Limnology and Freshwater Biology 2024 (2): 98-107 DOI:10.31951/2658-3518-2024-A-2-98

Original Article

LIMNOLOGY FRESHWATER BIOLOGY

Evaluating the water quality status using selected indexes and the aquatic arthropod species composition of the Idim Eye-Asana River, south Nigeria

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ABSTRACT. The objective of the study was to evaluate the water quality status and the aquatic arthropod species composition of the Idim Eye-Asana River, Edebom 1, between May and July 2023. The sampling area was divided into four (4) sampling sites with unique coordinates. The physico-chemical parameters such as dissolved oxygen (DO), pH, temperature, total dissolved solute (TDS), inorganic contents; nitrate, sulphate, nitrite, and phosphate were measured using standardised methods. The aquatic arthropod specimens were collected using standardised circular-framed net with a 0.05μm mesh size and 35cm in diameter with an iron handle of 2m in length. Single factor pollution index (Pi), Biological Monitoring Working Party (BMWP) index, and diversity indices were calculated to evaluate the water quality status of the river. The physico-chemical parameter results revealed that they were differently significant between the sampling sites. The inorganic contents (contaminants) results showed that nitrate, phosphate, nitrite, and sulphate were differently significant at a 95% t-test between the sampling sites. The Pi values for the inorganic contents revealed that the water quality at site 2 was moderately polluted (3.25) with nitrite, whereas sites 3 (2.85) and 4 (2.50) were lightly polluted. Three (3) arthropod classes, sorted into seven (7) orders, and thirty-four (34) families were collected. Through the BMWP index results, the water quality classification for the water status at site 1 was regular (moderately contaminated), site 2 (poor), and sites 3 and 4 (Good water quality). Sites 3 and 4 sections of the river had good water quality, and as indicated by the results, it was concluded that the sites (i.e., 3 and 4) have better ecological conditions that can sustain the development and survival of the aquatic arthropod species.

Keywords: Physico-chemical parameters, inorganic contents, single factor pollution index, diversity indices, biological monitoring working party index

For citation: Akpan A.U., Esenowo I.K., Effiong M.U., Yaro C.A., Ekedo C.M., Ukpong N.C., Oboho D.E., Ekpeno E.U., Ekpo E.J., Umondak E.D., Essien U.B. Evaluating the water quality status using selected indexes and the aquatic arthropod species composition of the Idim Eye-Asana River, south-south, Nigeria. // Limnology and Freshwater Biology. 2024. - № 2. - P. 98-107. DOI: 10.31951/2658-3518-2024-A-2-98

1. Introduction

Freshwater ecosystems are critical components of the Earth`s biosphere, supporting a diverse range of arthropod biodiversity and providing a variety of ecosystem services (Dudgeon et al., 2006). Rivers are natural freshwater streams that flow into other rivers, lakes, or the sea (Er˝os and Lowe, 2019). River ecosystems benefit society in multiple ways, such as by providing water and food, acting in climate regulation, and serving as recreational spaces (Orozco-González and Ocasio-Torres, 2023).

Water quality refers to the chemical, physical, and biological characteristics of water, which determine its suitability for various uses, such as drinking, irrigation, and sustaining aquatic life. Many rivers in Nigeria are impacted by anthropogenic activities, including industrial discharges, agricultural runoff, and domestic sewage, which can degrade water quality. Physicochemical parameters of water quality and nutrients include dissolved oxygen (DO), pH, turbidity, total suspended solids (TSS), nitrate, nitrite, phosphate, sulphate, and chloride, whose alteration in the river system could lead to pollution (Ochekwu and Odeh,

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Received: April 20, 2024; ***Accepted:*** April 27, 2024;
Available online: April 27, 2024

2018), and the latter influence the habitat quality of a river for aquatic arthropods (Ademoroti, 2005).

Inorganic contents, particularly nitrogen and phosphorus, play a significant role in the health of aquatic ecosystems. Excessive nutrient inputs can lead to eutrophication, algal blooms, and oxygen depletion. In Nigeria, nutrient loading is often associated with agricultural runoff, urbanization, and animal and industrial discharges (Ololade, 2020). Johnson and Williams (2011) and Martinez et al. (2017) reported that higher nutrient concentrations in rivers were associated with variations in macroinvertebrate community composition, regularly supporting pollution-tolerant species over sensitive ones.

The continuous deterioration in water quality and decline in arthropod diversity constitute a threat to freshwater bodies, and this reduces their ecosystem services to man and the environment (Bis and Mikulec, 2013). These different forms of degradation of the freshwater bodies have led to changes in the water quality, which in turn causes changes in the composition of the arthropod fauna inhabiting the river, which is usually evidenced in the reduction of taxon richness, species diversity, and evenness (Maddock, 1999; Mophin-kani and Murugesan, 2014; Esenowo et al., 2016; 2017).

Arthropods, which include many organisms such as insects and crustaceans, are essential components of freshwater ecosystems (river, stream) (Statzner and Hildrew, 2010). As a group, arthropods are sensitive to environmental changes and respond highly to changes caused by nature and human perturbation, which lead to different forms of degradation of the freshwater body (Barbour et al., 2013). Interests have evolved in the last years over the study of the group of aquatic macro-invertebrates (arthropods, mollusks, annelids), with little consideration of the arthropod groups. It is important to study the ecological dynamics; nutrient cycling, organic matter decomposition, and food source for higher trophic levels, of arthropod groups in rivers and the use of this group to assess aquatic ecosystem health (Tonkin et al., 2017). The composition and abundance of arthropod groups can provide a direct indication of water quality (Barbour et al., 1999).

Despite growing studies and publications on macroinvertebrates and the water quality of rivers (Bauernfeind and Moog, 2000, Asonye et al., 2007, Esenowo and Ugwumba, 2010, Andem et al., 2015; Esenowo et al., 2016, 2017; Rosenberg and Létourneau, 2016; Dala-Corte et al., 2020), this work will provide baseline information with emphasis on arthropod groups as bio-indicators for assessment of the water quality of the Idim Eye-Asana river system in the Nsit Ibom local government area of the south-south region of Nigeria.

There is a dearth of information and knowledge regarding the pollution status and arthropod species composition of the Eye-Asana River system, and this formed the core rationale for this study. The dearth of this information and knowledge about the river could be a barrier preventing the safe use of this water source for human consumption in the area.

This work stands to incorporate a single factor pollution index to assess the pollution status of water quality nutrient loads, diversity indices, the Biological monitoring working party (BMWP) score sheet (as adopted from Alba-Tercedor, 1996), and the Average score per taxon (ASPT) for a better representation and assessment of the pollution status of the Eye-Asana river ecosystem. BMWP assigns scores to each macroinvertebrate taxa according to their sensitivity to pollution caused by organic materials, and it is once assigned to a family regardless of the number of individuals collected. ASPT is the average sensitivity of the families of the macroinvertebrate organisms present (Orozco-González and Ocasio-Torres, 2023).

2. Materials and methods

2.1. Study area

The river is known as the Idim Eye-Asana River and is located in Edebom 1, Nsit Ibom Local Government Area, Akwa Ibom state, south-south Nigeria. Nsit Ibom shares common boundaries with Ibesikpo Asutan, Etinan, and Nsit Ubium Local Government Areas. The Idim Eye-Asana River is a significant freshwater body located in the Edebom area of the Nsit Ibom Local Government Area. The river takes its origin from Aba Ukpo and flows un-directionally through bushes and other villages within the Local Government and others. The river serves as a vital lifeline for the local communities, providing water for various home and agricultural activities. It also serves as a harbour for sand mining, swimming, and domestic activities such as bathing, laundry, and fetching water, as well as a water source for a fish farm nearby. The bank of the river is mostly surrounded by riparian vegetation, which includes shrubs and trees such as Raffia palm (Raphia vinifera) and Screw pine (Pandamus spp.). Tropical hydrophytes include emergent, free-floating, and submerged aquatic plants such as Water hyacinth (Eichhorina crassipe) and Water lilies (Nymphaea lotus).

2.2. Study site selection

Four representative sections of the river that were accessible with canon and with unique ecological characteristics were selected for sampling of the water and arthropods. Site 1 lies between Latitude 4.8925306N and Longitude 7.8960408E (Fig.1), which is the entrance into the river. Here, the water was shallow and transparent. A few plants such as water hyacinth (*Eichhorina crassipe*) characterised the study site. Site 2 lies between Latitude 4.8923615N and Longitude 7.8962651E. This site is closest to the right side of the fish farm. It is covered with aquatic vegetation such as water lilies (*Nymphaea lotus*), water Primrose (*Ludwigia repens*), and submerged plants of common eelgrass (*Zostera marina*). This site served as the receiving point for the effluence discharged from the fish farm, which then flows through the flow channel of the river.

Site 3 is located at Latitude 4.8915003N and Longitude 7.8956837E, this site was characterised by the over-heard bridge. The river water at this site flowed through the embankment of the bridge. Some aquatic plants found here were water lilies (*Nymphaea lotus*), water Primrose (*Ludwigia repens*), and bamboo.

Activities at the site included bathing, washing, and sand mining. Site 4 lies between Latitude 4.8913260N and Longitude 7.8954292E. Bamboo (*Bambusa vulgaris*) and Algae of *Chlorophyta* species are some of the aquatic macrophytes around this sampling site. Each sampling site was 120 m in length away from each other.

2.3. Collection of samples

The collection of samples was carried out between May and July 2023. Water samples and arthropod specimens were collected from each sampling site. Water samples were also subjected to a comprehensive water quality analysis, which included measurements of dissolved oxygen, pH, temperature, and nutrient concentrations. Several species of arthropod specimens were collected using the sweep-net method.

2.4. Water sample collection

Surface water samples were collected from each site for three (3) months from May to July 2023 at 9:00 a.m. and 11:00 a.m. Water samples were collected using clean 330 ml amber bottles from the four sampling sites. Dissolved oxygen (DO), temperature, conductivity, and pH were measured *in situ* using the Water Analysis kit model WA (Taiwan, 2015). From the water samples collected, about 10 ml was turned into a conical flask for *in situ* readings. The water analysis kit was turned on, and each parameter was measured twice to attain two readings each, and then the mode of the kit would be changed to measure the next parameter. This continued until all the parameters had been recorded properly. Afterward, all the samples were properly sealed and well stored in a bucket, covered, and taken to the Department of Chemistry, Faculty of Physical Science, University of Uyo for analysis of inorganic contents (nitrate, phosphate, sulphate, and nitrite) and Biological Oxygen Demand (BOD_5) following standard methods provided in (James, 2007).

2.5. Collection of arthropod samples

The arthropod specimens were collected from the four (4) selected sampling sites using a Circular-framed net made of a 0.05μm mesh-size net of 35cm in diameter, with an iron handle of 2m in length. Following standard methods, the net was submerged in the water and pushed repeatedly, backward and frontward, against and through marginal and aquatic vegetation for 30 minutes to dislodge invertebrates. This was carried out at all the sampling sites with the aid of Canon Man. Flying specimens were also collected using the net. At each sampling site, the whole content of the net, which included leaves, logs, sediment, and other loose debris, is carefully emptied into a properly labeled field sample container (with the site and date information) containing 10% formalin by inverting the net, and carefully sharking the net to ensure that no arthropod specimen remains attached to the net. The field containers and their contents are taken to the laboratory of the Department of Animal and Environmental Biology,

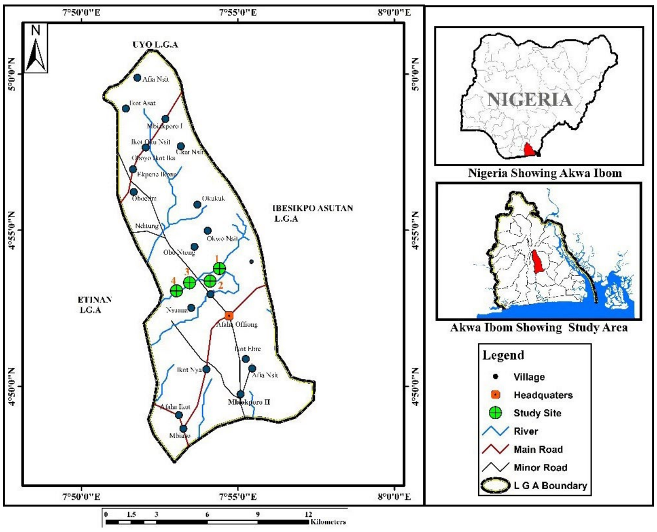

Fig.1. Map showing the selected study sites
Source: Cartography Studio, Department of Geography and Natural Resources Management, University of Uyo, Uyo.

University of Uyo, Uyo. In the laboratory, each of the field containers is emptied into a white tray, and water from the tap is made to run over the sample until a clean sample is observed. The leaves, logs, and other debris are carefully examined for any clinging invertebrates before putting them away in the trash. The specimens are harvested from the tray using forceps and handpicking methods and stored in 40% ethyl alcohol for later sorting, identification, and counting (Dickens and Graham, 2002; Orozco-González and Ocasio-Torres, 2023). The identification was carried out using guides provided by Danladi et al. (2013) to the genus level.

3. Statistical analysis

Calculation of pollution status (water quality) indexes:

1) Single Factor pollution index:

$$\text{Pi} = \frac{G}{S_1} \quad (1)$$

where G = measured value of pollutant content recorded in mg/L

S_1 = is the standard value of environmental quality of the pollutant (mg/L)

The results as calculated will be compared with the standards in Table 1.

Table 1. Water Quality classification using the Single Factor Pollution Index

Water Quality Category	Pollution Assessment	Pi
I	No pollution	≤ 1
II	Slightly polluted	1 – 2
III	Lightly polluted	2 – 3
IV	Moderately polluted	3 – 5
V	Seriously polluted	>5

2). BMWP = Σti (Orozco-González and Ocasio-Torres, 2023).
where ti is the score assigned to the pollution tolerance family

Σ = is the summation of the assigned score.

The resulting summation values from BMWP are compared to determine the pollution status in the water of the river, according to the categories listed in Table 2.

3) The average score per taxa (ASPT) value was calculated using the formula below:

ASPT = Σ BMWP score/total number of taxa species sampled (Bartram and Balance, 1996; Bawa et al., 2018)

The data was entered with Microsoft Excel 2019 and analysed for comparison of means of physiocochemical parameters, and inorganic contents, and diversity indices using SPSS 26.0 version and PAST 4.09 version, respectively.

Table 2. Water quality categories (pollution status) according to the values of BMWP (Source: Bawa et al., 2018, but modified)

S/N	BMWP	Water Quality
1	≥77	Good – not heavily polluted with contaminant
3	57–76	Regular—eutrophic, moderately contaminated
4	37–56	Poor—water contaminated
5	18–36	Poor—water very contaminated
6	≤10	Very poor—water extremely contaminated

4. Results

4.1. Physico-chemical parameters

The mean (±SE) physico-chemical results revealed that the water temperature is in the range of 26.0 – 28.0°C, with a total concentration of 27.3±0.3°C across the sampling sites, and was differently significant between the sampling sites at the significant value of 0.433. The water pH of the river was 5,8±0.2 and 5.5±0.2 at site 1 and site 2, respectively, within the range of 5.4 – 6.2 with a mean total of 5.8±0.1 between the sampling sites. The dissolved oxygen (DO) was relatively high at site 1 (2.1±0.0mg/L) followed by sites 2 and 3 (1.9±0.1mg/L) with a mean total concentration of 1.9±0.00mg/L. The physico-chemical parameters were significantly different between the sampling sites (Table 3a).

The inorganic contents (contaminants) results revealed that nitrate expressed in mg/L, phosphate (mg/L), sulphate (mg/L), and nitrite (mg/L) were differently significant at a 95% t-test between the sampling sites. The single factor pollution (P*i*) results revealed that the classification of nitrate (mg/L), sulphate (mg/L), and phosphate (mg/L) across the sampling sites was not polluted, less than 1 (< 1), whereas the single factor pollution (P*i*) index was 2.50 for nitrite (light pollution), but its value at site 4 was 3.25 (moderately polluted) (Table 3b).

Table 3a. Mean (±SE) results of the physico-chemical parameters and inorganic contents

Sites	Temperature (°C)	pH	Conductivity (µs/cm)	DO (mg/L)	BOD_5 (mg/L)	TDS (mg/L)
Site 1	27.1±0.1	5.8±0.2	15.3±0.8	2.1±0.0	0.8±0.2	7.8±0.4
Site 2	27.8±0.5	5.5±0.2	26.2±2.6	1.9±0.1	0.7±0.1	13.0±1.3
Site 3	27.6±0.8	6.1±0.2	20.8±0.5	1.7±0.1	0.5±0.2	10.5±0.2
Site 4	26.7±0.4	6.0±0.3	18.3±0.8	1.9±0.0	0.5±0.2	9.3±0.4
Range	**26.0 - 28.0**	**5.4 – 6.2**	**15.00 – 26.5**	**1.6 – 2.3**	**0.49 – 0.82**	**7.5 – 13.4**
Total	**27.3±0.3**	**5.8±0.1**	**20.2±1.1**	**1.9±0.0**	**0.6±0.1**	**10.2±0.5**
p (< 0.05)	0.433*	0.225*	0.000*	0.014*	0.481*	0.000*

Table 3b. Mean (±SE) results from inorganic contents and single factor pollution index (Pi) of the inorganic contents

Sites	Nitrate (mg/L)	Pi	Sulphate (mg/L)	Pi	Nitrite (mg/L)	Pi	Phosphate (mg/L)	Pi
Site 1	3.3±0.2	0.067 (**NP**)	7.6±0.1	0.076 (**NP**)	0.5±0.0	0.75 (**NP**)	1.9±0.0	0.55 (**NP**)
Site 2	3.9±0.0	0.078 (**NP**)	8.7±0.0	0.087 (**NP**)	0.8±0.0	3.25 (**MP**)	2.1±0.0	0.072 (**NP**)
Site 3	3.3±0.2	0.067 (**NP**)	7.5±0.2	0.075 (**NP**)	0.6±0.0	2.85 (**LP**)	2.1±0.1	0.61 (**NP**)
Site 4	3.1±0.1	0.063 (**NP**)	7.1±0.2	0.072 (**NP**)	0.7±0.0	2.50 (**LP**)	2.1±0.0	0.59 (**NP**)
Range	**3.0 – 3.5**		**7.0 – 9.0**		**0.49 – 8.20**		**1.85 – 2.00**	
Total	**3.4±0.1**	**0.69±0.003**	**7.7±0.1**	**0.078±0.003**	**0.6±0.0**	**2.17±0.714**	**2.1±0.0**	**0.46±0.128**
p (< 0.05)	0.019*	0.000*	0.000*	0.000*	0.000*	0.056*	0.052*	0.038*

Note: * = significant. NP = Not polluted; LP = lightly polluted; MP = moderately polluted

4.2. Arthropod species composition

The collected aquatic arthropod species were collected and classified into three (3) arthropod classes: Arachnida, Crustacean, and Insecta; seven (7) orders: Araneae, Decapoda, Coleoptera, Diptera, Hemiptera, Lepidoptera, Mantoidae, Odonata, Orthoptera, and Trichoptera, and thirty-four (34) families. *Arachnura* sp., *Cheiracanthium* sp., *Harpactea* sp., *Lycosidae* sp., *Pholcus* sp., *Pisaura* sp., *Sassacus* sp., *Sibianor* sp., *Tetragnatha* sp, *Cardisoma* sp., *Macrobrachium* sp., and *Palaemon* sp. are among the aquatic arthropod species that were collected and identified (Table 4).

Table 4. Aquatic arthropod species collected in the study areas of the Idim Eye-Asana River during the study period

S/N	Class	Order	Family	Scientific Name	Common Name
1	Arachnida	Araneae	Araneidae	*Arachnura* sp.	Scorpion sp.iders
2			Cheiracanthiidae	*Cheiracanthium* sp.	Black-footed yellow-sac sp.ider
3			Dysderidae	*Harpactea* sp.	Hunting sp.iders
4			Lycosidae	*Lycosidae* sp.	Wolf sp.ider
5			Pholcidae	*Pholcus* sp.	Daddy longlegs
6			Pisauridae	*Pisaura* sp.	Nursery web sp.ider
7			Salticidae	*Sassacus* sp.	Jumping sp.iders
8				*Sibianor* sp.	Jumping sp.ider
9			Tetragnathidae	*Tetragnatha* sp.	Long-jawed orb weaver
10	Crustacea	Decapoda	Gecarcinidae	*Cardisoma* sp.	Patriot/Moon Crab
11			Palaemonidae	*Macrobrachium* sp.	River Prawn (Crayfish)
12				*Palaemon* sp.	Caridean shrimp
13	Insecta	Coleoptera	Chrysomelidae	*Altica* sp.	Common flea beetle
14				*Charidotella* sp.	Golden tortoise beetle
15				*Chrysochus* sp.	Blue milkweed beetle
16			Dytiscidae	*Neobidessus* sp.	Diving beetle
17			Scarabaeidae	*Heteronychus* sp.	Long-jointed black beetle
18				*Protaetia* sp.	Beetles
19			Tenebrionidae	*Prionychus* sp.	Black beetle
20		Diptera	Muscidae	*Musca* sp.	Housefly maggot
21		Hemiptera	Alydidae	*Leptocorisa* sp.	Paddy ear head bug
22			Aphrophoridae	*Philaenus* sp.	Sp.ittlebugs
23			Belostomatidae	*Lethocerus* sp.	Giant water bugs
24			Gerridae	*Gerris* sp.	Water striders
25			Notonectidae	*Notonecta* sp.	Back swimmer
26			Pentatomidae	*Brochymena* sp.	Stink bug
27				*Halyomorpha* sp.	Brown marmorated stink bug
28			Reduviidae	*Reduvius* sp.	Assassin bugs
29		Hymenoptera	Formicidae	*Dinoponera* sp.	Black ant
30				*Formica* sp.	Field ants
31		Lepidoptera	Elachistidae	*Elachista* sp.	Moth larvae
32			Erebidae	*Lymantria* sp.	Nun moth
33			Tineidae	*Acrolophus* sp.	Tubeworm moths
34			Yponomeutidae	*Eucalantica* sp.	Small white moth
35		Mantoidea	Mantidae	*Polysp.ilota* sp.	Madagascan marbled mantis
36		Odonata	Calopterygidae	*Calopteryx* sp.	Damselfly
37			Coenagrionidae	*Argia* sp.	Pauite Dancer (Damselfly)
38				*Ischnura* sp.	Citrine forktail (Damselfly)
39			Corduliidae	*Neurocordulia* sp.	Dragonfly
40				*Procordulia* sp.	Dragon fly
41		Orthoptera	Acrididae	*Chrysochraon* sp.	Short-winged grasshopper
42				*Omocestus* sp.	Green grasshopper
43			Romaleidae	*Romalea* sp.	Romalea grasshopper
44		Trichoptera	Rhyacophilidae	*Rhyacophila* sp.	Caddisfly larvae

4.3. Composition and distribution of the arthropod species

The composition and distribution revealed that *Arachnura* sp. and *Altica* sp. were only present at site 3, and *Sassaccus* sp. and *Cardisoma* sp. were only present at site 4 (Table 5). The composition and distribution of the other arthropod species at the study sites are presented in Table 5.

4.4. Diversity indices and biomonitoring indexes (BMWP score and ASPT)

The highest number of Taxa species and individuals of the aquatic arthropod species were collected in sites 3 and 4, whereas site 2 recorded the least Taxa species (10), and site 1 (20) recorded the least individual aquatic arthropod species. Site 3 (4.178) and site 4 (4.26) recorded the highest ShannonH_log2 species diversity, and site 2 (2.755) recorded relatively low species diversity (H). The BMWP scores were high for site 4 (110) and site 3 (110), and low for site 2 (4.3). ASPT was also calculated and the results are expressed in Table 6.

4.5. Correlation between physico-chemical parameters, single factor pollution index (P*i*) of the contaminants (inorganic content), bio-indicator indexes, and diversity indices

The Pearson correlation results between physico-chemical parameters, single factor pollution index of the contaminants (inorganic content), bio-indicator indexes, and diversity indices in Table 7, indicate that TDS and conductivity positively correlated significantly ($r = 0.917$, $p = 0.01$). BMWP and pollution index of sulphate (P*i*Sulphate) inversely correlated ($r = 0.917$, $p = 0.05$), but positively correlated significantly with P*i*Nitrite. Taxa species showed a positive correlation with pH ($r = 0.943$, $p = 0.05$) but inversely correlated significantly with BOD_5 ($r = 0.905$, $p = 0.05$). pH positively correlated significantly with Shannon_H species diversity ($r = 0.994$, $p = 0.05$) (Table 7). The results of the correlation of the Shannon_H species diversity with the pollution level of the contaminants (inorganic contents) are also expressed in Table 7.

5. Discussion

The physico-chemical parameters of the Idim Eye-Asana River's water were taken into consideration to evaluate the water quality. In this study, it was deduced that temperature, pH, DO, and conductivity were in the range favourable for the survival and sustainability of life of aquatic organisms. The correlation results strengthened the fact that the physico-chemical parameters and single-factor pollution index of the inorganic contents are integral parts of the test indexes for the evaluation of the biomonitoring of the water quality of a river. Thus, by the indication of the correlation

Table 5. Aquatic arthropod species composition and distribution across the study areas during the study period

S/N	Scientific names	Sampling Sites			
		1	2	3	4
1	*Arachnura* sp.	-	-	+	-
2	*Cheiracanthium* sp.	-	-	+	+
3	*Harpactea* sp.	+	+	+	+
4	*Lycosidae* sp.	-	+	+	-
5	*Pholcus* sp.	-	+	+	+
6	*Pisaura* sp.	-	-	-	+
7	*Sassacus* sp.	-	-	+	-
8	*Sibianor* sp.	-	-	-	+
9	*Tetragnatha* sp.	-	-	+	+
10	*Macrobrachium* sp.	+	-	-	+
11	*Palaemon* sp.	+	+	+	+
12	*Cardisoma* sp.	-	-	-	+
13	*Acrolophus* sp.	-	+	-	-
14	*Altica* sp.	-	-	+	-
15	*Argia* sp.	-	-	+	-
16	*Brochymena* sp.	-	-	-	+
17	*Calopteryx* sp.	-	+	+	+
18	*Charidotella* sp.	-	-	-	+
19	*Chrysochraon* sp.	+	+	+	+
20	*Chrysochus* sp.	-	-	+	-
21	*Dinoponera* sp.	-	-	-	+
22	*Ectobius* sp.	-	-	-	+
23	*Elachista* sp.	+	-	-	-
24	*Eucalantica* sp.	-	-	-	+
25	*Formica* sp.	-	-	+	-
26	*Gerris* sp.	-	-	+	-
27	*Halyomorpha* sp.	-	-	-	+
28	*Harmonia* sp.	-	+	-	+
29	*Harpalus* sp.	-	-	+	-
30	*Heteronychus* sp.	-	+	-	-
31	*Ischnura* sp.	-	-	-	+
32	*Leptocorisa* sp.	-	-	+	-
33	*Lethocerus* sp.	-	-	+	-
34	*Lymantria* sp.	-	-	+	-
35	*Musca* sp.	+	-	-	-
36	*Neobidessus* sp.	-	-	-	+
37	*Neurocordulia* sp.	+	+	+	+
38	*Notonecta* sp.	-	-	+	+
39	*Omocestus* sp.	-	+	+	-
40	*Philaenus* sp.	-	-	-	+
41	*Polysp.ilota* sp.	+	-	+	-
42	*Prionychus* sp.	-	-	-	+
43	*Procordulia* sp.	-	-	-	+
44	*Protaetia* sp.	+	-	-	-
45	*Reduvius* sp.	+	-	-	-
46	*Rhyacophila* sp.	+	-	-	+
47	*Romalea* sp.	+	-	+	+

Note: - = absent, + = present

Table 6. Diversity Indices and Biomonitoring indexes (BMWP score and ASPT) of the water quality of the Idim Eye-Asana River

Variables	Site 1	Site 2	Site 3	Site 4
Taxa Species	13	10	25	24
Individuals	20	48	91	64
Dominance_D	0.05789	0.2083	0.0779	0.07341
Simpson_1-D	0.9421	0.7917	0.9221	0.9266
ShannonH_log2	3.917	2.755	4.178	4.29
Evenness_e^H/S	1.162	0.6749	0.7241	0.8152
Menhinick	2.907	1.443	2.621	3
Margalef	4.006	2.325	5.32	5.53
Equitability_J	1.059	0.8293	0.8997	0.9357
Fisher_alpha	16.1	3.843	11.38	13.95
BMWP scores for determination of the pollution status of the river	69	43	100	110
Water quality classification	Regular – water is moderately contaminated	Poor-water quality	Good water quality	Good water quality
ASPT	5.31	4.30	4.00	4.58

results, it was revealed that as the pH level increases the taxa species richness, BMWP scores, and species diversity (ShannonH_log2) increase. This explains the reason sites 3 and 4 recorded more taxa groups and individuals of the arthropod species.

Dissolved Oxygen (DO) is an important parameter that determines the survival of aquatic organisms. The low DO values record in these results suggest high loads of inorganic pollutants discharged from the nearby settlements, which are harmful and toxic for fauna growth. The decomposition of these inorganic contents by microorganisms and inorganic pollutants r esulted in the depletion of DO at the sampling sites (Jonah et al., 2020).

The physio-chemical parameters of a water body, such as temperature, pH, and salinity can have an impact on the levels of the nutrients (Gopalkrushna, 2011). The physico-chemical parameters were relative to the nutrient levels in the study area. The high level of nitrate in Site 2 is likely relative to the highest level of temperature in that the site had an increase in temperature level, which gave rise to the rate of nitrification. This is complimentary to the high level of nitrate and nitrite in Site Two, as the reverse was the case in Site 4 for both inorganic contents` relativeness to temperature levels.

Sulphate is an important inorganic content load for aquatic arthropod species and has a significant effect on their survival and reproduction in water (Coria et al., 2007). A high level of sulphate can lead to stress and mortality, while a low level can lead to reduced growth and reproduction (Ga et al., 2000).

Phosphates are more readily soluble in water with a low pH and may increase in concentration at higher pH levels (Golterman, 2004). This was typically the case in all sites, as the pollution index of phosphate was positively significant for pH levels.

Nitrate and Phosphate had similar trends, with high concentrations in sites 2 and 4, which could be because of the discharge of minute inorganic pollutants in the sites through point and non-point sources. Wastes from nearby shores and anthropogenic activities inside the water could also contribute to the variation of the values in sites 2 and 4. Chapman (1996) reported that nitrate values up to 5 mg/L in surface water are likely influenced by human activities. On the other hand, Mandal et al. (2012) associated high phosphate values with human activities. Okorafor et al. (2014) reported that leaching of fertilizer residues from cultivated farmlands and household effluents could contribute to high concentrations of phosphate in water. The variability in physico-chemical characteristics and anthropogenic perturbations in the water body of the Idim Eye-Asana River, Edebom 1, influenced the abundance of the aquatic arthropod species (Orozco-Gonzalez and Ocasio-Porres, 2023).

The use of aquatic arthropod species as bio-indicators of the water quality of the river made it possible to determine the water quality of the river and its degree of contamination through the calculation of the indices. The results showed that the families such as Aphrophoridae, Palaemonidae, Elachistidae, Mantidae, Calopterygidae, Corduliidae, and Rhyacophilidae, with the highest abundance at the sampling sites obtained high BMWP quality scores ($\geq$ 7), indicating that their presence and abundance reflect that the water quality of the river is good and that there is a low degree of contaminants (Gutiérrez et al., 2016; Orozco-Gonzalez and Ocasio-Porres, 2023). The presence of the families Tineidae, Pholcidae, and Acrididae at sampling site 2, which had low scores ($\leq$ 3) on the BMWP score quality index, indicates that their presence and level of abundance reflect poor water quality at site 2 of the river, and this indicates a relatively high degree

Table 7. Pearson correlation results between physico-chemical parameters, single factor pollution index of the contaminants, bio-indicator indexes, and diversity indices

	Temperature	Conductivity	pH	DO	BOD5	TDS	Pi Nitrate	Pi Sulphate	Pi Nitrite	Pi Phosphate	BMWP	ASPT	Taxa species	Individuals	ShannonH	Evenness	Magalef
Temperature	1																
Conductivity	0.770	1															
pH	-0.457	-0.543	1														
DO	-0.411	-0.486	-0.463	1													
BOD5	0.179	-0.118	-0.714	0.816	1												
TDS	0.767	1.000**	-0.527	-0.502	-0.137	1											
Pi Nitrate	0.822	0.828	-0.869	0.000	0.457	0.817	1										
Pi Sulphate	0.778	0.807	-0.903*	0.062	0.491	0.796	0.997**	1									
Pi Nitrite	-0.731	-0.800	0.925*	-0.100	-0.497	-0.788	-0.990**	-0.997**	1								
Pi Phosphate	-0.640	-0.822	0.924*	-0.095	-0.418	-0.812	-0.957*	-0.972*	0.985**	1							
BMWP	-0.623	-0.504	0.950*	-0.415	-0.798	-0.488	-0.899	-0.917*	0.917*	0.863	1						
ASPT	-0.551	-0.722	-0.188	0.954*	0.710	-0.735	-0.263	-0.209	0.180	0.201	-0.179	1					
Taxa species	-0.397	-0.291	0.943*	-0.643	-0.905*	-0.273	-0.760	-0.794	0.807	0.764	0.963*	-0.427	1				
Individuals	0.201	0.326	0.617	-0.975*	-0.918*	0.343	-0.206	-0.263	0.293	0.269	0.601	-0.888	0.791	1			
shannonH_log2	-0.692	-0.774	0.944*	-0.151	-0.525	-0.762	-0.980*	-0.992**	0.998**	0.988**	0.926*	0.132	0.830	0.339	1		
Evenness_e^H/S	-0.509	-0.851	0.052	0.813	0.622	-0.860	-0.410	-0.376	0.368	0.428	-0.025	0.944*	-0.249	-0.741	0.333	1	
Margalef	-0.619	-0.593	0.977*	-0.363	-0.724	-0.578	-0.932*	-0.951*	0.958*	0.925*	0.989**	-0.102	0.942*	0.546	0.967*	0.085	1

**. Correlation is significant at the 0.01 level (1-tailed).

*. Correlation is significant at the 0.05 level (1-tailed).

of pollution at the site. These results are corroborated by the single factor pollution indices (P*i*) calculated in this study, which revealed the presence of a high concentration of nitrite, an inorganic content, at sampling site 2, marking that the water quality at the sampling site is contaminated and polluted. During the study, it was observed that the farm that is located uphill of the river system, discharged wastewater from the pig pen, fish ponds, and poultry pens into the river at the point of sampling site 2, and this further explained the high level of the inorganic content contaminants at the site.

Taxonomic abundance at each sampling site revealed that fewer taxa were recorded at site 2 than at any other site. Taxa species richness equals the total number of taxa represented within the sample, and the healthier the community is, the greater the number of taxa found within that community (Mason, 2002; Bytyçi et al., 2018). The diverse structure of aquatic arthropod species showed that the water quality of the Idim Eye-Asana River is impacted by anthropogenic activities. Comparison of communities to identify biotic disturbances or level of stability can be done with species diversity indices as useful tools (Olawusi-Peters and Ajibare, 2014), and the indices increase as the complexity or stability of the habitat increases (Leinster and Cobbold, 2012). The Shannon-Weiner diversity values recorded at all the sites were within a range that could indicate a moderately polluted environment. The index categories calculated in this study indicated that values for sampling site 2 mid values of 2 and 3, which prostrated the water quality to be moderately polluted and contaminated, while for sampling sites 1, 3, and 4, the values were > 3 and the water quality at these sites could be described as having fewer contaminants and the sections of the river could be said to be of stable environment with sustainable and survival conditions for the aquatic arthropod species inhabiting these section (Mason, 2002, Yeom and Kim, 2011, Shah and Pandit, 2013). The low diversity recorded as reflected in the community structure (Shannon-wiener, Margalef, Simpson, and Evenness indices) may be attributed to anthropogenic impacts (Anyanwu et al., 2019). The anthropogenic impacts exerted on the river may have well led to arthropod species drifting from one section of the river to another, which may eventually lead to the complete drift of the arthropod species of importance from the river to another river that is away from the village.

6. Conclusion

The use of the physico-chemical parameters, inorganic contents, and the aquatic arthropod species to calculate the single factor pollution index, diversity indices, BMWP, and ASPT to evaluate the water quality status of the river was a great success. The four (4) water quality monitoring indexes revealed that site 2 is contaminated with inorganic contents because it is the receiving point from the farm yard located uphill of the river. The effects of the direct channeling of effluents from the farm are extended to site 1. Sites 3 and 4, which are at the downstream section of the river, by the monitoring indexes results revealed that the water quality status was of good quality. As evident by the results, it could be concluded that the sites have better ecological conditions that can sustain the development and survival of the aquatic arthropod species collected during this study. Nevertheless, the river should be managed properly given its ecological importance. Also, the farm should look elsewhere to channel their effluent.

Conflict of interest

The authors declare no conflicts of interest.

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