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Mangrove Vegetation Structure and Sediment Microbial Diversity Under Shoreline Disturbance at Iwofe Jetty, Port Harcourt, Nigeria

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ABSTRACT

This study assessed the floristic composition and sediment microbial diversity of mangrove forests at Iwofe Jetty, Port Harcourt, Nigeria. Three belt transects (100 m × 10 m) were established at the study location (A, B, and C), with a control station located approximately 500m away. Vegetation and sediment samples were collected in triplicate. Species richness and diversity were determined using Margalef's and Simpson's indices, while standard microbiological methods were used to isolate and identify sediment microorganisms. A total of 1,046 individual plants belonging to the family Rhizophoraceae were recorded, comprising Rhizophora racemosa, R. harrisonii, and R. mangle. R. racemosa was dominant across all locations (47.32–55.21%), whereas R. mangle showed the lowest abundance (12.95–17.47%). The control site exhibited relatively higher species abundance and diversity. Location A recorded the lowest richness (0.376) and diversity (2.535), while Location B had the highest values (0.549 and 2.756). Sediment analysis revealed bacterial genera including Bacillus, Pseudomonas, Staphylococcus, Aeromonas, Streptococcus, and Micrococcus, as well as fungal genera such as Aspergillus, Rhizopus, Fusarium, and yeast species. Spatial variations suggest potential anthropogenic influence, highlighting the need for continuous ecological monitoring to maintain ecosystem stability.

INTRODUCTION

Mangrove ecosystems are among the most productive and ecologically significant coastal environments worldwide. They provide essential ecosystem services, including shoreline stabilization, erosion control, nutrient recycling, water regulation, and habitat provision for diverse terrestrial and aquatic species (Blankespoor *et al.*, 2016; Kristensen *et al.*, 2008; Lee, 2016). Beyond their ecological functions, mangroves sustain the livelihoods of millions of people in tropical and subtropical coastal regions by providing fuelwood, timber, fisheries resources, and other subsistence products (Fernandes *et al.*, 2018; Primavera *et al.*, 2019). Their primary productivity is comparable to that of tropical rainforests (Alongi, 2014), and they represent some of the most carbon-rich ecosystems globally, playing a critical role in climate change mitigation through long-term carbon sequestration (Donato *et al.*, 2011; Hamilton & Friess, 2018). Despite their ecological and socio-economic importance, mangroves are increasingly threatened by anthropogenic pressures. Global mangrove loss has been estimated at approximately 1–2% annually due to land conversion for agriculture, aquaculture, urban expansion, industrial development, and logging activities (FAO, 2007; Valiela *et al.*, 2001). Such disturbances alter soil properties, reduce vegetation abundance and diversity, and disrupt ecosystem functioning (Ngole-Jeme *et al.*, 2016). The degradation of mangrove ecosystems compromises their capacity to deliver ecosystem services, thereby posing significant ecological and socio-environmental consequences for dependent coastal communities (Van Lavieren *et al.*, 2012) Mangrove forests are particularly sensitive to environmental changes and resource exploitation. Anthropogenic disturbances including habitat destruction, land-use conversion, biological resource overexploitation, and landscape modification, can significantly alter trophic dynamics and ecosystem stability (Akbar *et al.*, 2017; Cahyaningish *et al.*, 2022). The clearing of mangrove forests for plantations, settlements, industrial facilities, and aquaculture operations has been widely reported as a major driver of biodiversity decline and ecosystem deterioration. Such pressures reduce species diversity and ecological resilience, ultimately threatening both environmental integrity and socio-economic functions. In the Niger Delta, mangrove ecosystems are increasingly exposed to urban expansion and shoreline activities. The mangroves surrounding Iwofe Jetty in Port Harcourt are subject to continuous human disturbance; however, there is limited empirical information on their current floristic composition and sediment microbial communities. Such baseline ecological data are essential for assessing ecosystem health and guiding conservation efforts. Therefore, this study evaluated the floristic structure and sediment microbial diversity of mangrove forests around Iwofe Jetty to provide scientific evidence for sustainable ecosystem management.

MATERIALS AND METHODS

The study was conducted in Port Harcourt, Rivers State, Nigeria, a highly industrialized urban center within the Niger Delta region. The city serves as a major hub for petroleum exploration, refining, and related industrial

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activities. Port Harcourt lies between latitudes 4°43'–4°54' N and longitudes 6°56'–7°03' E, at an elevation of approximately 18 m above sea level. The area is characterized by a humid tropical climate with a mean annual rainfall exceeding 2,000 mm and an average annual temperature of about 29°C (NMS, 1998). The mangrove forest surrounding Iwofe Jetty is influenced by tidal fluctuations and anthropogenic activities associated with shoreline operations. The mangrove forest adjacent to Iwofe Jetty was delineated into three belt transects (100 m × 10 m), designated as Locations A, B, and C. A control station was established approximately 500 m away from the jetty to minimize direct anthropogenic influence. Vegetation and sediment samples were collected in triplicate along each transect. Plant species encountered within each transect were identified, counted, and recorded. Representative vegetative samples were carefully collected, labeled, and transported to the Department of Forestry and Environment, Rivers State University, for taxonomic identification. Sediment samples for microbial analysis were aseptically collected into sterile vial bottles and transported to the laboratory for microbiological examination.

Table 1: Coordinates of Study Locations

Location	N(Latitude)	E(Longitude)
Location A	40 48'38"	60 55'32"
Location B	40 48'44"	60 55'38"
Location C	40 48'56"	60 55'47"
Control	40 49'22"	60 56'11"

Species richness and diversity of the mangrove vegetation were quantified using established ecological indices. Simpson's diversity index (Simpson, 1949) was applied to evaluate species diversity, while its reciprocal (1/D) was used to interpret diversity in terms of evenness.

$$D = 1 - \left(\frac{\Sigma\, n(n-1)}{N(N-1)}\right)$$

Where D is the index of diversity, N is the total number of individuals observed, and n is the number of individuals of a particular species.

$D^1 = (1/D)$

Margalef's index (Margalef, 1958) was employed to estimate species richness. Calculations were based on the total number of individuals per species within each transect, with species richness reflecting the number of species relative to the total number of individuals. These indices provided insights into the floristic structure and distribution patterns of the mangrove forest surrounding Iwofe Jetty.

$d = (S - 1) / \text{In } N$

Where S is the total number of species, N is the total number of individuals in the sample, and ln represents the natural logarithm.

Sediment samples were processed using ten-fold serial dilutions with sterile physiological saline as the diluent. For bacterial enumeration, aliquots were inoculated onto nutrient agar (NA) plates, while fungi were cultured on mineral salt agar (MSA) using the vapour-phase transfer technique described by Okpokwasili and Amanchukwu (1987). Colonies observed were sub-cultured to obtain pure isolates, which were subsequently characterized and identified through standard biochemical tests following the procedures of Cowan and Steel (1965).

RESULTS AND DISCUSSION

The mangrove forest around Iwofe Jetty was represented by three species, all belonging to the family Rhizophoraceae: Rhizophora racemosa, R. harrisonii, and R. mangle (Fig. 1). A total of 1,046 individual plants were recorded across the study and control sites, with the control location exhibiting the highest total abundance (355 individuals) and Location A the lowest (205 individuals) (Table 2). Across all locations, R. racemosa was the dominant species, accounting for 47–55% of individuals, while R. mangle consistently had the lowest abundance (13–17%). The relative abundance of R.

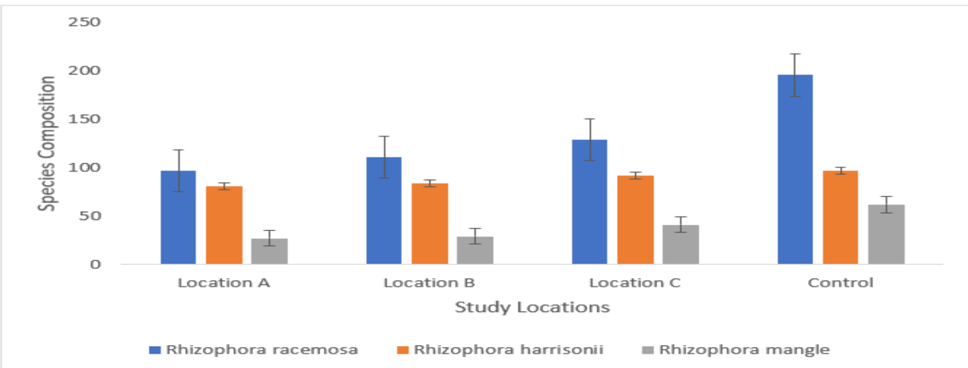

Figure1: Floristic Species Composition

Table 2: Abundance and Relative Abundance of Floristic Species

Species	Species Abundance				Relative abundance			
	A	B	C	Control	A	B	C	Control
Rhizophora racemose	97	111	129	196	47.32	49.55	49.24	55.21
Rhizophora harrisonii	81	84	92	97	39.51	37.50	35.11	27.32
Rhizophora mangle	27	29	41	62	13.17	12.95	15.65	17.47
SUM (N)	205	224	262	355	100	1000	100	100
No of Species (n)	3	3	3	3				

Source: Field survey, 2024

harrisonii ranged from 26–28% across the sites. These results indicate that R. racemosa is the most prevalent species in the study area, whereas R. mangle is relatively rare, and the control site supports higher overall species abundance compared to the impacted transects.

Species richness and diversity, as indicated by Margalef's and Simpson's indices (Table 3), varied across the study sites. Among the experimental transects, Location B exhibited the highest richness (0.549) and diversity (2.756), while Location A recorded the lowest values (richness = 0.376; diversity = 2.535). These results suggest spatial variation in floristic composition, with Location B supporting a relatively more diverse mangrove community compared to other transects.

Table 3: Richness and Diversity of Floristic Species

Indices	Location A	Location B	Location C	Control
Margalef's Species Richness	0.37573	0.54907	0.53802	0.50639
Simpson's Species Diversity	0.39455	0.36289	0.38205	0.37028
Simpson's Inverse	2.53453	2.75566	2.61746	2.70066

Source: Field survey, 2024

Analysis of sediment samples revealed a diverse microbial community (Table 4). The bacterial isolates included Bacillus sp., Pseudomonas sp., Staphylococcus aureus, Aeromonas sp., Streptococcus sp., and Micrococcus sp. Fungal species identified comprised Aspergillus sp., Rhizopus sp., Fusarium sp., and yeast species. These findings indicate that the mangrove sediments support a varied microbial population, reflecting the ecological complexity of the sediment environment around Iwofe Jetty.

Table 4: Bacteria and Fungi Species in the Mangrove Sediments

Study Locations	Microbes	
	Bacterial	Fungi
A	Staphylococcus aureus Bacillus sp.Pseudomonas aeruginosa Citrobacter sp.	Aspergillus niger Fusarium solani
B	Staphylococcus aureus Streptococcus sp. Bacillus subtilis Pseudomonas aeruginosa. Aeromonas aquariorum Micrococcus sp..	Fusarium solani Penicillium bilaiae Rhizopus stolonifer Candida albicans Aspergillus niger Yeast sp.
C	Staphylococcus aureus Aeromonas aquariorum Bacillus subtilis Pseudomonas aeruginosa	Aspergillus niger Fusarium solani Mucor amphiborum Yeast Rhizopus stolonifera
Control	Bacillus subtilis Staphylococcus sp. Micrococcus sp. Aeromonas aquariorum Proteus sp	Mucor amphiborum Candida albicans Aspergillus niger Rhizopus stolonifer Fusarium solani

Source: Field survey, 2024

Discussion

The mangrove forest surrounding Iwofe Jetty was dominated by three true mangrove species: Rhizophora racemosa, R. harrisonii, and R. mangle. This is consistent with reports that the Niger Delta mangroves are primarily composed of red mangrove (R. racemosa), black mangrove (Laguncularia racemosa), and white mangrove (Avicennia germinans) (Omogoriola *et al.*, 2012; Numbere, 2014). The exclusive presence of true mangrove species suggests that, despite proximity to the jetty, the forest is currently not severely disturbed. Previous studies have shown that anthropogenic disturbances often favor mangrove associates or non-mangrove species, replacing true mangrove species in degraded areas (Simbi-Wellington & David-Sarogoro, 2022; Okpiliya *et al.*, 2013). The control location exhibited higher species abundance and diversity compared to transects closer to the jetty, suggesting the onset of gradual degradation near the shoreline with diverse anthropogenic activities. Simpson's diversity index (inverse 1/D) values across all locations fell within the expected range, indicating moderate to high diversity consistent with other studies in the Niger Delta mangroves (Simbi-Wellington & David-Sarogoro, 2022). The highest richness and diversity observed at Location B highlight spatial variation in mangrove structure, likely influenced by microhabitat conditions and localized anthropogenic pressures. Sediment analysis revealed a diverse microbial community, including bacterial genera Bacillus, Pseudomonas, Staphylococcus, Micrococcus, Streptococcus, Citrobacter, Proteus, and Aeromonas, as well as fungal genera Aspergillus, Fusarium, Penicillium, Rhizopus, Candida, Mucor, and yeast species. These results are in agreement with previous reports from Niger Delta mangrove sediments (Simbi-Wellington & Chukunda, 2019; Nwaugo *et al.*, 2005; Ukoima *et al.*, 2016). Hydrocarbon-utilizing bacteria (Bacillus spp. and Pseudomonas bilaiae) and fungi (Fusarium sp. and Penicillium sp.) were detected, indicating potential hydrocarbon contamination in the sediments near the jetty. These microbes are known for their ability to degrade crude oil and other hydrocarbons (Prescott *et al.*, 1999; Ezeigbo *et al.*, 2013). The presence of these microorganisms reflects anthropogenic impacts associated with jetty activities, highlighting the importance of regular monitoring to mitigate environmental pollution and maintain sediment quality.

CONCLUSION

The mangrove forest around Iwofe Jetty is dominated by true mangrove species (Rhizophora racemosa, R. harrisonii, R. mangle), with no non-mangrove species observed, indicating a relatively healthy ecosystem. Sediment analysis revealed diverse bacteria and fungi, including species capable of surviving hydrocarbon-polluted conditions, reflecting the influence of anthropogenic activities. These findings highlight the ecological importance of the mangrove in supporting biodiversity and maintaining ecosystem functions. To preserve these benefits, human activities should be limited to the ecosystem's tolerance limits, and regular monitoring should be implemented. Also, hydrocarbon-tolerant microbes could be explored for biological remediation to support conservation and sustainable management of the mangrove ecosystem.

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