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Isolation and Characterization of Bacteria from Selected Forest Soil and Water Hyacinth (*eichhornia crassipes)* Compost for Effective Soil Amendments

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Abstract: *A forest is a sizable tract of agricultural land that has been left untouched for several decades and is covered with trees and plants. Water hyacinth and harboring river were collected from new Calabar River in River state Nigeria. Microbiological analyses of the samples were determined using standard techniques. Bacteria population of the soil and water hyacinth compost ranged from 100.66 ± 2.07x 10^9 CFU/g to 56.00 ± 8.88x 10^8 CFU/g. The hydrocarbon utilizing bacterial (HUB) counts range from 55.33± 5.50x 10^8 to 31.0± 3.11x 10^8 CFU/g respectively. Klebsiella sp., Escherichia sp., Staphylococcus sp., Bacillus sp., Pseudomonas sp and Serratia sp. with Bacillus sp. and Pseudomonas sp. as the predominate genera. This study finds that soil from forests and water hyacinth is a good source of microbes that contain organic soil amendment of various groups of nitrogen-fixing and phosphate-solubilizing bacteria. These bacteria can be harvested as biomass or prepared into microbial suspension. To assess their effectiveness in enhancing soil quality and integrity for productive agriculture, this study suggests using the isolates from water hyacinth (Eichhornia crassipes) compost and forest soil either separately or in combination as soil amendment*

Key words: forest, genera, water hyacinth compost, and microbe

INTRODUCTION

A forest is a large area of agricultural land covered with trees and other vegetation that has not been used for many years. Another way to define it is as a part of the earth with a high tree cover or a large area of tree-covered terrain that provides habitat for wild animals. In contrast to natural forests, which are created and managed by humans, all forests are either man-made or indigenous. The most common life form in this complex biological ecosystem is the tree. In 2019, Britannica et al. Organic amendments have been discovered as a substitute for chemical fertilizers in ecologically friendly agriculture, increasing crop yields and enhancing soil fertility. By offering more environmentally acceptable nutrient sources, it has grown to be an essential component of the integrated fertilizer delivery system and has the potential to boost agricultural output (Wu et al., 2005). They improve root development by releasing hormones that promote growth. Microorganisms convert complex nutrients into basic ones that plants can use. They are the result of one or more species of microorganisms that can mobilize nutritionally significant elements from non-useful to useable form through biological processes like nitrogen fixation, phosphate solubilization, removal of contaminants that support plant growth, and biodegradation in soil. Living microbial inoculants of bacteria, algae, or fungi, either separately or in combination, are known as biofertilizer

A soil amendment is a material that can improve the physical and/or chemical properties of soil to make it more favorable for plant growth. Examples of organic additions derived from living organisms include wood chips, grass clippings, straw, compost, manure, biosolids, sawdust, and wood ash (Davis & Wilson 2005). However, the focus of this review is on compost and farmyard manure. In general, plant and animal matter that has fully decomposed through a particular process initiated and supervised by humans is referred to as compost (FiBL, 2012). The average nutritional concentrations of compost are 0.95% N, 0.58% P2O5, and 0.95% K2O, albeit they vary based on the type of compost (farm and town compost). According to Sankaranarayanan (2004), well-decomposed FYM typically contains 0.5% N, 0.2% P2O5, and 0.5% K2O. FiBL (2012) asserts that the availability of potassium and phosphorus from FYM is comparable to that of chemical fertilizers. In contrast, farmyard manure is a more or less decomposed blend of straw and litter used as bedding material, along with livestock feces and urine, primarily from cattle, as well as potential leftovers from the cattle's feed.

Agriculture is the second most significant economic sector in Nigeria, after petroleum. For agriculture to be viable and for food security to be realized, soil integrity and quality must be maintained. Soil fertility refers to a soil's capacity to sustain plant growth by providing essential nutrients and a favorable physicochemical and biological environment as a growing medium. Biofertilizer, which contains living microorganisms, aids in plant growth by boosting the availability, supply, or uptake of primary nutrients to the host through natural processes like nitrogen fixation, phosphorus solubilization, and stimulating plant growth along with the synthesis of growth-promoting substances (FAO, 2020).

MATERIALS AND METHODS

Sample Collection

Soil samples were collected randomly from various forests (Etche, Ogbogoro, and Choba) in Rivers state.
Water hyacinth compost was obtained from new Calabar River in Rivers state and proceeds for composting procedures according to Abu et al., 2024

Microbiological Analysis

Media Preparation

To isolate complete heterotrophic bacteria, nutrient agar was produced in accordance with the manufacturer's instructions. According to Eze and Okpokwasili (2011), mineral salt agar was made with the following ingredients in one liter of aqueous solution: $MgSO_4$ 0.42g, KCl 0.28g, k_2HPO_4 1.25g, KH_2PO_4 0.83g, $NaNO_3$ 0.42g, NaCl 10.0g, and agar 15.0g.

Enumeration of Bacterial Population in Water Hyacinth compost

The microorganisms in the soil and water hyacinth compost were counted. Countable colonies of pure cultures of isolate strains on Nutrient Agar were obtained from the materials using serial dilution and plating procedures. To promote growth and proliferation, isolated isolates were cultivated on Nutrient Agar (NA) plates in a controlled laboratory environment. Nutrient Agar (NA) plates were used to count all of the heterotrophic bacteria present in biocompost samples. Following the proper sample dilutions, 0.1 ml aliquots were plated on NA plates and incubated for one to two days at 37.0C. Colonies were tallied at the conclusion of the incubation period.

Estimation of total hydrocarbon utilizing bacteria in soil and WHC

By plating aliquots (0.1 ml) of samples diluted 10-2, 10-3, and 10-4 on mineral salts agar, which contained (gl-1): NaCl, 10.00; $MgSO_4.7H_2O$, 0.42; KCl, 0.29; KH2PO4, 0.83; $Na_2HPO4.H2O$, 1.25; $NaNO_3$, 0.42; Agar, 15.0 and deionized or distilled water to the 1000 ml mark (pH, 7.2), mean counts of total hydrocarbon utilizers were determined. The medium was autoclaved for 15 minutes at 1210C and 15 psi of pressure to sterilize it. The culture was supplied with crude petroleum in the vapour phase, which was the only source of energy and carbon. To do this, inoculation plates were inverted over sterile filter paper that had been saturated with the sterile crude oil included in Petri dish covers. Every plate was incubated for 24 to 48 hours at 37.0°C.

Sub-culturing, purification, and preservation of isolates

Pure cultures were isolated from discrete colonies by subculturing on nutrient agar and incubated for 24 hours at 37°C. The plate cultures with the isolated bacterial colonies that had grown on them were located inside the laminar airflow. One colony was selected to be used in the inoculating loop. After that, the culture plate was once more sealed. The new plate was streaked with the single colony in a zigzag pattern. To minimize the risk of contamination, the plate's cover was minimized.

Identification of Isolates

An oil immersion objective (x100 magnification) was used to view the isolates, and their morphology and colony characteristics were examined macroscopically. Microscopical analysis was done using Gram staining. Indole, catalase, citrate, motility, urease, starch hydrolase, and sugar fermentation were among the biochemical tests that were carried out. The isolates were identified using Bergey's Manual of Systematic Bacteriology (Buchman & Gibbon, 2011)..

RESULTS

The cultural, morphological and biochemical properties

The cultural and morphological characteristics of bacteria isolated from the soil and water hyacinth. The sizes ranged from 0.1 to 0.9 (cm); the surface showed a variety of smooth, shiny, rough and dry characteristics; the opacity were opaque or transparent in nature; the isolates were circular, irregular and round and the edge were either entire or serrated in nature.

The isolates were identified as species of *Klebsiella, Escherichia, Staphylococcus, Bacillus, Pseudomonas* and *Serratia.*

Table 3.1A: Cultural and morphology test of bacteria isolated from the soil forest soil and WHC

ID	Colour	Size(cm)	Elevation	Surface	Edge	Form	Opacity	Organism suspected
PA1	White	0.3	Flat	SS	Entire	circular	Opaque	*Pseudomonas* sp.
PA2	White	0.1	Flat	SS	Entire	Round	Opaque	*Pseudomonas* sp.
PA3	Grey	0.3	Flat	SS	Serrated	Round	Transparent	*Klebsiella* sp.
PA4	White	0.3	Flat	SS	Entire	Round	Transparent	*Bacillus* sp.
PA5	White	0.4	Flat	Rough	Serrated	Round	Transparent	*Escherichia* sp.
PA6	White	0.3	Flat	SS	Entire	Round	Opaque	*Bacillus* sp.
PA7	White	0.2	Flat	SS	Entire	Irregular	Opaque	*Bacillus* sp.
PA8	Cream	0.4	Unbonated	Smooth/dry	Serrated	Irregular	Opaque	*Serratia* sp.
PA10	White	0.1	Flat	SS	Entire	Round	Transparent	*Staphylococcus* sp.
PA11	white	0.3	Flat	SS	Entire	Irregular	Opaque	*Bacillus* sp.
PA12	White	0.1	Flat	SS	Entire	Round	Transparent	*Pseudomonas* sp.
PA13	White	0.2	Flat	Dry	Serrated	Round	Opaque	*Pseudomonas* sp.
PA14	Cream	0.3	Flat	Dry /rough	Irregular	Round	Opaque	*Serratia* sp.
PA15	White	0.4	Flat	Dry /rough	Serrated	Irregular	Opaque	*Bacillus* sp.
PA17	Cream	0.3	Unbonated	Smooth/dry	Entire	circular	Opaque	*Serratia* sp.
PA18	White	0.4	Flat	Smooth/dry	Entire	Round	Opaque	*Bacillus* sp.
PA19	Green	0.4	Raised	Rough/dry	Serrated	Irregular	Opaque	*Pseudomonas* sp.
PA20	Brown	0.2	Flat	SS	Entire	Round	Transparent	*Bacillus* sp.

Key: SS = Smooth and shiny:
PA = Isolates code

Table 3.1b Biochemical test of bacteria isolated from the soil forest soil and WHC

Isolate ID	Catalase	Oxidase	Citrate	Glucose	Lactose	Indole	MR	VP	Sucrose	TSIA	H2S	Gram-stain	Starch hydrolysis	Motility	cmc hydrolysis
PA1	+	-	-	A	A	-	+	-	A	AB	-	-rod	-	-	-
PA3	+	-	-	A	-	-	+	+	-	AB	-	+rod	+	+	+
PA4	+	-	-	A	A	-	+	-	A	AA	-	+rod	-	+	-
PA5	+	-	+	A	A	-	-	+	A	AA	-	-rod	+	+	+
PA8	+	-	-	A	A	-	-	-	-	AB	-	+cocci	-	+	-
PA10	+	-	-	A	A	-	-	-	-	AB	-	+cocci	-	+	-

Microbiological Properties of Forest soil and water hyacinth compost

The Total Heterotrophic Bacterial Count (THBC) of the soil and water hyacinth compost samples is shown in Table 3.2. The counts range from 100.66 ± 2.07x 10^9 CFU/g to 56.00 ± 8.88x 10^8 CFU/g. The hydrocarbon utilizing bacterial (HUB) counts range from 55.33± 5.50x 10^8 to 31.0± 3.11x 10^8 CFU/g

Table 3.2: Microbial population on forest soil and water hyacinth compost

Samples	THBC (CFU/g)	THUB (CFU/g)
Control soil	75.00 ± 1.30x 10^9	35.2 0± 6.08x 10^9
Etche forest	69.33 ± 3.50x 10^8	32.33 ± 1.52x 10^8
Ogbogoro forest	100.66 ± 2.07x 10^9	55.33± 5.50x 10^8
Choba soil	68.00 ± 8.88x 10^8	43.66± 3.21x 10^8
WHC	56.00 ± 8.88x 10^8	31.0± 3.11x 10^8

Values are mean ± standard deviation (M±S.D) of triplicate determinations (n=3)

Values bearing the same superscript letter (a) is significantly different (P<0.05) when compared to control

Bacterial species found in forest soil and WHC

Bacterial species found in forest soil and WHC is shown in table 3.2 *Bacillus* sp and *Pseudomonas* sp seem to be the most predominate genera common in the samples is agree with

the work of (Abu et al., 2024) who discover that *Bacillus* sp and *Pseudomonas* sp are genera that have bioferilizing potential.

Table 3.3 Abundant of genera found in forest soil and WHC

Etche forest	Ogbogoro forest	Choba soil	WHC
Bacillus sp.	*Bacillus* sp.	*Bacillus* sp.	*Bacillus* sp.
Pseudomonas sp.	*Pseudomonas* sp.	*Pseudomonas* sp.	*Pseudomonas* sp
Serratia sp.	*Alcaligenes* sp.	*Alcaligenes* sp.	*Staphylococcus* sp.
Klebsiella sp	*Escherichia* sp.	*Escherichia* sp.	
Erwinia sp.	*Klebsiella* sp	*Streptococcus* sp	

DISCUSSION

The morphological characteristics and microscopic features of bacteria isolates from the study site which include. As shown in table 3.1 *Acinetobacter species, , Klebsiella species, , Escherichia species Staphylococcus, species, Bacillus species, Pseudomonas species* and *Serratia 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 and water hyacinth compost (Unanaonwi & Doubra, 2017) isolated similar microorganisms' including *Corynebacterium* and *Listeria* species which were absent in this study. From the morphological features, 6 bacteria species were suspected which include: *Klebsiella species, Escherichia species Staphylococcus, species, Bacillus species, Pseudomonas species* and *Serratia species* Mean values of bacteria isolates as presented in table 3.2 shows that the soil and WHC have bacterial population within a normal range and the sample are not a sterile in nature.

The total heterotrophic bacterial count (THB) of soil bacteria and WHC as shown in table 3.2indicated that the count range from $100.66 \pm 2.07 \times 10^9$ CFU/g to $56.00 \pm 8.88 \times 10^8$ CFU/g. The hydrocarbon utilizing bacterial (HUB) counts range from $55.33 \pm 5.50 \times 10^8$ to $31.0 \pm 3.11 \times 10^8$ CFU/g, this is in line with that the presence of bacterial activity increase the Microbial load in soil and WHC. The result obtained shows that the indigenous bacterial community in soil are and WHC were able to thrive and multiply themselves in the environment. A similar observation was reported by (Abu et al., 2024; Ibiene *et al* 2011 and Eze & Okpokwasili 2011)

Result from table 3.3 revealed the abundance of diverse genera of bacteria and fungi including those that have been classified as microbial biofertilizers. This finding agrees with Thomas & Sing (2019) who reported that the most important groups of microbes used in the preparation of biofertilizer are bacteria, which have symbiotic relationship with plants. The isolates A*zotobacter, Rhizobium, Bacillus Enterobacter, Klebsiella* and *Pseudomonas,* which were grouped as nitrogen

fixing, phosphate solubilizing, phosphate mobilizing and plant growth promoting rhizobacteria This result agrees with Adesemoye (2008) who also reported similar bacteria isolates classified as PGPR in his study on soil. In his study, he reported the following genera; *Pseudomonas, , Azotobacter and Klebsiella sp.*as organic amendment

CONCLUSIONS

Modern agriculture relies heavily on the use of organic amendments, which offer a substitute for chemical fertilizers and encourage plant growth and agricultural yield without endangering human or environmental health. In addition to being an annoyance in nutrient-rich water bodies, the seaweed (*Eichhornia crassipes*) sometimes known as water hyacinth, is an inexpensive substitute source of organic fertilizer that is widely available. Numerous bacterial biofertilizer species were isolated from the water hyacinth, (*Eichhornia crassipes).* In order to encourage plant growth and boost crop production for sustainable agriculture, this study finds that soil from forests and water hyacinth is a good source of microbes that contain organic soil amendment of various groups of nitrogen-fixing and phosphate-solubilizing bacteria. These bacteria can be harvested as biomass or prepared into microbial suspension. To assess their effectiveness in enhancing soil quality and integrity for productive agriculture, this study suggests using the isolates from water hyacinth *(Eichhornia crassipes*) and forest soil either separately or in combination as biofertilizer.

REFERENCES

Abu, G.O., Vincent-Akpu, I.F., Akwukwaegbu, R.N., Stanley. H.O., & Udume, O.A. (2024) Laboratory Production and Testing of Biocompost from Water Hyacinth (*Eichhornia Crassipes*) for Bioremediation of Crude Oil-Impacted Agricultural Soil. *International Journal of Research and Technopreneurial Innovations* 1(1): 85-91

Adesemoye, A., Obini M. & Ugoji E. (2008). Comparison of plant growth promotion with *Pseudomonas aeruginosa* and *Bacillus subtilis* in three vegetables. *Brazilian Journal of Microbiology, 39* (3): 423-426

Britannica, T. Editors of Encyclopaedia (2019). *forest*. *Encyclopedia Britannica*. https://www.britannica.com/science/forest

Davis, J. and C. Wilson, 2005. Choosing a Soil Amendment. F*act Sheet No. 7.235*. Colorado State University

Eze, V.C. & Okpokwasili, G.C. (2011). Microbial and other related changes in a Niger sediment receiving industrial effluents. Current. Journal of Microbiology. 4: 15-24.

FAO. (2020). Master Land Use Plan, Ethiopian Range Land/Livestock Consultancy Report Prepared for the Government of the People's Democratic Republic of Ethiopia, Technical Report. Rome, Italy;

FiBL (Forschungsinstitutfür biologischen Landbau) 2012 African Organic Agriculture Training Manual. Version1. Edited by Gilles Weidmann and Lukas Kilcher. Research Institute of Organic Agriculture FiBL, Frick.

Ibiene, A.A., Orji, F.A.& Orji-Nwosu, E.C. (2011). Microbial population in crude oil-polluted soils in the Niger Delta. Nigeria Jourunal of Agriculture and Food Environment. 7(3): 8-13.

Lacey, L.A.; Liu, T.X.; Buchman, J.L.; Munyaneza, J.E.; Goolsby, J.A.; Horton, D.R.(2011) Entomopathogenic fungi (Hypocreales) for control of potato psyllid, *Bactericera cockerelli* (Sulc) (Hemiptera, Triozidae) in an area endemic for zebra chip disease of potato. *Biology. Control*, *56*, 271–278.

Sankaranarayanan, K., 2004. Nutrient potential of organic sources for soil fertility management in organic cottonproduction. CICR, RS, Coimbatore.

Thomas l. & Singh I. (2019). Microbial biofertilizer: types and application. Biofertilizer for sustainable Agriculture and environment. *Soil Biology.* 55.

Unanaonwi O E & Doubra O, (2017) Studies on Soil Microbes of Tropical Moist Forest in Federal University Otuoke, Bayelsa State, Nigeria *International Journal of Environment, Agriculture and Biotechnology (IJEAB) Vol-2, Issue-3, May-Jun- 2017. http://dx.doi.org/10.22161/ijeab/2.3.37*

Wu SC, Cao ZH, Li ZG, Cheung KC & Wong MH (2005). Effects of biofertilizer containing N-fixer, P and K solubilizers and AM fungi on maize growth: A greenhouse trial. *Geoderma*, 125: 155-166.