

Abattoir and Industrial Waste impact on Abundance and Distribution of Zooplankton in New Calabar River, Choba, Nigeria

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Abstract: The abattoir and industrial waste cause a great impact on the zooplankton communities by depleting dissolved oxygen, increasing nutrient level and species abundance and distribution. This study reveals the variation in physicochemical parameters and the effect of industrial waste and industrial waste on zooplankton abundance and diversity in New Calabar River, Choba, Nigeria. The study area was located on the eastern side of the lower Niger Delta river which is about 15km from Port Harcourt and 98km long with three sampling stations- Abattoir (Station 1), indomie discharge facility (station 2), dredging (station 3) within the study location. Samples were collected once a month for six (6) months (March – May, 2015). Results obtained for the mean monthly variations of physicochemical parameter are pH 6.30 ± 0.09 - 6.80 ± 0.06 , temperature ranged between 25.00 ± 0.00 °C - 28.00 ± 1.00 °C salinity between 13.43 ± 2.11 - 17.00 ± 1.53 ppt, Total Dissolved Solids range between 17.97 ± 2.95 - 23.27 ± 0.92 mg/L, Transparency had the values (56.17 ± 1.09 m - 86.60 ± 3.10 m, phosphates ranged from 0.02 ± 0.00 mg/L - 0.11 ± 0.03 mg/L, nitrates 0.11 ± 0.02 mg/L - 0.82 ± 0.060 mg/L, Biological Oxygen Demand ranged from 20.00 ± 2.31 mg/L - 27.00 ± 1.26 mg/L and Dissolved Oxygen ranged from 2.70 ± 0.35 mg/L - 7.40 ± 0.03 mg/L. Three zooplankton phyla were recorded, they were dominated by Copepoda with the highest abundance made up of *Anomalocera patersoni*, *Temora longicornis*, *Centropages typicus*, *Calanus finmarchicus*, *Pseudocalanus elongatus*, then the Cladocera made up of *Bosmina longirostris*, *Alona affinis*, *Moina dubia*, *Trichura spp* and then the Ostracoda with the least abundance *Conchoecia spp*. The highest species diversity, richness and evenness value in Shannon-Weiner index, Specie evenness index, Margalef index and Simpson index was found in station one. It was concluded that the discharge of industrial and abattoir waste causes the disruption of water quality and abundance and distribution of zooplankton. Therefore, there should be regular monitoring of the water status.

Keywords: Abattoir, Industrial Waste, Abundance, Distribution, Zooplankton.

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I. INTRODUCTION

The aquatic ecosystems are highly sensitive to pollution, especially from anthropogenic sources which originate from multiple unrelated sources such as effluent discharge, dredging, abattoir waste and industrial sources (Ariho et al., 2025). These wastes are often rich in organic matter, blood fats and suspended solids, toxic chemicals, microbial content which can significantly alter the physicochemical properties of water bodies and the ecological balance. In Nigeria, industrial and abattoir effluents are often discharged directly into rivers without adequate treatment and its increase has caused deterioration of the river quality within Niger Delta

which has rendered these water bodies inaccessible and unable to sustain the aquatic life within the ecosystem (Akankali and Davies, 2021; Okonkwo et al., 2021). The basic effect of pollution is directly suffered by organisms that survive in the water. Some of these organisms are minute animals that might be seen either floating around or are microscopic in nature known as zooplankton (Souza-Araujo et al., 2022)

The zooplanktons are important in understanding the faunal biodiversity of the aquatic ecosystem which comprises of almost every taxonomic group of the animal kingdom and occur in the pelagic environment either as adult

(holoplankton) or eggs and larvae (meroplankton). They play an important role in the trophic relationship in the ecosystem by acting as a link in energy transfer between the phytoplankton and the higher aquatic fauna such as fishes by which they facilitate the conversion of plant material into animal tissue and also food for higher animals. Furthermore, zooplankton supports many major fisheries and chemical elements essential for life on earth (Isobo et al., 2024). For example, the larva fish survival in spawning areas can also be dependent on the sustainable densities of zooplankton species to feed upon.

Zooplankton consist of consumers from all major groups of microscopic aquatic animals as their sizes rarely exceed a millimetre (Kanam, 2024). They feed primarily on phytoplankton and are responsible regulating microbial and algal growth in aquatic ecosystem through grazing (Kigbu et al., 2015, Ovie et al., 2015) and help in energy transformation or transfer from primary producers to fish and other consumers. The zooplankton community under seasonal environmental conditions is necessary to support a healthy and productive aquatic ecosystem (Enerosisor et al., 2020). The abundance, diversity, biomass and distribution of zooplankton depends on the climatic condition, vegetation cover and physicochemical parameters and are effective to determine the strength and health of a biological system (Isobo et al., 2024). Environmental variables such as conductivity, turbidity, dissolved oxygen, flow rate and rainfall tend to cause an increase or decrease in its abundance (ukaonu et al., 2015).

They respond directly to environmental stressors and indirectly to changes in phytoplankton biomass and composition, making them effective indicators of trophic interactions and ecosystem disturbance. Furthermore, due to their sensitivity to environmental changes, these organisms are widely recognized as reliable bioindicators of water quality and ecosystem health (Jeppesen et al., 2011). Zooplankton such as copepods are filter feeders and are homeostatic in nature as they regulate their elemental composition (carbon and nitrogen ratios) adjusting to certain physiological functions and environmental conditions and their sensitivity to changes in water quality, makes them a good bio-indicators of environmental stress (pollution) and an important tool for environmental monitoring (Medina et al., 2020).

In recent decades, eutrophication due to decomposition of organic matter stimulates excessive algae growth leading to increased turbidity, reduced light penetration and decline in submerged macrophyte (Paerl et al., 2018) as well as alter the zooplankton community structure by reducing species diversity and disrupt grazing dynamics responsible for regulating algae population (Husman et al., 2018). Furthermore, sustained nutrient enrichment and organic pollution promote the proliferation of harmful algal blooms and negatively affect zooplankton, exposing them to toxins and hypoxic conditions and threatening overall ecosystem stability (Paerl et al., 2018).

The New Calabar River serves as a water body in which the Choba community and other nearby communities in Obio-Akpor LGA discharge its waste. It is also a critical habitat for a variety of aquatic organisms including zooplankton which is the foundation of the food web. Despite the ecological importance of zooplankton in maintaining water quality and supporting fish population, the lack of baseline ecological data, limits water quality management and biodiversity conservation strategies (Chukwu and Amachree, 2018).

Therefore, this study seeks to determine the effect of abattoir and Industrial discharge on the abundance of zooplankton in New Calabar River Niger Delta, Rivers state, Nigeria with the following objectives which are to;

- Evaluate the monthly variation of physicochemical parameters in water surface of the New Calabar River, Niger Delta
- Determine the species abundance of zooplankton in the New Calabar River
- Evaluate the species diversity in the New Calabar River.

II. MATERIALS AND METHODS

➤ Study Area

The study area was located on the eastern side of the lower Niger Delta river whose water body has gradual process of change from fresh to tidal brackish which is about 15km from Port Harcourt and 98km long. It is situated in Obio-Akpor Local Government Area. The river received effluents from the abattoir which is at the bank of the receiving water body with a weekly market and fishing activities at close proximity. A food production company (indomie) and dredging activities still continuous alongside other activities. The vegetation of the river is dominated by water hyacinth and some mangroves. Three stations were established which is at least 500m apart.

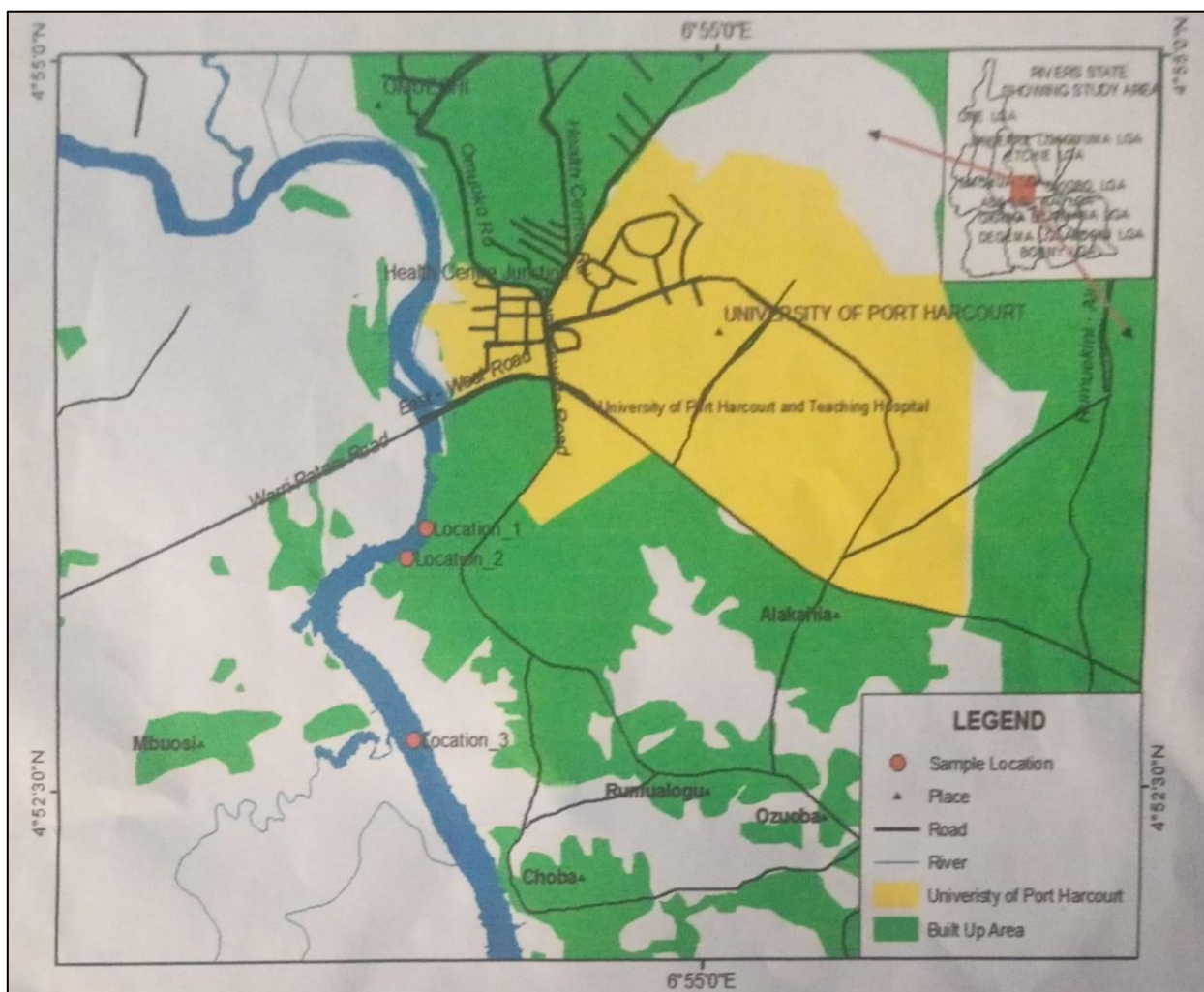


Fig 1 Map of New Calabar River with Sample Locations

➤ *Sample Collection*

Samples for physicochemical parameters (pH, temperature, salinity, Total Dissolved Solids, Electrical Conductivity, phosphates, nitrates, alkalinity, Biological Oxygen demand, and Dissolved oxygen) were collected at effluent at different stations along the upstream, midstream and downstream. Station 1- The abattoir where the farm animals were housed and slaughtered, Station 2-, Indomie discharge facility. station 3- Dredging. Sampling was done once in a month for six months (From March to August, 2023)

The sample for zooplankton were collected using plankton net of mesh size 100µm. The plankton net acts as a filter which is the most common method for the collection of zooplankton, by the filtration of a known quantity of water sample. A clean bucket of 10litres was used to collect water five times from different corners of the boat in the river and the water was filtered out. The zooplankton trapped in the cod-jar was collected in containers of 30ml and about 5ml of 2% formalin was added to preserve it. The sample solution was stained with eosin stain and kept for about 24 hours undisturbed for zooplankton to settle down. The sample were further decanted carefully until 50ml concentrated sample was achieved. The concentrated sample was properly shaken, about 1ml of the sample was collected and placed on the slide

with the help of a dropping pipette and observed under a light microscopic with the species identified with the aid of identification keys (Yamaguchi and Caitlin, 2007).

The number of zooplankton obtained was categorized into two groups: those in March and April were classified under dry season, while those in May, June, July and August, classified as wet season samples. Monthly ecological diversity of samples were determined by the following diversity indices:

- *Shannon-Wiener Diversity Index (H) (Ogbeibu, 2005)*
 Presented as:

$$H = \frac{S}{\sum P_i \ln P_i} \quad [1]$$

Where

S = The number of species in the sample and
 P_i = The proportion of individuals found in the *i*th species

The Shannon – wiener diversity index measures the importance of each species in the community.

- *Evenness (or Equitability (J) Index (E); (Ogbeibu 2005) Presented as:*

$$J = \frac{H}{H_{Max}} \quad [2]$$

The ratio of the observed diversity (H) to the maximum diversity (Hmax) was taken as a measure of the evenness According to Krebs (1989). It measures the distribution of individuals.

- *Margalef’s Species Richness Index, (d) Ogbeibu, (2005) as:*

$$d = \frac{S-1}{\ln N} \quad [3]$$

Where

S = Number of species in the sample
 ln = Natural or Napierian logarithm, and
 N = Total number of species in the sample

- *Simpson’s Dominance Index (c), (Ogbeibu, 2005):*

$$C = \frac{S}{\sum P_i^2} \quad [4]$$

i = i

Where

S = Number of species in the sample and
 P_i = The proportional abundance of the ith species

$$i. e. P_i = \frac{n_i}{N} \left(\frac{n_i}{N} \right)$$

Where = Number of Individuals in the ith species.

N = Total number of individuals for all species (ibidi)

➤ *Data Analysis*

Data was analyzed using one-way analysis of variance ANOVA, significant difference tested and significant means were separated using Duncan Multiple range. The analysis was done using IBM Statistical package for Social Sciences (SPSS) statistics 27.

III. RESULTS

➤ *Physicochemical Parameters*

The mean monthly variation during the study period is shown in Table 1. The highest recorded pH mean concentration was (6.80±0.06) and the lowest (6.30±0.09) with no significant difference (p > 0.05) across all months. The mean temperature during the period of study recorded the highest in July (28.00±1.00) and the lowest in may (25.00±0.00 °C) and there was significant difference (p < 0.05). The samples recorded for salinity did not significantly vary with the highest value (17.00±1.53) and lowest (13.43±2.11). The mean values for Total Dissolved Solids range from (23.27±0.92 and 17.97±2.95) as highest and lowest respectively. Transparency had the values (86.60±3.10 and 56.17±1.09 with significant difference (p < 0.05). The values recorded for phosphates ranges from (0.11±0.03 and 0.02±0.00) and nitrates (0.82±0.060 and 0.11±0.02 and) varies significantly (p < 0.05) across months. There is no significant difference recorded for BOD and there was significant difference in DO.

Table 1 Monthly Variation of Physicochemical Parameters of Surface Water of March 2015 – August 2015

Parameters	March± SEM	April ± SEM	May ± SEM	June ± SEM	July ± SEM	August ± SEM	p-value	Standard
pH	6.53±0.03 ^{ab}	6.80±0.06 ^b	6.70±0.1 ^b	6.70±0.58 ^b	6.67±0.14 ^b	6.37±0.09 ^a	0.053	6.5-8.5 (NESREA, 2011)
Temperature (°C)	26.00±0.00 ^{ab}	25.67±0.33 ^{ab}	25.00±0.00 ^a	27.00±0.58 ^{ab}	28.00±1.00 ^b	25.67±0.88 ^{ab}	0.027	≤38°C. (EPA, 2014)
Salinity (ppt)	13.50±1.85 ^a	13.90±1.95 ^a	13.43±2.11 ^a	14.80±2.15 ^a	17.00±1.53 ^a	15.73±1.93 ^a	0.745	NIS 554: 2015
T D S (mg/L)	17.97±2.95 ^a	18.97±3.01 ^a	18.53±3.16 ^a	18.30±3.19 ^a	18.73±3.67 ^a	23.27±0.92 ^a	0.790	500 (WHO, 2011)
Transparency	56.17±1.09 ^a	70.67±0.33 ^b	86.60±3.10 ^c	82.97±3.63 ^c	84.53±0.67 ^c	64.50±6.73 ^a	0.001	15 (WHO, 2011)
Phosphates	0.02±0.00 ^a	0.07±0.02 ^a	0.11±0.03 ^c	0.05±0.000 ^a	0.06±0.001 ^a	0.08±0.01 ^b	0.034	≤ 0.10 (EPA, 2014)
Nitrates (mg/L)	0.82±0.06 ^b	0.11±0.02 ^a	0.12±0.03 ^a	0.14±0.02 ^a	0.19±0.01 ^a	0.11±0.02 ^a	0.001	<8mg/l (EPA, 2014)
BOD (mg/L)	23.73±2.67 ^a	22.83±1.20 ^a	20.00±2.31 ^a	24.60±0.87 ^a	27.00±1.26 ^a	26.87±0.88 ^a	0.094	≤30mg/L (EPA, 2014)
DO (mg/L)	3.07±0.29 ^a	5.11±0.11 ^b	5.03±0.27 ^b	4.13±0.09 ^b	2.70±0.35 ^a	7.40±0.03 ^c	0.001	5-9 (WHO, 2011)

Means with Different Superscripts (a, b, c) within a row Differ Significantly (p < 0.05).

Note: TDS – Total Dissolved Solids, BOD- Biological Oxygen Demand, DO- Dissolved Oxygen

➤ Zooplankton

A total of ten (10) different species of zooplankton fauna was observed in New Calabar river during the period of study. Fauna belonging to three taxonomy group were identified from the three stations. They include the Copepoda, Cladocera and the Ostracoda.

The copepod has the highest number of species (18), the Cladocera (17) and the lowest number of species was recorded in ostracda (6). Variation in abundance was observed across station. A detailed presentation of zooplankton species was listed in Table 2.



Fig 3 Anomalocera Patersoni

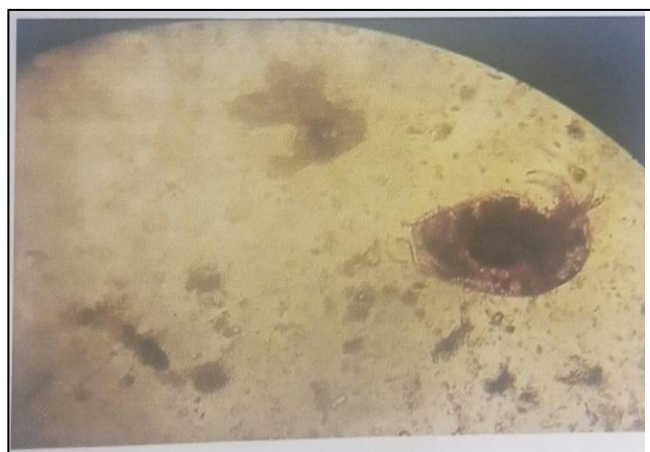


Fig 4 Alona Affinis
Source: Field Survey, 2015



Fig 2 Temora Longicornis

Table 2 Zooplankton Density Abundance at Various Stations in the New Calabar River (March, 2015 – August 2015).

Families / Species	STN 1	STN 2	STN 3	Total	% of species
COPEPODA					
<i>Anomalocera patersoni</i>	-	2	1	3	7.3
<i>Temora lungicornis</i>	-	3	-	3	7.3
<i>Centropages typicus</i>	-	-	3	3	7.3
<i>Calanus finmarchicus</i>	2	-	3	5	12.2
<i>Pseudocalanus elongatus</i>	-	2	2	4	9.9
Total	2	7	9	18	44
CLADOCERA					
<i>Bosmina longirostris</i>	-	3	-	3	7.3
<i>Alona affinis</i>	3	-	2	5	12.2
<i>Moina dubia</i>	-	5	1	6	14.6
<i>Trichura spp</i>	1	-	2	3	7.3
Total	4	8	5	17	41.4
OSTRACODA					
<i>Conchoecia spp</i>	-	6	-	6	14.6
Grand Total	6	21	14	41	100
Relative abundance (%)	14.6	51.2	34.2	100	

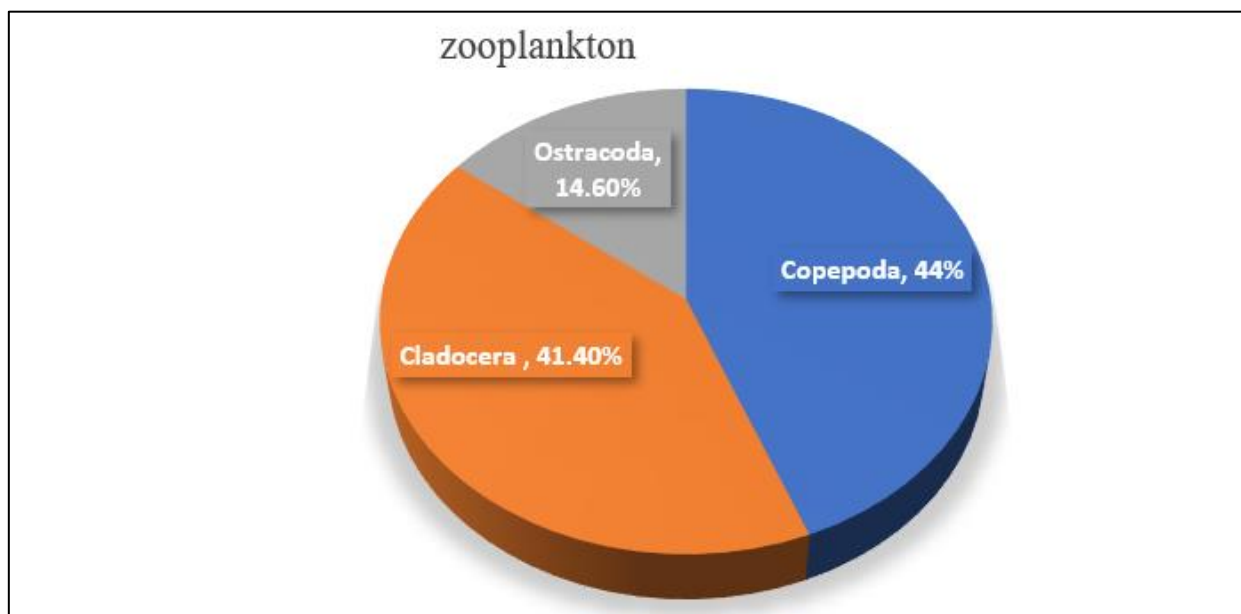


Fig 5 A Pie Chart Showing the Relative Abundance of Zooplankton

• *Seasonal Variations in Specie Occurrence*

A total of 16 species (43.24%) were observed in the wet months as against 21 species (56.76%) in the dry month shown in Table 3. The species with the highest catch in both

seasons were *Moina dubia* and *Conchoecia spp.* The least with just one (1) individual specie caught in the wet period is *Centropages typicus*, *Calanus finmarchicus*, *Bosmina longirostris*, *Cochoecia spp* while that caught in the dry period is *Pseudocalanus elongatus*, *Trichura spp.*

Table 3 Seasonal Variation of Species Abundance in New Calabar River (March – August 2015)

S/N	Species	Wet months	Dry months	Total
1.	<i>Anomalocera patersoni</i>	-	3	3
2.	<i>Temora lungicornis</i>	-	3	3
3.	<i>Centropages typicus</i>	1	2	3
4.	<i>Calanus finmarchicus</i>	1	2	3
5.	<i>Pseudocalanus elongatus</i>	3	1	4
6.	<i>Bosmina longirostris</i>	1	2	3
7.	<i>Alona affinis</i>	3	-	3
8.	<i>Moina dubia</i>	4	2	6
9.	<i>Trichura spp</i>	2	1	3
10.	<i>Conchoecia spp</i>	1	5	6
	Total no of Species	16	21	37
	Percentage (%) Composition	43.24	56.76	100

• *Zooplankton Diversity Index*

The zooplankton species indices of diversity, richness and evenness was shown on the three stations (Table 4). The

shanon weiner index ranged between 0.65 - 1.09, Species evenness ranged from 0.59 - 0.99, Margalef index was between 0.66 - 0.76 and the Simpson was between 0.93 – 1.

Table 4 Zooplankton Diversity Indices

Stations	Shannon Weiner Index (H)	Species Evenness (J)	Margalef Index (D)	Simpson's Index (D)
Station 1	1.01	0.92	1.12	1.00
Station 2	1.09	0.99	0.66	1.00
Station 3	0.65	0.59	0.76	0.93

IV. DISCUSSION

➤ *Physicochemical Parameters*

The mean value for pH in this study when compared with standards of NESREA was in the acceptable limit except at one month that it is slightly lower, this might be due to

effluents from abattoir waste. This disagrees with the findings of Edori and Nna (2018) who recorded a range of 3.43 ± 0.24 and 5.06 ± 1.42 at different locations of New Calabar River indicating the acidic level of water. The obtained temperature recorded in this study was within the threshold limit. This is in correspondence with the study conducted by Adesakin et

al. (2020) that recorded 26°C to 28°C which ensures optimal metabolic and physiological functions of aquatic organisms especially fishes and planktons but lower temperature was observed in Isiodu River water during dredging (5.81 – 13.2°C) in Niger Delta (Iyama and Edori, 2013). The salinity level recorded in this study agreed with the study reported by Iyama and Edori (2013), which can result from heavy rainfall and high tide. The obtained value of Total Dissolved Solids indicated the presence of organic and inorganic pollutant which agrees with that reported by Davies et al. (2018) in the upper reaches of Orashi River. The recorded mean value of transparency was above the acceptable standard of World Health Organization indicating high level of anthropogenic activities which can prevent light penetration (Davies et al. 2018). The obtained mean value for nitrate and phosphates were within and below the standard of USEPA. This concentration of nitrate and phosphate can prevent the concentration of algae growth for zooplankton consumption. However, an increase in both can cause eutrophication (Banerjee et al., 2022). This disagrees with the findings of Ikhuoriah & Orosanye (2016). The Biological Oxygen Demand and Dissolved Oxygen were slightly within and below the acceptable limit. This reduction might be due to high organic pollution which threaten aquatic health thereby leading to reduced growth rate of zooplankton and fish sustainability (Boyd, 2015).

➤ Zooplankton Abundance and Diversity

The obtained result for the zooplankton species abundance of the New Calabar River indicate that the zooplankton species varied both spatially and seasonally. The highest number of species (21) was recorded during the dry months compared to the wet season (16), this can be as a result of the water quality and increased salinity that result from pollution effluents from the industrial waste into the water bodies. This disagrees with the findings of Enerosisor et al., (2020) who recorded most species during the wet season and the lowest recorded during the month of March (dry season) and this increase can result from heavy rainfall.

Copepods were the most abundant with five (5) different species (*Anomalocera patersoni*, *Temora lungicornis*, *Centropages typicus*, *Calanus finmarchicus*, *Pseudocalanus elongatus*) of about 44% abundance in the New Calabar River compared to other specie family like Cladocera (41.4%) and Ostracoda (14.6%) which could be as a result of their tolerance to salinity which causes them to survive in both fresh water and brackish. The dominance of copepod in this study agrees with the findings of Sakhare and Jetithor (2021), and Ikhuoriah et al., (2015) who recorded high abundance which can be attributed to their morphological adaptations. A total of four Cladocera species namely *Bosmina longirostris*, *Alona affinis*, *Moina dubia*, *Trichura spp.*, were recorded in this study and this does not align with the study of Enerosisor et al., (2020) who recorded one specie of Cladocera which may be due to sampling time or variation in water bodies.

The specie diversity value in Shannon-Weiner index, Specie evenness index, Margalef index and Simpson index indicate a diversified species of zooplankton across stations. The high diversity, richness and moderate evenness found in

station 1 can indicate a favourable water quality and moderate nutrient levels. This agrees with report of Enerosisor et al., (2020) in Opobo town.

V. CONCLUSION

The release of abattoir and industrial waste into the New Calabar river led to the consequent effect on the water body. The obtained result on physicochemical parameters showed mean values were below and above permissible limit of surface water regulation while some were within the threshold limit. These fluctuations were caused by pollution from abattoir and industrial waste as well as waste dump from the market, thereby reducing water quality and ecological balance. The zooplankton abundance showed imbalances as some stations has more species than the other and also the seasonal variation where some species were favored by dry season while some the wet season. Also, the specie evenness, richness and diversity also varied across station which implies that, the discharge of abattoir and industrial waste causes disruption of the aquatic ecosystem.

RECOMMENDATIONS

Regular monitoring of the water body so as to determine the pollution status. The farmers and community should be enlightened on the effect of the uncontrolled use of chemical fertilizers such as nitrates, phosphates etc. that occur as a result of runoff into the water body Also, the need for further studies on the long-term discharge of abattoir waste should be done for proper monitoring of the study area.

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