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Assessment of the Physicochemical and Microbial Properties of Rhizosphere Soils Under Mono-plantations and Rain Forest in South Eastern Nigeria

Ediene VF[1]*, Ofem KI[1], Unuigbe BO[1], Enyiegoro KP[1]
[1]Department of Soil Science, University of Calabar, Calabar, Nigeria

[*]**Address for Correspondence:** Ediene Victoria Francis, Lecturer II, Department of Soil Science, University of Calabar, Calabar, Nigeria
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ABSTRACT- Composite soil samples were collected from the rhizospheres of *Gmelina arborea*, *Elaeis guineensis* and *Hevea brasiliensis* plantations as well as the Rain Forest of over 20 years of age in Akampa L.G.A. at depths of 0-15 cm (surface soil) and 15-30 cm (sub surface soil), to examine the effects of land use and management practices on some physical, chemical and microbial properties of the soils. The soils were mainly sandy loam, strongly acid in reaction and generally low in available P, exchangeable Ca^{2+}, K^{+} and Na^{+}, but moderate in Mg^{2+} except for the surface soil in *Elaeis guineensis* plantation which was however, high in organic C (4.29 %), total N (0.37 %) and Mg (3.9 cmol kg^{-1}). The soils regardless of the land use patterns were high in exchangeable acidity with *Elaeis guineensis* having the least values. Diverse species of microorganisms were isolated across the different plantations and rain forest, however, *Elaeis guineensis* recorded the highest microbial count. Land use altered the microbial population and also had an effect on the species composition of soil microbial communities. *Bacillus* sp, *Pseudomonas* sp., *Fusarium* sp, *Penicillium* sp and *Mucor* sp as well as *Aspergillus niger* were however, common across the study sites while other organisms were location specific suggesting vegetation and land use meddling. The effects of land use pattern were noted in the chemical and microbial alteration observed mostly in the top of rhizosphere soils. It is pertinent that good management practices such as liming, mulching as well as cover cropping be carried out to increase and maintain the fertility of the soils.

Key-words- Land use, Physicochemical and Microbial properties, Rain Forest, Rhizosphere

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INTRODUCTION

Land constitutes a sensitive asset resource that acts as pivot in agriculture and other industries. Over dependence on land to solve the common challenges of man has overburdened land and exposed it to the effects of degradation which include but not limited to loss of biodiversity and soils nutrients, soil acidification, alkalinization, salinization and other soil management induced threats to agriculture; consequently, land is shaped and designed to suite the economic or political benefit man intends to derive.

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This gives rise to land use which is the common series of operations carried out by man, with the intension to obtain products and benefits from land resources, hence inappropriate land use may aggravate the degradation of soil physicochemical and biological properties [1-3]. However, land use affects basic processes such as erosion, soil structure and aggregate stability, nutrients cycling, leaching, carbon sequestration and other physical and chemical processes [4].

The soil biological components are the active and primary factors in the physical and chemical formations of soils [5], and soil organisms tend to maintain a fertile soil as a vital ecological service [6], with a concomitant decomposition and mineralization of plant materials and the subsequent release of nutrients for crop uptake [7-8]. Soils under similar climatic condition that are put into different land uses are likely to be different in their fertility status mainly as a result of the age and type of organic materials; the rate at which they drop and mineralize and the capacity of a given type of crop roots to hold nutrients in place and reduce losses.

According to Oseni [9], forest soils are richer in chemical nutrients and microbial parameters than plantations or intensively cropped lands, while similar studies by Aisuene [10] revealed high total nitrogen and low available phosphorus, organic carbon and basic cations in oil palm plantations. However, the rate at which nutrients are depleted in different land use types shows that secondary forests < oil palm < arable cropping < building sites, with secondary forest being the most depleted [11].

Akamkpa Local Government Area (LGA) is richly blessed with diverse forest and mineral resources. Its highly dense tropical rain forest is a source of Gmelina, Teak, Opepe, Obeche, and numerous species of animals and insects. The area is a rich source of granitic materials and is known for its pure form of limestone in Nigeria. The exploitation of these resources, especially the solid minerals and forests for the purpose of development has severely affected and altered the natural ecosystem, affecting the soil nutrient reserve and having adverse effects on arable and tree crops in the area. This study is therefore imperative, as the physicochemical and microbial properties of the soils under different land use types will be assessed and the nutrient status compared with the view of identifying limiting nutrients. Ameliorative measures will also be suggested on limiting properties for improved productivity.

MATERIALS AND METHODS

Description of the Study Area

The study area is located in Akamkpa LGA (Longitude 5^0 00", 5^0 57" N and Latitude 8^0 06, 9^0 00" E) in southern Cross River State, Southeast Nigeria. Akamkpa is bordered by Odukpani and Akpabuyo LGAs to the West and South respectively, Biase and Yakurr to the Northwest, Ikom and Etung LGA to the North and the Republic of Cameroun to the West. The area is characterized by distinct rainy and dry seasons with a short spell of Harmattan between November and February. It has an annual rainfall of 1300–3000 mm and annual temperature range of 21–30^0C and relative humidity of 75–80%. The study area is gentle to flat with well drained soils that are characterized by a mixture of stones in the soil surface. Akamkpa LGA is underlain by Basement Complex rocks and consist basically of upper older granites in all identified land use types, though parts of the area is underlain by Sedimentary materials of limestone, shale and sandstone intercalation.

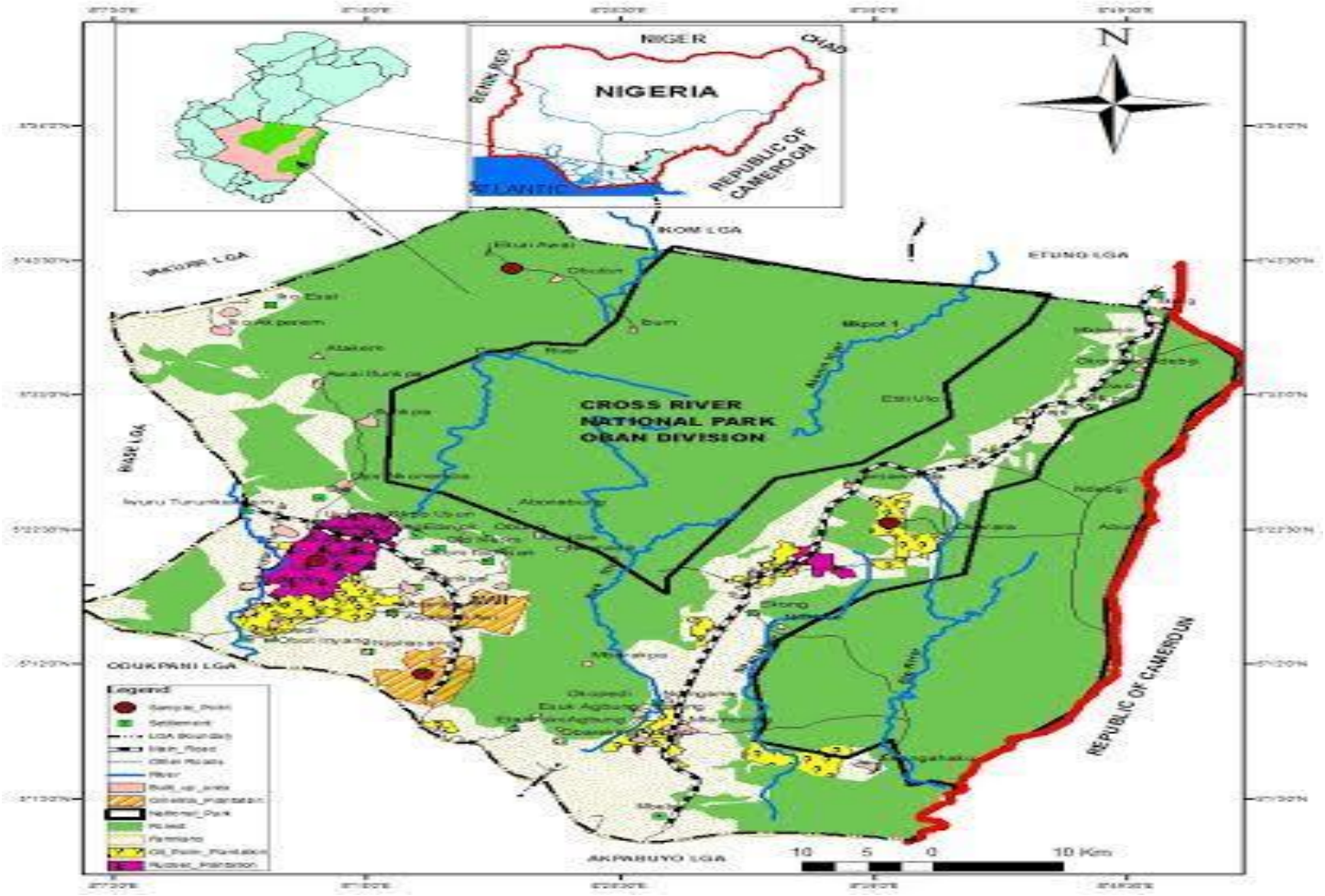

Fig. 1: Land Use Map of Akamkpa Local government Area

Vegetation and Land use

The vegetation is mainly humid tropical rainforest with the largest forest area in the state. It has fertile soils with many rivers and streams with a large tract of reserved forest, Gmelina, wood pulp plantations as well as privately owned Rubber and Oil palm plantations. A part from the abundance of granitic rocks, limestone and Kaolin also abound in the area. This has led to the establishment of quarries in the area.

Field studies

Four land use types ranging from Rainforest and Gmelina plantation to Oil palm plantation as well as Rubber plantation were identified within Akamkpa LGA (Fig. 1). A sampling area measuring 30 mx30 m was marked out in each land use type and soil samples collected with the aid of an auger from five points of the marked area (Fig. 2) at depths of 0–15 cm and 15–30 cm to represent top and subsoil respectively. At each depth, the five soil samples were bulked to form a composite sample. Eight representative composite soil samples were therefore collected from the four land use types in sampling bags, labeled and transported to the laboratory for physicochemical analyses. Soil samples for microbial analyses were collected aseptically in sterile poly bags, labelled and transported in ice parked coolers to the laboratory for analysis.

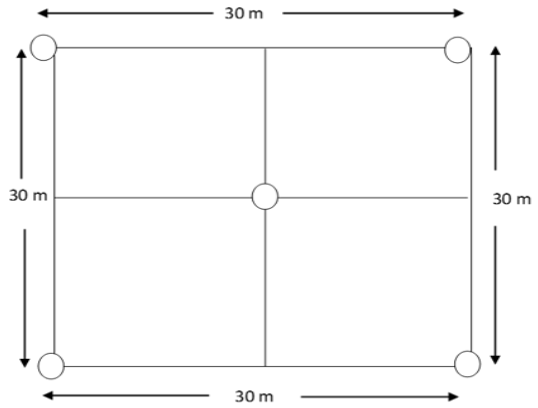

Fig. 2: Field Layout of the Sampling Area in each Land use type (Sampling points)

Laboratory studies

Soil samples meant for physiochemical analysis were air dried, crushed and sieved with a 2mm mesh sieve. The fine earth fraction (<2mm) was obtained and used for physicochemical analyses while the coarse fraction was discarded. Particle size distribution was determined by the Bouyoucos Hydrometer method [12]. Soil pH (H_2O) was determined potentiometrically in 1:1 soil: water while organic carbon was determined by the Walkley and Black Wet oxidation method [13] and total nitrogen by the Macro Kjeldahl digestion method [14]. Bray No. 1 method was used for the determination of available phosphorus [15], while exchangeable $Ca^{2+,}$ $Mg^{2+,}$ K^+ and Na^+ were extracted using I*N* NH_4OAc (pH 7.0). Exchangeable Ca^{2+} and Mg^{2+} were determined in the extract by atomic absorption spectrometry [16] while Na^+ and K^+ were determined by the flame photometry. Exchangeable acidity (Exch. Al^{3+} and H^+) was determined by using 1M KCl as extracting reagent and titrated against 0.01M NaOH [16]. Effective cation exchange capacity was determined by the sum of the exchangeable basic cations and exchangeable acidity.

Microbial Analyses

Reagents used in the study

Soil Extract was prepared by suspending 1000 g of soil in 1 litter (1000 ml) of distilled water and stirred vigorously using stirring rod. The mixture was filtered with a Whatman No. 4 filter paper. The filtrate was sterilized by autoclaving at a temperature of 121^0C and pressure of 1 b/sq. inch for 15 minutes. The extract was used in the preparation of agar for the estimation of total heterotrophic aerobic bacteria, purification and for stock culture. Malt extract agar was used for the isolation of fungi.

Enumeration of total heterotrophic Bacteria and Fungi

Soil samples were serially diluted in ten folds [17] at dilution factors of 10^{-6} and 10^{-3} for bacteria and fungi respectively. Total viable heterotrophic aerobic bacterial and fungal counts were determined using the pour plate technique. Molten soil extract agar and malt extract agar were poured into sterile Petri-dishes containing 1mL of the appropriate aliquot diluents for the isolation of total heterotrophic bacteria and fungi, however, plating was done in triplicates while observing all precautions. Colony counts were taken after incubating the plates at 30^0C for 24 and 48 hours for bacteria and fungi respectively. The bacterial isolates were sub cultured into nutrient agar slants which were then used for biochemical tests.

Characterization and Identification of isolates

Upon microscopic study of the bacterial isolates, characterization and identification was carried out at a magnification of X40 using an objective lens. Gram positive (+ve) organisms were seen as blue or violet colourations while red colours indicate gram negative (-ve) bacteria, however, spore formation, motility, oxidase and catalase production; citrate utilization, oxidative/fermentation (O/F) utilization of glucose; indole and coagulase production, starch hydrolysis, sugar fermentation, methyl red-Voges Proskaur reaction and urease production tests were also performed. The tests were performed by standard procedures [17-24], while microbial identification was performed as outlined by Bergey [25]. Fungal isolates were examined macroscopically and microscopically using the needle mounts technique [26-27].

RESULTS AND DISCUSSION

Physicochemical properties of the soils

The physicochemical properties of the soils are discussed with respect to Table 1. The particle size distribution was dominated by sand (Fig. 3), with values that ranged between 65.5% in the Oil palm plantation and 75.7% in the forest soils with a mean of 70.5% in the surface soils. Silt fraction ranged between 13.7% in the Gmelina plantation and 24.2% in the Oil palm plantation while clay was averaged at 10.3% in the entire surface soils (Fig. 3). The textural class was sandy loam irrespective of soil depth and land use type, an indication that the land use type had no effect on the textural class. Such sand dominated soils are likely to encourage water infiltration through the immediate soil surface, permit leaching of exchangeable bases and reduce the cation exchange surface on the mineral colloidal fraction.

The soil pH values ranged between 5.1 in Gmelina and Oil palm plantations and 5.4 in Rubber plantation with a mean of 5.2 in the surface soils. The soils are strongly acid [28] and are likely to encourage significant amounts of exchangeable Al^{3+} and H^{+} as to affect plant growth and encourage the solubility of Mn^{2+} and hinder plant root development.

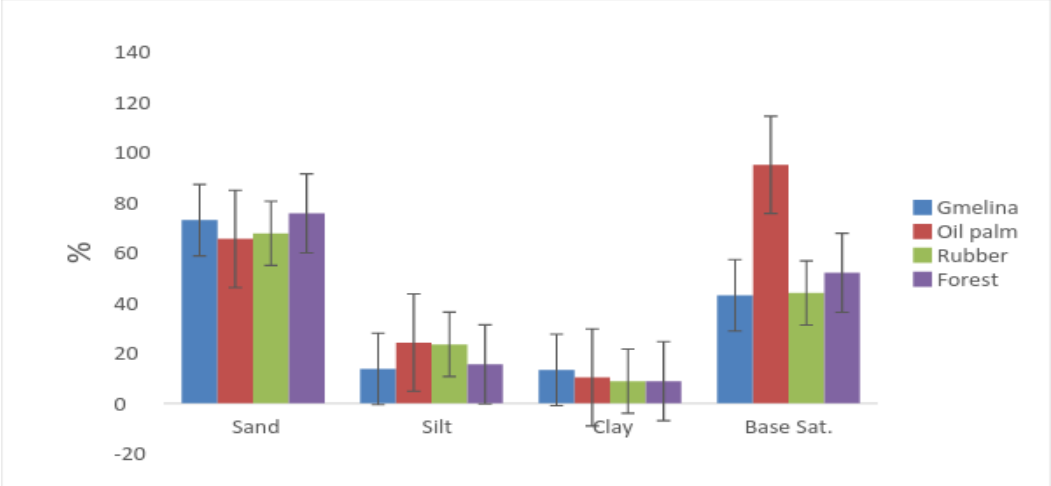

Fig. 3: Standard error bar charts showing physical properties for the soil surface

The continuous removal of bases through continuous cropping, harvesting of crops without the return of crop residues to soil and sandy textural class as well as high rainfall in the tropical rainforest region may have been responsible for such low pH values. Soil organic carbon content was higher in the surface soils and ranged between 0.86% in the Rubber plantation and 4.29% in the Oil palm plantation with a mean of 2.09% and 1.06% in the surface (Fig. 4) and subsurface of the entire soils. Such values are moderate [28], but relatively high in the Oil palm plantation. Total nitrogen was higher in the surface soil irrespective of the land use type (just like organic carbon was) and had values that ranged between 0.07% in the Rubber plantation and 0.37 % in the Oil palm plantation with means of 0.18 % and 0.09 % in the surface and subsurface of the soils respectively. The soils are moderate in total N [28], and may respond positively to the application of organic and inorganic fertilizers. Available P ranged between 0.40 mg/kg in the Rubber plantation and 0.81 mg/kg in the Gmelina plantation with values that generally increased with soil depth, such values are very low [28] for productive soils and may require phosphatic fertilizers in the entire soils. The value of exchangeable Ca^{2+} ranged between 1.3 $cmolkg^{1-}$ in the Rubber plantation and 4.3 $cmolkg^{-1}$ in the Oil palm plantation, with a mean of 2.2 $cmolkg^{-1}$ in the surface and 1.5 $cmolkg^{-1}$ in the subsurface. Exchangeable Mg^{2+} ranged from 0.8 $cmolkg^{-1}$ in the Gmelina plantation to 3.9 $cmolkg^{-1}$ in the Oil palm plantation with a mean of 2.2 $cmolkg^{-1}$ in the surface soil and 1.4 $cmolkg^{-1}$ in the subsurface soils. Mean values of 0.09 $cmolkg^{-1}$ and 0.08 $cmolkg^{-1}$ were obtained in the surface and subsurface soils for exchangeable K^{+} and Na^{+} respectively.

Irrespective of land use type, the entire soils are low in exchangeable Ca^{2+}, K^{+} and Na^{+} but moderate in exchangeable Mg^{2+} [28]; however, soils of Oil palm plantation were strikingly higher in the basic cations, probably due to the high organic carbon/matter content and comparatively higher silt content which may have contributed to the soil's cation exchange capacity. The fibrous and dense root system of Oil palm which concentrates in the soil surface, hold nutrients in place and decay to add organic materials to the soils which act as exchange cites for the basic cations. Exchangeable acidity was the sum of exchangeable $Al^{3+}$and H^{+}.

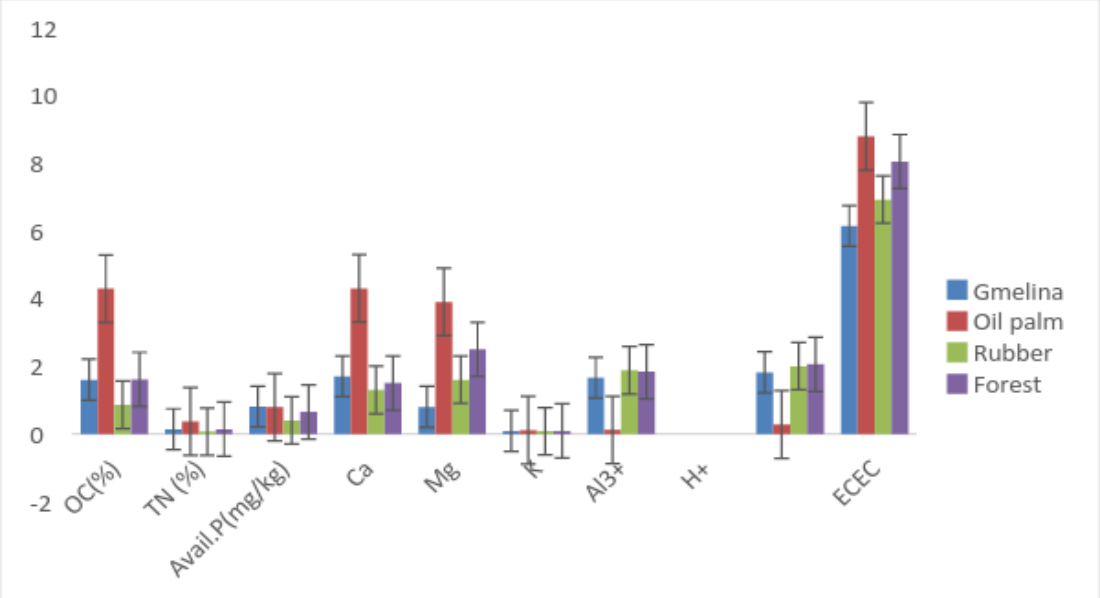

Fig. 4: Standard error bar charts showing chemical properties for the soil surface

Table 1: Physicochemical properties of the Land use types in Akamkpa L.G.A.

Land use Type	Soil Depth	Sand	Silt	Clay	Text.	pH	OM	OC	TN	Available P	Exchangeable Bases Ca	Mg	K	Na	Exchangeable Acidity Al^{3+}	H^+	ECEC	Base Sat.
	Cm	←	%	→			←	%	→	$mgkg^{-1}$	←			$cmolkg^{-1}$		→		%
Gmelina	0 - 15	73.0	13.7	13.3	Sl	5.1	2.85	1.60	0.14	0.81	1.7	0.8	0.09	0.07	1.66	1.82	6.14	43
	15-30	70.0	11.7	18.3	Sl	5.3	1.50	0.87	0.07	0.88	1.4	0.8	0.08	0.05	3.12	3.34	8.79	27
Oil palm	0 - 15	65.5	24.2	10.3	Sl	5.1	7.39	4.29	0.37	0.79	4.3	3.9	0.11	0.08	0.12	0.28	8.79	95
	15-30	62.5	22.7	14.8	Sl	5.4	3.37	1.96	0.17	0.55	2.3	1.3	0.09	0.06	0.24	0.56	4.55	82
Rubber	0 - 15	67.7	23.5	8.8	Sl	5.4	1.49	0.86	0.07	0.40	1.3	1.6	0.08	0.06	1.88	2.00	6.92	44
	15-30	67.7	19.5	12.8	Sl	5.4	1.50	0.87	0.07	0.94	1.2	1.4	0.07	0.06	2.13	2.64	7.5	36
Forest	0 - 15	75.7	15.5	8.8	Sl	5.1	2.77	1.61	0.14	0.65	1.5	2.5	0.09	0.05	1.84	2.06	8.04	52
	15-30	70.7	17.5	11.8	Sl	5.0	0.92	0.54	0.04	0.84	1.1	2.2	0.08	0.06	1.68	2.16	7.28	47
Mean Surface		70.5	19.2	10.3	Sl	5.2	3.63	2.09	0.18	0.66	2.2	2.2	0.09	0.07	1.38	1.54	7.48	59
Range Surface		65.5-75.7	13.724.2	8.8-13.3		5.1-5.4	1.49-7.39	0.86-4.29	0.07-0.37	0.40-0.81	1.3-4.3	0.8 - 3.9	0.08-0.11	0.05-0.08	0.12-1.88	0.28-2.06	6.14-8.79	43 – 95
Mean Subsurface		67.7	17.9	14.4	Sl	5.0	1.82	1.06	0.09	0.80	1.5	1.4	0.08	0.06	1.79	2.18	7.03	48
Range Subsurface		62.5-70.7	11.7-22.7	11.818.3		5.0-5.4	0.92-3.37	0.54-1.96	0.04-0.17	0.55-0.94	1.1-2.3	0.8 – 2.2	0.07- 0.09	0.05-0.06	0.24-3.12	0.56-2.64	4.55- 8.79	27 – 82

Sl. = Sandy loam

Exchangeable Al^{3+} ranged between 0.12 cmolkg^{-1} in the Oil palm plantation and 1.88 cmolkg^{-1} in the Rubber plantation with a mean of 1.38 cmolkg^{-1} in the surface and 1.79 cmolkg^{-1} in the subsurface soils. Exchangeable H^+ ranged between 0.28 cmolkg^{-1} in the Oil palm plantation and2.06 cmolkg^{-1} in the forest soils. Values for exchangeable acidity are high and are a reflection of low exchangeable bases and low pH values which were less than 5.5 in the entire soils.

Suffice it to say that, Oil palm plantation soils which had relatively high values for exchangeable bases, had the least values for exchangeable acidity, hence the availability of most nutrients. Consequently, high value of exchangeable acidity were obtained in the surface of Forest (3.90 cmolkg^{-1}) and subsurface of Gmelina soils (6.46 cmolkg^{-1}). Effective cation exchange capacity in the surface soils ranged between 6.12 cmolkg^{-1} in the Rubber plantation and 8.79 cmolkg^{-1}in the Oil palm plantation with a mean of 7.27 cmolkg^{-1} in the entire soils. These values are moderate [28] and are contributed mainly by exchangeable Ca^{2+}, Mg^{2+} and acidity parameters. Base saturation values ranged between 43 % in Rubber plantation and 95 % in the Oil palm plantation. Values in Oil palm plantation are high while those in other plantations are low [28].

Microbial properties of the soils

The microbial properties of the soils are discussed with respect to Tables 2 and 3. The probable bacterial isolates in the rhizosphere soils of *Gmelina arborea* plantation include *Athrobacter sp, Agrobacterium sp, Bacillus sp, Micrococcus sp* and *Pseudomonas* while the fungal isolates were *Aspergillus niger, Paecelomyces sp, Penicillium sp* and *Fusarium* sp. Mean counts of 33.5 x10^6 and 29 x10^6 were obtained in the top and sub soil respectively for bacterial isolates and 20 x10^3 and 11 x10^3 x 10^3 in the top and sub soils for fungal isolates respectively. Furthermore, bacterial isolates identified in *Elaeis guineensis* plantation are *Cellulosimicrobium sp, Enterobacter sp, Bacillus sp, Klebsiella sp, Pseudomonas sp, Enterococcus sp and Clostridium sp* while *Fusarium sp, Geotrichum sp, Verticillium sp, Penicillium sp, Trichoderma sp, Aspergillus sp, Mucor sp* and *Fusarium sp* were the fungal isolates. Mean count of 48.2 x10^6 and 37.4 x10^6 were obtained in the top and sub soils respectively for bacterial isolates while fungal isolates had mean counts of 27 x10^3 and 20 x10^3 in the top and sub soils respectively. In the Rain Forest rhizosphere, bacterial isolates observed include *Cladosporium sp, Penicillium sp, Verticillium sp, Aspergillus sp, Fusarium sp and Mucor sp* while *Cladosporium sp, Penicillium sp, Verticillium sp* and *Aspergillus sp* as well as *Fusarium sp* and *Mucor sp* were obtained for fungal isolates. Bacterial isolates had a mean count of 34 x10^6 and 30.1 x10^6 in the top and sub soils while fungal isolates had means of 20 x10^3 and 17 x10^3in the top and sub soils, respectively.

In the *Hevea brasiliensis* plantation, common bacterial isolates in the rhizosphere *Actinomyces sp, Actinoplanes sp, Arthrobacter sp, Streptomyces sp, Micromonospora sp,* and *Gordona sp* while *Nocardia sp, Aspergillus sp, Mucor sp, Penicillium sp, Pythium sp, Fusarium sp* and *Phytophthora sp* were obtained as fungal isolates in the rhizosphere. Bacterial isolates recorded means of 33 x10^6 and 23 x10^6 in the top and sub soils respectively, while fungal isolates had means of 18 x10^3 and 11 x10^3 in the top and sub soils respectively. *Elaeis guineensis* plantation recorded the highest microbial count in the study area.

This is attributed to the high accumulation of litter materials from palm fronds, fruits and empty bunches droppings present at various stages of decomposition. Bacterial population was higher than the population of fungi, however, bacterial and fungal population were higher in the top soils than in sub soils across the plantations and the Rain Forest. This result is in line with the reports of [9, 25].

The different microbial communities isolated for the various land uses may be as a result of ecological alteration by human activities, changes in species composition of the plants, variation in the decomposition stages of litter materials and the availability of substrate for utilization by the microorganisms. This diversity in species of organisms at the different land uses is an indication that the land use types may have experienced altered biogeochemical cycling, due mainly to cultivation [30,31], field management [32], or contamination [33]. This is in agreement with the findings of Ajwa [34], that human activities have diverse effects on organic matter turnover and therefore, affect microbial activities because microbes are sensitive to disturbance.

Table 2: Mean bacterial Population and probable bacterial isolates in soils of the rainforest and mono plantations in Akampa LGA

Land Use	**Plate count (cfu/g) (Top soil)**	**Plate count (cfu/g) (Sub soil)**	**Probable Bacterial Isolate**
Gmelina arborea	6×10^6	4×10^6	*Athrobacter sp*
Plantation	4×10^6	12×10^6	*Agrobacterium sp*
	8×10^6	6×10^6	*Bacillus sp*
	6×10^6	4×10^6	*Micrococcus sp*
	5.5×10^6	3×10^6	*Pseudomonas sp*
Total	33.5×10^6	29×10^6	
Elaeis guineensis	5×10^6	4×10^6	*Cellulosimicrobium sp*
Plantation			*Enterobacter sp*
	4×10^6	3×10^6	*Bacillus sp*
	16×10^6	13×10^6	*Klebsiella sp*
	5×10^6	4×10^6	*Pseudomonas sp*
	6×10^6	5.4×10^6	*Enterococcus sp*
	5×10^6	3×10^6	*Clostridium sp*
	7.2×10^6	5×10^6	
Total	48.2×10^6	37.4×10^6	
Rain Forest	1×10^6	2×10^6	*Athrobacter sp*
	7×10^6	6.1×10^6	*Agromyces sp*
	5×10^6	3×10^6	*Bacillus sp*
	5×10^6	5×10^6	*Klebsiella sp*
	9×10^6	6×10^6	*Micrococcus sp*
	7×10^6	8×10^6	*Pseudomonas sp*
Total	34×10^6	30.1×10^6	
Hevea brasilinesis	2×10^6	1×10^6	*Actinomyces sp*
Plantation	4×10^6	3×10^6	*Actinoplanes sp*
	4×10^6	2×10^6	*Arthrobacter sp*
	5×10^6	3×10^6	*Streptomyces sp*
	4×10^6	3×10^6	*Micromonospora sp*
	2×10^6	1×10^6	*Gordona sp*
	12×10^6	10×10^6	*Nocardia sp*
Total	33×10^6	23×10^6	

Table 3: Mean fungal Population and probable fungal isolates from soils of the rainforest and mono plantations in Akampa LGA

Land use type	Plate count (cfu/g) (Top soil)	Plate count (cfu/g) (Sub soil)	Probable Fungal Isolate
Plantation	8×10^{-3} 3×10^{-3} 5×10^{-3} 4×10^{-3}	6×10^{-3} 2×10^{-3} 3×10^{-3} 2×10^{-3}	*Aspergillus niger* *Paecelomyces sp* *Penicillium sp* *Fusarium sp*
Total	20×10^{-3}	11×10^{-3}	
Elaeis guineensis Plantation	5×10^{-3} 6×10^{-3} 6×10^{-3} 4×10^{-3} 3×10^{-3} 3×10^{-3}	3×10^{-3} 2×10^{-3} 5×10^{-3} 5×10^{-3} 2×10^{-3} 2×10^{-3} 1×10^{-3}	*Fusarium sp* *Geotrichum sp* *Verticillium sp* *Penicillium sp* *Trichoderma sp* *Aspergillus sp* *Mucor sp*
Total	27×10^{-3}	20×10^{-3}	
Rain Forest	3×10^{-3} 6×10^{-3} 5×10^{-3} 2×10^{-3} 5×10^{-3} 4×10^{-3}	3×10^{-3} 4×10^{-3} 3×10^{-3} 2×10^{-3} 2×10^{-3} 3×10^{-3}	*Cladosporium sp* *Penicillium sp* *Verticillium sp* *Aspergillus sp* *Fusarium sp* *Mucor sp*
Total	20×10^{-3}	17×10^{-3}	
Hevea brasilinesis Plantation	3×10^{-3} 4×10^{-3} 3×10^{-3} 4×10^{-3} 2×10^{-3} 2×10^{-3}	2×10^{-3} 3×10^{-3} 2×10^{-3} 2×10^{-3} 1×10^{-3} 1×10^{-3}	*Aspergillus sp* *Mucor sp* *Penicillium sp* *Pythium sp* *Fusarium sp* *Phytophthora sp*
Total	18×10^{-3}	11×10^{-3}	

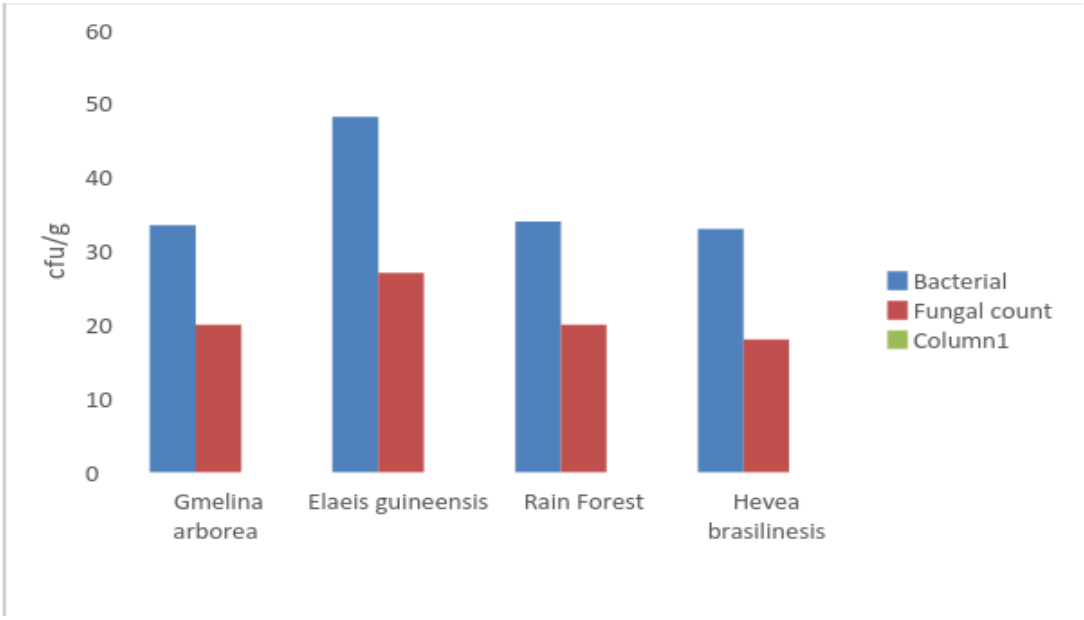

Fig. 5: Mean bacterial ($x\ 10^{6}$) and fungal ($x10^{3}$) Population from top soils of the rainforest and plantations in Akampa LGA

SUMMARY AND CONCLUSIONS

The soils were sandy loam irrespective of land use and soil depth with strongly acid reaction and high exchangeable acidity except in the Oil palm plantation which comparatively, had the best fertility status with the highest organic C content while Rubber plantation had the least values in most fertility properties including; organic C, total N, available P and exchangeable Ca^{2+}. However, diverse species of microorganisms were isolated across the different plantations and rain forest, as *Elaeis guineensis* recorded the highest microbial count. Land use altered the soil chemical properties as well as the microbial population and had an effect on the species composition of soil microbial communities. *Bacillus sp, Pseudomonas sp., Fusarium sp., Penicillium sp* and *Mucor sp* as well as *Aspergillus niger* were however, common across the study sites while other organisms were location specific**.**

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