Diversity of Meiofauna as Bioindicator of Water Quality in Luubara Creek, Rivers State, Nigeria

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Abstract
Meiofauna are a good indicator of water quality. The aim of this study was to evaluate the diversity of meiofauna in Luubara for three months (June and August, 2024). Four stations (1. Wiiyaakara; 2. Luubara; 3. Duburo and 4. Bane) were established along the creek. Sediment cores to a depth of approximately 10 cm were collected using a corer (2–4 cm). Sediment was analysed following the standard methods of APHA, and the organisms were identified to the species level using keys and descriptions. Species diversity of Meiofauna was calculated using Paleontological Statistics (PAST). The results showed that five phyla, nematoda (111), annelida (108), foraminifera (85), copepoda (70) and arthropoda (25) were present in the creek with nematoda as the most abundant. The presence of some notable pollution indicators such as Turbifex turbifex, Hirundo medicinalis, Capitella capitata, Lumbriculus variegatus (Mudworm) signified threat/pollution of the creek. Temporally, the highest meiofauna abundance was recorded in August (n=182) representing 45.81% while the least was in June (n=155). There were spatial variations with station 3 recording the highest meiofauna abundance representing 57.64% (n=230), followed by Station 1 (n=72; 18.05%) while the least was observed in station 2 (n=44, 24.81%). The Margalef index ranged between 5.224 (Station 2) and 6.355 (Station1) indicating high richness while Shannon weinner index ranged between 2.934 (Station 2) and 3.287(Station 3) indicating moderate pollution. Fisher alpha values ranging between 9.383 (Station 3) and 18.470 (Station 4) with high values indicates greater diversity relative to the number of species observed. Luubara creek based on the Shannon, Margalef and Menhinick indices and the presence of some pollution indicators is considered to be moderately polluted. Adequate measures should therefore be taken to ameliorate possibilities of further pollution in the area.

Keywords: *Diversity Indices, Meiofauna, Bioindicators, Water Quality, Luubara Creek*

INTRODUCTION

The diversity of meiofauna in aquatic ecosystems serves as a crucial bioindicator of water quality, particularly in freshwater environments such as Luubara Creek in Rivers State, Nigeria. Small invertebrates that live in the voids between sediment particles are part of the meiofauna, which is important for the cycling of nutrients and the general health of aquatic ecosystems. They are useful markers for evaluating the condition of aquatic environments because of their sensitivity to changes in the environment. One group of organisms that have gained attention as reliable bioindicators of water quality is the meiofauna, which are small benthic invertebrates that inhabit the sediments and substrates of aquatic ecosystems (Faccal *et al*., 2022). Meiofaunal communities are known to respond quickly to changes in environmental conditions, making them valuable tools for assessing the ecological status and water quality of aquatic habitats (Bouchet and Martins, 2023). The significance of meiofauna diversity in water quality monitoring has been emphasized by recent studies. For example, studies have demonstrated that shifts in meiofaunal populations might be a reflection of anthropogenic influences such as habitat degradation and pollution levels (González *et al.,* 2020). A water body's ecological condition can be determined by looking at the presence or absence of particular meiofaunal taxa, which can reveal information about how human activity affects aquatic ecosystems (Murray *et al.,* 2019).

In Nigeria, pollution from industrial discharges, urbanization, and agricultural runoff is posing a growing danger to freshwater habitats. Biodiversity and ecosystem services are seriously threatened by the deterioration of water quality. Hence, the importance of continual monitoring of water quality. Monitoring of water quality biologically can be known by the presence of various living things as bioindicators and one of such is meiofuana. Previous studies on meiofaunal diversity included: Buguma creek (Chukunda *et al.,* 2024), Bonny Estuary (Ideria *et al*., 2017), Bonny wetland (Chindah and Braide 2001), coastal area of Lagos (Ogunola *et al*., 2021) and Niger Delta area (Olatunde *et al.,* 2022).
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Rivers State's Luubara Creek is a significant freshwater resource that sustains a variety of aquatic species and gives local inhabitants a means of subsistence. Nevertheless, the creek is vulnerable to contamination from adjacent industrial and agricultural operations. Assessing the ecological health of Luubara Creek and developing management plans targeted at maintaining its biodiversity depend on an understanding of the meiofauna diversity found there. The purpose of this study was to assess the meiofauna's potential as a bioindicator of water quality and look into its diversity in Luubara Creek. This study will add to the expanding corpus of knowledge on freshwater ecology in Nigeria by examining meiofaunal groups and their interactions with environmental conditions. It will also offer important insights for the sustainable management of aquatic resources.

MATERIALS AND METHODS

Study Area

Luubara Creek (Fig. 1) is a significant freshwater body situated in Rivers State, Nigeria which is part of the Niger Delta region characterized by a complex network of rivers, creeks, and wetlands. The creek plays a vital role in the local ecosystem and supports a diverse range of aquatic life, including various species of fish and invertebrates. It is located on the geographical coordinates with longitude 7.0° E and latitude 4.5° N, the coordinates placing the Creek within a region influenced by both freshwater and brackish water conditions due to its proximity to the Atlantic Ocean. The creek is surrounded by a variety of land uses, including agricultural activities, residential areas, and industrial developments, which can impact its water quality and biodiversity. Luubara Creek serves as a habitat for numerous aquatic organisms, including meiofauna, which are small benthic invertebrates that inhabit the sediment. The diversity of meiofauna in this creek is indicative of the overall health of the aquatic ecosystem. Changes in meiofaunal communities can reflect alterations in water quality due to pollution or habitat degradation. The creek is susceptible to various anthropogenic pressures, including pollution from agricultural runoff, industrial waste and urbanization. These factors can lead to changes in water quality, which may adversely affect the diversity and abundance of meiofauna and other aquatic organisms. Monitoring the meiofauna in Luubara Creek can provide valuable insights into the ecological status of the water body and inform conservation efforts

Fig 1. Map showing Luubara creek

Sample Collection

To collect meiofauna from four locations in Luubara Creek, sediment samples were obtained using a coring method, where sediment cores were extracted to a depth of approximately 10 cm using a corer with a diameter of 2-4 cm. The samples were then processed in the laboratory by washing through a series of sieves (500 µm and 63 µm) to separate meiofauna from sediment particles, followed by preservation in 4% formaldehyde for identification under a microscope.

Analysis of Sample

Meiofaunal organisms were identified using a microscope, with reference to taxonomic keys and guides specific to meiofauna. Identification was conducted to the lowest possible taxonomic level, often to the genus or species level, depending on the available literature and expertise (Somerfield *et al*., 2005). Taxa richness (Margalef index), diversity (Shannon-Wiener index), evenness, Fisher-alpha and dominance indices among others were calculated using Statistical Packages for Social Sciences (SPSS) version 25.0.

RESULTS

Meiofauna Composition, Abundance and Distribution

A total of three hundred and ninety-nine individual per square (399/m^2) comprising five (5) phyla and thirty-one (31) species of meiofauna were identified (Tables 1,2 and 4). The five phyla, annelid (108), arthropods (25), copepod (70), foraminifera (85) and nematode (111) were reported from the study area (Table 1) with the phylum, nematoda having the highest abundance. *Hirudo medicinal* from the phylum, nematoda had the highest species abundance (28) just like *operculina species* from the phylum foraminifera (28) followed by *Capitella captita* (22) from the phylum annelid. Spatially, station 3 had the highest abundance representing 57.64% (230) of meiofauna, followed by station 1 representing 18.05% (72) while the least was observed in station 2 (44) (Table 1). Temporally, the highest meiofauna abundance was recorded in August (182) representing 45.81% followed by July (166) representing 41.60% of the population while the least was in June (155) (Table 2). The order of species composition in this study was Annelida> Copepoda > Nematoda > Foraminifera> Arthropoda with Annelida having the highest number of species (Table 2 and 3) while by abundance it is Nematoda>Annelida>Foraminifera> Copepoda >Arthropoda (Table 4).

Table 1: Spatial Values of Meiofauna in Luubara Creek

Taxa	S/N	Species	ST1	ST2	ST3	ST4	Total	%
Annelida	**1**	*Neresis niren* (common worm)	4	0	15	1	20	5.01
	2	*Capitella capitata* (Polychaete)	2	3	13	4	22	5.52
	3	*Lumbriculus variegatus (Mudworm*	3	1	6	1	11	2.76
	4	*Tubifex tubifex (Turbifex worm)*	3	0	9	2	14	3.51
	5	*Eisenia fetida (Red Wiggler*	1	0	2	0	3	0.75
	6	*Arenicola marina (Lugworm)*	3	1	6	0	10	2.51
	7	*Polynoe spp*.(Sea Mouse)	2	0	4	1	7	1.75
	8	*Syllis spp.*(Polychaete)	4	4	12	1	21	5.26
		Total	**22**	**9**	**67**	**10**	**108**	**21.55**
Arthropoda	**1**	*Gammarus locusta*	1	2	6	1	10	2.51
	2	*Nototropis swamidomi*	1	0	7	1	9	2.26
	3	*Orchomenalla nana*	1	0	3	2	6	1.50
		Total	**3**	**2**	**16**	**4**	**25**	**6.27**
Copepoda	**1**	*Acartia tonsa*	2	0	3	1	6	1.50
	2	*Calanus finmarchicus*	3	2	6	0	11	2.76
	3	*Pseudocalanus spp*	1	1	2	2	6	1.50
	4	*Temora longicornis*	3	0	10	2	15	3.76
	5	*Centropages typicus*	3	1	7	2	13	3.26
	6	*Eucalanus pileatus*	3	3	8	4	18	4.51
	7	*Metridia longa*	0	0	0	1	1	0.25

		Total	**15**	**7**	**36**	**12**	**70**	**17.54**
Foraminifera	**1**	*Ammonia buccanii*	2	2	7	1	12	3.01
	2	*Elpshidium spp*	4	2	7	1	14	3.51
	3	*Globigerina bulloides*	2	0	4	1	7	1.75
	4	*Textularia spp.*	3	1	6	0	10	2.51
	5	*Operculina spp.*	5	5	14	4	28	7.08
	6	*Nonion spp.*	2	0	7	5	14	3.51
		Total	**18**	**10**	**45**	**12**	**85**	**21.30**
Nematoda	**1**	*Caenorhabditis elegans*	2	2	10	2	16	4.01
	2	*Teratocephalus spp.*	1	3	9	3	16	4.01
	3	*Criconemoides spp.*	3	2	14	2	21	5.26
	4	*Rhabditis spp.*	0	2	2	0	4	1.00
	5	*Halicephalobus mephisto*	1	1	5	0	7	1.75
	6	*Glycera species*	4	3	7	5	10	2.51
	7	*Hirudo medicinalis*	3	3	19	3	24	6.02
		Total	**14**	**16**	**66**	**15**	**111**	**27.82**
		Grand Total (Spatial)	**72**	**44**	**230**	**53**	**399**	**100**
		Percentage (%)	**18.05**	**11.03**	**57.64**	**13.28**	**100.00**	

Table 2: Temporal Values of Meiofauna in the Study Area

Taxa	**S/N**	**Species**	**JUNE**	**JULY**	**AUG**	**Total**	**%**
Annelida	*1*	Neresis niren (common worm)	7	10	3	20	5.01
	2	*Capitella capitata* (Polychaete)	6	9	7	22	5.52
	3	*Lumbriculus variegatus (Mudworm*	9	0	2	11	2.76
	4	*Tubifex tubifex (Turbifex worm)*	7	3	4	14	3.51
	5	*Eisenia fetida (Red Wiggler*	0	3	0	3	0.75
	6	*Arenicola marina (Lugworm)*	3	5	2	10	2.51
	7	*Polynoe spp. (Sea Mouse)*	3	3	1	7	1.75
	8	*Syllis spp. (Polychaete)*	7	7	7	21	5.26
		Total	**42**	**40**	**26**	**108**	**21.55**
Arthropoda	*1*	*Gammarus locusta*	5	3	2	10	2.51
	2	*Nototropis swamidomi*	4	1	4	9	2.26
	3	*Orchomenalla nana*	4	1	1	6	1.50
		Total	**13**	**5**	**7**	**25**	**6.27**
Copepoda	*1*	*Acartia tonsa*	1	3	2	6	1.50
	2	*Calanus finmarchicus*	5	4	2	11	2.76
	3	*Pseudocalanus spp*	3	1	2	6	1.50
	4	*Temora longicornis*	5	4	6	15	3.76
	5	*Centropages typicus*	7	4	2	13	3.26

	6	*Eucalanus pileatus*	8	4	6	18	4.51
	7	*Metridia longa*	1	0	0	1	0.25
		Total	**30**	**20**	**20**	**70**	**17.54**
Foraminifera	*1*	*Ammonia buccanii*	3	4	5	12	3.01
	2	*Elpshidium spp*	2	3	9	14	3.51
	3	*Globigerina bulloides*	2	2	3	7	1.75
	4	*Textularia spp.*	7	2	1	10	2.51
	5	*Operculina spp.*	13	2	13	28	7.08
	6	*Nonion spp.*	4	4	6	14	3.51
		Total	**43**	**25**	**27**	**95**	**21.30**
Nematoda	*1*	*Caenorhabditis elegans*	8	4	4	16	4.01
	2	*Teratocephalus spp.*	5	6	5	16	4.01
	3	*Criconemoides spp.*	4	9	8	21	5.26
	4	*Rhabditis spp.*	0	0	4	4	1.00
	5	*Halicephalobus mephisto*	4	1	2	7	1.75
	6	*Glycera species*	6	6	7	19	2.51
	7	*Hirudo medicinalis*	12	8	8	28	6.02
		Total	**22**	**76**	**102**	**200**	**27.82**
		Grand Total	**150**	**166**	**182**	**399**	**100**
		Percentage (Temporal)	**37.60**	**41.60**	**45.61**	**100.00**	

Table 3: Percentage Composition of Meiofauna by Station in the Study Area

Station	Frequency	Percentage	Order of Abundance
1	72	18.05	2nd
2	44	11.03	4th
3	230	57.64	1st
4	53	13.28	3rd
Total	**399**	**100.00**	

Table 4: Percentage Composition of Meiofauna by Taxa /Phylum in the Study Area

S/N	Taxa/Phylum	Frequency	Percentage	Order of Abundance
1	Annelida	108	27.07	2nd
2	Arthropoda	25	6.27	5th
3	Copepoda	70	17.54	3rd
4	Foraminfera	85	21.30	4th
5	Nematoda	111	27.52	1st
	Total	**399**	**100.00**	

Table 5 showed the spatial values of diversity indices of meiofauna in the study area. Dominance index showed low values with the range of 0.041-0.059. Simpson index value was highest in station 3(0.958) and lowest in station 2(0.942). The Menhinick index ranged between 0.976 (Station 3) and 3.444 (Station 4). Margalef index ranged between 5.224 (Station 2) and

6.355 (Station1) while Shannon weinner index ranged between 2.934 (Station 2) and 3.287 (Station 3). The value of evenness index was highest in Station 1 (0.900) with stations 2-3 slightly uniform indicating high/perfect evenness. Brillouin index was highest in Station 3(3.065) but lowest in Station 2 (2.402) with slight uniform distribution. Menhinick index value was highest in station 1(3.347) but lowest in Station 3(0.976). Equitability index ranged between 0.947(Station 4) and 0.968 (Station 1). Fisher alpha values ranged between 9.383(Station 3) and 18.470(Station 4) with high values indicating greater diversity relative to the number of species observed. Berger-Parker values ranged between 0.071(Station 1) and 0.109 (Station 2) with the low values here indicating no single species is overly dominant in the community while Chao-1 ranged from Station 2 to Station 4 (Table 5).

Table 5: Spatial Values of Diversity Indices of Meiofauna in the Study Area

	S1	S2	S3	S4
Taxa_S	28	21	31	26
Individuals	72	44	230	53
Dominance_D	0.043	0.059	0.042	0.053
Simpson_1-D	0.957	0.941	0.958	0.947
Shannon_H	3.227	2.934	3.287	3.086
Evenness_e^H/S	0.900	0.895	0.864	0.841
Brillouin	2.727	2.402	3.065	2.556
Menhinick	3.347	3.096	0.976	3.444
Margalef	6.355	5.224	5.449	6.183
Equitability_J	0.968	0.964	0.9573	0.947
Fisher_alpha	17.300	14.930	9.383	18.470
Berger-Parker	0.071	0.109	0.077	0.088
Chao-1	31.00	22.670	31.00	32.880

Key: 1,2,3,4 are sampling Stations

DISCUSSION

Meiofauna, which are small benthic invertebrates typically ranging from 45 to 500 micrometers in size, play a crucial role in aquatic ecosystems and serve as effective bioindicators of water pollution. Their sensitivity to environmental changes makes them valuable for assessing the health of marine and freshwater habitats. Meiofauna are also known to be important organisms in any aquatic ecosystem since they form a link between producer and consumer and are also considered as metabolically important members of benthic ecosystem as in Chukunda *et al*. (2024). According to Zeppilli *et al*. (2015) and Pusceddu *et al*, (2014), meiofauna activities are known to modify series of physical chemical are biological properties of sediment.

This result is contrary to the finding of Alagoa *et al.* (2017) who reported total number of 16 species from 6 families of meiofauna predominantly made up of the families Linhomoeidae (2.25 – 32.14%) of the entire population, followed by Desmodoridae (14.61–28.57%) and Leptosomatidae (13.48 – 17.86%). This finding is also contrary to the 2 phyla and 16 species of meiofauna reported by Chukunda *et al*. (2024) from Buguma mangrove forest, Rivers State and the sixteen specie from 6 families reported by Ideria *et al.* (2017) from the lower Bonny estuary, Rivers State. It is also contrary to the twenty (20) species reported from the Tombia segment of the New Calabar river by Beulah(2023). The observed large/high spatio-temporal variations in meiofauna may also be as a result of changes in food supply correlations between any of the indicators and the concentrations of total protein, which represent the fraction of organic matter available for these benthic consumers (Vezzulli and Fabiano, 2006).

The presence of sensitive or tolerant meiofaunal taxa and nematode genera in this study appears to be particularly informative in highlighting the state of sediment pollution and allows the use of other tools of assessment of the spatial heterogeneity of environmental disturbance within the estuary. The presence of some notable pollution indicators such as *Turbifex turbifex, Hirundo medicinalis, Capitella capitata, Lumbriculus variegatus* (Mudworm) and among others signified threat/pollution in the study area (Ugwumba and Esenowo,2020). Ajao and Fagade (1990) reported species that are characteristic of stressed environments as *Capitella capitata* (Fabricius, 1780), *Nereis pelagica* (Linnaeus, 1758) and *Polydora cornuta* (Bosc, 1802).

The observed low abundance of meiofauna in Stations 2 and 4 compared to the higher numbers in Stations 1 and 3 in this study could be attributed to difference in anthropogenic activities and rainwater that carried organic and inorganic pollutants in the downstream area to respective Stations. Hence, the spatio-temporal variation with high abundance of meiofuana in station 3 than other stations could be attributed to favourable environmental condition in the area. Ajao and Fagade (2002) also reported declines in the abundance and distribution of benthic fauna, and through the food webs negative effects on fish caused by pollution effects from anthropogenic inputs.

This finding is in line with Werorilangi (2014) which states that anthropogenic activity is also a contributor to the hazardous pollutants in the northern and southern parts of Makassar City because it can create bioavailable fractions in the bottom sediment, i.e., the habitat of various marine organisms. Variation in abundance of meiofauna could be attributed to the assertion by Essien-Ibok *et al.* (2019) and Ekpo and Essien (2016) that variation in meiofauna abundance on different surfaces could be attributed to increased organic matter and detrital food sources, structural complexity, habited predation pressure and enhanced oxygen availability.

According to De-Hog *et al.* (2000) and Otene *et al*.,(2020) diversity index is seen to be a quantitative measure reflecting how many different species in a data set can be simultaneously taken into account how evenly the basic entities (such as individual) are distributed among the inadequate environment to assess ecosystem health (Chiu *et al.,* 2011). The observed slight variations in diversity in this study between the Stations could be attributed to the nature of anthropogenic activities in the respective locations. The observed consistently high Simpson and low dominance indices in this study signified a balanced, stable and healthy ecosystem with high level of biodiversity (community has a rich diversity of species) where no single species dominate but with all values high across the stations suggesting a diverse community with many species present (Ashwani *et al*.,2019, Nathan *et a*l., 2024). High biodiversity enhances ecosystem resilience, allowing organisms to better withstand environmental changes and disturbances (Kitikidou *et al*.,2024)

According to Otene *et al* (2019), Ansa *et al.,(*2022) and Ravera (2001) ecological indices such as Margalef and Menhinick measure the richness of species in an ecosystem while Shannon wiener index measures entropy. Fluctuation in values of indices such as Margalef, Menhinick and Shannon across the stations in this study could be attributed to fluctuation in number of species as confirmed by Ravera (2001) and Otene *et al* (2019). The consistently higher values of Margalef and Menhinick index in stations 3 and 2 in this study could be due to high level of meiofauna population and pollution resulting from degradation from anthropogenic activities in the area. Shannon diversity index in this study showed characteristics of moderate pollution as opined by Otene *et al*.,(2020) that values of Shannon diversity index greater than 3 indicates clean water, range of 1-3 are characterized by moderate pollution while values less than one (< 1) are characterized as heavily polluted. The high equitability/ evenness indices across the stations indicate a balanced distribution of species where no single species dominates the community with uniformity in distribution. The observed consistently low Berger-Parker index in this study indicates no single species is overly dominant in the community.

CONCLUSION/RECOMMENDATION

Based on the results of this study the presence of some notable pollution indicators such as *Turbifex turbifex, Hirundo medicinalis, Capitella capitata, Lumbriculus variegatus* (Mudworm) and among others and the range of values of Shannon, Margalef and Menhinick indices in the area signified threat/ moderate pollution. Therefore, adequate measures should be taken to ameliorate possibilities of further pollution in the area.

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