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Prevailing Physicochemical Properties of Soil Defined by Vegetation Types and Depth

Authors
*Egbe, V. N., Stanley, H. O. & Osu, C. I.

Institute of Natural Resources, Environment and Sustainable Development, University of Port Harcourt

***Corresponding Author**
Egbe, V. N.
(egbe_victor@uniport.edu.ng)

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Abstract

This study investigated the prevailing physicochemical properties of soils as influenced by vegetation types and depth, with emphasis on forest and farmland ecosystems in Port Harcourt and Bonny, Rivers State, Nigeria. Baseline physicochemical and microbial characteristics of soil samples were assessed to establish variations attributable to land use and vegetation cover. Soil samples were analyzed for temperature, pH, sulphate, nitrate, phosphate, total organic matter, soil texture, bulk density, and selected heavy metals (Lead, Zinc, Nickel, Chromium, Arsenic, Cobalt, and Copper). In addition, baseline microbial characteristics, including total heterotrophic bacteria and total fungi counts, were determined using standard microbiological methods. The results revealed significant variations in physicochemical properties across vegetation types and locations. Soil pH ranged from slightly acidic to alkaline in both forest and farmland soils, reflecting differences in organic matter input and land-use practices. Forest soils generally exhibited higher total organic carbon and lower bulk density (0.7–1.1 kg/m^3), while farmland soils recorded higher bulk density values (1.2–1.6 kg/m^3), likely due to cultivation and compaction effects. Heavy metal analysis indicated the presence of all tested metals; however, their concentrations were low and below the Department of Petroleum Resources (DPR) target limits, suggesting minimal contamination. Microbial analysis showed higher total heterotrophic bacterial and fungal counts in forest soils compared to farmland soils, indicating better microbial activity and soil health under natural vegetation. Variations in bacterial cultural morphology and fungal characteristics further reflected the influence of vegetation type and soil conditions on microbial diversity. Overall, the study demonstrates that vegetation type and land use significantly influence the physicochemical and microbial properties of soils, providing valuable baseline data for soil quality assessment, environmental monitoring, and sustainable land management practices in the study area.

Keywords: Physicochemical Properties, Microbial Properties, Soil Quality Assessment, Vegetation

Introduction

Soil serves as one of the planet's most significant carbon reservoirs, playing a crucial role in mitigating atmospheric carbon dioxide levels and regulating global climate. The capacity of soil to sequester carbon is intricately linked to microbial processes, particularly those mediated by bacteria. These microorganisms are central to soil carbon dynamics, contributing through the decomposition of organic matter, carbon fixation, and the enhancement of soil structure via aggregation. Their metabolic activities not only influence carbon turnover but also determine the long-term stabilization of carbon in soil matrices. However, the composition and functional capabilities of bacterial communities vary substantially across different plant-defined ecosystems (such as forests, grasslands, wetlands, and agricultural lands) each shaped by unique biotic and abiotic factors.

Soil organic carbon performs several functions in ecosystems and microbial communities play important roles in land–atmosphere carbon exchange and soil carbon storage. Climate change is a significant

environmental challenge that threatens ecosystems, human health, food security, water resources, and global economies. It results from a complex interplay of natural processes and human activities, leading to altered weather patterns, rising sea levels, melting ice caps, and more frequent extreme weather events. The primary driver is the increased concentration of greenhouse gases (GHGs) such as methane, nitrous oxide, and carbon dioxide (CO_2), primarily from burning fossil fuels, deforestation, and industrial activities (Voigt et al., 2017).

The intensified greenhouse effect, due to higher CO_2 levels, has caused global warming and broader climate change impacts. Over the past century, both global temperatures and CO_2 levels have risen significantly. This warming affects air and ocean temperatures, resulting in severe heatwaves, changing weather patterns, and ocean acidification, which disrupt marine ecosystems and food chains. Climate change also increases health risks, including heat-related illnesses and the spread of vector-borne diseases (Voigt et al., 2017).

Mitigating atmospheric CO_2 is essential, and carbon sequestration plays a critical role. Various methods, both natural and artificial, are employed. Technological sequestration includes direct air capture and mineral carbonation, while geological sequestration involves injecting CO_2 into underground formations. Oceanic sequestration relies on phytoplankton photosynthesis and seawater chemical processes to store CO_2, whereas biological sequestration uses plants, trees, wetlands, and soil microorganisms to enhance soil organic carbon (SOC) formation (Socolow et al., 2011; Mahmoudi et al., 2024). However, this study tends to determine the prevailing of physicochemical properties (including carbon storage) of soil defined by vegetation types and depth in the study area.

Literature Review
Climate Change and Soil Carbon Storage

The persistent rise in atmospheric carbon dioxide (CO_2) concentrations due to anthropogenic activities has profound implications for terrestrial carbon dynamics, particularly within soil ecosystems. Elevated CO_2 levels can influence soil carbon (C) inputs by modulating plant photosynthetic rates, which in turn affect the quantity and quality of organic carbon entering the soil through root exudates and litter deposition. Simultaneously, CO_2 enrichment may alter carbon losses via enhanced microbial respiration and accelerated decomposition of soil organic matter (SOM).

One notable consequence of elevated CO_2 (eCO_2) is the stimulation of rhizodeposition the release of organic compounds from plant roots—which can fuel heterotrophic microbial activity. This increased microbial activity may intensify SOM decomposition, potentially offsetting gains in soil carbon storage. However, findings from controlled experimental manipulations of eCO_2 have yielded inconsistent results regarding its impact on bacterial biomass, species richness, and community composition, suggesting complex and context-dependent microbial responses.

In parallel, global warming is expected to further influence soil microbial processes. Rising temperatures typically enhance microbial respiration rates by increasing the activity of soil enzymes responsible for organic matter breakdown. This enzymatic acceleration contributes to faster decomposition and greater carbon release from soils. Based on current projections, a global average temperature increases of just 2°C could stimulate soil carbon loss by approximately 10 gigatons per year. Nevertheless, this projected loss may be mitigated if microbial communities exhibit a decline in temperature sensitivity a phenomenon where microbial metabolic rates become less responsive to warming over time, potentially due to physiological or community-level adaptations (Singh et al., 2010).

Despite these insights, significant gaps remain in our understanding of the microbial mechanisms underlying soil carbon sequestration, particularly the roles of bacterial communities across different plant-defined ecosystems. This study aims to address these gaps by employing metagenomic approaches to:

- Characterize the taxonomic and functional diversity of soil bacterial communities under varying CO_2 and temperature regimes.
- Identify key genes and metabolic pathways involved in carbon fixation, transformation, and stabilization.
- Investigate how plant-associated factors such as root exudates, soil type, and nutrient availability; modulate microbial responses to environmental change.

By integrating metagenomic data with ecosystem-level variables, this research will provide a comprehensive understanding of how soil bacteria contribute to carbon sequestration under changing climatic conditions,

offering insights that could inform sustainable land management and climate mitigation strategies.

Factors that Enhance Soil Carbon Sequestration

Soil carbon sequestration (CS) is influenced by physical, chemical, biological, and management factors.

Physical factors include soil texture and structure, where clay content protects organic matter from decomposition by forming stable organo-mineral complexes (Sarkar et al., 2018). Good soil structure enhances water infiltration, root penetration, and microbial activity, all contributing to carbon sequestration. Soil depth and bulk density also play roles; subsoil layers often have lower decomposition rates, contributing to long-term carbon storage, while high bulk density can limit root growth and microbial activity (Nawaz et al., 2013). Proper moisture retention supports plant and microbial life, and moderate temperatures generally enhance carbon sequestration (Nanda et al., 2016). Erosion control is crucial to prevent the loss of topsoil rich in organic matter, aiding in carbon sequestration.

Chemical factors involve soil pH and nutrients. An optimal pH of 6-7 supports microbial activity and plant growth, crucial for carbon sequestration (McCauley et al., 2009). Nutrient availability, especially nitrogen and phosphorus, is critical. The chemistry of soil organic matter, including the carbon-to-nitrogen ratio and content of lignin and polyphenols, affects decomposition rate and stability. Soil redox potential and interactions with minerals like clay protect organic matter from decomposition, with aerobic conditions favoring rapid decomposition and anaerobic conditions stabilizing organic matter (Chen et al., 2019).

Biological factors highlight the role of microorganisms. Bacteria decompose organic matter, converting it into stable forms that contribute to long-term carbon storage (Jagadesh et al., 2024). Microbial biomass and products like extracellular polysaccharides enhance soil structure and stability. Symbiotic relationships, such as those between mycorrhizal fungi and plant roots, enhance plant growth and organic matter input. Microorganisms also regulate carbon availability through processes like mineralization and immobilization (Arenberg & Arai, 2019).

Management practices that affect soil carbon sequestration include crop management through diverse rotations, residue retention, and cover cropping to enhance soil organic matter (SOM). Conservation tillage practices like no-till preserve soil structure and organic matter. Organic amendments, such as compost, manure, and biochar, enrich the soil, supporting carbon sequestration. Agroforestry and silvopasture, which integrate trees into agricultural systems, increase biomass production and protect the soil. Grazing management, including rotational grazing and erosion control measures, preserve topsoil and organic matter. Adequate irrigation and proper drainage support plant growth and microbial activity, promoting carbon sequestration (Nazir et al., 2024). Microorganisms, particularly fungi and bacteria, play critical roles in soil carbon sequestration through decomposition, formation of stable carbon compounds, and improving soil structure. Their diverse activities enhance soil ecosystem resilience and functionality, contributing significantly to soil organic carbon (SOC) stability and long-term storage.

Materials and Method

Site Selection and Description

The selected study sites for sampling were 4.39^0 N, 7.18^0" E (Lat/Lon: 4.390741/7.180854) in Bonny LGA of Rivers State and 4.895N, 6.9319E in Port Harcourt, Rivers State respectively (Figure 1).

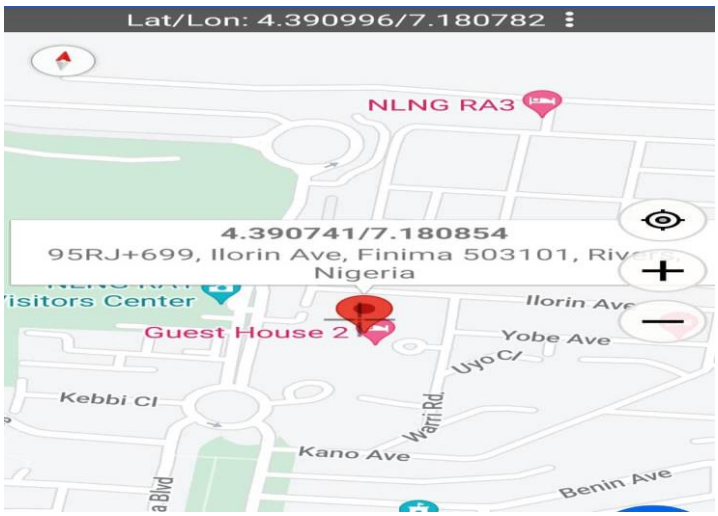

Figure 1: Nature Finima Park, Bonny, Rivers State (Lat/Lon: 4.390741/7.180854)

Source Materials and Media

Soil samples A1, A2, B1 and B were collected four different plant-defined ecosystems 150 m away from one another in Bonny, Rivers State: Lat/Lon: 4.390741/7.180854. The media that were used include but are not limited to the following: Nutrient Agar (Merck, Germany) Potato Dextrose Agar, PDA (Merck, Germany) Bushnell Hass Medium (BHM; TM Media Lab. Pvt. Ltd, UK), Luria Betarni broth (TM Media UK) and Mueller-Hinton agar (TM Media USA).

Sample Collection and Processing

Composite sampling technique was employed which is standard methods as described by American Society for Testing and Materials (ASTM, 2010)**.** Two different plant-defined ecosystems in the two different locations as defined above were selected for sampling: The Forests; encompassing tropical, undisturbed areas dominated by deciduous trees. The farmland; which is a human-managed vegetation primarily used for agricultural activities such as crop cultivation. A road side soil sample was also collected as control for comparison. Each site was georeferenced using a GPS device to record exact coordinates for reproducibility. For each sampling site, a total of four soil samples were obtained from four different points in each site at two depths: 0–15 cm (surface soil) and 15–30 cm (subsurface soil) using a soil auger. This was done triplicates per depth for each ecosystem to ensure statistical robustness. A total of 12 samples for each sample were then bulked together as a representative sample from each ecosystem. The following are the representative samples:

Sample A1= Forest soil from Port Harcourt, **Sample A2**= Forest soil sample from Bonny, **Sample B1**=Farmland soil sample from Bonny, **Sample B2**=Farmland soil sample from Port Harcourt , **Sample C**= Control (road soil sample)

Baseline Physicochemical Analysis of the Soil Samples

Baseline Physicochemical Analysis was carried out at Austino Research and Analysis Laboratory Nig, LTD. At No.2 UPTH Road, Alakahia Junction Port Harcourt. Baseline physicochemical analysis of the soil samples was determined using standard methods as described by American Society for Testing and Materials (2010). The physicochemical parameters analyzed include: pH, temperature, total nitrogen and nitrate, total phosphorus and phosphate, sulphate and heavy metals (chromium (Cr^{6+}), lead (Pb), zinc (Zn), Iron (Fe^{3+}), copper (Cu), and nickel (Ni). Analyses of TOC (OM), total nitrogen, and nitrate contents were performed according to EPA (2013) protocols with the detailed procedure given below:

Soil pH and Temperature

The pH was determined using a pH meter (Hanna pH meter). The pH meter was first calibrated with a neutral pH buffer (pH 7.0). About 10 g of soil was placed into 50-mL beaker and 20 mL of deionized water added to it. The suspension thereafter was stirred for 30 min; pH was recorded thereafter (EPA, 2013).

Total Organic Carbon (TOC) Determination Procedure

(a) Weigh 0.5 g of powdered and sieved (2 mm) soil into a 500 ml conical flask (b) Add 10 ml of 1 Normal K_2 Cr_2 O_7 solution and shake to mix (c) Add 20 ml of concentrated H_2 SO_4 from the sides of the flask (d) Keep the contents of the flask undisturbed for 30 min (e) Add 3 g Sodium fluoride (NaF) or 10 ml of H_3 PO_4 and 100 ml of distilled water and shake vigorously (f) Add 10 drops of diphenylamine indicator, which turns the solution violet (g) Titrate against 0.5 Normal ferrous ammonium sulphate (FAS) solution until the colour changes from violet to bright green and note the volume of solution used (h) Carry out a blank titration in a similar manner without the soil.

Total Organic Matter (TOM) Determination Procedure

For the oven method, a porcelain crucible was first weighed, after which approximately 10 g of compost or soil was added. The sample was then dried in an oven at 105°C for 24 hours. After drying, the sample was cooled in a desiccator and reweighed. It was subsequently ignited by placing the crucible in a 500°C oven overnight. After ignition, the crucible was removed using tongs, cooled again in a desiccator, and the ash was weighed.

For the Bunsen burner or hot plate method, a fan or another form of ventilation was set up to avoid inhaling fumes. While wearing goggles for protection, the sample was heated gently at first, then the heat was gradually increased until the crucible turned red. The compost was stirred occasionally during heating, and the combustion was continued until the sample became light in color and no more vapour was visible.

The percentage of organic matter was calculated using the formula:

Percentage of organic matter = (Wd – Wa) / Wd × 100%

where *Wd* is the dry weight of the sample and *Wa* is the weight of the ash.

Nitrate Determination Procedure

A filtered sample is passed through a column containing granulated copper-cadmium to reduce nitrate to nitrite. The nitrite (that was originally present plus reduced nitrate) is determined by diazotizing with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride to form a highly coloured azo dye which is measured calorimetrically. Separate, rather than combined nitrate-nitrite, values are readily obtained by carrying out the procedure first with, and then without, the Cu-Cd reduction step.

Phosphate Determination Procedure

To extract phosphate, 50 mL of distilled water was added to a flask containing the soil sample, and the mixture was shaken thoroughly. A sulfuric acid solution (5–10 mL) was then added to adjust the pH, after which the flask was shaken again and allowed to stand for 30 minutes to 1 hour. The mixture was centrifuged at 3000 rpm for 10 minutes, and the supernatant was carefully decanted into a clean 100 mL volumetric flask.

For the determination of phosphate, colour development was initiated by adding 5 mL of ammonium molybdate solution to the flask, followed by 2–3 mL of ascorbic acid solution. The mixture was well mixed and left to stand for 10–15 minutes to allow the blue colour to develop. Spectrophotometric measurement was then carried out by measuring the absorbance of the solution at 660 nm using a spectrophotometer, with distilled water serving as the blank reference.

A standard curve was prepared using known concentrations of phosphate, and their absorbance values were measured. Absorbance was plotted against phosphate concentration to generate the standard curve. The phosphate concentration in the soil extract was determined by referencing the standard curve. Final results were calculated and expressed in milligrams per kilogram (mg/kg) or parts per million (ppm) of soil.

Soil Texture Determination (Particle Size Distribution)

Soil texture, is a constant soil characteristic that impacts on physical and chemical quality of soils. Soil particle size has direct relationship with particles' surface area and several binding forces and factors that control soil aggregation. These binding forces were taken care of by dispersion before any effective estimation of the individual soil particles' content sizes.

The soil texture was estimated using hydrometer method (EPA, 2013). The hydrometer was removed with suspension shaken vigorously in a back-and-forth manner. After 20 s, the hydrometer was carefully inserted and reading taken at 40 s for the second time. Thereafter hydrometer reading was recorded. The suspension temperature was noted; for each degree rise above or below 20 ^{o}C, 0.36 was either added or subtracted, respectively. The suspension was re-shaken and the cylinder placed on a table to avoid disturbance. The hydrometer reading was taken after 2 h and corrected for temperature as described earlier. The sand, silt and clay percentages were estimated and texture class derived from the textural triangle.

Determination of Bulk Density

A 10 ml capacity graduated measuring cylinder was weighed empty. The test sample was then used to fill the cylinder up to the 10 ml mark. The bottom of the cylinder was tapped gently on a table surface until the sample settled and the level no longer decreased. The final weight of the cylinder with the sample was then recorded.
The bulk density (BD) was calculated using the equation:
$BD = W / V$
where W is the weight of the sample and V is the volume occupied by the sample.

Determination of Moisture Content

A clean crucible was dried to a constant weight in an air oven at 110°C, then cooled in a desiccator and weighed (W1). Two grams of finely ground sample was accurately weighed into the labeled crucible, and the crucible with the sample was reweighed (W2). The crucible containing the sample was then dried in an oven to a constant weight (W3).

The percentage moisture content was calculated using the formula:
$\%\ \text{Moisture content} = (W2 - W3) / (W2 - W1) \times 100$

Measurement of Electrical Conductivity (EC) in Soil

The conductivity cell was first calibrated using a standard KCl solution, and the cell constant was determined. The same soil-water suspension prepared in a 20 g to 50 ml ratio for pH determination was used for conductivity measurements. After recording the pH, the suspension was allowed to settle for an additional half hour, making the total intermittent shaking period one hour. Once calibration was complete, the conductivity cell was dipped into the supernatant liquid of the soil-

water suspension. The conductivity of the test solution was read using the appropriate conductance range. After taking the measurement, the cell was removed from the suspension, cleaned with distilled water, and then dipped into a beaker of distilled water. The electrical conductivity (EC) was expressed in deciSiemens per meter ($dS.m^{-1}$).

The conductivity cell was kept immersed in distilled water when not in use. During the test, the temperature of the soil-water suspension was also recorded.

The cell constant (K) was calculated using the formula:

Cell constant (K) = ECe25 = ECT × K × ft

where ECe25 represents the conductivity of the extract at 25°C. The known conductivity of 0.01 N KCl was used as a reference for the calculation, and the measured conductivity of the 0.01 N KCl solution was recorded.

Heavy Metals Analysis

The instrument was calibrated using calibration blank and five series of working standard solutions of each metal to be analyzed. The digested samples were determined for the concentrations of heavy metals (Fe, Zn Mn, Cu, Co, Ni, Cd, and Pb) using flame atomic absorption spectrophotometer (FAAS, Model: AA-320N, Shanghai, China). Final concentrations of the metals in the soil samples were calculated using appropriate formula.

Results

Baseline Physicochemical Characteristics of Soil Samples

The soil samples were examined for physicochemical parameters such as temperature, pH, Sulphate, Nitrate, Phosphate, Total organic matter, Soil texture, Heavy Metals (Lead, Zinc, Nickel, Chromium Arsenic, Cobalt and Cu) and the result summarized in Table 1. The physicochemical properties of soils varied significantly across ecosystems. Heavy metal analysis revealed that the samples contain the tested heavy metals, but all at low levels below Department of Petroleum Resource (DPR) target limit. Forest soils and farmland soils exhibited variable pH values, from slightly acidic pH to alkaline pH. Soil Organic Carbon (TOC): Forest soils and farmland soils TOC also varied in both locations in their percentages as seen in the table 4.1. For bulk density, Forest soils had the lowest bulk density (0.7-1.1 kg/m^3), while farmland soils showed the highest (1.2-1.6 kg/m^3).

Baseline Microbial Characteristics and Counts of Soil Samples

The soil samples were subjected to baseline microbial characteristics and counts. Total heterotrophic bacteria and total fungi were determined. Table 2 summarizes the count of each soil sample; Table 3 summarizes the cultural morphology of bacterial isolates while Tables 4 and 5 respectively summarizes the biochemical test of bacterial isolates and cultural/microscopy of fungal isolates obtained from soil samples.

The present study analyzed soil bacterial metagenomes involved in carbon sequestration in different plant-defined ecosystems. Baseline physicochemical parameters (temperature, pH, Sulphate, Nitrate, Phosphate, Total organic matter, Soil texture) as summarized in Table 1 varied across vegetation types. Heavy Metals (Lead, Zinc, Nickel, Chromium Arsenic, Cobalt and Cu) were all within intervention limits**.** The physicochemical properties of soils varied significantly across ecosystems. Heavy metal analysis revealed that the samples contain the tested heavy metals, but all at low levels below Department of Petroleum Resource (DPR) target limit. Forest soils and farmland soils exhibited variable pH values, from slightly acidic pH to alkaline pH. Soil Organic Carbon (TOC): Forest soils and farmland soils TOC also varied in both locations in their percentages as seen in the table 4.1. For bulk density, Forest soils had the low bulk density (0.7-1.1 kg/m^3), while farmland soils showed the higher (1.2-1.6 kg/m^3). Notably also was higher Total Organic Carbon (TOC) and Total Organic Matter (TOM) values in the forest samples. As displayed in Table 1. Several studies have reported similar higher values of Total Organic Carbon (TOC) and Total Organic Matter (TOM) to be generally higher in forest soils compared to farmland soils primarily due to the continuous input of organic residues such as leaf litter, root exudates, and minimal human disturbance. Forest ecosystems naturally accumulate organic material over time, and the slower decomposition rates, especially in forests dominated by ectomycorrhizal species, further contribute to the buildup of organic matter and carbon (Akinbola et al., 2018). In contrast, farmland soils are often depleted of organic matter through regular tillage, harvesting, and limited organic residue return, resulting in lower TOC and TOM levels (Yüksel et al.,2024).

Table 1: Baseline physicochemical characteristics of the four soil samples and a control

Sample	A1	A2	B1	B2	C	DPR Target limit	DPR Target limit
Texture	Loamy	Sandy/Loamy	Loamy	Sady/loamy	Sandy		
pH	5.90	7.50	5.89	6.52	7.5		
Moisture content (%)	24.81	17.67	19.57	13.72	2.0		
Bulk Density (kg/m3)	0.842	1.601	0.743	1.201	0.5		
TOC (%)	10.10	8.56	9.80	7.99	1.5		
E.C (µS/cm)	120.13	124.16	112.40	97.14	10		
TOM (%)	14.50	9.39	13.21	8.30	0.2		
Nitrate (mg/kg)	23.61	12.22	20.38	13.38	5		
Phosphate (mg/kg)	0.214	0.158	0.364	0.136	0.08		
Zn (mg/kg)	8.60239	8.87091	4.51402	5.31571	0.7	140	720
Pb (mg/kg)	4.85610	4.61398	6.73512	7.14932	0.3	85	530
Cu (mg/kg)	11.64893	9.14265	8.74093	9.21586	0.02	140	720

Key: A1= Forest soil from Port Harcourt A2= Forest soil sample from Bonny B1=Farmland soil sample from Bonny B2=Farmland soil sample from Port Harcourt C= Control (road soil sample)

Table 2: Mean baseline microbial counts for the soil samples

Soil sample	Total, Heterotrophic Bacteria (cfu/g)	Total utilizing fungi (cfu/g)
A1	$4\pm0.3x10^8$	$3\pm0.2x10^7$
A2	$4.2\pm0.4x10^8$	$3\pm0.3x10^7$
B1	$3.1\pm0.3x10^8$	$2\pm0.4x10^7$
B2	$2.3\pm0.5x10^8$	$\pm0.9x10^7$

Values represent mean and standard deviation from three replicate counts

Baseline microbial characteristics and counts was carried out as we don't have to bypass the conventional microbiological identification of the culturable microbiome. Total heterotrophic bacteria and total fungi counts is summarized in Table 2 for each soil sample. Good counts were exhibited by each soil samples. This is because, soils under vegetation like grasslands, forests, even well-managed agriculture/farmland generally exhibit higher total heterotrophic microbial counts due to higher organic matter and microbial substrates. This was also reported by Rousk et al., 2009. Table 3 summarizes the cultural morphology of bacterial isolates

while Tables 4 and 5 respectively summarizes the biochemical test of bacterial isolates and cultural/microscopy of fungal isolates obtained from soil samples.

Table 3: Cultural Morphology of Bacterial Isolates

Sample	color	shape	margin	surface	Opacity	Elevation	Size(mm)	Code
A1	White	Circular	Serrated	Rough &dull	Opaque	Raised	7	Ng1
	Greyish	Circular	Entire	Smooth& shining	Translucent	Flat	2	Ng2
B1	White	Irregular	Serrated	Rough &dull	Translucent	Flat	20	Ng3
	White	Circular	Serrated	Rough &dry	Translucent	Flat	8	Ng4
	Cream	Irregular	Serrated	Smooth & shining	Transparent	Flat	5	Ng5
	Cream	Circular	Serrated	Smooth & dull	Opaque	Flat	3	Ng5a
	Brown	Circular	Entire	Smooth &dull	Opaque	Raised	2	Ng5b
	White	Circular	Entire	Smooth & shining	Opaque	Raised	2	Ng5c
A2	White	Circular	Serrated	Smooth & shining	Opaque	Flat	2	Ng6
	Yellow brown	Circular	Entire	Smooth & shining	Opaque	Raised	3	Ng7
	White	Irregular	Serrated	Smooth & shining	Opaque	Flat	12	Ng8
	Cream	Circular	Entire	Smooth & shining	Opaque	Raised	5	Ng9
B2	White	Circular	Entire	Smooth & shining	Opaque	Raised	4	Ng10
	White	Irregular	Serrated	Smooth & shining	Opaque	Flat	4	Ng11
	White	Circular	Entire	Smooth & shining	Opaque	Flat	7	Ng12

As earlier stated, two soil samples (A1 and A2) were further studied to the metagenomic level due to financial constraints and very high rate of metagenomic analysis. From the result (the comparative relative abundance of bacterial phyla in the two samples A1 and A2), both samples share a similar overall microbial composition, dominated by Pseudomonadota, Actinomycetota, and Bacillota. Sample A1 has a slightly higher proportion of Actinomycetota, whereas Pseudomonadota is more abundant in A2. Several other phyla are present in low abundances, with little variation between the two samples. The presence of a large proportion of unclassified sequences (82% in A1 and 83% in A2) suggests a high level of microbial diversity and highlights the limitations of the current reference database in capturing the full taxonomic spectrum. This comparative analysis of bacterial phyla in soil samples A1 and A2 from a plant-defined ecosystem reveals a microbial community structure dominated by Pseudomonadota (formerly Proteobacteria), Actinomycetota (formerly Actinobacteria), and Bacillota (formerly Firmicutes). These dominant phyla are known to play significant roles in soil carbon cycling processes. Pseudomonadota, particularly the Gammaproteobacteria class, are prevalent in various soil environments and are associated with the decomposition of organic matter, contributing to carbon mineralization. Actinomycetota are recognized for their ability to decompose complex organic compounds, such as cellulose and lignin, facilitating the turnover of soil organic carbon (SOC). Bacillota are also involved in the decomposition of organic matter and have been linked to carbon cycling in soil ecosystems.

The high proportion of unclassified sequences (82% in A1 and 83% in A2) suggests the presence of potentially novel or poorly characterized microbial taxa involved in carbon sequestration. This highlights the limitations of current reference databases and underscores the need for further metagenomic studies to uncover the full extent of microbial diversity and function in soil ecosystems. We can say that the microbial community composition in samples A1 and A2 indicates a robust potential for carbon sequestration, driven by the dominant bacterial phyla known for their roles in carbon cycling. The presence of a substantial proportion of unclassified sequences points to the existence of yet-to-be-characterized microbial taxa that may contribute to carbon sequestration processes in plant-defined ecosystems.

Conclusion

The findings of this study underscore the significant impact of land-use type on the composition and function of soil microbial communities. Forest soils (Sample A1) harbour a more metabolically diverse and functionally specialized bacterial community capable of autotrophic CO_2 fixation, primarily via the CBB cycle. This aligns with the broader ecological role of forest ecosystems in

carbon sequestration. Numerous studies have demonstrated that forest soils consistently exhibit superior microbial traits that are highly conducive to carbon sequestration. These soils are typically rich in organic matter, possess stable microaggregate structures, and support diverse and functionally active microbial communities. To enhance carbon sequestration in farmland soils, it is essential to adopt and promote a suite of sustainable agricultural practices that support microbial activity and diversity.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Credit Authorship Contribution Statement

Egbe, V. N., .: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, Visualization, Project administration, Writing - original draft. **Stanley, H. O and Osu, C. I..:** Supervision, Methodology, Validation, Formal analysis, Data curation, Visualization, Review & Editing.

References

Akinbola, G. E., & Adigun, A. O. (2018). Soil physico-chemical properties and fertility status of long-term land use and cover changes: A case study in forest vegetative zone of Nigeria. Eurasian Journal of Soil Science, 7(2), 133–150. https://doi.org/10.18393/ejss.366168

Albuquerque, L., & da Costa, M. S. (2014). The family idiomarinaceae. In *The Prokaryotes* (pp. 361-385). Springer, Berlin, Heidelberg.

Arenberg, M. R., & Arai, Y. (2019). Uncertainties in soil physicochemical factors controlling phosphorus mineralization and immobilization processes. *Advances in agronomy*, *154*, 153-200.

EPA (2013). Introduction to in situ bioremediation of groundwater. Office of Solid Waste and Emergency Response. United State Environmental Protection Agency, EPA 542-R-13-18

Chen, X., Yang, K., Xu, Y. & Li, K. (2019). Top-100 highest-cited original articles in inflammatory bowel disease a bibliometric analysis. Medicine. 98, e15718 https:// doi.org/10.1097/MD.0000000000015718.

McCauley, A., Jones, C., & Jacobsen, J. (2009). Soil pH and organic matter. *Nutrient management module*, *8*(2), 1-12.

Nazir, M. J., Li, G., Nazir, M. M., Zulfiqar, F., Siddique, K. H., Iqbal, B., & Du, D. (2024). Harnessing soil carbon sequestration to address climate change challenges in agriculture. *Soil and Tillage Research*, *237*, 105959.

Sarkar, B., Singh, M., Mandal, S., Churchman, G. J., & Bolan, N. S. (2018). Clay minerals—Organic matter interactions in relation to carbon stabilization in soils. In *The future of soil carbon* (pp. 71-86). Academic Press.

Yüksel, E. E., & Yavuz, G. (2024). Evaluating the soil properties of different land use types in the Deviskel watershed in the hilly region of Northeast Türkiye. Sustainability, 16(22), 9732. https://doi.org/10.3390/su16229732