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Full Length Research Article

THE HYDROCHEMISTRY, SEDIMENT AND BENTHIC MACROINVERTEBRATES OF SOME ANTHROPOGENICALLY STRESSED PARTS OF LAGOS LAGOON, NIGERIA

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ABSTRACT
The introduction of biodegradable wastes into the coastal waters has altered the water and sediment qualities and constituted stressors to the aquatic biota. This research was carried out to evaluate the impact of anthropogenic inputs on the water, sediment, and benthic fauna of the Lagos lagoon. Six sampling locations were studied from July to December, 2023. Water as well as benthic samples were collected monthly at each study station using the *Hydrobios* water sampler and the Van-veen grab respectively, and analyzed in the laboratory following standard procedures. The analysis of variance (ANOVA) showed that there was no significant difference (P> 0.05) in values of the pH, salinity, The sediment particle composition was dominated by mud. A total of 597 benthic macrofauna individuals comprising 3 Phyla, 4 Classes, 4 Orders, 8 Families, 8 Genera and 8 Species were sampled. The gastropods, *Tympanotonus fuscatus* dominated the benthic Macrofauna assemblage of the study area accounting for 56.0%. The Phylum Arthropoda was represented by one species *Clibanarius africanus*, recorded the least number of individuals, which contributed 0.05% of the total number of individuals collected during the Sampling period. The low abundance of the filter-feeding bivalves, the highly sensitive arthropod species as well as *Pachymelania aurita* in the study area may be indicative of stressed nature of the area. The existence of benthic macroinvertebrates must be guaranteed by ensuring healthy water bodies. This is possible through the implementation of environmental protective measures, which should be on the bases on the baseline condition of these pollution hotspots of the Lagos lagoon.

Keywords: Organic Pollution; Benthic Macroinvertebrates; Water Chemistry; Lagos Lagoon; Sedentary.

1. INTRODUCTION

The health of the aquatic biota is controlled by the quality of the residential water (Mushtaq, *et al*., 2020; Varol & Tokatlı, 2023), and in addition, as in the case of the benthic organisms, the sediment quality (Landrum & Robbins,2020; Zhang *et al*., 2020). Anthropogenic input into the coastal waters has altered the water and sediment qualities and constituted stressors to the biota (Martínez-Megías & Rico, 2022). The benthic macroinvertebrates are the most impacted as their sedentary nature renders them vulnerable to impacts from the stressors (Nwabueze *et al.,* 2020; Nkwoji *et al.,* 2020). These group of organisms which spend at least part of their life cycle at the sediment under water bodies, represent site-specific ecological conditions and serve as useful bioindicators of pollution (Nkwoji *et al.,* 2020; Sumudumal *et al*., 2021; Nkwoji, 2023).

Sediment are the deposits of insoluble material, mainly rock and soil particles, remains of aquatic organisms, chemical precipitates from water, and products of volcanic eruption, that makes up the bottom of aquatic ecosystems (Povinec *et al.,* 2021). Sediment have been identified as a sink and reservoir for a variety of pollutants particularly heavy metals (Bhuiyan *et al*., 2018) as they are the primary repository for materials that are released into the aquatic environment. usually providing a good record of pollutants inputs into aquatic ecosystem. Contaminated sediment are the main indicators of pollution in aquatic ecosystems (Povinec *et al.,* 2021). This is because they have the ability to absorb and act as sinks for all sorts of anthropogenic inputs and can also release same to the overlying water column through resuspension (Jafarabadi *et al.,* 2019; Cui *et al.,* 2022).

The sediment quality of Lagos lagoon has been altered as a result of some obnoxious anthropogenic activities in the lagoon (Adesakin *et al*., 2023, Nkwoji and Awodeyi, 2018). The lagoon which is strategically located in Lagos, Nigeria, has tremendous ecological and economic value and serves as a major hub of fishing, transportation, recreation and research for the Lagos population. Unfortunately, the Lagos Lagoon is heavily impacted with pollutants due to the high human population and concentration of industries around the lagoon. The strategic location of the Lagos lagoon has earned it much research attention and quite a number of published information. These coastal ecosystems which were once rich in biodiversity and biological productivity are considered mismanaged and under-utilized (Bolarinwa, *et al*., 2013).

The continuous growth in human population in and around the Lagos metropolis has resulted to such tremendous increase in generated wastes of unprecedented quantities and variants. Industries of various types and nature have been birthed and in addition, recreational and tourist centers have been built around the lagoon. These have impacted on the water and sediment chemistry of the lagoon, as well as the benthic macroinvertebrate assemblages. The current study is aimed at evaluating the water and sediment chemistry of some stressed parts of the lagoon in respect to the community structure of the benthic macroinvertebrates.

2.0 MATERIALS AND METHODS

2.1 Description of Study Area and Stations

The Lagos Lagoon (Figure 1) which is situated in Lagos State, Nigeria, is the largest in the Gulf of Guinea with an area of over 6,000 km^2 (Ibe 1988; Benson *et al*., 2023). It is positioned between the Atlantic Ocean and Lagos State and forms an integral part of the lagoon system along the Gulf of Guinea. Hydrologically, the

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lagoon is sandwiched between the Atlantic Ocean and Ogun River, with several adjourning creeks and tributaries (Alademomi *et al*., 2020). The lagoon experiences semi-diurnal tidal regime, with an average depth of 2 meters. Ecologically, the lagoon serves as habitat for diverse aquatic organisms, including various shell and finfishes (Nkwoji and Edokpayi, 2013).

Six sampling stations (Table 1) were selected for this study. The coordinates of the sampling stations were marked using Global Positioning System (GPS) (Magellan SporTrak GPS receiver). The stations were chosen based on their importance as sources of specific type of pollutants).

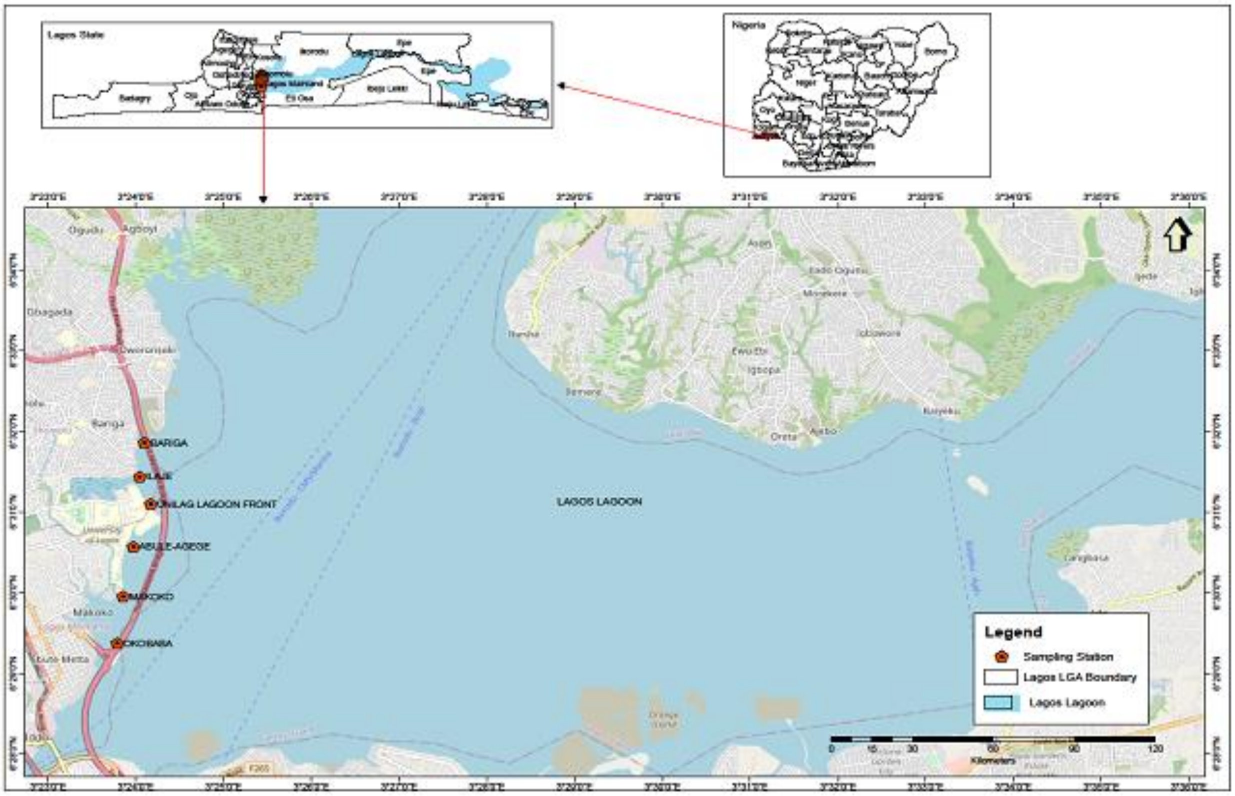

Figure 1: Study Area Showing the Sampling StationsA

Table 1: Sampling stations and their Coordinates

Station No.	Station Name	Latitude	Longitude
1	Bariga	6° 31' 51.2" N	3° 24' 5.7" E
2	Ilaje	6° 31' 26.4" N	3° 24' 2.6" E
3	Unilag lagoon front	6° 31' 5.9" N	3° 24' 10" E
4	Abule-Agege	6° 30' 34.2" N	3° 23' 58.1" E
5	Makoko	6° 29' 57.2" N	3° 23' 51.2" E
6	Okobaba	6° 29' 22.6" N	3° 23' 47.2" E

2.2. Collection and analysis of samples

2.2.1. Collection and analysis of water samples

Monthly sampling for water was conducted for six months at the six sampling stations between the hours of 0800 and 1200. Subsurface water samples were collected with 1dm^3. *In-situ* measurements of water temperature, dissolved oxygen (DO), and total dissolved solids (TDS) were conducted at each sampling station using a mercury-in-glass thermometer, a handheld LaMotte DO Meter (DO 6 PLUS), and a LaMotte TDS Meter (TDS 6 PLUS) respectively. *Hydrobios* water sampler at each study station, stored in a labeled container, and transported to the laboratory for further analyses for pH, salinity, conductivity, turbidity, TSS and BOD following standard procedures outlined in APHA (2002).

2.2.2. Collection and analysis of benthic samples

Benthic samples were obtained using a 0.25 m^2 Van-Veen grab at every designated station. Sediment samples were removed from the portion of each benthic sample, stored in labelled aluminum foil container and transported to the laboratory for the analysis of sediment particle size following standard procedures. The sediments are first air dried for four weeks and then oven dried to constant weight. About 5 g of each oven dried sample is ground in a mortar with pestle and reweighed and sieved through a 63-micrometer sieve. The particles that pass through the sieve are termed mud while the ones that retained on the sieve are termed sand. The percentage mud and the percentage sand of the sediment are calculated as appropriate.
The remaining portion of each benthic sample was sifted through a sieve with a mesh size of 0.55 mm. Substances retained on the

sieve were collected into pre-labelled plastic containers and fixed with 10% formalin, and transported to the benthic ecology laboratory for sorting, grouping, and classification of the benthic macroinvertebrates following standard procedure.

2.3. Statistical analysis

Descriptive and inferential statistical analyses of the physicochemical parameters of water were conducted with the *Statistical Package for the Social Sciences* 21 (SPSS 21) for Windows. Diversity indices were calculated using the Paleontological statistical (PAST) program. Principal Component Analysis was employed via Originlab software to discern interrelations between the physicochemical parameters and study stations. Canonical Correspondence Analysis, carried out with PAST, aimed to estimate the relationship between the physicochemical parameters and the macroinvertebrate fauna across the study area.

3.0 RESULTS AND DISCUSSION

3.1 Hydrochemistry of the Study Stations

The P-statistics and F-distribution results of the physical and chemical parameters of the water samples measured indicated that water temperature, total suspended solids (TSS), total dissolved solids (TDS) and dissolved oxygen (DO) showed significant differences (P<0.05) while pH, Salinity, Conductivity, Turbidity and BOD showed no significant difference (P>0.05) across study stations. (Table 2).

Makoko sampling station has a very low pH level (6.67 ± 0.14) and high BOD while Bariga study station recorded high turbidity (17.17 ± 3.9 mg/L). Low pH level is an index of stressed environment. Water bodies with a lower pH will be less able to control odour, destroy pathogen, and nitrify. A low or decreasing pH is often caused by low dissolved oxygen (DO) or organic overloading (Kade, *et al*., 2023). A low pH (acidic conditions) generates excessive odour and sludge production. A low pH may also indicate an excessive loading rate; volatile acids form faster than they can be converted into the end products of methane and carbon dioxide (Fan *et al*., 2020).

Biochemical oxygen demand (BOD) indicates the amount of organic matter present in water. Therefore, a low BOD is an indicator of good quality water, while a high BOD indicates polluted water (Mitra *et al*., 2018). The study area receives high load organic matter mainly from agriculture, domestic, and industrial wastes. This has constituted stressors to the study area.

Okobaba recorded high level of TSS (17.3±5.5). Ilaje recorded a very low concentration of DO (4.7±0.1) Turbidity has a direct effect on the amount of sunlight available to aquatic ecosystem. High turbidity which translates into high levels of total suspended solids can clog fish gills and, if they settle on the bottom of the waterbody, can smother fish eggs along with the benthic organism. (Pérez et al., 2013, Kader *et al*., 2023).

Aquatic biota require oxygen to survive. Fish for instance, cannot survive for long in water with dissolved oxygen less than 5 mg/L. The low level of dissolved oxygen in water is a sign of contamination and is an important factor in determining water quality, pollution control and treatment processes. The general low level in the dissolved oxygen at the study stations is an indication of high load of organic pollutants (Coffin *et al*., 2018).

Table 2: The Mean±SD of the Physico-chemical Parameters of the Water Samples in the Study Area for the Period of Study

	Water Temp.	pH	Salinity	Conductivity	Turbidity	T.S.S	T.D.S	D.O	BOD
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
BARIGA	28.3±0.7	6.8±0.1	9.2±2.3	12.7±0.8	17.2±4.3	17.2±1.2	11.3±0.7	4.9±0.2	10.4±2.2
ILAJE	29.0±0.3	6.8±0.2	9.0±2.7	12.6±0.8	14.7±3.7	11.0±1.0	11.2±0.4	4.7±0.1	9.6±2.1
UNILAG LAGOON	29.3±0.3	6.9±0.1	10.5±3.0	14.4±1.2	10.5±0.5	11.0±1.3	11.3±0.4	5.3±0.2	8.1±1.5
ABULE AGEGE	28.7±0.6	6.8±0.1	10.3±2.3	13.7±1.4	14.2±3.2	12.1±1.2	13.2±0.4	5.5±1.6	8.3±0.8
MAKOKO	29.3±0.4	6.6±0.2	9.1±2.7	12.0±1.2	13.8±1.3	17.2±3.2	14.2±3.0	4.8±1.6	10.6±2.3
OKOBABA	29.3±0.4	6.7±0.2	10.2±2.4	13.2±1.2	13.8±2.4	17.3±5.5	15.8±1.0	5.3±0.3	10.3±2.3
F-Value	4.610	2.043	0.413	3.679	3.281	8.292	12.222	10.557	1.997
P-Stat.	P<0.05	P>0.05	P>0.05	P>0.05	P>0.05	P<0.05	P<0.05	P<0.05	P>0.05

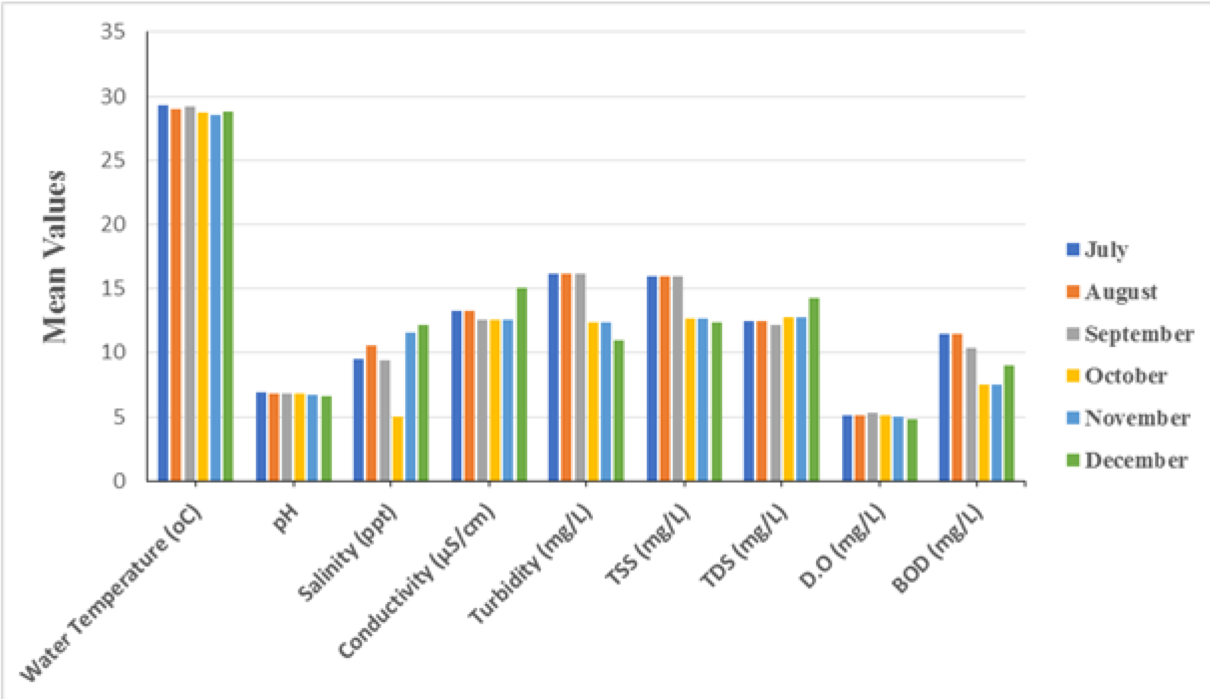

Figure 2: The monthly variations in the water chemistry parameters

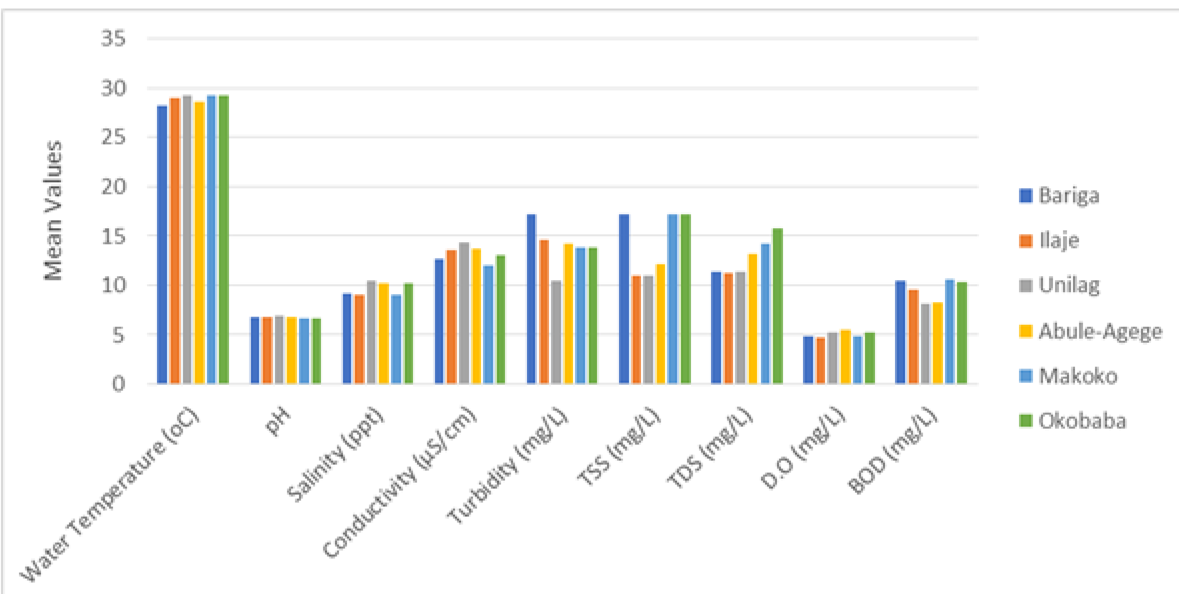

Figure 3: The spatial variations in the water chemistry parameters

3.2 Sediment Particle Sizes of the Study Stations

The spatial variations in the sediment particle size of the study area are shown in Figure 4. A higher percentage of muddy than sandy particles were observed in all the sampled stations except in stations 4 (Abule-Agege) and 6 (Okobaba) which had more percentage of sand than mud. This disagrees with the findings by Fasuyi *et al.* (2021) who reported that the sediment grain sizes from ten sampling stations in the Lagos lagoon were dominated by sand in all their study stations, except for three stations which had more mud than sand. This was attributed to intense dredging and sediment mining activities being carried out in these three stations, which has made them relatively deeper than other stations, leading to siltation and accumulation of mud (Fasuyi *et al.,* 2021). There was no statistically significant variation (P>0.05) in the sediment particle sizes of the six sampled stations.

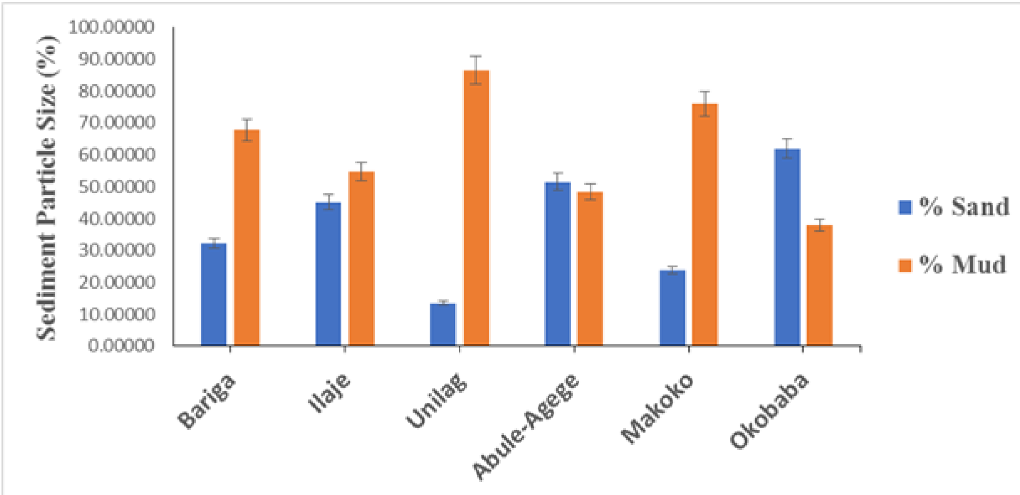

Figure 4: Spatial Variations in the Sediment Particle Size of the Lagos Lagoon

3.3 Community Structure of Benthic Macroinvertebrates in the Study Area

Figures 5 represents the spatial and monthly variations in numerical abundance of benthic macroinvertebrates during the period of stud. The observed general low diversity is an indication of the stressed nature of the study stations. Four study stations: Bariga, Ilaje, Makoko and Okobaba recorded very low abundance of the benthic macroinvertebartes. These stations also recorded very poor water quality of low pH, low dissolved oxygen, high turbidity and total suspended solids, and high biochemical oxygen demand.

The overall percentage contribution of species to the benthic macroinvertebrates sampled during the study period is represented in Figure 6. The gastropod *Tympanotonus fuscatus* dominated the macrobenthic assemblage, contributing 56% and followed by the Bivalve, *Aloides trigona* (12%). The least sampled benthic macroinvertebrates during the period of study were the Crustacea, *Penaeus notialis*. The dominance of *T. fuscatus* could be attributed to its level of pollution tolerance (Nkwoji and Awodeyi; 2018; Nkwoji, 2023). The relatively high abundance of *A. trigona* could be attributed to the Bivalve's preference of muddy sediment which dominated the sediment particle size of the study stations. However, the near total absence of the class crustacea in the benthic macroinvertebrates assemblage in the study area is a pointer to the stressed nature of the area. The crustacea have been identified as pollution sensitive species (Bertrand *et al*., 2018) and therefore, its absence denotes a polluted environment (O'Callaghan *et al*., 2019).

The study shows a very low abundance and diversity of the Macrobenthic fauna at the study stations were very low compared to earlier studies (Ajao, 1990; Ajao and Fagade, 1991). The recorded low abundance may be as a result of the much anthropogenic stressors on the study area that has resulted in the defaunisation of the benthic organisms. The sedentary nature of the benthic macroinvertebrates makes them very vulnerable to the impacts of these stressors (Ajao, 1990). The relatively high abundance and distribution of the gastropod *Tympanotonus fuscatus* shows its adaptability to habitat modification and resilience to anthropogenic stressors. The low abundance of pollution sensitive species like *Pachymelania* sp.and *Paneaus notialis* in the study area is a reflection of the pollution status

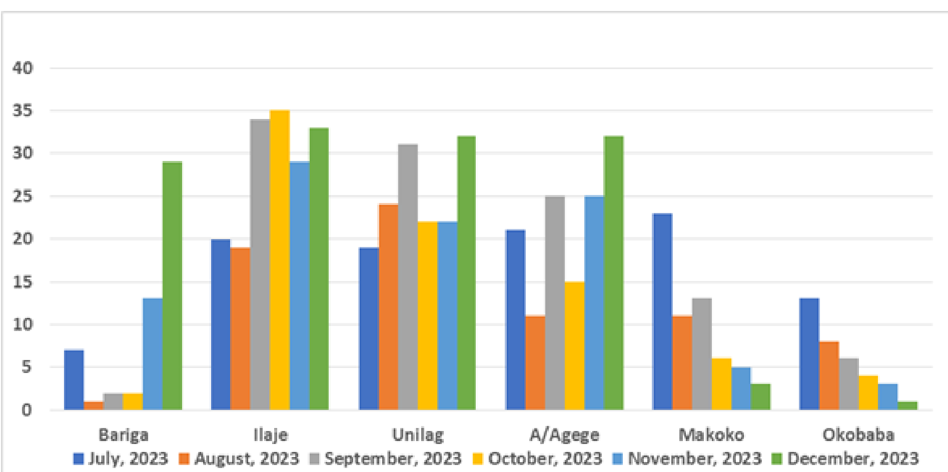

Figure 5: Mean spatial and monthly variations in numerical abundance of benthic macroinvertebrates during the period of study.

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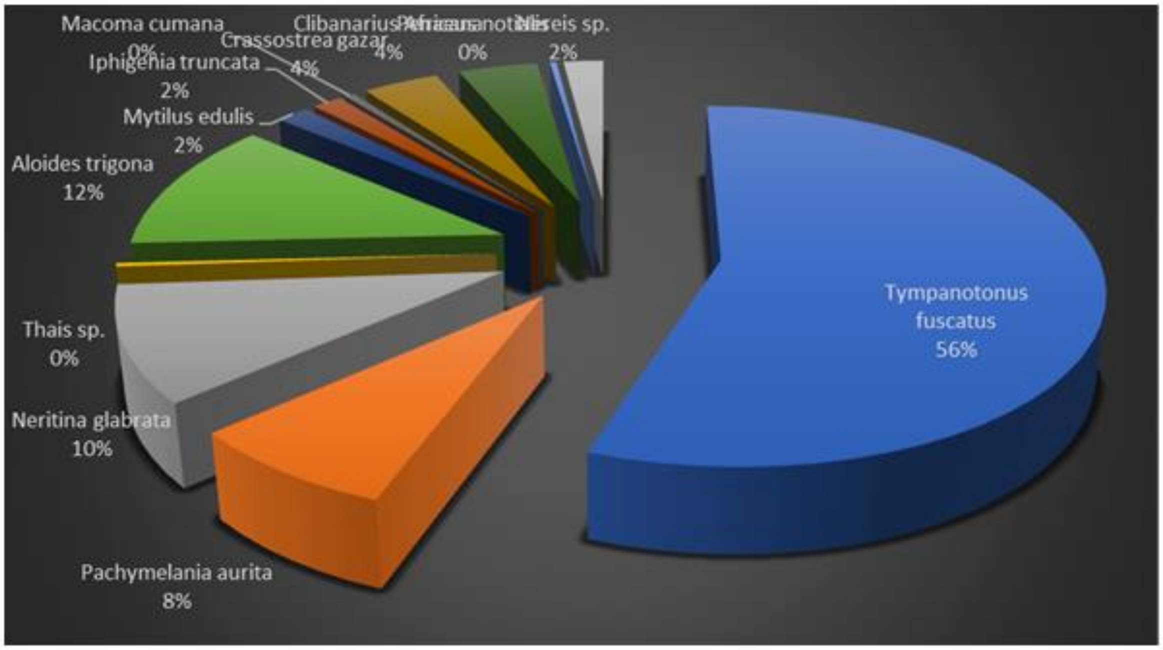

Figure 6: Percentage Species contribution to the total macrobenthic fauna abundance during the period of study

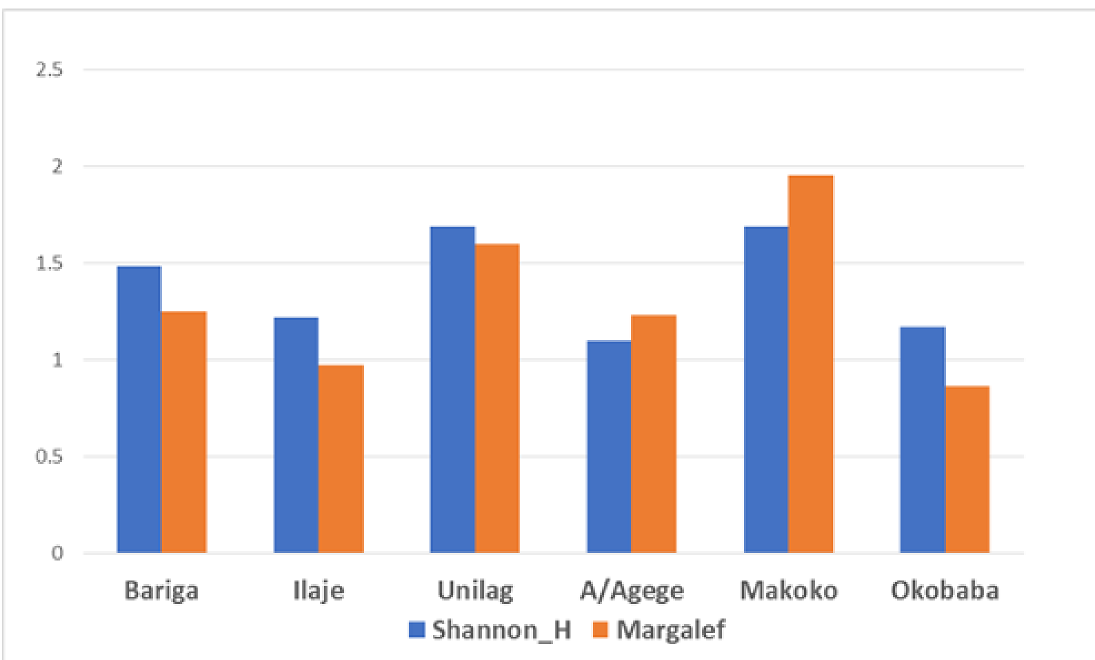

Figure 7: Spatial Variation in Values of Diversity and Richness Indices during the Period of Study (July-December, 2023)

Conclusion

The study area is highly stressed by anthropogenic activities. This has resulted to the low distribution and diversity of benthic organisms in response to the very low water quality. The deteriorating water quality of the study area and the low species richness and diversity are indications of the negative impact of anthropogenic stressors in the study area. Since the benthic fauna are needed for a balanced energy transfer in the food web, their existence must therefore, be guaranteed by ensuring healthy water bodies. This is can be achieved through the continuous monitoring of the lagoon, and by reducing the negative anthropogenic impacts on the lagoon.

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