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Relative Abundance, Richness and Diversity of Bottom Sediment of Macroinvertebrates in Okhuaihe River, Ikpe community, Ikpoba Okha Local Government Area, Edo State, Nigeria

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ABSTRACT: Components of species diversity involves species richness and relative abundance within a biological community. Hence, this paper is set out to assess the relative abundance, richness and diversity of bottom sediment of macroinvertebrates in Okhuaihe River, Ikpe Community, Ikpoba Okha Local Government Area, Edo State, Nigeria, using standardized analytical techniques. Data obtained reveals that most of the metrics in the sediment samples fell within the tolerable ranges allowed by the Federal Ministry of Environment and the World Health Organization. Dipterans were the majority group among the twenty-eight (28) taxa that made up the 931 individuals collected, and an analysis of variance (ANOVA) showed no significant difference in the overall density ($p > 0.05$) between the sampling stations. Shannon (H) showed that Station 2 was more diverse (2.723) and least in Station 4 (2.496), while evenness (E) was highest in Station 2 (0.6342) and lowest in Station 3 (0.5248). Species richness as measured by Margalef's index showed that Station 1 was highest (4.873) and least in Station 4 (3.99). There was a remarkable presence of Diptera, Coleoptera, Odonata, and Haplotaxida, while the nonappearance of sensitive species suggests possible contamination and pollution. Regular monitoring of the river's sediment quality, including the activities and effluents that are discharged into the river is advised.

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According to the United States Environmental Protection Agency (USEPA) (2002), sediment is the loose sand, silt, and other soil particles that collect at the bottom of bodies of water that may result from soil erosion or the decay of living things like plants and animals. These particles are assisted to get to rivers, lakes, and streams by wind, water, and ice. Abowei and Sikoki (2005), stated that sediment strata provide an essential habitat for benthic macroinvertebrates whose metabolic processes increase aquatic productivity. Sediments affect ecological quality either by their quantity, quality, or both (Stronkhorst *et al.*, 2005). Lokhande *et al.* (2011), reported that sediment analysis is crucial for determining the overall ecological characteristics of a body of water. Sediment testing, as opposed to water testing, provides an independent reflection of the long-term quality situation (Hodson, 1986). Pollutant particles can

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adhere to the suspended and precipitated (non-floating) compounds and organic substances in waterways (adsorption) (Biney *et al*., 1995; Barbour *et al*., 1998 and 1999). The sediments, both suspended and precipitated chemicals held on the water's surface, form a reservoir for numerous contaminants and trace substances with low solubility and a low degree of degradability. As a result of their chemical persistence and the physical-chemical and biological properties of the substrate, pollutants are preserved in sediments for a long time. This makes it possible to deduce the origins of contamination. Chemical analysis for the characterization of sediments also provides environmentally significant information about the natural and anthropogenic influence on the water bodies (Menounou *et al*., 2003; Spooner *et al*., 2003; Sahu *et al*., 2009; Lokhande 2011; Singhare *et al*. 2011). This is because sediments act as sinks and sources of contaminants in aquatic systems. Benthic and other creatures connected with the sediment can be affected by contaminated sediment in both a fatal and sub-lethal manner (USEPA 2001). A sizeable amount of the annual movement of metals, phosphate, chlorinated pesticides, and many industrial compounds like polychlorinated biphenyls, dioxins, and furans is carried by fine-grained sediment (silt + clay). In relation to the 128 priority contaminants specified by the United States Environmental Protection Agency (USEPA 2001), sediment and biota are detected in conjunction with each other 65 percent of the time. The sediment load, which influences both the types of insects that may live in streams, is determined by the type and intensity of agricultural land usage (Dance and Hynes, 1980). There's yet to be any record of research on the biodiversity of the Okhuaihe River of the Ikpe community, Benin City, Edo state. Therefore, this objective of this paper was to assess the relative abundance, richness and diversity of bottom sediment of macroinvertebrates in Okhuaihe River, Ikpe Community, Ikpoba Okha Local Government Area, Edo State, Nigeria.

MATERIALS AND METHODS

Geographical Location: This section of Okhuaihe River studied is located at Ikpe Village in Ikpoba-Okha Local Government Area of Edo State, Nigeria within Latitudes 6^0 12'25.19"N and 6° 12' 29.93"N and Longitudes 5° 45' 17.12" E and 5° 45' 3.84" E. The river runs across the Benin-Abraka Express Road, 30 kilometers from Benin City lying within the tropical rainforest of Southern Nigeria with an average elevation of -8.48m below sea level to 1.87m above sea level. The river is one of the major rivers which flows into Ossiomo River emptying into the Atlantic Ocean. The river provides water for both domestic and agricultural use to the inhabitants of the community.

Vegetation and Land Use: The vegetation in this area includes *Mimosa pundica* (Sensitive plant), Ferns, *Elaeis guineensis* (Palm tree), Plantain (*Musa sapientum), Sida acuta* (Stubborn grass), *Colocasia esculenta* (Cocoyam plant), Coconut tree (*Cocos nucifera)*, Raffia palms (*Raphia farinifera)*, Bahama grasses *(Cynodon dactylon)*. Observed also was the presence of floating and submerged macrophytes such as water hyacinth (*Eichhornia crassipes)*. Most human activities in the study area include swimming, farming, fishing, bathing, local gin production, palm wine production, timber and lumber production, broom making, mat weaving and some spiritual activities.

Sampling Stations: Four sampling stations were chosen for their proximity to facilities, structures or human activities that could potentially affect water quality and biodiversity.

Station 1: is located at Latitude 6° 12' 25.19" N and Longitude 5° 45' 17.12" E with an elevation of -37.87m below sea level and bearing of 62.81^0. The water in this station is clear and human activities includes laundry activities, swimming, timber and Palm wine production. The vegetation around this station includes *Mimosa pundica* (Sensitive plant), Ferns, *Elaeis guineensis* (Palm tree), *Sida acuta* (Stubborn grass), Bahama grasses, and Water hyacinth. The substratum contains a mixture of sandy, human wastes and organic matter.

Station 2: is located at Latitude 6° 12' 24.18" N and Longitude 5° 45' 15.99" E with an elevation of -8.48m below sea level and a bearing of 91.06^0. The water in this station is not entirely clear. The activities carried out here include cooking, laundry and some traditional activities. Vegetation in this station includes *Elaeis guineensis* (Palm tree), Plantain (*Musa paradisiaca)*, *Sida acuta* (Stubborn grass), wild cocoyam plants, and water hyacinth. The water in this station is not entirely transparent with a moderate flow rate.

Station 3: Station 3 is located at Latitude 6° 12' 28.76" N and Longitude 5° 45' 8.55" E with an elevation of 1.4m above sea level and a bearing of 95.74^0. School of fingerlings were discovered in the water. Activities in this station include timber production, traditional activities, and swimming. The vegetation in this area includes *Elaeis guineensis* (Palm tree), Fern, *Colocasia esculenta* (wild Cocoyam plant), coconut trees, submerged and floating macrophytes.

Station 4: Station 4 is located at Latitude 6° 12' 29.93" N and Longitude 5° 45' 3.84" E with an elevation of 1.87m above sea level and a bearing of 90.0^0. The water in the station is not clean at all and also not transparent. Human activities in this station include dumping of refuse close to the river, timber production, laundry, and cooking. The vegetation in this area includes *Elaeis guineensis* (palm tree), *Colocasia esculenta* (Cocoyam plant), ferns, plantain trees and floating macrophytes.

Benthos Collection: Sediment samples were collected from each station and put into labeled polythene bags for subsequent determination of the sediment's physico-chemical properties. The remaining samples were washed through a sieve of 1mm x 1mm mesh size to collect the benthos. The washed sediment with macrobenthos was emptied into a wide-mouth labeled plastic container and preserved with 10% formalin solution. The preserved samples were later taken to the laboratory for further analysis.

Sorting and Identification of Benthos: In the laboratory, the washed and preserved sediment with benthic invertebrates was poured into a white enamel tray and sorted. The sorting was made effective by adding a moderate volume of water into the container to improve visibility. Large benthos samples were picked using forceps while the smaller ones were viewed using a magnifying lens and pipetted out. The organisms were sorted and preserved in 10% formalin. Identification to the lowest possible taxonomic level was performed under a light microscope using keys of macrobenthos and some basic texts (Olomukoro 1996; Mackie, 1998; Olomukoro and Egborge, 2003).

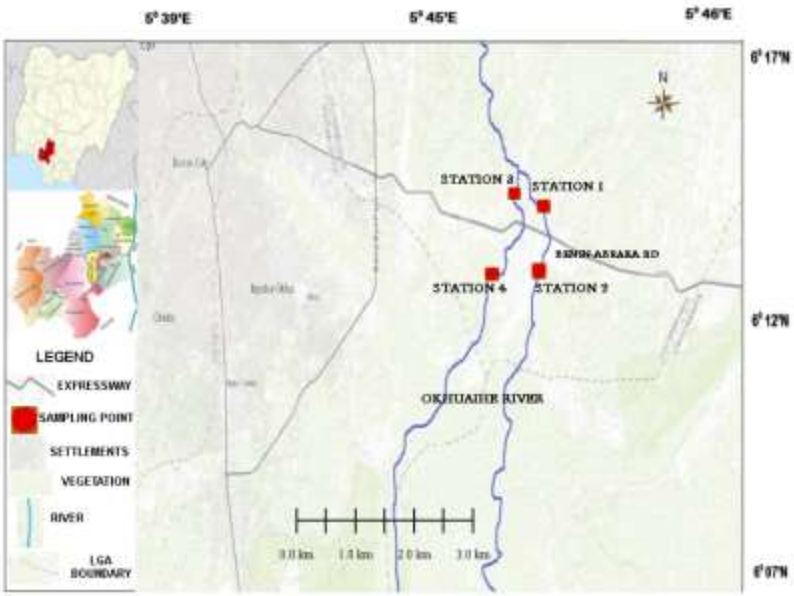

Fig 1: Map of Okhuaihe River with the Study Locations

RESULTS AND DISCUSSION

The summary of the physical and chemical parameters of the sediment samples of the study stations of Okhuaihe River, Edo State is presented for spatial comparisons (Table 1). All parameters except sand and clay were not significantly different (P>0.05) among all the stations. The sand parameters of stations 2 and 4 were significantly higher (P<0.05) than others. The clay of stations 3 and 4 was significantly higher (P<0.05) than others.

Community Structure of Benthic Macroinvertebrate Fauna in Okhuaihe River: Checklist Of Benthic Macroinvertebrate Fauna: A total of 28 macrobenthic invertebrate taxa comprising 931 individuals were recorded. They include Haplotaxida (2 species), Coleoptera (6 species), Decapoda (1 species), Diptera (6 species), Ephemeroptera (5 species), Hemiptera (2 species), Odonata (5 species), Plecoptera (1 species), Trichoptera (1 specie), and Gastropoda (1 species) were identified.

Relative Abundance of Benthic Macroinvertebrates: The overall taxa composition, abundance and distribution of benthic macroinvertebrates fauna are presented graphically in Fig 2. Haplotaxida accounted for 8.49% of the total number of individuals, Decapoda 0.86%, Ephemeroptera 3.76%, Hemiptera 1.07%, Coleoptera 24.17%, Tricoptera 3.86%, Diptera 43.5%, Odonata 7.84%, Plecoptera 4.73%**,** Gastropoda 1.72%. The spatial distribution of the different order of benthic macroinvertebrate when subjected to Chi-square goodness of fit test showed no significant difference (p>0.05).

Table 1: Spatial Variation of Physical and Chemical Parameters for Sediment Samples of Okhuaihe River

Parameters	**STATION 1** $\bar{X}$±SD **(Min-Max)**	**STATION 2** $\bar{X}$± SD **(Min-Max)**	**STATION 3** $\bar{X}$± SD **(Min-Max)**	**STATION 4** $\bar{X}$± SD **(Min-Max)**	***p*-Value**
pH	5.48±1.00 (4.20-6.30)	5.53±0.96 (4.30-6.30)	5.67±0.77 (4.60-6.30)	5.62±0.75 (4.80-6.30)	$p > 0.05$
Electrical Conductivity (µS/cm)	68.33±22.29 (50.00-100.00)	63.33±15.06 (50.00-80.00)	65.00±17.61 (50.00-90.00)	60.00±24.49 (40.00-90.00)	$p > 0.05$
Phosphate (mg/kg)	4.77±6.00 (1.33-16.92)	3.03±1.22 (0.93-4.51)	3.40±2.36 (1.08-6.58)	5.10±2.63 (1.56-8.10)	$p > 0.05$
Nitrate (mg/kg)	1.99±1.54 (0.24-4.70)	2.21±1.39 (0.82-4.58)	2.50±1.19 (1.54-4.82)	2.37±1.26 (1.12-3.93)	$p > 0.05$
Iron (mg/kg)	374.66±37.03 (329.11-428.75)	375.84±37.34 (339.55-428.23)	416.56±74.19 (378.65-567.48)	397.35±43.17 (347.69-476.36)	$p > 0.05$
Zinc (mg/kg)	83.21±10.18 (67.98-92.17)	80.64±2.62 (78.17-85.24)	83.12±10.63 (65.33-94.28)	81.38±7.80 (68.45-91.77)	$p > 0.05$
Copper (mg/kg)	46.79±4.83 (38.29-51.23)	43.69±4.78 (37.67-48.76)	37.91±6.08 (26.54-43.78)	40.90±6.26 (29.63-47.16)	$p > 0.05$
Manganese (mg/kg)	10.40±1.31 (8.26-11.76)	12.25±1.41 (10.11-14.32)	9.83±2.16 (7.53-13.94)	11.16±1.66 (8.74-13.26)	$p > 0.05$
Chromium (mg/kg)	18.77±2.57 (14.44-21.68)	16.36±1.86 (13.87-18.47)	14.44±2.73 (12.01-18.34)	16.94±2.84 (13.78-20.56)	$p > 0.05$
Silt (%)	12.83±2.48 (10.00-16.00)	12.50±2.74 (9.00-16.00)	11.67±3.61 (8.00-17.00)	11.50±1.76 (9.00-14.00)	$p > 0.05$
Sand (%)	$76.33±0.52^{A}$ (76.00-77.00)	$98.33±1.97^{C}$ (96.00-100.00)	$82.83±7.41^{B}$ (77.00-96.00)	$98.67±1.51^{C}$ (97.00-100.00)	$p < 0.01$
Clay (%)	$12.83±1.33^{AB}$ (11.00-15.00)	$10.83±0.75^{A}$ (10.00-12.00)	$13.83±2.40^{B}$ (11.00-16.00)	$13.33±2.25^{B}$ (11.00-16.00)	$p < 0.05$

NOTE: p < 0.01 – Highly Significant Difference; p> 0.05 – No Significant Difference; Similar Superscripts Row-wise – No Significant Difference using Duncan Multiple Range Tests (DMRT). Where X = Mean, SD = Standard Deviation, Min. = Minimum value and Max. = Maximum value.

Table 2: Checklist Of Benthic Macroinvertebrate Fauna

Phylum	Class	Order	Family	Organism	Author
Annelida	Clitellata	Haplotaxida	Naididae	*Nais sp.*	Nais Muller, 1774.
				Nais obtuse.	Nais Muller, 1774.
Arthropoda	Crustacea	Decapoda	Atyidae	*Caridina africana*	Kingsley, 1882.
	Insecta	Ephemeroptera	Baetidae	*Centroptilum sp.*	Eaton, 1969.
				Baetis sp.	Leach, 1942.
				Pseudocloeon sp.	Klapalek, 1905.
				Cloeon simplex	McDunnough, 1925
			Leptophlebiidae	*Leptophlebia sp.*	Westwood, 1840.
		Hemiptera	Veliidae	*Microvelia* sp.	Westwood, 1834.
			Nepidae	*Nepa apiculata*	Uhler, 1862.
		Coleoptera	Hydrophilidae	*Amphiops gibbos*	Erichson, 1843
				Hydrophilus sp.	Geoffroy, 1762.
				Philhydrus sp.	Thomson, 1859.
			Dytiscidae	*Dytiscus marginalis*	Linnaeus, 1758.
				Copelatus sp.	Erichson, 1832.
			Elmidae	*Dubiraphia* sp.	Sanderson, 1954.
		Trichoptera	Hydroptilidae	*Agraylea* sp.	Curtis, 1834.
		Diptera	Chironomidae	*Ablabesmyia* sp.	Johannsen, 1905.
				Chironomus fractilobus	Kieffer, 1923.
				Chironomus transvalensis	Kieffer, 1923.
				Pentaneura sp.	Johannsen, 1905.
				Polypedilum sp.	Kieffer, 1912.
			Culicidae	*Culex* sp. (larvae)	Linnaeus, 1758.
		Odonata	Libellulidae	*Libellula sp.*	Linnaeus, 1758.
				Sympetrum striolatum	Charpentier, 1840.
				Enallagma sp.	Charpentier, 1840.
			Coenagrionidae	*Coenagrion pulchellum*	Van der Linden, 1823.
				Coenagrion scitulum	Rambur, 1842.
		Plecoptera	Perlidae	*Neoperla sp.*	Needham, 1905.
Mollusca	Gastropoda	Cycloneritida	Neritida	*Neritina sp.*	Rafinesque, 1815.

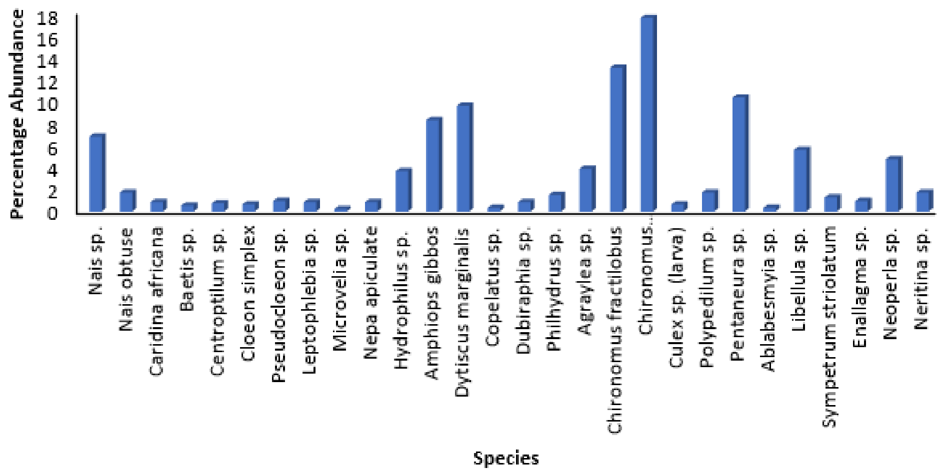

Fig 2: Relative Abundance of Benthic Macroinvertebrates across the Study Stations.

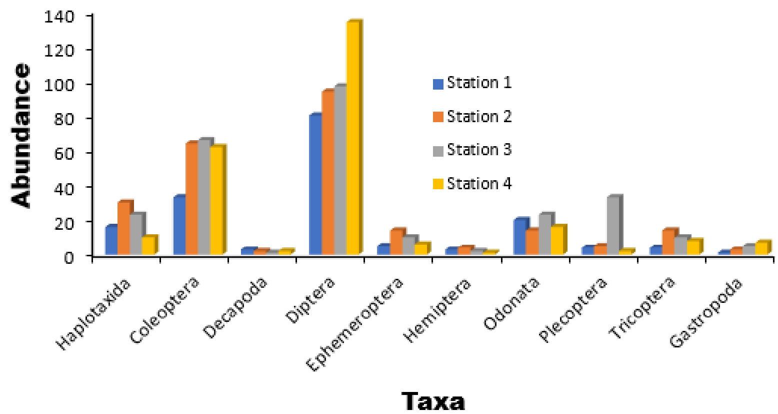

Fig 3: Spatial Distribution of Benthic Macroinvertebrates across the Station

Diversity Indices: The diversity indices for the stations are displayed in Table 2. The Margalef index, which measures species richness, showed the highest and lowest values at stations 1 and 4 with indices of 4.873 and 3.99 respectively. However, with a Shannon-weiner index of 2.723, station 2 has the highest level of general diversity among the study stations. Station 1 came in second with a rating of 2.649. Station 4 has the lowest diversity index of the research stations, at 2.496. Station 2 (0.6342) has the highest evenness, closely followed by station 1. (0.544). Station 3 got the lowest value of evenness (0.5248), closely followed by station 4 with a value of 0.5274. Station 4 (0.1203) had the most dominance, closely followed by station 1. (0. 09569). Station 2 recorded the lowest value, 0.09418), while Station 3 obtained the highest value (0.08623).

*Correlation between Sediment Quality and Benthic macroinvertebrates***:** Correlation statistics was adopted in testing the sediment quality and benthic samples of the river. Positive correlations were observed between the concentrations of Nitrate, Ammonia, Sulphate, Phosphate, Chloride, Manganese, Chromium, pH, Electrical Conductivity, Gastropodas, Tricopterans, Plecopterans, Odonatans, Hemipterans, Ephemeropterans, Dipterans, Coleopterans and Haplotaxidas.

Table 3: Diversity Indices of Benthic Macroinvertebrates in the Study Area.

Diversity Indices	Station 1	Station 2	Station 3	Station 4
Taxa_S	26	24	26	23
Individuals	169	244	270	248
Dominance_D	0.09569	0.08623	0.09418	0.1203
Shannon_H	2.649	2.723	2.613	2.496
Simpson_1-D	0.9043	0.9138	0.9058	0.8797
Evenness_e^H/S	0.544	0.6342	0.5248	0.5274
Margalef	4.873	4.184	4.466	3.99
Equitability_J	0.8131	0.8567	0.8021	0.796

The benthic macroinvertebrate fauna connected to the Okhuaihe River's bottom sediment exhibits a qualitative nature that is revealed by the community structure. 931 individuals belonging to 28 different taxa of benthic macroinvertebrates were counted. There are two species of Haplotaxida, six species of Coleoptera, one species of Decapoda, six species of Diptera, five species each of Ephemeroptera and Hemiptera, five species each of Odonata and Plecoptera, one species each of Trichoptera, and one species of Gastropoda (1 species). Rather than the physical and chemical factors, the distribution of benthic macroinvertebrates is frequently influenced by the availability of food and shelter. The study's database of taxa is rather vast, and this is corroborated by the fact that tropical streams often host more species than temperate streams (Hynes, 1970; Bishop, 1973). Additionally, tropical rivers tend to rebound quickly; it has been argued that this is due to the pace of reproduction and the comparatively high primary output (Wallace and Hynes, 1981). Wokoma and Umesi (2017) reported a benthic macro-faunal community represented by 8 species from 4 different phyla and 6 classes in which polychaetes were the most abundant with 104 individuals representing 70.27%, followed by Gastropoda with 39 individuals (26.35%), Insecta was next with 2 individuals (1.35%) and others (crustacean, Bivalvia and Pisces) contributed 1 individual each (0.67%). Olaniyan *et al.*, (2014) reported benthic macroinvertebrates which is made up of 17 species belonging to three phyla; Arthropoda, Annelida, and Mollusca consisting of five classes: Crustacea, Gastropoda, Insecta, Oligochaeta, and Polychaetae giving a total abundance of 2264 individual macroinvertebrates species from the bottom sediment. Udaghe (2013) reported A total of thirty-eight (38) taxa which comprises of 2276 individuals were collected. Plesiopora accounted for 1.14%, Haplotaxida 3.29%, Cyclopoidea 0.57%, Odonata 9.62%, Ephemeroptera 13.32%, Hemiptera 20.12%, Coleoptera 9.62%, Trichoptera 0.70%, Diptera 30.71%, Araneida 8.40%, Prostigmata 2.33%, Mesogastropoda 0.18%. The family Baetidae (Ephemeroptera), Culicidae, Chironomidae (Diptera), Gerridae, Pleidae (Hemiptera), and Dytiscidae (Coleoptera) were the most abundant species. The Diptera, Coleoptera, Odonata, and Haplotaxida were the major groupings in this study. Some of the uncommon groups include Decapoda, Hemiptera, and Gastropods. All of the study stations lacked Odonata, Trichoptera, and Coleoptera-sensitive species, which signify clear water with little organic debris. This suggests contamination. The presence of insects at all of the sampling locations attests to their ubiquity and the fact that they do not signify habitat restriction. The presence of pollution-tolerant species like Chronomous *sp*. demonstrates the impact perturbation stress has on organisms and the state of diminishing water quality (Saliu and Ekpo, 2006). The diversity and evenness indices show no appreciable variations in the species composition between the sites. All three stations have remarkably similar creatures. While high diversity is regarded to be a reflection of a stress-free environment, low diversity is thought to be a symptom of stress in the community. Diversity has been used to gauge the stability of a community (MacArthur, 1965, Olomukoro, 1996). The diversity indices revealed that there are significant differences across sites in the species composition.

Conclusion: The benthic macroinvertebrate diversity of Okhuaihe River's bottom sediment at the Ikpe community showed a varied community structure, with 28 taxa recognized. Remarkably, Diptera, Coleoptera, Odonata, and Haplotaxida were major groupings, while the nonappearance of sensitive and delicate species suggests possible contamination and pollution. Constant monitoring of water quality, community engagement initiatives, habitat restoration efforts, should be encouraged to guarantee the long-term health and sustainability of the river ecosystem.

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