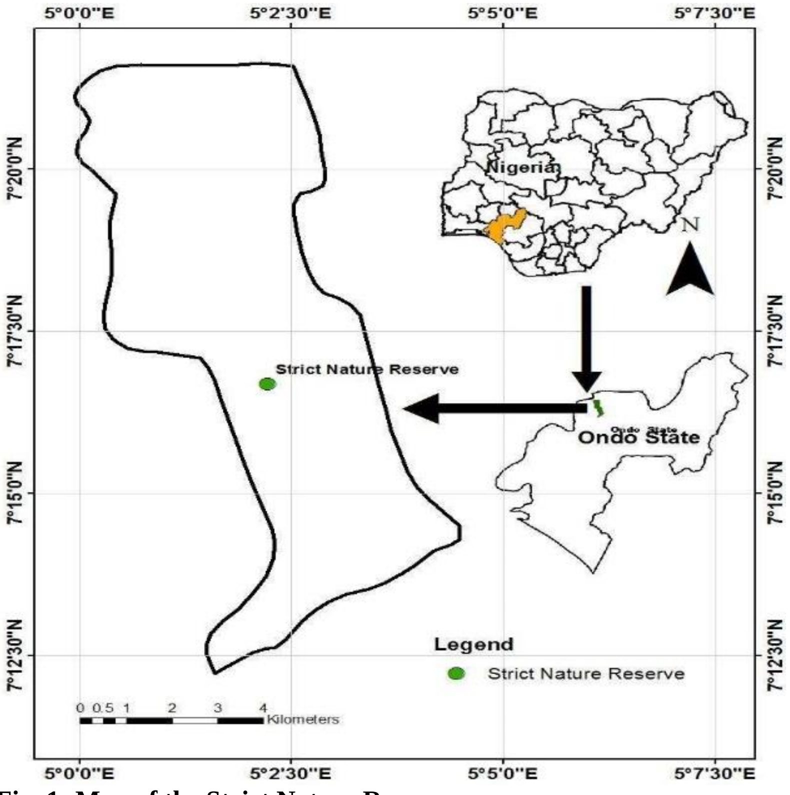

Fig. 1: Map of the Strict Nature Reserve

Method of Data Collection

Systematic sampling technique was used for soil sample collection in the undisturbed portion of the SNR. This entails the laying of two parallel transects of 1100 m with a distance of 500 m between them. Sample plots of 25 × 25 m was laid in alternate direction along each transect at an interval of 250 m. A total of 4 plots was laid per transect and 8 sample plots under this forest classification. In each plot, a diagonal line was laid within the sample plots for soil sample collection. Soil samples were taken from four soil depths of 0–15 cm, 15–30 cm, 30–45 cm and 45–60 cm at three points (i.e. at the two edges and middle of the line). More so, the degraded portion of the SNR was partitioned into three areas namely: degraded area without hemp, degraded area with hemp in 2020 and degraded area with hemp in 2023. Also, Soil samples were collected randomly in each area at four soil depths as done in the undisturbed area of the forest.

METHODS OF SOIL ANALYSIS

Soil Particles Size Determination

This analysis was carried out using the Bouyoucos hydrometer method, involving the treatment of 50g of air-dried soil samples (< 2mm) with a mixture of 50ml of 5% calgon (sodium hexametaphosphate) and 100 ml of distilled water in plastic bottles. After stirring for 15 minutes, the suspension was transferred to glass cylinders, topped with distilled water to 100 ml, and inverted for complete mixing. The hydrometer was inserted immediately, and the reading was taken after 40 seconds. 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 the suspension. The second reading indicated the percentage of total clay in the suspension. Thus, the percentage composition of sand, silt, and clay was calculated using the formula below.

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

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

(Silt) % = (1) – (2) ………….……..…………………………...….. (3)

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

Soil Chemical Analysis

Core cylinder samples were dried for two days at 105 °C to estimate the bulk density as a ratio of oven-dry weight of soil to cylinder volume. The determined bulk density was corrected for percent coarse fractions. The corrected bulk density (g m^{-3}) was used for the estimation of SOC stock. The soil samples collected from each layer separately were air dried and sieved through 2 mm sieve. They were crushed with pestle and mortal and sieved to past through a 2mm mesh. Soil organic carbon was determined by Walkley-Black net oxidation method. Organic matter content was estimated by multiplying the carbon value by a factor of 1.724 (Walkley and Black, 1934). The values were expressed in percentage. The total nitrogen content of the soil was also determined. The sample solutions were digested using the semi-micro-kjedahl method with selenium catalyst (Bremmer, 1996). The digested samples were distilled after the addition of 40% of sodium hydroxide (NaOH) and the ammonia thus released was determined by simple acid-base titration. The values were expressed in percentage (%).

SOC density (gha^{-1}) was obtained with the formula:

$$\text{SOC} = \frac{SOC(\%)}{100} \times Corrected \ \rho_b \ (gm^{-3}) \times \text{layer depth (m)} \times 10^4 \ (m^2ha^{-1})$$

Where ρ_b = bulk density

$$\text{Corrected bulk density } (g\ m^{-3}) = \text{bulk density } (g\ m^{-3}) \times \frac{(100 - \text{ per cent coarse fraction})}{100}$$

Soil PH

The method used in the determination of the pH of the soil was the potentiometer method. A 10g of air-dried sample was weighed into a cup, and 10 ml of distillation water was added and stirred several times with a glass rod. The electrode wasinserted in the partly settled solution, and the pH was measured

Cation Exchange Capacity (CEC)

A 25g of air-dry soil with particle size less than 2mm was measured into a 250-ml Erlenmeyer flask. Subsequently, 50 ml of ammonium acetate (NH_4OAC) solution was added, and the mixture was agitated for 30 minutes before being left to settle overnight. Afterward, the mixture was filtered into a volumetric flask, followed by the addition of 150 ml of NH4OAC, and the volume was made up to 200 ml. Ethanol(95%) was introduced to the ammonium-saturated soil on the funnel and allowed to leach. The resulting leachate was discarded, and the soils, along with the filter paper, were transferred to a Kjeldahl flask. To this, 400 ml of water, approximately 10g of NaCl, and 5 drops of the antifoam mixture were added. Additionally, 2g of granular zinc and 40 ml of 1N NaOH were included. In the Kjeldahl flask, 200 ml of the mixture underwent distillation into 50 ml of a 40% boric acid solution in a conical flask. The distillate was then titrated until the first appearance of a purple colour using 0.2 NH_4Cl, 10 drops of mixed indicators, and 2 drops of bromocresol green. The resulting titration value was employed to calculate the cation exchange capacity, applying the formula developed by Jackson(1962).The Calcium (Ca^{2+}) and magnesium (Mg^{2+}) content in the sampled soil were determined by employing the EDTA titration method.

$$\%Ca = \frac{T^1 \times 0.01}{1000} \times \frac{V1}{V2} \times \frac{100}{W2} \times 40$$

$$\%Mg = \frac{T^m \times 0.01}{1000} \times \frac{V1}{V2} \times \frac{100}{W2} \times 24$$

T^1	=	Titre value for Ca
T^m	=	Tite value for Mg
Vl	=	Volume of extract
V2	=	Extraction volume used in titration
W2	=	Weight of sample
40	=	Atomic mass of Ca
24	=	Atomic mass of Mg

%Ca and Mg were converted to mol/kg.
Availabe Na and K was determined using digital flame photometer

Phosphorus

Phosphorus was determined using ammonium fluoride (NH_4F) and HCL extract solutions. A 5g of each soil sample passed through a 2mm sieve was weighed into a plastic bottle, and 35 ml of the extract (NH_4F/HCL) was added. The content was shaken for 5 minutes on the mechanical shaker. The suspension was gently decanted through filter paper and then transferred to a 50-ml volumetric flask and made up to the mark with distilled water. A 5 ml of the filtrate was measured into a test tube, and 25 ml of ascorbic acid (colour developer) was added. The colours were allowed to develop for 15 minutes, and phosphorus was determined using a colorimeter (spectrophotometer 20).

Data Analysis

All measured soil physical and chemical characteristics were subjected to one-way analysis of variance (ANOVA) to test the significant difference in the measured variables among the forest classes. Where significant differences exist, Duncan's Multiple Range Test (DMRT) was used to separate the mean difference.

RESULTS AND DISCUSSION

RESULTS

The comparison of soil physic-chemical properties based on the forest classification is presented in Table 1 and 2. Sand content did not vary significantly at 0-15cm, 15-30cm, 30-45cm in all the forest classes but significantly higher at 45-60cm in the "degraded with hemp in 2023". Clay content was significantly higher at 0-15cm (56.60±1.00) in the degraded without Hemp, followed by un-degraded portion (54.35±1.18). There was no significant difference in the clay content at 15-30cm and 30-45cm in all the forest classes. At 45-60cm depth, the clay content was higher in the un-degraded portion (57.54±1.44), followed by the degraded without Hemp (56.58±0.75). The degraded with Hemp in 2020 (56.60±1.35) and 2023 (55.60±0.82) had the same clay content statistically at 45-60cm as presented in Table 4. Silt content in all the forest classes did not vary significantly at 0-15cm, 30-45cm and 45-60cm but was significantly higher at 15-30cmcm in the degraded with Hemp in 2020 (6.00±0.91) than in other forest classes.

For soil pH, significant difference was only recorded for all the forest classes at 30-45cm and the degraded with Hemp in 2020 had the highest pH of 5.84±0.10.Percentage organic carbon was significantly higher in un-degraded (2.16±0.59) and degraded without Hemp (2.19±0.29) at 0-15cm depth whereas significant difference did not exist in the percentage organic carbon at 0-15cm in both degraded with Hemp in 2020 (1.85±0.28) and 2023 (1.48±0.47). More so, the percentage organic carbon did not differ significantly among the forest classes across other soil depths. Similar finding was observed for the percentage organic matter except that the percentage organic matter was significantly higher in the degraded with Hemp in 2020 (3.19±0.49) than in the degraded with Hemp in 2023 (2.56±0.82).

Percentage Nitrogen in the soil was found to be the same in all the forest classes and across the depths investigated.More so, phosphorus was found to vary significantly among the forest classes and across the depths. Magnesium (Mg) was statistically the same irrespective of the forest class and depth. Cation exchange capacity (CEC) was significantly higher in the degraded forest with Hemp and in all the studied soil depths.

Table 1: Comparison of soil characteristics based on the forest classification

	Soil physical characteristics of the study area					
	Soil variables/ Degraded classes/Depth (cm)	**0 – 15**	**15 – 30**	**30 – 45**	**45 – 60**	**Mean**
Sand	Degraded without Hemp	40.40±2.61^{a}	41.65±1.11^{a}	40.40±2.00^{a}	36.40±1.58^{b}	**39.71±1.14^{a}**
	Degraded with Hemp in 2023	42.90±1.50^{a}	42.90±0.65^{a}	43.15±0.75^{a}	42.40±0.00^{a}	**42.84±0.16^{a}**
	Degraded with Hemp in 2020	40.90±1.32^{a}	38.90±1.66^{a}	39.40±1.47^{a}	38.15±0.95^{b}	**39.34±0.58^{a}**
	Un-degraded	43.65±0.48^{a}	40.65±1.25^{a}	39.65±1.89^{a}	34.15±1.84^{b}	**39.53±1.98^{a}**
Clay	Degraded without Hemp	56.60±1.00^{a}	55.60±0.82^{a}	56.60±0.58^{a}	59.10±1.71^{ab}	**56.98±0.75^{a}**
	Degraded with Hemp in 2023	53.10±0.29^{b}	54.10±0.65^{a}	55.35±0.25^{a}	55.60±0.82^{b}	**54.54±0.58^{a}**
	Degraded with Hemp in 2020	53.60±0.71^{b}	55.10±0.96^{a}	57.10±1.55^{a}	56.60±1.35^{b}	**55.60±0.79^{a}**
	Un-degraded	54.35±1.18^{ab}	56.35±1.25^{a}	58.35±1.49^{a}	61.10±0.87^{a}	**57.54±1.44^{a}**
Silt	Degraded without Hemp	2.61±1.78^{a}	2.75±1.25^{b}	3.00±1.73^{a}	4.50±1.44^{a}	**3.22±0.44^{a}**
	Degraded with Hemp in 2023	1.50±1.35^{a}	3.00±0.82^{b}	1.50±0.87^{a}	2.00±0.82^{a}	**2.00±0.35^{a}**
	Degraded with Hemp in 2020	1.32±1.04^{a}	6.00±0.91^{a}	3.50±0.50^{a}	5.25±2.25^{a}	**4.02±1.04^{a}**
	Un-degraded	0.48±1.35^{a}	3.00±0.00^{b}	2.00±0.71^{a}	4.75±1.38^{a}	**2.56±0.90^{a}**

DISCUSSION

Forest is an important component of natural ecosystem. Asides, the trees that sequester carbon when growing, forest soil is regarded as a carbon reservoir (Lawal and Adekunle, 2013). Cannabis cultivation has been criticized by many authors for threatening forests, streams, wildlife, and groundwater (Bodwitch *et al*., 2019). In Nigeria, illegal farming practices such as cannabis cultivation often occur in forested areas, intensifying the loss of tree cover (Adeoye *et al.*, 2012). This Illicit farming poses significant socio-economic pressures; smallholder farmers are encouraged to engage in Cannabis farming because of the high monetary rewards (Giade, 2014). The expansion of cannabis agriculture could leads to land use changes, with significant habitat encroachment for various species.

This study revealed that the soil physical properties could be distorted with anthropogenic activities. In the pristine area of SNR2, It was discovered that the percentage of sand decreased with depth while the percentage of clay increased with depth. This finding suggests that water holding capacity of this forest increased with depth and can continuous sustain the growth of trees in perpetuity. Izwaida *et al*. (2015) reported significant importance of clay in formation of organic matter and its capacity to retain the nutrients in the soil as well as influencing the nutrient level of the soil. Naturally, there is a vital relationship between trees and soil because they depend on each other. The support, nutrients and water needed by trees to grow is provided by soil; while trees and other plants are important factors in the formation and enrichment of soil (FAO, 2015).

Table 2: Comparison of soil characteristics based on the forest classification

	Soil chemical characteristics of the study area					
pH	Degraded without Hemp	5.66±0.04^{a}	4.72±0.39^{a}	4.99±0.28^{b}	4.65±0.32^{a}	**5.01±0.23^{b}**
	Degraded with Hemp in 2023	5.60±0.17^{a}	5.49±0.23^{a}	5.29±0.17^{ab}	4.92±0.43^{a}	**5.33±0.15^{ab}**
	Degraded with Hemp in 2020	5.50±0.14^{a}	5.68±0.10^{a}	5.84±0.10^{a}	5.51±0.36^{a}	**5.63±0.08^{a}**
	Un-degraded	5.72±0.20^{a}	5.55±0.38^{a}	5.49±0.38^{ab}	5.14±0.30^{a}	**5.48±0.12^{ab}**
Organic Carbon (%)	Degraded without Hemp	2.19±0.29^{a}	1.21±0.15^{a}	0.88±0.45^{a}	1.07±0.27^{a}	**1.34±0.29^{a}**
	Degraded with Hemp in 2023	1.48±0.47^{b}	0.96±0.32^{a}	1.29±0.58^{a}	1.11±0.54^{a}	**1.21±0.11^{a}**
	Degraded with Hemp in 2020	1.85±0.28^{b}	1.14±0.39^{a}	0.86±0.55^{a}	0.86±0.42^{a}	**1.18±0.23^{a}**
	Un-degraded	2.16±0.59^{a}	0.92±0.03^{a}	1.01±0.36^{a}	0.89±0.14^{a}	**1.25±0.31^{a}**
Organic Matter (%)	Degraded without Hemp	3.78±0.50^{a}	2.08±0.25^{a}	1.51±0.77^{a}	1.84±0.47^{a}	**2.30±2.30^{a}**
	Degraded with Hemp in 2023	2.56±0.82^{b}	1.64±0.55^{a}	2.22±1.01^{a}	1.91±0.94^{a}	**2.08±2.08^{a}**
	Degraded with Hemp in 2020	3.19±0.49^{ab}	1.96±0.66^{a}	1.49±0.95^{a}	1.47±0.72^{a}	**2.03±2.03^{a}**
	Un-degraded	3.72±1.02^{a}	1.58±0.04^{a}	1.74±0.62^{a}	1.53±0.24^{a}	**2.14±2.14^{a}**
Nitrogen (%)	Degraded without Hemp	0.19±0.02^{a}	0.16±0.02^{a}	0.17±0.01^{a}	0.20±0.03^{a}	**0.18±0.01^{a}**
	Degraded with Hemp in 2023	0.18±0.02^{a}	0.18±0.01^{a}	0.19±0.02^{a}	0.17±0.02^{a}	**0.18±0.00^{a}**
	Degraded with Hemp in 2020	0.17±0.01^{a}	0.17±0.02^{a}	0.19±0.02^{a}	0.18±0.02^{a}	**0.18±0.00^{a}**
	Un-degraded	0.19±0.01^{a}	0.19±0.02^{a}	0.14±0.00^{b}	0.17±0.02^{a}	**0.17±0.01^{a}**
P	Degraded without Hemp	19.71±1.37^{ab}	18.19±1.69^{ab}	14.45±2.31^{ab}	18.41±3.00^{a}	**17.69±1.13^{ab}**
	Degraded with Hemp in 2023	32.38±10.66^{ab}	22.25±2.93^{a}	20.62±3.31^{a}	17.50±3.27^{a}	**23.19±3.22^{a}**
	Degraded with Hemp in 2020	38.16±2.44^{a}	22.73±3.73^{a}	15.90±2.36^{ab}	17.86±3.44^{a}	**23.66±5.04^{a}**
	Un-degraded	14.78±3.38^{b}	11.51±2.45^{b}	10.46±1.82^{b}	7.88±0.80^{b}	**11.16±1.43^{b}**
Mg	Degraded without Hemp	2.43±0.33^{a}	1.88±0.73^{a}	2.73±0.56^{a}	1.73±0.31^{a}	**2.19±0.23^{a}**
	Degraded with Hemp in 2023	1.25±0.38^{a}	2.03±0.38^{a}	2.58±0.53^{a}	1.65±0.57^{a}	**1.88±0.28^{a}**
	Degraded with Hemp in 2020	1.50±0.57^{a}	1.60±0.64^{a}	2.30±0.44^{a}	1.50±0.23^{a}	**1.73±0.19^{ab}**
	Un-degraded	1.20±0.32^{a}	1.08±0.43^{a}	1.50±0.29^{a}	0.88±0.18^{a}	**1.17±0.13^{b}**
CEC	Degraded without Hemp	18.96±4.08^{a}	17.02±2.43^{a}	16.53±1.86^{a}	15.56±1.37^{a}	**17.02±0.72^{a}**
	Degraded with Hemp in 2023	10.21±0.93^{b}	9.73±1.12^{b}	10.21±1.46^{b}	10.70±0.56^{b}	**10.21±0.20^{b}**
	Degraded with Hemp in 2020	10.70±1.25^{b}	9.73±1.12^{b}	12.64±1.26^{ab}	11.18±1.22^{b}	**11.06±0.61^{b}**
	Un-degraded	10.21±0.49^{b}	10.21±0.93^{b}	10.21±1.84^{b}	9.24±0.93^{b}	**9.97±0.24^{b}**
	Degraded with Hemp in 2023	4.12±0.21^{ab}	3.06±0.22^{a}	3.40±0.34^{bc}	4.27±0.21^{a}	**3.71±0.29^{a}**
	Degraded with Hemp in 2020	4.55±0.36^{a}	3.05±0.18^{a}	4.49±0.33^{a}	4.24±0.20^{a}	**4.08±0.35^{a}**
	Un-degraded	3.67±0.20^{b}	3.63±0.34^{a}	4.27±0.11^{ab}	3.79±0.30^{ab}	**3.84±0.15^{a}**

Mean in the same column followed by the same letter(s) are not significantly different at 0.05 level of significance. Note: P - phosphorus, Mg - Magnesium, CEC – Cation Exchange Capacity

In this study, no significant difference (p = 0.05) was reported in the percentage of sand, silt and clay in the degraded forest without hemp with depth. Similarly, the physical properties of the soil in the degraded area with hemp in 2020 and 2023 were all the same with depth except for the percentage of clay that showed a significant difference with depth in the degraded area with hemp in 2023. This implies that destruction of forest estates though anthropogenic activities such as illegal logging and removal of harvesting residues could alter the soil structure and gradually reduce soil quality. Also, planting of Hemp has a great potential to impact the physical properties of forest soil. Illegal cannabis farming typically involves unsustainable agricultural practices, such as the use of harmful pesticides that could exacerbate environmental degradation, leading to soil pollution and degradation (Wartenberg*et al*., 2021).

This study revealed a significant increase in the sand content of the degraded forest with hemp in 2023 at 45-60cm but sand content in the degraded forest with Hemp in 2020 was the same statistically with other forest classes regardless of the soil depth. The higher sand content in the degraded forest with hemp in 2023 could be attributed to the land preparation activities involved during Hemp cultivation. The similarity in the sand content of the degraded forest with hemp in 2020 and other forest classes without hemp indicated that forest land used for Hemp cultivation could reverse to the original land structure if left undisturbed.

Soil pH in the study area could be said to be slightly acidic to neutral because it ranged from 4.65 to 5.84. According to Suleiman *et al.*(2017), this range provides the best growing condition and influences the uptake of nutrients by plants.

Akintola (2014), opined that soil organic matter content is the rich-mineral constituents in the soils that allow development and growth of trees, It has an important function in soil texture, water retention and contributes immensely to soil nitrogen, phosphorus, sulphur, cation capacity and exchangeable cation. Soil organic matter, organic carbon and Nitrogen were higher at 0-15cmin the undisturbed forest and in the degraded forest without hemp than other forest classes. This is expected as more litters are converted to soil organic matter on daily bass under these forest conditions. However, degraded forest with Hemp in 2020 and 2023 revealed a different pattern. Of course, no significant difference was recorded in the Soil organic matter, organic carbon and Nitrogen in the degraded forest with Hemp in 2020 and 2023. This means Hemp planting had negative impact on organic matter and Nitrogen in the soil. According to this study, this impact may be irreversible after about three years of no disturbance.

CONCLUSION

This research investigated soil physical and chemical characteristics as impacted by several anthropogenic activities, particularly Hemp planting in Akure Forest Reserve, Ondo State, Nigeria. We discovered that the percentage clay increased with depth while sand content decreased with depth in the undisturbed portion of the forest. However, percentage clay, sand and silt were the same with depth in other forest classes. Soil organic matter, organic carbon and percentage Nitrogen were significantly higher in the undisturbed portion of the forest than other forest classes. Distortion in soil structure and reduced organic matter in the degraded portions of this forest will negatively impact regeneration and tree growth. To avert any serious effect this may have on the earth climate, government should discourage forest destruction for Hemp planting and implement sustainable forest management practices.

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