PRINT ISSN 1119-8362
Electronic ISSN 2659-1499

Full-text Available Online at
https://www.ajol.info/index.php/jasem
https://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 29 (5) 1512-1521 May 2025

Assessment of Physicochemical Characteristics and subtidal benthic macroinvertebrate communities in Luubara Creek and New Calabar River, situated in the Niger Delta region of Nigeria

[1*]NWIBANI, BH; [1]OLAGBEMIRO, TO; [1]BOB-MANUEL, KNO; [2]UYI, H

*[1]*Department of Animal and Environmental Biology, Rivers State University, Nkpolu-Oroworukwo, Port-Harcourt, Rivers State, Nigeria*
[2]*Institute of Pollution Studies, Rivers State University, Nkpolu-Oroworukwo, Port-Harcourt, Rivers State, Nigeria*

**Corresponding Author Email: bariesuador@gmail.com*
**ORCID ID: http://orcid.org/0009-0000-0222-6212*
**Tel: +2348121425347*

Co-Authors Email: theresaolagbemiro@gmail.com; bob-manuel.karibi@ust.edu.ng; hansonuyi@gmail.com

ABSTRACT: The objective of this paper was to assess the Physicochemical Characteristics and subtidal benthic macroinvertebrate communities in Luubara Creek and New Calabar River, situated in the Niger Delta region of Nigeria using appropriate standard procedures. In Luubara Creek, the physicochemical values ranged from 25.1±0.1 to 29.2±0.15 ºC for temperature, 5.26±0.02 to 6.65±0.02 for pH, 3.95±0.06 to 5.02±0.02 mg/l for dissolved oxygen, 0.44±0.01 to 1.23±0.02 mg/l for salinity, 16.5±0.07 to 20.7±0.03 µS/cm for electrical conductivity, 0.23±0.01 to 1.61±0.06 mg/l for nitrate, 0.21±0.02 to 0.75±0.03 mg/l for phosphate and 122.8±1.21 to 210.9±1.03 mg/l for total dissolved solids values. Similarly, in New Calabar River the physicochemical values ranged from 26.9±0.15 to 33.4±1.85 ºC for temperature, 6.79±0.02 to 7.33±0.04 for pH, 3.91±0.03 to 4.53±0.38 mg/l for dissolved oxygen, 0.51±0.02 to 1.14±0.01 mg/l for salinity, 19.8±0.12 to 26.9±0.06 µS/cm for electrical conductivity, 1.62±0.04 to 3.62±0.04 mg/l for nitrate, 0.36±0.02 to 0.58±0.02 mg/l for phosphate and 126.7±1.13 to 236.5±2.52 mg/l for total dissolved solids values. Benthic macroinvertebrate communities in Luubara Creek were dominated by Thiaridae, Sesarmidae, and Chironomidae, while New Calabar River showed dominance by Neridiidae, Capitellidae, and Spionidae. These findings suggest relatively low diversity in these water bodies, which is consistent with observations in the Niger Delta region. This study shows importance of assessing water quality using biological indicators.

DOI: https://dx.doi.org/10.4314/jasem.v29i5.16

Cite this Article as: NWIBANI, B. H; OLAGBEMIRO, T. O; BOB-MANUEL, KNO; UYI, H (2025) Assessment of Physicochemical Characteristics and subtidal benthic macroinvertebrate communities in Luubara Creek and New Calabar River, situated in the Niger Delta region of Nigeria. *J. Appl. Sci. Environ. Manage.* 29 (5) 1512-1521

Dates: Received: 12 March 2025; Revised: 19 April 2025; Accepted: 22 April 2025; Published: May 2025

Keywords: benthic; water quality; physicochemical; subtidal; macroinvertebrates

Water is a substance that can never be underestimated as it covers 70% of the earth surface (ironically the earth is called earth instead of water), this is the basis of organic life. The ecosystem depends on the resources that water provides because it ensures the continuation of life and generates economic benefits for human development (for waste management, provision of food, electricity, etc.). The diversity of aquatic habitats has decreased as a result of these anthropogenic changes, and water quality has varied (Abiola *et al*., 2023). This puts at risk aquatic life that depends on aquatic vegetation for refuge and food, such as benthic macroinvertebrates. A threat to the biodiversity of the organisms present in these environments is posed by the increased dredging of inland waters and the filling of these bodies of water with solid and liquid wastes from home and industrial usage. The application of

**Corresponding Author Email: bariesuador@gmail.com*
**ORCID ID: http://orcid.org/0009-0000-0222-6212*
**Tel: +2348121425347*

biological indicators, for instance, allows one to assess the level of pollution by counting the individual organisms in rivers. Changes in land use, such as agricultural intensification and pressure from humans, can significantly change its biodiversity and composition (Zaghloul *et al.*, 2020). Macroinvertebrates can provide information on the water quality by their existence or absence, their behaviour or their disappearance, and their susceptibility to a variety of disturbance types (Gabriels *et al.*, 2010). To accurately quantify the gradients of natural and human disturbance's effects on macroinvertebrate populations, this knowledge is essential. In addition, biological indicators are being used in environmental laws to monitor, regulate, and preserve freshwater environments to determine the state of these ecosystems (Edegbene *et al.*, 2021).

Among various biological indicators, macroinvertebrates have proven to be highly effective and cost-efficient in assessing water quality (Akindele and Olutona, 2015). Unlike other species, macroinvertebrates are widely distributed, particularly sensitive to organic contaminants, and easily sampled, making them ideal candidates for biological monitoring. Numerous studies on macrobenthos have been conducted in creeks like the Bonny estuary and Sombreiro River system (Wokoma and Umesi, 2017; Ezekiel *et al*., 2011; Daka *et al*., 2018). However, the existing literature on Luubara Creek is limited to only one study by Deekae *et al*. (2010a), which focused on certain physical and chemical parameters.

Although the studies have contributed valuable insights, they may suffer from some limitations. First, the focus on solely physical and chemical parameters in the study by Deekae *et al*. (2010a) overlooks the crucial biological aspect of water quality assessment. Hence, the objective of this paper was to assess the Physicochemical Characteristics and subtidal benthic macroinvertebrate communities in Luubara Creek and New Calabar River, situated in the Niger Delta region of Nigeria.

MATERIALS AND METHODS

Study Area: Luubara Creek: The study area is the Middle to lower reach of the Luubara creek in Khana Local Government Area as shown in Fig. 1. The Luubara Creek lies between longitudes 7°24'37.16" E – 7°31'03.77" E and latitudes 4°40'45.14" N – 4°39'56.56" N (Table 1) in Khana, Local Government Area, Rivers State, Nigeria, in the coastal area of the eastern arm of the Niger Delta and empties into the Imo River enroute the Atlantic Ocean. The source of the creek is at Kor Kor, where the surface water is fresh and at Bane the creek's mouth it is brackish and tidal. Kor Kor is the upstream part of the river where the river is fresh and tidal (Deekae *et al*., 2010a). Luubara Creek is among the important water resources in the Niger Delta region of Southern Nigeria. Most communities within this area are directly dependent on the creek for their agricultural, recreational, and sometimes, domestic water supplies. Fishing is one of the major activities going on along the creek because it ~~is~~ serves as the main water channel.

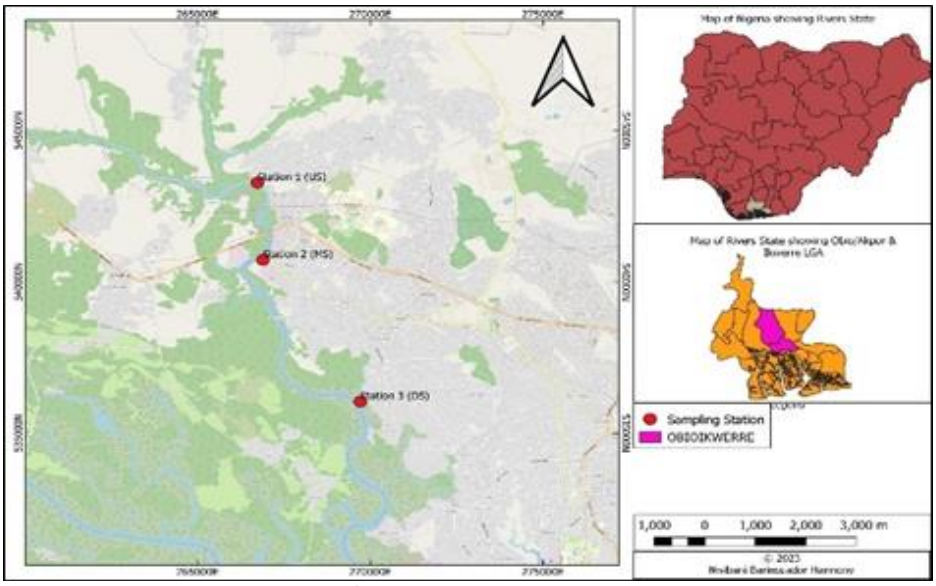

Fig. 1: Map of sampling stations along Luubara Creek.

New Calabar River: The study area is the upper reach of the New Calabar River as shown in Fig. 2. The New Calabar River lies between longitude 6º 53' 53.086" E and latitude 04º 53' 19.020" N in Choba, Rivers State, Nigeria. The entire river course is situated between longitude 7º 60'E and latitude 5º 45'N (Table 1) in the coastal area of the Niger Delta and empties into the Atlantic Ocean at Bakana where it is brackish and tidal. The source of this river is at Elele-Alimini where it is fresh water (Dienye and Woke, 2015) located in Rivers State, Nigeria. Most communities (Bakana, Elele-Alimini, Choba, Ogbogoro, Aluu, Rumuepirikom, Old Bakana, etc.) within this area are directly dependent on the river for their agricultural, recreational, and sometimes, domestic water supplies. The river is subjected to effluent discharge from Industries sited along its banks. Also, surface run-off resulting from soil erosion, lumbering activities, forestry operations, dredging activities, and domestic sewage inputs may lead to wide-scale contamination of the river.

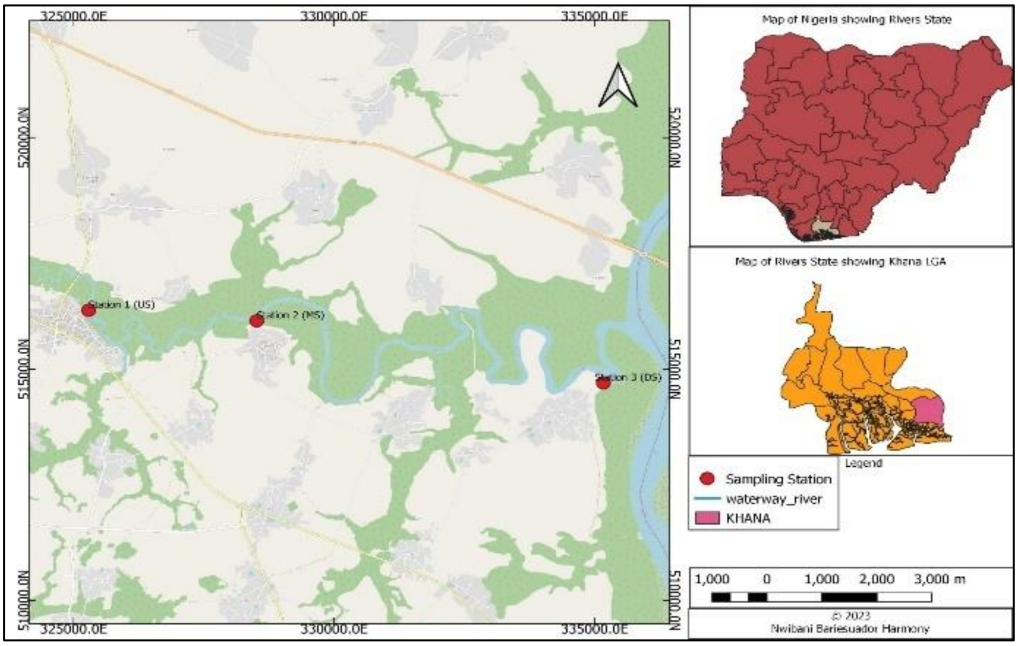

Fig. 2: Map of sampling stations along New Calabar River.

Table 1: Stations and co-ordinates.

S/N	Study Area	Sampling Stations	Coordinate	Description
1	Luubara Creek	LB 1 (Upstream)	4°40'8.39"N 7°25'29.64"E	Wiiyakara, Under the bridge (new construction ongoing), coarse sediments.
2		LB 2 (Midstream)	4°40'1.20"N 7°27'14.40"E	Luubara, wood chips visible in the sediment.
3		LB 3 (Downstream)	4°39'18.00"N 7°30'50.40"E	Bane, muddy black sediment, and mangrove plants are visible.
4	New Calabar River	NK 1 (Upstream)	4°54'42.49"N 6°53'47.53"E	Umuochi, Aluu, close to African Regional Aquaculture Centre (ARAC).
5		NK 2 (Midstream)	4°53'19.49"N 6°53'53.06"E	Located at the Choba market, Abattoir is located close to the river.
6		NK 3 (Downstream)	4°50'47.22"N 6°55'24.81"E	Located in the Ogbogoro area, dredging, activities are visible, and municipal runoff is direct to the river.

Collection of Samples: Surface water samples were collected in triplicates in one-litre plastic capacity bottles, from each sampling station, and were kept in a water cooler before analyses. Each sample collected was used for the determination of physicochemical parameters. Temperature, pH, transparency, electrical conductivity, and total dissolved solids were determined in situ using the PC60 premium multiparameter while Nitrate and Phosphate were determined using the APHA (2012) procedure in the Wet Chemistry Laboratory of Institute of Petroleum Studies, Rivers State University.

Benthic Macrofauna Analyses: Sub-tidal benthic samples for the analysis of benthos were collected bimonthly in triplicates, using an Ekman grab (152×152×152 mm) from each station. The remaining benthic samples were gently washed through a sieve of 1mm x 1mm mesh size to collect the sample. The sieved sample was poured into a wide mouth labelled 250ml plastic container and preserved with a 10% formalin against the volume of the sample to which a 0.1% strength of Rose Bengal (dye) was added (Udeme *et al.*, 2020). The preserved samples were later taken to the laboratory for sorting and identification to the lowest taxonomic group using the key of Days (1967). All the sorted organism was placed in labelled containers and preserved in 70% ethanol.

Measurement of Physicochemical Characteristics: Temperature, pH, salinity, Dissolved oxygen, electrical conductivity, and total dissolved solids were analysed in-situ using an in-situ using portable metre (PC60 Premium multiparameter). Nitrate and phosphate were analysed using standard procedures (APHA, 2012).

Statistical Analyses: Data collected for the surface water physicochemical parameters and macrobenthos were subjected to statistical analysis using Analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT) analyses were carried out to show the significance of physicochemical variables means at a 5% significance level, to determine their variations at stations and months. Permutations. A t-test was used to compare the physicochemical parameter of the study areas wet and dry season at a 5% significance level. The correlation depending on Cannonical Component Analysis (CCA) between physicochemical and macrobenthos was conducted. All analyses were done with Microsoft Excel, SPSS 25 and Past 4.03 software.

Diversity indices such as Shannon-Weiner Diversity Index expressed as in equation 1 (Shannon and Weiner, 1963):

$$Hs = \sum \frac{Ni}{N} \log_2 \frac{Ni}{N} \quad (1)$$

Where Hs = Shannon-Weiner index, N = total number of individuals in the sample and Ni = the number of individuals of species in the sample.

Margalef Richness Index calculated as in equation 2 (Margalef, 1967):

$$D = \frac{S-1}{\log_e N} \, (2)$$

Where D = Margalef value, S = number of species collected and N = total number of individuals in the sample.

Simpson's Diversity index calculated as in equation 3:

$$D = 1 - \frac{\sum n(n-1)}{\mathrm{N}(N-1)} \quad (3)$$

Where n = total number of macrobenthos of a particular order and N = total number of macrobenthos of all orders. D = measure of dominance

Evenness calculated as in equation 4:

$$Eveness = \frac{Hs}{LnS} \quad (4)$$

Where Hs = Shannon-Weiner Diversity Index. LnS is a natural logarithm of a number of species.

Sørenson calculated as in equation 2:

$$CC = \frac{2C}{(a+b+2c)} \quad (5)$$

Where CC = Sørenson Similarity Index. a and b = number of species in samples A and B, respectively and C = number of species shared by the two samples.

RESULTS AND DISCUSSION

Physicochemical parameters in the study areas: The analysis of variance (ANOVA) results showed that the mean values for physicochemical parameters among stations in each month differed significantly ($p < 0.05$) while the student t-test, the means for wet and dry seasons for the stations were significantly different ($p < 0.05$). In Luubara Creek, the temperature values range from 25.1±0.1 to 29.2±0.15 ºC and in New Calabar River it ranged from 26.9±0.15 to 33.4±1.85 ºC. The pH values obtained from Luubara Creek ranged from 5.26±0.02 to 6.65±0.02 and in New Calabar River from 6.79±0.02 to 7.33±0.04. The dissolved oxygen values ranged from 3.95±0.06 to 5.02±0.02 mg/l for Luubara Creek, and in New Calabar River it ranged from 3.91±0.03 to 4.53±0.38 mg/l. The salinity values ranged from 0.44±0.01 to 1.23±0.02 mg/l for Luubara Creek, and in New Calabar River it ranged from 0.51±0.02 to 1.14±0.01 mg/l. The electrical conductivity values ranged from 16.5±0.07 to 20.7±0.03 µS/cm for Luubara Creek, and from 19.8±0.12 to 26.9±0.06 µS/cm in New Calabar River. The nitrate values ranged from 0.23±0.01 to 1.61±0.06 mg/l for Luubara Creek, and in New Calabar River it ranged from 1.62±0.04 to 3.62±0.04 mg/l. The phosphate values ranged from 0.21±0.02 to 0.75±0.03 mg/l for Luubara Creek, and in New Calabar River it ranged from 0.36±0.02 to 0.58±0.02 mg/l. The total dissolved solids values ranged from 122.8±1.21 to 210.9±1.03 mg/l for Luubara Creek, and in New Calabar River it ranged from 126.7±1.13 to 236.5±2.52 mg/l. The physicochemical parameters in relation to the sampling period for Luubara Creek and New Calabar River are presented in Table 2 and Table 3.

Table 2: Mean variation of physicochemical parameters in Luubara Creek.

Month	Station	°C	pH	DO (mg/l)	Salinity (mg/l)	EC (µS/cm)	Nitrate (mg/l)	Phosphate (mg/l)	TDS (mg/l)
	LB1 (US)	28.1±0.25a	6.63±0.02a	4.61±0.02b	0.46±0.02c	16.9±0.15c	0.65±0.03c	0.46±0.02c	125.8±1.17c
Jun-22	LB2 (MS)	27.2±0.1b	6.63±0.02a	4.84±0.03a	0.51±0.02b	18.1±0.15b	0.83±0.04b	0.61±0.03b	136.5±0.81b
	LB3 (DS)	26.1±0.25c	6.59±0.01b	4.57±0.03b	0.97±0.02a	19.3±0.17a	1.61±0.06a	0.66±0.02a	210.9±1.03a
	LB1 (US)	26.5±0.1a	6.2±0.1c	4.7±0.1b	0.5±0.01c	17.5±0.03c	0.45±0.02c	0.47±0.06b	141.2±0.09c
Sep-22	LB2 (MS)	26.6±0.01a	6.61±0.01a	5.02±0.02a	0.53±0.02b	19±0.02b	0.64±0.02b	0.5±0.02b	156±0.3b
	LB3 (DS)	25.1±0.1b	6.32±0.01b	4.37±0.06c	1.01±0.01a	20.7±0.03a	0.83±0.02a	0.75±0.03a	198.9±0.1a
	LB1 (US)	29.8±0.21a	6.84±0.1a	4.06±0.05b	0.5±0.02c	17±0.42c	0.34±0.01b	0.21±0.02c	123.8±1.31c
Dec-22	LB2 (MS)	28.4±0.21c	5.54±0.09b	4.82±0.01a	0.58±0.01b	17.8±0.01b	0.23±0.01c	0.33±0.01b	133.1±0.52b
	LB3 (DS)	29.2±0.15b	5.26±0.02c	3.95±0.06c	1.23±0.02a	19.6±0.04a	0.57±0.01a	0.38±0.02a	188.8±1.4a
	LB1 (US)	27.8±0.35a	6.64±0.03a	4.77±0.03b	0.46±0.04b	16.8±0.45c	0.64±0.07c	0.44±0.02c	123.2±2.27c
Mar-23	LB2 (MS)	27.2±0.21b	6.65±0.02a	5±0.09a	0.49±0.01b	17.8±0.16b	0.82±0.03b	0.59±0.03b	133.3±1.21b
	LB3 (DS)	25.9±0.2c	6.6±0.02a	4.77±0.05b	0.94±0.04a	18.9±0.27a	1.56±0.06a	0.65±0.03a	205.7±3.64a
	LB1 (US)	27.8±0.15c	6.64±0.01c	4.81±0.02b	0.44±0.01c	16.5±0.07c	0.61±0.01c	0.44±0.01c	122.8±1.21c
Jun-23	LB2 (MS)	27.1±0.12b	6.62±0b	5.01±0.02a	0.47±0.02b	17.7±0.03b	0.8±0.01b	0.58±0.01b	132.6±0.77b
	LB3 (DS)	25.9±0.1a	6.59±0.01a	4.77±0.02c	0.94±0.01a	19±0.04a	1.57±0.02a	0.65±0.01a	204±1.21a

Levels not connected by same letter are significantly study based on Duncan Multiple Range Test (DMRT) post-hoc.

Table 3: Mean variation of physicochemical parameters in New Calabar River.

Month	Station	°C	pH	DO (mg/l)	Salinity (mg/l)	EC (µS/cm)	Nitrate (mg/l)	Phosphate (mg/l)	TDS (mg/l)
	NK1 (US)	27.4±0.21b	7.35±0.13a	4.5±0.1a	0.53±0.02c	22.6±0.17b	2.47±0.15b	0.51±0.01a	126.7±1.13c
Jun-22	NK2 (MS)	26.9±0.15c	7.09±0.04b	4.2±0.1b	0.68±0.01b	20.4±0.2c	3.62±0.04a	0.36±0.02c	168±0.04b
	NK3 (DS)	28±0.1a	6.98±0.01b	4.1±0.1b	1.09±0.01a	25.6±0.11a	1.62±0.04c	0.41±0.02b	234.6±0.65a
	NK1 (US)	28.1±0.1a	7.53±0.02a	4.8±0.1a	0.51±0.02c	19.9±0.09c	2.62±0.03b	0.63±0.01a	133.7±0.27c
Sep-22	NK2 (MS)	27.5±0.2a	7.13±0.02b	4.37±0.15b	0.76±0.01b	24.5±1.81b	3.41±0.04a	0.53±0.02c	172.5±0.57b
	NK3 (DS)	20.6±0.31a	6.79±0.02c	3.91±0.03c	1.02±0.01a	26.9±0.06a	2.11±0.04c	0.58±0.02b	223.9±0.21a
	NK1 (US)	28.5±0.15b	7.64±0.02a	4.6±0.1a	0.52±0.01c	20±0.04b	2.6±0.02b	0.61±0.01a	128.9±0.23c
Dec-22	NK2 (MS)	29.1±0.1b	7.33±0.04b	4.2±0.1b	0.77±0.01b	20.1±0.07b	3.34±0.03a	0.49±0.02c	166.9±0.35b
	NK3 (DS)	33.4±1.85a	6.94±0.02c	3.98±0.02c	1.05±0.02a	26.8±0.08a	1.85±0.01c	0.53±0.01b	215.7±0.62a
	NK1 (US)	29±0.15c	7.54±0.02a	4.73±0.15a	0.54±0.02c	19.9±0.11c	2.68±0.03b	0.61±0.02a	130.6±0.57c
Mar-23	NK2 (MS)	29.7±0.21b	7.15±0.03b	4.43±0.15b	0.79±0.02b	22±0.17b	3.5±0.03a	0.47±0.02c	168.5±1.04b
	NK3 (DS)	31.1±0.4a	6.89±0.05c	4.13±0.06c	1.11±0.01a	25.8±0.14a	1.9±0.05c	0.5±0.01b	223.4±3.32a
	NK1 (US)	29.8±0.25b	7.57±0.01a	4.97±0.15b	0.56±0.01c	19.8±0.12c	2.78±0.02b	0.66±0.03a	132.3±0.5c
Jun-23	NK2 (MS)	30.4±0.36b	7.22±0.02b	4.53±0.38b	0.84±0.01b	22.7±0.13b	3.58±0.01a	0.5±0.01c	172.6±1.54b
	NK3 (DS)	32±0.81a	6.92±0.01c	4.3±0.17a	1.14±0.01a	26.6±1.21a	2.03±0.01c	0.54±0b	236.5±2.52a

Levels not connected by same letter are significantly study based on Duncan Multiple Range Test (DMRT) post-hoc.

The temperature (25.1±0.1 to 29.2±0.15 ºC for Luubara Creek and 26.9±0.15 to 33.4±1.85 ºC for New Calabar River) and pH values (5.26±0.02 to 6.65±0.02 for Luubara Creek and 6.79±0.02 to 7.33±0.04 for New Calabar River) obtained from both study areas were similar to that of Deekae *et al*. (2010b) which was 27.58±0.18ºC for Luubara Creek, Dienye and Woke (2015) which ranged from 6.18 to 7.08 for pH and 26.02 to 26.53ºC in New Calabar River. The pH values reported in this study, although within permissible limits, tends towards the alkalinity of the surface water body. This is expected when rivers have some interaction with saltwater bodies, particularly from the mangrove swamp ecosystem in the Niger Delta region (Davies and Ekperusi, 2021). However, pH values recorded in this Luubara Creek and New Calabar Rivers area were well within the preferred pH of 6.5 to 9.0 recommended for optimal fish and aquatic life (Ukenye and Taiwo, 2019). The dissolved oxygen values (3.95±0.06 to 5.02±0.02 mg/l for Luubara Creek and 3.91±0.03 to 4.53±0.38mg/l for New Calabar River) of this study were similar to those reported for many other polluted Nigerian waters including 6.9 to 8.8 mg/l (Abiola *et al*., 2023; Edegbene *et al*., 2021; Bassey *et al*., 2020), and 4.00 to 7.50 mg/l for Luubara Creek in Niger Delta (Deekae *et al*., 2010a, b). The observed lower conductivity value in the dry season than in the rainy season indicated that the sampling station might contain more amount of suspended and dissolved solid materials, which increased the concentration of cations such as calcium, magnesium, and sulphate (Mustapha, 2008; Arimoro *et al*., 2015). High nitrate (.62±0.04 to 3.62±0.04 mg/l) and phosphate values (0.36±0.02 to 0.58±0.02) recorded during the study period in New Calabar River were indicators of different anthropogenic activities around the study areas in wet season. However, this finding corroborates the findings of Ehiagbonare and Ogunrinde (2010) who reported nitrate values of between 2.21mg/l and 4.91mg/l. High nitrate and phosphate contents may be as a result of different anthropogenic activities and surface runoff from farms and the decomposition of organic matter into the water (Ibrahim *et al*., 2009). Phosphate and nitrate are one of the limiting factors of environmental variables because when used up, the aquatic environment becomes unproductive (Arimoro *et al*., 2015). The total dissolved solids values were lower in dry season (December to March) indicative of less amount of rainfall which leads to less runoff which brings soil materials into the study areas. Ayeni *et al*. (2011) and Sikoki and Anyanwu (2013) reported similar values with physicochemical parameters at Ala River, Ondo State.

Species Composition, Abundance and Diversity of Benthic Macroinvertebrates in the study areas: A total of 701 individuals from 15 species belonging to 12 families and 6 classes of benthic macroinvertebrates were found in the Luubara Creek and a total of 375 individuals from 11 species belonging to 6 classes and 8 families of macroinvertebrates were found in the New Calabar River. Taxonomic breakdown of macroinvertebrates from the Luubara Creek showed the dominance of Thiaridae (71%), Sesarmidae (10.7%) and, Chironomidae (8.8%). In New Calabar River Nerididae (66.4%), Capitellidae (17.3%) and Spionidae (3.5%) showed dominance. The Simpson diversity index varied from 0.624 (June 2023) to 0.857 (December 2022) for Luubara Creek and for New Calabar River it varied from 0.674 (September 2022) to 0.879 (March 2023) as such the study areas may have moderate anthropogenic pressures. Shannon-Weiner diversity values in the Luubara Creek ranged from 0.386 (June 2023) to 2.08 (December 2022) while the values in New Calabara River ranged from 0.735 (June 2023) to 1.74 (December 2022). In this study, the values of Margalef richness were between 4.0 (March 2023) to 5.12 (December 2022) in Luubara Creek and 3.03 (December 2022) to 5.92 (March 2023) in New Calabar River. The evenness index varied from 0.161 (June 2022) to 0.868 (December 2022) in Luubara Creek and 0.335 (June 2023) to 0.895 (December 2022) in New Calabar River. Sorenson similarity index also varied from 0.353 (June 2022 Vs December 2022) to 0.462 (September 2022 Vs December 2022 and December 2022 Vs March 2023) in Luubara Creek and 0.348 (June 2022 Vs December 2022) to 0.474 (March 2023 Vs June 2023) in New Calabar River. The benthic macroinvertebrates composition and diversity indices across the sampling period for Luubara Creek and New Calabar River are presented in Table 4 and Table 5. The low diversity of the benthic macroinvertebrates in this study is not unusual in the Niger Delta. Udebuana *et al*. (2015) reported 23 taxa from New Calabar River and George *et al*. (2010) reported 19 species from Okpoka creek sediments. Chironomids are important indicators of freshwater quality and the presence of their larvae and abundance in Luubara Creek indicates good water quality same as in Arimoro *et al*. (2018). Also, the observed dominance of Nerididae (Polychaeta) in the New Calabar River agrees with the study of George *et al*. (2010) and, Edokpayi and Nkwoji (2007) which indicated that the dominance of Polychaeta in their study area may be attributed to their level of pollution tolerance. The diversity indices distribution patterns in relation to the sampling period are presented in Table 4-7.

Table 4: Subtidal benthic macroinvertebrates composition and diversity indices across the sampling period in Luubara Creek

Class	Family	Species	Jun 2022	Sept 2022	Dec 2022	Mar 2023	Jun 2023	Total
Insecta	Chironomidae	*Chironomus ablabiemyia*	7	1	4	5	3	20
		Corynoneura sp.	7	0	2	9	2	20
		Chironomid larvae	0	4	11	4	3	22
	Ceratopogonidae	*Forcipomyla sp.*	1	0	0	0	0	1
	Hydropsychidae	*Hydropsyche sp.*	2	0	0	5	2	9
Gastropoda	Thiaridae	*Pachymelania fusca*	92	35	21	68	57	273
		Pachymelania aurita	45	23	20	51	86	225
	Neritidae	*Neritina glabrata*	1	0	3	1	0	5
Polychaeta	Nephtyidae	*Nephlithys hombergi*	6	4	2	3	0	15
Bivalvia	Cyrenoididae	*Cyrenoida sp.*	1	8	7	0	1	17
Teleostei	Nothobranchiidae	*Epiplatys sexfasciatus*	0	1	0	0	0	1
Malacostraca	Sesarmidae	*Sesarma sp*	19	4	13	26	13	75
	Alpheidae	*Potamalpheops pylorus*	1	0	0	0	0	1
	Grapsidae	*Pachygrapsus sp.*	0	1	3	0	1	5
	Palaemonidae	*Macrobracium macrobacium*	0	1	4	6	1	12
		Total	**182**	**82**	**90**	**178**	**169**	
Margalef Richness			4.42	4.7	5.12	4	4.04	
Simpson diversity index			0.672	0.731	0.857	0.749	0.624	
Shannon-Weiner index (H) – Bits/Ind.			0.386	0.737	2.08	1.66	1.25	
Evenness (E)			0.161	0.32	0.868	0.719	0.541	

Sorenson similarity index	Jun-22 Vs Sep-22	Jun-22 Vs Dec-22	Jun-22 Vs Mar-23	Jun-22 Vs Jun-23	Sep-22 Vs Dec-22	Sep-22 Vs Mar-23	Sep-22 Vs Jun-23	Dec-22 Vs Mar-23	Dec-22 Vs Jun-23	Mar-23 Vs Jun-23
	0.364	0.353	0.432	0.400	0.462	0.412	0.444	0.462	0.432	0.444

Table 5: Subtidal benthic macroinvertebrates composition and diversity in across the sampling period in New Calabar River

Class	Family	Species	June 2022	September 2022	December 2022	March 2023	June 2023	Total
Polychaeta	Capitellidae	*Capitella capitata*	5	13	20	4	19	61
		Notomastus latericeus	1	3	0	0	0	4
	Nereididae	*Nereis (Hediste) diversicolor*	18	60	28	9	18	133
		Nereis (Alitta) virens	3	34	19	9	16	81
		Nereis pelagica	0	8	11	9	7	35
	Spionidae	*Polydora (Dipolydora) capensis*	2	1	7	1	2	13
Insecta	Chironomidae	*Chironomus sp.*	2	0	2	5	2	11
Gastropoda	Potamididae	*Tympanotonus fuscatus*	1	0	0	6	3	10
	Ampullariidae	*Pila ovata*	0	0	8	1	3	12
Malacostraca	Sesarmidae	*Sesarma alberti*	1	3	0	3	5	12
Teleostei	Gobiidae	*Porogobius schlegeili*	0	1	0	1	0	2
Malacostraca	Palamonidae	*Palaemonetes africana*	0	0	0	1	0	1
		Total	**33**	**123**	**95**	**49**	**75**	
		Margalef Richness	4.16	3.35	3.03	5.92	4.27	
		Simpson diversity index	0.682	0.674	0.811	0.879	0.826	
		Shannon-Weiner index (H) Bits/Ind.	1.28	1.38	1.74	0.839	0.735	
		Evenness (E)	0.616	0.664	0.895	0.350	0.335	

	Jun-22 Vs Sep-22	**Jun-22 Vs Dec-22**	**Jun-22 Vs Mar-23**	**Jun-22 Vs Jun-23**	**Sep-22 Vs Dec-22**	**Sep-22 Vs Mar-23**	**Sep-22 Vs Jun-23**	**Dec-22 Vs Mar-23**	**Dec-22 Vs Jun-23**	**Mar-23 Vs Jun-23**
Sorenson similarity index	0.429	0.348	0.444	0.414	0.400	0.424	0.414	0.438	0.467	0.474

Generally, the Simpson index ranges from 0 to 1. Mature and stable communities have high diversity values (0.6 to 0.9), while the communities under conditions not favourable for growth, exhibiting low diversity, usually show close to zero values (Dau and Meer, 2023). Simpson diversity index is always higher where the community is dominated by less number of species and when the dominance is shared by a large number of species (Shah and Pandit, 2013). In biological communities, the Shannon-Wiener diversity index varies from 0 to 5 Bits/Ind. According to this index, values less than 1 characterize heavily polluted conditions, and values in the range of 1 to 2 are characteristics of moderately polluted conditions while a value above 3 signifies stable environmental conditions (Shah and Pandit, 2013). Thus, these values suggest that the Luubara Creek and New Calabar River are moderately polluted and the macrobenthic community may be under stress due to natural and/or anthropogenic factors. Margalef richness has no limit value, and it shows a variation depending upon the number of species. Thus, it is used for comparison of the sites (Shah and Pandit, 2013) and takes only one component of diversity (species richness) into consideration reflecting sensitivity to sample size. The low diversity of Shannon and Margalef in this study may be attributed to declining numerical species composition induced by environmental degradation due to anthropogenic pressures, besides other biotic factors (Obiefuna *et al*., 2012).

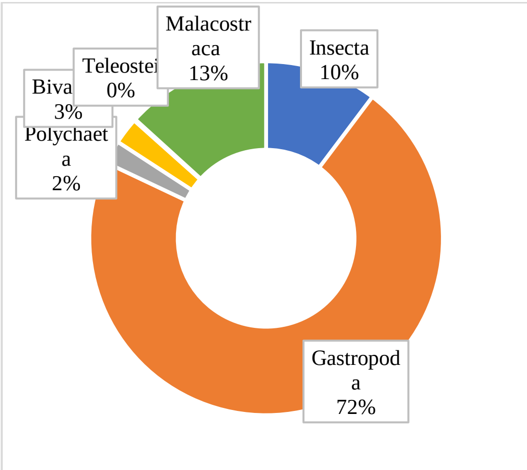

Fig. 3: Percentage composition of class of macrobenthic invertebrate Luubara Creek

This study showed that there was spatial and temporal variation in macroinvertebrate abundance in the study areas. A high abundance of macroinvertebrates was encountered in the wet season than in the dry season. From the Canonical correspondence analysis, the electrical conductivity and total dissolved solids showed a strong association with most of the species in Luubara Creek, indicating that these parameters have a significant impact on the macrobenthos community while temperature and salinity emerged as influential factors for species abundance in New Calabar River, along with phosphate.

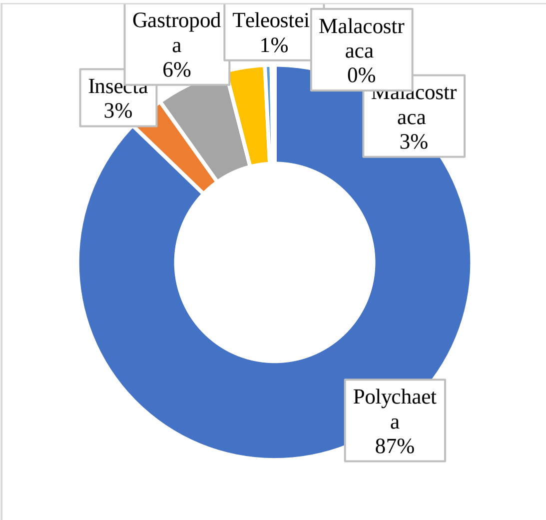

Fig. 4: Percentage composition of class of macrobenthic invertebrate New Calabar River

Canonical Correspondence Analysis: The canonical correspondence analysis (CCA) showed which parameters affected macrobenthos abundance. In Luubara Creek *Cyrenoida* sp., *Epiplatys sexfasciatus*, *Pachygrapsus* sp. and Chironomid larvae were affected by total dissolved solids, salinity, electrical conductivity and temperature which accounted for 56.6% variation while *Nephlithys hombergi*, *Epiplatys sexfasciatus*, *Potamalpheops pylorus*, *Chironomus ablabiemyia*, *Corynoneura* sp., *Forcipomyla* sp., *Pachymelania fusca* and *Pachymelania aurita* were affected by pH, dissolved oxygen, electrical conductivity, total dissolved solids, nitrate, and phosphate which accounted for 25.3% variation. Most of the species showed a strong association with electrical conductivity and total dissolved solids. In New Calabar River, there was a correlation between the abundance of macrobenthos and physicochemical parameters. *Pila ovata*, *Capitella capitate*, *Notomastus latericeus*, *Nereis (Hediste) diversicolor*, *Nereis (Alitta) virens*, *Nereis pelagica* and *Polydora (Dipolydora) capensis* were affected by pH, temperature, salinity, and phosphate which accounted for 67.6% variation while *Pila ovata*, *Sesarma alberti*, *Porogobius schlegeili*, *Palaemonetes africana*, *Capitella capitate*, *Nereis (Alitta) virens*, *Nereis pelagica*, *Chironomus sp.* and *Tympanotonus fuscatus* were affected by temperature, dissolved oxygen, salinity, nitrate, and phosphate which accounted for 15.3% variation. Most of the species showed a strong association with temperature, salinity, and phosphate.

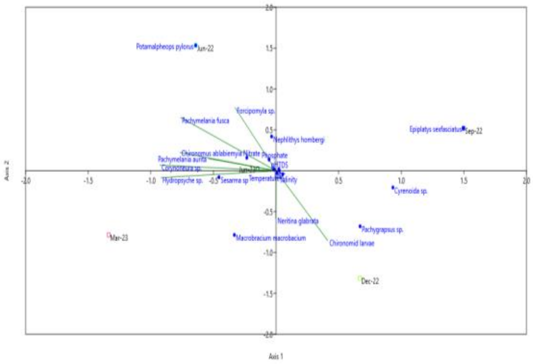

Fig. 5: Canonical correspondence analysis of physicochemical parameters and diversity indices of benthic macroinvertebrate of the Luubara Creek.

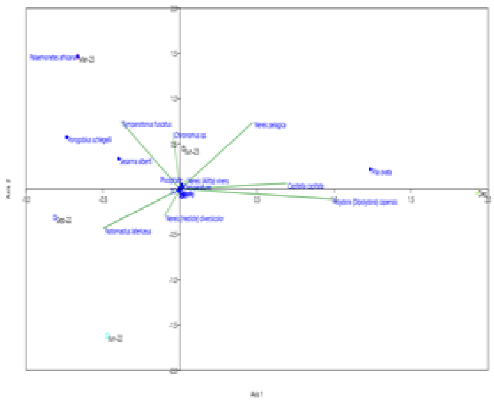

Fig. 6: Canonical correspondence analysis of physicochemical parameters and diversity indices of benthic macroinvertebrate of the New Calabar River.

Conclusion: This study provides insights into the water quality and sub-tidal benthic macroinvertebrates in Luubara Creek and New Calabar River in part of the Niger Delta, Rivers State, Nigeria. Elevated nitrate and phosphate levels, particularly in New Calabar River, raise concerns about nutrient loading, potentially from agricultural runoff and domestic wastewater discharges. Subtidal benthic macroinvertebrate communities in both water bodies varied, with different dominant taxa. Luubara Creek was dominated by Thiaridae, Sesarmidae, and Chironomidae, while New Calabar River had a higher presence of Neridideae, Capitellidae, and Spionidae. The relatively low diversity of these taxa suggests environmental stress and habitat alterations in both ecosystems. To protect these ecosystems, it is essential to establish water quality monitoring and sustainable management practices, targeting nutrient pollution sources and benthic macroinvertebrate habitats. Further research should explore the broader ecological impacts of water quality changes and develop focused conservation strategies.

Declaration of Conflict of Interest: The authors declare no conflict of interest.

Data Availability: Data are available upon request from the first author or corresponding author or any of the other authors

REFERENCES

Abiola, MAG; Amina, OV; Oluwatobi, AS; Oyeleke, OAM (2023). Biomonitoring of Aquatic Habitat Using Apodu Dam in Malete, Moro Local Government Area of Kwara State Nigeria as a Case Study. *Annu. Mar. Sci.* 7(1): 006-013.

Akindele, EO; Olutona, GO (2015). Environmental Variables and Benthic Macroinvertebrate Assemblage in The Headwater Streams of an Afro-Tropical Reservoir. *Water Environ. J.* 29(4): 541-548.

American Public Health Association (APHA) (2012). Standard Methods for the Examination of Water and Wastewater. Washington D.C, USA, 1090.

Arimoro, FO; Auta, YI; Odume, ON; Keke, UN; Mohammed, AZ (2018). Mouthpart Deformities in Chironomidae (Diptera) as Bioindicators of Heavy Metals Pollution in Shiroro Lake, Niger State, Nigeria. *Ecotoxicol. Environ. Saf.* 149: 96-100.

Arimoro, FO; Odume, NO; Uhunoma, SI; Edegbene, AO (2015). Anthropogenic Impact on Water Chemistry and Benthic Macroinvertebrate Associated Changes in a Southern Nigeria Stream. *Environ. Monit. Assess.* 187: 1-14.

Ayeni, AO; Balogun, II; Soneye, ASO (2011). Seasonal Assessment of Physicochemical Concentration of Polluted Urban River: A Case of Ala River in Southwestern Nigeria. *Res. J. Environ. Sci.* 5(1): 22-35.

Bassey, BO; Nosazeogie, EO; Izge, MA; Bello, BO; Abiodun, O; Olapoju, O; Ajani, G; Igbo, JK; Balogun, KJ; Yakub, AS (2020). Diversity of Macrobenthic Invertebrates in Relations to Some Selected Water Quality Parameters in Lagos Lagoon, Nigeria. *J. Sci. Tech. Res.* 30(1): 22993-23002.

Daka, ER; Moslen, M; Onwumere, DC (2018). Spatial Variation in Sediment Characteristics and Macrofaunal Diversity in the Intertidal Zones of Elechi Creek, Upper Bonny Estuary. *J. Environ. Toxicol. Public Health* 3: 30-37.

Dau, J; Meer, B (2023). Structure, Alpha and Beta Diversity of Natural Forest Areas in Eco-Zones of Taraba State, Nigeria. *J. For. Environ. Sci.* 39: 1-12.

Davies, CI; Ekperusi, AO (2021). Evaluation of Heavy Metal Concentrations in Water, Sediment and Fishes of New Calabar River in Southern Nigeria. *J. Limnol. Freshw. Fish. Res.* 7(3): 207-218.

Days, JA (1967). A Monograph on The Polychaeta of Southern Africa Part I Errantia. *Br. Mus. Nat. Hist. London*, 458.

Deekae, SN; Abowei, JFN; Alfred-Ockiya, JF (2010b). Seasonal Variation of Some Physical and Chemical Parameters of Luubara Creek, Ogoni Land, Niger Delta, Nigeria. *Res. J. Environ. Earth Sci.* 2(4): 208-215.

Deekae, SN; Abowei, JFN; Chindah, AC (2010a). Some Physical and Chemical Parameters of Luubara Creek, Ogoni Land, Niger Delta, Nigeria. *Res. J. Environ. Earth Sci.* 2(4): 199-207.

Dienye, HE; Woke, GN (2015). Physicochemical Parameters of The Upper and Lower Reach of the New Calabar River Niger Delta. *J. Fish. Livest. Prod.* 3(154): 2.

Edegbene, AO; Odume, ON; Arimoro, FO; Keke, UN (2021). Identifying and Classifying Macroinvertebrate Indicator Signature Traits and Ecological Preferences Along Urban Pollution Gradient in the Niger Delta. *Environ. Pollut.* 281: 117076.

Edokpayi, CA; Nkwoji, JA (2007). Annual Change of the Physicochemical and Macrobenthic Invertebrate Characteristics of the Lagos Lagoon Sewage Dump Site at Iddo, Southern Nigeria. *Ecol. Environ. Conserv.* 13(1): 13.

Ehiagbonare, JE; Ogunrinde, YO (2010). Physicochemical Analysis of Fishpond Water in Okada and Its Environs, Nigeria. *Afr. J. Biotechnol.* 9(36).

Ezekiel, EN; Abowei, JFN; Hart, AI (2011). The Distribution and Seasonality of Benthic Macro-Invertebrates in Sombreiro River, Niger Delta, Nigeria. *Res. J. Appl. Sci. Eng. Technol.* 3: 264-271.

Gabriels, W; Lock, K; De Pauw, N; Goethals, PL (2010). Multimetric Macroinvertebrate Index Flanders (MMIF) for Biological Assessment of

Rivers and Lakes in Flanders (Belgium). *Limnologica* 40: 199-207.

George, ADI; Abowei, JFN; Daka, ER (2010). Benthic Macro Invertebrate Fauna and Physicochemical Parameters in Okpoka Creek Sediments, Niger Delta, Nigeria. *Int. J. Anim. Vet. Adv.* 1(2): 59-65.

Mustapha, MK (2008). Assessment of the Water Quality of Oyun Reservoir, Offa, Nigeria, Using Selected Physicochemical Parameters. *Turk. J. Fish. Aquat. Sci.* 8: 309-319.

Obiefuna, JN; Nwilo, PC; Atagbaza, AO; Okolie, CJ (2013). Land Cover Dynamics Associated with the Spatial Changes in the Wetlands of Lagos/Lekki Lagoon System of Lagos, Nigeria. *J. Coast. Res.* 29(3): 671-679.

Shah, JA; Pandit, AK (2013). Application of Diversity Indices to Crustacean Community of Wular Lake, Kashmir Himalaya. *Int. J. Biodivers. Conserv.* 5(6): 311-316.

Sikoki, FD; Anyanwu, IN (2013). Spatial and Temporal Variations of Physicochemical Variables in a Small Pristine Stream in Niger Delta, Nigeria. *J. Fish. Aquat. Sci.* 8(1): 129-135.

Udebuana, OO; Irubor, K; Mansoor, S (2015). Physiochemical Factors Affecting Macrobenthic Invertebrates Distribution in the Bottom Sediments of Okhuo River. *Int. J. Nat. Sci. Res.* 5(5).

Udeme, J; Anyanwu, E; Avoaja, D (2020). Assessment of Macrobenthic Invertebrate Fauna and Physicochemical Characteristics of Etim Ekpo River, South-South, Nigeria. *Jordan J. Nat. Hist.* 7: 37-49.

Wokoma, OAF; Umesi, N (2017). Benthic Macro-Fauna Species Composition and Abundance in the Lower Sombreiro River, Niger Delta, Nigeria. *Eur.-Am. J.* 1: 17-23

Zaghloul, A; Saber, M; Gadow, S; Awad, F (2020). Biological Indicators for Pollution Detection in Terrestrial and Aquatic Ecosystems. *Bull. Natl. Res. Cent.* 44: 127