Transpublika International Research in Exact Sciences
https://ojs.transpublika.com/index.php/TIRES
Online ISSN 2828-5921

https://doi.org/10.55047/tires.v4i2.1687

Original Article

An Appraisal of Soil Organic Carbon Content Availability Under Diverse Vegetation Cover in Delta State, Southern Nigeria

Edewor Akpezi Okiemute

Department of Geography and Regional Planning, Faculty of the Social Sciences, Delta State University, Abraka, Nigeria
Email: aoedewor@delsu.edu.ng

Received : 04 March 2025
Accepted : 10 April - 2025
Published online : 14 April - 2025

Abstract

Organic carbon availability is crucial for effective soil capability, suitability, and fertility potentials, which makes it a serious consideration among all soil parameters in the evaluation of soil nutrient availability and general carbon sequestration. This research article explored an appraisal of soil organic carbon content availability across diverse vegetation covers in Delta State, Southern Nigeria, including lowland rainforests, secondary regrowth, and wet grasslands. The study aimed to establish whether significant differences exist in organic carbon availability across the landscapes to determine soil suitability for functional utilitarian purposes. The methodology adopted was strictly a field survey where soil samples were collected in situ across the three different landscapes at depths of 0-15 cm (not meters), which is the zone of nutrient uptake and activity. A total of 90 samples, with 30 collected from each landscape, were drawn based on systematic stratification. The one-way ANOVA revealed no significant difference in soil organic carbon content across the studied landscapes ($p = 0.54$, $p > 0.05$), leading to the acceptance of the null hypothesis. This indicates that the landscapes share similar soil fertility and nutrient availability, supporting their equal suitability for agricultural uses, particularly for arable crop production and precision farming in wet grasslands.

Keywords: Appraisal, Organic Carbon, Vegetation Cover, Availability, Diverse.

1. Introduction

The nature of land cover in any given vegetation and soil ecosystem is a major prerequisite to the nature of soil physiochemical parameters available in both vegetation and soil ecosystems (King et al., 2020). A causal link usually exists between vegetation cover and the various soil physiochemical parameters available for plant growth. The quantity of organic carbon in the soil is a function of the input and output vegetation cover (Sukma et al., 2024).

Soil organic carbon is a major indicator of soil health, in other words, it is the carbon stored within the soil and available for plant growth. Ogunleye et al. (2018) posited that carbon makes up 60% of soil organic matter content while the other 40% is distributed among other soil physiochemical parameters such as calcium hydrogen, oxygen and nitrogen. Aweto & Areola (1979) in their application of the soil-vegetation model, explained the intricate relationship between land cover and soil and the role of both soil and vegetation in the cycling and recycling of matter.

Okiemute & Orovwigho (2021) opined that soil macro and micro physiochemical parameters including soil organic carbon are major soil fertility indicators in the enhancement of soil fertility status of the soil. Silt is a major attribute in the determination of soil fertility index (SFI) and soil fertility index classification all these soil attributes, of soil physiochemical parameters irrespective of the nature of the vegetation cover. Akpokodje & Aweto (2007) in related research emphasized the role of litterfall in the transformation and enhancement of soil fertility especially in the process of evaluation of SFI (soil fertility index) and soil fertility index classification (SFCC). Sanchez et al. (2003) further identified organic carbon content as an excellent modifier for soil fertility capacity and classification. Edewor & Atubi (2021) emphasized the role of soil physiochemical parameters especially the organic carbon content of soil fertility index under diverse vegetation cover in the moderation of soil fertility and soil quality especially as it relates to plant growth and sequestration of carbon dioxide. Balesdent et al. (2000), also emphasized the relevance of Organic Carbon in the stability of soil nutrients.

King et al. (2020) also affirmed that organic carbon content is a veritable catalyst in the process of carbon sequestration to ensure a delicate balance in both organic carbon removed from the atmosphere and the return of organic carbon to the soil. The authors' pontification indicated that it is only agriculture that possesses the magic ability to return organic carbon to the soil through regenerative agriculture.

Therefore, soil organic carbon generates impetus for the basics of sustainable agriculture. In a related study on soil organic carbon, Lanigan & Hackett (2017) reiterated the role of organic carbon in the soil. The author stated that its value in diverse vegetation landscapes of soil ecosystems cannot be underestimated it plays such roles as accelerating soil stability and mitigating soil erosion and environmental stability of soil health.

Adamu et al. (2015) also opined that soil organic carbon is a significant contributor to the cycling of nutrients for plant growth. Therefore, considering the role of organic carbon content in the soil, it is expedient that its availability in diverse land cover should be accorded utmost priority to ensure its availability in the right proportion to safeguard the soils and vegetation of the environment for sustainable use of soil resources in the environment.

Given these established connections, this study seeks to assess whether significant differences in soil organic carbon content exist across varying vegetation covers namely lowland rainforests, secondary regrowth, and wet grasslands in Delta State, Southern Nigeria. The overarching objective is to evaluate the suitability and functional utility of these landscapes for sustainable land use and agriculture, based on the availability of organic carbon.

2. Literature Review

2.1. The Carbon Cycle

The carbon cycle is an important example of the organic gaseous cycle and also one of the most efficient cycles carbons are the principal constituent of soil organic matter though its initial source is from the atmosphere.

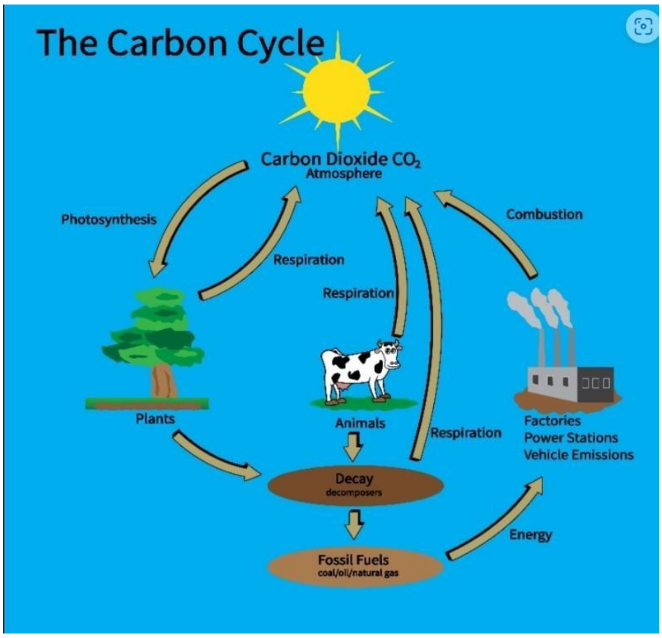

Figure 1. Diagram of Carbon Circle
Source: farmtimestories.com

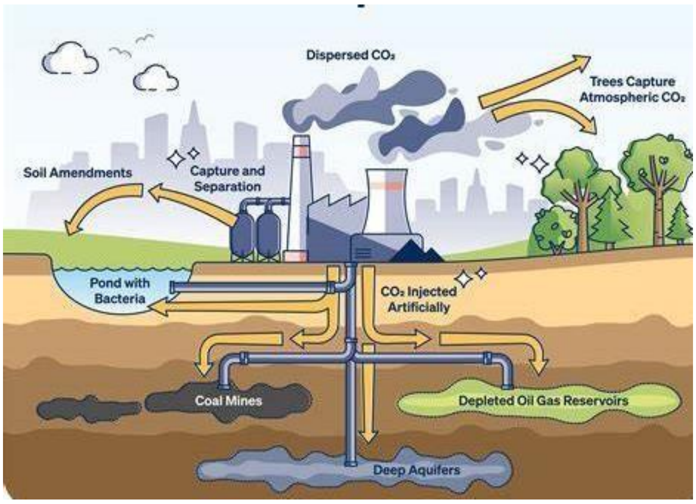

Figure 2. Diagram of Carbon Sequestration
Source: greentourism.world

2.2. The Study Area, Location, and Vegetation

The study was carried out in Delta State, Southern Nigeria. Delta lies between latitude 50 and 70 North of the equator and longitude 5 and 60 30 East of the Greenwich meridian. The state is bounded in the north by Edo State, south by Beyelsa State and Bight of Benin, East by Anambra, Imo and River States and West by Ondo State. The size of the state is approximately 16,842km.

Delta State has a wide range of vegetation types with diverse species. These include the swamp forest along the coast and the southern part of the state to the tropical rainforest in the central and northern parts of the state (Akpovwovwo, 2014).

As a result of anthropogenic disturbance, there also exist secondary regrowth forests which are vestiges of the natural vegetation structure. The main vegetation types in the state are as follows:

a) The mangrove swamp forest
b) The freshwater swamp forest
c) The tropical lowland rainforest
d) The grasslands/derived savanna which is discontinuous in nature.

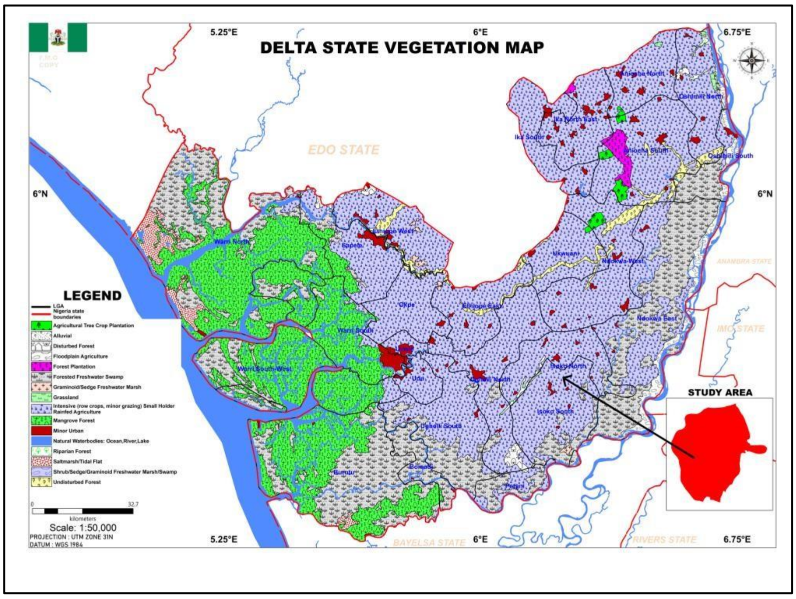

Figure 3. Vegetation Map of Delta State
Source: Fieldwork, 2024

3. Methods

The research is/was strictly based on a field survey. Soil samples were collected on site with the aid of a hand soil auger. They were dried and sent for laboratory experimentation at the University of Ibadan soil analytical laboratory. The state was systematically stratified into three zones as Zone A = Delta North, Zone B = Delta Central, and Zone C = Delta South. All the different landscapes where samples were collected houses the various landscapes under enquiry.

Soil samples were collected at the depth of 0-15cm which is the zone of nutrient activity and nutrient uptake. The samples were drawn from a pre-determined depth of 0-15cm. The justification for this approach to sampling is to ensure comparison between samples collected from different sampled quadrants. A total of 30 samples were collected from each of the zones which adds up to 90 samples in all the sampled points.

The null hypothesis guiding this study posits that there is no significant difference in soil organic carbon content across the various vegetation covers under investigation. This hypothesis was tested using Analysis of Variance (ANOVA).

4. Results and Discussion

This section presents the results of the statistical analysis conducted to determine whether significant differences exist in soil organic carbon content across the three distinct vegetation landscapes: lowland rainforest, secondary regrowth, and wet grassland. The hypothesis was tested using one-way Analysis of Variance (ANOVA), and the outcome is summarized in the table 1 below.

Table 1. ANOVA Table for Differences in Soil Organic Carbon Across Vegetation Types (Lowland Rainforest, Secondary Regrowth, and Wet Grassland)

	Sum of squares	DF	Mean sequence	F	Sig
Between Groups	2.071		2	6/9	0.54
Within Groups	145.623		87		
Total	147.694		89		

Source: Author's computation, 2024

The null hypothesis was accepted and the alternative was rejected as the significant value of 0.54 indicates that there is no significant difference in organic content based on P>0.05. this implies that all the landscapes evolve similar characteristics in organic content availability.

Table 2. Descriptive Statistics of Organic Content in the Various Landscapes

Zone	Vegetation Type	Lowland Rainforest	Secondary Regrowth	Grassland	Threshold Standard
Zone A	Lowland Rainforest	2.43	2.17	3.61	2.40
Zone B	Secondary Regrowth	2.11	4.29	4.26	
Zone C	Grassland	3.40	2.41	2.93	

Source: Author's computation, 2024

Findings from the study indicated that there is no significant difference in the availability of organic carbon across the diverse vegetation covers studied which includes lowland rainforest, grasslands and secondary regrowth vegetation landscapes. The significant values for the relationship between OC (Organic Carbon) values in the lowland rainforest grassland are 0.769 and 0.655, is because P(sig)> 0.05. This justifies the null hypothesis being accepted signifying that there is no significant difference in organic contents of the diverse vegetation covers.

The importance of this study is a confirmation that soil organic carbon across the landscapes studies is an indication that soil organic carbon is an active catalyst in the enhancement of organic carbon classification in both biological physical and chemical components which is a major boost to (CEC) Calton Exchange Capacity across all the landscapes studied. Also, all the landscapes have positive potential for carbon sequestration.

The import of this outcome is an indication that the grasslands are rich in organic carbon content compared to the rainforest, likely due to the positive effects of carbon accumulation from decaying plant materials and microbial activities in the upper soil layers of available farmland. This accumulation enhances nutrient cycling and contributes to improved soil fertility and structure.

Soil organic carbon content is not a constraint to any of the landscapes studied therefore, they are all suitable for arable farming and precision agriculture, availability of soil organic carbon also reduces soil compaction. Its presence therefore catalyses soil management and conservation.

All the landscapes exhibit similar characteristics in terms of organic carbon content. Therefore, they are adequately suitable for arable farming and other environmental benefits derived from the presence of organic carbon in soils, such as enhanced water retention, reduced erosion, and increased biological activity that supports sustainable land use practices.

The importance of this study is a confirmation that soil organic carbon across the landscapes studies is an indication that soil organic carbon is an active catalyst in the enhancement of organic carbon classification in both biological physical and chemical components which is a major boost to (CEC) Calton Exchange Capacity across all the landscapes studied. Also, all the landscapes have positive potential for carbon sequestration.

5. Conclusion

This study concludes that organic carbon is sufficiently available across all the vegetation landscapes examined. The findings demonstrate that the lowland rainforest, secondary regrowth, and grasslands possess comparable potentials for supporting soil fertility. This is attributed to the role of organic carbon in enhancing plant growth, maintaining soil health, and contributing to environmental stability through its involvement in nutrient cycling and carbon sequestration. Consequently, each of these landscapes is deemed suitable for arable farming and other sustainable land-use practices.

Based on the findings of this study, we recommend that agricultural development and land management strategies in Delta State should recognize the comparable organic carbon potential across diverse vegetation covers. Since no significant differences in soil organic carbon content were found between lowland rainforests, secondary regrowth, and wet grasslands, conservation efforts should focus on sustainable practices that maintain or enhance this organic carbon equilibrium. Future research should investigate seasonal variations in organic carbon content, explore deeper soil profiles beyond the 0-15cm zone, and examine the influence of specific agricultural practices on organic carbon dynamics across these landscapes. Additionally, establishing long-term monitoring sites would provide valuable data on carbon sequestration trends under changing climate conditions. This knowledge would further support policy development for sustainable land use planning and climate change mitigation strategies in Southern Nigeria's diverse ecosystems.

6. References

Adamu, U., Mrema, J., & Msaky, J. (2015). Growth Response of Maize (Zea mays L.) to Different Rates of Nitrogen, Phosphorus and Farm Yard Manure in Morogoro Urban District, Tanzania. *American Journal of Experimental Agriculture*, *9*, 1–8. https://doi.org/10.9734/AJEA/2015/19164

Akpokodje, U. E., & Aweto, A. O. (2007). Effects of an exotic tree legume on soil in farmland in the Ibadan area, southwestern Nigeria. *Agricultural and Food Sciences, Environmental Science*. https://doi.org/10.2462/09670513.846

Akpovwovwo, U. E. (2014). Fertility capability classification and GIS mapping of soils in Agbarho town, Delta state, Nigeria. *African Journal of Agricultural Research*, *9*(21). https://doi.org/10.5897/AJAR2013.7189

Aweto, A. O., & Areola, O. (1979). Soil-plant inter-relationships during secondary succession in the forest zone of Nigeria in Okali, DUU. *The Nigerian Rainforest Ecosystems*.

Balesdent, J., Chenu, C., & Balabane, M. (2000). Relationship of soil organic matter dynamics to physical protection and tillage. *Soil and Tillage Research*.

Edewor, A. O., & Atubi, A. O. (2021). Statistical Analyses of the Physiochemical Properties of Derived Savanna, Rainforest Landscapes of Delta State Nigeria. *Journal of Research in Humanities and Social Science*.

King, A. E., Ali, G. A., Gillespie, A. W., & Wagner-Riddle, C. (2020). Soil organic matter as catalyst of crop resource capture. *Frontiers in Environmental Science*.

Lanigan, G., & Hackett, R. (2017). Improving soil organic carbon. *Teagasc: Agriculture and Food Development Authority*, *12*(3).

Ogunleye, G. O., Fashoto, S. G., Mashwama, P., Arekete, S. A., Olaniyan, O. M., & Omodunbi, B. A. (2018). Fuzzy logic tool to forecast soil fertility in Nigeria. *The Scientific World Journal*.

Okiemute, E. A., & Orovwigho, A. A. (2021). Study of Soil Management for Cassava Production in Isoko, Delta State Nigeria. *International Journal of Advances in Scientific Research and Engineering*, *7*(12), 16–22. https://doi.org/10.31695/IJASRE.2021.34116

Sanchez, P. A., Palm, C. A., & Buol, S. W. (2003). Fertility capability soil classification: a tool to help assess soil quality in the tropics. *Geoderma*.

Sukma, N., Karma, T., & Hidayatullah, M. (2024). Characteristics of Moringa Leaf Powder (Moringa oleifera L.). *TRANSPUBLIKA INTERNATIONAL RESEARCH IN EXACT SCIENCES*, *3*(1), 28–32. https://doi.org/10.55047/tires.v3i1.1222