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Hydrochemistry and Community Structure of Benthic Macroinvertebrates of Lagos Lagoon, Nigeria

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ABSTRACT

The west of the Lagos lagoon, Nigeria has been subjected to lots of stress resulting from various anthropogenic activities around it. The sedentary nature of the benthic macrofauna makes them a very useful tool for assessing the health of this water body. Ecological study of these benthic organisms was conducted between January, 2007 and December, 2008 with the aim of using them to assess the pollution status of this part of the lagoon. Water and benthic samples were collected monthly and analysed in a standard laboratory. Results of the analysis of the physico-chemical parameters of water samples indicated that their temporal variation was controlled by the rainfall pattern while their spatial variation was controlled by proximity to sea and pollution sources. A total of 3,159 individuals comprising three phyla, five classes, nineteen families and twenty-three species were recorded. More individuals were recorded in the dry than in wet season. Iddo I, Iddo II, Ogudu and Agboiyi recorded very low individuals, but relatively high number of opportunistic species like the polychaetes. There was generally low biodiversity which indicates the stressed nature of the study area.

Key words: Ecology, benthic, macroinvertebrates, lagoon, pollution

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INTRODUCTION

Benthic macrofauna, or more simply "benthos", are animals that are larger than 0.5 millimeter (the size of a pencil dot) living on or partially/wholly buried in the sediment of the sea bottom. The benthos includes a diverse assemblage of animals across almost all the animal phyla.

Benthic macroinvertebrates are spineless aquatic fauna inhabiting the bottom of marine and fresh waters and are larger than 0.5mm in diameter [14]. These animals live on rocks, logs, sediment, debris and aquatic plants during some parts or the whole of their lifespan. They include crustaceans such as crayfish, mollusks such as clams and snails, aquatic worms and the immature forms of aquatic insects such as stonefly and mayfly nymphs.

The benthic macroinvertebrates have limited mobility and may not easily avoid pollutants. They are therefore widely used as biological indicators. 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. Sensitivity is commonly expressed as a change in reproduction, growth rate, or mortality, as well as changes in species distribution.

Earlier works on the benthic macroinvertebrates of the Lagos lagoon include Oyenekan (1979), on genus *Pachymelania*; Yoloye (1977), Oyenekan and Bolufawi, (1986), and Oyenekan (1988) on *Iphigenia truncata*. Ajao and Fagade (1990b) worked on the seasonal and spatial distribution of the population of benthic macroinvertebrate, *Capitella capitata* in Lagos lagoon while.

Edokpayi and Nkwoji [11] worked on the physico-chemical and macrobenthic invertebrate characteristics of a sewage dumpsite along the bank of Lagos lagoon. Edokpayi *et* al, (2010) worked on the hydrochemistry and macrobenthic fauna characteristics of an urban draining creek of the Lagos lagoon. This study seeks to investigate some aspects of the ecology of the benthic macroinvertebrates of the western axis of Lagos lagoon.

MATERIALS AND METHODS

Description of Study Area

Lagos lagoon (Figure 1), located between latitude 6° 26' and 6°38' N, and longitude 3° 23' and 3° 43' E is a major part of the barrier-lagoon complex of the Nigerian coastal zone which extends eastwards for about 200km from the Nigerian-Benin Republic border to the western limit of the transgressive mud coast covering an area of about 208 km^2 (FAO, 1969). The morphology has been determined by coastal dynamics and drainage and largely affected by the long shore current actions (Ibe, 1988). The tidal range is small, about 0.3m – 1.3m.

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Twelve sampling stations selected for this study were based on their importance as sources of different forms of contaminants into the lagoon. The stations stretch for about 9.5 miles (15.29km) in length between Iddo and Agboiyi axis of the lagoon. The spatial distance between sampling stations is about 0.75 miles (1.2km). Abule-Agege and Mid-lagoon study stations served as control because they are relatively distanced from anthropogenic activities. Locations of the stations were determined with the aid of the Global Positioning System.

Table 1: The study stations, their coordinates and approximate depths

S/no.	Study Station	Coordinates	Approx. Depth (m)
1	Iddo I	Latitude 6° 28' 01.9'' N, Longitude 3° 22' 57.9'' E	3.64
2	Iddo II	Latitude 6°28' 03.2'' N, Longitude 3°23' 02.4'' E	3.38
3	Carter Bridge	Latitude 6° 28' 09.0'' N, Longitude 3° 23' 05.2'' E	1.97
4	Oyingbo Jetty	Latitude 6° 28' 29.2'' N, Longitude 3° 23' 13.0'' E	2.16
5	Okobaba	Latitudes 6° 29' 25.2''N, Longitude 3°23' 49.2'' E	1.19
6	Makoko	Latitude 6° 29' 51.4'' N, Longitude 3° 23' 46.4'' E	1.66
7	Abule-Agege	Latitude 6°30' 19.7'' N, Longitude 3° 23' 55.8'' E	0.81
8	Mid-lagoon	Latitude 6°31' 23.4'' N, Longitude 3° 24' 33.0'' E	2.20
9	Unilag lagoon front	Latitude 6° 31' 08.2 N, Longitude 3° 24' 10.7'' E	1.60
10	Eledu Creek	Latitude 6° 31' 24.2'' N, Longitude 3° 23' 57.7'' E	0.90
11	Ogudu	Latitude 6° 33' 49.4'' N, Longitude 3° 24' 11.3'' E	0.40
12	Agboiyi	Latitude 6°33' 55.6'' N, Longitude 3° 24' 14.5'' E	2.32
	Parameter/ Unit	Method / Device	Reference(s)
1	Air temperature (oC)	Mercury – in – glass thermometer	
2	Water temperature (oC)	Mercury – in – glass thermometer	
3	Rainfall (mm)	Acquired from NIMET, Oshodi, Lagos	
4	Depth (cm)	Graduated pole	Brown (1998)
5	Turbidity (NTU)	Horiba water checker (Model U10)	APHA (1998)
6	Total Dissolved Solids (mg/L)	Hannah pH-EC-TDS meter (Model 9812)	APHA (1998)
7	Total Suspended Solids (mg/L)	Gravimetric	APHA (1998)
8	Salinity (‰)	Horiba water checker (Model U10)	APHA (1998)
9	Dissolved oxygen (mg/L)	Titration	APHA (1998)
10	Biological oxygen demand (mg/L)	Incubation and Titration	APHA (1998)
11	Chemical oxygen demand (mg/L)	Titration	APHA (1998)
12	pH	Hannah pH-EC-TDS meter (Model 9812)	APHA (1998)
13	Conductivity (mS/cm)	Horiba water checker (Model U10)	APHA (1998)
14	Nitrate – nitrogen (mg/L)	Hach Spectrophotometer (Model DR/2010)	APHA (1998)
15	Phosphate – phosphorus (mg/L)	Hach Spectrophotometer (Model DR/2010)	APHA (1998)
16	Sulphate (mg/L)	Hach Spectrophotometer (Model DR/2010)	APHA (1998)
17	Oil and Grease	Gravimetric	APHA (1998)
18	Iron (mg/L)	Atomic Absorption Spectrophotometer Perkin Elmer 5000 AAS	APHA (1998)
19	Copper (mg/L)	Atomic Absorption Spectrophotometer Perkin Elmer 5000 AAS	APHA (1998)
20	Zinc (mg/L)	Atomic Absorption Spectrophotometer Perkin Elmer 5000 AAS	APHA (1998)

Field Studies

Monthly sampling for water was conducted for twenty four months (January, 2007-December, 2008) between the hours of 0800 and 1200. Bottom water samples were collected with $1dm^3$ Hydrobios bottom water sampler at each study station, with motorized boat, stored in a labeled container and transported to the laboratory where it was stored in the refrigerator at -5^0C prior to further analyses. 250ml dissolved oxygen bottles were used to collect water samples for dissolved oxygen estimation using iodometric Winkler's method. Benthic samples were collected concurrently using a Van-veen grab. At each study station, two grab hauls were sieved, fixed and labeled for macrobenthic fauna analysis.

Measurement of Physico-chemical Characteristics

Benthic Macrofauna Analyses

Sieving and fixing for the benthic macroinvertebrates were conducted on the field with 0.55mm mesh size sieve and 10% formalin respectively. Treatment and sorting of pure samples were conducted at the Nigerian Institute for Oceanography and Marind Research, Lagos laboratory. Relevant texts (Olaniyan, 1968; Edmunds, 1978; Yankson and Kendall, 2001) were used for identification. Zar (1984), SPSS 11.0 Window application and Microsoft Excel were used for the biostatistical analyses. Data processing involved the calculation of biological indices such as Margalef's index for species richness, Shannon-Wiener and Simpson's indices for species diversity, and the Equitability index for evenness of the community:

Margalef's Index: This is a species richness index and was used to measure the diversity in the community structure. The equation below was applied in the calculation: $d = \frac{S-1}{\ln N}$

Where: d = Species richness index
S = Number of species in a population
N = Total number of individuals in S species

Shannon-Wiener diversity index: This is a measure of faunal diversity (Ogbeibu, 2005). It usually indicates the degree of uncertainty involved in predicting the species identified of randomly selected individuals. It is calculated using the following equation:

$$Hs = \frac{N \log N - \Sigma Pi \log Pi}{N}$$

Where: Hs = Shannon and Wiener diversity Index
i = Counts denoting the ith species ranging from 1 – n
Pi = Proportion that the ith species represents in terms of numbers of individuals with respect to the total number of individuals in the sampling space as whole.

Species Equitability or Evenness index

Species evenness or equitability (Ogbeibu, 2005) was used to calculate how evenly the species are distributed in a community. It was determined by the equation: $J = \frac{Hs}{\log_2 S}$

Where: J = Equitability index
Hs = Shannon and Weiner index
S = Number of species in a population

RESULTS

Variations in the Physico-chemical Characteristics of the Water Samples

The summary of the physico-chemical characteristics of the water samples in the study stations for the period of study is shown in Table 3. The monthly variation in the mean concentration of such parameters as turbidity, TSS, salinity and conductivity in the water samples is shown in Figure 2 while that of D.O, nitrates, iron and water temperature is represented in Figure 3. The values for turbidity, TSS and DO were higher in the wet than in the dry months, while salinity, conductivity, nitrates and water temperature were higher in the dry than in the wet months. The spatial varaitons in some of the physico-chemical parameters are shown in the Figure 4. The relationship between the monthly rainfall distribution and the mean salinity of the water of the study station is shown in Figure 5. Months with high rainfall recorded lower salinity values and vice-versa.

Benthic Community Structure

A summary of the benthic macroinvertebrates collected at the study stations is presented in Table 4. A total of 3,159 individuals comprising three phyla, five classes, nineteen families and twenty-three species were recorded. Figure 6 shows that the benthic community was dominated by the Phylum Mollusca (86.23%), followed by the Phylum Annelida (8.58%) and lastly by the Phylum Arthropoda (5.19%). Monthly variation in the numerical abundance of dominant benthic fauna for the period of study is presented in Figure 7. More individuals were recorded in the wet than in the dry months.

The spatial distributon of dominant species during the period of study is presented in Table 5 Abule-Agege study station recorded the highest number of individuals (1,364) while Carter Bridge study station recorded the least number of individuals (42) during the period of study.

The relationship between the abundance of polychaete worms and the values of DO in the water is presented in Figure 8. Study stations with low DO values recorded higher number of polychaetes than the stations with relatively higher DO values. The biodiversity indices of benthic macroinvertebrates in the study stations for the period of the study (January, 2007 – December, 2008) is presented in Table 6. Shannon-Wiener Index (Hs) was between 0.17 and 0.86. Margalef Index (d) values were from 1.79 to 2.57, Equitability was between 0.29 and 0.90 and Simpson's Dominance Index was between 0.14 and 0.83.

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Table 3a: A summary of the physico-chemical characteristics of the water samples in the study area (Jan., 2007– Dec., 2008)

	Iddo I			Iddo II			Cater Bridge			Oyingbo Jetty			Okobaba			Makoko		
	Min	Max	Mean±SD	Min	Max	Mean±SD	Min	Max	Mean±SD	Min	Max	Mean±SD	Min	Max	Mean±SD	Min	Max	Mean±SD
A. Temp	26	32	28.3±1.45	25.5	32	27.9±1.7	26.5	32	28.5±1.8	26	30.2	28.0±1.5	26	30	27.9±1.4	26	31	28.2±1.5
W. Temp	26	29.5	27.9±1.2	24	30	27.9±1.7	26	29.5	27.5±1.2	25	30	27.8±1.5	26	30.5	27.5±1.3	26	30.5	27.8±1.3
Turbidity	8	205	44.1±51.6	8.7	50	34.0±10.4	7.9	47.9	32.5±8.7	5.8	48	30.5±11	6	225	56.8±55.4	7.1	90.5	45.2±22.4
TSS	3	40	19.5±11.2	10	55	21.0±10.2	6	48	17.0±9.3	3	35	16.9±7.9	5	52	25.5±12.5	3	32	17.7±8.3
TDS	1005	33900	15068.3 ±12591.6	98	33915	13626.3 ±13908.9	997	33500	14707.4 ±13052.6	1030	30730	12794 ±11508.6	38.1	24900	8411.2 ±9392.1	92.7	23700	8230 ±9609.8
Salinity	2.5	29.6	14.5±8.8	2.1	29.4	13.4±9.3	1.2	29.3	12.5±9.4	0.5	28.3	11.6±9.1	0	22.1	9.3±7.5	0	20.4	8.0±7.2
D.O	3.1	5	4.3±o.5	3.9	4.8	4.2±0.3	3.7	5.6	4.5±0.7	3.9	5.9	4.8±0.7	3.2	5.1	4.4±0.6	3.8	5.2	4.4±0.5
BOD	4	32	12.7±7.0	5	22	12.7±5.8	2	19	11.2±5.8	2	22	11.3±5.7	3	38	14.0±11.6	3	25	11.8±7.3
COD	7	48	27.2±17.6	14	55	36.5±7.8	26	45	35.6±3.4	17	38	29.3±4.9	6	66	25.0±21.2	6	45	35.8±10.4
pH	6.8	8.66	7.9±0.4	7	8.78	7.6±0.4	7.2	8.81	8.0±0.4	7.1	8.25	8.0±0.3	7.4	8.58	7.9±0.2	7.17	8.7	7.8±0.3
Conduct.	5.8	45.8	30.3±12.7	0.2	45.3	24.4±17.1	2.4	45.2	26.8±13	1.5	43.7	26.4±13	0.1	35.5	17.6±14.0	0.2	32.9	17.0±12.9
Nitrates	1	5.8	1.8±1.3	0.7	4.8	1.7±1.1	0.8	5	1.5±1.2	0.6	3.5	1.2±0.9	0.7	4.1	1.4±1.0	0.1	5.1	1.6±1.0
Phosphat	0.25	0.3	0.2±0.03	0.1	0.5	0.13±0.1	0.1	0.3	0.13±.04	0.15	0.2	0.1±0.03	0.1	0.8	0.14±0.15	0.2	0.5	0.2±0.1
Sulphate	130	202.3	157.2±19	138.2	215	154.9±19	150	198.6	161.1±13	135.9	200	154.8±14	60	102	81.0±7.4	106.5	180	156.7±15.6
Oil/Greas	0.1	3.5	1.2±1.4	0.1	4.9	1.2±1.4	.04	4.3	1.2±1.6	0.03	2.5	0.7±0.9	.04	9.2	2.9±4.0	0.04	4.8	0.9±1.3
Iron	0.12	0.45	0.3±0.10	0.2	0.5	0.4±0.1	.11	0.6	0.4±0.2	0.15	0.5	0.3±0.1	0.15	0.5	0.4±0.1	0.2	0.45	0.4±0.1
Copper	.001	0.003	.002±.001	0.001	0.003	.002±.001	.001	.005	.003±.001	.001	.003	.002±.004	.001	.003	.002±.0002	0	.005	.004±.002
Zinc	.001	0.02	.004±.005	0.002	0.03	.004±.007	.002	.04	.008±.003	.003	.03	.004±.005	.001	.04	.005±.01	.001	.04	.01±.01

Table 3b: A summary of the physico-chemical characteristics of the water samples in the study area (Jan., 2007– Dec., 2008)

	Abule Agege			Unilag Front			Eledu Creek			Mid-lagoon			Ogudu			Agboiyi		
	Min	Max	Mean±SD	Min	Max	Mean±SD	Min	Max	Mean±SD	Min	Max	Mean±SD	Min	Max	Mean±SD	Min	Max	Mean±SD
A. Temp.	26.5	32	28.3±1.7	26	31.3	28.2±1.7	27	32.6	28.8±1.7	26	30.8	28.4±1.5	26.5	32.8	28.6±2.0	26	32.7	28.6±2.0
W. Temp	26	31	28.2±1.4	25	31	27.9±2.2	25	31	27.9±1.8	25	30	27.7±1.6	26	31.5	28.1±1.7	25	30	27.6±1.7
Turbidity	5.2	72	29.3±18.2	5.5	58.3	28.4±17.1	13.8	155	37.1±29.7	5.5	52	23.7±10.3	26	212	79.7±54.9	25	125	60±37.9
TSS	1	28	12.0±7.9	10	25	16.2±4.9	10	31.9	17.0±6.7	2	28.5	12.7±8.2	2	58	25.6±16.7	14	74	28.2±16.7
TDS	93.9	25380	5470.8 ±7485.4	103.5	24800	9563.5 ±10191.0	40.5	22850	8875.4 ±9802.2	1223	29100	13613 ±11562.6	50.1	24770	7104.8 ±9262.6	50	22700	7604.5 ±9165.8
Salinity	0	25.8	8.6±8.2	0	20.2	8.7±8.7	0	18.6	7.4±8.1	2	22.2	11.1±8.1	0	5.85	2.1±2.0	0	8.8	2.8±2.9
D.O	4	5.8	5.1±0.5	4	5.2	4.6±0.4	3.9	5.3	4.6±0.5	4.4	5.6	5.0±0.3	3	4.8	3.7±0.4	2.8	4.2	3.6±0.4
BOD	3	18	10.3±5.0	4	20	10.9±4.8	5.4	19	11.0±4.6	2.2	18	11.6±4.5	7	32.9	19.0±7.6	8	42	19.9±9.9

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COD	4	50	28.2±14.6	24	33	29.0±2.19	28	36	31.5±2.8	13.5	65	27.0±8.7	12	60	41.2±14.0	22	50	37.6±11.6
pH	7.1	9.72	7.9±o.5	7.1	8.3	7.9±0.3	7.1	8.7	8.2±0.3	7.14	8.03	7.8±0.3	7.1	8.8	7.9±0.4	7.2	8.59	7.9±0.3
Cond.	0.2	45.5	19.0±15.1	0.3	35.5	18.1±13.4	0.1	33.9	15.8±12.5	4.3	48.9	27.4±11.5	0.1	30.2	8.2±8.7	0.4	28	10.5±8.7
Nitrates	0.3	3.4	0.9±0.8	0.5	5	1.2±1.1	0.7	5.2	1.4±1.1	0.1	4.2	0.9±1.1	0.9	6	2.3±1.4	1	7.6	2.5±1.5
Phosphate	0.1	0.8	0.2±0.2	0.03	0.2	0.1±0.05	.04	0.9	0.4±0.4	0.1	0.3	0.1±0.04	0.1	2.2	0.9±0.8	0.1	2.9	1.5±1.3
Sulphates	7.2	175.2	64.5±57.5	49.5	160.5	94.8±43.5	60.7	148.7	103.1±34	4.5	160.2	83.4±71.7	106	172.5	131.0±19	128	220	154.3±22
Oil/Greas	0.03	4.5	1.4±1.8	0.1	2.8	0.9±1.1	0.1	2.8	0.7±0.8	.02	3	0.8±1.1	0.04	5.4	1.6±1.7	0.05	4.9	1.2±1.5
Iron	0.2	0.65	0.3±1.1	0.15	0.3	0.2±0.1	0.2	0.3	0.2±0.1	0.1	0.4	0.3±0.1	0.15	0.5	0.31±0.1	.20	0.6	0.4±0.2
Copper	.001	0.02	0.01±0.01	.001	.003	.002±.001	.001	.003	.002±.004	.001	0.003	.002±.001	.001	.005	.003±.001	.001	.005	.005±.001
Zinc	.001	0.15	0.1±0.1	.001	.02	.005±.01	.001	.02	.004±.004	.002	0.03	.01±.01	.002	0.06	.01±.03	.002	.03	.01±.01

Table 4: A summary of total benthic macroinvertebrates collected at the study stations in the western part of Lagos lagoon for the period of study (January, 2007 – December, 2008)

Benthic Taxa	**Iddo I**	**Iddo II**	**Carter Bridge**	**Oyingbo Jetty**	**Okobaba**	**Makoko**	**Abule-Agege**	**Unilag lagoon**	**Eledu creek**	**Mid-lagoon**	**Ogudu**	**Agboiyi**	**Total**
Mollusca													
Neritina senegalensis	-	-	-	-	-	-	-	14		3	-	-	**17**
Neritina glabrata	1	-	1	11	41	14	357	28	8	51	1	3	**516**
Pachymelania aurita	2	-	7	34	4	4	866	127	20	84	1	9	**1156**
Tympanotonus fuscatus	6	1	7	13	53	14	13	98	46	66	7	8	**332**
T.fuscatus Var radula	3	-	5	4	13	9	6	26	10	10	-	2	**88**
Thais haemostoma	-	-	-	-	-	-	-	-	-	2	-	-	**2**
Mytilus perna	-	-	-	-	-	-	-	-	-	3	-	-	**3**
Mytilus edulis	-	-	-	-	2	-	14	-	-	40	-	-	**56**
Crassostrea gasar	-	-	-	-	-	-	1	-	5	-	-	5	**11**
Dosinia isocarda	-	-	3	5	-	-	-	-	-	-	-	3	**11**
Mactra glabrata	-	-	-	-	-	-	-	1	-	5	-	-	**6**
Iphigenia rostrata	-	-	-	-	-	-	9	-	-	5	-	-	**14**
Iphigenia truncata	1	-	6	5	5	2	45	16	7	29	-	2	**118**
Tellina nymphalis	4	2	3	32	18	1	19	31	7	17	1	9	**144**
Aloides trigona	2	1	7	20	12	4	57	55	18	35	2	2	**215**
Aloides sulcata	-	-	-	5	3	-	13	8	1	5	-	-	**35**
	19	**4**	**39**	**129**	**151**	**48**	**1400**	**404**	**122**	**355**	**12**	**43**	**2724**
Annelida													
***Glycera* sp**	2	-	1	1	-	-	-	-	-	-	-	-	**4**

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Nephtys sp	-	-	-	2	-	-	-	-	-	-	-	-	**2**
Nereis diversicolor	37	40	6	23	3	-	1	4	2	-	45	18	**179**
Capitella capitata	-	-	-	3	4	-	-	-	-	-	32	38	**77**
Tubifex sp	-	-	-	-	-	-	-	-	-	-	1	8	**9**
	39	**40**	**7**	**29**	**7**	**0**	**1**	**4**	**2**	**0**	**78**	**64**	**271**
Arthropoda													
Penaeus notialis	-	-	-	2	-	-	-	-	-	-	-	-	**2**
Clibinarius africanus	-	-	-	-	-	-	50	85	22	-	-	-	**157**
Sersama huzardi	4	-	-	1	-	-	-	-	-	-	-	-	**5**
	4	**0**	**0**	**3**	**0**	**0**	**50**	**85**	**22**	**0**	**0**	**0**	**164**
TOTAL	**62**	**44**	**46**	**161**	**158**	**48**	**1451**	**493**	**146**	**355**	**90**	**107**	**3159**

Table 5: Spatial Distribution of Dominant Species in the study stations (January, 2007 – December, 2008)

	Neritina glabrata	*P. aurita*	*T. fuscatus*	*Iphigenia truncata*	*Tellina nympalis*	*Aloides trigona*	*Nereis diversicolor*	**Total**
Iddo I	1	2	9	1	4	2	37	**56**
Iddo II	0	0	1	0	2	1	40	**44**
Carter Bridge	1	7	12	6	3	7	6	**42**
Oyingbo Jetty	11	32	17	5	32	20	23	**140**
Okobaba	41	4	66	5	18	12	3	**149**
Makoko	14	4	23	2	1	4	0	**48**
Abule Agege	357	866	19	45	19	57	1	**1364**
Unilag Lagoon	28	127	124	16	31	55	4	**385**
Eledu Creek	8	20	56	7	7	18	2	**118**
Mid lagoon	51	84	76	29	17	35	0	**292**
Ogudu	1	1	7	0	1	2	55	**67**
Agboiyi	3	9	10	2	9	2	18	**53**
								2,758

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Table 6: Biodiversity Indices of Benthic Macroinvertebrates in the Twelve Study Stations (January, 2007 – December, 2008)

	Iddo I	Iddo II	Carter Bridge	Oyingbo Jetty	Oko-baba	Makoko	Abule Agege	Unlag Lagoon	Eledu creek	Mid-lagoon	Ogudu	Agboiyi
Taxa S	9	4	9	14	10	6	12	11	10	13	8	11
Individuals	62	44	46	159	158	48	1451	493	146	355	100	107
Dominance	0.39	0.83	0.16	0.14	0.26	0.33	0.42	0.18	0.21	0.15	0.41	0.19
Shannon	1.41	0.40	1.98	2.19	1.66	1.34	1.25	1.91	1.84	2.06	1.14	1.99
Simpson	0.61	0.17	0.84	0.86	0.74	0.67	0.58	0.82	0.79	0.85	0.59	0.81
Evenness	0.45	0.37	0.80	0.63	0.53	0.64	0.29	0.62	0.63	0.61	0.39	0.67
Margalef	1.94	0.79	2.09	2.57	1.78	1.29	1.51	1.61	1.81	2.04	1.52	2.14
Equitability	0.64	0.29	0.90	0.83	0.72	0.75	0.50	0.80	0.80	0.80	0.55	0.83

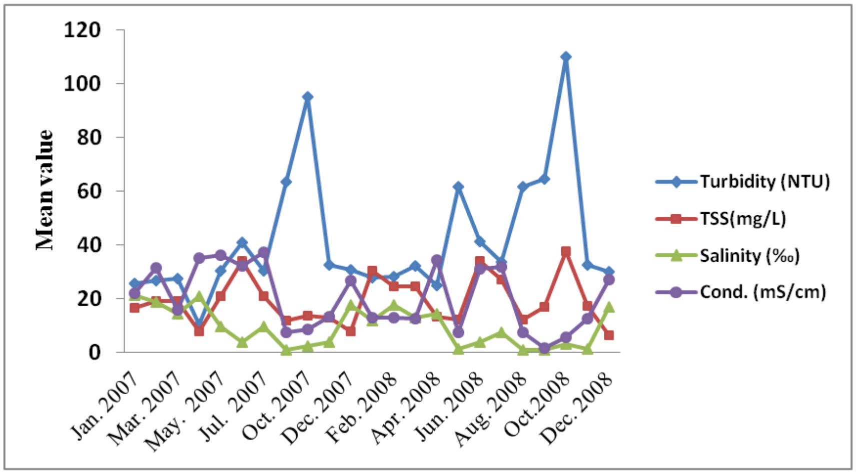

Figure 2: Monthly variation in the mean conc. of Turbidity, TSS, Salinity and Conductivity of the water samples

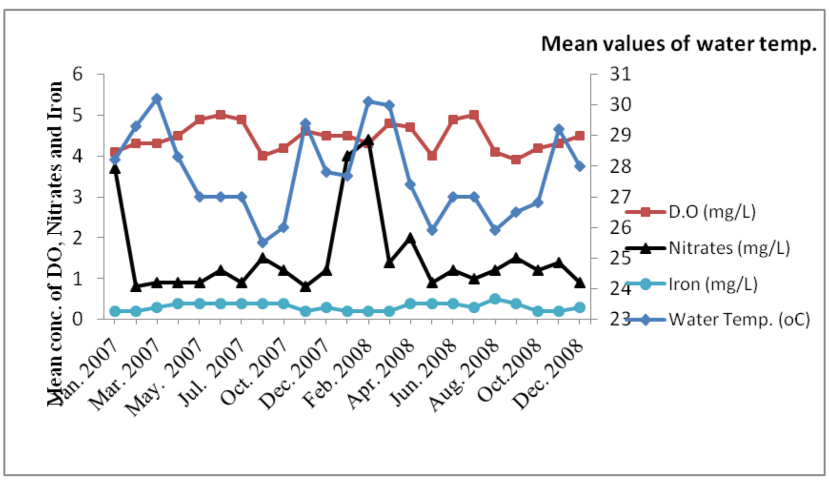

Figure 3: Monthly variation in the mean values of Water temp., D.O, Nitrates and Iron of the water samples

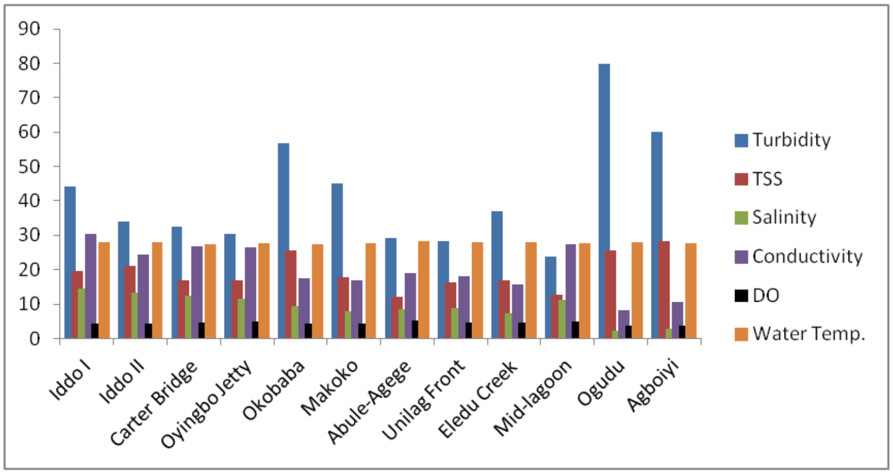

Figure 4: The spatial varaitons in some of the physico-chemical parameters (Jan., 2007 – Dec., 2008)

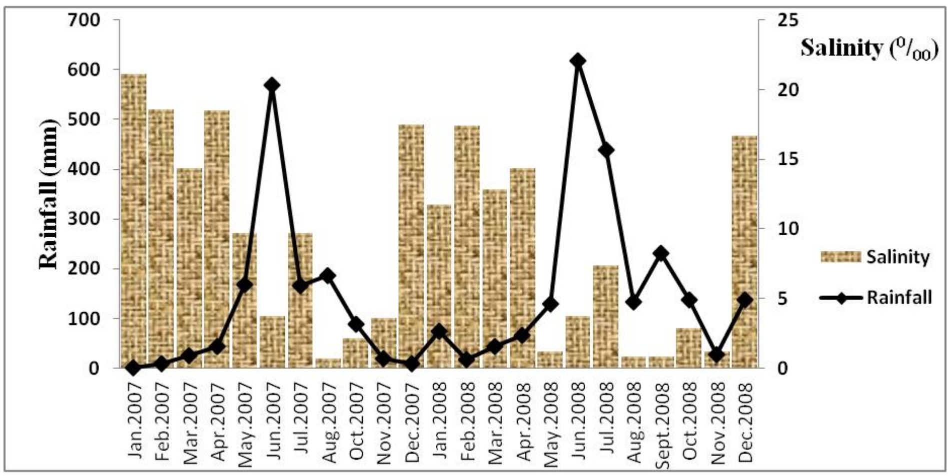

Figure 5: Monthly variation in rainfall distribution and mean salinity in the western part of Lagos lagoon (January, 2007 – December, 2008)

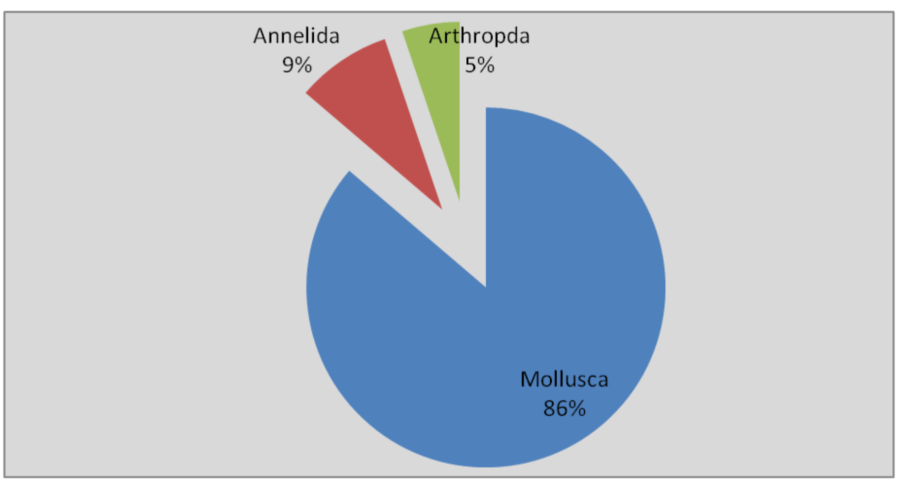

Figure 6: Overall percentage abundance of benthic macrofauna in the study area

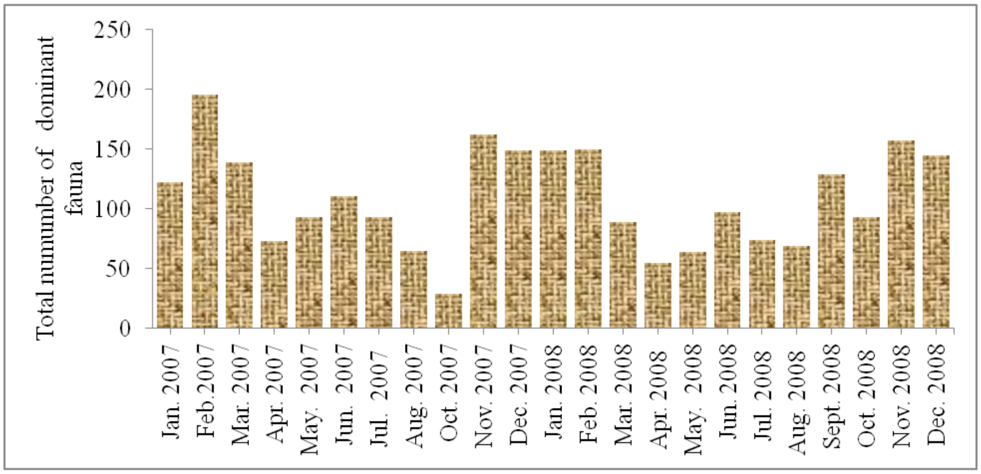

Figure 7: Monthly variation in the total number of dominant benthic macroinvertebrates in the study area (January, 2007-December, 2008)

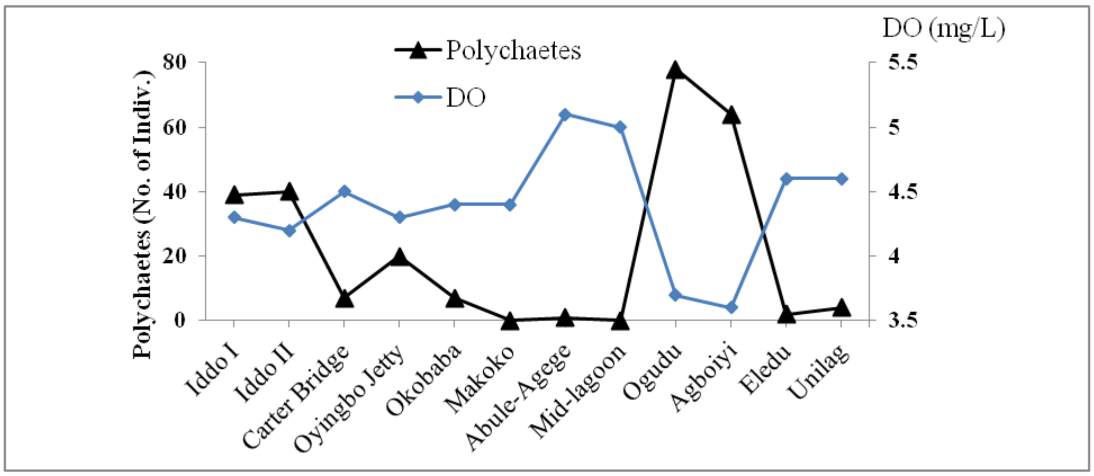

Figure 8: Relationship Between DO Values and Number of Polychate individuals at the Study Stations

DISCUSSIONS

The slight rise in air and water temperatures recorded along the study stretch could be attributed to the time of sampling. Temperature has been shown to be a less significant factor in lagoons and estuaries in the tropics (Ajao and Fagade, 1990b; Nkwoji *et al*., 2010). The high turbidity values recorded at Ogudu and Agboiyi were because these points serve as sink for the domestic and industrial wastes from canals and other local drainage systems.

Differences in the salinity values were as a result of differences in season and proximity to the sea. Stations close to the harbour recorded higher salinity than station removed from the harbour. For any particular station, higher salinities were recorded in the dry than in the wet season. This could be attributed to higher evaporation in the dry season as well as reduced influx of fresh water. The observed values for conductivity of water at the study stations varied in similar pattern as the salinity and are controlled by similar factors. Values of dissolved oxygen obtained in the wet season were relatively higher than in the dry season. Ajao [2] recorded higher DO values in the wet than in the dry season and attributed it to increased perturbation caused by the influx of fresh water from run-offs. Furthermore, the low values in water temperature recorded in the wet season could largely be responsible for the relatively higher DO value. 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 DO in the former than in the later. Areas of pronounced inputs of organic wastes recorded low values of dissolved oxygen. This could be attributable to the consumption of the dissolved oxygen by aerobic microorganisms which biodegrade the organic wastes.

The observed higher value of nitrate-nitrogen in the dry than in the rainy season was however, contrary to Ajao [2] who recorded lower values during the dry months but the stations were quite different. The high values recorded in the dry season could be attributed to concentration of the already introduced nitrates in the waters of this part of the lagoon, due to vaporisation of fresh water caused by high temperature in this part of the year. High level of microbial degradation occasioned by the high temperature in the dry season could also be responsible for the high nitrate level.

In general, the concentration of iron and other heavy metals measured were low in all the study stations for the period of the study. This is in agreement with earlier studies on the lagoon [5, 6, 7]. The general low values of iron and other heavy metals (copper and zinc) in the water of the study stations could be attributed to low heavy metals composition in the effluents and run-offs introduced into this part of the lagoon.

The monthly rainfall volume observed during the period of study was very consistent with rainfall distributive pattern recorded by earlier authors [9, 10, 14, 18].

The benthic fauna of the study area was dominated by molluscs. Both abundance and diversity of the macrobenthic fauna at the study stations were very low compared to earlier studies [1, 2, 6]. The low numerical abundance and diversity are largely due to physical variability of the study area, sampling methodology, and the prevailing ecological conditions, including the state of contamination from anthropogenic sources of the study area at the time of study. According to Chukwu and Nwankwo (2004) and Edokayi and Nkwoji (2007), the western part of Lagos lagoon and its adjacent creeks are under stress resulting from pollution sources from both industrial and anthropogenic sources. The sedentary nature of the benthic macroinvertebrates makes them very vulnerable to the impacts of the pollution [1].

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