Polychaete Dominance and A Localised *Nephtys* Aggregation in The Macrobenthos of a Tidal Peri-Urban River in The Niger Delta: The Egbelu Reach of The New Calabar River, Nigeria

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Abstract
Benthic macroinvertebrates live in close contact with sediments, cannot easily escape disturbance and reflect conditions over weeks to months, which makes them good indicators of river condition. We described the macrobenthos of the Egbelu reach of the New Calabar River, a tidal oligohaline river in the Niger Delta, at three stations sampled monthly from May to July 2026, and measured eleven water quality variables together with sediment texture and organic matter. The water was well oxygenated (6.50–6.80 mg L^{-1}) and BOD_5 was low (2.50–2.80 mg L^{-1}), but salinity, conductivity and total dissolved solids differed among stations. Twenty-seven grabs yielded 768 individuals in nine taxa, a mean density of 1,264 ind. m^{-2}. Polychaetes made up 78.4% of the fauna and decapod crustaceans 21.6%. Nereididae (31.6%) and Capitellidae (27.9%) were the leading families, and opportunistic capitellids (Capitella capitata complex and Notomastus) occurred at every station. Station 2 had the highest density (1,595 ind. m^{-2}), and Nephtys sp. alone made up a third of its fauna, giving it the lowest diversity (H′ = 2.011) and evenness (J′ = 0.915). Stations 1 and 3 were more even (J′ = 0.960–0.990) and most similar to each other (Bray–Curtis similarity 81.8%). Sediments were sandy clay loam to sandy clay with 3.5–4.0% organic matter. In a descriptive canonical correspondence analysis, Nephtys sp. lined up with the finest, most organic sediment at Station 2. The assemblage suggests a moderately stressed, enrichment-tolerant soft-bottom community, and the Nephtys patch at Station 2 is a priority for follow-up monitoring.

Keywords: *macrobenthos; Polychaeta; Capitella; Nephtys; organic enrichment; bioindicators; Niger Delta*

1. Introduction

Rivers and estuaries rank among the most threatened ecosystems on Earth. Pollution, habitat modification and flow change usually act on them together, and their combined effects on biodiversity are hard to predict (Reid et al., 2019; Birk et al., 2020). Benthic macroinvertebrates

are especially useful for tracking these effects. Most of them stay put or move very little, many live for months or years, and they live in the sediment, where contaminants and organic matter build up. Their composition, abundance and diversity change in fairly predictable ways along gradients of organic enrichment, from diverse communities in clean sediments to assemblages dominated by a few tolerant, opportunistic species where enrichment is heavy (Pearson & Rosenberg, 1978). Polychaetes sit at the heart of this framework. Some polychaete families are sensitive to disturbance, while others, the Capitellidae in particular, thrive in organically enriched, oxygen-poor sediments and are often the first to colonise disturbed ground (Giangrande et al., 2005; Dean, 2008). This contrast is the basis of biotic indices such as AMBI, which assign soft-bottom taxa to ecological groups according to how well they tolerate enrichment (Borja et al., 2000). In transitional waters, though, the fauna is naturally adapted to shifting salinity and sediment conditions, and community indices can stay stable even under real human pressure, so the results have to be read with care (Elliott & Quintino, 2007).

The New Calabar River is a tidal blackwater river that rises near Elele-Alimini and flows south past Aluu, Choba and Ogbogoro before it joins the Bonny estuary (Dienye & Woke, 2015; Nwibani et al., 2025). Its middle and lower reaches receive abattoir waste, effluents and urban runoff, and they are affected by dredging and sand mining (Imachrist et al., 2024; Nwibani et al., 2025). Heavy metals have been found in its sediments (Davies & Ekperusi, 2021), and sand extraction is known to change riverbed habitat, sediment texture and benthic communities (Koehnken et al., 2020). Across the Niger Delta, macrobenthic communities respond clearly to oil pollution and urban effluents (Zabbey & Uyi, 2014; Edegbene et al., 2021). On the New Calabar River itself, Nwibani et al. (2025) recently reported subtidal assemblages dominated by Nereididae and Capitellidae between Aluu and Ogbogoro. The Egbelu reach, however, has never been described, and few studies on the river have related benthic composition to measured sediment variables. We aimed to (i) describe how physico-chemical conditions in the Egbelu reach varied between stations and between months in the early rainy season; (ii) determine the composition, abundance and diversity of its benthic macroinvertebrates; (iii) assess how similar the assemblages were from station to station; and (iv) explore how benthic composition related to sediment characteristics.

2. Methodology

2.1. Study area

The Egbelu reach lies in Obio/Akpor Local Government Area, Rivers State, Nigeria (Fig. 1). The climate is humid tropical, with a long rainy season from about March to October and annual rainfall that often exceeds 2,000 mm. The reach is tidal and oligohaline, and its banks carry houses, small landing points and secondary vegetation. We placed three stations along the reach to capture likely differences in freshwater input, human activity and sediment character, and fixed their positions with a handheld GPS receiver: Station 1 (upstream; 4.8499° N, 6.9238° E), Station 2 (midstream; 4.8470° N, 6.9296° E) and Station 3 (downstream; 4.8438° N, 6.9355° E). Stations 1 and 2 were about 0.72 km apart and Stations 2 and 3 about 0.74 km apart, so the stations covered roughly 1.5 km of river.

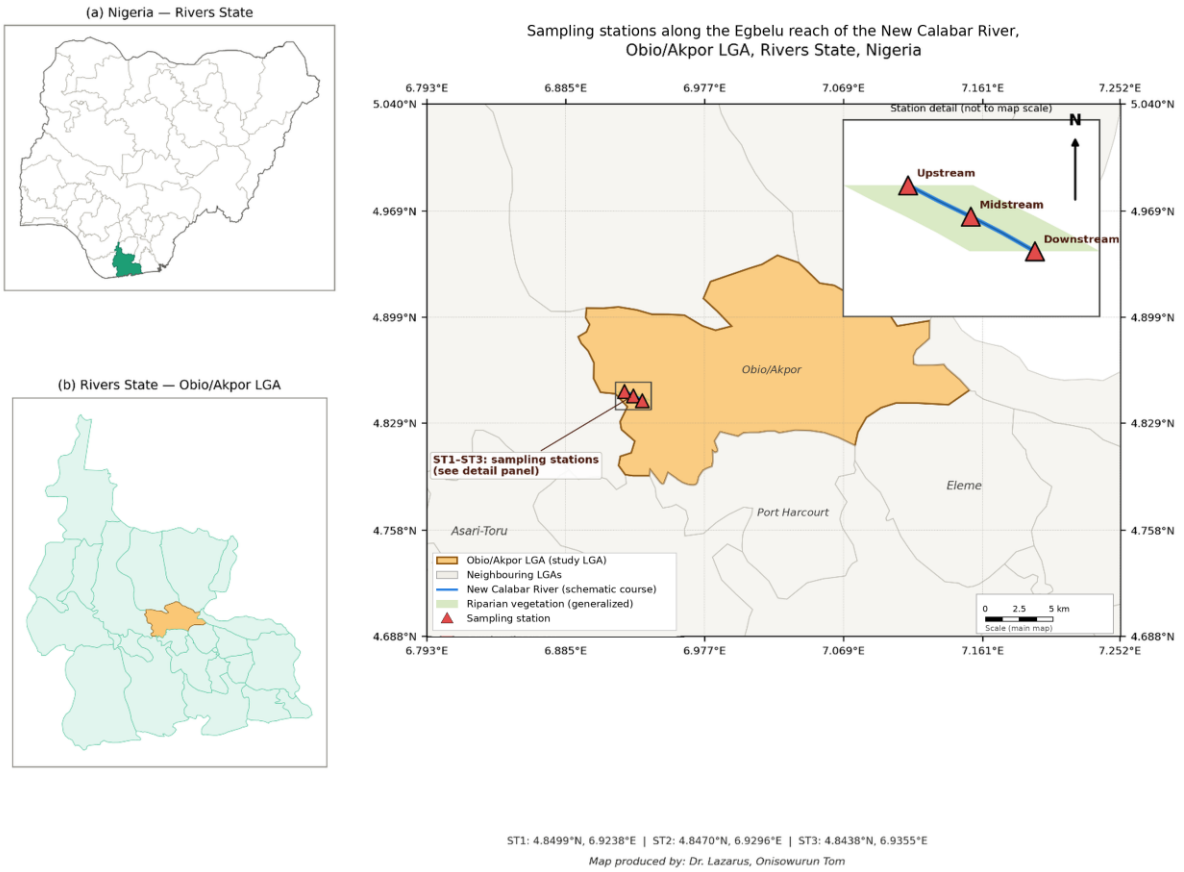


Fig. 1. Location of the study area: (a) Nigeria, showing Rivers State; (b) Rivers State, showing Obio/Akpor Local Government Area; (c) the Egbelu reach of the New Calabar River with sampling Stations 1–3 (ST1–ST3). The station detail panel is not drawn to the map scale.

2.2. Water quality

Surface water was sampled in triplicate at each station once a month from May to July 2026. Temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), salinity and dissolved oxygen (DO) were measured on site with calibrated meters. Turbidity, current velocity, nitrate, phosphate and five-day biochemical oxygen demand (BOD_5, incubated in the dark at 20 °C) were determined following APHA (2017). Nitrate was measured by cadmium reduction and phosphate by the ascorbic acid method (Murphy & Riley, 1962), both on a spectrophotometer. The water quality data come from a single field campaign that also served companion studies of the fish and plankton of the reach (Wala et al., in preparation), and we report them in full so that this paper can be read on its own.

2.3. Benthic macroinvertebrate and sediment sampling

Benthic macroinvertebrates were collected every month at each station with a grab sampler that had a 15 × 15 cm opening (0.0225 m^2 per grab). We took three replicate grabs at each station on each visit (0.0675 m^2 per station per visit; 0.2025 m^2 per station over the three months). In the field, the sediment was washed through a 0.5 mm sieve, and the material left on the sieve was fixed in 4–5% buffered formalin and later moved to 70% ethanol in the laboratory (Eleftheriou & McIntyre, 2005). Animals were sorted, counted and identified to the lowest practicable level. Polychaetes were identified with Fauchald (1977) and Day (1967). Where a species could not be confirmed with literature suited to West African waters, we reported the specimens at genus or family level as numbered taxa, and we treated *Capitella*

capitata as a species complex. Decapod crustaceans were identified with Powell's (1983) keys to Nigerian crabs. Triplicate sediment samples from each station were dried to constant mass, homogenised and analysed for particle size using a combined sieve and hydrometer procedure. The sand fraction was separated by sieving, and the finer fraction was analysed by sedimentation with the hydrometer method (Gee & Bauder, 1986). Sand, silt and clay were calculated on a dry-mass basis and expressed as percentages. Organic matter was determined separately by loss on ignition (Buchanan, 1984). We used sediment texture and organic matter both to characterise the benthic habitat at each station and as explanatory variables in the multivariate analysis.

2.4. Data analysis

Differences in physico-chemical variables among stations and among months were tested with one-way ANOVA, followed by Tukey's honestly significant difference test where $p < 0.05$ (Tukey, 1949; Zar, 2010). Some variables gave identical readings in every replicate and month at a station; because their within-station variance was zero, they were not tested among stations. The density (ind. m^{-2}) of each taxon at each station was calculated by dividing the number of individuals in the nine grabs (three grabs × three months) by the area sampled (0.2025 m^2). Percentage relative abundance and the diversity indices were calculated from the same pooled counts. Diversity at each station was described with the Shannon–Wiener index, $H' = -\Sigma\, p_i \ln p_i$ (Shannon & Weaver, 1949); Simpson's dominance, $D = \Sigma\, p_i^2$, and diversity, $1 - D$ (Simpson, 1949); Pielou's evenness, $J' = H'/\ln S$ (Pielou, 1966); and Margalef's richness, $d = (S - 1)/\ln N$ (Margalef, 1958). Similarity among stations was measured with the Bray–Curtis coefficient on untransformed abundances (Bray & Curtis, 1957), and the stations were grouped by UPGMA clustering (Clarke & Warwick, 2001). We examined how macroinvertebrate composition related to sediment characteristics (percentage sand and organic matter) with canonical correspondence analysis (CCA; ter Braak, 1986). The nine station × month samples were used as sites and the station-level sediment values as constraints. Species scores were scaled to emphasise distances between species (Hill's scaling). Because the constraints did not vary within stations, we interpreted the ordination descriptively (Section 3.4). Analyses were run in PAST (Hammer et al., 2001) and R version 4.3 (R Core Team, 2023) with the vegan package (Oksanen et al., 2022), and $p < 0.05$ was taken as significant.

3. Results

3.1. Water quality and sediments

The water was warm (27.50–28.00 °C), close to neutral (pH 7.03–7.15) and well oxygenated (6.50–6.80 mg L^{-1}), and BOD_5 stayed below 3 mg L^{-1} at every station (Table 1). Temperature and pH rose slightly but significantly from May to July, and for both variables July differed from May (Tukey HSD). Salinity, conductivity and TDS differed significantly among stations but not among months. Salinity was lowest at Station 1 (0.45 ppt) and highest at Station 2 (1.88 ppt), yet conductivity and TDS were, unexpectedly, highest at Station 1, the least saline station. Station 2 had the highest turbidity, current velocity, nitrate, phosphate and BOD_5, and Station 1 the lowest. These readings were identical in every replicate and month at a given station, so we report the differences descriptively rather than testing them. Monthly trends appear in Appendix Fig. A1. The sediments were dominated by sand (55–60% sand, 30–35% clay and 10% silt) and held 3.5–4.0% organic matter (Table 2). Station 2 had the finest sediment (55% sand, 35% clay) and the most organic matter (4.0%). Station 1 had the coarsest sediment (60% sand) and the least organic matter (3.5%), and Station 3 fell between the two on both measures.

Table 1. Spatial (station) and temporal (month) variation in physico-chemical parameters of the Egbelu reach of the New Calabar River, May–July 2026.

Parameter	Station (spatial)				Month (temporal)			
	Station 1	Station 2	Station 3	*p*	May	June	July	*p*
Temperature (°C)	27.77 ± 0.22[a]	27.67 ± 0.25[a]	27.67 ± 0.25[a]	0.600	27.50 ± 0.00[a]	27.60 ± 0.15[a]	28.00 ± 0.00[b]	<0.001
Salinity (ppt)	0.45 ± 0.04[a]	1.88 ± 0.07[b]	1.68 ± 0.07[c]	<0.001	1.27 ± 0.66	1.35 ± 0.68	1.40 ± 0.68	0.914
pH	7.05 ± 0.04[a]	7.15 ± 0.04[b]	7.05 ± 0.04[a]	<0.001	7.03 ± 0.05[a]	7.08 ± 0.05[ab]	7.13 ± 0.05[b]	0.001
EC (µS cm^{-1})	9700 ± 173[a]	4133 ± 109[b]	4200 ± 87[b]	<0.001	5867 ± 2725	6017 ± 2763	6150 ± 2813	0.977
TDS (mg L^{-1})	4850 ± 87[a]	2063 ± 52[b]	2073 ± 22[b]	<0.001	2933 ± 1363	3007 ± 1383	3047 ± 1428	0.985
DO (mg L^{-1})	6.50 ± 0.00	6.80 ± 0.00	6.70 ± 0.00	n.t.	6.67 ± 0.13	6.67 ± 0.13	6.67 ± 0.13	1.000
Turbidity (NTU)	15.00 ± 0.00	18.00 ± 0.00	16.00 ± 0.00	n.t.	16.33 ± 1.32	16.33 ± 1.32	16.33 ± 1.32	1.000
Current velocity (m s^{-1})	0.30 ± 0.00	0.35 ± 0.00	0.32 ± 0.00	n.t.	0.32 ± 0.02	0.32 ± 0.02	0.32 ± 0.02	1.000
Nitrate (mg L^{-1})	0.80 ± 0.00	0.90 ± 0.00	0.85 ± 0.00	n.t.	0.85 ± 0.04	0.85 ± 0.04	0.85 ± 0.04	1.000
Phosphate (mg L^{-1})	0.20 ± 0.00	0.25 ± 0.00	0.22 ± 0.00	n.t.	0.22 ± 0.02	0.22 ± 0.02	0.22 ± 0.02	1.000
BOD_5 (mg L^{-1})	2.50 ± 0.00	2.80 ± 0.00	2.60 ± 0.00	n.t.	2.63 ± 0.13	2.63 ± 0.13	2.63 ± 0.13	1.000

Values are mean ± SD (n = 9 per station: three months × triplicate samples; n = 9 per month: three stations × triplicate samples). p values are from one-way ANOVA. Within the station columns and within the month columns, means sharing a superscript letter do not differ significantly (Tukey HSD, $\alpha = 0.05$); monthly letters are shown only for the two variables with a significant monthly effect. n.t., not tested: readings were identical in every replicate and month at each station, so within-station variance was zero and a station ANOVA is undefined; these station values are reported descriptively. EC, electrical conductivity; TDS, total dissolved solids; DO, dissolved oxygen; BOD_5, five-day biochemical oxygen demand.

Table 2. Sediment characteristics at the three stations on the Egbelu reach of the New Calabar River. Values are means of triplicate determinations, which were identical at each station. Texture classes (USDA): Stations 1 and 3, sandy clay loam; Station 2, sandy clay.

Variable	Station 1	Station 2	Station 3
Sand (%)	60.0	55.0	58.0
Silt (%)	10.0	10.0	10.0
Clay (%)	30.0	35.0	32.0
Organic matter (%)	3.5	4.0	3.8

3.2. Composition and abundance

We collected 768 individuals from 27 grabs (0.6075 m^2), a mean density of 1,264 ind. m^{-2} across the reach. They belonged to nine taxa in five families and two major groups (Table 3). Polychaetes dominated, with seven taxa and 78.4% of individuals (991 ind. m^{-2}), and two decapod crustaceans made up the remaining 21.6% (273 ind. m^{-2}). Nereididae was the leading family (31.6%), followed by Capitellidae (27.9%), Nephtyidae (18.9%), Sesarmidae (11.6%) and Portunidae (10.0%). All nine taxa were found at every station.

Density was highest at Station 2 (1,595 ind. m^{-2}), followed by Station 1 (1,230 ind. m^{-2}) and Station 3 (968 ind. m^{-2}). What mainly set the stations apart was which taxon was most abundant (Fig. 2). At Station 1 the fauna was spread fairly evenly among three nereidids, Nereididae sp. 2 (15.7%), Nereididae sp. 1 (12.9%) and Nereididae sp. 3 (12.5%), and the capitellid *Notomastus* sp. 1 (11.6%). Station 2 was dominated by *Nephtys* sp., which made up 33.4% of the fauna (533 ind. m^{-2}), over three times its share at the other two stations. At Station 3, Nereididae sp. 1 was the leading taxon (23.5%), and the two crabs together made up more than a quarter of the assemblage (26.0%). The opportunistic *Capitella capitata* complex contributed a steady 7.4–10.0% at every station.

Table 3. Density (ind. m^{-2}) and percentage relative abundance (%) of benthic macroinvertebrates at three stations on the Egbelu reach of the New Calabar River (May–July 2026 pooled).

Taxon	Station 1		Station 2		Station 3		Total	
	ind. m^{-2}	%	ind. m^{-2}	%	ind. m^{-2}	%	ind. m^{-2}	%
Polychaeta								
Capitellidae								
Capitella capitata complex	123	10.04	119	7.43	94	9.69	112	8.85
Notomastus sp. 1	143	11.65	128	8.05	99	10.20	123	9.77
Notomastus sp. 2	99	8.03	163	10.22	89	9.18	117	9.24
Nephtyidae								
Nephtys sp.	94	7.63	533	33.44	89	9.18	239	18.88
Nereididae								
Nereididae sp. 1	158	12.85	99	6.19	227	23.47	161	12.76
Nereididae sp. 2	193	15.66	138	8.67	54	5.61	128	10.16
Nereididae sp. 3	153	12.45	114	7.12	64	6.63	110	8.72
Subtotal Polychaeta	*963*	*78.31*	*1,294*	*81.11*	*716*	*73.98*	*991*	*78.39*
Crustacea: Decapoda								
Portunidae								
Callinectes amnicola	133	10.84	128	8.05	119	12.24	127	10.03
Sesarmidae								
Guinearma huzardi	133	10.84	173	10.84	133	13.78	147	11.59
Subtotal Crustacea	*267*	*21.69*	*301*	*18.89*	*252*	*26.02*	*273*	*21.61*
Total	**1,230**	**100**	**1,595**	**100**	**968**	**100**	**1,264**	**100**

Densities are numbers of individuals per square metre, calculated from nine grabs per station (0.2025 m^2); the Total column is the mean density over the three stations (27 grabs; 0.6075 m^2). Subtotals may differ from the sum of rounded values. Percentages are relative to each station total and to the grand total (N = 768 individuals). Polychaetes whose species identity could not be confirmed with literature appropriate to the region are reported at genus or family level. *Callinectes amnicola* (syn. *C. latimanus*); *Guinearma huzardi* (syn. *Sesarma huzardi*) belongs to Sesarmidae.

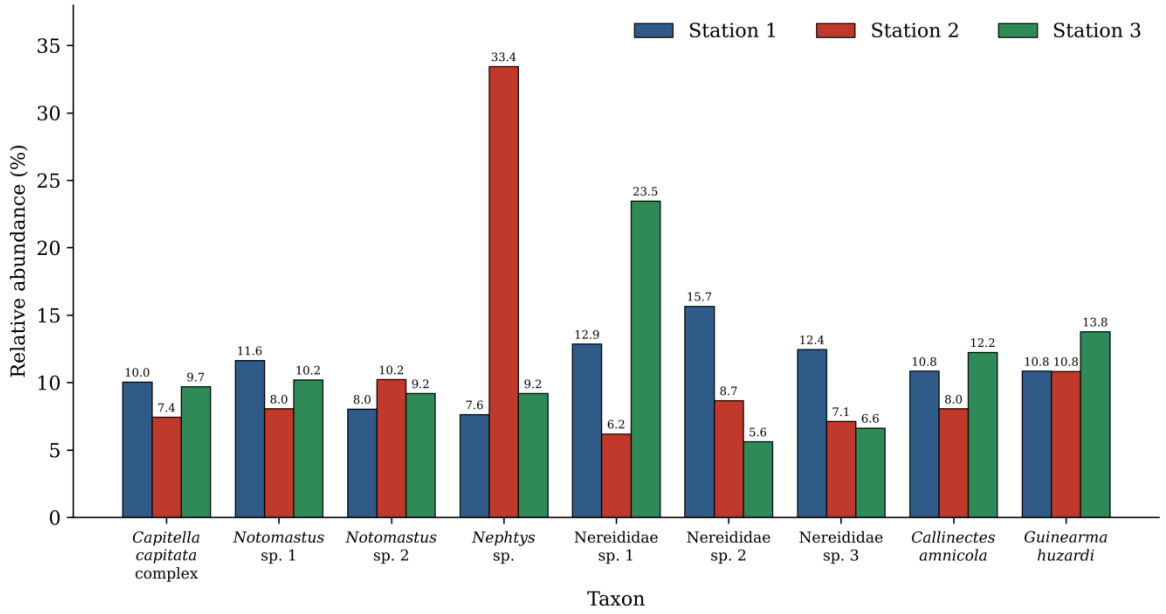


Fig. 2. Percentage relative abundance of benthic macroinvertebrate taxa at Stations 1–3 on the Egbelu reach of the New Calabar River.

3.3. Diversity and similarity among stations

Since all nine taxa occurred everywhere, richness was the same at each station, and the differences in diversity came down to evenness (Table 4). Station 1 was the most diverse and even (H′ = 2.175; J′ = 0.990) and Station 3 was intermediate (2.110; 0.960). Station 2 was the least diverse and least even (2.011; 0.915), with the highest Simpson's dominance (D = 0.169) and therefore the lowest 1 − D (0.831). Margalef's richness ranged from 1.385 at Station 2 to 1.516 at Station 3, a difference that reflects sample size rather than the number of taxa.

Bray–Curtis similarity was highest between Stations 1 and 3 (81.8%), lower between Stations 1 and 2 (74.5%) and lowest between Stations 2 and 3 (65.5%) (Table 5). The UPGMA dendrogram therefore grouped Stations 1 and 3 at a dissimilarity of about 0.18 and joined Station 2 at about 0.30 (Fig. 3). Station 2 stood apart mainly because of its large *Nephtys* population, and to a lesser extent because Nereididae sp. 1 was more abundant at Station 3 and nereidids in general were more abundant at Station 1.

Table 4. Diversity indices of benthic macroinvertebrates at three stations on the Egbelu reach of the New Calabar River.

Station	*N*	*S*	H′	*D*	1 − *D*	J′	*d*
Station 1	249	9	2.175	0.116	0.884	0.990	1.450
Station 2	323	9	2.011	0.169	0.831	0.915	1.385
Station 3	196	9	2.110	0.133	0.867	0.960	1.516
Pooled	768	9	2.165	0.119	0.881	0.985	1.204

N, number of individuals; *S*, number of taxa; H′, Shannon–Wiener index (natural log); *D*, Simpson's dominance; 1 − *D*, Simpson's diversity; J′, Pielou's evenness; *d*, Margalef's richness.

Table 5. Bray–Curtis similarity (%) among stations based on untransformed abundance.

	Station 1	**Station 2**	**Station 3**
Station 1	—	74.48	81.80
Station 2	74.48	—	65.51
Station 3	81.80	65.51	—

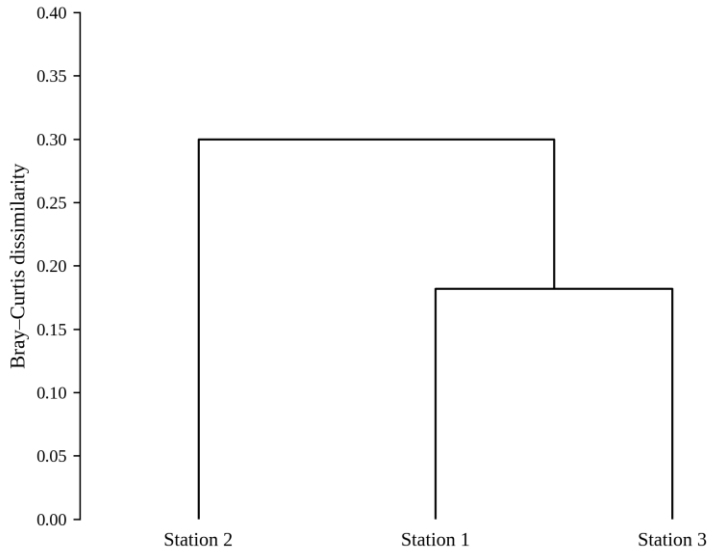


Fig. 3. UPGMA dendrogram of the three stations based on Bray–Curtis dissimilarity of benthic macroinvertebrate abundance.

3.4. Relationship with sediment variables

The two sediment variables sat at opposite ends of the first CCA axis. Sand content was negatively correlated with axis 1 ($r = -0.916$) and organic matter positively ($r = 0.817$) (Table 6; Fig. 4). The constrained axes explained only a small share of the total variation in composition (4.4% for axis 1 and 0.9% for axis 2). The triplicate sediment determinations were identical within each station, so the two constraints took only three distinct values and were strongly collinear ($r = -0.97$ between sand and organic matter). In effect they describe a single gradient of fine sediment and organic enrichment. A valid permutation test would have to permute whole stations, which allows only 3! = 6 arrangements and a minimum attainable p of 0.167. The constrained axes could therefore not be tested formally, and we present the ordination descriptively. Station 2 lay towards the organic-rich end of axis 1, and *Nephtys* sp. had by far the highest positive score on this axis (1.930). Nereididae sp. 1, the dominant taxon at Station 3, sat at the sandy end of axis 1 and the positive end of axis 2 (−1.259; 1.786), whereas Nereididae sp. 2 and Nereididae sp. 3, both most abundant at Station 1, scored strongly negative on axis 2. The capitellids and the two crabs lay near the centre of the ordination, as expected from their even spread across stations.

Table 6. Species scores and intraset correlations of sediment variables with the first two CCA axes.

Taxon / variable	CCA1	CCA2
Species scores		
Capitella capitata complex	−0.355	−0.196
Notomastus sp. 1	−0.355	−0.441
Notomastus sp. 2	0.230	−0.090
Nephtys sp.	1.930	0.450
Nereididae sp. 2	−0.362	−1.953
Nereididae sp. 3	−0.474	−1.189
Nereididae sp. 1	−1.259	1.786
Callinectes amnicola	−0.503	0.098
Guinearma huzardi	−0.262	0.414
Sediment variables (intraset correlations)		
Sand (%)	−0.916	−0.402
Organic matter (%)	0.817	0.577

Species scores follow Hill's scaling (scaling 2, inter-species distances); sediment values are correlations between each standardised variable and the site scores on each axis.

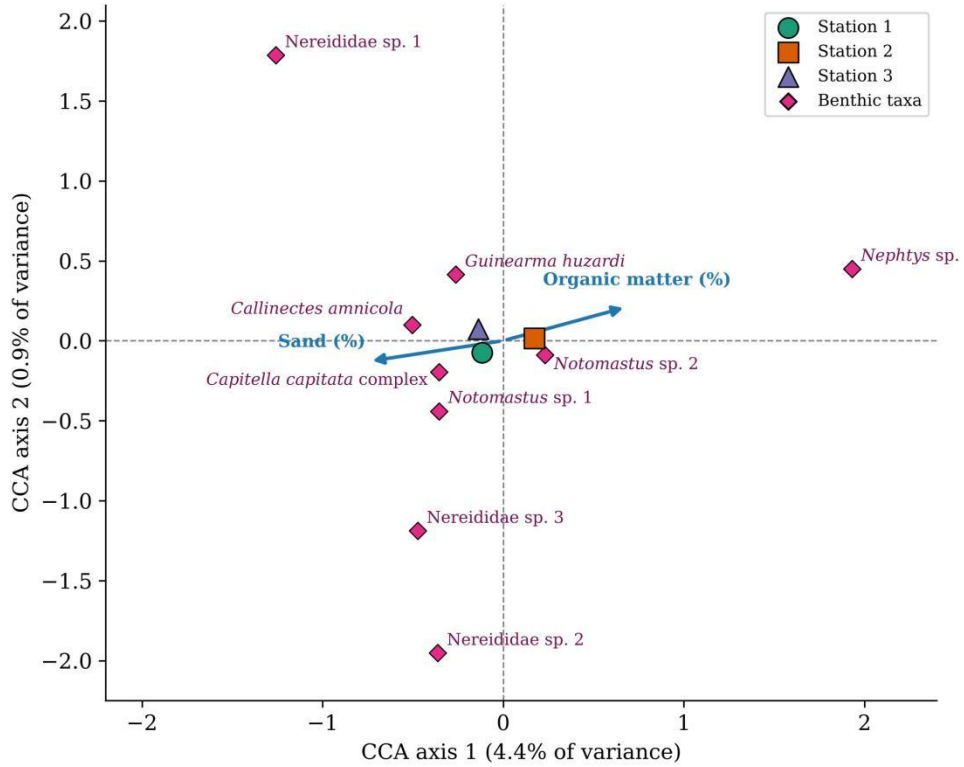


Fig. 4. CCA biplot of benthic macroinvertebrate taxa (diamonds; species scores as in Table 6), sampling stations (coloured markers) and sediment variables (arrows). Station points are station-level constrained scores, shared by the three monthly samples from each station. Axis labels give the percentage of total variance explained.

4. Discussion

4.1. A polychaete-dominated, enrichment-tolerant assemblage

The macrobenthos of the Egbelu reach had a simple structure: nine taxa, nearly four-fifths of them polychaetes, and no molluscs or insects. Nwibani et al. (2025) reported a similar profile for the subtidal New Calabar River between Aluu and Ogbogoro, where Nereididae and Capitellidae together made up more than 80% of the fauna and many of the same polychaete taxa were found. Low taxon richness and polychaete dominance are common in Niger Delta soft sediments under urban and industrial pressure (Zabbey & Uyi, 2014; Edegbene et al., 2021). Low salinity and shifting sandy substrates, however, can also keep richness low in tidal rivers that are free of human influence (Telesh & Khlebovich, 2010).

The make-up of the polychaete fauna tells us something. Capitellids, which accounted for more than a quarter of all individuals, are classic deposit-feeding opportunists. The *Capitella capitata* complex in particular is widely used as an indicator of organic enrichment and is ranked among the most tolerant taxa in biotic indices such as AMBI (Pearson & Rosenberg, 1978; Borja et al., 2000; Dean, 2008). Nereidids are also generally tolerant of low salinity and moderate enrichment (Giangrande et al., 2005). The steady presence of both groups at every station, alongside 3.5–4.0% sediment organic matter, therefore points to sediments that are at least moderately enriched. The water column, by contrast, was well oxygenated and had low BOD_5. This apparent mismatch is not surprising. Water measurements capture conditions at the moment of sampling, while the benthos reflects sediment conditions over much longer periods (Pearson & Rosenberg, 1978).

4.2. The Nephtys hotspot at Station 2

The most distinctive feature of the data is the cluster of *Nephtys* sp. at Station 2, where it made up a third of the fauna. This one population accounts for the station's lower evenness, higher dominance and separation in composition from the other two stations. *Nephtys* species are mobile, burrowing predators and scavengers of soft sediments, and in the CCA they were associated with more organic matter and less sand. Station 2 also had the highest turbidity, nutrients and BOD_5 in the water column. Put together, these observations suggest that Station 2 receives more fine, organic material than the other stations, which could support larger populations of the small invertebrates that *Nephtys* feeds on. Natural patchiness is another possibility, since mobile predators can gather in one place for reasons that have nothing to do with pollution. Repeated sampling across the seasons would show whether the hotspot persists.

The modest fall in evenness at Station 2 should not be over-interpreted. Its diversity ($H' = 2.011$) was still higher than the monthly values of 0.735–1.74 that Nwibani et al. (2025) reported for the New Calabar River, although our values come from pooled monthly samples and would be expected to be higher. Benthos in transitional waters is naturally adapted to stress, so diversity indices can stay high even under real human pressure (Elliott & Quintino, 2007). A change in which taxa dominate, such as the rise of *Nephtys* at Station 2, may give an earlier and more sensitive warning than the indices themselves.

4.3. Sediment and water quality links

The CCA arranged the three stations along one sediment gradient, from the course, organically poorer sediment of Station 1 (60% sand; 3.5% organic matter) to the finer, more organic sediment of Station 2 (55% sand; 4.0%). The constrained axes, however, explained only a small part of the total variation and could not be tested formally. With only three distinct sediment values, one per station (the triplicate determinations at each station were identical), the analysis cannot separate the influence of sediment from any other difference between stations. Much of the variation in composition clearly arose between months within stations, so the ordination is

best read as descriptive. Future work should measure sediment variables in every sample, add sediment total organic carbon, redox potential and metals, and record any dredging or sand mining near the stations, since removing and resuspending sediment can change benthic habitat drastically (Koehnken et al., 2020; Davies & Ekperusi, 2021). The combination of the lowest salinity with the highest conductivity at Station 1 also needs attention. In estuaries, conductivity depends mainly on sea salts, so a fresher but more conductive station suggests an extra, non-marine source of dissolved ions, such as effluent, leachate or groundwater. Measurement limits may also play a part. Salinities below about 2 are close to the resolution of hand-held refractometers, whereas a conductivity of 9,700 µS cm^{-1} would equal a practical salinity of about 5 if it came from sea salts alone. Even so, Station 1 held the most even benthic assemblage, which suggests that whatever causes its high conductivity had little effect on the benthos during the study.

4.4. Limitations

The study covered three months of one rainy season at three stations, and densities were based on nine grabs per station pooled over the three months. Sediment was analysed in triplicate at each station, but the replicates gave identical values and were not broken down by month, so sediment could be related to the fauna only at station level. Several polychaetes could be identified only to genus or family, and voucher-based identification using literature for West African waters would sharpen the indicator interpretation. Within these limits, the data give the first quantitative description of the macrobenthos of the Egbelu reach and point to Station 2 as a place where change linked to enrichment may be under way.

5. Conclusion

In the early rainy season of 2026, the Egbelu reach of the New Calabar River supported a macrobenthic assemblage of low richness, dominated by polychaetes and with opportunistic capitellids common throughout. Stations 1 and 3 were fairly even and resembled each other. Station 2, in contrast, was dominated by *Nephtys* sp., had the lowest evenness and was associated with more organic, less sandy sediment. Although the water column was well oxygenated, the benthic fauna points to moderately enriched sediments. Monitoring of this reach should include sediment organic matter and densities measured at every sampling event, and Station 2 should be given priority for repeated, year-round sampling.

Declarations

Author contributions. All authors contributed to the conception and design of the study, field sampling, laboratory work, data analysis and preparation of the manuscript. All authors read and approved the final version.

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Declaration of competing interest. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability. The data supporting this study are available from the corresponding author on reasonable request.

References

APHA. (2017). *Standard methods for the examination of water and wastewater* (23rd ed.). American Public Health Association, American Water Works Association and Water Environment Federation.

Birk, S., Chapman, D., Carvalho, L., Spears, B. M., Andersen, H. E., Argillier, C., Auer, S., Baattrup-Pedersen, A., Banin, L., Beklioğlu, M., Bondar-Kunze, E., Borja, A., Branco, P., Bucak, T., Buijse, A. D., Cardoso, A. C., Couture, R.-M., Cremona, F., de Zwart, D., … Hering, D. (2020). Impacts of multiple stressors on freshwater biota across spatial scales and ecosystems. *Nature Ecology & Evolution, 4*(8), 1060–1068. https://doi.org/10.1038/s41559-020-1216-4

Borja, A., Franco, J., & Pérez, V. (2000). A marine biotic index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments. *Marine Pollution Bulletin, 40*(12), 1100–1114. https://doi.org/10.1016/S0025-326X(00)00061-8

Bray, J. R., & Curtis, J. T. (1957). An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs, 27*(4), 325–349. https://doi.org/10.2307/1942268

Buchanan, J. B. (1984). Sediment analysis. In N. A. Holme & A. D. McIntyre (Eds.), *Methods for the study of marine benthos* (2nd ed., pp. 41–65). Blackwell Scientific Publications.

Clarke, K. R., & Warwick, R. M. (2001). *Change in marine communities: An approach to statistical analysis and interpretation* (2nd ed.). PRIMER-E.

Davies, I. C., & Ekperusi, A. O. (2021). Evaluation of heavy metal concentrations in water, sediment and fishes of New Calabar River in southern Nigeria. *Journal of Limnology and Freshwater Fisheries Research, 7*(3), 207–218.

Day, J. H. (1967). *A monograph on the Polychaeta of southern Africa. Part 1. Errantia*. British Museum (Natural History).

Dean, H. K. (2008). The use of polychaetes (Annelida) as indicator species of marine pollution: a review. *Revista de Biología Tropical, 56*(Suppl. 4), 11–38.

Dienye, H. E., & Woke, G. N. (2015). Physico-chemical parameters of the upper and lower reach of the New Calabar River, Niger Delta. *Journal of Fisheries & Livestock Production, 3*, 154.

Edegbene, A. O., Odume, O. N., Arimoro, F. O., & Keke, U. N. (2021). Identifying and classifying macroinvertebrate indicator signature traits and ecological preferences along urban pollution gradient in the Niger Delta. *Environmental Pollution, 281*, 117076. https://doi.org/10.1016/j.envpol.2021.117076

Eleftheriou, A., & McIntyre, A. (Eds.). (2005). *Methods for the study of marine benthos* (3rd ed.). Blackwell Science.

Elliott, M., & Quintino, V. (2007). The estuarine quality paradox, environmental homeostasis and the difficulty of detecting anthropogenic stress in naturally stressed areas. *Marine Pollution Bulletin, 54*(6), 640–645. https://doi.org/10.1016/j.marpolbul.2007.02.003

Fauchald, K. (1977). *The polychaete worms: Definitions and keys to the orders, families and genera* (Science Series 28). Natural History Museum of Los Angeles County.

Gee, G. W., & Bauder, J. W. (1986). Particle-size analysis. In A. Klute (Ed.), *Methods of soil analysis, Part 1: Physical and mineralogical methods* (2nd ed., pp. 383–411). American Society of Agronomy and Soil Science Society of America.

Giangrande, A., Licciano, M., & Musco, L. (2005). Polychaetes as environmental indicators revisited. *Marine Pollution Bulletin, 50*(11), 1153–1162. https://doi.org/10.1016/j.marpolbul.2005.08.003

Hammer, Ø., Harper, D. A. T., & Ryan, P. D. (2001). PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica, 4*(1), 1–9.

Imachrist, I. D., Sikoki, F. D., Kika, P., & Chris, D. I. (2024). Biological significances of environmental pollution in the New Calabar River, southern Nigeria: a case study in zooplankton composition. *Journal of Bioresource Management, 11*(1), 7. https://doi.org/10.35691/JBM.4202.0016

Koehnken, L., Rintoul, M. S., Goichot, M., Tickner, D., Loftus, A.-C., & Acreman, M. C. (2020). Impacts of riverine sand mining on freshwater ecosystems: a review of the scientific evidence and guidance for future research. *River Research and Applications, 36*(3), 362–370. https://doi.org/10.1002/rra.3586

Margalef, R. (1958). Information theory in ecology. *General Systems, 3*, 36–71.

Murphy, J., & Riley, J. P. (1962). A modified single solution method for the determination of phosphate in natural waters. *Analytica Chimica Acta, 27*, 31–36. https://doi.org/10.1016/S0003-2670(00)88444-5

Nwibani, B. H., Olagbemiro, T. O., Bob-Manuel, K. N. O., & Uyi, H. (2025). Assessment of physicochemical characteristics and subtidal benthic macroinvertebrate communities in Luubara Creek and New Calabar River, situated in the Niger Delta region of Nigeria. *Journal of Applied Sciences and Environmental Management, 29*(5), 1512–1521. https://doi.org/10.4314/jasem.v29i5.16

Oksanen, J., Simpson, G. L., Blanchet, F. G., Kindt, R., Legendre, P., Minchin, P. R., O'Hara, R. B., Solymos, P., Stevens, M. H. H., Szoecs, E., Wagner, H., Barbour, M., Bedward, M., Bolker, B., Borcard, D., Carvalho, G., Chirico, M., De Cáceres, M., Durand, S., … Weedon, J. (2022). *vegan: Community ecology package* (R package version 2.6-4) [Computer software]. https://CRAN.R-project.org/package=vegan

Pearson, T. H., & Rosenberg, R. (1978). Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology: An Annual Review, 16*, 229–311.

Pielou, E. C. (1966). The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology, 13*, 131–144. https://doi.org/10.1016/0022-5193(66)90013-0

Powell, C. B. (1983). Keys to the identification of Nigerian crabs. In B. H. R. Wilcox & C. B. Powell (Eds.), *The mangrove ecosystem of the Niger Delta* (pp. 226–238). University of Port Harcourt Press.

R Core Team. (2023). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. https://www.R-project.org/

Reid, A. J., Carlson, A. K., Creed, I. F., Eliason, E. J., Gell, P. A., Johnson, P. T. J., Kidd, K. A., MacCormack, T. J., Olden, J. D., Ormerod, S. J., Smol, J. P., Taylor, W. W., Tockner, K., Vermaire, J. C., Dudgeon, D., & Cooke, S. J. (2019). Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biological Reviews, 94*(3), 849–873. https://doi.org/10.1111/brv.12480

Shannon, C. E., & Weaver, W. (1949). *The mathematical theory of communication*. University of Illinois Press.

Simpson, E. H. (1949). Measurement of diversity. *Nature, 163*, 688. https://doi.org/10.1038/163688a0

Telesh, I. V., & Khlebovich, V. V. (2010). Principal processes within the estuarine salinity gradient: a review. *Marine Pollution Bulletin, 61*(4–6), 149–155. https://doi.org/10.1016/j.marpolbul.2010.02.008

ter Braak, C. J. F. (1986). Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. *Ecology, 67*(5), 1167–1179. https://doi.org/10.2307/1938672

Tukey, J. W. (1949). Comparing individual means in the analysis of variance. *Biometrics, 5*(2), 99–114. https://doi.org/10.2307/3001913

Zabbey, N., & Uyi, H. (2014). Community responses of intertidal soft-bottom macrozoobenthos to oil pollution in a tropical mangrove ecosystem, Niger Delta, Nigeria. *Marine Pollution Bulletin, 82*(1–2), 167–174.

Zar, J. H. (2010). *Biostatistical analysis* (5th ed.). Pearson Prentice Hall.

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Appendix

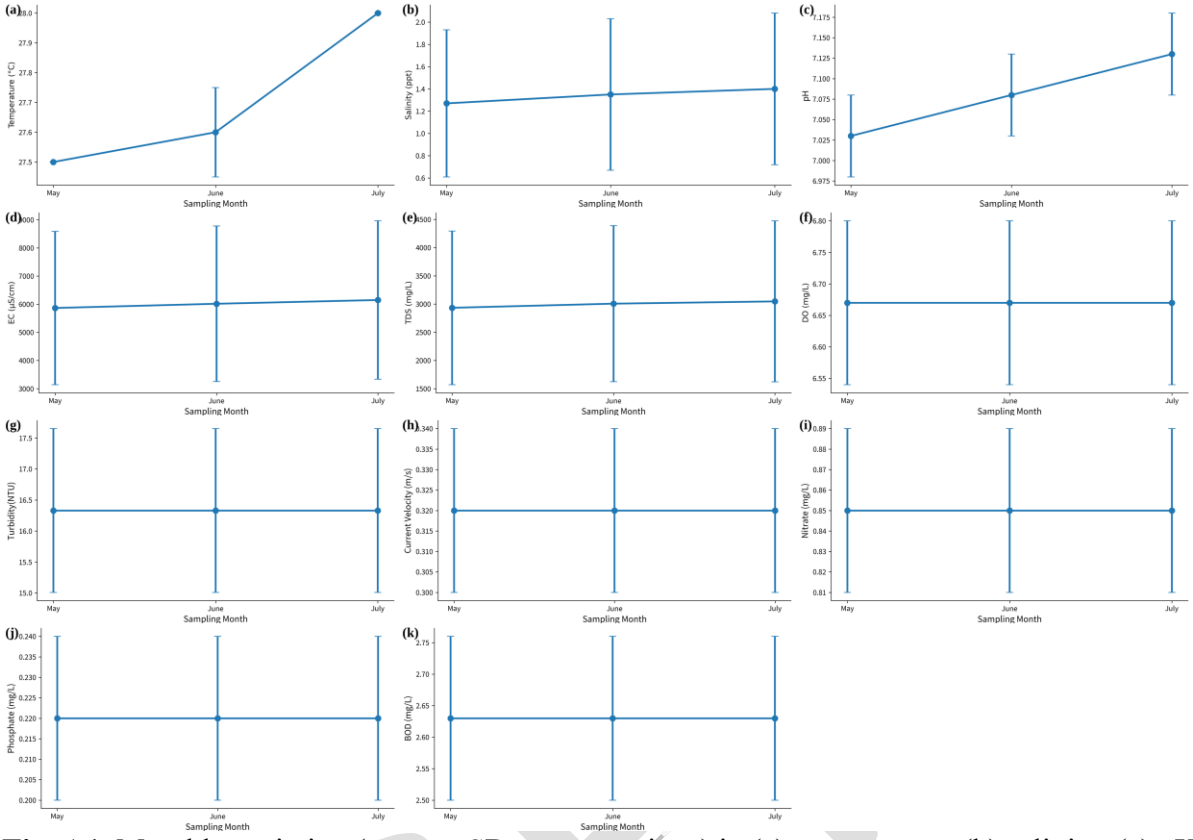


Fig. A1. Monthly variation (mean ± SD across stations) in (a) temperature, (b) salinity, (c) pH, (d) electrical conductivity, (e) total dissolved solids, (f) dissolved oxygen, (g) turbidity, (h) current velocity, (i) nitrate, (j) phosphate and (k) BOD_5 in the Egbelu reach of the New Calabar River, May–July 2026.