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BENTHIC MACROINVERTEBRATE DIVERSITY AND ECOLOGICAL INTEGRITY OF EBUTE LAGOON: IMPLICATIONS FOR MANGROVE CONSERVATION AND THE BLUE ECONOMY IN SOUTHWESTERN NIGERIA

Agoro Taiwo Olatunbosun[1], Adesina Temitope Abiodun[1] & Ofunama Preye[3]
[1,3]Department of Oceanography and Fisheries Science, Federal Polytechnic Ekowe, Bayelsa State, Nigeria
[2]Department of Chemistry, McPherson University, Ogun State, Nigeria
***Corresponding author**: teegoro@yahoo.com*

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ABSTRACT
The state of the water ecosystem can be assessed using the diversity in the macroinvertebrate community in addition to the instantaneous physicochemical assessment. This research aimed to evaluate the biodiversity and community structure of macroinvertebrates at three stations within a settlement-to-mangrove gradient in Ebute Lagoon, Ikorodu, Lagos State, Nigeria, sampled monthly from March to May 2026 by D-frame sweep-netting. A total of 245 individuals belonging to 13 taxa across 8 orders were recorded, four of which- *Architaenioglossa*, *Haplotaxida*, *Amphipoda*, and *Arhynchobdellida*- were pooled into a single low-count category for statistical testing due to their small individual counts. Species richness was comparable at the settlement-adjacent and mangrove-fringed stations and marginally lower at the intermediate station, but richness relative to sample size, expressed through the Margalef index, was highest at ST3 despite its lowest total abundance. The mangrove-fringed station also recorded the highest Shannon-Wiener diversity, the highest Pielou's evenness, and the lowest Simpson's dominance, indicating the most balanced and structurally diverse community of the three stations. Rank-abundance curves showed a flatter profile at ST3 relative to the steeper, dominance-skewed curve at ST1. A chi-square test of independence on order-level composition across stations was non-significant, indicating that the broad taxonomic composition of the assemblage was proportionally similar across the gradient even though total abundance and fine-scale diversity metrics differed. These findings indicate that Ebute Lagoon retains moderate ecological integrity overall, with the mangrove-fringed margin functioning as the most biodiverse zone of the system, supporting its prioritisation in mangrove conservation and blue economy planning for the Ikorodu axis of Lagos Lagoon.

Keywords: macroinvertebrate biodiversity; community structure; ecosystem health; diversity indices; blue economy; Ebute Lagoon; Nigeria

Introduction

The idea of biodiversity as an indicator of ecosystem health is well-established because it indicates the structural characteristics of a biological community as a product of all the environmental factors acting together over time (Nkwoji, 2023; Kitikidou et al., 2024). The concept becomes especially important in the case of mangrove-affected coastal lagoons because mangroves create complex ecosystems where diverse communities of invertebrates thrive, providing essential ecosystem services and the basis for fisheries, thus forming the foundation for the blue economy (Rodrigues-Filho et al., 2023; Miththapala, 2013). A community survey that not only describes the taxonomic structure of the community but also identifies how biodiversity patterns indicate the integrity of the ecosystem is relevant in terms of conservation of Ebute Lagoon in Ikorodu, Lagos State, where the mangrove-affected lagoon margin had not been studied before in terms of biodiversity indices.

Aquatic macroinvertebrates are ideal for this task since each taxon has a specific place in the pollution tolerance scale from most sensitive such as Ephemeroptera, Plecoptera, and Trichoptera to highly tolerant Chironomidae and Tubificidae (Sabha et al., 2022; Nkwoji et al., 2020). Ecological indicators on the basis of community structure, such as species richness, diversity, evenness and dominance, bring together all these reactions of particular taxa to create indices to compare in space to detect ecologically healthy zones (Padmanabha, 2011; Farukuzzaman et al., 2023).

This study assessed macroinvertebrate biodiversity and community structure across a settlement-to-mangrove gradient in Ebute Lagoon in order to evaluate what these patterns indicate about the ecosystem health of the lagoon as a whole, and specifically what they imply for the conservation status of its mangrove-fringed margin and the blue economy value of the wider system. The study aimed to: (i) characterise the frequency, abundance, and taxonomic composition of macroinvertebrates at each station; (ii) compute a comprehensive suite of biodiversity indices, including richness, diversity, evenness, and dominance measures, for each station; (iii) examine community structure through rank-abundance analysis; and (iv) statistically evaluate whether taxonomic composition differed significantly across the gradient. The null hypothesis this study tests is attached to the fourth objective: taxonomic composition does not differ significantly among stations (H_0: taxonomic composition is independent of station).

Materials and Methods

Study Area and Station Design

Sampling was conducted at three stations in Ebute Lagoon, Ikorodu Local Government Area, Lagos State, Nigeria, spanning a gradient from the main settlement margin (ST1) through an intermediate fishing and transportation zone (ST2) to the mangrove-fringed outer margin (ST3), as described in Adogame (2014) for the wider Lagos Lagoon system.

Macroinvertebrate Sampling

Macroinvertebrates were sampled monthly from March to May 2026 using a hand-held D-frame sweep net (500 µm mesh), with three one-minute sweeps performed at each station per visit across open water, vegetation margins, and shoreline sediment, following standard sweep-netting protocol. Specimens were sorted in the field, preserved in 70% ethanol, and identified to species where possible and to genus otherwise, using standard identification keys, representing the lowest feasible taxonomic level achievable for each specimen. Representative voucher specimens were retained at Lagos State University of Science and Technology (LASUTECH).

Descriptive and Community Analyses

For each station, taxon frequency, total abundance, and relative abundance (percentage of the grand total) were tabulated. Rank-abundance curves were constructed by plotting the abundance of each taxon (log scale) against its abundance rank within each station, providing a visual representation of community evenness and dominance structure independent of the summary indices below.

Biodiversity Indices

Species richness (S) was recorded as the number of taxa per station. The Margalef richness index (d) was calculated as $d = (S - 1) / \ln(N)$, where N is total abundance, to express richness relative to sampling intensity. The Shannon–Wiener diversity index (H) was calculated as $H = -\Sigma(p_i \times \ln p_i)$, where p_i is the proportion of individuals belonging to taxon i. Pielou's evenness index (J′) was calculated as $J' = H / \ln(S)$, expressing the observed diversity relative to the maximum possible diversity at a given richness. Simpson's dominance index (λ) was calculated as $\lambda = \Sigma\, n_i(n_i - 1) / N(N - 1)$, where n_i is the abundance of taxon i, and Simpson's diversity index was derived as its complement $(1 - \lambda)$. A species accumulation curve was not constructed, as the underlying dataset reports pooled three-month totals per station rather than sequential per-visit or per-sweep counts, which this technique requires; this is addressed in the Limitations section.

Statistical Analysis

Because pooled station-level diversity indices (H, J′, λ) were each derived from a single aggregated community per station, they could not be subjected to inferential comparison (e.g., ANOVA or Kruskal–Wallis) without artificial replication. Instead, a chi-square (χ^2) test of independence was applied directly to the observed order-level abundance counts (a genuine contingency table with individual organisms as the unit of count, n = 245) to test the null hypothesis that the proportional taxonomic composition of the assemblage did not differ among the three stations. Orders with very low total counts (Architaenioglossa, Haplotaxida, Amphipoda, Arhynchobdellida) were pooled into a single 'Other' category to satisfy the assumptions of the test. Significance was set at $p < 0.05$. The chi-square test and all diversity index calculations were computed using Python (SciPy v1.11).

Results

Taxonomic Composition, Frequency, and Relative Abundance

Thirteen taxa were recorded across the three stations (Table 1). Geograpsus lividus was the most frequent and abundant taxon overall (50 individuals, 20.41% relative abundance), followed by Culex spp. and Libellula spp. (36 individuals each, 14.69%), Coenagrion spp. (31 individuals, 12.65%), Callinectes sapidus (27 individuals, 11.02%), and Chironomus spp. (24 individuals, 9.80%). These six taxa together accounted for 83.26% of all individuals recorded. Pachymelania spp. and Tubifex spp. were the rarest taxa, each recorded as a single individual, and each restricted to a single station (ST3 and ST1, respectively).

Table 1: Frequency, station-level abundance, and relative abundance of macroinvertebrate taxa recorded at Ebute Lagoon (March–May 2026). Source: Field Data (2026).

Taxon	ST1	ST2	ST3	Total	Rel. Abd. (%)
Geograpsus lividus	30	15	5	50	20.41
Callinectes sapidus	18	6	3	27	11.02
Palaemon serratus	3	2	2	7	2.86
Culex spp.	20	10	6	36	14.69
Chironomus spp.	15	7	2	24	9.80
Libellula spp.	20	8	8	36	14.69
Coenagrion spp.	22	6	3	31	12.65
Tympanotonus spp.	2	1	1	4	1.63
Pachymelania spp.	0	0	1	1	0.41
Tubifex spp.	1	0	0	1	0.41
Gammarus spp.	2	1	1	4	1.63
Dystiscus spp.	9	4	4	17	6.94
Hirudo spp.	3	2	2	7	2.86
Total	145	62	38	245	100

Source: Field Data (2026)

Biodiversity Indices

Table 2 summarises the full suite of biodiversity indices computed for each station. Species richness was equal at ST1 and ST3 (S = 12) and one taxon lower at ST2 (S = 11). When richness was expressed relative to sample size through the Margalef index, however, ST3 recorded the highest value (d = 3.024), followed by ST2 (d = 2.423) and ST1 (d = 2.210), reflecting the fact that ST3 achieved equal or greater richness with substantially fewer individuals (N = 38 versus N = 145 at ST1). The Shannon-Wiener index was highest at ST3 (H = 2.276) and lowest at ST2 (H = 2.132), with ST1 intermediate (H = 2.138). Pielou's evenness followed the same pattern, increasing from ST1 (J′ = 0.860) to ST3 (J′ = 0.916), indicating a progressively more balanced distribution of individuals among taxa along the settlement-to-mangrove gradient. Correspondingly, Simpson's dominance was lowest at ST3 (λ = 0.097; Simpson's diversity index 1 − λ = 0.903) and highest at ST1 (λ = 0.129; 1 − λ = 0.871), confirming that no single taxon dominated the mangrove-fringed assemblage to the degree observed at the settlement-adjacent station.

Table 2: Macroinvertebrate Diversity Indices at Ebute Lagoon Sampling Stations

Index	ST1	ST2	ST3
Total Abundance	145	62	38
Taxa Richness (S)	12	11	12
Margalef richness index (d)	2.210	2.423	3.024
Shannon-Wiener diversity index (H)	2.138	2.132	2.276
Pielou's evenness index (J′)	0.860	0.889	0.916
Simpson Dominance (λ)	0.129	0.125	0.097
Simpson’s diversity index (1-λ)	0.871	0.875	0.903

Source: Author's Computation

Rank-Abundance Structure

Rank-abundance curves for the three stations are presented in Figure 1. The ST1 curve was the steepest of the three, reflecting strong numerical dominance by a small number of taxa (principally Geograpsus lividus, Coenagrion spp., and Culex spp.) before a rapid decline toward the rarer taxa. The ST3 curve was visibly flatter, consistent with its higher evenness (J′ = 0.916) and lower dominance ($\lambda = 0.097$): although Geograpsus lividus remained numerically prominent, the gap between the first- and lowest-ranked taxa was proportionally smaller than at ST1. The ST2 curve had an intermediate slope. This pattern corroborates the index-based findings that community balance improved progressively from the settlement margin toward the mangrove-fringed station.

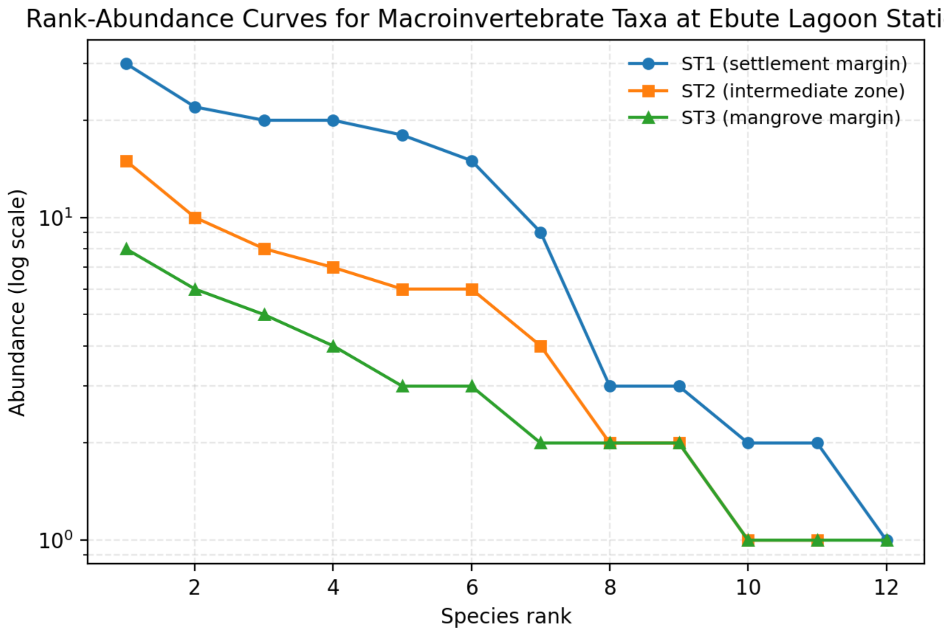

Figure 1: Rank-abundance curves for macroinvertebrate taxa at ST1 (settlement margin), ST2 (intermediate zone), and ST3 (mangrove margin), Ebute Lagoon.

Taxonomic Composition Across Stations

Order-level abundance counts used in the chi-square test of independence are presented in Table 3. The test indicated no statistically significant association between order-level taxonomic composition and station ($\chi^2 = 5.38$, df = 8, $p = 0.717$), meaning that the proportional representation of major taxonomic groups (Decapoda, Diptera, Odonata, Coleoptera, and the pooled minor orders) did not differ significantly across the settlement-to-mangrove gradient, even though total abundance declined sharply from ST1 to ST3 and fine-scale diversity indices varied as described above.

Table 3: Order-level macroinvertebrate abundance by station, used in the chi-square test of taxonomic composition.

Order	ST1	ST2	ST3	Total	% of Total
Decapoda	51	23	10	84	34.29
Odonata	42	14	11	67	27.34
Diptera	35	17	8	60	24.49
Coleoptera	9	4	4	17	6.94
Other (Architaenioglossa, Haplotaxida, Amphipoda, Arhynchobdellida)	8	4	5	17	6.94

Source: Field Data (2026)

Discussion

From the results of this study, the biodiversity indices show that the 3rd station sampled in this study, which is the station harbouring the mangrove, supports the most balanced community of macroinvertebrates among the three, despite having the lowest abundance of individual organisms. The low abundance and high diversity and evenness (relative to sample size as captured by the Margalef index) of the macroinvertebrate composition can be seen as somewhat paradoxical, but it indicates that this particular station is the least impacted, that is, no single tolerant taxon is free from competition or predation pressure to dominate the community (Padmanabha, 2011; Farukuzzaman et al., 2023). In contrast, the high abundance, low evenness, and high dominance of the community at ST1 is consistent with organic enrichment of the environment, whereby a few tolerant taxa (Geograpsus lividus, Culex spp., Coenagrion spp.) thrive at the expense of the balance in the ecosystem. However, as no physicochemical or water-quality parameters were measured alongside the macroinvertebrate sampling in this study, this interpretation of organic enrichment is inferential: drawn from established ecological relationships reported in the literature, rather than a cause that this study's data can confirm directly. The same pattern is nonetheless supported by the rank-abundance curves, the steepness of which indicates numerical dominance of the community at ST1.

The non-significant chi-square result for order-level composition ($p = 0.717$) is an important complement to the diversity indices rather than a contradiction of them. It indicates that the same broad taxonomic groups (crabs and shrimps, dipteran larvae, dragonflies and damselflies, beetles, and the minor orders) are present in similar proportions at all three stations; what differs along the gradient is not which orders occur, but how evenly individuals are distributed among the finer taxa within those orders, and how many individuals occur overall. This distinction matters for interpretation: it suggests that Ebute Lagoon has not yet lost entire functional groups from any station, which is a relatively reassuring finding for overall ecosystem function, but that the settlement-adjacent margin is nonetheless undergoing a measurable shift toward numerical dominance by a smaller number of taxa within the community that is present. This pattern is consistent with an early-to-intermediate stage of anthropogenic pressure rather than severe degradation, though, as noted above, this study did not measure the physicochemical conditions that would be needed to confirm anthropogenic pressure as the specific cause.

Implications for Mangrove Conservation

The consistently superior performance of ST3 across every biodiversity metric: richness relative to abundance, Shannon diversity, Pielou evenness, and Simpson diversity, provides converging, multi-metric evidence that the mangrove-fringed margin functions as the most biodiverse and structurally balanced habitat within Ebute Lagoon (Biswas & Biswas, 2021; Abduljaleel et al., 2026; Ferreira et al., 2024). This finding directly supports the focus on mangrove biodiversity and ecosystem function: it offers a site-specific empirical basis for treating the Ebute Lagoon mangrove fringe as a priority zone for conservation and restoration investment, since the biological evidence indicates that this habitat is currently performing the ecological role expected of a healthy mangrove margin, in contrast to some other Lagos Lagoon segments where potamidid gastropods and other mangrove-associated taxa have declined under sustained pollution pressure (Ogunrinola, 2023; Bassey et al., 2020).

Implications for the Blue Economy

The presence of biodiversity, along with evenness in the invertebrate communities found on the mangrove fringe, not only contributes to conservation but also to the productivity of the habitat, since invertebrate communities form the food web upon which commercially valuable species such as the blue swimming crab Callinectes sapidus, found at all three stations, feed (Öndes et al., 2025; Rady et al., 2018). The relatively lower dominance and greater evenness at Station 3 mean that the invertebrate community at this location will not be easily vulnerable to sudden collapse in the event of an impact on any dominant taxon at a more disturbed station, such as *Geograpsus lividus* and Culex *spp*. at Station 1, whether from disease, pollution, or overfishing. In light of blue economy development within the Ikorodu axis, the findings imply that maintaining the ecological status of the mangrove edge is consistent with fishery productivity, and not opposed to it.

Additionally, rank-abundance curves and evenness indices measure sensitivity to changes in dominance before the absolute loss of species richness, making them an indispensable tool for tracking the ecological trajectory and providing early-warning signals for Ebute Lagoon over time. Repeated sampling via the same sweep-netting method can be carried out periodically to observe whether the trend of the rank-abundance curve at ST1 is getting steeper, suggesting increased dominance and poorer ecological health, or whether the favourable evenness that is characteristic of the mangrove station persists.

Limitations of the Study

This study employed sweep-netting, which under-samples benthic, sediment-dwelling taxa relative to water-column and vegetation-associated taxa, and the three-month sampling window does not capture full seasonal variation in community structure. This timeframe yielded a small dataset that was not suitable for more analysis to be carried out, which prevents more inferential interpretation of the true ecological condition of the study area. Critically, no physicochemical or water-quality parameters were measured alongside the macroinvertebrate sampling in this study; consequently, the interpretation of community patterns at ST1 as consistent with organic enrichment is inferential, drawn from established relationships reported in literature, rather than a conclusion this study's data can confirm directly.

Conclusion and Recommendations

This study assessed macroinvertebrate biodiversity and community structure across a settlement-to-mangrove gradient in Ebute Lagoon using a comprehensive suite of richness, diversity, evenness, and dominance indices, supported by rank-abundance analysis and a chi-square test of taxonomic composition. The mangrove-fringed station consistently outperformed the settlement-adjacent and intermediate stations across every diversity metric, despite recording the lowest total abundance, indicating that it functions as the most ecologically balanced habitat in the lagoon. Taxonomic composition at the order level did not differ significantly across stations, indicating that no major functional group has yet been lost from any part of the system, even as within-community balance deteriorates toward the settlement margin.

It is recommended that: the mangrove-fringed margin of Ebute Lagoon be prioritised in conservation and restoration planning based on its demonstrated biodiversity value; future biomonitoring retain per-visit and, where feasible, per-replicate taxon counts to enable proper inferential statistical comparison of diversity indices and construction of species accumulation curves; direct physicochemical and water-quality measurement be incorporated alongside macroinvertebrate sampling in future studies at this site, to confirm or refute the organic-enrichment interpretation offered here; and community-based monitoring involving Ikorodu fishing cooperatives be explored as a low-cost means of tracking rank-abundance and evenness trends over time, given their sensitivity as early indicators of ecological change relevant to both conservation and blue economy planning.

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