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Full Length Research Paper

Spatial distribution of saline water and possible sources of intrusion into a tropical freshwater lagoon and the transitional effects on the lacustrine ichthyofaunal diversity

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The spatial distribution of saline water and possible sources of intrusion into Lekki lagoon and transitional effects on the lacustrine ichthyofaunal characteristics were studied during March, 2006 and February, 2008. The water quality analysis indicated that, salinity has drastically increased recently in the lagoon (0.007 to 4.70%). This study has identified three possible sources for saline water intrusion, beyond the seasonal input from the two adjacent lagoons (Lagos and Mahin), salt water intrusion by subsurface flow through the barrier beach from the ocean, and leaching of ions through lagoon bottom sediments. Eighty one fish species belonging to 40 families, 56 genera and 14 orders encountered were mostly freshwater, euryhaline and marine species adapted to life in the lagoon. The shell fish included the freshwater prawns *Macrobrachium* spp and the portunid crab *Callinectes amnicola.* This high number of fish species recorded from Lekki Lagoon in this study has confirmed the fact that this lagoon is a transition area between brackish water (Lagos Lagoon and Mahin Creek) and freshwater (Rivers Saga and Oshun).

Key words: Spatial distribution, saline water, lacustrine, ichthyofaunal, diversity.

INTRODUCTION

Human population growth rate has brought about an increase of water supply, irrigation, fish production, recreation and navigation offered by lagoons and this has put enormous pressure and stress on the quality of lagoon water. The impact of human activities in and around the reservoir is felt on the unique physical and chemical properties of water on which the sustenance of fish that inhabit the lagoon is built, as well as to the functions of the reservoir. Water quality is determined by the physical and chemical limnology of a reservoir (Sidnei et al., 1992) and includes all physical, chemical and biological factors of water that influence the beneficial use of the water. Water quality deterioration in lagoons usually comes from excessive nutrient inputs, eutrophication, acidification, heavy metal contamination, organic pollution and obnoxious fishing practices. Djukic et al. (1994) have used the physico-chemical properties of water to assess the water quality of a reservoir. The use of these properties gives a good impression of the status, productivity and sustainability of such a water body. The changes in temperature, transparency and chemical elements such as dissolved oxygen, chemical oxygen demand, nitrate and phosphate of water provide valuable information on the quality of the water, the source(s) of the variations and their impacts on the functions and biodiversity of the lagoon.

Freshwater fishes are a distinct ecological group in estuaries (Day et al., 1989; Blaber, 1997) that have been characterized as migratory (Rebelo, 1992) adventitious (Elliott and Dewailly, 1995), stragglers (Whitfield, 1999) or vagrants (Garcia et al., 2001). Although some freshwater fishes inhabit and reproduce in brackish waters (Palacios and Ross, 1992) most are vagrants intermittently entering estuaries in relatively low numbers (Garcia et al., 2001). These fishes usually complete their entire life cycle in freshwater upper reaches of estuaries and coastal lagoons, and invade lower mixohaline zones during

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periods of reduced salinity (Day et al., 1989). The number of freshwater species found in estuarine fish assemblages appears to vary among regions. Potter et al. (1990) had showed that freshwater fishes comprised a minor part of fish diversity in temperate estuaries of southern Africa and Western Australia. In contrast, freshwater species can be diverse in warm temperate and tropical estuaries of the western Atlantic (Vieira and Musick, 1994). In Patos Lagoon estuary of southern Brazil, inter-annual variation in estuarine fish diversity is strongly influenced by abundance and richness of freshwater species (Garcia et al., 2003). Non-indigenous freshwater fishes frequently invade estuaries, especially after major hydrological disturbance (Moyle and Light, 1996). Many studies (Lob´on-Cervi´a, 1996; Livingston et al., 1997; Swales et al., 1999; Mol et al., 2000; Garcia and Vieira, 2001) have shown that extreme climatic events (e.g., storms, flash floods, droughts, El Ni˜no) can affect fish community dynamics.

Welcomme (1972, 1983 and 1985) presented a report on the inland waters of Africa, River basins and River fisheries of the world with an in depth appraisal of the hydrology, fishes and fisheries as well as management issue. Miller et al. (1990) had noticed that physical processes in coastal lagoons were influenced most by winds, tides and morphometry. Among the most important morphometric factors are pass dimensions, lagoonal width to length to depth ratios; bottom topography and mean depth. Solarin (1998) reported that the precipitation pattern, seasonal changes and fish species composition as well as the fisheries are all linked to or influenced by the hydrological cycles. The relationships between hydraulics and production in lagoons have been highlighted, among others, by Colombo (1977), Cordell (1978) and Miller et al. (1990). Ardizzone et al. (1988) reported that increased yields can be obtained by stocking additional larvae or juveniles in many lagoons suggests that, the carrying capacity is not exceeded by the numbers, which normally colonize these lagoons. Kusemiju (1973) had reported the occurrence of 28 species of fish in Lekki lagoon. In the adjoining Epe lagoon, Balogun (1980) reported the occurrence of 56 species while in Lagos lagoon, Fagade and Olaniyan (1974) reported the occurrence of 72 species but Solarin (1998) found only 60 species in Lagos lagoon. This variation in species diversity, therefore, instigated this study in this major lagoon. Through this investigation the species diversity and the water quality status of the lagoon with respect to saline water intrusion were ascertained.

MATERIALS AND METHODS

Description of the study area

The Lekki lagoon is one of the largest lagoons in West Africa and it supports a major fishery. The lagoon is located between Lagos and Ogun States of Nigeria and lies between longitude 4° 00’ and 4° 15’ E and between latitude 6° 25’ and 6° 37’N (Figure 1). The lagoon has a surface area of about 247 square kilometers and it is mostly shallow (less than 3.0 m deep), the maximum depth being 6.4 m (Kusemiju, 1973). Lekki lagoon is a freshwater environment fed by the River Oni in the North Eastern part and by Rivers Oshun and Saga in the north western parts of the lagoon. It opens into the sea via the Lagos lagoon and Lagos harbour. The lagoon is transitional in that it connects three south western states (Ondo, Ogun and Lagos). The lagoon is part of an intricate system of waterways made of lagoons and creeks that are found along the coast of South-western Nigeria from the Dahomey border to the Niger Delta.

The two distinct seasons, dry and rainy, are observable in the lagoon, which is typical of the southern part of Nigeria. The fisheries techniques practiced in the lagoon are mostly small-scale based. The lagoon serves as the fish basket of the protein source of the surrounding settlements. The salt water incursion into Lekki lagoon was examined by collecting water samples from Ricket (Ebutte Meta) (Lagos) to Ori-oke Iwamimo (Ondo state) (Figure 1). Six trips were made from Lagos to Ondo state via the coastal road and the villagers along the coast were interviewed to ascertain whether there was any link between the sea and the lagoon. Figure 1 and Table 1 shows 18 sampling stations of water samples for salt water incursion studies from the two ends of the Lekki lagoon. Surface water temperature, pH, electrical conductivity (EC) and total dissolved solids (TDS) were measured *in situ* using Hanna portable pH/EC/TDS/temperature combined water proof tester model HI 98129. Transparency was evaluated by using the secchi disc; dissolved oxygen was determined by Winkler method. Nitrate, phosphate and sulphate were measured according to APHA (1995) standard procedures using Hach spectrophotometer model DR-EL/2. All the analyses were done at the central laboratory of the Department of Chemistry, University of Lagos, Nigeria.

RESULTS

Salt water incursion into Lekki lagoon

The physico-chemical characteristics in the lagoons of the South-Western Nigeria between Ebute metta - Lagos state and Ori-oke Iwamimo-Ondo state is shown in Figures 2 - 9. The Conductivity readings for wet season ranged between 3025 (Station N) and 27500 μScm^{-1} (Station A), while for the dry season it ranged between 466.0 (Station G) and 51400 μScm^{-1} (Station B) (Figure 2). Conductivity values were distinctly higher at stations in the Lagos lagoon (A, B, C) and Mahin lagoon (R, Q, P) with proximity to the sea in the dry season but lower at stations P, Q, R (Mahin lagoon) during the wet season. Values for conductivity were higher in the dry season. The total dissolved solid values for wet season ranged between 905.0 mg/L (Station T) and 12800.0 mg/L in Station B while for the dry season it ranged between 234.0 mg/L (Station G) and 25800.0 mg/L (Station B) (Figure 3). Total dissolved solid values were distinctly higher at stations in the Lagos lagoon (Stations A, B, C, D) and Mahin lagoon (R, Q, P) with proximity to the sea in the dry season but lower at stations P, Q, R (Mahin lagoon) with proximity to the Atlantic ocean in wet season. Total dissolved solid values were higher in the dry season. The pH data for wet season ranged between 6.60 (Station G) and 7.9 (Stations E and T) while for the 6.60 (Station G) and 7.9 (Stations E and T) while for the

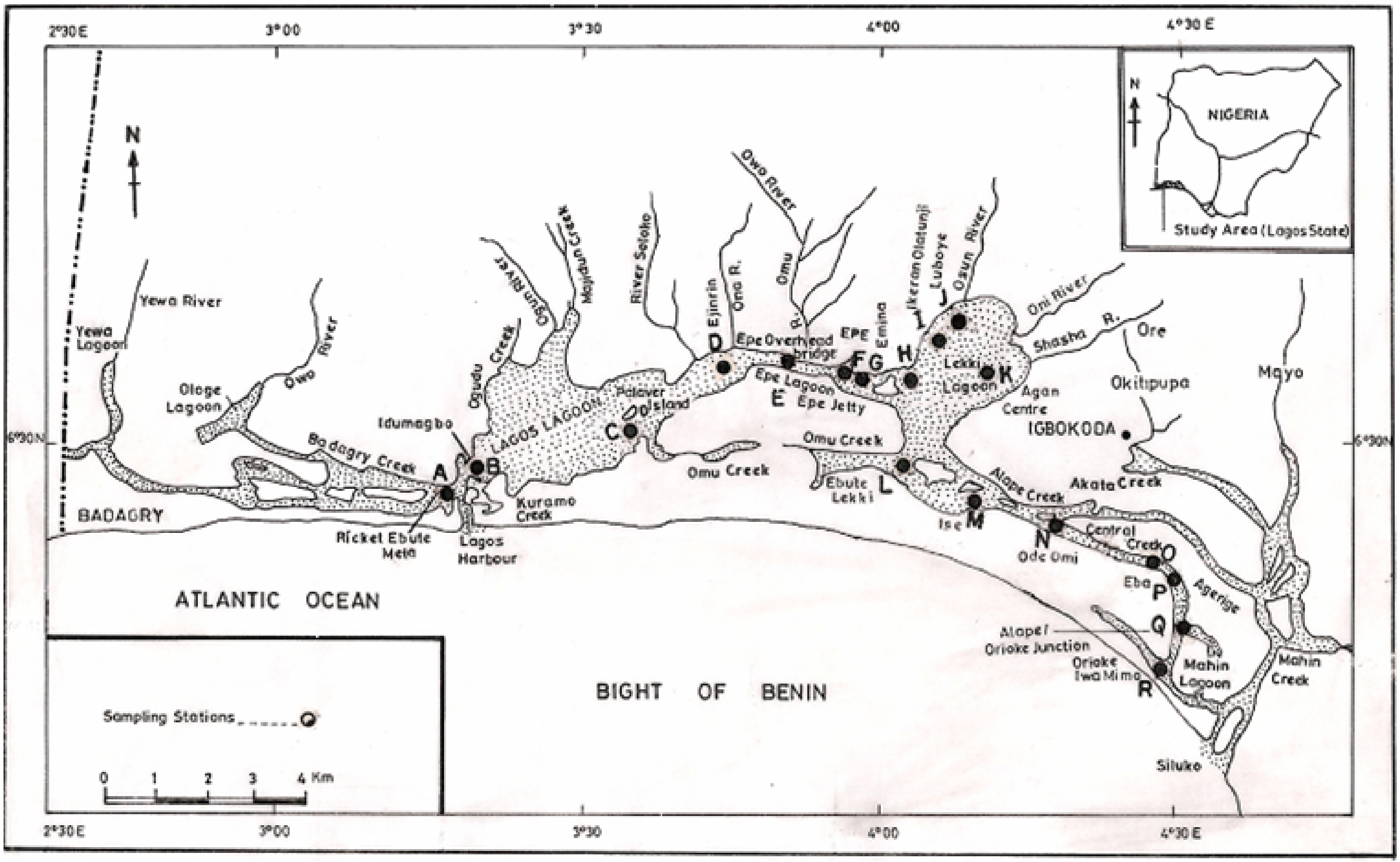

Figure 1. Map of the lagoons of the south – western Nigeria showing water sampling stations (•)

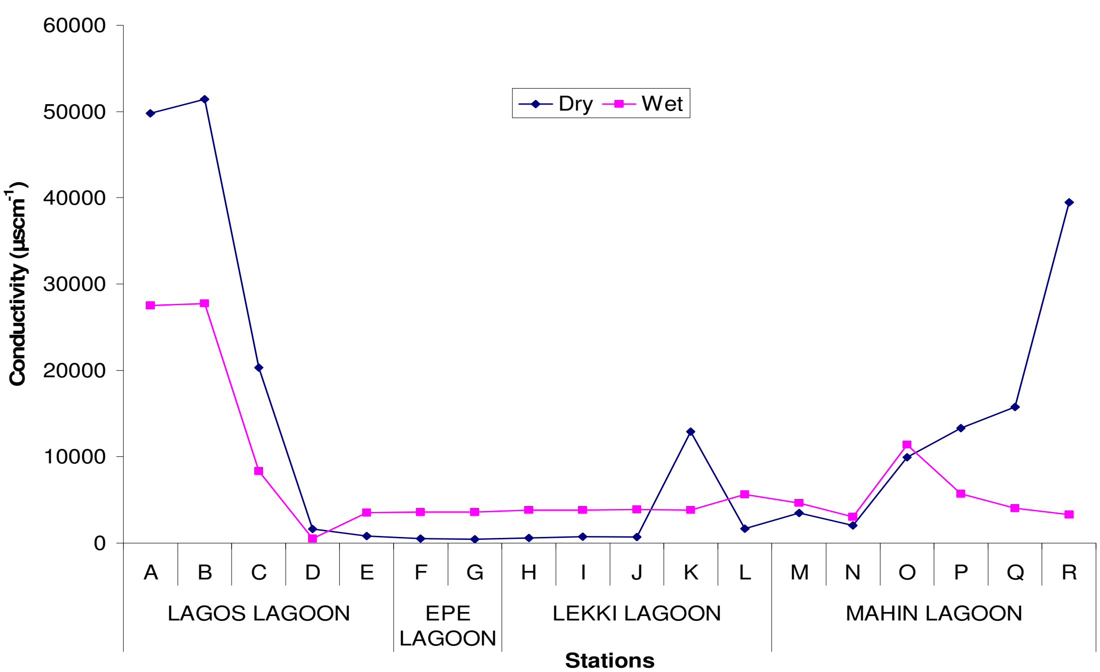

Figure 2. Dry and wet season conductivity variation from Lagos lagoon via Epe and Lekki lagoons to Mahin lagoon in Ondo state.

Table 1. Water sampling stations along the South-Western lagoons (Ebute metta – Lagos state to Ori-oke Iwamimo – Ondo state).

Station code	Water sampling station	Coordinates
A	Ebute meta (Ricket)	06° 28.531N, 003° 23.174E
B	Idumagbo	06° 27.920N, 003° 23.910E
C	Palaver island (Ijede)	06° 31.484N, 003° 33.218E
D	Ijede power house	06° 32.793N, 003°36.450E
E	Ejirin	06° 32.594N, 003°38.059E
F	Epe overhead bridge	06° 34.521N, 003°57.292E
G	Epe jetty	06° 34.607N, 003°58.571E
H	Emina	06° 32.741N, 004°04.845E
I	Ikeran Olatunji	06° 32.232N, 004° 05.386E
J	Luboye	06° 31.910N, 004° 05.589E
K	Agan centre	06° 29.930N, 004° 06.919E
L	Ebute Lekki	06° 26.952N, 004° 09.390E
M	Ise	06° 25. 214N, 004° 13.084E
N	Ode omi	06° 24. 540N, 004° 20. 005E
O	Eba	06° 23. 483N, 004° 29.204E
P	Agerige	06° 20. 476N, 004° 37.345 E
Q	Alape/Ori-oke Iwamimo junction	06° 15. 980N, 004 ° 44.176 E
R	Ori-oke Iwamimo beach	06 ° 15. 957 N, 004 ° 44. 143E

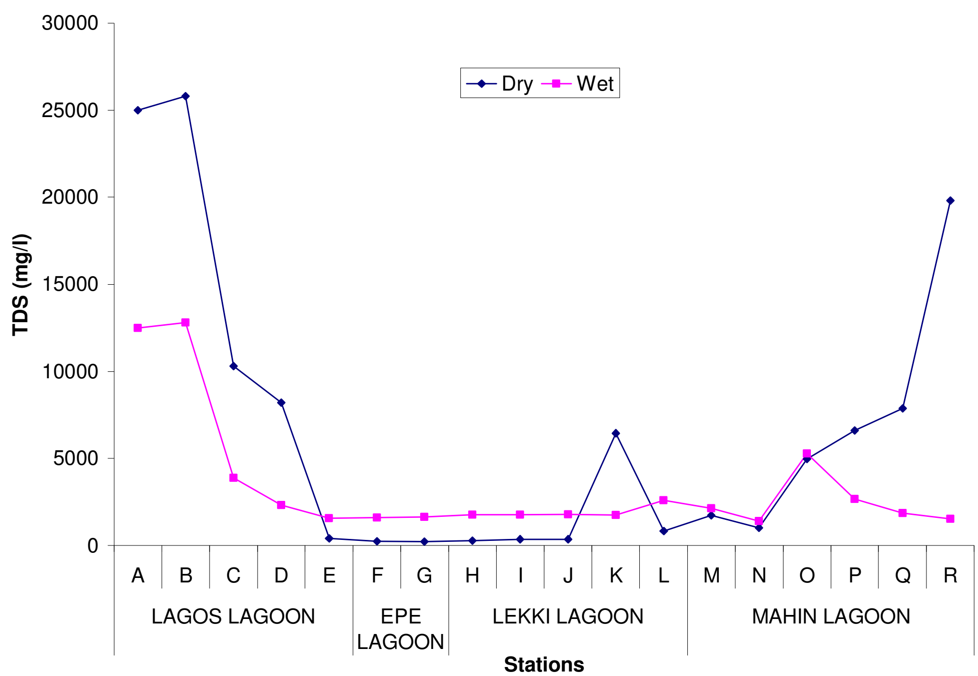

Figure 3. Dry and wet season total dissolved solids variation from Lagos lagoon via Epe and Lekki lagoons to Mahin lagoon in Ondo state.

dry season it ranged between 6.83 (Station R) and 9.33 (Station L) (Figure 4). There were no significant differences in pH values across the lagoons for both the seasons except in station L (Lekki lagoon) where a higher pH value (9.33) was recorded in the dry season.

Values of total suspended solids for wet season ranged between 1.0 mg/L (Stations G, H and M) and 36.0 mg/L in (Station R) while the TSS for dry season ranged between 1.0 mg/L in Station N and 28.0 mg/L (Station A) (Figure 5). Total suspended solids values were distinctly

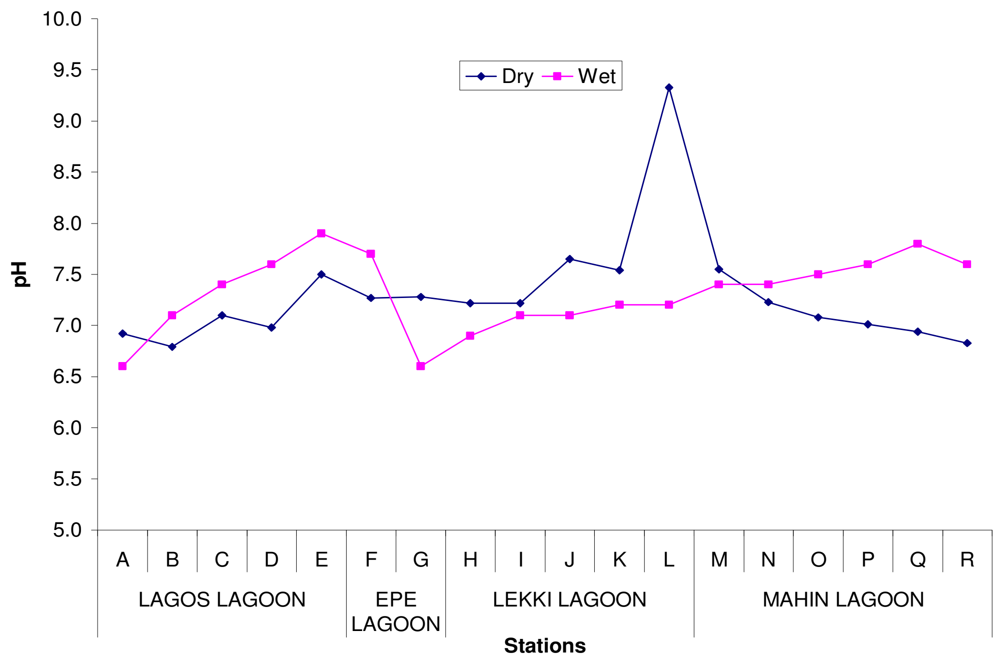

Figure 4. Dry and wet season pH variation from Lagos lagoon via Epe and Lekki lagoons to Mahin lagoon in Ondo state.

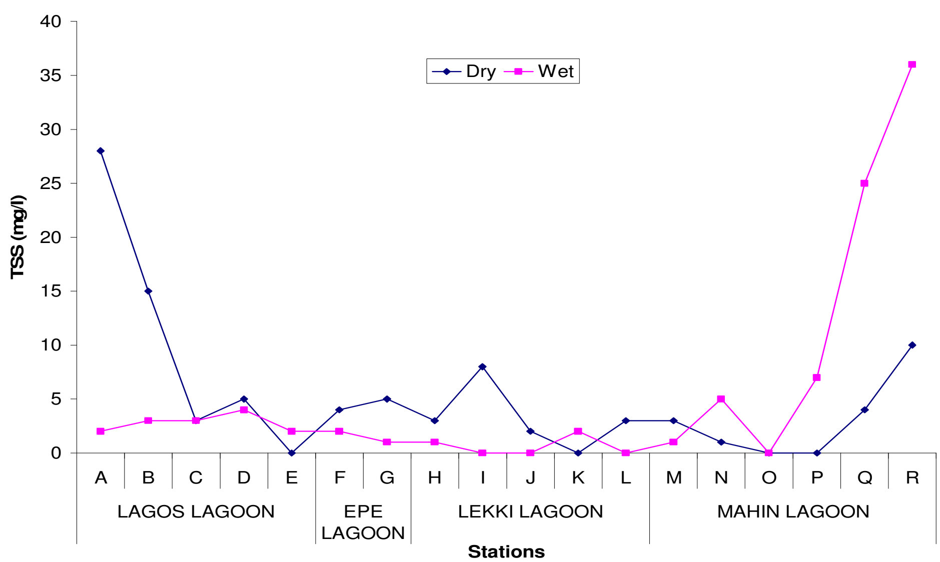

Figure 5. Dry and wet season total suspended solids variation from Lagos lagoon via Epe and Lekki lagoons to Mahin lagoon in Ondo state.

higher at stations in the Lagos lagoon (A, B) for dry and Mahin lagoon (R, Q, P) for both seasons with proximity to the Atlantic Ocean. The salinity data for wet Season ranged between 1.05‰ Station Q) and 15.59‰ (Station S) while for the dry season salinity ranged between 0.40‰ (Station F and J) and 35.6‰ (Station A and B). The characteristic feature of the lagoon is its high bioactivity and a distinctive regime of saline water mixing with fresh water. The data showed, in general, that the salinity decreased with the increase of the distance from Lagos lagoon (Station A) and Mahin lagoon (Station R).This shows that saline water intrusion from the two main adjacent lagoons (Lagos via Epe and Mahin Lagoon) might cause a substantial increase in water salinity of the Lekki lagoon. The salinity at the extreme end station L (3.16‰) during the wet season was the highest in the

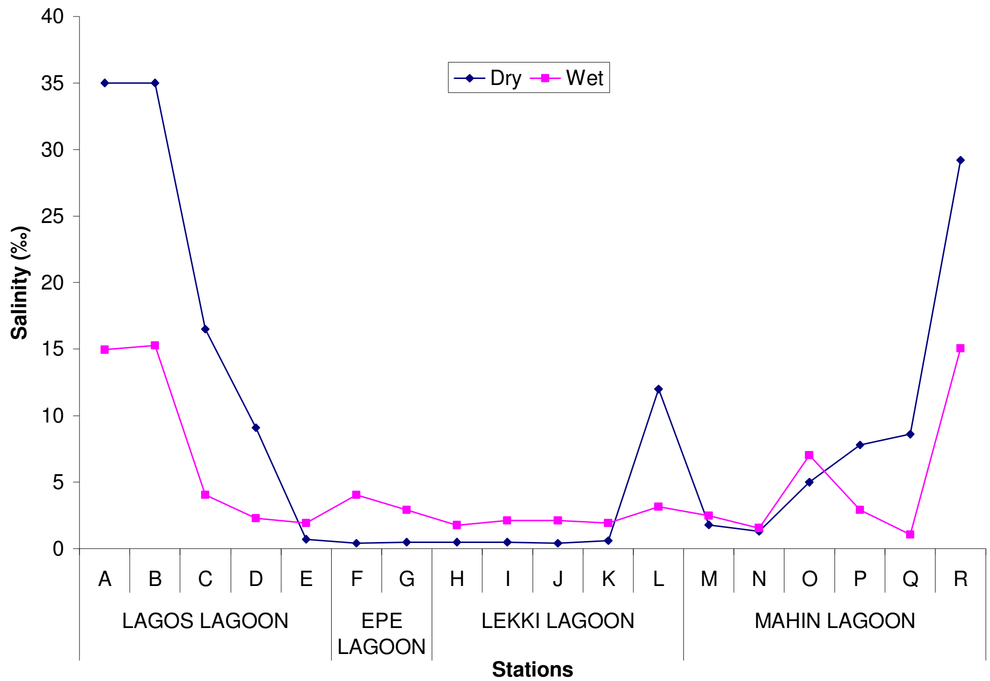

Figure 6. Dry and wet season salinity variation from Lagos lagoon via Epe and Lekki lagoons to Mahin lagoon in Ondo state.

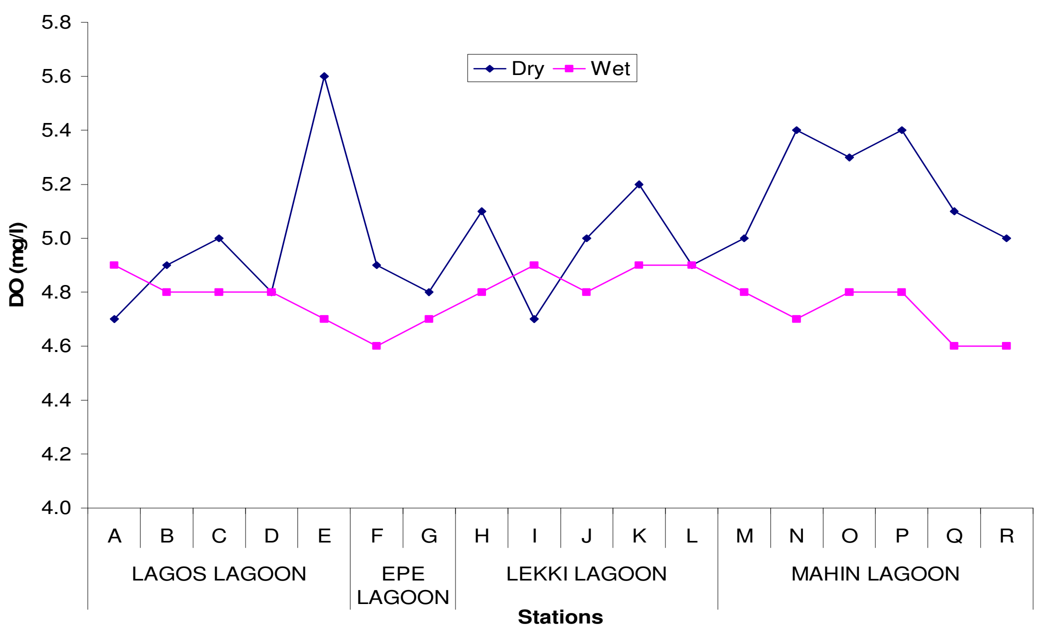

Figure 7. Dry and wet season dissolved oxygen variation from Lagos lagoon via Epe and Lekki lagoons to Mahin lagoon in Ondo state.

lagoon followed end of the lagoon to the Mahin lagoon side, while the least salinity of 0.4 was noted in station J, which is the centre of the lagoon skewed towards the Lagos lagoon end (Figures 6). Also seasonal salinity variations were noticed in the analyzed area of the Lekki lagoon. The dissolved oxygen values for wet season ranged between 4.6 mg/L (Stations F, Q, R and T) and4.9 mg/L (Stations A, I and L), and for the dry season DO values ranged between 4.7 mg/L (Stations A) and 5.6 mg/L (Station E) (Figure 7). The dissolved oxygen level is

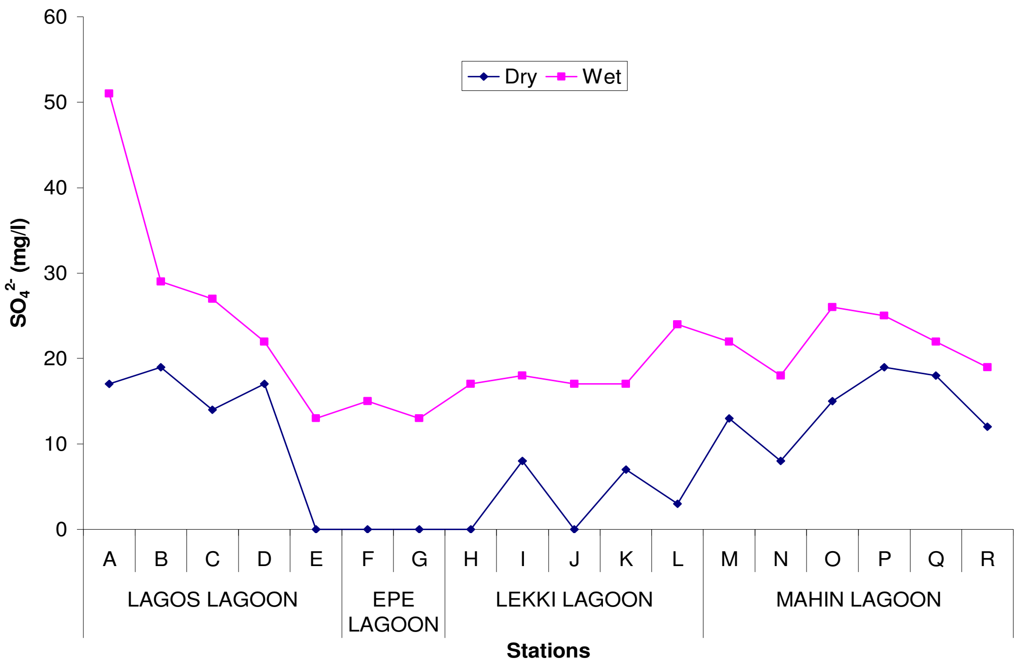

Figure 8. Dry and wet season sulphate variation from Lagos lagoon via Epe and Lekki lagoons to Mahin lagoon in Ondo state.

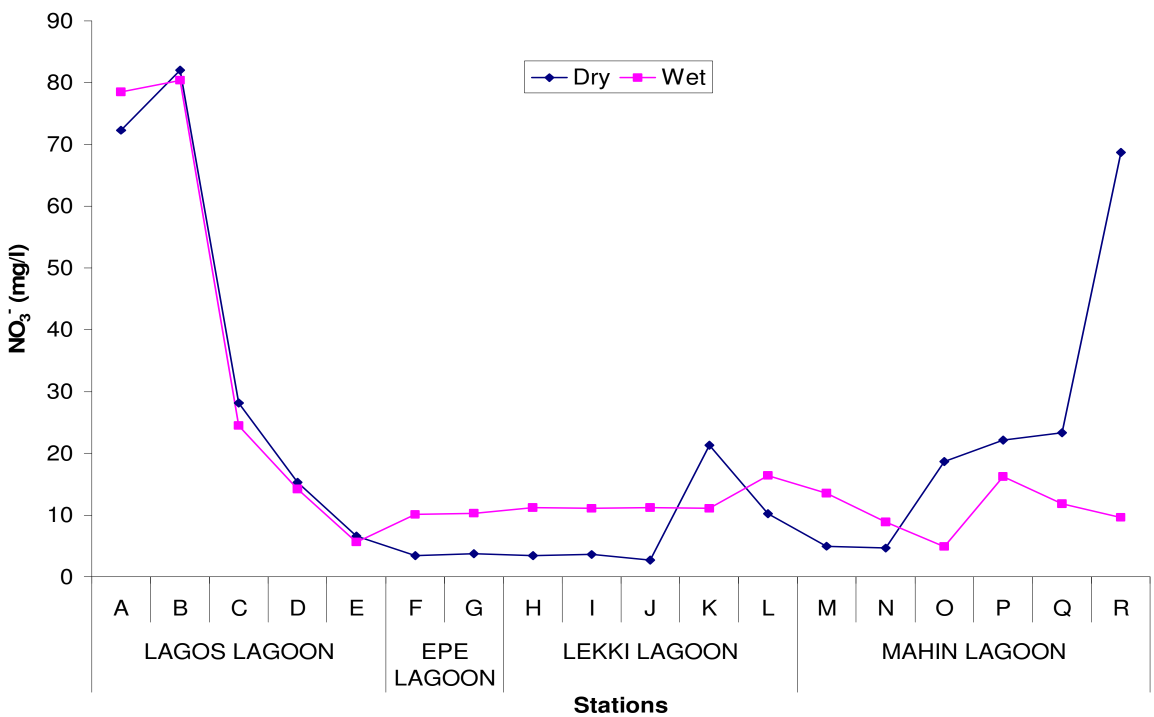

Figure 9. Dry and wet season nitrate variation from Lagos lagoon via Epe and Lekki lagoons to Mahin lagoon in Ondo state.

good for better growth condition of aquatic organisms. There was no distinction in the dissolved oxygen values across the lagoon but the higher dissolved oxygen values were recorded in the dry season. The sulphate content of the study area ranged between 13 mg/L (Station G) and 51 mg/L (Station A) for wet season and between 3.0 mg/L (Station L) and 19.0 mg/L for the dry season (Station B) (Figure 8). There was no distinction in the sulphate values across the lagoon but sulphate was higher in the dry season.

The nitrate composition for wet season ranged between 4.9 mg/L (Station P) and 80.4 mg/L (Station B), and for the dry season it ranged between 2.72 mg/L (Station J) and 82.05 mg/L (Station B) (Figure 9).Nitrate values were distinctly higher at stations in the Lagos lagoon (A, B) for both the seasons, and Mahin lagoon (R, Q, P) for dry season with proximity to the sea in the dry season. High salinity gradients were observed from the two ends of the lagoon. The salinity at the Lagos end tends to decrease toward Lekki lagoon and the same from Orioke Iwamimo end. In this study, two major sources of saline water incursion were identified which were Lagos lagoon and Mahin creek. The third source was, salt water intrusion by subsurface flow through the barrier beach from the ocean and leaching of ions through lagoon bottom sediments as reported by Waljeski and Williams (2004).

Fish fauna composition in Lekki lagoon

A total of 16,960 specimens comprising of juveniles and adults caught with different fishing gears types in the Lekki lagoon, were identified and classified. They included eighty one – fish species belonging to 40 families, 56 genera and 14 orders (Table 2). Decapod crustaceans comprised of the freshwater prawns, *Macrobrachium vollenhovenii* (Herklots) and *Macrobrachium macrobrachion* (Herklots), and the swimming crab *Callinectes amnicola* (De Rocheburne). Table 3 shows a list of fish order, family and species, the size and weight ranges of the fish specimens. Anabantidae was represented by the species *Ctenopoma petherici*. This species was caught mainly with double funnel traps from in and around the river mouth between H and I. Dasyatidae was represented by only one species *Dasyatis garouaensis* (Stanch and Blanc) and being listed in the Lekki Lagoon for the first time. The species was caught with boat seine in the sandy area of the Agan station K and the specimen had a length of 65.0cm, and weighing 400 g. The family mormyridae was represented by twelve species, and had the highest species in the lagoon. Only two specimens of *H. longifilis* were recorded throughout this study.

DISCUSSION

The physical - chemical data from this study show clearly that the Lekki lagoon is an open and low brackish lagoon. The air temperature ranged between 24.0 and 34.0℃ and the water temperature between 26.4 and 32.5℃ during the two year period of March, 2006 to February, 2008. Kusemiju (1981) recorded the air and water temperatures of 21.3 - 31.9℃ and 22.7 - 31.0℃, respectively, over a period of two years in Lekki lagoon. Hayes et al. (1984) recorded air temperature range of 27.0 - 28.2℃ in the Lekki lagoon Solarin (1998) recorded air and water temperatures of 25.0 - 33.2℃ and 25.0 - 32.4℃ over a period of three years in Lagos lagoon, andOnyema et al. (2007) in the range of 27.0 - 31.0℃, also in the Lagos lagoon. The temperature range observed in this study agreed with the observation of Vanden-Bossche and Bernacsek (1990) who recorded surface water temperature range of 27.5 - 34.0℃ in Malonda lagoon in Congo, 25.0 -32.0℃ in Ebrie lagoon, Cote d'ivoire, and a range of 18.0 - 34.3℃ in the brackish water lagoons in Ghana. If the present work was compared to the report of Fagade and Olaniyan (1974) in Lagos lagoon where temperature range was 24.5 – 31.5℃, and Kusemiju (1981) in Lekki lagoon it could be concluded that the temperature had greatly increased as a result of recent changes in climatic characteristics. Though there was no regular pattern in the *in-situ* changes in temperature in the stations sampled (A-E), the monthly mean surface water temperature was slightly higher than the air temperature in most cases as observed by Kusemiju (1981) and Solarin (1998) in Lekki and Lagos lagoon respectively. In general, dry season temperature values were slightly higher because of high radiation from the sun resulting from clear atmosphere and low humidity. The lower temperature during the rainy season could be attributed to the greater cloud cover during the season, which reduced the heating effect of the sun. Higher water transparency wasrecorded during the dry season, an indication of low water turbidity. It is an optical property that expresses the degree to which light is scattered and absorbed by molecules and particles which during the rains was less due to influx of debris from rivers and run-off into the lagoon. The work of Kusemiju (1973) over three decades ago recorded a minimum of 0.52 m in March and 1.04 m in October and attributed the higher turbidity during the rains to discharge of rain water into the Lekki lagoon bringing debris, suspended particles and disturbance at the bottom. On the contrary, in this study, the minimum water transparency observed was 0.80 m (October) and the maximum was 2.13 m in May in the same lagoon. Solarin (1998) recorded minimum water temperature of 0.4 m (June, July) and maximum transparency of 1.9 m in April in Lagos lagoon and this was related to the influx from inland waters, sand extraction and filling of shallow areas in the lagoon and land reclamation for urban development as well as the construction of bridges which increased water turbidity in those areas. The importance of water transparency in the lagoons was reported by Turner and Millward (2002) as a majordeterminant of the condition and productivity of an aquatic system and the tractability of water for human consumption, recreation

Table 2. Fish species composition in Lekki lagoon.

Order/family/species	Total length range (cm)	Standard length (cm)	Weight (g)
Perciformes Anabantidae *Ctenopoma petherici* (Gunther, 1864)	6.0 – 13.5	4.5 – 11.0	20.0 – 95
Centropomidae *Lates niloticus* (Linne, 1762)	10.5 – 60.0	8.2 – 55.0	40.0 – 4000
Carangidae *Caranx hippos* (Linnaeus, 1766)	5.5 – 59.5	4.0 – 53.5	9.0 – 3900
Trachinotus teraia (Cuvier, 1832)	9.5 – 45.0	7.0 – 40.5	20.0 – 3600
Cichlidae *Tilapia guineensis* (Bleeker, 1862)	4.0 – 21.0	3.0 – 19.5	2.81 – 700
Tilapia zilli (Gervais, 1848)	5.5 – 24.0	3.5 – 18.40	5.94 – 530
Tilapia mariae (Boulenger, 1899)	5.7 – 16.0	3.5 – 14.5	3.0 – 410
Chromidotilapia guntheriguntheri (Sauvage, 1882)	5.0 – 12.0	3.0 – 9.5	4.0 – 200
Sarotherodon melanotheron (Rupell, 1852)	4.4 – 16.0	3.0 – 14.0	3.70 – 375
Oreochromis niloticus (Linne, 1758)	6.8 – 26.0	4.5 – 23.0	13.0 – 857
Hemichromis fasciatus (Peters, 1852)	4.4 – 12.0	3.2 – 10.0	4.16 – 120
Hemichromis bimaculatus (Gill, 1862)	3.9 – 10.0	2.5 – 8.5	3.39 – 30.0
Eleotridae *Eleotris vittata* (Dumeril, 1858)	7.8 – 14.5	5.5 – 10.5	7.95 – 150.0
Kribia nana (Boulenger, 1961)	3.4 – 4.5	2.5 – 3.5	3.40 – 10.0
Channidae *Parachanna obscura* (Gunther, 1861)	14.1 – 30.8	11.5 – 28.5	89.5 – 400
Parachanna africana (Steindachner, 1879)	13.0 – 29.5	10.2 – 27.0	79.8 – 390
Pomadasysidae *Pomadasys jubelini* (Cuvier, 1830)	9.3 – 22.0	7.0 – 19.5	19.75 – 309
Lutjanidae *Lutjanus dentatus* (Dumeril, 1860)	9.3 – 22.0	7.0 – 18.0	20.20 – 311
Polynemidae *Polydactylus quadrifilis* (Cuvier, 1829)	18.0 – 105.0	16.0 – 85.0	20.70 – 6000
Gobiidae *Bathygobius soporator* (Valenciennes, 1873)	12.90 – 14.60	10.90 – 12.5	24.8 – 40.0
Goboides ansorgii (Boulenger, 1909)	15.40 – 32.50	13.00 –30.10	25.0 – 65.0
Spyraenidae *Sphyraena barracuda* (Walbaum, 1792)	30.9 – 103.0	27.5 – 87.0	98.5 – 4000
Monodactylidae *Psettias sebae* (Cuvier, 1931)	5.5 – 10.5	3.5 – 8.2	10.5 – 65.0
Distichodontidae *Ichthyborus monodi* (Pellegrin, 1929)	6.0 – 16.5	4.0 – 14.0	16.9 – 66.5
Rajiformes Dasyatidae *Dasyatis garouaensis* (Stauch and Blanc, 1962)	35.0		600
Polypteriformes Polypteridae *Polypterus senegalus* senegalus (Cuvier, 1829)	9.0 – 30.0	7.0 – 28.0	20.5 – 150.0
Erpetoichthys calabaricus (Smith, 1866)	20.2 – 35.5	18.0 – 33.5	19.5 – 50.2
Elopiformes Elopidae *Elops lacerta* (Valenciennes, 1846)	11.0 – 27.0	9.2 – 25.0	9.5 – 241
Osteoglossiformes Pantodontidae *Pantodon buchholzi* (Peters, 1876)	5.6 – 10.0	3.0 – 7.0	10.0 – 20.0
Notopteridae *Papyrocranus afer* (Gunther, 1868)	12.2 – 55.5	10.5 – 52.0	12.5 – 1069
Xenomystus nigri (Gunther, 1868)	12.0 – 45.0	10.0 – 42.0	13.0 – 1050
Osteoglossidae *Heterotis niloticus* (Cuvier, 1829)	14.5 – 54.5	12.0 – 50.5	20.0 - 2000
Mormyriformes Mormyridae *Mormyrus rume* (Valennciennes, 1846)	12.5 – 48.0	9.5 – 46.5	15.6 – 868
Mormyrus macrophthalmus (Gunther, 1866)	12.2 – 30.1	9.2 – 46.5	20.0 – 600
Hippopotamyrus pictus (Marcusen, 1864)	5.5 – 15.5	4.0 – 12.5	15.0 – 50.5
Hippopotamyrus psittasus	6.5 – 25.0	5.0 – 23.0	18.0 – 75.9
Hyperopisus bebe (Lacepede, 1803)	15.6 – 50.0	12.5 – 48.0	20.5 – 850
Mormyrops anguilloides (Linnaeus, 1758)	9.1 – 63.3	7.0 – 60.0	5.8 – 2453
Marcusenius senegalensis (Steindachner, 1870)	9.6 – 27.3	7.0 – 25.3	10.0 – 248
Pollimyrus adspersus (Gunther, 1866)	5.2 – 9.6	3.5 – 7.2	17.0 – 50.0
Marcusenius brucii (Boulenger, 1910)	6.3 – 30.8	5.0 – 28.5	12.1 – 515
Brienomyrus longianalis (Boulenger, 1901)	16.0 – 30.8	14.0 – 28.5	50 – 610
Gnathonemus petersii (Gunther, 1862)	15.0 – 35.0	13.5 – 33.0	48.5 – 590
Mormyrops caballus (Pelledrin, 1927)	9.1 – 46.0	7.1 – 44.2	15.8 – 850
Gymnarchidae *Gymmarchus niloticus* (Cuvier, 1829)	35.0 – 120.0	32.5 – 117	89.0 – 3000
Clupeiformes Clupeidae *Pellonula afzeliusi* (Johnels, 1954)	4.0 – 10.1	3.0 – 8.0	5.0 – 26.0
Ethmalosa fimbriata (Bowdich, 1825)	8.70-14.70	6.80-11.40	5.35-32.26
Characiformes Citharinidae *Citharinus latus* (Muller and Troschal, 1845)	7.0 – 46.0	5.0 – 43.5	25.5 – 1065

Table 2. Cont'd.

Cithranus citharus (Goeffrey Saint Hilane, 1809)	10.0 – 50.0	8.0 – 47.5	45.0 – 2010
Hepsetidae Hepsetus odoe (Bloch, 1794)	7.5 – 30.5	5.6 – 28.8	9.26 – 856
Characidae Alestes macropthalmus (Gunther, 1867)	20.5 – 30.6	18.2 – 29.0	45.0 – 150.0
Alestes baremose (de Joannis, 1835)	10.5 – 40.5	8.5 – 38.2	20.2 – 300
Brycinus nurse (Ruppell, 1832)	5.3 – 20.5	3.8 – 18.2	5.2 – 212
Brycinus longipinnus (Gunther, 1864)	4.8 – 10.7	3.0 – 8.8	3.6 – 41.6
Siluriformes Bagridae *Chrysichthys Walkeri*	5.5 – 36.5	3.5 – 33.6	4.36 – 724
Chrysichthys nigrodigitatus (Lacepede, 1803)	5.8 – 42.5	4.0 – 40.5	5.0 – 1500
Chrysichthys filamentosus (Boulenger, 1912)	5.6 – 38.5	3.8 – 36.8	4.0 – 798
Parauchenoglanis akiri (Risch, 1987)	10.0 – 12.5	8.0 – 10.0	15.9 – 45.6
Auchenoglanis occidentalis (Valenciennes, 1840)	15.0 – 20.0	13.0 - 18.0	24.0 – 50.1
Schilbeidae *Schilbe mystus* (Linne, 1758)	7.0 – 21.0	5.8 – 19.0	4.15 – 119.5
Schilbe uranoscopus (Ruppell, 1832)	6.2 – 28.5	5.0 – 26.5	7.61 – 360
Clariidae *Clarias gariepinus* (Burchell, 1822)	20.0 – 50.5	17.0 – 46.8	78.00 – 1920
Clarias jaensis (Boulenger, 1909)	10.2 – 20.0	7.5 – 17.9	22.8 – 64.25
Clarias agboyiensis (Sydenham, 1980)	11.2 – 21.0	8.5 – 18.7	21.9 – 72.96
Clarias anguillaries (Line, 1758)	9.0 – 34.5	7.2 – 31.5	17.0 – 65.0
Heterobranchus longifilis (Valenciennes, 1840)	40.5 – 50.0	37.8 – 48.5	1002 – 2100
Malapteruridae *Malapterurus electricus* (Gmelin, 1789)	13.0 – 16.5	11.5 – 14.0	60.6 – 89.8
Malapterurus minjiraya (Sagua, 1987)	14.0 – 17.5	12.2 – 15.0	64.7 – 92.0
Mochokidae *Synodontis eupterus*	4.5 – 22.0	3.0 – 20.0	9.2 – 218
Synodontis clarias (Linne, 1758)	5.5 – 22.5	3.8 – 21.0	10.2 – 316
Synodontis couterti (Pellergrin, 1906)	6.5 – 20.6	4.2 – 18.0	10.5 – 212
Synodontis filamentosus (Boulenger, 1901)	5.5 – 18.6	3.0 – 16.2	8.9 – 200
Mugiliformes Mugilidae *Liza falcipinnis* (Valenciennes, 1836)	13.0 – 26.5	10.5 – 19.2	41.6 – 200
Mugil cephalus (Linnaeus, 1758)	12.5 – 20.5	10.0 – 18.0	41.2 – 360
Synbranchiformes Mastacembelidae *Caecomastacembelus decorsei* (Pellegrin, 1919)	14.2 – 36.5	12.5 – 35.0	20.0 – 96.0
Pleuronectiformes Citharidae *Citharus linguatula* (Linnaeus, 1758)	10.30 – 15.0	8.0 – 13.2	9.0 – 15.9
Cynoglossidae *Cynoglossus senegalensis* (Kaup, 1858)	15.6 – 54.0	13.8 – 49.2	20.0 – 460.0
Gonorychiformes Phractolaemidae *Phractolaemus ansorgii* (Boulenger, 1901)	10.5 – 19.0	8.0 – 17.0	17.0 – 56.0
Decapoda Palaemonidae *Macrobrachium vollenhoveni*	6.4 – 13.0	3.00 – 600*	6.06 – 32.4
Macrobrachium macrobrachion	6.4 – 12.00	3.00 – 5.50*	6.04 – 28.29
Portunidae *Callinectes amnicola*	3.4 – 15.5**		19.5 – 115.5

* Carapace length.
** Carapace width.

and manufacturing. The high transparency water in the lagoon during the study supports the life of the fisher folk in the fishing village since the only means of drinking water in the area is the lagoon water. The high transparency increases light penetration for photosynthesis resulting in high phytoplankton production, which serves as natural food for fishes and other aquatic organisms. This is in agreement with the report of Turner and Millward (2002) who remarked that the most obvious effect of increased turbidity was reduction in light availability for photosynthesis. Lekki lagoon is a shallow water body except in station A where a minimum depth of 4.88 m was recorded. Dufour (1987) and Solarin (1998) noted that shallow lagoons tend to be more productive than deep ones on account of the presence of shallow littoral margins, which serve as spawning and nursery ground for fish. According to Brown and Kusemiju (2002) and Onyema (2008), rainfall pattern in the tropics creates the dry and wet season experienced in West Africa. The seasonal differences determine salinity in coastal waters and the distribution of aquatic biota (Brown and Oyenekan, 1998 and Onyema, 2008). The salinity in Lekki lagoon showed a peculiar trend in that rainy season salinity was higher than dry season. This may be as a result of daily intrusion of the ocean into under groundwater table, which was transported by hydraulic gradients in the direction of the lagoon as reported by Waljeski and Williams (2004). A period of significantly higher dissolved oxygen concentration was associated with the peak rainfall season when nutrients and debris were brought into the lagoon with the influx of fresh water from inland rivers. High dissolved oxygen concentrations also corresponded with the low temperature season indicating an inverse relationship (Ajao, 1990). The hydrogen ion index ranged from 6.0 to 9.33. For most parts of each year the pH varied very little. The pH of the environment into which a pollutant is deposited may influence the chemical form, the solubility and its toxicity to exposed biota (Sheehan, 1984; Ajao, 1990). Changes in pH can drastically affect the structure and function of the ecosystem, directly and indirectly. The relatively small pH range in the study area would seem to depend largely on the salinity regime in the lagoon. This is in agreement with Ajao (1990) who reported that the relatively small pH range in the study area would seem to depend largely on the salinity regime in the brackish environment. The dry season was associated with the lowest values of nitrate while gradual increase occurred during the wet season. The levels obtained were possibly governed by the transport of suspended sediments with the influx of inland water into the study area during the wet seasons. Nitrate generally occurred in trace quantities in surface water (< 0.1 mg/l) but was enriched by inputs from other sources (Ajao, 1990).

The dry season was associated with the lowest values of sulphate while gradual increase occurred during the wet season. The levels obtained were possibly governed by the transport of suspended sediments with the influx of inland water into the study area during the wet seasons. This is in agreement with the observation of Olaniyan (1969) and Ajao (1990) who remarked that during rainy season, and in particular from the early rains to the peak of the rains, mineral salts would be leached from the soil into the rivers and thence to the lagoons. Eighty one fish species belonging to 40 families, 56 genera and 15 orders were recorded during this study period. Kusemiju (1973) recorded only 28 species, Ekpo (1982) recorded 43 non-cichlid species in the same lagoon. Solarin (1998) reported that Lekki lagoon, Epe lagoon, Lagos lagoon, Badagry Lagoon and Badagry creek are connected by an intricate network of water ways that open to Gulf of Guinea via the Lagos Harbour mouth. Additionally, this study has also identified two links to Gulf of Guinea, Lagos Harbour and Mahin Creek, and two salinity peaks at both ends. William (1962) recorded 48 species in Lagos lagoon, and Fagade and Olaniyan (1974) recorded 72 fish species in the same lagoon. Also Solarin (1998) recorded 60 fish species belonging to 34 families in Lagos lagoon. Several workers have recognized the phenomena of an optimum salinity level of about 34.7%o associated with diversity of fishes and that any variation from that optimum level would cause variation in the number of species available (Hesse et al., 1951; Hedgepeth, 1957). Grunter (1945) (cited from Ikusemiju, 1973) found that a decrease in salinity from the optimum caused a decline in the number of species. For instance, it was found that of the 112 species commonly caught on the Texas coast, 109 were taken at salinity greater than 30‰, 73 at 20‰ or less and only 39 at les than 5‰. Woolton (1992) noted that species richness was greatest in shallow tropical waters and would decrease as the abiotic conditions become less favourable for life. Macan (1963) (cited from Kusemiju ,1973) observed that where masses of fresh water and seawater adjoined, species from each invaded the brackish region between them, but few penetrated far and the number of species at a point midway between the two was small. So, the increase in salinity from 0.05 - 0.30‰ (Kusemiju, 1973) to 0.02 - 4.70‰ as observed in this study may likely be responsible for the increase in species diversity of the lagoon. Olaniyan (1968) (cited from Solarin, 1998) noted the variable fluctuation in abiotic factors in brackish water restricting the number of species that could exist under such condition, and these few required particular adaptations to enable them to survive. Motwani and Kanwai (1970), who had worked in the completely freshwater environment, recorded 82 species of fish belonging to eighteen families at Kanji Lake, Nigeria. The high number of 81 species recorded for Lekki Lagoon in this study confirmed the fact that the lagoon is a transition area between brackish water (Lagos Lagoon and Mahin Creek) and freshwater (Rivers Saga and Oshun). The fact that there was variation in the salinity of Lekki Lagoon (0.007 - 4.70‰) further showed that the lagoon was not completely a freshwater system. Kusemiju (1973) also confirmed that Lekki Lagoon with a salinity range of 0.05 - 0.30‰ was not completely fresh.

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