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# Macroinvertebrates Assemblage Study: An Attempt to Assess the Impact of Water Quality on Qua Iboe River Estuary, Akwa Ibom State, Nigeria

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**ABSTRACT:** This study was conducted to access the water quality of Qua River Estuary, Akwa Ibom state, Nigeria by collecting water samples and macroinvertebrates using standard sampling procedures and analytical methods. The mean values of physicochemical parameters assessed in water samples gave the following ranges: DO (2.38 – 4.63 mg/l), water temperature (26.13 – 29.18 ºC), turbidity (22.56 – 39.24 NTU),TDS (224.8 – 332.51 mg/l), pH (6.3 – 7.5 mg/l), salinity (3.13 – 4.84 ppt),BOD (1.13 – 3.64 mg/l), nitrate (2.45 – 6.72 mg/l), phosphate (2.12 – 5.93 mg/l) and Flow velocity (0.23 – 0.38 ms-1). ANOVA reveals significant variation in some parameters**.** A total of 308 individual species, comprising of three phyla and seven taxonomic groups of macro-invertebrate were identified. Arthropoda constituted the highest percentage composition (75.4%), followed by Mollusca (18.8%), and Annelida (5.8%). The dominant group was Decapoda (35.7%) and the least was Odonata accounted only for 1.9%. Station 5 has the highest number of individual's species (112), station 3 had the least (43). *Chironomus plumosus* was the most occurring species, accounted for 19.2%. The result reveals that anthropogenic activities in the water system influence the abundance of aquatic biota; based on the macro-invertebrates identified, it shows that the water quality is moderately polluted owing to human activities.

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Water pollution is a global problem generally that threatens life. Water is an essential for human and aquatic organisms; it served as an important source of food and nutritional value for man, as well as a medium for recycling of nutrients, survival, reproduction and growth of aquatic biota (Jonah *et al*., 2019). But today, the illicit activities of mankind on the waterways and environment have changed the favorable habitat, leaving behind the tolerant species. George and Efiom (2018) affirmed that the major cause of environmental degradation is as a result of nefarious activities of mankind which include industrial, mining (dredging), agricultural and road construction. However, research in various capacities had been carried out within the Nigerian coastal area; identified anthropogenic activities as a threat to the aquatic ecosystem (Ekiye and Zejioa 2010; Wanjala *et al*. 2018 and Jonah *et al*. 2019) which may alter the biological structure, including macro-invertebrates (fauna). Aquatic macro-invertebrates are threatened by changes in their habitat structure associated with pollution (Caryn 2010). The use of the macro-invertebrates in the monitoring of environment has been consistent and reliable since they are sensitive to environmental changes in terms of pollution as well as their wide distribution. Furthermore, several studies

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have employed macro-invertebrates to assess the health status of the aquatic ecosystem (Emere and Nasiru 2007 and Arimoro *et al*. 2015). Qua Iboe River Estuary is located in the urban area, it receives wastes from municipal runoff, industrial and agricultural activities. The proliferation of urban and commercial establishments along the shores of the estuary resulted in addition of allochthonous complex mixtures into the water body which could have a substantial effect on the autochthonous invertebrate abundance and distribution. Therefore, the objective of this study is to evaluate the physicochemical characteristics and macro-invertebrate assemblage in relation to the state of water quality of the Qua Iboe River Estuary, Akwa Ibom State, Nigeria.

## MATERIALS AND METHODS

*Study area and sampling stations:* Qua Iboe River Estuary is located in Niger Delta area of Akwa Ibom State, Nigeria. It lies within Latitude 4 45'31 North and Longitude 7 55'0 East (Figure 1). The river flows in north-south direction from Ikwuamo Local Government Area of Abia State into Akwa Ibom State through Usaka community in Obot Akara Local Government Area and traverse in many communities before pouring into the Altantic Ocean. The area is characterized by fluctuation of water currents and mangrove plants such as *Avicennia*, *Rhizophora* and *Nypa palm*. Human activities observed were fishing in large and small scales, farming, dredging, boat making, laundry, logging of mangrove vegetation and other domestic activities within the watershed. On this study, five sampling stations were selected, in which the criteria were based in anthropogenic activities and the ecological settings in each sampling station. Station 1 was located at the upper estuary (Iwuokpom); the identified activities were fishing in large and small scales. The station is close to market and residential area, featuring sandy to muddy substrate. Station 2 (Mkpanak), located at the middle zone of the estuary, 3km away from station 1; characterized by intense anthropogenic activities such as off-loading of refined petroleum product, laundering and fishing. The station received wastes from inhabitants of the watershed and other domestic activities. The observed mangrove vegetation was *Nypa fructicans*, *Avicennia* a*fricana* and *Rhizophora*; substrate is muddy and clay. Station 3 (Iwuochang) also located at the middle zone, 2km away from station 2. It characterized by intense anthropogenic activities including boat construction, fishing and sand mining. The station receives wastes from the market via surface runoff and direct discharge of household wastes. Station 4 (Eketai), located at the lower zone, 2km distance from station 3. The observed activities were lumbering, dredging, boat construction, fishing and laundering. All these contribute to accumulation of organic pollutants in the station. Station 5 (Atabong), located also at the lower region of the coastline, 3km away from station 4; the human activity there is fishing. The identified vegetation included *Nypa frutican*, *Rhizophora*, and *Avicenna africana.*

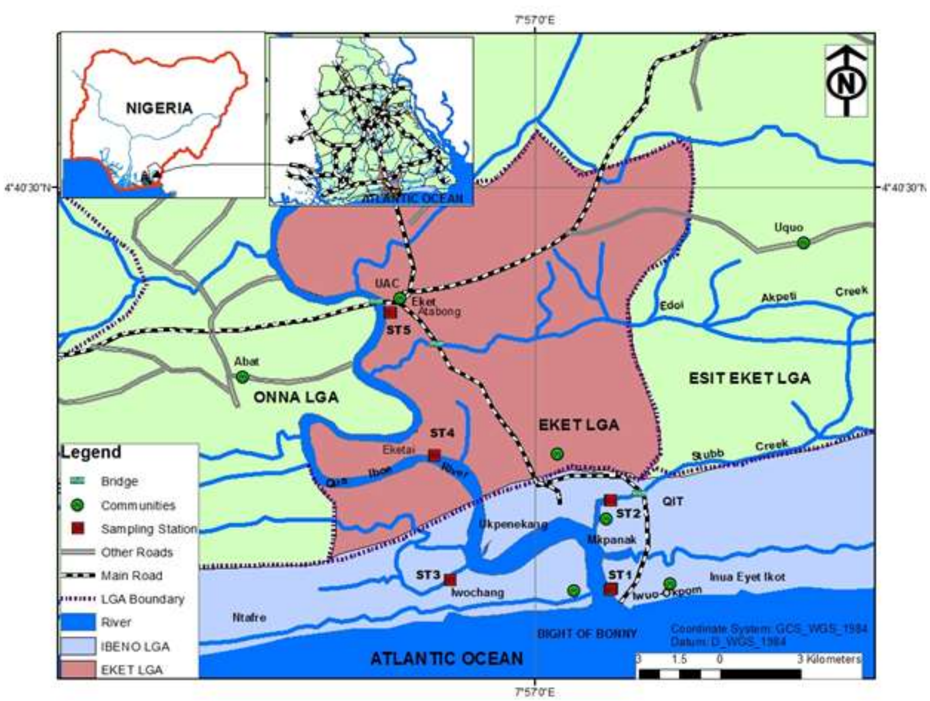


**Fig 1** Map of Qua Iboe River with sampling stations

*Samples collection and Analysis:* Water samples for physicochemical analysis were collected on monthly basis for eight (8) months between May and December 2021. The samples were collected using washed and sterilized plastic bottles (1litre). Some parameters were determined *in situ* using Extech meter probe (Exstick II), flow velocity was determined by floatation method, while phosphate, nitrate and biochemical oxygen demand were analyzed *ex-situ*. All parameters were determined according to standard examination methods of water and wastewater (APHA 2005 and AOAC 2000). Macro-invertebrate's samples were collected using a standard hand net and Van-veen grab sampler (0.05m$^2$surface area) in four replicates. The sediment samples collected were sieved with nets of mesh sizes 0.5, 1 and 2 mm respectively. The residues retained on the sieves screen were washed with white enamel tray with moderate volume of water to improve visibility for sorting. The concentrated samples were stored in a small glass jars, labeled and preserved in 10%buffered formalin. In the laboratory, the identification of the isolated macro-invertebrates was conducted to the lowest taxonomic level aided with following taxonomic keys: Ward and Whipple (1959), Edmondson (1959) and Pennak (1978). The isolated macro-invertebrates from each station were counted and classified respective their own phyla, classes, orders, families and species.

*Statistical Analysis:* Statistical Package for Social Science (SPSS) Version 20 was employed to compute the mean, variance and standard error in the data collected. Also, one-way analysis of variance (ANOVA) and least significant difference (LSD) test were used to separate significance in mean values computed for stations. The probability level was set at p=0.05.

*Diversity structure:* The diversity structure of the macro-invertebrates was determined using biological indices such as Shannon wiener index (H), Margalef's index (d), and Evenness index (E)based on the methods used by (Andem *et al*. 2012; Okorafor *et al.* 2014; Job *etal.*2019 and George *et al*. 2020) in similar studies.

## RESULTS AND DISCUSSION

*Physicochemical parameters:* The mean values and standard error of physicochemical parameters are presented in Table 1.Dissolved oxygen (DO) highest value was in station 5 (4.63 mg/l), while the lowest was in station 4 (2.38 mg/l); ANOVA showed significant difference in values among the stations. Surface water temperature ranged from 26.13 to 29.18$^0$C. The lowest mean value of 26.13$^0$C was recorded in station1, while the highest of 29.18$^0$C was observed in station 4. All values obtained were documented within the range (25 - 40$^0$C), acceptable by FMEnv (2011) for the survival of aquatic organisms. The mean value of turbidity was highest in station 3(39.24 NTU), and the lowest was recorded in station 5(22.56 NTU). All values obtained were exceed the range (<5 NTU), acceptable by FMEnv (2011).Statistical analysis showed no significant differences among the stations (P<0.05).Total dissolved solids (TDS) highest value was in station 2 (333.51 mg/l), and the lowest (224.8 mg/l) was recorded in station 3. Statistical analysis showed significant differences station 2 (P>0.05).Hydrogen–ion concentration (pH) ranged between 6.3 and 7.5mg/l, with the highest value in station 1. Salinity recorded the highest mean value in station 2 (4.83 ppt), with the lowest in station 5 (1.13ppt). There is a significant difference among the sampling stations at P>0.05 level. Biochemical Oxygen Demand (BOD) mean values ranged from 1.13 to 3.64 mg/l, with the lowest in station 5 (1.13 mg/l), while the highest was in station 4 (3.64 mg/l). ANOVA indicated significant difference in station 5 (P<0.05).Nitrate ($N0_3^-$) values were ranged between 2.45 and 6.72 mg/l, highest value was recorded in station 3 (6.72 mg/l), the lowest was obtained in station 5 (2.45 mg/l). Statistical analysis showed significant difference in between the stations (P<0.05).

**Table 1:** Mean and standard error of physicochemical parameters of Qua Iboe River Estuary

| Parameters | Stn1 | Stn2 | Stn3 | Stn4 | Stn5 | FMEnv |
|---|---|---|---|---|---|---|
| DO(mg/l) | 3.41±0.26$^a$ | 2.69±0.22$^b$ | 2.56±0.11$^b$ | 2.38±0.09$^b$ | 4.63±0.0.21$^a$ | >6.0 |
| Temp.($^o$C) | 26.52±0.17 | 28.34±0.27 | 29.0±0.38 | 29.18±0.15 | 26.13±0.11 | 40 $^o$C |
| Turb. (NTU) | 32.44±0.28 | 33.14± 0.31 | 39.24±2.21 | 28.33±1.53 | 22.56±1.03 | <5 |
| TDS (mg/l) | 234.4 ±0.52$^a$ | 332.51±0.13$^b$ | 224.8±0.53$^a$ | 263.10±0.33$^a$ | 231.6± 0.32$^a$ | NI |
| pH | 7.5±0.23 | 6.3±0.42 | 7.2±0.36 | 6.3±0.14 | 6.6±0.16 | 6.5 – 8.5 |
| Salinity (ppt) | 4.13±0.55$^a$ | 4.83±0.42$^a$ | 3.33±0.25$^a$ | 2.35±0.11$^b$ | 1.13 ±0.34$^c$ | NI |
| BOD (mg/l) | 2.62±043$^a$ | 3.17 ±0.13$^a$ | 3.19 ±0.24$^a$ | 3.64 ±0.19$^a$ | 1.13± 0.45$^b$ | 3.0 |
| $N0_3^-$(mg/l) | 3.25± 0.42$^a$ | 5.48± 0.11$^b$ | 6.72± 0.21$^b$ | 3.21 ±0.32$^a$ | 2.45± 0.29$^a$ | NI |
| $S0_4^{3-}$(mg/l) | 3.32± 0.19$^a$ | 5.73± 0.21$^b$ | 5.93± 0.14$^b$ | 3.66± 0.45$^a$ | 2.12± 0.38$^c$ | 3.5 |
| Flow vel.(m/s) | 0.23± 0.24 | 0.35± 012 | 0.32± 0.41 | 0.32± 0.19 | 0.38± 0.15 | NI |

*±= standard error; means values with different superscript in the same row are significantly different (p<0.05)*

Phosphate ($S0_4^{3-}$) mean values ranged from 2.12 to 5.93 mg/l. Highest values were recorded in stations 2 and 3 (5.73 and 5.93mg/l), while the least was in station 5 (2.12 mg/l). The values obtained in station 1 and 5 within the range recommended by FMEnv (2011) while the values in stations 2, 3 and 4 were exceed the ranged (3.5), acceptable by FMEnv (2011). Statistical analysis (ANOVA) showed significant difference between the stations (P<0.05).Flow velocity mean values ranged from 0.23 to 0.38 m/s. Highest value was recorded in station 5 (0.38 m/s), while the least was in station 1 (0.23 m/s). Statistical analysis (ANOVA) showed no significant difference between the stations (P>0.05).

Dissolved oxygen values recorded across the stations were significantly low when compared with FMEnv limits (>6.0 mg/l). This could be caused by the consistent discharge of wastes from various anthropogenic sources into the water body. Dredging and sewage contribute to the increased loading of unwarranted toxicants into the water body. Slight increase in this parameter in station 5 could be attributed to limited human activities at station. Wastes decomposition by microbe demand oxygen; this could have contributed to the reduced DO values noticeable in all the stations. Anago *et al*. (2013) avowed that the decline in DO values could be due to chemical and biological oxidation processes in the water. The range of water temperature values obtained in the study is in accordance with the reports of Akpan and Etim (2015) for Uta Ewa Estuary. Slight variations in temperature values as recorded spatially could be attributed to weather conditions at the time of sampling and to the location of those stations. The observed values of turbidity across the stations could be ascribed to impact of surface runoff on these stations and the usual direct dumping of non-dissolvable wastes into the water couple with sand mining. Sand mining resulted in re-suspension of organic debris deposited at the sediment back to the water surface. The turbidity values obtained for all the stations were higher than FMNnv standard (<5 NTU). High concentration of TDS in station 2 corresponds with the level of anthropogenic activities at this station such as off-loading of refined petroleum products and other domestic activities. The elevated value in station 2 could be attributed to impact of surface runoff, transporting toxic substance into the station. Jonah *et al*. (2020) affirmed that increased precipitation and subsequent runoffs from the surrounding lands increased the TDS values of any water body. The pH values obtained were varied across the stations; this could be due to the anthropogenic activities within the watershed. Off-loading of refining petroleum product in station 2 and other domestic discharge in station 4 could contribute to the high pH value. The values recorded fall within the recommended limits (6.5 – 8.5) by FMEnv (2011).High salinity values were recorded in stations 1 and 2; this may be attributed to evaporation of water and intrusion of saltwater into the water body during low tide. The values recorded in this study were within the range values reported by Akpan *et al*. (2019) for Uta Ewa Estuary and George and Atakpa (2015) for Cross River Estuary. Biochemical oxygen demand (BOD) is one of the essential parameters usually used to assess the pollution load in water bodies (Bhatti and Latif, 2011). BOD values obtained in stations 2, 3 and 4 exceed the recommended value (<3.0 mg/l) by FMEnv (2011) indicating high level of pollution and correspond with recorded values of DO. Biodegradation of wastes required a lot of DO resulted in significant increase of BOD level. The higher values recorded in these stations may be linked to the high accumulation of organic and inorganic pollutants via human activities which usurp dissolved oxygen in large amounts during biodegradation. Findings coordinate with the reports of Jonah *et al.* (2019) for Ikpe Ikot Nkon River and Anyanwu *et al*. (2019) in Ossah River, Nigeria. Unpolluted water bodies have BOD values of 2.0 mg/l or less while values between 3.0mg/l and 10mg/l or more (Chapman and Kimstach 1996 and Utang and Akpan 2012). The BOD values recorded for stations 1 and 5 was within the acceptable limit (<3.0 mg/l) by FMEnv (2011). Higher nitrate and phosphate values noticed in stations 2 and 3 may be linked to combined effects of precipitation and anthropogenic inputs. The findings are in agreement with the reports of Mandal *et al*. (2012). According to the author, higher concentration of these parameters owed to anthropogenic activities like laundering, discharge of contaminated sewage, and runoffs laden with fertilizers and pesticides. Phosphate values in stations 1 and 5 in this study were within the acceptable limit (3.5mg/L) by FMEnv (2011).

*Macroinvertebrate composition*: The composition and relative abundance of macroinvertebrates fauna are presented in Table 2. A total of 308 individual species belonging to three (3) phyla, comprising of seven (7) taxonomic groups of macro-invertebrates were encountered; dominated by tolerant species. Phylum Arthropoda constituted the highest percentage composition (75.4%), followed by Mollusca (18.8%) and the least wasAnnelida(5.8%). Concerning taxonomic groups, their percentage composition was in the following order: Decapoda (35.7%)>Diptera (21.5%)> Gastropoda (18.9%) > Ephemeroptera (10.0%) >Coleoptera (6.2%) > Clitellata (5.8%) >Odonata (1.9%). Spatially, high number of individual species was recorded in station 5 (112), followed by station 4 (55), while station 1 had 54, station 2 (44) and station 3 (43) with their relative abundance 36.4%, 17.8%, 17.6%, 14.3% and 13.9%respectively. Percentage composition of taxa showed that *Chironmous plumosus* specie had the highest number of individuals59 with relative abundance of 19.2%, followed by *Cardisoma armatum* 44 with relative abundance (14.3%) and the lowest was *Homarinus capensis*(5) with 1.6% relative abundance. The diversity indices indicated that Shannon-Weiner index (H) value ranged between 1.62 and 2.18; the highest value was obtained in station 5 (2) and the lowest was in station 3(1.62). Margalef index (D) highest value was in station 3 (3.07), with station 2 being the least 2.16. Evenness index (E) obtained spatially was relatively high, with the highest value in station 5 (0.8) and the lowest was in station 2(0.73).

**Table 2:** Macro-invertebrates identified during the study period (May2021 - December2021)

| Groups | Taxa | Stn1 | Stn2 | Stn3 | Stn4 | Stn5 | Total |
|---|---|---|---|---|---|---|---|
| **Arthropoda** | | | | | | | |
| Insecta | | | | | | | |
| Diptera | *Tipula sp* | 1 | 1 | 3 | 2 | - | 7 |
| | *Chironomus plumosus* | 3 | 22 | 16 | 18 | - | 59 |
| Ephemeroptera | *Baetisca laurentina* | 6 | - | - | - | 25 | 31 |
| Odonata | *Micromia splendens* | - | - | - | - | 6 | 6 |
| Coleoptera | *Gyrinus sp* | - | - | - | - | 13 | 13 |
| | *Cybister larvae* | 1 | - | - | - | 5 | 6 |
| Decapoda | *Pandalus sp* | 3 | 2 | - | - | 11 | 16 |
| | *Homarinus capensis* | 2 | - | - | 1 | 2 | 5 |
| | *Gammarinus pulex* | 5 | 3 | 4 | 6 | 16 | 34 |
| | *Cardisoma armatum* | 10 | 4 | 8 | 10 | 12 | 44 |
| | *Nematopalaemon hastatus* | 4 | 3 | 1 | 1 | 2 | 11 |
| **Mollusca** | *Littorina punctuate* | 7 | 3 | 3 | 5 | 5 | 23 |
| Gastropoda | *Planobis carinatus* | 10 | 2 | 4 | 5 | 14 | 35 |
| **Annelida** | | | | | | | |
| Clitellata | *Limnodrilus hoffmeisteri* | 0 | 3 | 2 | 1 | 1 | 7 |
| | *Hirudo medicinalis* | 2 | 1 | 2 | 6 | - | 11 |
| | No. of taxa ( species) | 12 | 10 | 9 | 10 | 12 | 15 |
| | No. of individuals | 54 | 44 | 43 | 55 | 112 | 308 |
| | Margalef's index (d) | 3.0 | 2.7 | 2.16 | 2.25 | 2.55 | |
| | Shannon- weiner (H) | 1.91 | 1.68 | 1.62 | 1.73 | 2.18 | |
| | Equitability(E) | 0.76 | 0.73 | 0.77 | 0.75 | 0.80 | |
| | Relative abundance | 17.6 | 14.3 | 13.9 | 17.8 | 34.4 | 100 |

Arimoro and Muller (2010) proposed that the immediate substrate, food availability and physico-chemical characteristics of the prevailing environment influenced the inhabitant organism's abundance including benthic invertebrates. In this study, a total of15taxa accounting for 308 individual species, underlying 7 taxonomic groups of macro-invertebrates encountered, were dominated by tolerant species. The number recorded is low when compared with the documented reports of Arimoro and Keke (2017) for Gbako River; Olomukoro and Oviojie( 2015) for Obazuwa Lake. The dominance of tolerant species in this study is compatible with the reports from most Nigerian water bodies (Emere and Nasiru 2007; Akaahan 2014 and Anyanwu *et al*. 2019). Spatially, high species of macro-invertebrates was found in station 5 against other stations; this could be traceable to high discharge of wastes into the water body and to the level of anthropogenic activities in these stations. The abundance of Arthropoda is not unprecedented, it attributed to their ubiquitous nature and the knowledge that they do not show habitat restriction (Jonah *et al*. 2020). Similar observations were reported by Imoobe (2008) in Ologe Lagoon and Anyanwu *et al*. (2019) for Ossah River. The prevalence of Decapoda as observed may be linked to favorable environment and their ability to adapt to organic pollutants. Low abundance of species belonging to Ephemeroptera, Odonta and Coleoptera may link to the fact that they are sensitive to poor water quality and anoxic condition. This elucidated their absence in stations 2, 3, 4 and few in station 1 where their presence reflects clean water condition (Miserendino and Pizzolon 2003; Arimoro and Keke 2017). Diptera was represented by two species dominated by *Chironomus sp*, this may be attributed to their ability to survive in an environment with low dissolved oxygen, and their possession of hemoglobin pigment (Tyokumbur *et al*. 2002) and its presence is an indication that the water is polluted. A similar observation was reported by Hansen *et al.* (1998), Olomukoro and Oviojie (2015) and George *et al*. (2020).Presence of the gastropod *Planobis* and annelids *Limnodrilus* and *Hirudo medicinalis* may be linked to the favorable substrate. They can also be found in any water body and are capable of tolerating the high level of the organic pollutants (Adeogun and Fafioye 2011). This finding is in accordance with the reports of Sharma and Chowdhary (2011), Anyanwu *et al*. (2019) and Jonah *et al*. (2020) where they recorded the presence of *Limnodrilus* and *Hirudo medicinalis* in an effluent receiving water. The diversity indices have been applied in macro-invertebrate assessments in order to evaluate the environmental conditions. According to Ishag (2013), the diversity indices were all based on two assumptions, first that the stable community has high diversity values, while unstable ones have lower diversity values. Shannon-weiner and evenness index values were higher in station 5, while high Magalef's index was obtained in station 1; the low values for these aforementioned indices from stations 1 to 4are believed to have emanated from severe stress imposed by anthropogenic activities. This confirms the documented statement of Olomukoro (1996) that diversity was considered as a measure of community stability, where low diversity is an indication of stress in the environment while high diversity is a reflection of stress free environment. The high diversity recorded in station 5 may entail that this station is relatively stable and stress free.

*Conclusion:* The macro-invertebrates fauna encountered in this study were dominated by pollution tolerant species. The low diversity of sensitive invertebrate species observed could partly be due to the stress imposed on the water body. This study indicates the necessity of continuous monitoring of our water bodies as this will provide vital information on the ecological status and productivity of water bodies in Nigeria and develop measures to mitigate water pollution and prevent loss of biodiversity.

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