



Physicochemical Properties of Surface Water, Heavy Metals Levels in Sediments and Macroinvertebrates Community of Ikpoba River, Benin City, Edo State, Nigeria

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ABSTRACT: The objective of this paper was to investigate the physicochemical properties of surface water, heavy metals levels in sediments and macroinvertebrate community of the Ikpoba River, Benin City, Edo State, Nigeria using appropriate standard methods. Data obtained show that the pH in the surface water ranged between 4.30 and 8.90 with a mean of 5.23. There was no significant difference ($p > 0.05$) in the physicochemical properties of surface water across the three stations. The mean values of heavy metals for iron, zinc, copper, lead and cadmium in sediments ranged from 22.30 - 45.30, 8.46 - 27.10, 1.80 - 12.40, 0.01 - 4.75 and 0.00 - 1.15 mg/l with a mean of 32.71 ± 2 , 17.62 ± 1 , 7.24 ± 1 , 1.29 ± 0.1 and 0.17 ± 0.1 mg/l respectively. However, metals such as iron, zinc, copper and lead were above the recommended limit for freshwater ecosystems. A total of 482 individual macroinvertebrate organisms were recorded in the study. The benthic organisms were dominated by the orders Ephemeroptera (23.03%), Diptera (22.61%), Hemiptera (18.26%) and Odonata (17.01%) with *Baetis* sp (6.02%), *Velia* sp (5.60%), *Heptagenia* sp (5.39%) and *Lestes* sp (4.36%) as the major representative species. For the biological indices, station 1 had the highest diversity, species richness and evenness. Station 3 had the lowest diversity and richness while the lowest species evenness was recorded in station 2. A weak correlation between the physicochemical parameters and the macroinvertebrate fauna was recorded. The calculated EPT Index for the macroinvertebrate fauna was 31.67 % indicating a fairly polluted river.

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There is a growing concern about the degradation of freshwater ecosystems and a possible global biodiversity crisis arising from the rapidly accelerating loss of species and natural habitats, particularly tropical rainforests and aquatic ecosystems due to population growth, urbanization and industrialization (Egborge, 1981; Ekperusi *et al.*, 2022; Nwerem *et al.*, 2023). It has also been estimated that more than half of the habitable surface of the planet has already been altered by human

activity (Hengeveld, 1990). These concerns stem from the realization that our knowledge of the diversity and variability of plants, animals, microorganisms and the ecosystems in which they occur is incomplete (Egborge, 1981; Olomukoro and Ezemonye, 2007). Freshwater ecosystems play a vital role in the socio-economic development of every nation. Nigeria is rapidly turning to industrialization with increased demand for freshwater resources. Consequently, the degradation of water bodies

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necessitates regular assessment and management of aquatic resources (Egborge, 1981; Olomukoro and Ezemonye, 2007; Arimoro and Muller, 2010; Ekperusi *et al.*, 2022; Nwerem *et al.*, 2023). Invertebrate communities change in response to changes in physicochemical factors and available habitats (de Alba-Guzmán *et al.*, 2024). The biotic structure and water quality of streams and rivers reflect an integration of the physical, chemical and anthropogenic processes occurring in a catchment area (Olomukoro and Ezemonye, 2007; Ekperusi *et al.*, 2022). Human-induced hydrological changes, physical disturbances and point and non-point sources of pollution are examples of processes responsible for a broad-scale deterioration of lotic ecosystems (Chatzinikolaou *et al.*, 2006; Ekperusi *et al.*, 2022; Alum *et al.*, 2023).

Macroinvertebrate organisms form an integral part of an aquatic environment and are of ecological importance as they maintain various levels of interaction between the community and the environment (Anderson and Sedel, 1979; Ekperusi *et al.*, 2022). According to Marques *et al.* (2003), the knowledge of the structure of the benthic macroinvertebrate community provides precise and local information on recent events. Benthic macroinvertebrates are bioindicators of the overall biodiversity in aquatic ecosystems (Chatzinikolaou *et al.*, 2006; Alum *et al.*, 2023). Macrobenthic invertebrates form the basis of the trophic level and any negative effects caused by pollution in the community structure can affect trophic relationships (Sharma and Chowdhary, 2011). The abundance of benthic fauna greatly depends on the physical and chemical properties of the substratum. Their taxonomic diversity has allowed aquatic macroinvertebrates to adapt to environmental conditions and factors. The type of river habitat being studied can be used to predict the traits of macroinvertebrates within them, as well as the taxonomic composition present. Factors such as pH, elevation, water depth, and substrate type affect how organisms adapt to their aquatic habitats (Demars *et al.*, 2012; Alum *et al.*, 2023). Benthic species perform a variety of functions in freshwater food webs. They provide essential ecosystem services by accelerating detrital decomposition (van de Bund *et al.*, 1994; Wallace and Webster, 1996).

Over the last five decades, there has been a considerable effort to document the ecology, composition, spatial distribution and diversity of macrobenthic invertebrate communities of Nigerian inland waters (Egborge, 1972; Bidwell and Clarke, 1977; Ogbeibu and Victor, 1989; Olomukoro and Ezemonye, 2000; Arimoro and Muller, 2010; Eze *et al.*, 2021; Ekperusi *et al.*, 2022; Iyama and Etori, 2023; Alum *et al.*, 2023) across the different ecological zones to understand the water and

sediment quality and ecological status of freshwater ecosystems and the anthropic pressures originating from municipal, industrial, agricultural and recreational areas for effective water resources management (Adakole and Annune, 2003; Ekperusi *et al.*, 2022). The objective of this paper was to investigate the physicochemical properties of surface water, heavy metals levels in sediments and macrobenthic invertebrate community of the Ikpoba River, Benin City, Edo State, Nigeria.

MATERIALS AND METHOD

Study Area: The study was carried out at the Ekosodin community section of Ikpoba River, Benin City. The area lies within the geographical coordinates of latitude 06°24'41" N and longitude 005°38'34" E with an elevation of 21 metres above sea level (Figure 1). The topography of the area is lowland with compact red laterite which is often flooded and washed into the river during heavy rains. The area has a humid tropical climate characterized by two distinct conditions of wet and dry seasons. The wet season covers April to October with a short break in August and the dry season is from November to March with a cold harmattan from December to January. The annual rainfall averages 250 cm. The daily temperature is relatively high and normally ranges from 24 - 36 °C with high relative humidity due to the high rainfall. The area is dominated by a dense evergreen and luxuriant cover of deciduous trees such as rubber plants, bamboo and oil palms. Farming of cash crops, petty trading and fishing are the mainstay of the people in the area and the major agricultural products are cassava, oil palm, yam, cocoyam, plantain and vegetables. Other domestic use of the river includes washing clothes and traditional religious worship.

Sampling Stations: Three sampling stations were selected along the river for the study. Station 1 is located upstream of the river (06°24'48.24" N and 005°38'39.55" E). It is surrounded by a thick cover of forest with limited human activities. The vegetation includes bamboo (*Bambusa bambusa*), water lily (*Nymphae lotus*), fern (*Cyclosorus* sp) and duck potato (*Saggitaria* sp.). Station 2 is the mid-stream (06°24'41.04" N and longitude 005°38'34.66" E) and is more exposed to communal activities such as washing of clothes, traditional and religious activities from the inhabitants of the area with increased sunlight penetrating the water. The vegetation is mainly essential plants like castor oil (*Ricinus communis*), rubber plants (*Hevea brasiliensis*), orchid trees (*Bauchinia monadra*) and Raphia palm (*Raphia hookeni*). Station 3 is located under the bridge (06°24'29.50" N and 005°38'34.22" E) that links the community to the main campus of the University of Benin. The dominant vegetation of this station includes oil palms (*Eliaes guineensis*), bamboo

macroinvertebrate indices, especially in lotic ecosystems where they are the dominant component of the representative community (Lenat, 1988). The EPT Index was calculated as in equation 1.

$$EPT\ Index = \frac{Total\ EPT\ taxa}{Total\ taxa} \times 100\% = \% Abundance \quad (1)$$

According to the United States Geological Survey (2002), taxa richness and EPT taxa richness will decrease with decreasing water quality as represented in Table 1.

Table 1: EPT Index for freshwater quality assessment

Stream-quality assessment	EPT taxa richness
Non-impacted	> 10
Slightly impacted	6 – 10
Moderately impacted	2 – 5
Severely impacted	0 – 1

RESULTS AND DISCUSSION

Physicochemical Properties of Surface Water in Ikpoba River: The variation in the physicochemical parameters in Ikpoba River across the three sampled stations is shown in Table 2. There was no significant difference ($p > 0.05$) in the physicochemical properties of surface water across the three stations. The pH and water temperature were within the regulatory limit for freshwater ecosystems as stipulated by the Federal Ministry of Environment (FMEEnv), while parameters such as conductivity, TDS, TSS, turbidity, DO, BOD, calcium, magnesium, sodium, phosphate, sulphate, nitrate and ammonium nitrate were below the recommended limit for surface water in freshwater ecosystem.

The pH in the surface water ranged between 4.30 and 8.90 with a mean of 5.23 during the study period, while monthly variation showed that the pH was highest in December at station 1 and lowest in October at station 3. The mean pH revealed that the water is moderately acidic and below the slightly acidic conditions of freshwater bodies. This acidic nature may be attributed to the effluents being generated upstream of the river where Guinness Brewery is located and transported along the river since there is no industrial presence in the community. Although most aquatic organisms live within a narrow range of pH, the range of pH reported in this study does not pose a threat to aquatic organisms. The observed pH level is consistent with that reported by Imoobe (2011) in Okhuo River, Edo State but contrasted with the reports of Omoigberale and Ogbeibu (2010), Ibrahim and Nafiu (2017) and Mohammed *et al.* (2021) that observed a pH ranging from 6.5 to 8.2 at Osse River in Edo State, Chikke Stream and Thomas Dam in Kano and Niger states respectively.

On the other hand, electrical conductivity is a measure of the ability of water to conduct an electrical current. Conductivity is influenced by the

amount of electrical charge on each ion, ion mobility and temperature of the water (Chapman, 1996). In this study, conductivity in surface water ranged between 4.0 and 24.0 $\mu\text{S}/\text{cm}$ with a mean of 11.21 ± 01 $\mu\text{S}/\text{cm}$. Monthly variation showed that the conductivity was highest in August at station 2 and lowest in February at station 2. The observed conductivity was lower than the values reported by Omoigberale and Ogbeibu (2010) and Mohammed *et al.* (2021) but exceeded those reported by Imoobe (2011).

Temperature is an important parameter that influences almost all the physical, chemical and biological components of water bodies. The temperature in the surface water ranged between 24.60 and 27.40 $^{\circ}\text{C}$ with a mean of 25.36 ± 01 $^{\circ}\text{C}$ during the study period and was within the limit for surface water across the stations. Monthly variation showed that water temperature was highest in November at station 2 and lowest in August at station 3. The value for temperature reported in our study was similar to that observed in Chikke Stream (Mohammed *et al.*, 2021).

Total dissolved solid (TDS) and total suspended solid (TSS) relate to the total amount of particles that are dissolved or suspended in water. Both parameters affect the levels of oxygen present in the surface water. The observed TDS and TSS ranged between 2.0 - 12.0 and 0.03 - 2.85 mg/l with a mean of 5.60 ± 1 and 0.47 ± 01 mg/l respectively. These values were within the recommended limits. Monthly variation showed that the TDS was highest in August at station 2 and lowest in February at station 2, while TSS was highest in August at station 3 and lowest in October at station 3.

Another important physicochemical property of aquatic ecosystems is turbidity. Water turbidity is an indicator of sediment load and water clarity. Turbidity in the surface water ranged between 0.05 and 0.90 NTU with a mean of 0.44 ± 01 NTU. Monthly variation showed that turbidity was highest in January at station 2 and lowest in September across the three stations. This indicates that the water does not receive much runoff from the community. The landmass adjoining the river is covered by vegetation which could make it less likely for run-off to reach the river. The reported turbidity contrasted that reported by Olomukoro and Eloghosa (2009) at Eruvbi Stream, Edo State and Shelle *et al.* (2013) at Egin Power Station reservoir in Lagos State.

Dissolved oxygen (DO) is an important limnological parameter indicating levels of water quality and organic pollution in a water body (Wetzel and Likens, 2006). DO in the surface water ranged between 1.6 and 8.80 mg/l with a mean of 4.64 ± 01 mg/l during the study period. DO was within the recommended

limit in freshwater ecosystems. Monthly variation showed that the DO was highest in November at station 3 and lowest in September at stations 1 and 2. The low DO in September could be associated with the peak of rainfall which comes with increased debris into the river, while the increased levels in November could be associated with the end of the wet season where suspended particles in the river may settle down towards the end of the season. The DO reported in our study was comparable to that reported by Arimoro and Muller (2010) and Mohammed *et al.* (2021) at River Orogo and Chikke Stream respectively, but higher than the levels reported by Emere and Nasiru (2009) in an urbanized stream in Kaduna and Iloba and Ruejoma (2014) at Ekpan River in Delta State.

The observed BOD in the surface water ranged between 0.01 and 4.80 mg/l with a mean of 1.81 ± 01 mg/l during the study period. Monthly variation showed that the BOD was highest in December at station 1 and lowest in August at 2. This is expected since August is the peak of the wet season in Nigeria. Rainfall comes with the introduction of dead and decaying organic matter being washed into the river. This finding is similar to those of water bodies receiving low levels of pollution in Nigeria. Emere and Nasiru (2009) reported a range of 0.00 and 2.00 mg/l in Kaduna State, while Olomukoro *et al.* (2013) reported a similar BOD of 1.20 and 6.30 mg/l at selected ponds at Agbede environs in Edo State. A BOD value of 2 mg/l or less indicates a fairly unpolluted water body.

Trace elements like sodium, calcium and magnesium are vital for the effective functioning of biota in benthic ecosystems. This study revealed that trace elements such as sodium, calcium and magnesium range from 0.91 - 4.80, 0.64 - 1.92 and 0.00 - 1.95 mg/l with a mean of 1.85 ± 01 , 1.13 ± 01 and 0.84 ± 01 mg/l for the mentioned elements respectively. No obvious trend was reported for the spatial variation in the trace elements in the study period. Although,

sodium and calcium were highest in the wet season the opposite was the case for magnesium.

Nutrients such as sulphate, phosphate, nitrate and ammonium nitrate in surface water ranged from 0.05 - 2.02, 0.02 - 1.51, 0.05 - 11.50 and 0.01 - 1.20 mg/l with a mean of 0.37 ± 01 , 0.60 ± 01 , 1.53 ± 01 and 0.20 ± 01 mg/l respectively during the study period. Spatial variation did not show any regular trend in the values of nutrients in surface water. Sulphate and ammonium nitrate were highest in November at station 2 and lowest in August across the three stations. Phosphate and ammonium nitrate were highest at the peak of the wet season while sulphate and nitrate were the opposite. Phosphate is an essential nutrient for living organisms and is often the limiting nutrient for algal growth and primary production. Phosphorus or phosphate is rarely found in high concentrations in freshwaters as it is actively taken up by plants (Chapman, 1996). Natural concentrations of phosphorus in surface waters usually range from 0.005 to 0.020 mg/l which is similar to the levels reported in this study. On the other hand, nitrate is the common form of nitrogen found in natural waters. It may be biochemically reduced to nitrite, usually under anaerobic conditions. The nitrite ion is rapidly oxidized to nitrate (Chapman, 1996). Natural levels of nitrate in surface waters seldom exceed 0.1 mg/l, but waters influenced by human activity could reach up to 5 mg/l with levels over 5 mg/l indicating pollution by animal, human wastes or fertilizer runoff. The observed phosphate values were similar to those reported by Imoobe (2011), Olomokoro *et al.* (2013) and Iloba and Ruejoma (2014) while phosphate and nitrate values contrasted those of Arimoro (2009), Arimoro and Muller (2010), Adeogun and Fafioye (2011) and Imoobe (2011) that reported lower values in southern Nigerian rivers and reservoir. Similarly, Ibrahim and Nafiu (2017) and Mohammed *et al.* (2021) reported phosphate and nitrate values from Chikke Stream and Thomas Dam in northern Nigeria comparable to the values reported in our study.

Table 2: Summary of physicochemical parameters (Mean $\pm$ SE and range in bracket) in Ikpoba River, Benin City, Nigeria

Parameters	Station 1	Station 2	Station 3	P-value	FMEnv.
pH	5.54 $\pm$ 1 (4.6-8.9)	5.13 $\pm$ 1 (4.4-8.1)	5.01 $\pm$ 01 (4.3-7.6)	0.685	6-9
EC	12.75 $\pm$ 1.8 (5-22)	12.00 $\pm$ 2 (4-24)	8.88 $\pm$ 1 (5-12)	0.296	-
Temp	25.89 $\pm$ 01 (25-27)	26.15 $\pm$ 01 (25-27)	25.54 $\pm$ 1 (25-27)	0.457	< 40
TDS	6.38 $\pm$ 1 (2.5-11)	6.00 $\pm$ 1 (2-12)	4.44 $\pm$ 1 (2.5-6)	0.296	2,000
Turbidity	0.32 $\pm$ 01 (0.1-0.6)	0.50 $\pm$ 01 (0.1-0.9)	0.50 $\pm$ 01 (0.1-0.7)	0.268	-
TSS	0.40 $\pm$ 01 (0.1-1.65)	0.44 $\pm$ 01 (0.1-2.1)	0.56 $\pm$ 01 (0.1-2.9)	0.908	30
DO	5.15 $\pm$ 1 (1.6-8.4)	4.12 $\pm$ 1 (1.6-7.6)	4.65 $\pm$ 1 (2.8-8.8)	0.700	-
BOD	2.53 $\pm$ 1 (0.8-4.8)	1.28 $\pm$ 01 (0-3.2)	1.63 $\pm$ 01 (0.4-3.4)	0.122	50
PO ₄	0.53 $\pm$ 01 (0.1-1.51)	0.61 $\pm$ 01 (0.1-1.41)	0.65 $\pm$ 01 (0.1-1.39)	0.908	5
SO ₄	0.32 $\pm$ 01 (0.1-1.13)	0.45 $\pm$ 01 (0.1-2.02)	0.35 $\pm$ 01 (0.1-0.87)	0.848	500
NO ₃	2.31 $\pm$ 1 (0.2-11.5)	0.73 $\pm$ 01 (0.1-2.71)	1.55 $\pm$ 1 (0.1-5.32)	0.457	20
Ca	1.12 $\pm$ 01 (0.6-1.92)	1.40 $\pm$ 01 (0.6-1.92)	0.88 $\pm$ 01 (0.6-1.28)	0.09	200
Mg	0.78 $\pm$ 01 (0.4-1.95)	0.92 $\pm$ 01 (0-1.94)	0.83 $\pm$ 01 (0.4-1.56)	0.861	200
Na	2.06 $\pm$ 01 (1-4.4)	2.00 $\pm$ 01 (1-4.8)	1.50 $\pm$ 01 (1-2.2)	0.483	200
NH ₄ N	0.20 $\pm$ 01 (0.1-0.9)	0.27 $\pm$ 01 (0.1-1.2)	0.15 $\pm$ 01 (0-0.66)	0.716	-

Heavy Metals in Sediments of the Ikpoba River: The variation in the selected heavy metals concentration

of the Ikpoba River is shown in Figure 2. The mean values for iron, zinc, copper, lead and cadmium in

sediments ranged from 22.30 - 45.30, 8.46 - 27.10, 1.80 - 12.40, 0.01 - 4.75 and 0.00 - 1.15 mg/l with a mean of 32.71 ± 2 , 17.62 ± 1 , 7.24 ± 1 , 1.29 ± 0.1 and 0.17 ± 0.1 mg/l respectively. The values of the heavy metals reported in the study were higher than those reported by Adakole *et al.* (2008) on a man-made lake in Zaria, Adeogun *et al.* (2011) at Awba Stream in Oyo State, Olomukoro *et al.* (2022) in Orogodo River, Delta State and Michael and Chukwu (2023) at Alape River in Ondo State. Higher values were reported in the sediments of River Siluko, Edo State (Keke *et al.*, 2021), Silver River, Bayelsa State (Kieri *et al.*, 2021), River Benue, Benue State (Egesi *et al.*, 2023), River Iyiudene, Ebonyi State (Nwazue *et al.*, 2022) and Challawa River, Kano State (Sani *et al.*, 2022). The metals reported in our study were in the decreasing order of $\text{Fe} > \text{Zn} > \text{Cu} > \text{Pb} > \text{Cd}$. Similar trends in metal distribution were also reported by previous authors (Kieri *et al.* 2021; Nwazue *et al.* 2022). There was no significant difference ($P > 0.05$) in the levels of heavy metals across the three stations, but the values for iron, zinc, copper and lead, except cadmium were above the recommended limit in sediments for freshwater ecosystems. The increased levels of the heavy metals above the recommended limits could impact the health of aquatic life forms especially at the sediment surface and alter the chemistry of the surface water which may have direct effects on the benthic community. The increased anthropogenic activities from brewery effluents and abattoir operations along the upstream of the river a few kilometres from the sampling sites could be impacting the river at the Ekosodin section resulting in heavy metal concentration above the recommended limits. There is a need for increased water monitoring and compliance as municipal and economic activities increase within Benin City. Spatial and temporal data showed increased levels of the heavy metals across the sample stations during the dry season compared to the wet season. This observation was also similar to that reported by Okwodu *et al.* (2021) from Orashi River, Rivers State and Sani *et al.* (2022) in Challawa River, Kano State.

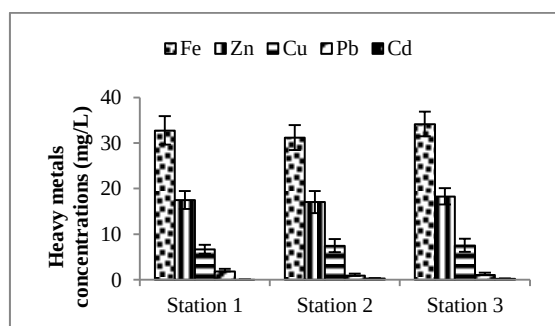


Fig. 2: Heavy metal concentration (Mean $\pm$ SE) in sediment across the sampled stations of Ikpoba River

Macrobenthic Invertebrate: The overall taxa composition, distribution, and abundance of macrobenthic invertebrate organisms recorded during

the study period are presented in Tables 3 and 4. A total of 39 macroinvertebrate taxa comprising 482 individuals were reported during the study period. Several authors had reported low or similar taxonomic distribution in freshwater ecosystems across Nigeria. Olomukoro and Eloghosa (2009) reported 34 taxa in Ogba River in Benin City, while Olomukoro and Dirisu (2014) recorded 33 taxa in Edion and Omodo rivers. Similarly, Mohammed *et al.* (2021) reported 35 taxa in Chikke stream in Niger State while Enabulele and Olomukoro (2024) reported 23 taxa from Ozomu Lake in Edo State. In contrast, Keke *et al.* (2021) reported 49 taxa in River Siluko in Edo State whereas Olomukoro *et al.* (2022) reported 44 taxa from Orogodo River in Delta State. The major taxonomic groups recorded in this study include Ephemeroptera (23.03%), Diptera (22.61%), Hemiptera (18.26%) and Odonata (17.01%). Haplontaxida, Coleoptera, Trichoptera, and Plecoptera were represented by 7.68%, 6.85%, 2.49% and 2.07% respectively. The Ephemeropterans which are largely represented by mayflies are commonly known to be abundant in well-oxygenated freshwater ecosystems because they exhibit low tolerance in waters with depleting dissolved oxygen. Their abundance which is more prevalent in the upstream compared to the midstream is expected given the low anthropic influence in the upstream due to the lack of human activities. This implies that the water quality in the upstream and the midstream is relatively good to support sensitive species in the river. The absence of the group downstream of the river calls for concern and reflects the influx of contaminants especially heavy metals into the downstream of the river. This is further supported by the increased prevalence of dipterans as the second most prevalent group in the river with more abundance in the downstream of the river. The highest number of taxa were recorded in the upstream of the river at station 1 followed by station 2 and the least was at station 3. The findings are consistent with that of other researchers within southern Nigeria. Omoigberale and Ogbeibu (2010) on the macrobenthic invertebrate fauna of Osse River, reported that Ephemeroptera accounted for 26.30%, which is followed by Decapoda (21.53%), Diptera (17.04%), Oligochaeta (11.31%), Odonata (6.56%), Nematoda (1.45%), Coleoptera (0.75%) and Hemiptera (0.28%). On the macroinvertebrate communities of Edion and Omodo Rivers in Edo State, Olomukoro and Dirisu (2014) reported the dominant group in descending order as Ephemeroptera (45.4%), Diptera (24.7%) and Decapoda (24.03%). Tubić *et al.* (2024) reported that Ephemeroptera were the most dominant (22.12%) order among macroinvertebrate community in streams from Serbia. However, Arimoro and Osakwe (2006) documented the influence of sawmill wood wastes on the distribution and population of macroinvertebrates at Benin River and reported that sensitive species such as Ephemeroptera or

Plecoptera were completely absent from station 2, the impacted site while Olumukoro and Eloghosa (2009) reported that the dominant taxonomic groups were Diptera (39.7%), Crustacea (20.70%) and Plecoptera (19.6%). Mohammed *et al.* (2021) also reported a low abundance of Ephemeropterans in Chikke stream.

The species of macrobenthic organisms were dominated by *Baetis* sp (6.02%), *Velia* sp (5.60%), *Heptagenia* sp (5.39%), *Lestes* sp (4.36%) and the least was *Amphiops gibbose* (0.21%). *Baetis* sp were also the most common genera found in Malaysian headwaters (Hamid and Rawi, 2017). *Baetis* sp which are majorly represented by mayflies are usually found in freshwater ecosystems with good water quality. They are sensitive to pollution and survive in well-oxygenated waters. In contrast, species tolerant to degrading water quality like *Chironomus* sp (2.07%) are less represented in the benthic group reported in the study.

Table 3: Checklist of the family of macrobenthic organisms sampled across the station from Ikpoba River

Order	Family	Stn 1	Stn 2	Stn 3
Coleoptera	Dytiscidae	5	5	1
	Elmidae	2	3	1
	Gyrinidae	3	1	2
	Hydrophilidae	3	5	2
Diptera	Ceratopogonidae	1	2	8
	Chironomidae	15	12	22
	Psychodidae	1	0	10
	Tanyptodinae	9	10	19
Ephemeroptera	Baetidae	41	16	0
	Caenidae	2	0	0
	Heptageniidae	15	11	0
	Leptophlebiidae	16	10	0
Haplontaxidae	Naididae	5	4	9
	Tubificidae	4	7	8
Hemiptera	Aphididae	8	7	5
	Gerridae	3	5	8
	Pleidae	11	10	4
	Valiidae	5	13	9
Odonata	Agrionidae	6	2	0
	Coenagrionidae	8	3	2
	Gomphidae	6	5	7
	Libellulidae	9	6	7
Plecoptera	Zygoptera	12	7	2
	Perlidae	7	3	0
Trichoptera	Polycentropodidae	8	4	0
Total		482	205	126

Table 4: Summary of the various order of macrobenthic organisms reported from Ikpoba River.

Order	No of individuals	% individuals
Coleoptera	33	6.85
Diptera	109	22.61
Ephemeroptera	111	23.03
Haplontaxidae	37	7.68
Hemiptera	88	18.26
Odonata	82	17.01
Plecoptera	10	2.07
Trichoptera	12	2.49
Total	482	100

Biological Indices: The general biological indices for the macrobenthic community recorded at Ikpoba River showed that Margalef richness was the highest, followed by Shannon-Weiner diversity and the least

was evenness during the study period (Figure 3). Shannon-Weiner diversity indices across the three stations sampled showed that station 2 (3.298) had the highest followed by station 1 (3.273) and the lowest was station 3 (3.097). Station 2 had the highest evenness (0.8196) followed by station 3 (0.8195) and the least was observed in station 1 (0.754). Margalef taxa richness showed that station 1 (6.387) had the highest richness, followed by station 2 (6.378) and the least was in station 3 (5.376). The low evenness and diversity compared to the taxa richness reflect the disparity of certain species from certain parts of the freshwater ecosystems due to the variation in anthropogenic inputs into the freshwater ecosystem. The broader implication is that species could be gradually declining across the freshwater gradients resulting in a lack of adequate functionality for the local ecosystem, especially life at the bottom sediment.

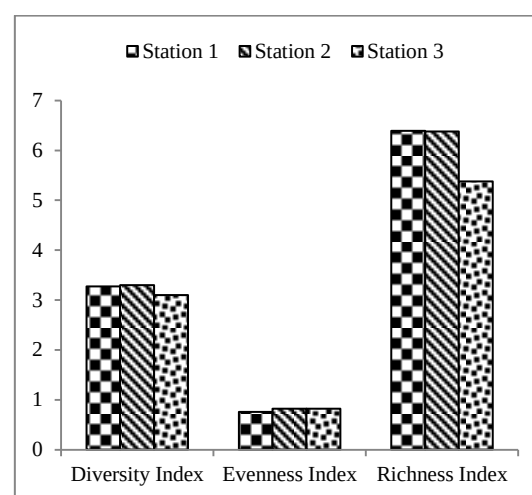


Fig. 3: General ecological indices of the macrobenthic fauna of Ikpoba River.

EPT Index of Ikpoba River: The environmental condition of an aquatic ecosystem can be assessed using physical, chemical and biotic conditions. Among aquatic organisms, one of the groups most affected by anthropogenic changes are benthic organisms within the order Ephemeroptera, Plecoptera and Trichoptera because of their close relationships and sensitivity to environmental disturbances, making them important bioindicators of environmental quality for biomonitoring (Faria *et al.*, 2017; Wong *et al.*, 2020; Faria *et al.*, 2021). The EPT method is a quick and reliable water quality assessment method that has been applied in many temperate and tropical countries. In this study, a calculation of the EPT index for Ikpoba River gives a value of 31.67% indicating that the water quality of the river is less impacted by contaminant fluxes entering the river from domestic and industrial activities compared to other river systems in Nigeria. This is reflected in the abundance of EPT taxa reported upstream and midstream of the river. On the assessment of the water quality status of the Kibisi

River in Kenya, Bonzemo (2018) indicated that the analysis of the EPT index correlated closely with the physical and chemical parameters, which is also similar to the case with our study. Applying the EPT index in their study, Moskova *et al.* (2008) reported a high proportion of intolerance order of Ephemeroptera, Plecoptera and Trichoptera, exceeding 50% in Kamchia River, eastern Bulgaria. Hamid and Rawi (2017) reported an EPT taxa richness >10 indicating good water quality and non-impacted conditions in all rivers of Malaysian headwaters. In contrast, Jacobsen *et al.* (2003) reported an EPT index of 6.04 - 6.86 in high-mountain streams with a decrease in oxygen compared to low-mountain streams, while Poulton and Tao (2019) observed EPT values ranging between 0.6% - 10.3% in urban streams compared to control sites (18%) in small streams in Kansas City, Missouri.

The EPT index provide important information on changes in water quality conditions with regards to sensitive species and an important tool for the ecological categorization of freshwater bodies (Tubić *et al.*, 2024).

Relationship between Physicochemical Parameters and Macrobenthic Fauna: The relationship between the physicochemical parameters and macrobenthic fauna was assessed using Pearson's correlation. There was no strong correlation (0.5) between the physicochemical parameters and the macrobenthic organisms observed in the study. This is expected since the physicochemical characteristics of the river do not have a significant impact on the water quality and the distribution of the macrobenthic community reported in the study.

Conclusion: The regular assessment of inland water bodies for their physicochemical condition and the application of bioindicators like benthic organisms is paramount in providing insight into the water quality and health status of freshwater ecosystems. The assessment of the Ekosodin section of the Ikpoba River indicates some form of anthropic inputs could be impacting the river. The contaminants load in the river may have been transported from the point of entry at the urban centres from the upstream into the river several kilometres away. There is a need for a continuous assessment of the river to monitor the water quality for the effective management and development of freshwater ecosystems especially in southern Nigeria.

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REFERENCES

Adakole, JA; Abulode, DS; Balarabe, ML (2008). Assessment of water quality of a man-made lake

in Zaria, Nigeria. Proceedings of Taal, 2007: The 12th World Lake Conference, pp 1373-1382

Adakole, JA; Anunne, PA (2003). Benthic macroinvertebrates as indicators of environmental quality of an urban stream, Zaria, Northern Nigeria. *J. Aquat. Sci.* 18(2): 85-92

Adeogun, AO; Fafioye, OO (2011). Impact of effluents on water quality and benthic macroinvertebrate fauna of Awba Stream and Reservoir. *J. Appl. Sci. Environ. Manage.* 15(1): 105-113.

Adeogun, AO; Chukwuka, AV; Ibor, OR (2011). Impact of abattoir and saw-mill effluents on water quality of Upper Ogun River (Abeokuta). *American J. Environ. Sci.* 7: 525-530.

Anderson, NH; Sedell, JR (1979). Detritus processing by Macroinvertebrates in some ecosystems. *Ann. Rev. Entomol.* 24: 357-377.

APHA (1998) Standard methods for the Examination of Water and Waste water. 20th Edn. American Public Health Association, Washington. pp 1134.

Arimoro, FO; Osakwe, EI (2006). The influence of sawmill wood wastes on the distribution and population of macroinvertebrates at Benin River, Niger Delta Area, Nigeria. *Chem. Biodiversity.* 3: 578-592.

Arimoro, FO; Muller, WJ (2010). Mayfly (Insect: Ephemeroptera) community structure as an indicator of the ecological status of a stream in Niger Delta, Nigeria. *Environ. Monit. Assess.* 165: 581-594

Arimoro, FO (2009). Impact of Rubber Effluent Discharges on the Water Quality and Macroinvertebrate Community Assemblages in a Forest Stream in Niger Delta. *Chemosphere.* 77: 440-449.

Armitage, PD (1978). Downstream changes in the composition, numbers and biomass of bottom fauna in the Tees below Cow Green Reservoir and an unregulated tributary, Maize Beck, in the first five years after impoundment. *Hydrobiologia.* 58: 145-56.

Bidwell, A; Clarke, NV (1977). The invertebrate fauna of Lake Kainji, Nigeria. *Field.* 42: 104-110.

Bonzemo, SB (2018). An Application of Ephemeroptera, Plecoptera and Trichoptera (EPT) Index Method in Assessing Water Quality: A Case Study of River Kibisi, Mt. Elgon area, Kenya. *J. Educ. Pract.* 9(14): 16-36.

- Chapman, D (1996). Water Quality Assessments: A Guide to the Use of Biota, Sediments and Water. Environmental Monitoring. Second Edition. UNESCO, WHO, and UNEP. E&FN Spon, London UK.
- Chatzinikolaou, Y; Dakos, V; Lazaridou, D (2006). Longitudinal impacts of anthropogenic pressures on benthic macroinvertebrate assemblages in a large transboundary Mediterranean river during the low flow period. *Acta hydrochim. Hydrobiol.* 34: 453-463.
- de Alba-Guzmán, C; Cabral-Tena, RA; Rodríguez-Zaragoza, FA; Tortolero-Langarica, JJA; Cupul-Magaña, AL; Rodríguez-Troncoso, AP (2024). Decadal Changes in Benthic Community Structure and Function in a Coral Community in the Northeastern Tropical Pacific. *Diversity.* 16(7): 372. <https://doi.org/10.3390/d16070372>
- Demars, BOL; Kemp, JL; Friberg, N; Usseglio-Polatera, P; Harper, DM (2012). Linking Biotopes to invertebrates in rivers: Biological traits, taxonomic composition and diversity. *Ecol. Indic.* 23: 301-311
- Egborge, ABM (1981). The suspended matter content of Lake Asejire: A new impoundment in Nigeria. *Freshw. Biol.* 1: 402-412
- Egborge, ABM (1972). A preliminary checklist of the Zooplanktonic organisms of the River Oshun, in the Western State of Nigeria. *Niger. Sci.* 6: 67-71
- Egesi, OC; Alum-Udendi, O; Ogbonna, PC; Ugor, NN (2023). Assessment of Heavy Metals in Water, Fish, and Sediment of River Benue, Benue State, Nigeria. *Niger. Agric. J.* 54(1): 55-67
- Ekperusi, OH; Ekperusi, OA; Olomukoro, JO (2022). Assessment of Anthropogenic Influences on Benthic Invertebrate Community of Oghan River in Edo State, Nigeria. *J. Appl. Sci. Environ. Manage.* 26(8): 1423-1431. <https://dx.doi.org/10.4314/jasem.v26i8.16>
- Emere, MC; Nasiru, CE (2009). Macroinvertebrates as Indicators of the Water Quality of an Urbanized Stream, Kaduna Nigeria. *Nat. Sci.* 7(1): 1545-0740.
- Enabulele, CO; Olomukoro, JO (2024). Benthic Macroinvertebrates as Indicators of Water Quality and Ecological Health in a Tropical Lake, Southern Nigeria. *Limnol. Freshw. Biol.* 5: 1276-1283. DOI:10.31951/2658-3518-2024-A-5-1276
- Faria, APJE; Ligeiro, R; Callisto, M; Juen, L (2017). Response of aquatic insecta assemblages to the activities of traditional populations in eastern Amazonia. *Hydrobiologia.* 802(1): 39-51
- Faria, APJE; Paiva, CKS; Calvao, LB; Cruz, GM; Juen, L (2021). Response of aquatic insects to an environmental gradient in Amazonian streams. *Environ. Monit. Assess.* 193: 763
- FME (1999) Interim Guidelines and Standards for Industrial Effluent, Gaseous Emissions and Noise Limitations, Federal Ministry of Environment, Abuja, Nigeria pp 252
- Hamid, SA; Rawi, CSM (2017). Application of Aquatic Insects (Ephemeroptera, Plecoptera and Trichoptera) In Water Quality Assessment of Malaysian Headwater. *Trop. Life Sci. Res.* 28(2): 143-162. doi: 10.21315/tlsr2017.28.2.11
- Hengeveld, R (1990). Dynamic Biogeography. Cambridge University Press, Cambridge.
- Ibrahim, S; Nafiu, SA (2017). Macroinvertebrates as Indicators of Water Quality in Thomas Dam, Dambatta, Kano State, Nigeria. *UMYU J. Microbiol. Res.* 2(1): 61-71. <https://doi.org/10.47430/ujmr.1721.010>
- Iloba, KI; Ruejoma, MGO (2014). Physico-chemical characteristics and zooplankton of Ekpan River, Delta State, Nigeria. *IJABR* 6(1): 8-30
- Imoobe, TOT (2011). Diversity and Seasonal Variation of Zooplankton in Okhuo River, a Tropical Forest River in Edo State, Nigeria. *Centrepint J.* 17(1): 37-51
- Jacobsen, D; Rostgaard, S; Vásconez, JJ (2003). Are macroinvertebrates in high altitude streams affected by oxygen deficiency? *Freshw. Biol.* 48: 20252032.
- Keke, UN; Omoigberale, MO; Ezenwa, I; Yusuf, A; Biose, E; Nweke, N; Edegbene, AO; Arimoro, FO (2021). Macroinvertebrate communities and physicochemical characteristics along an anthropogenic stress gradient in a southern Nigeria stream: Implications for ecological restoration. *Environ. Sustain. Indic.* 12: 100157. <https://doi.org/10.1016/j.indic.2021.100157>.
- Kieri, IBS; Ekpote, OA; Edori, OS (2021). Assessment of Heavy Metal Pollution in Sediments of Silver River, Southern Ijaw, Bayelsa State, Nigeria. *Environ. Anal. Eco. Stud.* 7(5): 000675. doi: 10.31031/EAES.2021.07.000675

- Lenat, DR (1988). Water quality assessment of streams using a qualitative collection method for benthic macroinvertebrates. *J. N. Am. Benthol. Soc.* 7: 222-233
- Lenat, DR; Penrose, DL; Eagleson, KW (1981). Variable effects of sediment addition on stream benthos. *Hydrobiologia* 79:187-194.
- Marques, MJ; Martinez-Conde, E; Rovira, JV (2003). Effects of zinc and lead mining on the benthic macroinvertebrate fauna of a fluvial Ecosystem. *Water Air Soil Pollut.* 148: 363-388.
- Mellanby, H (1963). Animal life in freshwater – A guide to freshwater invertebrate. Chapman and Hall Ltd, London. pp 308
- Micheal, P; Chukwu, UJ (2023). Physicochemical, Heavy Metals and Hydrocarbons Study of Surface Water and Sediment from Alape River and Its Watershed In Igbokoda, South-West Nigeria. *J. Chem. Soc. Niger.* 48(4): 620-646. <https://doi.org/10.46602/jcsn.v48i4.901>
- Mohammed, YM; Arimoro, FO; Ayanwale, AV; Adamu, KM; Keke, UN; Abubakar, MD; Achebe, AC (2021). The current state of water quality and benthic invertebrate fauna in Chikke Stream (North-Central Nigeria). *Ukr. J. Ecol.* 11(3): 26-34.
- Moskova, G; Soufi, R; Uzunov, Y (2008). Application of the EPT-index for Ecological Status Assessment of the Riverine Water Bodies within the Basin of Kamchia River. *Bioautomation* 11: 73-79
- Nwazue, E; Omietimi, E; Mienye, E; Imarhiagbe, O; Adeosun, O; Nnabo, P (2022). Heavy Metal Dispersion in Stream Sediments in River Iyiudene, Abakaliki South-Eastern Nigeria: Source, Distribution Pattern, and Contamination Assessment. *J. Geosci. Environ. Protect.* 10: 48-69. doi:10.4236/gep.2022.107004.
- Ogbeibu, AE; Victor, R (1989). The effect of road and bridge construction on the bank root macrobenthic invertebrates of a southern Nigeria stream. *Environ. Pollut.* 58: 85-100.
- Okwodu, NE; Okorie, PU; Nwoke, BEB (2021). Determination and Evaluation of Heavy Metal Concentration in Surface Water and Sediment from Orashi River in Rivers State, Nigeria. *Current J. Appl. Sci. Technol.* 40(46): 50-65. <https://doi.org/10.9734/cjast/2021/v40i4631632>.
- Olomukoro, JO; Osamuyiamen, IM; Dirisu, AR (2013). Ecological Survey of Macrobenthic Invertebrates of Selected Ponds in Agbede Flood Plain, Southern Nigeria. *J. Biol. Agric. Healthcare* 3(10): 23-29.
- Olomukoro, JO; Eloghosa, O (2009). Macroinvertebrate Colonisation of artificial Substrates in a Nigerian River III: Cements and Bricks, Ceramic tiles and Macrophytes. *African Scientist* 10(1): 53-63.
- Olomukoro, JO; Ezemonye, L (2000). Studies on the Macro Benthic Fauna of Eruvbi Stream, Benin City, Nigeria. *Trop. Environ. Res.* 7(2): 125-136
- Olomukoro, JO; Dirisu, AR (2014). Status and the Diversity of Macrobenthos of Udu-Ghievwen Wetlands in the Niger Delta, Nigeria. *J. Nat. Sci. Res.* 4(18): 20-34
- Olomukoro, JO; Ezemonye, LIN (2007). Assessment of the macro-invertebrate fauna of rivers in southern Nigeria. *African Zoology* 42(1): 1-11
- Olomukoro, JO; Obi-Obueze, NO; Eko-Imirany, R; Anani, OA; Obot, V (2022). Water quality evaluation using physicochemical and biological indices to characterize the integrity of the Orogodo River in sub-Saharan Africa. *Front. Environ. Chem.* 3: 961369. doi: 10.3389/fenvc.2022.961369
- Omoigberale, MO; Ogbeibu, AE (2010). Environmental impacts of oil exploration and production on the invertebrate fauna of Osse River, southern Nigeria. *Res. J. Environ. Sci.* 4: 101-114.
- Plafkin, JL; Barbour, MT; Porter, KD; Gross, SK; Hughes, RM (1989). Rapid bioassessment protocols for use in streams and rivers: Benthic macro-invertebrates and fish. EPA 444/4-89-001. United States Environmental Protection Agency, Washington, DC.
- Poulton, BC; Tao, J (2019). Evaluation of EPT macroinvertebrate metrics in small streams located within the non-connected stormwater management region of Kansas City, Missouri, USA. *Trans. Mo Acad. Sci.* 47: 21-34. <https://doi.org/10.30956/MAS-29R1>
- Sani, A; Idris, KM; Abdullahi, BA; Darma, AI (2022). Bioaccumulation and health risks of some heavy metals in *Oreochromis niloticus*, sediment and water of Challawa river, Kano, Northwestern Nigeria. *Environ. Adv.* 7: 100172. <https://doi.org/10.1016/j.envadv.2022.100172>
- Santos, JVA; Lima, M; Monteles, JS; Carrera, DLR; Faria, APJ; Brasil, LS; Juen, L (2023). Assessing physical habitat structure and biological condition

- in eastern Amazonia stream sites. *Water Biol. Secur.* 2(2): 100132. <https://doi.org/10.1016/j.watbs.2022.100132>
- Sharma, KK; Chowdhary, S (2011). Macro invertebrate assemblages as biological indicators of pollution in a Central Himalayan River, Tawi (J&K). *Inter. J. Biodiver. Conserv.* 3(5): 167-174.
- Shelle, ROD; Akinnigbagbe, AE; Adeleye, AO (2013). Hydrochemistry and benthos around Egbin Power Station, southwestern Nigeria. *Acta SATECH* 4(2): 133-144
- Tubić, B; Andjus, S; Zorić, K; Vasiljević, B; Jovičić, K; Atlagić, JČ; Paunović, M (2024). Aquatic Insects (Ephemeroptera, Plecoptera and Trichoptera) Metric as an Important Tool in Water Quality Assessment in Hilly and Mountain Streams. *Water* 16(6): 849. <https://doi.org/10.3390/w16060849>
- USGS (2002). Fact Sheet FS-118-02, Technical Note 3, Watershed Condition Series, Watershed Science Institute, December 2002, United States Geological Survey, Department of the Interior.
- lake sediment. *J. N. Am. Benthol. Soc.* 13: 532-539.
- Wallace, JB; Webster, JR (1996). The role of macroinvertebrates in stream ecosystem function. *Annu. Rev. Entomol.* 41: 115-139.
- Wetzel, RG; Likens, GE (2006). Limnological analysis. 3rd ed. Springer-Verlag, New York, pp 391
- Wong, AB; Chaw, V; Fikri, AH (2020). Land use effects on Ephemeroptera, Plecoptera, and Trichoptera (EPT) communities in Ranau-beluran district, Sabah, Malaysia. *Aquacult. Aquarium, Conserv. Legis.* 13(4): 1812-1819
- van de Bund, WJ; Goedkoop, W; Johnson, RK (1994). Effects of deposit-feeder activity on bacterial production and abundance in profundal