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Full Length Research Paper

Seasonal variation in fish abundance and physico-chemical parameters of Lagos lagoon, Nigeria

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A Study was conducted to determine abundance of fish over two seasons (dry and wet) in Lagos lagoon. Fish sampling was carried out in four selected stations. Physico – chemical characteristics of Lagos lagoon and fish distribution was also studied. The results revealed that Cichlids contributed the highest number of fish in the two seasons. Fish species were more evenly distributed in the dry seasons than wet seasons. Species evenness for wet and dry seasons was 0.40 and 0.43 respectively. There is a positive correlation between fish abundance and biomass for wet and dry seasons (r = 0.60 and 0.76 respectively). There was no significant difference between fish abundance in the two seasons. Variations occurred between physico-chemical parameters of water samples. Analysis of the lagoon waters showed that oil and grease of 11.0 – 12.0 mg/l higher than the FEPA'S limit for effluent discharge. The oil and grease levels exhibited significant difference ($p<0.05$) between the dry and wet seasons in all the stations in all the zones and also there are significant relationship ($p<0.05$) among the stations. It is clear from the results that lagoon pollution can also be traceable to the effluent discharged from transportation and therefore there is a need to take appropriate measures to preserve the aquatic life. The information and observation in this study will be very useful in formulating management policies on the future use of Lagos lagoon especially multi-usage of fisheries with other sectors like oil and transportation.

Key words: Fish distribution, seasonal variation, lagoon.

INTRODUCTION

With an estimated population of over 140 million people, Nigeria is blessed with a vast expense of inland and ma-rine ecosystems. The surface area of marine and brac-kish water resources covers estimated area of 233, 000 km^2 (Ita, 1993) and the brackish –marine fishery potential has been estimated at 273, 500 metric tonnes per annum (Amadi, 1991). Lagos lagoon is one of the major lagoon systems in Nigeria. It is an extremely important eco-system and, apart from high levels of biological produc-tivity, it plays various important ecological roles such as transportation of nutrients and organic material to marine system through circulation (FAO, 2002). Sustainability of lagoon fisheries is now threatened by coastal degradation for the great majority of species which spend their earliest stages near coast, estuarine, brackish or freshwater. The most noticeable hydrological features of lagoons and es-tuaries ecosystem in Nigeria is the diurnal and seasonal variations in salinity level of the water usually caused by tidal effects and influx of inshore waters (Ibe, 1990). In terms of biological production, the Nigeria lagoons have wide diversity of both flora and fauna (Amadi, 1990). Fish are appropriate indicators of trends in aquatic environ-ment because of the impact they have on the distribution and abundance of other organisms in the water they in-habit (Olopade, 2001). Dublin-Green and Tobor (1992) classified the resources in the marine environment into two: renewable and non-renewable. They include the al-gae, some plants and finfish, marine mammals, reptiles shell fishes, etc.

Arabatizis and Kokkinakis (2005) observed that lagoon systems are places of great biological importance where fishery is the main economic activity but intensive agri-culture, industry and tourisms have degraded their sensi-tive environmental structure.

There is therefore need to assess the fish distribution and abundance of Lagos lagoon in order to give a good insight into the state of biological production in the sy-

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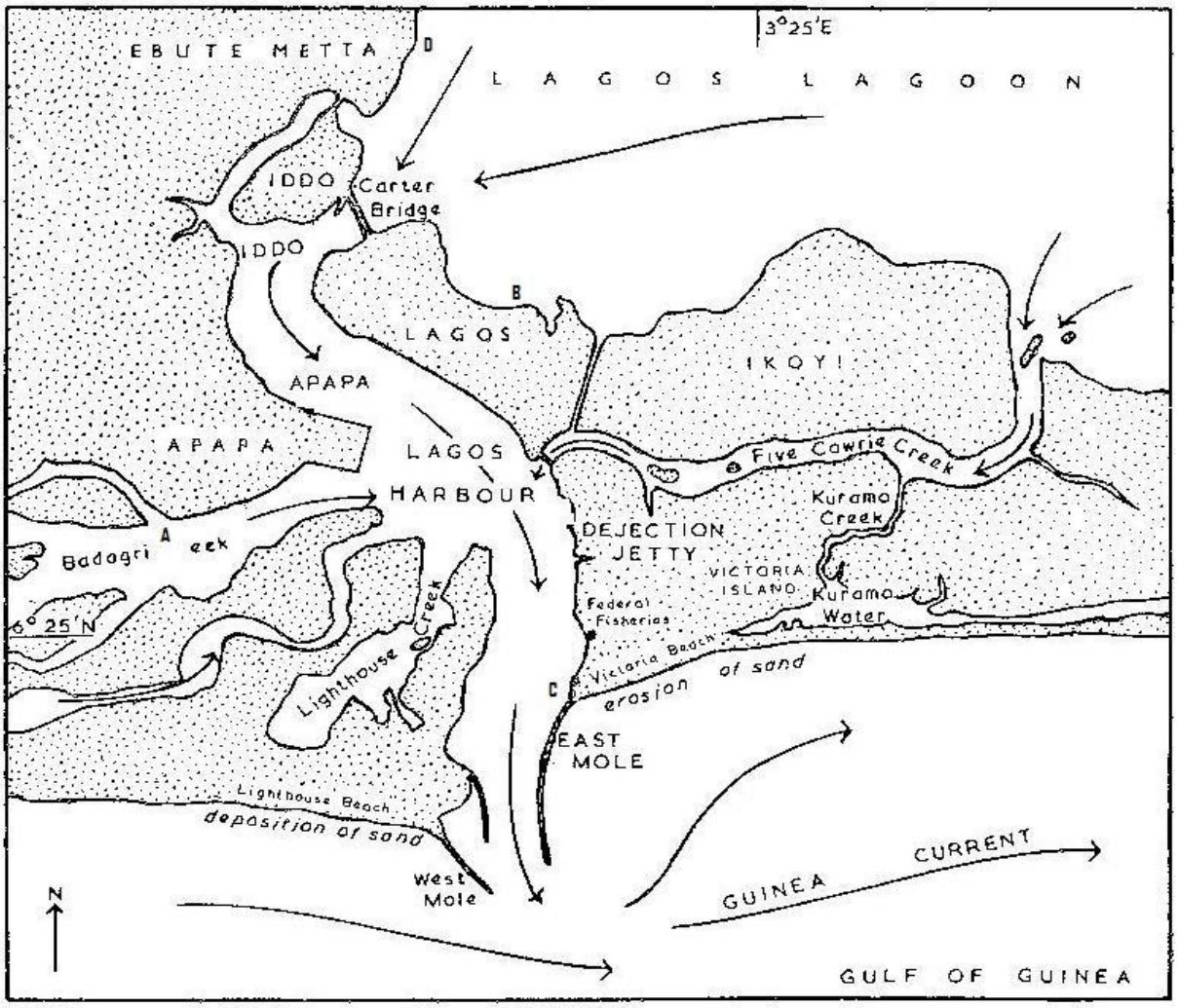

Figure 1. Shows the map of Lagos lagoon and sampling sites
Legend:
A-TINCAN JETTY
B-MAROKO SANDFILL JETTY
C-NIOMR/FDF JETTY
D-OKO BABA

stem and the physico - chemical characteristics in evaluating future changes that may occur in response to increasing pollution in the Lagos lagoon.

MATERIALS AND METHODS

Description of study site

The Lagos lagoon is part of the continuous system of lagoons and creeks that are found along the coast of Nigeria from the border with the Republic of Benin to Niger-Delta. This lagoon bordering the Lagos Island is located between longitude $3^{o}10'$ and $3^{o}45'$ E and $6^{o}15$;N and $6^{o}36'$.N. It stretches for about 257 km from Cotonuon in the Republic of Benin to the Western edge of the Niger-Delta. The lagoon boarders the forest belt and receives input from a number of important large rivers draining more than 103,626 km of the country (Ajao, 1996). Four (4) stations (Tincan=A, Maroko Sandfill jetty=B, NIOMR/FDF Jetty=C and Okobaba=D) and were purposive selected on basis of their activeness in ship harbour and jetty transportation (Figure 1).

Experimental procedures

Fish distribution and Abundance

Fish from the study sites were sampled using gill nets (mesh size: 9 inches length: 6 m), cast nets (mesh size: 9 inches), hook (size: 2 inches and lines. The fish species were identified to the lowest taxonomic level using Idodo-Umen (2003). Species were counted for number of individuals. The sampling is done bimonthly for two dry (November-March) and two wet (April- October) seasons (FAO, 2004) between 2004 and 2006.

The fish abundance was determined by monitoring and recording the fish catch data from various fishing locations in the Lagos lagoon. The fish sample data were collected from some selected fish-

ing villages and landing sites. The fish species caught were identified to the lowest taxonomic level using FAO (1992), and Holden and Reeds (1972). The total weight of the fish was taken and measured to the nearest gram using a pan balance (Salter Model). Also, the standard length of the fish was taken and recorded to the nearest centimeter using a measuring board.

Determination of fish diversity

The diversity indices used were:

i) Species richness (S), which is the total number of different fish species present.

Where S = Σ n1 + n2 + n3 +……ni

ii) Simpson index (D), which is the measurement that accounts for the percent of each species from a biodiversity sample within a local aquatic community. The index assumes that the proportion of in-dividuals in an area indicates their importance to diversity.

Simpson index (D) = Sum $(Pi)^2$

Where Pi = the number of given species divided by the total number of fishes observed. The probability computed for each species is gi-ven in decimal percent.

iii) Shannon – Weiner index (H) = - Sum (Pi ln (Pi)) (natural log). This index measures the order or disorder observed with a particular system. This order is characterized by the number of indivi-duals observed for each species in the sample site (Simpson, 1949).

Collection of water sample

Surface water samples for two seasons (wet and dry) from the selected locations were collected by dipping plastic containers of 1.5 ml to about 6-10 cm below the surface film. The plastic containers were mouth sealed with cellotape and carried to the laboratory where it was stored in a refrigerator before the commencement of analysis.

Determination of physico-chemical parameters of water samples

Temperature was determined using mercury –in-glass thermometer calibrated in degree centigrade (^oC). The surface water temperature was measured on site. pH was measured using a Horiba D – 51 pH meter. The electrode was directly dipped into the water samples and the readings were taken. Salinity was determined by argentiometric titration according to Swingle (1979) by first getting the chloride converted which was then concentrated to salinity using the following factor,

$S\%_o = 1.805 \times CL\%_o + 0.03$

Dissolved oxygen was determined using Rex portable Dissolved Meter Model– JPB – 607. The nitrate concentration was measured calorimetrically using brucine sulphate, sulphanilic acid diazotization according to Murphy and Riley's method (1962). Phosphate –phosphorus level was determined using calorimetric method (APHA, 1989).

The depth was also measured using a sinker mode of leads attached to a calibrated rope (Arowomole, 2000). The sinker was lowered into the water and the rope slowly released until the sinker rest at the bottom of the water. The depth was then read off a calibrated rope. This process was repeated at every site.

Biological Oxygen Demand (BOD) was carried out by measuring the amount of dissolved oxygen present in the samples before and after incubation in the dark at 20^oC for five days. The samples were measured into the BOD bottles in duplicates. The Biological Oxygen Demand in mg/litre of dissolved oxygen in incubated sample bottle from the dissolved oxygen in the initial bottles.

Total dissolved solids (TDS) were determined by gravimetric me-thod after evaporation. 100 ml of water sample was measured into an already weighted evaporating dish. It was weighted and then placed in an oven at 105^oC for 24 h to dry after which it was weight-ed. The content was to dry after which it was weighted again. The amount of solids in mg/l was calculated. Chemical Oxygen Demand (COD) was determined by adding mercury sulphate, 5 ml concen-trated sulphuric acid (H_2SO_4) to 5 ml of samples and 25 ml of potas-sium permanganate was added. The mixture was refluxed for 2 h and allowed to cool: the solution was titrated against ammonium sulphate solution using the ferroin as indicator.

$$COD\ (ppm) = \frac{(a-b)\ N \times 800}{S}$$

Where;
N = Normality of ferrous ammonium sulphate, a-b = Volume (ml) of ferrous ammonium sulphate used in titration of Blank (a) and of sample efficient (b)
S = Volume (ml) of sample water
COD = Chemical Oxygen Demand

Oil and grease was determine by acidifying 500 ml of the sample with concentrated sulphuric acid (H_2SO_4) and then extracted in soxhlet extractor thrice with dimethylesher (200 ml). The ether extract was evaporated under a hood on a water bath before final blowing down with Nitrogen. The residue was cooled and oil & grease content weighed.

RESULTS

The abundance and biomass composition of fish species in Lagos lagoon during the wet and dry seasons are presented in Tables 1 and 2. Nineteen families of twenty four species were identified during the wet seasons, while twenty-three families of thirty–nine fish species were identified during the dry season. Species of fish are more abundant in the dry seasons than wet seasons, so also their abundance and biomass. Chchlids contributed the highest number of fish in the two seasons. The Diversity function H(S) for wet seasons and dry seasons was 3.93 and 4.70 while evenness (J) for the seasons was 0.40 and 0.43 respectively. Species equitability (E) for the wet and dry seasons was 0.052 and 0.55 respectively. There is a positive correlation between abundance and biomass of fish in the two seasons giving by r = 0.60 for wet seasons and r = 0.76 for dry seasons. Fish abundance was higher in the dry seasons than that of wet seasons. There is no significant difference ($p>.0.05$) between the two seasons.

The physico-chemical parameters of water samples in Lagos lagoon for both wet and dry seasons are presented in Tables 3 and 4. Maximum temperature of 31^oC was recorded in both seasons. The minimum temperature re-corded was 26^oC at station D in the dry season. No sig-nificant difference ($p>0.05$) occurred between the two seasons. Station B recorded the highest DO level of 4.7

Table 1. Abundance and biomass composition of species during the wet season In Lagos lagoon.

Family	Species	Abundance	%Abundance	Biomass (g)	%Biomass	Length range (cm)
Mochokidea	*Synodontis claris*	3	0.3040	700	0.2128	15.0 -20.0
	Synodontis niloticus	67	6.7882	7585	2.3061	10.0 - 15.0
	Synodontis membranous	80	8.1054	8490	2.5813	8.0 – 15.0
Mulgilidae	*Mugil cephalus*	53	5.3698	5208	1.5834	10.0 – 15.0
Gymnarchidae	*Gymnarchus*	17	1.7224	37240	11.3225	25.0 – 140.0
Cichlidae	*Hermichromis fasciatus*	22	2.2290	7985	2.4278	15.0 -20.0
	Sarotherodon melanotheron	184	18.6424	51985	15.8055	20.0-40.0
Cluoeidae	*Ethmalosa fimbriata*	63	6.3830	6670	2.0279	7.0 -15.0
Lutjanidae	*Lutjnus goorensis*	5	0.5066	12210	3.7123	20.0 – 50.0
Cynogglossidae	*Cynogglossus senegalensis*	48	4.8632	11840	3.5998	15.0 – 45.0
Pomadasydae	*Pomadasys*	61	6.1803	5660	1.7209	8.0 -12.0
Bagridae	*Chrysicthys nigroditatus*	99	10.0304	24110	7.3304	5.0 -35.0
Haemulidae	*Brachydeuterus aureaus*	62	6.2817	9526	2.8963	12.0 -18.0
Sphyaenidae	*Sphyraena piscatorium*	92	9.3212	83865	25.4983	15.0 -150.0
Osteodlossidae	*Heterotis niloticus*	28	2.8369	29425	8.9464	25.0-110.0
Carangidae	*Tranchinotus goorensis*	7	0.7092	3060	0.9304	20.0 -40.0
Drepanidae	*Drepane Africana*	10	1.0132	985	0.2995	10.0 -12.0
Trichiuridae	*Trichiurus lepturus*	7	0.7092	3110	0.9456	45.0 -52.0
Characidea	*Alestes fasciatus*	21	2.1277	2830	0.8604	15.0 -12.0
	Alestes baremose	10	1.0132	758	0.2387	8.0 -12.0
Hepsetidae	*Hepsetus odoe*	18	1.8237	5025	1.5278	8.0 -20.0
	Papyrocranus afer	16	1.6210	7000	2.1283	45.0 -53.0
Centropomidae	*Lates niloticus*	1	0.1013	2300	0.6993	65.0
Malapteridae	*malapterus electricus*	13	1.3171	1310	0.3983	9.0 -15.0

mg/l in the dry seasons while station D recorded a minimum DO level of 3.12 mg/l. No significant difference ($p>0.05$) between the two seasons. The peak of salinity in the seasons was at station A in the dry seasons and the value was 6.03 mg/l. The minimum salinity of 2.58 mg/l was recorded at station C of the wet seasons. There is no significant difference between the two seasons. pH of 7.29 was recorded at zone 4 in the dry seasons and this was the highest pH recorded.

pH of the two seasons showed no significant difference ($p>0.05$). The maximum concentration of nitrate of 2.24 mg/l was recorded at zone D in the wet season and station C in the dry season recorded 1.25 mg/l of nitrate concentration which was the minimum. Nitrate concentration shows a significant difference ($p>0.05$) in the two seasons. Nitrate was higher in dry seasons than in wet seasons. The highest level of phosphate recorded was 0.50 mg/l and this occurred in station D of the wet seasons. The lowest phosphate level occurred at station 1 and 3 of the dry seasons and the value was 0.15 mg/l. The highest depth recorded was at station D in the wet season which is 4.0 m while the lowest depth of 1.9 m was recorded of station C in the wet seasons. There is no significant difference between the wet and dry season ($p>0.05$).

The Biological Oxygen Demand (BOD) of the sampled zones had higher concentration during

Table 2. Abundance and biomass composition of species during the dry season in Lagos lagoon.

Family	Species	Abundance	%Abundance	Biomass (g)	%Biomass	Length range (cm)
Mugilidea	*Mugill cephalus*	82	4.0959	12978	2.0443	10.0 -32.0
	Mugil curema	51	2.5475	9985	1.5728	15.0 -28.0
	Liza falcipinnis	73	3.6464	8497	1.3384	10.0 -20.0
Cichlidea	*Hemichromis fasciatus*	34	1.6983	6325	0.9963	15.0 -22.0
	Sarotherodon melanotheron	216	10.7892	70135	11.0477	16.0 -29.0
	Tilapia guineensis	105	5.2448	28075	4.4224	10.0 -21.0
	Tilapia zilli	85	4.2458	18356	2.8914	12.0 -23.0
Bargridae	*Chrysichtthys nigrodigitatus*	162	8.0919	48125	7.5807	5.0 -40.0
Ariidea	*Arius latisculatus*	70	3.4965	23670	3.7285	15.0 -40.0
	Arius heudeloti	23	1.1489	15865	2.4991	20.0- 53.0‘
Carangidae	*Tranchinotus goorensis*	11	0.5495	8370	1.3184	20.0 – 38.0
	Caranx hippos	15	0.7493	10210	1.6083	20.0 -54.0
	Caranx senegallus	13	0.6594	3265	0.5143	10.0-15.0
	Chloroscombrus chrysurus	20	0.9990	3025	0.4765	8.0 – 15.0
Sphyreanidae	*Sphyreana piscatorium*	176	8.7912	167730	26.4209	15.0 – 15.0
Soleidea	*synatura lusitanica*	82	4.0959	19260	3.0338	13.0 -29.0
Clupeidae	*Ilisha Africana*	98	4.8951	20750	3.2685	12.0 -20.0
	Ethmalosa fimbriata	72	3.3964	12462	1.9630	10.0 -30.0
	Sardinella *madernsis*	122	6.0939	38785	6.1094	16.0 -28.0
	Pellonula leonesis	27	1.3486	3200	0.5041	7.0 - 8-5
Elopidea	*elops lacerta*	17	0.8492	12405	1.9540	20.0 -45.0
Drepanidae	*Drepane africana*	13	0.6493	3215	0.5064	10.0 -15.0
Polynemidae	*Galeoides decadactylus*	32	1.5984	6300	0.9924	15.0 -25.0
	Polydactylus quadrifilis	41	2.0480	8425	1.3271	16.0-32.0
Pomadasydea	*pomadasys jubelini*	88	4.3956	7320	1.1530	8.0 – 15.0
Sciaenidae	*Pseudotolithus epipercus*	30	1.4985	5376	0.8468	10.0 -25.0
	Pseudotolithus elongates	38	1.8981	102550	1.6146	15.0 -40.0
Bothidea	*Citharichthys stampflii*	15	0.7492	1253	0.1974	7.0 -12.0
Tetraodontidae	*Lagocephalus leavigatus*	8	0.3996	950	0.1496	10.0 -15.0
Belonidea	*Strongylura senegalensis*	11	0.5494	6375	1.0042	17.0 – 22.5
Lobotidea	*Lobotes surinamensis*	13	0.6493	9565	1.5067	20.0-36.0
Lutjanidae	*Lutjanus goorensis*	18	0.8991	7200	1.1341	20.0 -32.0
	Lutjanus agennes	6	0.2997	2530	0.3985	15.0 -24.0
Serranidea	*Epinephelus goorensis*	53	2.6473	4510	0.7104	15.0 -80.0
	Epinephelus aeneus	42	2.0979	5892	0.9281	18.0 -92.0
Scombridae	*Scomberomorus tritor*	10	0.4995	3765	0.9531	25.0 – 62.0
Trichiuridae	*Trichiurus lepturus*	6	0.2997	4320	0.6805	45.0 -10.0
Gerreidae	*Gerres melanopterus*	19	0.9490	4250	0.6695	18.0 – 26.0
Monodactylidae	*Psettias sebae*	5	0.2498	1870	0.2946	15.0 - 23

Table 3. Physical and chemical parameters for wet seasons.

	A	B	C	D	FEPA 1991 LIMIT
Depth (m)	3.20 ± 0.01^{b}	2.00 ± 0.02^{a}	1.90 ± 0.15^{a}	4.00 ± 1.0^{C}	NS
Temperature (^{O}C)	27.0 ± 0.1^{b}	26.9 ± 0.1^{a}	27.00 ± 0.1^{b}	26.6 ± 0.1^{a}	40
Do (mg/l)	3.45 ± 0.4^{b}	3.63 ± 0.01^{b}	3.79 ± 0.1^{b}	3.12 ± 1.2^{a}	5.0
Salinity (mg/l)	5.22 ± 0.06^{a}	3.59 ± 0.02^{b}	2.58 ± 0.03^{a}	4.95 ± 0.001^{c}	NS
PH	7.18 ± 0.1^{b}	7.10 ± 0.1^{b}	6.73 ± 0.1^{a}	$6.81 \pm 0l^{a}$	6 – 9
Nitrate (mg/l)	2.19 ± 0.1^{b}	1.55 ± 0.03^{a}	1.36 ± 0.01^{a}	2.24 ± 1.0^{b}	20
Phosphate (mg/l)	0.50 ± 0.02^{b}	0.20 ± 0.06^{a}	0.50 ± 0.2^{b}	0.22 ± 0.03^{a}	5
TDS (mg/l)	193.28 ± 0.11^{a}	213.52 ± 0.16^{b}	212.04 ± 0.1^{b}	214.04 ± 0.01^{b}	2000
BOD (mg/l)	9.18 ± 0.2^{a}	10.10 ± 0.1^{b}	11.7 ± 0.2^{b}	11.9 ± 0.3^{a}	50
COD (mg/l)	14.3 ± 0.2^{b}	16.9 ± 0.5^{a}	17.3 ± 0.6^{c}	20.0 ± 0.1^{a}	NS
Oil and grease (mg/l)	5.0 ± 0.1^{a}	7 ± 0.3^{b}	9.6 ± 0.3^{c}	11.0 ± 0.1^{a}	10

Ns = Not specified
Mean values followed by the superscript in each row are not significantly different ($p<0.05$)

Table 4. Physical and chemical parameters for dry seasons.

	A	B	C	D	FEPA 1991 LIMIT
Depth (m)	3.00 ± 0.01^{b}	2.40 ± 0.02^{a}	2.00 ± 1.0^{a}	3.80 ± 0.3^{C}	NS
Temperature (^{O}C)	31.00 ± 0.1^{b}	29.00 ± 0.1^{a}	31.00 ± 0.1^{a}	30.00 ± 0.1^{a}	40
Do (mg/l)	4.5 ± 0.0^{a}	4.72 ± 0.03^{a}	4.2 ± 0.3^{a}	4.2 ± 0.3^{a}	5.0
Salinity (mg/l)	6.03 ± 0.2^{d}	4.0 ± 0.05^{b}	3.2 ± 0.2^{a}	5.2 ± 0.041^{c}	NS
PH	7.29 ± 0.01^{a}	7.21 ± 0.01^{a}	7.00 ± 0.1^{a}	$7.00 \pm 0.0l^{a}$	6 – 9
Nitrate (mg/l)	2.0 ± 0.02^{b}	1.70 ± 0.01^{a}	1.25 ± 0.1^{a}	2.1 ± 0.01^{b}	20
Phosphate (mg/l)	0.21 ± 0.02^{b}	0.23 ± 0.02^{a}	0.29 ± 0.02^{b}	0.15 ± 0.02^{a}	5
TDS (mg/l)	162.10 ± 0.2^{a}	196 ± 0.05^{b}	189.0 ± 0.21^{b}	196.0 ± 0.03^{b}	2000
BOD (mg/l)	7.23 ± 0.1^{a}	8.6 ± 0.3^{b}	9.2 ± 0.3^{b}	10.1 ± 0.2^{c}	50
COD (mg/l)	12.3 ± 0.3^{b}	$13.7. \pm 0.2^{a}$	15.7 ± 0.3^{d}	16.9 ± 0.1^{c}	NS
Oil and grease (mg/l)	7.3 ± 0.2^{a}	8.3 ± 0.2^{b}	11.3 ± 0.1^{c}	12.0 ± 0.2^{c}	10

Ns = Not specified
* Mean values followed by the superscript in each row are not significantly different ($p<0.05$)

Key

Station A - Tincan/Apapa
B - Maroko Sand fill Jetty
C - NIOMR/FDF Jetty
D - Oko Baba

the wet seasons than in the dry seasons with value ranging from 9.18 to 11.9 mg/l in the wet period. The values ranged from 7.23

to 10.1 mg/l in the dry period. The variation in the biological oxygen demand at different zones during the sampling period are presented in Tables 3 and 4

The total dissolved solids values ranged from 16.2 to 196.0 mg/l and 193.28 to 214.04 in dry and wet seasons respectively. The total dissolved solids contents were significantly higher in zones B and D then in zones A and C.

The Chemical Oxygen Demand (COD) exhibited significant difference ($p<0.05$) between the dry and wet seasons in all the zones and also there significant relationship ($p<0.05$) among the zones. The values varied 14.3 to 20.1 mg/l during the wet seasons while its ranges from 12.3 to 16.9 mg/l grease range from 5.0 to 11.0 mg/l during the wet seasons while its values ranged from 7.3 to 12.0 mg/l during the dry seasons. The oil and grease levels exhibited significant difference ($p <0.05$) between the dry and wet seasons in all the zones and also among the zones.

DISCUSSION

Thirty two families of fifty –two fish species were recorded during the period of this study. This varies with Fagade and Olaniyan (1994) who recorded seventy-two fish species distributed among thirty-four families. This variation may be attributed to human activities of dredging and sand mining of some part of the lagoon. Sand filling may

also cause loss of some fish species due to inhibition of their movement from the marine or fresh water environment to the brackish environment. This error may also be due to selling of fish by fishermen on board without bringing to the landing station. Olaniyan (1969) observed that there was higher plankton density in the dry season that wet season. This is responsible for higher Cichlids abundance in the dry season than wet season. Low water level in the dry season caused an increase in catch in the season and generally increases abundance of fish species more than that of wet season. Fagade and Olaniyan (1974) recorded higher fish species of marine origin during the dry season. This is linked with the fact that the juvenile stages of many marine species are known to live in water of reduced salinity and therefore many of these inhabit Lagos lagoon. This is in agreement with this research. Families Mugilidae, Cichilae clupeidae, Bagridae, Sphyraenidae, pomadasydae and Lutijanidae were recorded in both seasons. Fagade and Olaniyan (1974) recorded these families as being among the fishes caught in the lagoon throughout the year.

There is positive correlation between the fish abundance and biomass of the respective seasons. This implies that the number of fish species of the sample data of the respective seasons had an impact on the biomass of the seasons as observed by Arowomole (2000). The species diversity in terms of species richness is higher in the dry seasons than in the wet seasons. This agrees with Dublin-Green (1994) that H(s) values were higher in the dry seasons than wet seasons during the study of benthic foraminifera; species evenness value is higher in the dry seasons than wet seasons. This implies that species are evenly distributed in the dry seasons than in the wet seasons. Species equitability (E) values is low ($p<0.05$) in the samples collected in both seasons. This implies that the two seasons had a dominant fish species abundant. Dry season had higher equitability than that of wet seasons and it implies that there are many dominant fish species in the dry than wet seasons.

The uniformity of water temperature readings may be linked to the shallowness of the Lagos lagoon and regular tidal motions, which ensured the complete mixing of the water. This observation agrees with Ajao (1990) and Oyewo (1998) in their works on the temperature of Lagos Lagoon. The temperature of the two seasons ranged between 26.6^{o}C and 31.0°C. This is in line with the temperature range of 24.5 to 31.5°C recorded by Fagade and Olaniyan (1994). There is no significant difference in the temperature of the two seasons. However, the relatively small range of variation in water temperature observed in this study area is in line with the observations of Hill and Webb (1958), Longhurtst (1958) and Olaniyan (1969). They agreed that temperature is a stable environmental factor in the shallow brackish environments of West Africa, and it is most unlikely that this variation in temperature constitutes an important ecological factor in this area. The dissolved oxygen levels were generally low and below the critical level of 5 mg/l for fish. Lower dissolved oxygen concentration was usually observed at the height of wet seasons during which nutrients and debris are flushed into the Lagos lagoon with influx of fresh water from the adjoining rivers. The DO level observed in this study is lower to the level recommended by Bolarin and Hatton (1981) as cited by Olaniran (1991) that the desired range for the culture of warm water fish is 5 mg/l and above but not more than 12 mg/l. The dissolve oxygen concentration was fairly stable throughout the sampling period and there was no abnormal decrease in the dissolved oxygen distribution in this area thus indicating a significance pollution load. The influx of water mainly due to rainfall has been the major factor controlling the seasonal distribution of salinity in Lagos lagoon. This observation agrees with Olaniyan (1969), Dublin-Green (1990) and Oyewo, (1998).

This reason was attributed to the variation in the salinity level observed during the sampling seasons in the study years. In the dry season, the increase in the water salinity was mainly due to low freshwater discharge and increased evaporation while the reduction in wet season water salinity was due to dilution by heavy rainfall and increase in fresh water discharge. The finding in this study agrees with a lot of work which had been carried out on the Salinity of sea surface water, harbour and main lagoon system in Nigeria and West Africa (Ajao, 1990; Dublin-Green 1990; Oyewo, 1998). The pH of the lagoon varied between 6.7 and 7.3. The variation in pH for most of the sampling year was very small. High seawater influx and strong tidal currents due to high buffering capacity of the system and effective flushing cause the relatively stable pH observed in this environment. Ajao (1990) linked the small pH range observed in the Lagos lagoon to the Salinity regime in this environment.

There was a marked seasonal variation on the nutrients level of the study area with the lowest value in the dry season but this increase gradually during the wet period. This is in agreement with Ajao (1990) who observed that the nutrient levels obtained in Lagos lagoon were mainly governed by suspended sediments transportation with the fresh water influx into the study area and this usually occurs during the wet seasons. The phosphate is also of great importance as an essential nutrient in aquatic system.

The nitrate values obtained are common to a fairly polluted coastal system. Nitrate is an essential nutrient but at high concentration, is becomes toxic and are capable of disturbing the aquatic environment but nitrate level less than 0.5 ml/l will not pollute the water. Under normal condition the nitrate content of the surface water occur in trace amount but the value in enhanced by the inputs from other sources (Bilger and Atkinson, 1997).

The depth range recorded was between 2.0 to 4.0 m. This is in agreement with the average depth of 2.6 m recording by Fagade and Olaniyan (1974). The highest depth of 4.0 m recorded could be attributed to various

human influences on the sedimentary condition of the Lagos lagoon as a result of sand mining and dredging activities currently going on in Lagos lagoon and its environs, the physical environment of the lagoon especially the topography is being altered. The biological oxygen demand observed in all the zones indicates considerably level of nutrient and this agrees with the report of Vannote et al. (1980) that rivers with high BOD have high nutrient levels in the water. The organisms consume most of the oxygen. Unpolluted, natural waters will have a BOD of 5 mg/l or less. The seasonal changes in BOD during the rainy season (wet) seasons are attributed to increased effect of surface run-off, soil erosion and efflux-ents discharge into the receiving water body (Oyewo et al., 1999). The level of total dissolved solids were higher in the zones during the wet seasons, this may be linked to the observation of Ajao (1990) that effluents can introduce some reaction which precipitates more solids in the solution, leading to high TDS but due to natural filtration TDS can decrease down the stream, with increasing distance away from the source of affluent discharge.

The chemical oxygen demand exhibited the same trend as that of biological oxygen demand in dry and wet seasons. COD is the extent of chemical (organic and inorganic) present. The high level of COD indicated that there was decomposition of organic and inorganic compounds in the water that requires high level of oxygen in the water. Similar observation was made by Wooton (1992), who stated that low oxygen concentrations in water were often caused by presence of decaying organic matter which generates toxic gases such as hydrogen sulphide and methane. The low level of dissolved oxygen in the water observed can be attributed to the high level of oil and grease detected in all the stations. A wide variety of pollutant occurred throughout the zones. *In situ* observation indicated that organic matter and hydrocarbons from degraded petrogenic sources were present.

Conclusion

There is a great variation in fish abundance and distribution in Lagos lagoon according to seasonal changes as advanced by this research work. This is also linked to the physical and chemical state of the water in the lagoon during the seasons and this is very crucial to the biological life of the lagoon. Human activities like sand mining, dredging and sand filling could also have a great impact on the fish abundance and distribution of the lagoon. The information and observation of this research will be very useful in formulating management policies on the future use of Lagos lagoon especially multi-usage of fisheries with other sector like transportation, oil etc.

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