

# Studies on Soil Microbes of Tropical Moist Forest in Federal University Otuoke, Bayelsa State, Nigeria

Unanaonwi O E<sup>\*1</sup>, Doubra O<sup>2</sup>

<sup>1</sup>Department of Biology Federal University Otuoke, Bayelsa State, Nigeria

<sup>2</sup>Department of Microbiology Federal University Otuoke, Bayelsa State, Nigeria

**Abstract**—Soil microbes vary according to forest stand and composition and this two governs soil condition. Rural farmers believe that moist or wet soil is not suitable for forest and agricultural production. This study investigated soil microbes in a tropical moist forest soil as well as the physico-chemical properties, on the backdrop that soil microbial population, organic carbon content, electrical conductivity, and acidity have been used as good indicators of soil fertility. Three forest stands were chosen viz; high forested area (site A), low forested area (site B), and cultivated area (site C) 5m x 5m sample plot sizes were mapped out from each selected site and one sample plot per selected area were randomly chosen for investigation. Soil samples were collected for analyses. Results shows that mean values for bacteria counts were not significantly different among the sites ( $p < 0.05$ ). Mean values for fungi isolates were significantly different among the sites ( $p < 0.05$ ), the mean values of bacteria counts for low forested soil and cultivated land were significantly different ( $p < 0.05$ ) while site A was not. Mean values for the physico-chemical parameters investigated were not significantly different ( $p < 0.05$ ) across the sites. The soil could sustain plantation forestry and crop production.

**Keywords**—Soil Microbes, Tropical Moist Forest, Plantation Forestry, Crop Production.

## I. INTRODUCTION

Soil as a natural phenomenon on the earth's surface is as vital as air and water for human survival and continuity of life in general (Garg, 2010). Soil is a natural medium for the growth of plants and if the forest must continue to supply its numerous resources (timber and non-timber), nature of the soil must also be understood because forest productivity is a high index for site quality (Unanaonwi and Bada, 2013). It has been stated that people all over the world have attached some importance to soil and the forest for a variety of

highly significant features such as food supply, production of fibers and drugs, infiltration of surface water, purification of groundwater, recycling of solid wastes (especially organic wastes), and other human need (Eilers, 2012).

However, studies have revealed that soil is not an inert static material, but a medium for certain pulsating lives. The soil is one of the main reservoirs of microbial life; it is an excellent culture media for the growth and development of various microorganisms (Kormondy, 2012). It contains several distinct groups of microorganisms and among them are bacteria, fungi, actinomycetes, algae, protozoa and viruses. However, soil contains millions of microbes in each gram and each organism or group of organisms are responsible for a specific change and transformation in the soil. It is believed that microbes have spatial distribution in soil, i.e. microbial population differs with soil location (Ogidiolu, 2003; Olubiyo, 2003). The various activities of microorganisms in the soil are to make the soil fit for growth and development of higher plants, including forest trees; decomposition, nitrogen fixation etc. (Ukpong, 2009). Plant and Soil microbial activities contributes to a balance in the ecosystem and this balance is as a result of interactions between the producers (plants), consumers (animals and man) and decomposers (microorganisms). A functional ecosystem is dynamic which brings about ecological balance (Bardgett, 2005). In soil ecosystem, there is continuous interaction between plants and soil microbes which have increase soil fertility, promote plant growth, and decompose organic matters (Onduru *et al*, 2006). This interaction has maintained a natural balance in all soil types. A decrease in soil microbial population affects plants growth thus affecting man (i.e consumers). This balance is altered when there is over proliferation of soil microbial population or a drastic decrease in soil microbial population (Stine *et al*, 2002, Boyle *et al*, 2008). A functioning soil must be balance for plant growth leading

to increase crop yield. However, Soil microbial populations differ from one location to another and this research wants to ascertain this assertion in wetland soil of Otuoke.

### 1.1 Soil and soil microbes

Soil is one of the most dynamic sites of biological interactions in nature. It is the regions where most physical, biological and chemical reactions related to decomposition of organic weathering of parent rock takes place (Rebecca, 2015). Soil is regarded as an excellent culture media for growth and development of various microorganisms. Soil is known to contain several distinct groups of microorganisms and each soil organism is responsible for a specific change and transformation in the soil. Soil organisms play key roles which are either beneficial or harmful to plants, some soil microbes play supportive roles in supporting plant community and the earth surface while others cause diseases to plants (Bardgett, 2005).

Otuoke soil is a wetland soil located in the tropical moist forest region of Nigeria. The soil is water logged year round (Horsfall, 2015). Swampy soil is believed to affect microbial communities, by causing either a decrease or increase of soil microbes in soil. Soil microbes are known to thrive well in moderate soil with available nutrient, however, any alteration from the normal soil affect microbial communities or population which in turn affects plant growth. It has been recognized by scientists that soil microbes improve soil fertility through their activities thus enhancing plants growth and development (Bardgett, 2005). The significant for an in-depth survey of soil samples has been carried out by various scientists including Warcup (1951), Wakman (1927) and Rossi- Cholodny (1928). These scientists discovered that soil contains various microorganisms and these microbes can be grown on a culture medium to obtain visible colonies, and samples stained and viewed under the microscope. Various methods have been carried out to culture soil samples such as serial dilution method, soil plate method and Rossi cholodny slide method (Lauber *et al.* 2010). However, this study focuses on soil microbes in tropical moist forest soil in Otuoke. The project involved investigating microbial population in soil as to gather information about the spatial distribution of soil microbes with various plant densities within the Federal University Otuoke.

In a wetland soil, some specific arable crops are known to grow such as plantain, cassava, banana, cocoyam etc. Soil microbes contribute to the growth of these crops. When soil samples are taken from these plant locations and cultured, it is observed that the soil microbial population differs according to plant density. The area in which plant grows in

large quantities has more microbial communities when compared to areas of less plant population. This could be as a result of soil microbes differing according to plant populations in the soil (Collins, 2010).

### 1.2 Soil Microbes

The term soil microbes refer to organisms that inhabit the soil. Soil is made up of two categories of organism which are soil flora (bacteria, fungi, algae, actinomycetes), and soil fauna (protozoa, termites, ants, nematodes, earthworm, rodent, moles) (Darius, 2008). These organisms are either beneficial or harmful and thus are responsible for specific change or transformation in the soil. However, the various activities of microorganism in the soil makes the soil fit for growth and development of higher plant (Jousset, 2011).

Microorganisms (bacteria and fungi) in the natural environment or from known sources (in vivo) can be grown in an artificial environment in the laboratory (in vitro). However, there must be a supply of raw materials or nutrients for the growth of these microbes. All microbial nutrients are compounds constructed from the chemical elements, such as Carbon, Oxygen, Hydrogen and Nitrogen and others like Phosphorus, Sulphur, potassium, Magnesium, Calcium, sodium (macronutrients). While others such as Copper, Iron, Cobalt, Manganese, Zinc, Molybdenum, Nickel, etc and vitamins (micronutrients) (Ros *et al.* 2008).

A growth environment called a medium (plural media) is used to cultivate microorganisms. Soil microbes formed a very small fraction of the soil mass and occupy a volume of less than 1% in the upper layer of the soil (topsoil) and the range is 15-30cm. In the topsoil, microbial population is very high but decreases with soil depth (Dehlin *et al.* 2006; Slabbert *et al.* 2010).

The spatial pattern of soil microbial community is created by differences in soil parent materials and textures, plant communities, the quantity and quality of soil organic matter and macro- and microclimatic conditions related to altitude and land topography (Girvan *et al.* 2003; Ulrich *et al.* 2006). In addition, the intensity of management of soil tillage has a large impact on soil microbial communities (Bossio *et al.* 2005). Changes in land use and agricultural management greatly alter soil characteristics including physical, chemical and biological properties. For example, conversion from forest to cropped field typically involves major changes in plant biomass and species diversity (Ceja *et al.* 2010). The position and species identity of trees have been shown to influence the spatial pattern of soil microbial communities (Priha *et al.* 2001).

### 1.2.1 Bacteria

Historically, bacteria have been the most important group of soil organisms. They live mainly on the surface of the soil and humus particles. Soil bacteria can be cultured using MacConkey agar, Tryptose Soy Agar and their numbers in soil have been reported to be 100 million to 1 billion bacteria per gram of soil, from a soil containing sufficient farmyard manure (Joanne, *et al.* 2011). Fertile soils contain a greater proportion of bacteria than infertile. Bacteria count can be made using Nutrient agar and the sizes of the bacteria are very small. They are of the figures of small cocci, short straight rods, short curved rods, long rods, rods with branching, thin flexible rods (Bhardwaj *et al.*, 2014, Dastager *et al.*, 2010). These are of the sizes of 0.5µm in diameter to 10µm long. The bacteria's genera are: *Arthrobacter*, *Corynebacter*, *Mycobacter*, *Pseudomonas*, *Actinobacter*, *Radiobacter*, *Rhizobia*. This entire genus's plays an important role in the decomposition of organic matter in the soil, which helps to improve soil fertility (Rudrappa *et al.*, 2008).

### 1.2.2 Actinomycetes

The typical filamentous actinomycetes belong predominantly to the *Streptomyces* and *Micromonospora* groups. Actinomycetes are cultured using peptone water (broth) and they form very fine often much branched hyphae when growing, which break up into spores, either by the tip of the hyphae producing one or two spores (Ochei *et al.*, 2000). They use carbon and nitrogen compound such as cellulose, hemicelluloses, proteins and lignin. Most members are aerobic and some may have a limited ability to reduce nitrates (Gupta *et al.*, 2004). They also appear to be active under pastures and may be the dominant microorganisms in the surface layers of grass lands and thatch surfaces (Hayat *et al.*, 2010). Actinomycetes contribute to the decomposition of dead organic matter, degradation of large organic compounds such as cellulose, carbohydrate, proteins and lignin to smaller organic compounds, thus, supplying nutrient available for plant and other microbes. They also play roles in denitrification, ammonification, and nitrogen fixation (Jousset, 2011).

### 1.2.3 Fungi

Soil fungi are a diverse group of multi-cellular organisms. The best known soil fungi are mushrooms, molds, and yeast, but there are many others that go unnoticed, particularly those living in the soil (Boyle *et al.*, 2008). Soil Fungi can be culture using Sabauraud agar, Potato Dextrose Agar. They grow as long strands called hyphae which they use to push their way between soil particles, rocks, and roots (Raina *et al.*, 2009). The fungi form the second of the

two great groups of soil microorganisms. They cannot be seen with either the naked eye or with a magnifying glass in normal arable soils (Lakshmannan, 2012).

Soil fungi predominantly belong to the groups that form filaments or mycelia, though some species of *Myxomycetes* (slime fungi), yeasts and *Chytridiales* (Chytrids) are also found. Some of its genera are *Mucor*, *Rhizopus*, *Zygorrhynchus*, *Trichoderma*, *Aspergillus*, *Penicillium*; *Cephalosporium* and *Fusarium* (Kenneth, 2012). These are probably usually present as spores in soils to which fresh organic matter has not recently been added (Arora, 2008). The soil fungi are probably all heterotrophic, but the species present have a wide variety of food requirements, ranging from those which can utilize simple carbohydrates, alcohols and organic acids, nitrates or ammonia as the source of nitrogen (Kumar, 2008). Nearly all soil fungi need to be supplied with either inorganic nitrogen salts or organic nitrogen compounds, though some yeasts, such as *Saccharomyces* and *Rhodotorula*, which are mainly subsoil inhabitants, can fix atmospheric nitrogen (Song *et al.*, 2010). The saprophytic fungi can be very efficient converters of food into microbial tissues, some can synthesise 30 to 50 percent of the carbon in the food into their cell substance. The filamentous fungi generally need aerobic conditions all along their filaments. *Penicillium nigricans*, a fungus usually restricted to the upper 5 cm of the surface soil, is less tolerant of high CO<sub>2</sub> concentration than *Zygorrhynchus vuillemini*, a species, which is usually more abundant below 10 cm. The fungi species plays very important role in the fertility of the soils (Joanne *et al.* 2011)

### 1.2.4 Algae

The soil algae are microscopic chlorophyll- containing organisms and belong mainly to the *Cyanophyceae* (*Myxophyceae*) or blue-green algae, the *Xanthophyceae* or yellow-green algae, the *Bacillariaceae* or diatoms and the *Chlorophyceae*; or green algae (Raina *et al.*, 2009). The soil forms typically comprise smaller and simpler species than the aquatic forms and consist either of species which only occur as small organisms or of dwarfed forms of species that can occur as large organisms. Many of the soil algae have their cell walls covered with a thick layer of gummy substances while the cell walls of most diatoms are partially signified.

The soil algae are found not only on the surface and just under the surface, where sunlight or diffused light may be able to penetrate, but also several centimeters below the surface where no light can penetrate (Marasco *et al.*, 2012). Algae develop most readily in damp soils exposed to the sun (the sun is not too hot). They develop most freely on

fertile soils well supplied with nutrients, and tend to be less numerous on light infertile acid soils. The green algae are the dominant group of algae in acid soils, but as the soils become more neutral the blue-green algae and the diatoms become equally important and on fertile soils the blue green algae may be the dominant group. Their members in soil vary from  $2 \times 10^5$  to  $3 \times 10^5$  per gram of soil. They add organic matter to soil, help to bind the soil particles, improve the aeration of swamp soils and fix atmospheric nitrogen (Joanne *et al*, 2011).

Some of the blue-green algae of the family *Nostocaceae*, including members of genera *Nostoc*, *Anabaens*, *Aulosira* and *Cylindrospermum* as well as a few belonging to the families *Rivulariaceae*, *Stigonemataceae* and *Seytonemataceae* have been shown to possess the power of fixing nitrogen from the atmosphere, and thus have simpler food requirements than any other organisms, since they can obtain both their carbon and nitrogen from the air (Schwenke, 2004).

They are of great importance in colonizing bare soil or soil devoid of organic matter, but only the blue-green algae have proved important agriculturally, and then only in hot climates (Jousset, 2011).

### 1.2.5 Protozoa

The soil protozoa are mostly rhizopods and flagellates, include the amoebae, of which *Naegleria gruberi* and *Hartmanella hyalins* are typical representatives. Protozoa are single-celled animals that feed primarily on bacteria, but also eat other protozoa, soluble organic matter, and sometimes fungi. Protozoa are several times larger than bacteria and are classified into Ciliates (move by cilia), Amoebae (move by pseudopod) and Flagellates (use whip-like flagella for locomotion). They play an important role in nutrient cycling, decomposition, thus making nutrient available for use by forest trees and other soil organisms (Ochei *et al*, 2000). They can be used as bio control agent as they help in regulating the population of bacteria by feeding on them. Protozoa are found in moist environment where they are active in the rhizosphere next to the root.

However, the various groups of soil organisms do not live independently of each other, but form an interlocked system more or less in equilibrium with the environment (Kenneth *et al*, 2012). Their activity in soil depend on moisture content, temperature, soil enzymes, dissolution of soil minerals, and breakdown of toxic chemicals (Bardgett, 2005).

### 1.2.6 Microbes of Tropical Forest Soil

Soil profile involves the arrangement of soil into horizons. In addition to horizontal gradient, soil depth has a strong

impact on microbial community composition and biomass and the highest biomass is generally in the top soil (Allison *et al.*, 2007; Ekelund *et al.* 2001; Fierer *et al.*, 2003; Blume *et al.*, 2002). Also soil physical characteristics such as moisture content, pH and temperature causes' temporal variation in microbial structure and activity (Kennedy *et al.*, 2005). Seasonal changes in soil affect microbial communities and also microbial communities are more in uncultivated soil than cultivated soil (Jangid *et al.*, 2011).

Wetlands are transitions between terrestrial and aquatic ecosystems. Wetlands consist primarily of hydric soil, which support aquatic plants. The water found in wetlands can be salt water, fresh water or brackish water. Main wetlands types are swamps, marshes, bogs and fens. Sub-types include mangrove, carr, pocosin, and varzea (Casey *et al*, 2001). Wetlands play a number of roles in the environment, principally water purification, flood control, and shoreline stability. Wetlands are considered to be the most biologically diverse of all ecosystems, serving as home to a wide range of plant and animal life (Bossio *et al*, 2005).

Microbial activities of a wetland are favored due to the mineral content in the soil and its healthful structure. It is the life in the earth that powers its cycles and provides its fertility. Without the activities of soil organisms, organic materials would accumulate and litter the soil surface, and there would be no food for plants. Soil bacteria and fungi play key roles in maintaining a healthy soil, however, soil pH and temperature affects microbial population. They act as decomposers that break down organic materials to produce detritus and other break down products for plant growth (Gupta *et al*, 2004).

Bacteria are present in high diversity in wetland environments, and the largest group of wetland bacteria is the proteobacteria (e.g *Nitrosomonas*, *Pseudomonas* etc) which are capable of a number of important functions ranging from Nitrogen fixation, to denitrification, to iron and sulfate reduction. Another group is the cyanobacteria which are photosynthetic organisms (Joanne *et al*, 2011).

## II. MATERIALS AND METHOD

### 2.1 Study area

The study was conducted in Federal University, Otuoke located at Otuoke town in Ogbia Local Government Area of Bayelsa State, Nigeria. The study area is bounded by Latitude  $4^{\circ} 51' 05.23''$  N, Longitude  $6^{\circ} 20' 14.2''$  E and Latitude  $4^{\circ} 43' 48.69''$  N, Longitude  $6^{\circ} 20' 19.84''$  E. It is bounded to the North by Elebele Community, to the East by Emeyal I and Kolo, to the West by Onuebum and Otuogori,

and to the South by Otuaba and Ewoi Communities; all in Ogbia Local Government Area of Bayelsa State. Otuoke, occupies a central position in the Niger Delta region of Nigeria. The surface is majorly drained by Otuoke Creek-Drainage System, cutting through the community from Elebele in the North, to Otuaba in the South, and emptying into Kolo Creek at Otuogidi/Ogbia town the down South. Its soil, forestlands and extended territories are drained by Ekole Creek in the West through Atubu sub – creek and swamp drainage system; in the East by Kolo Creek drainage system, and South East by Akoloman Creek drainage system (Allison *et al*, 1999).

Three sample sites were purposefully selected within the Federal university, Otuoke. The chosen sites accommodated high density (forest), low density (less forested) and cleared (agricultural land) areas. 5m x 5m sample plot sizes were mapped out from each selected site and one sample plot per selected area were randomly chosen for investigation. One soil sample per plot was collected from 0-15cm, giving a total of three samples. 1kg each of the samples was collected in a labeled sterile pack. Samples were then transported to the laboratory for microbial and physico-chemical analyses. The method of study and isolation of soil organisms in the laboratory was carried out using soil plate dilution or Serial dilution method (Waksman, 1927). Chemical properties such as pH, Electrical Conductivity (EC), Organic Carbon (C), and soil temperature were taken from one soil location to another.

Soil acidity was taken using the pH meter, Electrical conductivity was measured using handheld battery operated meter, soil temperature was taken using a thermometer, and total organic carbon was determined by Rapid Titration Method (Walkley-Black Method, 1947). The data generated were analyzed statistically using T-test.

### III. RESULTS AND DISCUSSION

Table 1 and 2 shows the morphological characteristics and microscopic features of bacteria isolates from the study site which include *Pseudomonas* species, *Bacillus* species, *Staphylococcus* species, *Vibrio* specie, *Streptococcus* species and *Escherichia* species, *Klebsiella* species, *Proteus* species, *Acinetobacter* species. However, other additional microorganisms were Isolated in this study. This could be as a result of the high organic carbon content of a wetland soil. Hashem (2000) isolated similar microorganisms' including *Corynebacterium* and *Listeria* species which were absent in this study. From the morphological features, 5 bacteria species were suspected which include *Aspergillus*

*species*, *Candida species*, *Rhizopus species*, *Mucor species*, *Blastomyces species* and *Geotrichum species*.

Mean values of bacteria and fungi isolates as presented in table 3 and 4 shows that the soil has microbial population within a normal range and it is not a sterile soil despite its wet nature. A wetland soil is highly fertile with efficient number of microbial population and this population is spatially distributed from one soil location to another. The physico-chemical parameters of a wetland soil as shown in Table 6 indicates that a tropical moist forest soil is highly fertile with an Electrical Conductivity (EC) value of 437  $\mu\text{S}/\text{cm}$  at site 1, 469 at site 2 and 364 at site 3. Electrical conductivity is the quantity of available nutrients in the soil. The soil EC reading shows the level of ability the soil water has to carry an electrical charge. EC level in the soil is a good indicator of the amount of nutrients available for crops to absorb. A good EC level will be somewhere above 200 $\mu\text{S}/\text{cm}$  and 1200 $\mu\text{S}/\text{cm}$ . Any soil below 200 means there is not enough nutrients available to the plant and could perhaps show a sterile soil with little microbial activity (Jennifer, 2016). Above 1200 $\mu\text{S}/\text{cm}$  may indicate too much high salt or perhaps a salinity problem in the soil. Otuoke soil is within a good range of EC value which means the soil is highly fertile. The soil has a temperature range between 24°C and 25°C in all three sites, thus favouring the growth of most mesophilic bacteria's and fungi species. All soil is expected to have a yemperature range of 0-60°C (Joanne *et al*, 2011) and Otuoke soil being a wetland soil falls between that rang. The pH of Otuoke soil slightly varies from 7.9 at siteA, 8.5 at site B and 7.3 at site C. Site A and site B has a slightly neutral range, site B has a moderate alkaline soil, and thus the pH shows a basic nature. Therefore, Otuoke soil is not acidic neither is it extremely alkaline but it has a moderate range of alkalinity favouring the growth of bacteria and fungi. This pH result is different from that of Horsfall *et al* (2015), as he described Otuoke soil to have a average pH range of 4.4 that is acidic despite his conclusion that Otuoke soil is highly fertile. Also the organic carbon value in the soil is from 2.3% to 5.8% (range: 0-15% and higher), indicating that the soils are inherently fertile in organic content. This organic carbon is moderately similar to that of Horsfall *et al* (2015) whose values ranges from 2.45% to 3.05% in eight different sites at Otuoke community.

In addition, all the data obtained were subjected to T-test and the results (table 3 and 4) shows that no significant differences were obtained for the bacteria isolates ( $p>0.05$ ). Significant differences were observed for Fungi isolates ( $p<0.05$ ). Also, the mean values of bacteria counts of Site B

and C (table 5) were significant ( $p < 0.05$ ), though site A was not significant ( $p > 0.05$ ). Mean values of the physico-chemical parameters (table 6) of the soil were not significantly different ( $p > 0.05$ ).

#### IV. CONCLUSION

The study has shown that the status of organic carbon content and the Electrical conductivity of Otuoke soil are within the range of high fertility. Though a moist forest soil with water logged nature, it has efficient number of microbial population that is spatially distributed. The soil indicates good amount of nutrients available for crops which is useful information for farmers to engage in agricultural production and perhaps plantation forestry, without the fear of poor yield as a result of infertility.

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Table.1: Morphological Characteristics of bacteria isolates from a tropical moist forest soil in Federal University Otuoke

Morphological characteristics	Media	Gram stain	Oxidase test	Catalase test	Coagulase test	Kligler iron Agar				Suspected organisms	
						slant	Butt	H <sub>2</sub> S	Gas		
Colour	Texture					slant	Butt	H <sub>2</sub> S	Gas		
Pale Pink	Slightly raised	MacConkey	-	+	+	-	R	R	-	-	<i>Pseudomonas</i> Species
Greenish		CLED									
Pinkish	Mucoid	MacConkey	-	-	+	-	Y	Y	-	+	<i>Klebsiella</i> species
Yellow	Slightly raised	CLED									
Pink	Rough surface	MacConkey	-	-	-	-	Y	Y	-	+	<i>Escherichia coli</i>
Yellowish		CLED									
Creamy	Flat surface	Blood Agar	-	+	+	-	R	Y	-	-	<i>Vibro</i> species
Blue-grey	Round colonies	CLED	-	-	+	-	R	Y	+	d	<i>Proteus</i> species

Mucoid with grey colour	Rough surface	Blood Agar Chocolate	+	-	-	-	-	-	-	-	-	<i>Streptococcus</i> species
Creamy	Smooth and	Blood Agar	+	-	+	-	-	-	-	-	-	<i>Staphylococcus</i> species
Smaller colonies	slightly Raised	MacConkey										
Deep Yellow colonies		CLED										
Greyish	Small round colonies	Blood Agar	+	-	+	-	-	-	-	-	-	<i>Bacillus</i> species
Creamy	Small round colonies	MacConkey	-	-	+	-	-	-	-	-	-	<i>Acinetobacter</i> species

Key: Y-yellow, R-red, and d-different strains produce different result.

Table.2: Morphological and Microscopic features of Fungi isolates from a tropical moist forest soil in Federal University, Otuoke

<u>Morphological Characteristics</u>	<u>Microscopic Examination</u>	<u>Suspected Organisms</u>
Velvety filamentous white growth that sporulate black powdery spores	Long septate hyphae with a conidia formed in chains	<i>Aspergillus</i> species
Colonies are cream coloured, raised, entire, smooth and butyrous.	Spherical budding chlamydo spores .	<i>Candida</i> species <i>Rhizopus</i> species
Long hyphael growth which sporulate within two days to turn black spores	Non-septate, branched mycelium with round shaped sporangia.	<i>Mucor</i> species
White and wooly aerial growth that darkens as it sporulate.	Non-septate hyphae with straight sporangiospore with many spherical spores.	<i>Blastomycets</i> species
Cottony texture, colonies produce white area hyphae on the surface which later turn to a yellowish colour as the colony ages.	Produces septate hyphae unbranched conidiophores, conidia are tear drop in shape and develop directly on the hyphae.	<i>Geotrichum</i> species
Whitish smooth circular and raised colony or growth .	Presence of artrospores With rounded end.	

Table.3: Mean values of bacterial isolates from a moist Tropical forest soil in Federal University Otuoke

<u>Bacterial Species isolates</u>	<u>Site A (%)</u>	<u>Site B (%)</u>	<u>Site C (%)</u>
<i>Klebsiella</i>	0.06±0.00	0±0.00	0 ±0.00
<i>Pseudomonas</i>	0.06±0.00	0.08±0.00	0.15±0.00
<i>Escherchia Coli</i>	0.06±0.00	0.08±0.00	0 ±0.00
<i>Vibro species</i>	0.03±0.00	0.04 ±0.00	0 ±0.00
<i>Proteus species</i>	0.030 ±0.00	0±0.00	0.04±0.00
<i>Staphylococcus</i>	0.06±0.00	0 ±0.00	0.08±0.00
<i>Streptococcus</i>	0.19±0.00	0.08±0.00	0.08±0.00
<i>Bacillus species</i>	0±0.00	0.15±0.00	0.08±0.00

<i>Acinetobacter</i>	0±0.00	0.08±0.00	0±0.00
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Table.4: Mean values of Fungi isolates from a Tropical Moist Forest in Federal University Otuoke

Fungal Isolates	SITE A (%)	SITE B (%)	SITE C (%)
<i>Candida</i> species	0.35±0.00	0.36±0.00	0.4±0.00
<i>Blastomyces</i> species	0.04±0.00	0±0.00	0±0.00
<i>Rhizopus</i> species	0.04±0.00	0.07±0.00	0±0.00
<i>Mucor</i> species	0.04±0.00	0±0.00	0.1±0.00
<i>Geotrichum</i> species	0.04±0.00	0±0.00	0±0.00
<i>Aspergillus</i> species	0±0.00	0.07±0.00	0±0.00

Note: Data presented are mean ± standard error of mean; p<0.05= there is significant difference

Table.5: Mean values of Bacteria Counts from a Tropical Moist Forest Soil in Federal University Otuoke

	Site A (×10 <sup>5</sup> )	Site B(×10 <sup>5</sup> )	Site C(×10 <sup>5</sup> )
Bacteria Sample 1	134±0.00 <sup>a</sup>	102.5±0.00 <sup>b</sup>	97.5±0.00 <sup>b</sup>
Sample 2	113±0.00 <sup>a</sup>	93±0.00 <sup>b</sup>	86.5±0.00 <sup>b</sup>

Figures with superscripts b in the same column are significantly different from each other (p<0.05) while superscript a; is not significant (P>0.05).

Table.6: Mean values of Physico-Chemical properties of a Tropical Moist Forest Soil in Federal University Otuoke

Parameters	SITE A	SITE B	SITE C
Electrical conductivity (µS/cm)	218.5±0.00	234.5±0.00	182±0.00
Temperature (°C)	13±0.00	13±0.00	13±0.00
pH	3.95±0.00	4.25±0.00	3.65±0.00
Soil organic carbon (%)	2.9±0.00	2.1±0.00	1.15±0.00

Note: Data presented are mean ± standard error of mean; p>0.05= no significant differences