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ASSESSMENT OF WATER QUALITY AND MACROBENTHIC FAUNA OF LAGOS LAGOON, LAGOS, NIGERIA

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ABSTRACT
The decomposition of biodegradable wastes in aquatic ecosystem is the main cause of organic pollution with its consequent hazardous effects on the environment. Six stations in the Lagos lagoon were studied between July and December, 2023. The aim was to evaluate the impact of biodegradable wastes on the water and benthic fauna of the lagoon. Water and 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, conductivity, turbidity and biochemical oxygen demand measured among the study stations, while dissolved oxygen, total dissolved solids and total suspended solids showed significant differences (P< 0.05). A total of 597 benthic macrofauna individuals comprising three phyla, four classes, four orders, eight families, eight genera and eight 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 poor water quality due to organic pollution.

Keywords: Organic pollution, benthic macroinvertebrates, water chemistry, Lagos lagoon, sedentary

INTRODUCTION

Pollution of coastal water body has been a serious global challenge in recent time especially in developing nation (Wang *et al*., 2022; Iyiola *et al*., 2022). The Lagos lagoon receives unprecedented waste such as industrial effluents, household sewage, urban and agricultural run offs and municipal waste, which may lead to various changes in the physico-chemical characteristics of the marine ecosystem (Nubi *et al*., 2024). The physical and chemical characteristics of water constitute an important component of aquatic ecosystem (Gambín *et al*., 2021). The waste discharges into marine ecosystem are liable to upset the ecological equilibrium of both living and non-living resources (Nath, 2023; Abirami, 2024; Datta, 2023).

Organic pollution results from the introduction of biodegradable wastes into the aquatic environment in such a level that it interferes with the normal ecosystem functions (Singh *et al.*, 2021). As these wastes are released into the aquatic ecosystem, they act as substrates for microorganisms which also facilitate their decomposition (Chynoweth *et al*., 2020). During the decomposition process, the dissolved oxygen in the receiving water is depleted greater than it can be replenished, resulting in hypoxia (Nkwoji *et al*., 2016) and having severe consequences on the soil, vegetation, organisms and water depending on their density on the biota, (Ribaudo *et al.* 1999).

There are complex biogeochemical interactions involving the water column, sediment and biota once pollutants are introduced into the aquatic environment (Norkko *et al*., 2002). The benthic macrofauna are at the centre of all these interplays as their sedentary nature makes them the worst hit by pollutants, and hence, are widely used as biological indicators (Pardo *et al*., 2023; McLaverty *et al*., 2020; Magni, 2003). They are commonly used as environmental monitors because they contact with both the water column and the sediment covering the ocean floor and are sensitive to toxic compounds in both (Nkwoji *et al*., 2016). Benthic macroinvertebrates are useful bioindicators providing a more accurate understanding of changing aquatic conditions than chemical and microbiological data in the water body (Adesakin *et a*l., 2023).

Benthic macrofauna are good bioindicators as they express the synergetic and antagonistic effects of multiple pollutants and are relatively easy to sample. (Adesakin *et al*., 2023). According to Burger and Gochfeld (1999), Holt and (2011), and Fränzle, (2006), a bioindicator should exhibit changes in response to a stressor (sensitivity), have low natural variability, have measurable changes (preferably monotonically in response), exhibit persistent changes that are most likely attributable to the stressor (specificity), encompass variations in scale and complexity, and embody biologically important changes. Benthic macrofauna are particularly suitable as ecological indicators because their habitat preference and relatively low mobility cause them to be directly affected by substances that enter the environment (Otway *et al.*, 1996). Their sedentary nature makes them the worst hit by pollution as they are unable to

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escape from unfavourable environmental conditions (Nkwoji *et al*., 2016).

MATERIALS AND METHODS

Study Area and Sampling Stations

The study area, Lagos lagoon (Figure 1) which lies between latitude 6.49942° N and Longitude 3.48003° E is located in Lagos State, Nigeria, and receives lots of biodegradable wastes. The lagoon is sandwiched between the Atlantic Ocean and Ogun River, with several adjourning creeks and tributaries (Alademomi *et al*., 2020), and relatively shallow (less than 2 m depth) except in areas that are dredged. Salinity of the Lagos lagoon is highly influenced by the season. Ecologically, the lagoon serves as habitat for diverse aquatic organisms, including various shell and finfishes (Nazneen *et al*., 2021).

Six sampling stations (Table 1) were selected for this study using the global positioning system (GPS) to ascertain the exact coordinates. The stations were chosen based on their importance as sources of specific type of pollutants.

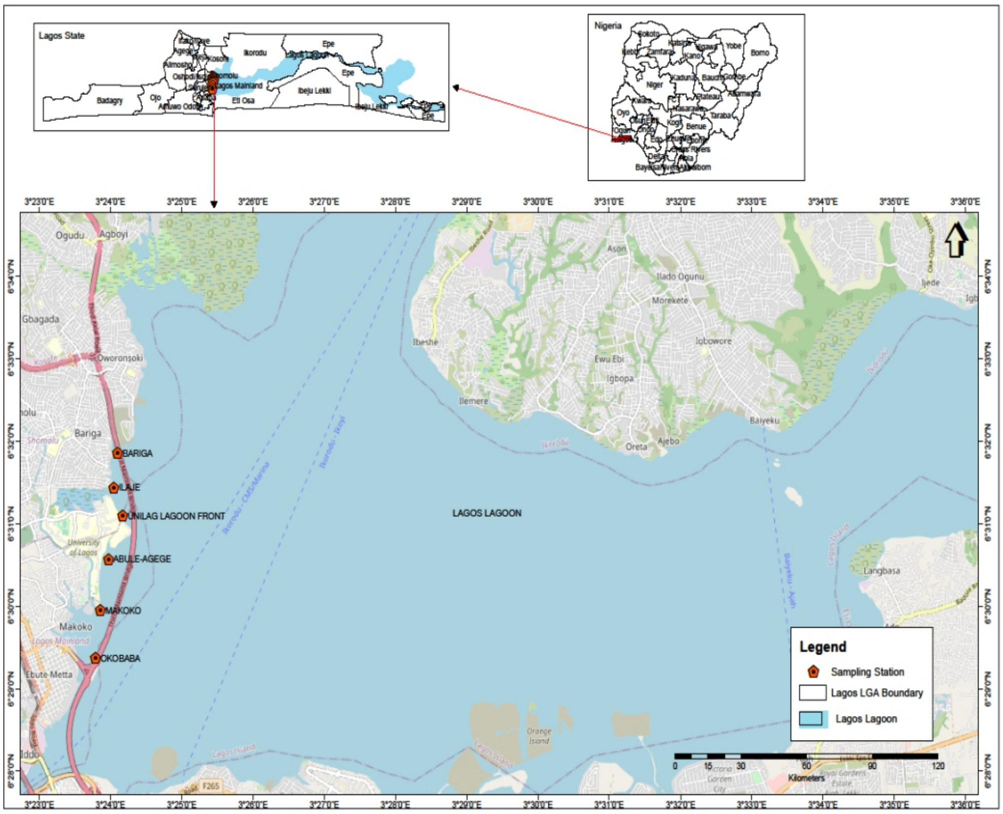

Figure 1: Showing the Sampling Stations Study Area

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	uUnilag 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

Collection and analysis of samples Surface water samples were collected with *Hydrobios* water sampler and emptied into a 1-litre pre-labelled plastic containers at each study station. The temperature of the surface water was measured *in situ* using the mercury-in-glass thermometer. In the laboratory, turbidity and salinity of water samples were measured using Horiba water checker (Model U10) while total suspended solid (TSS) was estimated gravimetrically according to APHA (2002). The total dissolved solid (TDS), pH and electrical conductivity were measured with Hannah pH-EC-TDS meter (Model 9812). Dissolved oxygen (DO) and biochemical oxygen demand (BOD) in the water were titrimetrically determined as described in APHA (2002).

***Collection and analysis of benthic samples**:* Benthic samples were collected with the use of the Van-veen grab. The collected sediment at each station were sieved *in situ* through a 0.5 mm sieve according to Nkwoji *et al*. (2016). The sieved samples were preserved in 10% formalin and transported to the laboratory for analysis. Sorting of the samples was performed in the laboratories and 70% ethanol was used to fix the clean benthic. The sorted

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benthic macroinvertebrates were identified and classified using the relevant identification guides (Easton *et al*., 2012; Mike *et al*., 2005; Prabhakaran, 2017). The benthic macroinvertebrates were identified to at least genus level and their distribution, abundance and diversity determined using relevant biostatistics tools.

Statistical analysis: The statistical package for social sciences (SPSS) 11.0 Windows application was used to carry out the analysis of variance (ANOVA) while Microsoft Excel was used for the descriptive statistics of the data. The diversity indices were computed using the PAST statistical program (Ogbeibu, 2005). The community structure of the benthic macroinvertebrates indicated by these indices was used to assess the impact of the different pollution sources.

RESULTS

Summary of the hydrochemistry of the study area for the period of study is shown in Table 2. Turbidity level was highest (17.2±4.3mg/L) in Bariga and lowest (10.5±0.5 mg/L) at Unilag lagoon front. However, the level of total suspended solid was highest (18.2±5.5 mg/L) at Okobaba study station. The lowest level of dissolved oxygen (4.3±1.6mg/L) which corresponded with the highest level of biochemical oxygen demand (10.6±2.3 mg/L) was recorded at Makoko study station while the highest level of dissolved oxygen (5.5±1.6 mg/L) that corresponded with the least level of biochemical oxygen demand (8.0±0.8 mg/L) was recorded at Abule-Agege study station. The correlation between the parameters is shown in Table 3. There existed a strong positive correlation between turbidity of water and its total suspended matter, and the strong inverse relationship between DO and BOD. Figure 2 shows the monthly variation in the water chemistry of the study area during the period of study. The Figure highlights the impact of rain on some water parameters studies. Highest levels of sanity and conductivity were recorded in December while the lowest were recorded in October. However, water temperature and pH values showed no significant variation during the period of study.

The spatial variation in the physicochemical parameters of water is shown in Figure 3. Okobaba was the high volume of wood shavings recorded the highest value for TSS while the lowest value was recorded at Abule-Agege study station, which also recorded the highest level of dissolved oxygen. However, the dissolved oxygen level was lowest at Makoko study station.

Table 2: Summary of the hydrochemistry of the study area

	Water Temp. Mean ±SD	pH Mean ±SD	Salinity Mean ±SD	Conductivity Mean ±SD	Turbidity Mean ±SD	T.S.S Mean ±SD	T.D.S Mean ±SD	D.O Mean ±SD	BOD Mean ±SD
BARIGA	28.3±0.7	6.8±0.1	9.2±2.3	12.7±0.8	17.2±4.3	18.2±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	4.8±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	8.0±0.8
MAKOKO	29.3±0.4	6.7±0.2	9.1±2.7	12.0±1.2	13.8±1.3	17.2±3.2	14.2±3.0	4.3±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	17.2±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

Table 3: Pearson correlation among physicochemical parameters

	W.Temp	pH	Salinity	Cond	Turb	TSS	TDS	DO	BOD
W.Temp	1.00								
pH	0.20	1.00							
Salinity	-.357**	-0.16	1.00						
Cond	-.300*	-.277*	**.809****	1.00					
Turb	.248*	0.07	-.242*	-.328**	1.00				
TSS	.238*	0.02	-.324**	-.328**	**.805****	1.00			
TDS	-0.22	-0.15	.371**	.356**	-0.10	-0.14	1.00		
DO	0.13	.431**	-0.22	-0.09	-0.06	0.00	0.22	1.00	
BOD	0.01	0.15	0.01	-0.10	.594**	.500**	0.12	**-0.75**	1.00

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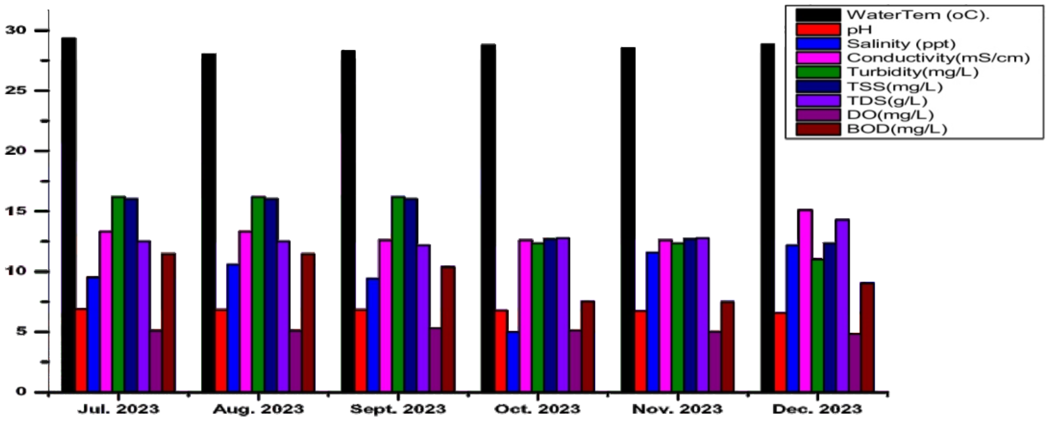

Figure 2: Mean monthly variation in the water chemistry of the study area

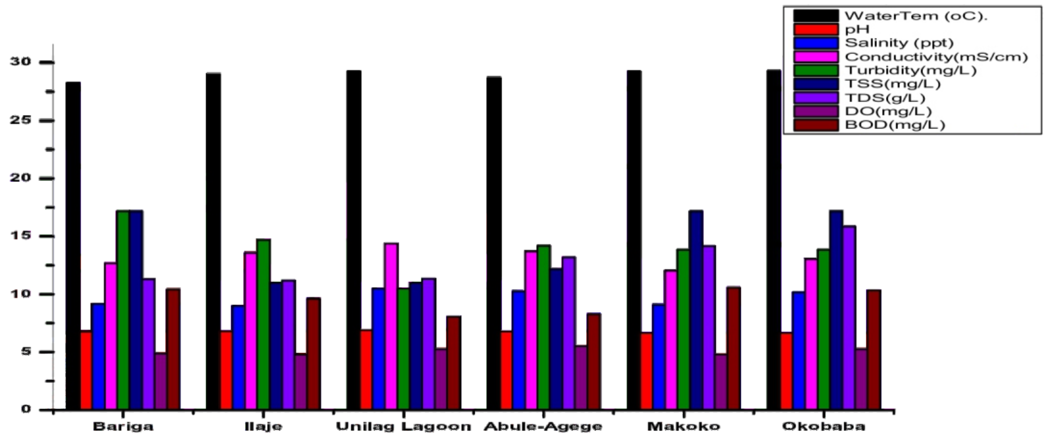

Figure 3: Mean spatial variation in the water chemistry of the study area

The percentage contribution by class of the benthic fauna is represented in Figure 4. Out of the four classes represented, Gastropod dominated the microbenthic assemblage, contributing 74% while the least contribution (2%) was made by the Polychaetes. Classes Bivalvia and Ceustacea contributed 20% and 4% respectively.

Figure 5 shows the percentages species contribution to the total benthic macrofauna. The gastropods, *Tympanotonus fuscatus* recorded the highest number of individuals (56%), followed by *Aloides trigona* (12%), *Neritina glabrata* (10%), and *Pachymelania aurita* (8%). *Penaeus notialis* was the least with less than 1% contribution.

Figure 6 represents the species diversity index of the benthic macrofauna across the study stations. Species diversity was highest (1.69) in Unilag lagoon front and least (1.0) in Makoko study station while species richness was highest (1.93) in Unilag lagoon front and least (0.86) in Okobaba study station (Figure 7).

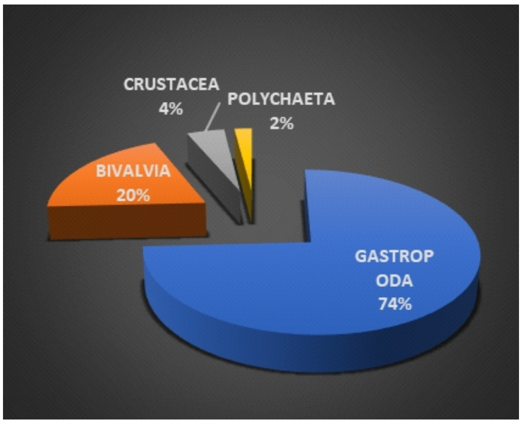

Figure 4: Percentage contribution by Class of the benthic macrofauna

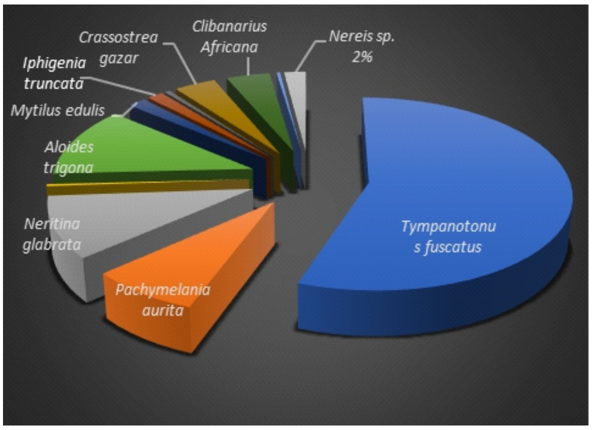

Figure 5: Percentage species contribution to the total benthic macrofauna

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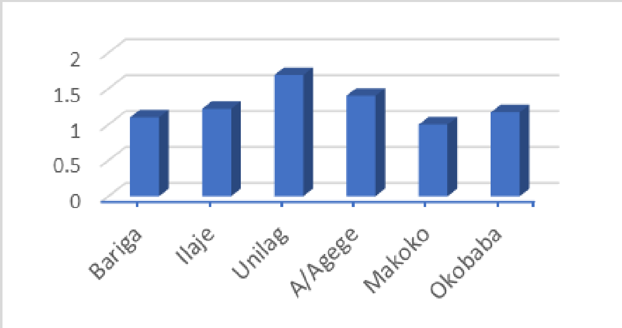

Figure 6: Species diversity index of the benthic macrofauna

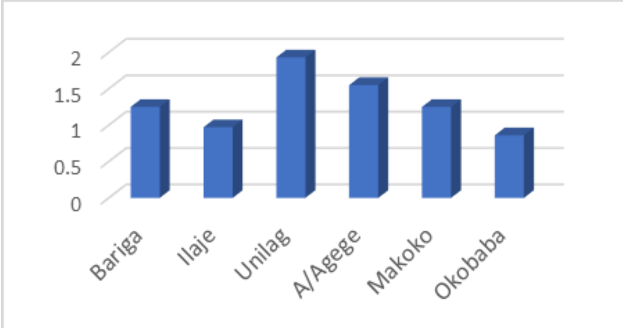

Figure 7: Species richness index of the benthic macrofauna

DISCUSSION

Water Chemistry

A relatively high turbidity (17.2mg/L) corelated positively with that of high suspended particles (18.2mg/L). Apart from adding high particulate materials into the water, these wastes release exudates and leachates that reduce water transparency, and also reduce photosynthesis layer and area by refracting solar radiations. The relatively low dissolved oxygen (4.3mg/L) recorded in Makoko is a reflection of high input of domestic wastes, including sewage from this study station. This corresponds with high biochemical oxygen demand (10.6mg/L). The microbial decomposition of these wastes results to both the depletion of the dissolved oxygen (DO) and high biochemical oxygen demand (BOD) values. Water and sediment with low DO and high BOD hamper the wellbeing of benthic fauna and reduce their diversity Arya *et al*. (2022).

The relationship that existed between D.O and BOD at the study stations was generally an inverse one. It is the dissolved oxygen in the water that is being depleted or utilized by the microorganisms and hence, the elevated biochemical oxygen demand value. It therefore, entails that a high value of biochemical oxygen demand will imply a low-level dissolved oxygen and vice. This observation agrees with (Sahu *et al*., 2023). Areas of pronounced inputs of organic wastes such as Ilaje, Bariga and Makoko study stations recorded low values of dissolved oxygen. This could be attributable to the consumption of the dissolved oxygen by aerobic microbes which biodegrade the organic wastes. Temperature is an important factor in dissolved oxygen concentration as gases dissolve more in cold water than in warmer water. Biological activities are also reduced in colder water than in warmer water hence a relatively higher values of D.O in the former than in the later (Chaikin *et al*., 2022).

Concentration and values of some of these water chemistry parameters are affected by rainfall (Liu *et al*., 2010; Ouyang *et al*., 2006). The study period spanned through both the rainy and dry season. Apart from the Water temperature and pH which remained relatively stable throughout the period of study (Figure 2), other parameters were influenced to an extent, by the rain. For example, while rainfall and the subsequent run-offs would introduce particulate matter into the water body and increase TSS and turbidity, lack of it (dry season) would reduce dilution by the fresh water, and increase the salinity as seen especially in November and December (Figure 2). Rainfall and run-off can cause the excitation of water and marginally increase DO level.

In general, temporal variation in the physicochemical characteristics of water in the study area is largely controlled by rainfall pattern, as the influx of fresh water alters the physico-chemistry of the water while the run-off introduces new materials into the water body. (Nkwoji *et al*., 2010). The spatial variation in the physicochemical characteristics of water in the study area is largely influenced by proximity of the study station to Harbour as well as the type of pollutant. in the study station. Such parameters as salinity, conductivity and TDS increase with nearness of the study station to the Harbour, while different pollution sources introduce different pollutants which exhibit their peculiar impact on the Physico-chemistry of the water of the study station. According to Nkwoji *et al*. (2016) Makoko is known for high organic wastes, basically due to organic wastes which requires the utilization of oxygen for its degradation, the biota in this site are deprived of oxygen, resulting in low dissolved oxygen and high BOD (Chaikin *et al*., 2022). Stations with more wastes recorded relatively high BOD, TSS and turbidity, and low level of DO (Figure 3).

Benthic Macrofauna

There is a general low species richness and diversity of benthic macrofauna in the study area. The sedentary nature of the benthic macroinvertebrates makes them very vulnerable to the impacts of the pollution (Ajao and Fagade, 1990). Both abundance and diversity of the Macrobenthic fauna at the study stations were low compared to earlier studies (Ajao and Fagade, 1990; Brown and Oyenekan, 1998; Chukwu and Nwankwo, 2004). The abundance and high distribution of the gastropod *Tympanotonus fuscatus* shows its adaptability to habitat modification and organic pollution of the Lagos Lagoon (Nkwoji, *et al* 2010). The low numerical abundance and diversity could largely be attributed to high presence of organic wastes that have impacted the hydrochemistry of the area (Ashade *et al*., 2024).

CONCLUSION

The Lagos lagoon has been under severe anthropogenic

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pressure due to poor waste management. This has altered the water quality and consequently, the biodiversity and biological productivity of benthic macrofauna have been negatively impacted. The existence of these organisms must be guaranteed by ensuring healthy water quality. This could be achieved through the implementation of environmental protection measures which includes routine biomonitoring of the Lagos lagoon and a deliberate policy targeted at forestalling the indiscriminate disposal of wastes into the lagoon.

AUTHORS' CONTRIBUTION

Nkwoji conceptualized and designed the study, collected the data and prepared the manuscript for publication. Enukorah reviewed and edited the original draft while Yusuf analysed the data and reviewed the manuscript. All authors approved the manuscript for submission.

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