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PHYSIOCHEMICAL PARAMETERS AND MACROBENTHIC INVERTEBRATES OF JEDDO RIVER, DELTA STATE, NIGERIA.

Anigboro O.D., Ikomi, R.B. and Nwaiku, F.
Department of Animal and Envronmental Biology,
Faculty of Science,
Delta State University, Abraka

Abstract
This study assessed the physicochemical parameters and macrobenthic invertebrate community of Jeddo River, Delta State, Nigeria, to evaluate water quality and ecological integrity. Sampling was conducted monthly for 12 months (January–December 2024) at three stations along the river. Water samples were collected using sterilized plastic containers, while macroinvertebrates were sampled using a D-frame aquatic net and standard kick-sampling techniques. Laboratory analyses followed established protocols. Physicochemical parameters recorded included air temperature (28.3–33.2 °C), water temperature (26.8–30.1 °C), depth (47.4–159.8 cm), dissolved oxygen (5.2–9.3 mg/L), biochemical oxygen demand (2.5–8.9 mg/L), pH (5.3–7.6), conductivity (97.2–138.7 µS/cm), acidity (50.1–81.4 mg/L), alkalinity (122.5–265.3 mg/L), total dissolved solids (88.0–141.2 mg/L), phosphate (1.2–3.6 mg/L), sulphate (21.5–48.9 mg/L), and nitrate (15.6–25.8 mg/L). Conductivity, BOD, phosphate, and nitrate differed significantly ($p < 0.05$) among stations. A total of 1,075 macroinvertebrates representing 19 families across Insecta, Mollusca, Annelida, Nematoda, Crustacea, and Arachnida were recorded. Coleoptera dominated the assemblage (45.8%), followed by Hemiptera (14.23%) and Diptera (11.63%). Station 2 showed the highest abundance (693 individuals), while station 3 had the lowest (150 individuals), likely reflecting greater anthropogenic disturbance. Species richness and evenness were highest at station 1, whereas station 2 exhibited the lowest evenness. Functional feeding groups comprised predators, collector-gatherers, and grazers, with predators overwhelmingly dominant and shredders absent, indicating ecological stress. High predator–prey ratios (>2.0) suggested trophic imbalance. Canonical Correspondence Analysis revealed strong relationships between macroinvertebrate distribution and key water chemistry variables. Overall, Jeddo River shows moderate environmental impact, emphasizing the need for improved management and continuous biomonitoring using macroinvertebrates.

Keywords: Jeddo river, Physiochemical parameters, Macrobenthic invertebrates, Ecology

Introduction
Jeddo river is located in Okpe Local Government Area, Delta State, Nigeria, at coordinates 5° 35' 48" N and 5° 42' 14".The Jeddo River empties into the Warri River, one of the largest coastal rivers in Nigeria's Niger Delta. The Warri River in turn empties into the Atlantic Ocean via the Forcados estuary.

Studies in Nigeria have identified anthropogenic activities as the easiest source of water pollution Obasi and Balogun, 2001; Ogidiaka *et. al*., 2012 and Adjarho *et. al*., 2013. These water bodies are always used as receptacles for untreated wastewater or poorly treated effluents from industries (textile and chemical processing plants), agricultural activities (fertilizer- and pesticide-laden runoff), commercial activities (effluents from restaurants and car-wash centers), or domestic activities (household sewage and laundry wastewater) (Adeyemi-Ale et al., 2014). Therefore, the increase in anthropogenic inputs of impurities, through erosion, leaching, and weathering of rock materials, has led to the rapid degradation of surface water and has thus rendered most water bodies unsuitable for their multipurpose use, such as artisanal fishing and domestic activities (Tharme, 2003).

Changes in the physico-chemical features of water bodies can have detrimental consequences on the functioning of ecosystems and the biological community, depending on the severity of disturbances (Edegbene *et al.,* 2021; Ogidiaka *et al.,* 2022). As a result, determining the overall health of aquatic systems is based mostly on physico-chemical factors, such as temperature, pH, Salinity, Alkalinity, Dissolved Oxygen, Biochemical Oxygen Demand, and Nutrients (nitrate, sulfate, and phosphate) are some of the most often utilized physico-chemical variables (Okogbule Wonodi et al., 2025).

Changes in the physico-chemical features of water bodies can have detrimental consequences on the functioning of ecosystems and the biological community, depending on the severity of disturbances (Edegbene *et al.,* 2021; Ogidiaka *et al.,* 2022). For determining the health and sustainability of macrobenthic invertebrate populations in rivers, measuring water quality is crucial. For their survival, development, and reproduction, macrobenthic invertebrates are dependent on the quality of the water they live in (Oriabure & Ogbeibu, 2024).

The anthropogenic activities and inputs from neighboring communities, which include run-offs from agricultural farms containing manure and fertilizers, have been reported to contaminate several water bodies and have been associated with certain diseases (Chia and Oniye, 2013). These inputs can cause serious effects on the water quality and subsequently affect the biodiversity of organisms within the river. The role of nutrients in controlling seasonal succession of macrobenthic invertebrate composition and diversity in the River has not been documented (Mustapha, 2010).

Several studies have been carried out on macroinvertebrates' assemblage and water quality characteristics in Nigeria. Ibemenuga et al. (2017) studied the influence of abattoir wastes on macroinvertebrates' distribution in River Idemili, South-Eastern Nigeria, while Iyagbaye et al. (2017) studied the diversity and seasonal variation of the benthic macroinvertebrates of Ovia River, Edo State, Southern Nigeria. Edegbene et al., (2019) on the other hand, developed and applied a macroinvertebrate-based multimetric index for assessing water quality condition of impacted urban river systems in the Niger Delta, Nigeria, whereas Olaniyan et al., (2019) studied the macroinvertebrate fauna of Oluwa River, Ilaje Local Government Area, Ondo State, Southwest Nigeria. Recently, Aliu et al. (2020) assessed three major tributaries (Obudu, Opa, and Esinmirin rivers) of a tropical reservoir in Ile-Ife, Southwest Nigeria, while Edegbene (2020) studied the probable menacing effects of the Typha grass and some selected environmental variables on the composition and diversity of benthic macroinvertebrates of Kalgwai Dam, Jigawa State, Northwest Nigeria. Among all these, there is no study concerned with the Jeddo River. Since there is little information on the macrobenthic invertebrates and physicochemical parameters of the Jeddo River, it is essential to determine the temporal variation, composition, abundance, and distribution of the macrobenthic invertebrates of the Jeddo River.

Although numerous studies have examined macrobenthic invertebrate assemblages and their relationships with water quality across different Nigerian freshwater ecosystems, these investigations have been largely site-specific and geographically limited to rivers and reservoirs outside the Jeddo River system. Existing studies have focused on the impacts of anthropogenic activities, seasonal variations, and the development of bioassessment indices in other Nigerian rivers, leaving the Jeddo River unstudied. Consequently, there is a clear lack of baseline data on the macrobenthic invertebrate community structure and associated physicochemical characteristics of the Jeddo River. In particular, information on the temporal variation, species composition, abundance, and spatial distribution of macrobenthic invertebrates in relation to water quality in the Jeddo River is absent. This knowledge gap limits the understanding of the ecological status of the river and hinders effective monitoring, management, and conservation of the Jeddo River ecosystem. The general objective of this study is to examine the physicochemical Parameters and macrobenthic invertebrates of the Jeddo River, Delta State, Nigeria.

Material and Methods

Study Area

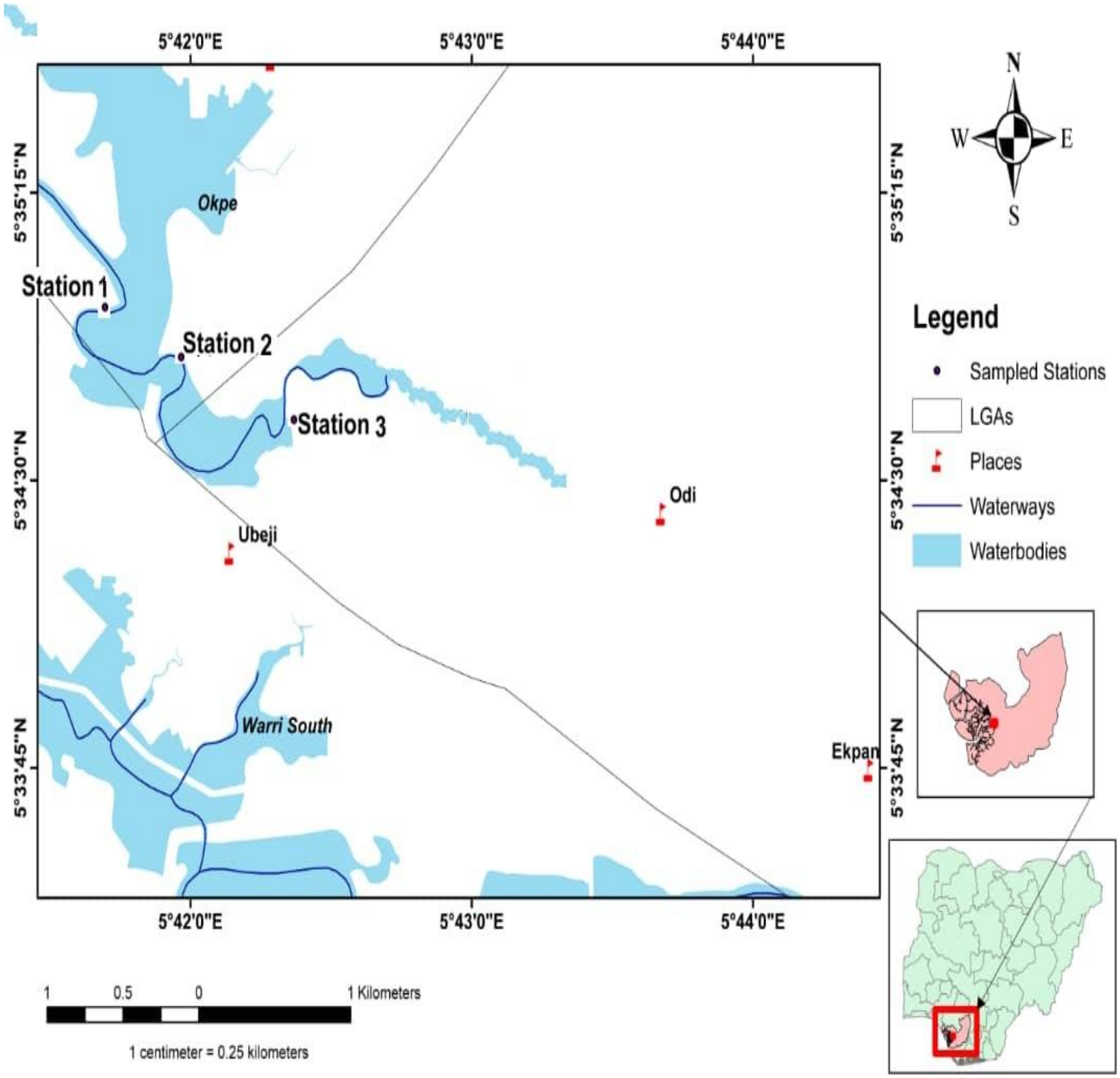
In Figure 3.1, the study area's map is displayed. Located in Jeddo, Okpe, Delta State, Nigeria, at coordinates 5° 35' 48'' N and 5° 42' 14''. The Jeddo River is connected to the Warri River. One of the largest coastal rivers in Nigeria's Niger Delta. It empties into the Atlantic Ocean via the Forcados estuary. In the lower Niger Delta, Jones Creek connects the Warri River to the Forcados River and the Escravos River. At the southernmost point of Nigeria, the Niger Delta region is a about 70 000 km^2 area (Edegbene *et al.,* 2021). According to Uluocha and Okeke (2004) and Adekola and Mitchell (2011), the area is home to the third-largest wetland system in the world. Mangrove swamps, marshes, vegetation, and a sizable tropical rain forest are features of the region (Umoh, 2008; Tonkin *et al.,* 2016). According to Adekola and Mitchell (2011), the region has a high level of biodiversity, although it is rapidly dwindling as a result of many anthropogenic effects.

This area has two seasons: rainy and the dry season. The rainy season, which has an average rainfall of 20 days in a month, runs from May to October, while the dry season, characterised by average rainfall days lower than 20 in a month, runs from November to April.

Station 1: This station occupied a location within the Jeddo river, precisely 5.576454N and 5.716672N. The distance between this station and Station 2 is 200 metres. This station is close to an abattoir that empties the animals' waste into the river. It is rich with many aquatic weeds. The mangrove trees that used to be there some years back have been removed, probably because of development.

Station 2: This station occupied 5.577285N and 5.716570N. The vegetation is made up of some young mangrove, *Rhizophora* spp, and some economic trees. The surface of the water is covered with invasive water hyacinth (*Eichhornia crassipes*) that is spreading rapidly.

Station 3: This station is an open water body, like station 2, it has some young mangrove (*Rhizophora* spp) and some economic trees, but this station has no aquatic weeds. Anthropogenic activities such as dredging take place here occasionally.



Map of the Study area
Developed using Google Maps (2024)

Determination of physico-chemical parameters

At each sampling site, selected physico-chemical parameters were measured *in situ*, while others were analyzed in the laboratory. Water samples that could not be measured on site were collected in clean 5-L containers, preserved in an ice chest, and transported to the laboratory for analysis following standard methods (APHA, 1998). Dissolved oxygen (DO) was determined using the modified Winkler's titrimetric method, while biochemical oxygen demand (BOD_5) was measured after five days of incubation using the difference between initial and final DO values. Hydrogen ion concentration (pH) was measured *in situ* using a calibrated portable pH meter. Air and water temperatures were measured with a calibrated mercury-in-glass thermometer and recorded in degrees Celsius. Electrical conductivity and salinity were measured using a conductivity meter, with results expressed in µS/cm and g/L respectively. Nitrate concentration was determined using the ultraviolet spectrophotometric method, while sulphate was analyzed by the turbidimetric method using barium chloride. Phosphate was determined by the stannous chloride colorimetric method, with absorbance measured using a spectrophotometer. Concentrations of nutrients were calculated from calibration curves and expressed in mg/L. (APHA, 2017)

Sampling of macroinvertebrates

Macroinvertebrate samples was collected between 07.00hrs – 12.00hrs, alternating from upstream (i.e., station 1 to station 3) and downstream to upstream (i.e., station 3 to station 1), on every other sampling day, using the "Kick sampling technique". The modified "Kick sampling technique" described by Kellogg (1984) was used to sample benthic macroinvertebrates. The kick net has a mesh size measuring 154µm. It was placed downstream of the collector, with the flat side of the "D-shaped" frame resting on the substrate or stream bed. This collector will walk forward, while the net stands behind, while he disturbs the substrate and littoral macrophytes by kicking against them. The water current carries the dislodged animals into the standing net. Sampling was extended only along the area adjacent to the stream bank, because this region is known to have aquatic macrophytes that support macroinvertebrate fauna (Stubbington *et al*, 2023).

Sample processing

Samples were preserved directly without sorting, in 70% ethanol. The debris and associated macroinvertebrate organisms from each sample was stained with Rose Bengal (a stain that attaches to animal tissues) and transported to the laboratory of the Department of Animal and Environmental Biology, Delta State University, Abraka. The stained samples were processed by using the flotation technique as adopted by Arimoro (2007). The technique involved submersing the sample into a solution of sodium chloride, in filtered river water (12.2g/l) with a specific gravity higher than that of the macroinvertebrate organisms. The invertebrates thus float to the surface, where they were easily removed by forceps.

Statistical Analysis

With the aid of statistical software, Principal component analysis (PCA), was applied to physical (air and water temperature) and chemical (conductivity, pH, alkalinity, dissolved oxygen, sulphate, nitrates, and total phosphorus) and macroinvertebrate abundance to evaluate the variations which exist between the various sampling stations in Jeddo river. A One-way ANOVA was applied to physicochemical parameters to determine any variations between the various stations. The Turkey's pairwise analysis was used to determine the points of these variations, if present. Microsoft Excel 2010 was used to plot simple line graphs and bar charts showing the fluctuations in the values of measured parameters.

Results

The mean, standard error and range of the physicochemical parameters measured in Jeddo River are shown in Table 1

The mean pH values across the stations ranged from slightly acidic to alkaline, with no significant spatial variation ($P<0.05$). pH fluctuated seasonally at all stations, showing occasional acidic conditions during some months. Mean electrical conductivity increased from station 1 to station 3, indicating variations in ionic content. Conductivity values showed wide monthly fluctuations but no significant differences among stations. Salinity levels were generally low to moderate and varied seasonally across the three stations. Station 3 recorded the highest salinity values, particularly during the wet season. Mean dissolved oxygen (DO) values were moderate and comparable across all stations. DO exhibited monthly fluctuations, with higher values recorded during some mid-year months. There was no statistically significant difference in DO levels among stations ($P<0.05$). Biochemical oxygen demand (BOD) values were generally low to moderate across the study period. Station 2 recorded slightly higher mean BOD values, though differences were not significant. Seasonal variations in BOD reflected changes in organic load and microbial activity. Mean nitrate concentrations were low across all stations, indicating limited nutrient enrichment. Nitrate levels varied monthly, with occasional peaks during the later months of the year. No significant spatial variation in nitrate concentration was observed among stations. Sulphate concentrations were relatively high but comparable across the three stations. Monthly sulphate levels fluctuated, with occasional high values recorded at individual stations. Phosphate concentrations were generally low, except for sporadic peaks at station 2. Temporal variation in phosphate was evident, though spatial differences were insignificant. Overall, all measured parameters showed seasonal variability but no significant differences among stations.

Table 1: A summary of the results of the physico-chemical parameters of the sampled stations, showing sample means ± standard deviation, F-value, p-value, and standard limits of these parameters in drinking water.

Water Parameter	Station 1 Mean±SD	Station 2 Mean±SD	Station 3 Mean±SD	F-value	P-value	WHO/NSDWQ /SON
Air Temperature (^{0}C)	30.94±0.49 (27.00-34.50)	30.00±0.37 (27.32-33.00)	31.51±0.46 (28.00-34.90)	2.98	0.2397	Not Listed
Water Temperature (^{0}C)	28.52±0.34 (26.00-33.10)	28.14±0.29 (26.00-30.10)	28.88±0.52 (21.00-33.50)	0.88	0.0962	≤40
Ph	6.08±0.21 (3.39-7.28)	6.02±0.20 (3.51-7.45)	9.15±2.35 (3.63-63.00)	1.71	0.1900	6.5-8.5
Conductivity (µS/cm)	107.85±7.86 (35.90-200.00)	128.62±24.28 (43.20-516.00)	143.94±23.56 (4.00-516.00)	0.82	0.0365	1000
Salinity (mg/L)	23.46±4.44 (1.00-66.00)	19.91±4.22 (0.00-57.00)	31.16±5.34 (2.00-80.00)	1.50	0.4357	
D.O. (mg/L)	5.75±0.69 (2.90-17.00)	5.43±0.52 (2.40-12.00)	5.95±0.64 (2.60-16.40)	0.19	0.8287	5
B.O.D (mg/L)	2.12±0.18 (0.80-4.00)	2.70±0.39 (0.90-8.40)	2.52±0.30 (1.00-5.80)	0.28	0.7513	5
Nitrates (mg/L)	1.24±0.12 (0.44-2.53)	1.16±0.15 (0.05-3.00)	1.52±0.18 (0.22-3.20)	1.56	0.4206	50
Sulphates (mg/L)	102.02±9.24 (20.00-181.20)	103.83±9.20 (30.50-198.00)	94.90±10.20 (0.16-180.80)	0.24	0.4738	100
Phosphates (mg/L)	0.31±0.04 (0.02-0.82)	2.95±1.88 (0.02-35.00)	0.39±0.06 (0.05-1.20)	1.92	0.2213	5

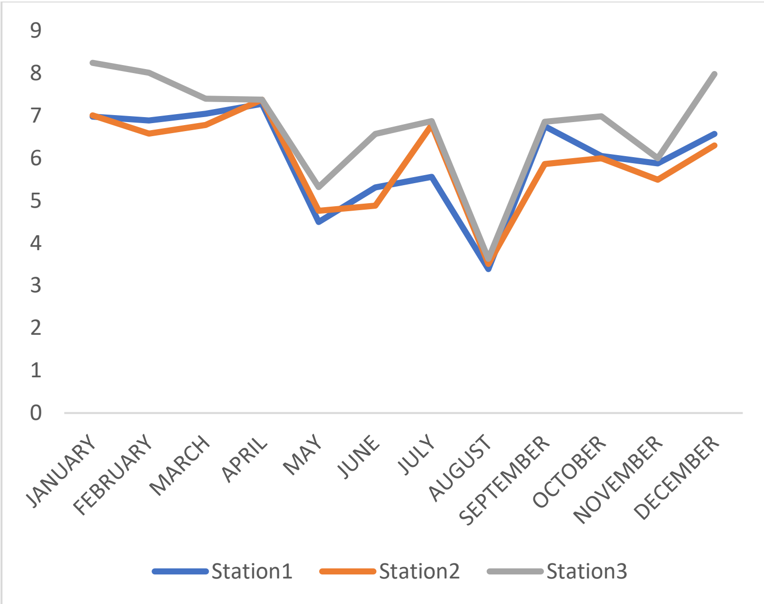


Figure 2: Monthly variations in pH values across the three sampling stations in Jeddo river.

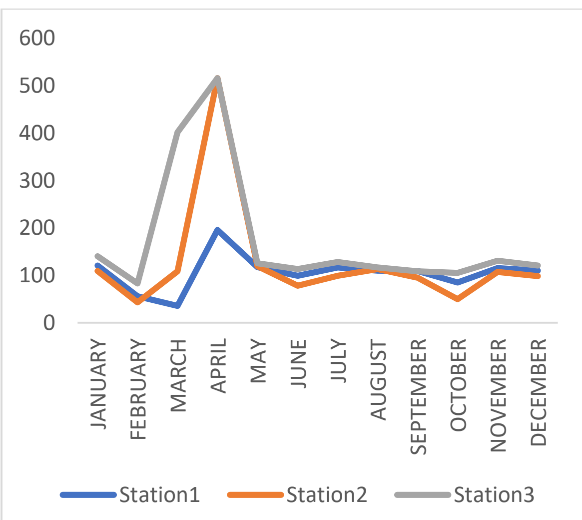


Figure 4.4: Monthly variations in the Conductivity values across the three sampling stations in Jeddo river.

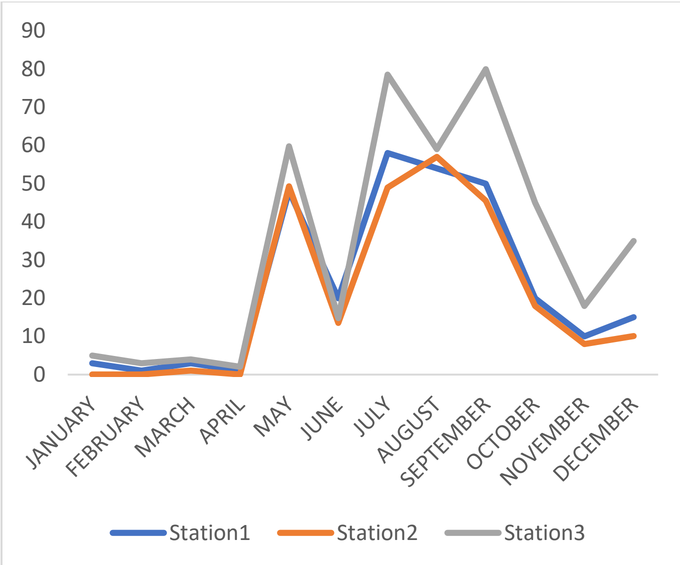


Figure 4.5: Monthly variations in the Salinity values across the three sampling stations in Jeddo river.

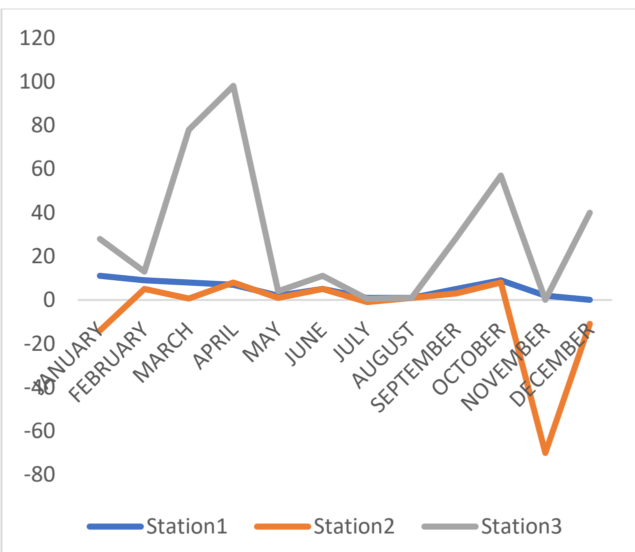


Figure 4.6: Monthly variations in the Turbidity values across the three sampling stations in Jeddo river.

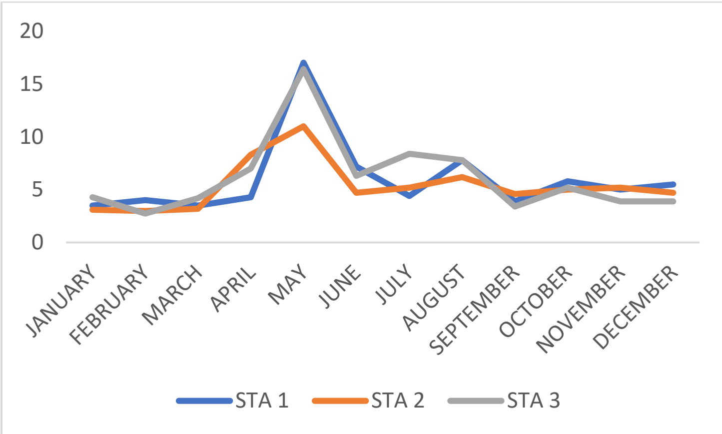


Figure 4.7: Monthly variations in the D.O. values across the three sampling stations in Jeddo river.

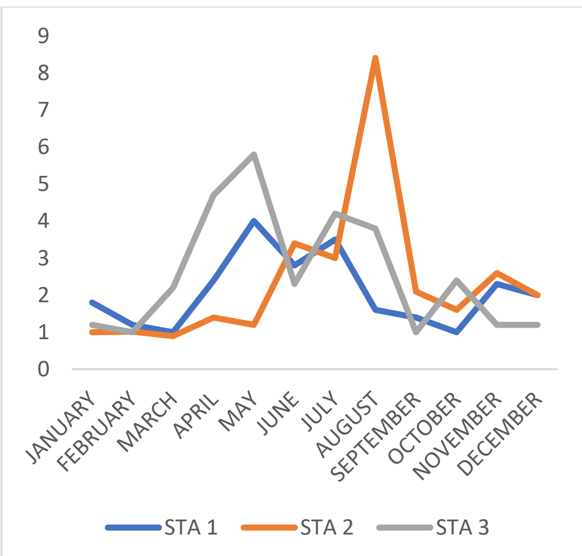


Figure 4.8: Monthly variations in the B.O.D values across the three sampling stations in Jeddo river.

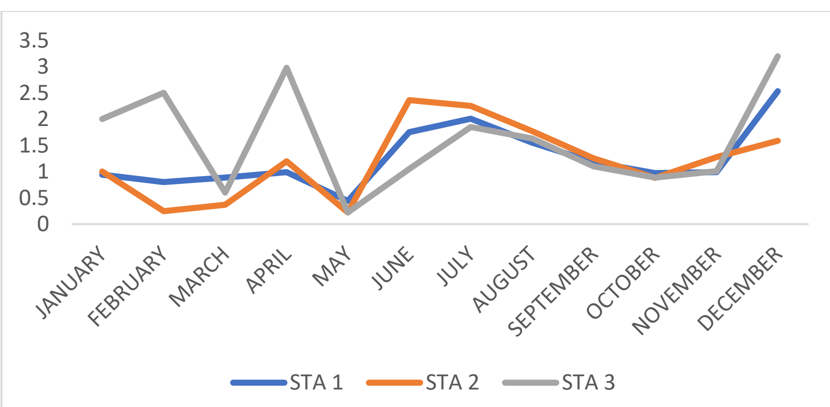


Figure 4.9: Monthly variations in the Nitrate values across the three sampling stations in Jeddo river.

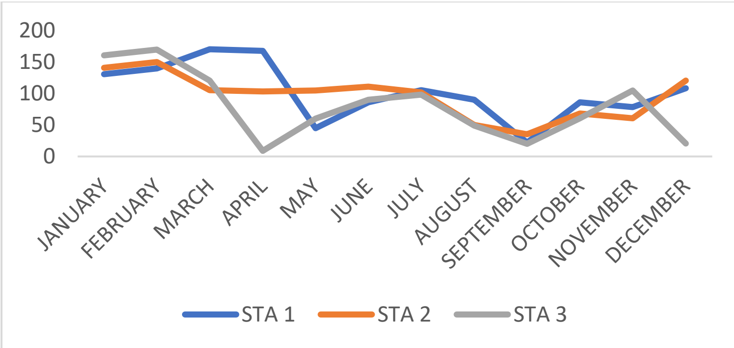


Figure 4.10: Monthly variations in the Sulphate values across the three sampling stations in Jeddo river.

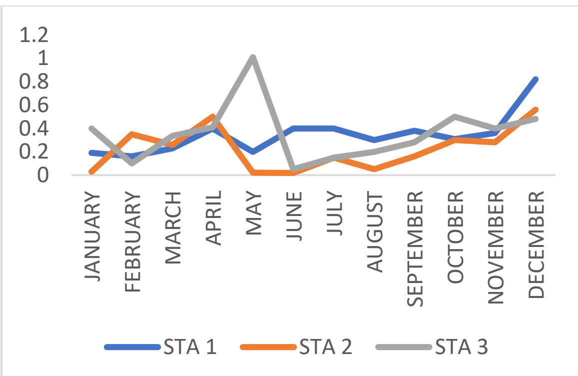


Figure 4.11: Monthly variations in the Phosphatevalues across the three sampling stations in Jeddo river.

Macroinvertebrates Composition, Distribution, and Abundance

The macroinvertebrate community in Jeddo river is dominated by the Coleoptera with 490 individuals, accounting for about 45.8% of the total population; Neochetia sp. (17.02%) with 183 individuals was the most dominant, this was followed by Hydropylus sp. (175) 16.28%, and Dysticus sp. (132) was the least, contributing at 12.8%. The Hemiptera with four Species; *Naucoris obscruratus* (74 individuals and 6.88%), *Ilyocauris simicoides (*26 individuals: 2.42%)*, Ranatra sp.* (23 individual accounted for 2.14%) and *Gerris lacustris* (30 individuals and accounted for 2.79%)*,* was next to the Coleoptera with 153 individuals and contributed 14.23% of the macroinvertebrate population. The Diptera with three species; *Chironomus trasvatensis* (90 individuals and 8.37%)*, Penteura sp (23 individuals and 2.14%)* and *Tabanus sp*. (12 individuals and 1.12%), contributed 11.63% of the total population with 125 individual organisms. As shown in tab. 4.5; the diptera was followed by the Arachnida (9.02%) with 97 individuals, Crustacea (5.3%) and 57 individuals; Nematodes (5.12%) and 55 individuals, Nematodes (4.09%) were next with 44 individuals, followed by Odonata 36 individuals and 3.35% of the population, while the Mollusc with just 18 individuals and 1.67% of the population were the least dominant group.

Table 4.5: Composition, Distribution and Abundance of Macroinvertebrate Community in Jeddo River.

ORDER	FAMILY	SPECIES	STATION 1	STATION 2	STATION 3	TOTAL	% Abundance
DIPTERA							
	Chironimidae						
		Chironomes trasvaatensis	50	31	9	**90**	**8.37**
		Pentaneura sp	12	7	4	**23**	**2.14**
	Tabanidae						
		Tabunus sp	10	2	0	**12**	**1.12**
Sub-total			***72***	***40***	***13***	***125***	
COLEOPTERA							
	Dystiscidae						
		Dysticus sp	17	89	26	**132**	**12.28**
	Curculionidae						
		Neochetia sp	0	155	28	**183**	**17.02**
	Hydrophihilae						
		Hydrophilus sp	18	125	32	**175**	**16.28**
Sub-total			***35***	***369***	***86***	***490***	
ODONATA							
	Libellulidae						
		Anax junias	8	0	0	**8**	**0.74**
		Pachydiplax longipennis	8	0	0	**8**	**0.74**
	Petalumdae						
		Petalura gigantea	4	0	0	**4**	**0.37**
	Coenagrionidae						
		Pseudagrion sp	8	5	3	**16**	**1.49**
Sub-total			***28***	***5***	***3***	***36***	
HEMIPTERA							
	Naucoridae						
		Naucoris obscuratus	16	52	6	**74**	**6.88**
		Ilyocoris cimicoides	4	15	7	**26**	**2.42**
		Ranatra sp	7	14	2	**23**	**2.14**
	Gerridae						
		Geris lacustris	8	18	4	**30**	**2.79**
Sub-total			***35***	***99***	***19***	***153***	
DECAPODA							
	Atyidae						
		Caridina africana	2	15	5	**22**	**2.05**
	Desmoearidae						
		Desmocaris trispinosa	7	12	4	**23**	**2.14**

	Palaemonidae	*M. macrobrachion*	0	10	2	**12**	**1.12**
Sub-total			***9***	***37***	***11***	***57***	
ARANEAE							
	Pisauridae						
		Thalassius sp	11	59	3	**73**	**6.79**
		Dolomedes sp.	12	10	2	**24**	**2.23**
Sub-total			***23***	***69***	***5***	***97***	
TUBIFICIDA							
	Naididae						
		Pristina aequiseta	0	14	2	**16**	**1.49**
		E. eugeniea	10	14	4	**28**	**2.60**
Sub-total			***10***	***28***	***6***	***44***	
ARAEOLAIMIDA							
	Araeolaimidae						
		Rhabdolaimus sp	6	12	2	**20**	**1.86**
Sub-total			***6***	***12***	***2***	***20***	
DORYLAIMIDA	Dorylaimidae						
		Dorylaimus sp	10	20	5	**35**	**3.26**
Sub-total			***10***	***20***	***5***	***35***	
VENERIDA							
	Cyrenidae	***Corbicula fluminea***	4	12	0	**16**	**1.49**
Sub-total			***4***	***12***	***0***	***16***	
CAENOGASTRODA	Cerithlidae	***Cerithium spp.***	0	2	0	**2**	**0.19**
Sub-total			***0***	***2***	***0***	***2***	
TOTAL			**232**	**693**	**150**	**1,075**	**100**

Discussion

Natural factors and human activities within the Jeddo River watershed significantly influence the physicochemical properties of the aquatic ecosystem, affecting macroinvertebrate communities and overall water quality, as earlier noted by Ikomi and Arimoro (2014). Recent studies confirm this strong linkage between watershed stressors and river health in Nigerian systems. For example, urbanization and unplanned settlements have been shown to significantly alter physicochemical conditions and macroinvertebrate assemblages in the Wuye River, with elevated nutrients and turbidity linked to poor water quality and degraded biological communities (Nature Scientific Reports, 2025).

Most water quality parameters measured in the Jeddo River generally fall within acceptable limits defined by FEPA (2003), NSDWQ (2007), and WHO (2011), except for biological oxygen demand (B.O.D.) and turbidity, which exceed recommended thresholds. Elevated B.O.D. and turbidity are consistent with other Nigerian rivers exposed to anthropogenic pressures, where pollution reduces water suitability for domestic use and corresponds to changes in macroinvertebrate abundance (Ahuchaogu et al., 2025).

Similar to observations in other Nigerian rivers, slightly higher air temperatures were recorded compared to water temperatures, consistent with Ikomi et al. (2003) and Iloba and Egborge (2002). Seasonal shading and heat exchange processes likely drive these differences, reflecting natural moderating factors in river systems. The water depth in Jeddo River was lower than historical measurements, which may be explained by increased sediment deposition from surface runoff and channel modification due to land use change. Comparable influences of watershed land use on macroinvertebrate traits and habitat quality have been documented in streams experiencing varied anthropogenic stressors in Osun State (Akinpelu et al., 2024).

Dissolved oxygen (D.O.) concentrations in Jeddo River were notably high, mirroring results from other Nigerian systems with active photosynthesis and dynamic hydrology, though contrasting with earlier lower levels in more polluted environments. Enhanced oxygenation during the rainy season due to increased flow and mixing has been observed in other tropical freshwater studies. Elevated B.O.D. levels likely reflect organic pollution from storm runoff and nutrient inputs, consistent with reports that nutrient enrichment from agricultural and urban runoff drives higher B.O.D. in Nigerian waters (e.g., Okulu River studies).

These conditions place Jeddo River in a category of moderate pollution. Macroinvertebrate-based assessments continue to validate moderate to poor water quality in impacted Nigerian rivers, supporting the use of macroinvertebrate communities as indicators of ecological impairment. The development of macroinvertebrate-based biotic indices in Niger State further highlights how disturbance gradients correlate with biodiversity and water quality (development of NSRBI).

The pH values recorded in Jeddo River ranged from acidic to slightly alkaline, averaging slight acidity. Similar pH ranges were found in Nigerian systems where organic decomposition and riparian inputs contribute to acidification. Recent studies also report pH variability across seasons and land use types, supporting the notion of dynamic water chemistry influenced by human activities and natural processes.

Elevated alkalinity beyond permissible limits suggests geologically influenced buffering capacity, comparable to findings in other Nigerian rivers where bicarbonate content and buffering help maintain pH stability despite acid inputs. Increasing conductivity trends have been linked to evaporation, fertilizer and detergent runoff, and urban land use, echoing broader regional observations of anthropogenic influence on ionic water chemistry.

Nutrient levels including phosphate, nitrate, and sulfate though within drinking water guidelines, were higher than earlier reports but aligned with values from other Nigerian rivers impacted by agriculture and organic waste. Nutrient enrichment from agricultural runoff and human wastes is a consistent driver of water quality change and macroinvertebrate community shifts in tropical lotic systems.

Overall, the water quality of Jeddo River reflects a balance between natural seasonal influences and human-induced pressures, with moderate pollution levels influenced by nutrient loading and organic matter inputs. This aligns with recent literature that underscores the need for effective watershed management to mitigate pollution and sustain aquatic ecosystem health.

A total of 1,075 individual macroinvertebrate organisms belonging to 19 families were recorded in this study, a figure that falls within ranges documented in other Nigerian systems. Recent research on Owena River reported macroinvertebrate communities correlated with water quality parameters, confirming that both environmental conditions and pollution levels shape macroinvertebrate distribution and abundance (Abubakar et al., 2025).

Macroinvertebrate community structure varied across stations, with Coleoptera and Hemiptera dominant, consistent with other Nigerian rivers where insects often indicate relative water quality conditions. Spatial and temporal variability in community composition, driven by water quality and habitat conditions, mirrors patterns observed in other recent assessments of freshwater systems in Nigeria.

These findings highlight the importance of maintaining habitat integrity and continued monitoring of physicochemical parameters to preserve river ecological health in the face of natural variability and ongoing anthropogenic pressures.

Conclusion

The physico-chemical analysis of Jeddo River reveals that both natural processes and human activities within the watershed significantly influence its water quality and aquatic ecosystem health. While most water quality parameters generally fall within acceptable limits set by regulatory bodies such as FEPA, NSDWQ, and WHO, elevated biological oxygen demand (B.O.D) and turbidity levels indicate moderate organic pollution and sediment influx, particularly during the rainy season. Seasonal variations in water depth and temperature, alongside high dissolved oxygen levels, reflect natural hydrological and ecological dynamics influenced by precipitation and vegetation cover.

Slight acidity in the river's pH, coupled with elevated alkalinity beyond permissible limits, points to complex chemical interactions driven by organic matter decomposition, agricultural runoff, and the watershed's geology. Nutrient concentrations—including phosphate, nitrate, and sulfate—though within drinking water standards, suggest enrichment from anthropogenic sources such as farming activities and domestic waste. This is further supported by principal component analysis, which identifies nutrient loading and organic pollution as the dominant factors affecting water quality variability, with certain river sections showing higher pollution levels.

Overall, the water quality status of Jeddo River can be classified as moderately polluted, highlighting the pressing need for integrated watershed management to control nutrient and pollutant inputs, mitigate runoff, and protect the river's ecological functions. Addressing these challenges will help sustain the aquatic biodiversity and ensure the river remains a valuable resource for the surrounding communities.

This study comprehensively assessed the macroinvertebrate community of the Jeddo River across three sampling stations, revealing significant spatial and ecological variations in species composition, abundance, diversity, and functional organization. A total of 1,075 individual macroinvertebrates from 19 distinct families and various taxonomic groups, including insects (Diptera, Hemiptera, Odonata, Coleoptera), molluscs (Gastropoda), annelids, nematodes, and arachnids, were recorded.

Station 2 emerged as the most biodiverse and populated, contributing 693 individuals (64.5% of the total), likely due to favorable physicochemical parameters and the presence of varied microhabitats. Station 1 followed with 232 individuals, while Station 3 recorded the least with 150, suggesting that environmental stressors and habitat disturbances were more pronounced there. A number of species showed station-specific occurrences, such as Cerithium sp. (station 2 only) and Odonates like Anax junius and Petularia gigantea (station 1 only), while some species were ubiquitous, indicating wide ecological tolerance.

The community was numerically dominated by Coleoptera (45.8%), particularly Neochetia sp. and Hydrophylus sp., suggesting good water quality in some sections, especially station 2. Hemipterans followed, with notable taxa such as Naucoris obscuratus and Gerris lacustris, known to inhabit a variety of aquatic conditions. Dipterans (notably Chironomus transvaalensis) also contributed significantly, reflecting moderate tolerance to pollution.

The diversity indices further supported these observations. Station 1 had the highest species diversity (Shannon index = 2.784) and evenness, indicating a relatively balanced ecosystem. Conversely, station 3 showed reduced diversity (2.445) and lower evenness, pointing to habitat degradation or pollution. The Margalef's index showed species richness highest in station 3, likely due to the presence of multiple low-abundance species.

Recommendation

- Implement watershed management to reduce sediment and nutrient runoff, using riparian buffers, soil conservation, and land-use monitoring.
- Control nutrient and organic pollution through proper fertilizer use, improved wastewater management, and community awareness.
- Restore and protect aquatic habitats by conserving microhabitats, minimizing disturbances, and establishing conservation zones.
- Conduct regular monitoring of water quality and macroinvertebrate communities to guide management and policy decisions.

References

Abubakar, A., Adebola, O. T., & Awe, O. (2025). *Assessment of the impact of water quality parameters on macroinvertebrates in Owena River, South Western Nigeria. International Journal of Zoology Studies* 10 (4), 27-35.

Adeyemi-Ale, O. A., Aladesida, A. A., and Esenowo, I. K. (2014). The effect of detergent on the physicochemical characteristics and plankton diversity of Osere Stream, Ilorin, Kwara State, Nigeria. *Journal of Applied Sciences and Environmental Management*, **18**(1), 109–113.

Adjarho, U. B., Esenowo, I. K., and Ugwumba, A. A. A. (2013). Physico-chemical parameters and benthic macroinvertebrate fauna of Ona River at Oluyole Estate, Ibadan, Nigeria. *Research Journal of Environmental and Earth Studies*, **5**(11), 671–676.

Adu, B. W., and Oyeniyi, E. A. (2019). Water quality parameters and aquatic insect diversity in Aahoo Stream, Southwestern Nigeria. *Journal of Basic and Applied Zoology*, **80**(15), 1–9.

Ahuchaogu, W. R., Eludoyin, O. S., Osita, J. C., & Mpakaboari, N. T. (2025). *Impact of pollution on aquatic macroinvertebrate abundance in the Okulu River Eleme, Rivers State, Nigeria*. *International Journal of Research and Innovation in Social Science* (Vol. 9, Issue 2). https://doi.org/10.47772/IJRISS.2025.9020286 RSIS International

Akinpelu, O. T., Arimoro, F. O., Ayanwale, A. V., Chukwuemeka, V. I., Oladeji, T. A., & Akindele, E. O. (2024). *Habitat characteristics and anthropogenic activities influence the distribution of freshwater macroinvertebrates in Nigerian streams*. *Aquatic Ecology / Ecohydrology & Hydrobiology*. Bohrium

American Public Health Association (APHA). (1998). *Standard methods for the examination of water and wastewater* (20th ed.). APHA, AWWA and WEF, Washington DC, USA.

Amusan, B., and Balogun, I. (2019). Assessment of the aquatic insect assemblage and water quality of a tropical stream in Southwestern Nigeria. *Journal of Entomology and Zoology Studies*, **7**(1), 1199–1205.

Ananthakrishnan, S., and Ahamed, A. J. (2012). Study on groundwater quality and its suitability for drinking purposes in Alathur Block–Perambalur District. *Archives of Applied Science Research*, **4**(3), 1332–1338.

Anyanwu, E. D., Okorie, M. C., and Odo, S. N. (2019). Macroinvertebrates as bioindicators of water quality of effluent-receiving Ossah River, Umuahia, Southeast Nigeria. *Zanco Journal of Pure and Applied Sciences*, **31**(5), 9–17.

Arimoro, F. O. (2010). Microhabitat preference, diversity and ecology of aquatic mites in a municipal stream in the Niger Delta. *Journal of Applied Biosciences*, **27**, 1687–1696.

Arimoro, F. O., and Ikomi, R. B. (2008). Response of macroinvertebrates to abattoir wastes and other anthropogenic activities in a municipal stream in the Niger Delta, Nigeria. *The Environmentalist*, **28**, 85–98.

Arimoro, F. O., and Osakwe, E. I. (2006). Influence of sawmill wood wastes on the distribution and population of macrobenthic invertebrates in Benin River at Sapele, Niger Delta, Nigeria.

Chemistry and Biodiversity, **3**, 578–592.

Arimoro, F. O., Ikomi, R. B., and Iwegbue, C. M. A. (2007a). Ecology and abundance of oligochaetes as indicators of organic pollution in an urban stream in southern Nigeria. *Pakistan Journal of Biological Sciences*, **10**(3), 446–453.

Arimoro, F. O., Odume, O. N., Uhunoma, S. I., and Edegbene, A. O. (2015). Anthropogenic impact on water chemistry and benthic macroinvertebrate-associated changes in a southern Nigerian stream. *Environmental Monitoring and Assessment*, **187**, 1–14.

Azrina, M. Z., Yap, C. K., Abdul Rahim, I., Ismail, A., and Tan, S. C. (2006). Anthropogenic impacts on the distribution and biodiversity of benthic macroinvertebrates and water quality of Langat River, Peninsular Malaysia. *Ecotoxicology and Environmental Safety*, **64**, 337–347.

Camara, I. A., Kra, M. K., Kouadio, N. K., Konan, M. K., Edia, E. O., Doumbia, L., Ouattara, A., and Diomande, D. (2020). Composition, structure and functional feeding of aquatic entomofauna in Kodjoboué Lake: Water quality assessment. *Open Journal of Ecology*, **10**, 160–176.

Cummins, K. W. (2016). Combining taxonomy and function in the study of stream macroinvertebrates. *Journal of Limnology*, **75**(s1), 235–241.

Development of a macroinvertebrate-based biotic index to assess water quality of rivers in Niger State, North Central Ecoregion of Nigeria. (2025). *Peer-reviewed study on macroinvertebrate assessment methods* (PubMed abstract). PubMed

Dissecting the urban footprint of unplanned settlements shaping macroinvertebrate communities in Wuye River, Abuja, Nigeria. (2025). *Scientific Reports*.

Edegbene, A. O., and Arimoro, F. O. (2012). Ecological status of Owan River, southern Nigeria using aquatic insects as bioindicators. *Journal of Aquatic Sciences*, **27**(2), 99–111.

Edegbene, A. O., and Omovoh, G. O. (2014). Community structure and diversity of macrobenthic invertebrates in relation to some water quality parameters in a municipal river in southern Nigeria. *The Zoologist*, **12**, 69–77.

Edegbene, A. O., Arimoro, F. O., Nwaka, K. H., Omovoh, G. O., and Ogidiaka, E. (2014). Macrohabitat preference and spatio-temporal variation of macroinvertebrates in Atakpo River, Niger Delta, Nigeria. *Journal of Global Biosciences*, **3**(4), 735–743.

Edegbene, A. O., Odume, O. N., Arimoro, F. O., and Keke, U. N. (2021). Identifying and classifying macroinvertebrate indicator signature traits along an urban pollution gradient in the Niger Delta. *Environmental Pollution*, **281**, 117076.

Fu, L., Jiang, Y., Ding, J., Liu, Q., Peng, Q. Z., and Kang, M. Y. (2015). Impacts of land use and environmental factors on macroinvertebrate functional feeding groups in the Dongjiang River Basin, Southeast China. *Journal of Freshwater Ecology*, **31**(1), 21–35.

Gbarakoro, T. N., Jude, C., and Onwordi, J. O. (2021). Assessment of the impact of in-stream sand mining on macroinvertebrate biodiversity at Eleme River, Nigeria. *International Journal of Research in Environmental Science*, **7**(3), 13–21.

Gholizadeh, M., and Heydarzadeh, M. (2020). Functional feeding groups of macroinvertebrates and their relationship with environmental parameters in Zarin-Gol River. *Iranian Journal of Fisheries Sciences*, **19**(5), 2532–2543.

Hussain, Q. A., and Pandit, A. K. (2012). Macroinvertebrates in streams: A review of ecological factors. *International Journal of Fisheries and Aquaculture*, **4**(7), 123–134.

Ikomi, R. B., and Arimoro, F. O. (2014). Effects of recreational activities on littoral macroinvertebrates of Ethiope River, Niger Delta, Nigeria. *Journal of Aquatic Sciences*, **29**(1), 155–170.

Ikomi, R. B., Arimoro, F. O., and Odihirin, O. K. (2005). Composition, distribution and abundance of macroinvertebrates of the upper reaches of River Ethiope, Delta State, Nigeria. *The Zoologist*, **3**, 68–81.

Keke, U. N., Omoigberale, M. O., Ezenwa, I., Yusuf, A., Biose, E., Nweke, N., Edegbene, A. O., and Arimoro, F. O. (2021). Macroinvertebrate communities and physicochemical characteristics along an anthropogenic stress gradient in a southern Nigeria stream. *Environmental and Sustainability Indicators*, **12**, 100157.

Kolkwitz, R., and Marsson, M. (1902). Grundsätze für die biologische Beurteilung des Wassers nach seiner Flora und Fauna. *Mitteilungen der Prüfungsanstalt für Wasserversorgung und Abwasserreinigung*, **1**, 33–72.

Obasi, R. A., and Balogun, O. (2001). Water quality and environmental impact assessment of water resources in Nigeria. *African Journal of Environmental Studies*, **2**(2), 228–231.

Ogidiaka, E., Esenowo, I. K., and Ugwumba, A. A. A. (2012). Physico-chemical parameters and benthic macroinvertebrates of Ogunpa River at Bodija, Ibadan, Oyo State. *European Journal of Scientific Research*, **85**(1), 89–97.

Ogidiaka, E., Ikomi, R. B., Akamagwuna, F. C., and Edegbene, A. O. (2022). Increasing pollution gradients and macroinvertebrate assemblages in an Afrotropical estuary. *Biologia*, **77**, 1–15.

Okogbule Wonodi, A., Philip, U. E., & Uchendu, O. F. (2025). *Physicochemical parameters for water-environment quality testing: A review. International Journal of Pollution: Prevention & Control, 3*(1), 08-12.

Oriabure, P. A., & Ogbeibu, A. E. (2024). *Ecological structure of macrobenthic invertebrates of the Benin River, Southern Nigeria, before the seaport development project*. Journal of Sustainable Development, 17(6). https://doi.org/10.5539/jsd.v17n6p25

Stubbington, R., Longstaffe, O., Sarremejane, R., Bates, P., Gething, K. J., Jones, J. I., Kelly-Quinn, M., Laini, A., Murray-Bligh, J., Rippon, L., & Rouen, S. (2024). *A kick in the headwaters: Evaluating a macroinvertebrate sampling method for ecological condition monitoring in small streams*. **River Research and Applications, 41**(7), 808–819. https://doi.org/10.1002/rra.4405

Tharme, R. E. (2003). A global perspective on environmental flow assessment. *River Research and Applications*, **19**(5–6), 397–441.

Uwadiae, R. F. (2010). Macroinvertebrate functional feeding groups as indices of biological assessment in a tropical aquatic ecosystem. *New York Science Journal*, **3**(8), 6–15.

World Health Organization (WHO). (2011). *Guidelines for drinking-water quality* (4th ed.). WHO Press, Geneva, Switzerland.