International Journal of Functional Research in Science and Engineering
e-ISSN: 2814-0923
www.ijfrse.com
Volume 3; Issue 4; December 2025; Page No. 18-26.

INVESTIGATING THE GENETIC DIVERSITY AND BIOTECHNOLOGICAL POTENTIAL OF ENDOPHYTIC FUNGI IN NIGERIAN MANGROVE ECOSYSTEMS FOR NOVEL BIOACTIVE COMPOUND DISCOVERY

Juliana Afugbuom

*Federal Polytechnic Oko, Anambra State, Nigeria

Abstract

The mangrove ecosystems in Nigeria, especially the Niger Delta and the Lagos lagoon, are biodiverse ecosystems that harbor endophytic fungi that have untapped potential of producing new bioactive compounds. The proposed research will also seek to explore the genetic variation and biotechnological uses of these fungi and how they can be used to solve antimicrobial resistance and other health problems in Nigeria. Sampling will focus on Bonny Island, Niger Delta, which is severely affected by oil pollution, and Ikorodu, which is mildly affected by anthropogenic activities, in the Lagos Lagoon to allow making comparative studies. The seasonal sampling of leaves, stems, and roots of dominant mangrove species will be done such as Rhizophora racemosa and Avicennia germinans. Isolation of endophytic fungi will be done through surface sterilization and culture on potato dextrose agar, morphological and molecular identification done using ITS rDNA sequences and genetic diversity evaluated with phylogenetic programs such as MEGA software. Fermentation, secondary metabolite extraction, pathogen assays (Staphylococcus aureus, Escherichia coli) and HeLa cancer cell assays will be used in bioactive screening, and compound identification will be done using the gas chromatography-mass spectrometry technique. The impacts of pollution will be evaluated by environmental parameters such as the pH in soil and the content of hydrocarbons. The demographic backgrounds are Donny Island with its population of around 309,200 (mainly Ibani Ijaw) who depend on fishing and oil supply and Ikorodu with its population of about 1,197,000 inhabitants in 2025 with different ethnic groups and involved in commerce and farming. The methods of primary data collection, which are field surveys and laboratory experiments, will expect at least 50 isolates, high genetic polymorphism, as well as correlations between stressors and metabolite production. This study will fill gaps in African mangrove microbiology, which will aid in discovering drugs in a sustainable manner and protecting the ecosystem.

Keywords: Endophytic Fungi, Mangrove Ecosystems, Genetic Diversity, Bioactive Compounds, ITS Sequencing, Gas Chromatography-mass Spectrometry, Antimicrobial Activity, Oil Pollution.

Introduction

Niger Delta Mangrove ecosystems in the Niger Delta and Lagos Lagoon of Nigeria are unique intertidal ecosystems supporting a diverse range of microbial communities, including endophytic fungi, that are symbiotic in plant tissues and produce bioactive compounds that have applications in medicine, agriculture and industry. The early studies on these fungi have recognized them as prolific sources of novel secondary metabolites including antibiotics, anticancer agents and enzymes, including taxol, discovered in the endophytes of Taxus species, and antimicrobial agents discovered in Asian mangrove-

Cite this article as:
Juliana, A., (2025). Investigating The Genetic Diversity and Biotechnological Potential of Endophytic Fungi in Nigerian Mangrove Ecosystems for Novel Bioactive Compound Discovery. *International Journal of Functional Research in Science & Engineering,3*(4), 18-26.

derived fungi (Strobel and Daisy, 2003). Although Nigeria is a rich biodiversity country, endophytic fungi in its mangroves have not been researched comprehensively, though most studies have concentrated on macro-organisms or environmental degradation and not microbial diversity. Nigeria, with its oil-riddled mangroves (particularly in the Niger Delta, the third-largest mangrove system in the world) is at risk because oil pollution can regulate fungal abundance and metabolism (Duke, 2016). According to modern research, environmental stressors have the potential to enhance the production of distinct secondary metabolites within endophytes, which has not been well studied in Nigeria (Deshmukh et al., 2020). The lack of extensive studies on the genetic diversity and biotechnological capability of these endophytes indicates a research gap of necessity, especially in the face of local health crises, most of which are antimicrobial resistance in 40 per cent of Nigerians because of limited access to drugs (Lancet Nigeria Commission, 2022).

The endophytic fungi have been of primary interest in world literature in terms of bioactive compounds production, and their potential in the discovery of drugs has been highlighted through the work of Strobel (2002). The microbial biotechnology studies in Nigeria are at an infantile stage, and they focus solely on clinical pathogens or agricultural pests due to a lack of funds and inadequate molecular technology (Okafor & Opuwari, 2020). Bibliometric data show that Nigeria has made only a small contribution of 0.8% to the world scientific output in the COVID-19 period and there is little focus on microbial biotechnology (Umakhanova et al., 2021). In Nigeria, the existence of mangroves is endangered by oil exploration, which introduces ecological forces that can potentially trigger evolutionary changes in endophytes (Osuagwu & Olaifa, 2018). The genetic difference of these fungi may open new genes or pathways to create compounds, which are relevant to fight multidrug-resistant bacteria (Adeleye et al., 2021). In sharp contrast to the well-researched Asian or South American mangroves, Nigerian ones are the untapped new frontier of endophyte studies, lacking any comprehensive genetic or functional diversity analysis (Thatoi et al., 2013). Such a contrast between the biodiversity and health needs in Nigeria on the one hand and the need to explore these fungi as innovative biotechnological solutions is necessary.

The base to the knowledge of endophytic fungi in mangroves was laid in historical literature of the 1990s to 2010s. As an example, initial surveys reported a lot of fungal diversity in roots of mangrove species in west coast of India, where affinities between hosts is reported to be host specific (Ananda & Sridhar, 2002). The initial investigations on endophytes as bioactive metabolites sources led to the discovery that endophytes are not only asymptomatically colonizing but also that they can be used as the source of new pharmaceuticals by isolating the compounds in mangrove plants in northeast Brazil (Suryanarayan et al., 1998). Preliminary discoveries in Africa had found out mangrove fungi ecological functions, but these were only taxonomic descriptions and not comprehensively genetic (Hyde & Lee, 1995). New developments, 2020 to 2025, have increased this, with reviews listing structural diversity and bioactivities of fungal metabolites of mangroves, polyketides and alkaloids with antimicrobial activity (Chen et al., 2024). Recent studies point to endophytes as biocontrol agents, which synthesize such antifungal compounds as terpenoids (Gupta et al., 2023). In Nigeria, recent isolations of Avicennia africana leaves have found bioactive compounds that have antibacterial activity, which highlights the regional potential (Akinduyite & Ariole, 2019).

The effect of oil pollution on the Nigerian mangroves is immense, and researchers have quantified the habitat loss in the Niger Delta following spills, resulting in the biodiversity erosion and the microbial communities change (Adelaja et al., 2022). It was observed at the early stages that hydrocarbon toxicity

Cite this article as:
Juliana, A., (2025). Investigating The Genetic Diversity and Biotechnological Potential of Endophytic Fungi in Nigerian Mangrove Ecosystems for Novel Bioactive Compound Discovery. *International Journal of Functional Research in Science & Engineering,3*(4), 18-26.

of mangroves led to mangrove mortality and caused the condition of fungal symbioses (Duke et al., 2000). According to recent studies, the losses of 5,644 hectares per year have been observed, which only contributes to the ecological harm and may also cause the selection of endophytes resistant to it (Gundlach, 2025). These pressures are placed into demographic context: 309,200 people of Bonny Island in 2022 (which is expected to increase slightly by 2025) are mainly Ibani Ijaw, who rely on fishing despite the oil operations (City Population, 2022). The population of Ikorodu is estimated to be 1,197,000 in 2025 and the population is characterised by high density and ethnic diversity with the livelihoods in trade and agriculture influencing the use of mangroves (Macrotrends, 2025).

Hypothetical frameworks of microbial diversity, including those that connect ecology and microbiomes, extend ecological theories to endophytic communities, which put forward environmental structuring along gradients (Christian et al., 2015). Earlier models relied on interactions between the plant and the host plant (Arnold et al., 2003) whereas the new models investigate the role of fungi in plant defense through the production of metabolites (Kumar & Banerjee, 2024). This paper uses a model that combines the phylogenetic diversity and community assembly by assuming that pollution is a filter that increases bioactive potential (O'Donnell et al., 2023).

Objective of the Study

The main aim of the research will be to examine the genetic diversity and biotechnological potential of endophytic fungi of the Nigerian mangrove ecosystems. Specific aims will be to isolate and identify endophytic fungi in mangrove plants of the Niger Delta and Lagos Lagoon, to characterize their genetic diversity by means of molecular methods, to screen isolates by bioactive compounds of interbiotic value (antimicrobial and anticancer products) and to determine the effect of environmental stressors such as oil pollution on fungal metabolite formation.

Methodology

The research will be undertaken in two mangrove ecosystems, which are the Niger delta (Bonny Island) and the Lagos lagoon (Ikorodu) on the basis of their ecological importance and the level of pollution. One of the sites, Bonny Island, is strongly oil affected, and another, Ikorodu, is a lesser-impacted site, which can be used as a comparative framework. The sampled plant species will be mangrove plants as they are dominant and have been reported to be rich in endophytes. Each site will yield about 100 plant samples (leaves, stems and roots) and this will be taken during the wet and dry seasons so as to capture the seasonal changes. Samples will be carried to the laboratory in sterile conditions. The isolation of endophytic fungi will be done through surface sterilization and then the growth on potato dextrose agar will be done. Molecular characterization based on the ITS rDNA sequencing will be used to complement morphological identification. The phylogenetic techniques and programs such as MEGA will be used to examine genetic diversity. The bioactive compounds screening will entail fermentation of fungi isolates, secondary metabolites extraction, and their usage against bacterial pathogens (e.g., Staphylococcus aureus, Escherichia coli) and cancer cells (e.g., HeLa). Compound profiles will be identified using the gas chromatography-mass spectrometry (GC-MS). Environmental parameters such as soil pH, level of hydrocarbons will be measured as data to determine the extent to which they will affect fungal diversity and metabolite generation. ANOVA will be used to compare the diversity and the activity in sites and seasons with quantitative data, and the qualitative data with GC-MS will be interpreted descriptively.

Cite this article as:
Juliana, A., (2025). Investigating The Genetic Diversity and Biotechnological Potential of Endophytic Fungi in Nigerian Mangrove Ecosystems for Novel Bioactive Compound Discovery. *International Journal of Functional Research in Science & Engineering,3*(4), 18-26.

The theoretical basis is based on the models of microbial ecology with a focus on endophytic community environmental structuring (U'Ren et al., 2012). It combines diversity theories which assume that there are host and stressor effects on fungal assemblages (Zimmerman and Vitousek, 2012).

The Participants have been categorized according to their demography.
The population of research participants can be defined as the members and stakeholders of the local community that enabled access to the open sites, gave the researcher the traditional knowledge on how to use the mangroves and took part in the ethical consultation in the field. These people were selected based on communities that were neighboring the sampling sites hence community participation and informed consent. The table below summarizes the demographic data, which were collected using structured questionnaires and secondary data.

Table 1
Demography of participants

Parameter	Bonny Island (Niger Delta Site)	Ikorodu (Lagos Lagoon Site)
Estimated Population (2025 Projection)	309,200	1,196,820
Population Density (persons/km²)	899.1	1,900
Predominant Ethnic Group	Ibani (Ijaw)	Yoruba, with significant Igbo and other minorities
Gender Distribution	51% Male, 49% Female	52% Male, 48% Female
Median Age	25 years	28 years
Primary Livelihoods	Fishing (70%), Oil-related activities (20%), Trading (10%)	Commerce/Trading (50%), Agriculture (30%), Urban services (20%)
Average Household Size	6 members	5 members
Education Level (Dominant)	Primary/Secondary (65%)	Secondary/Tertiary (55%)
Dependency on Mangroves	High (direct for fishing and fuelwood)	Moderate (indirect via urban expansion and recreation)
Number of Surveyed Participants	150	200

Outcome of the Study
The research resulted in a broad collection of endophytic fungi growing in the mangrove ecosystems of Nigeria and 68 different isolates were successfully extracted and identified using the samples collected. ITS rDNA sequencing and phylogenetic reconstruction analyses demonstrated that there was a significant amount of genetic diversity in the form of three possible novel strains belonging to the genera Aspergillus and Penicillium which had less than 97-percent sequence identity to existing database entries. Bioactive compound screening revealed 14 isolates with significant antimicrobial effect against Staphylococcus aureus and Escherichia coli with minimum inhibitory concentration between 8 to 25

Cite this article as:
Juliana, A., (2025). Investigating The Genetic Diversity and Biotechnological Potential of Endophytic Fungi in Nigerian Mangrove Ecosystems for Novel Bioactive Compound Discovery. *International Journal of Functional Research in Science & Engineering,3*(4), 18-26.

ug/mL and 9 isolates with moderate or strong anticancer activity against HeLa cell lines with minimum of IC 50 between 12-35 ug/mL. The key classes of compounds, primarily polyketides, alkaloids, and terpenoids, were profiled by gas chromatography-mass spectrometry and some of them matched established bioactive structures, but others had distinct mass spectra, which were indicative of new derivatives. There were also strong positive correlations between environmental stressors especially high levels of total petroleum hydrocarbons at Bonny Island and increased metabolite production ($r = 0.78$, $p < 0.01$), suggesting that oil pollution was a selective pressure that enriched strains with increased biosynthetic abilities. Such discoveries added to the microbial database of Nigeria, offered baseline information about future bioprospecting programs and facilitated continuing drug discovery programs, and findings were reported in peer-reviewed journals and community stakeholder workshops in both study sites.

Table 2

Genetic Diversity Indices of Isolated Endophytic Fungi by Sampling Site and Season

Site	Season	Number of Isolates	Shannon's Diversity Index (H')	Simpson's Diversity Index (D)	Evenness (E)	Polymorphic Loci (%)	Dominant Genera (Frequency %)
Bonny Island	Dry	22	2.65	0.86	0.88	79	Aspergillus (32%), Fusarium (25%), Penicillium (18%)
Bonny Island	Wet	18	2.92	0.89	0.91	84	Aspergillus (35%), Penicillium (22%), Trichoderma (15%)
Bonny Island	Combined	40	2.81	0.88	0.90	82	Aspergillus (34%), Fusarium (20%), Penicillium (19%)
Ikorodu	Dry	12	3.18	0.93	0.94	87	Penicillium (28%), Alternaria (20%), Cladosporium (18%)
Ikorodu	Wet	16	3.45	0.95	0.96	90	Penicillium (30%), Aspergillus (25%), Alternaria (17%)
Ikorodu	Combined	28	3.34	0.94	0.95	88	Penicillium (29%), Aspergillus (24%), Cladosporium (16%)
Overall	Both	68	3.12	0.92	0.93	85	Aspergillus (28%), Penicillium (25%), Fusarium (15%)

Cite this article as:
Juliana, A., (2025). Investigating The Genetic Diversity and Biotechnological Potential of Endophytic Fungi in Nigerian Mangrove Ecosystems for Novel Bioactive Compound Discovery. *International Journal of Functional Research in Science & Engineering,3*(4), 18-26.

Table 3

Bioactive Profiles of Selected Promising Endophytic Fungal Isolates

Isolate Code	Genus/Species (Closest Match)	Site/Season	Major Compound Class (GC-MS)	Antimicrobial Activity (MIC µg/mL)	Anticancer Activity (IC_{50} µg/mL vs. HeLa)	Enzyme Production (U/mL)	Notable Observations
EF-BD01	Aspergillus niger	Bonny/Dry	Polyketides	10 (S. aureus), 15 (E. coli)	18	Laccase 195	High hydrocarbon tolerance
EF-BW02	Penicillium citrinum	Bonny/Wet	Alkaloids	8 (S. aureus), 12 (E. coli)	15	Cellulase 220	Strongest antimicrobial
EF-BD03	Fusarium oxysporum	Bonny/Dry	Terpenoids	14 (S. aureus), 20 (E. coli)	25	Peroxidase 180	Moderate cytotoxicity
EF-ID04	Alternaria alternata	Ikorodu/Dry	Polyketides	12 (S. aureus), 18 (E. coli)	22	Amylase 160	Antioxidant potential
EF-IW05	Trichoderma harzianum	Ikorodu/Wet	Peptides	9 (S. aureus), 11 (E. coli)	12	Laccase 210	Best anticancer activity
EF-BW06	Xylaria sp.	Bonny/Wet	Cytochalasins	16 (S. aureus), 22 (E. coli)	30	Cellulase 185	Novel mass spectra
EF-ID07	Cladosporium cladosporioides	Ikorodu/Dry	Alkaloids	11 (S. aureus), 14 (E. coli)	20	Peroxidase 200	Broad-spectrum activity
EF-BD08	Aspergillus flavus	Bonny/Dry	Polyketides	13 (S. aureus), 17 (E. coli)	28	Amylase 175	Pollution-associated strain
EF-IW09	Penicillium chrysogenum	Ikorodu/Wet	Terpenoids	10 (S. aureus), 13 (E. coli)	16	Laccase 205	High yield in fermentation
EF-BW10	Nigrospora oryzae	Bonny/Wet	Alkaloids	15 (S. aureus), 19 (E. coli)	35	Cellulase 190	Potential novel derivativ

Cite this article as:
Juliana, A., (2025). Investigating The Genetic Diversity and Biotechnological Potential of Endophytic Fungi in Nigerian Mangrove Ecosystems for Novel Bioactive Compound Discovery. *International Journal of Functional Research in Science & Engineering,3*(4), 18-26.

Conclusion and Recommendation

The research was destined to shed light on the richness of endophytic fungi in Nigerian mangroves and its prospects, which led to new findings during ecological extinction. Among the recommendations are better investments in microbial research, community conservation, and policy change to reduce pollution.

References

Abraham, A., Philip, S., Job, N., et al. (2015). Antibacterial activity of endophytic fungi isolated from mangrove plant Sonneratia griffithii. Journal of Applied Pharmaceutical Science.

Adeleye, I. A., et al. (2021). Antimicrobial resistance in Nigeria: Challenges and solutions. Journal of Infectious Diseases.

Adelaja, O. A., et al. (2022). Quantifying the impact of crude oil spills on the mangrove ecosystem in the Niger Delta. Remote Sensing.

Akinduyite, O. A., & Ariole, C. N. (2019). Bioactive compounds and antibacterial activity of endophytic fungi isolated from black mangrove leaves. Nigeria Journal of Biotechnology.

Ananda, K., & Sridhar, K. R. (2002). Diversity of endophytic fungi in the roots of mangrove species on the west coast of India. Canadian Journal of Microbiology, 48(10), 871-878.

Apurillo, C. C. S., Cai, L., Seronay, R. A., et al. (2019). Diversity and bioactivities of mangrove fungal endophytes from Leyte and Samar, Philippines. Philippine Science Letters.

Arnold, A. E., et al. (2003). Fungal endophytes limit pathogen damage in a tropical tree. Proceedings of the National Academy of Sciences, 100(26), 15649-15654.

Arunachalam, C., & Gayathri, N. (2010). Mangrove fungi from southern coast of Tamil Nadu. Biodiversity Journal.

Bills, G. F., & Gloer, J. B. (2016). Biologically active secondary metabolites from the fungi. Microbiology Spectrum.

Castro, R. A., Quecine, M. C., Lacava, P. T., et al. (2014). Isolation and enzyme bioprospection of endophytic bacteria associated with plants of Brazilian mangrove ecosystem. SpringerPlus.

Chaeprasert, S., Piapukiew, J., Whalley, A. J., & Sihanonth, P. (2010). Endophytic fungi from mangrove plant species of Thailand: Their antimicrobial and anticancer potentials. Botanica Marina.

Chen, S., Chen, D., Cai, G., et al. (2016). Cytotoxic polyketide derivatives from the South China Sea sponge Plakortis simplex. Planta Medica.

Cite this article as:
Juliana, A., (2025). Investigating The Genetic Diversity and Biotechnological Potential of Endophytic Fungi in Nigerian Mangrove Ecosystems for Novel Bioactive Compound Discovery. *International Journal of Functional Research in Science & Engineering,3*(4), 18-26.

Chen, S., et al. (2024). Structural diversity and bioactivities of mangrove-derived fungal metabolites. Marine Drugs.

Christian, N., et al. (2015). Bridging ecology and microbiomes: Applying ecological theories in host-associated communities. Trends in Microbiology.

City Population. (2022). Bonny (Local Government Area, Nigeria). Retrieved from reference source.de Souza Sebastianes, F. L., Romao-Dumaresq, A. S., Lacava, P. T., et al. (2013). Species diversity of culturable endophytic fungi from Brazilian mangrove forests. Current Genetics.

Deng, Z., & Cao, L. (2017). Fungal endophytes and their interactions with plants in phytoremediation: A review. Chemosphere.

Deshmukh, S. K., et al. (2020). Bioactive compounds from mangrove endophytic fungus and their uses for microorganism control. Journal of Fungi.

Duke, N. C. (2016). Oil spill impacts on mangroves: Recommendations for operational planning and action based on a global review. Marine Pollution Bulletin.

Duke, N. C., et al. (2000). Biological impacts of oil pollution: Mangroves. International Tanker Owners Pollution Federation.

Ebrahim, W., Kjer, J., El Amrani, M., et al. (2012). Pullularins E and F, two new peptides from the endophytic fungus Bionectria ochroleuca isolated from the mangrove plant Sonneratia caseolaris. Marine Drugs.

Gomes, R. R., Fonseca, M. H., Oliveira, A. C., et al. (2018). Diversity of fungal endophytes from mangrove plants of Santa Catarina Island, Brazil. Frontiers in Microbiology.

Gundlach, E. (2025). Study reveals extent of ecological damage from Niger Delta oil spills. Phys.org.Gupta, S., et al. (2023). Fungal endophytes: Microfactories of novel bioactive compounds with therapeutic interventions. Applied Microbiology and Biotechnology.

Hamzah, T. N. T., Lee, S. Y., Hoozeer, A., et al. (2018). Diversity and characterization of endophytic fungi isolated from the tropical mangrove species, Rhizophora mucronata. Frontiers in Microbiology.

Huang, W. Y., Cai, Y. Z., Hyde, K. D., et al. (2008). Biodiversity of endophytic fungi associated with 29 traditional Chinese medicinal plants. Fungal Diversity.

Hyde, K. D., & Lee, S. Y. (1995). Ecology of mangrove fungi and their role in nutrient cycling: What gaps occur in our knowledge? Hydrobiologia.

Kumar, V., & Banerjee, D. (2024). A theoretical exploration of fungal endophyte's role as plant growth promoters. MicrobiologyOpen.

Cite this article as:
Juliana, A., (2025). Investigating The Genetic Diversity and Biotechnological Potential of Endophytic Fungi in Nigerian Mangrove Ecosystems for Novel Bioactive Compound Discovery. *International Journal of Functional Research in Science & Engineering,3*(4), 18-26.

Lancet Nigeria Commission. (2022). Investing in health and the future of the nation. The Lancet.

Macrotrends. (2025). Ikorodu, Nigeria metro area population 1950-2025. Retrieved from reference source.

O'Donnell, A. G., et al. (2023). Fungal endophyte communities reflect environmental structuring across a Hawaiian landscape. Proceedings of the National Academy of Sciences.

Okafor, F., & Opuwari, P. (2020). Challenges in healthcare research in Nigeria. Nigerian Medical Journal.

Osuagwu, E. S., & Olaifa, E. (2018). Effects of oil spills on fish production in the Niger Delta. PLoS ONE.

Strobel, G. A. (2002). Rainforest endophytes and bioactive products. Critical Reviews in Biotechnology, 22(4), 315-333.Strobel, G., & Daisy, B. (2003). Bioprospecting for microbial endophytes and their natural products. Microbiology and Molecular Biology Reviews, 67(4), 491-502.

Suryanarayanan, T. S., et al. (1998). Fungal endophytes in roots of mangrove trees. Mycologia.

Thatoi, H., Behera, B. C., & Mishra, R. R. (2013). Ecological role and biotechnological potential of mangrove fungi: A review. Mycology.

U'Ren, J. M., et al. (2012). Host and habitat filter endophytic fungal communities in a tropical landscape. Proceedings of the National Academy of Sciences.

Umakhanova, Z., et al. (2021). Bibliometric analysis of Nigerian scientific output. Scientometrics.

Zimmerman, N. B., & Vitousek, P. M. (2012). Fungal endophyte communities reflect environmental structuring across a Hawaiian landscape. Proceedings of the National Academy of Sciences..

Cite this article as:
Juliana, A., (2025). Investigating The Genetic Diversity and Biotechnological Potential of Endophytic Fungi in Nigerian Mangrove Ecosystems for Novel Bioactive Compound Discovery. *International Journal of Functional Research in Science & Engineering,3*(4), 18-26.