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Variations in the physico-chemical parameters of water quality of coastal waters of Lagos State, Nigeria

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ABSTRACT

Background: The marine and brackish waters are dynamic aquatic environment and complex systems mainly influenced by various physical and chemical processes. Physico-chemical parameters such as temperature, rainfall, pH, dissolved oxygen and salinity play important role in influencing the aquatic environment.
Objectives: This study was conducted on physico-chemical water quality parameters of water from marine waters (LC) and brackish waters (LLC) of Lagos state and aimed at assessing the suitability of the environment for fish production.
Methods: Seven (4 LC and 3 LLC) stations were selected and seven physico-chemical parameters were investigated monthly by standard methods of APHA. Data on temperature, pH and dissolved oxygen (DO) were obtained in-situ using mercury-in-glass thermometer, pH meter and DO meter respectively. Salinity, dissolved oxygen, total alkalinity, total suspended and dissolved solids were obtained in the laboratory using standard methods.
Results: The result showed that LC and LLC had pH, 7.74 ± 0.21 and 7.44 ± 0.11; DO 6.88 ± 0.24 mg/l and 7.11± 0.24 mg/l; Temperature 29.04 ± 0.11ºC and 29.0 ± 0.02ºC respectively as mean values. Salinity 29.06 ± 0.68‰ and 10.38 ± 0.48%; TDS 22.58 ± 0.22 mg/l and 8.12 ± 1.14 mg/l and total alkalinity 109.74 ± 0.22 mg CaCo3 /l and 123.5.18 ± 1.12 mg CaCo3 /l showed significant difference between the marine and brackish waters environments at $P < 0.05$.
Conclusions: The water parameters favoured the survival and production of fish from both the LC and LLC water despite the differences in the salinity gradient of the two environments. High dissolved oxygen content indicated that the coastal water of Lagos state can successfully support aquatic life including fish.

Keywords: Physico-chemical parameters, marine waters, brackish water, salinity, temperature, dissolved oxygen

INTRODUCTION

The marine and brackish waters are dynamic aquatic environment and complex systems mainly influenced by various physical and chemical processes. Physico-chemical parameters such as temperature, rainfall, pH, dissolved oxygen and salinity play important role in influencing the aquatic environment. Others are total dissolved solid, total suspended solids, total alkalinity and conductivity. Temperature variation is one of the factors in the coastal and estuarine system, which may influence other Physico-chemical characteristics, the distribution and abundance of flora and fauna (Soundarapandian *et al.,* 2009). Temperature controls the rate of fundamental biochemical process in organism and a limiting factor in the aquatic environment. Rainfall distributive pattern has great impact on both the chemistry of the water and the population dynamics of the fauna and flora of the lagoon (Onyema 2009). Flood waters associated with rainfall are known to enrich the coastal environment, dilute its ionic concentration and break down existing environmental gradients (Nwankwo, 1996). He also reported that in the dry season, freshwater inflow is greatly reduced and seawater enters the Lagoon through the harbour giving rise to marine conditions near the harbour and brackish water extending

far inland.
Dissolved oxygen affects the solubility of and availability of nutrients. It is also an important parameter in primary production. Dissolved oxygen decreased as temperature increased exhibiting the expected physical properties of decreased gas solubility with increasing temperature (Cornell, 2007). Onyema (2009) had attributed high level of dissolved oxygen to the perturbation of water and this was prevalent in the wet season. Salinity has been reported to be one of the most important variables influencing the utilization of oxygen in the estuaries (Marshell and Elliot, 1998) and expressed as the total concentration of electrically charged ions (cations) in water in part per thousand (‰).
Hydrogen ion concentration (pH) is one of the vital environmental characteristics, decides the survival, metabolism, physiology and growth of aquatic organism. Abowei, (2010) reported that pH between 7 and 8.5 should be too ideal for biological productivity. Alkalinity of a water body is a measure of its capacity to neutralize acid to a designated pH (Edopkayi 2005). Alkalinity between 30 and 500mg/l is generally acceptable to fish and shrimp production. This is an indirect measure of concentration of anion in water. This study on Physico – chemical parameters of coastal waters of Lagos state was carried out to assess the water quality of coastal waters in Lagos state and also to provide valuable information on the quality and productivity potential of coastal water of Lagos state.

Materials and Methods

Study Area and sampling sites

The study area covered coastal waters of Lagos State from Yovoyan in Badagry to Lekki Lagoon (Fig. 1). The study area is located between longitude 2º 45´and 3º 60´ and latitude 6º 20´and 6º 34´. This part of the Nigerian coastline covers a distance of approximately 200km. The climate is typical of rainforest/tropical coastal waters with prolonged wet season (April - October) and short dry season (November - March). Relative humidity in the Coastal waters of Lagos state is high throughout the year (73% to 90%) resulting in humid conditions. Meteorological Agency (NIMET) Victoria Island, Lagos, 2011.
Seven sampling sites (A, B, C, D, E, F and G) were selected along the coastal villages of the coastal waters of Lagos state. (Fig.1). Global positioning system (GPS) coordinates of the sampling points are as shown in Table 1.

Collection and Analysis of water sample

Monthly sampling was carried out from four stations from the marine water and three stations from brackish water of Lagos state between 07.00am and 10.00am from August 2009 to July 2011. Surface water samples were collected with 500ml plastic containers from all the stations. Some parameters such as water temperature, hydrogen ion concentration (pH), salinity, water transparency and dissolved oxygen were measured in-situ while other parameters such as total suspended solid and conductivity were measured in the laboratory. Water and air temperature were measured *in situ* using a mercury-in-glass thermometer calibrated from 0 ºC to 100 ºC. For water temperature measurement, the thermometer was allowed to stabilize for about 5 minutes in surface water and reading were taken to the nearest 0.1 ºC. An Oakton pH meter (Model 356 24-00) was used to measure pH. Dissolved oxygen content (DO) was determined with a Jenway DO meter (Model 970). The accuracy of the meters was determined by testing with standard solutions or water sample of known values and the measurements were taken in-situ by immersing the electrode (probes) at a depth of 30cm below the water surface. Salinity was determined using a hand refractometer (Bio marine, Aquafauna model). Water transparency values were obtained in the field using a Secchi disc (Ruthner, 1963). The disc is 20cm in diameter having black and white colour and a graduated line was used to lower the Secchi disc into the water. The depth of which the disc disappeared inside the water and re- appears again was measured. The average of the depths represented Secchi disc visibility or transparency of water.
Conductivity of the water was determined in the laboratory (physical and chemical Oceanography laboratory, NIOMR) using a Horiba 10 multi- meter water checker. The result was expressed in micro-Siemens per centimeters (µs/cm) and total suspended solids were measured using TDS meter (Hanna Hi 98303).

Statistical analysis

All the data presented were means of the

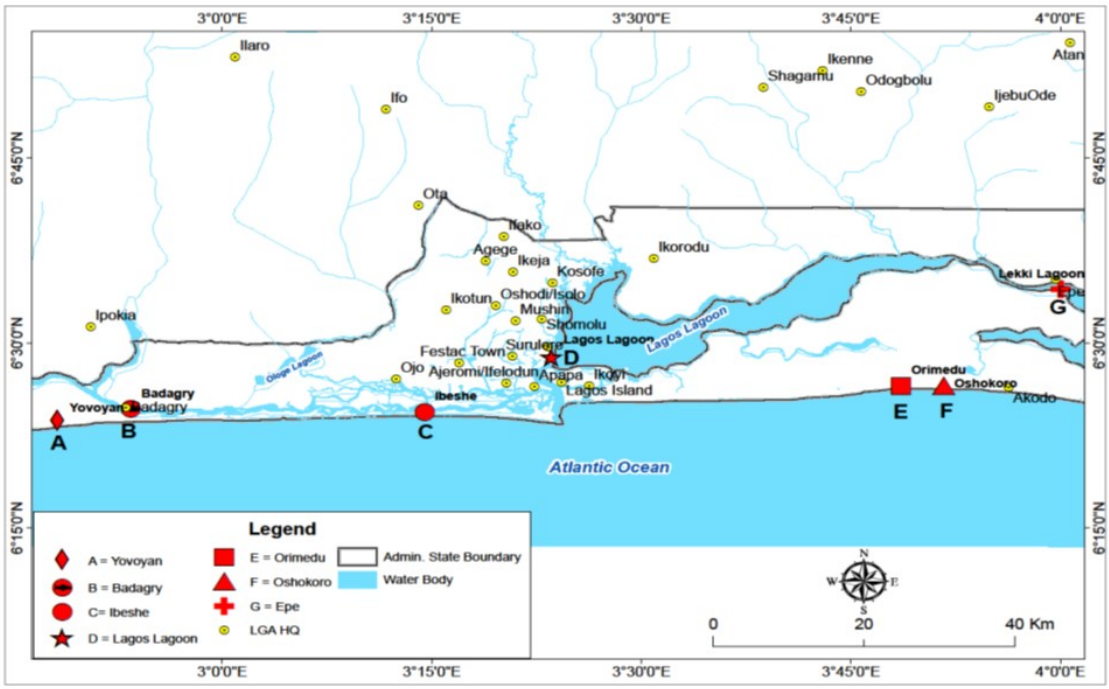


Fig.1: The map of coastal waters of Lagos state showing sampling stations.

Table 1: GPS coordinates of sampling sites on the coastal waters of Lagos state

S/N	Sampling Stations	Code	Northing	Easting
1	Yovoyan	A	2° 47' 44.644"	6° 26' 26.481"
2	Badagry lagoon	B	2° 53' 27.859"	6° 24' 45.133"
3	Ibeshe	C	3° 15' 20.559"	6°24' 17.592"
4	Lagos lagoon	D	3° 23' 50.901"	6° 29' 5.782"
5	Orimedu	E	3° 49' 47.983"	6°26' 27.648"
6	Oshoroko	F	3° 53' 45.614"	6° 26' 26.481"
7	Lekki lagoon	G	3° 59' 50.165"	6° 34' 26.54"

triplicate with standard deviations. The study of correlation reduces the range of uncertainty associated with decision–making, very helpful tools in promoting research and contributing to knowledge.

The correlation coefficient r was calculated using the equation

$$R = \frac{\sum xy}{\sqrt{\sum x^2 X}}$$

Results

Physico-chemical Parameters of Coastal Waters of Lagos State

The results obtained for the Physico-chemical parameters measured in coastal waters of Lagos state from August 2009 - July 2011 are shown in Figures 2-9, Tables 2 and 3.

The surface water temperature ranged from 27.5 ºC to 31.5 ºC with a mean temperature value of 29.01 ± 0.08ºC during the study period. Marine waters temperature ranged from 27.5 ºC to 31.5 ºC (mean 29.04 ± 0.17 ºC) while brackish waters temperature ranged from 27.5 ºC to 31.0 ºC (mean 29.0 ± 0.2 ºC) higher temperature was recorded between December 2009 to February 2010 and also between December 2010 to February 2011. The lowest water temperature of 27.5 ºC was recorded in April 2010 and 2011 in both marine and brackish waters (Fig.2). There was no significant difference between the surface water temperature of marine and brackish waters ($p < 0.05$). There was significant difference in the temperature between the dry and rainy season ($p < 0.05$) in marine waters and no significant difference was observed between the seasons in the brackish waters. Water temperature negatively correlated at $P < 0.05$ with alkalinity ($r = -0.5790$) in LLC and positively with salinity

(r= 0.6723) and water transparency (r= 0.6022) in LC water (Tables 2 and 3).

The pH of LC from 6.5− 8.45 (mean 7.74 ± 0.21) and LLC ranged from 4.5− 8.3 (mean 7.44 ± 0.11). The values were higher between December 2009 and March 2010 (mean 8.1 ± 0.02) and between December 2010 and February 2011 (mean 8.0 ± 0.03) in both water bodies. The pH values were relatively lower during the rainy season months (mean 7.47± 0.21) (Fig.3). Highest pH of 8.45 was recorded in January, 2010 in LC while the lowest value of 4.5 was recorded in May 2010 in the LLC. There was no significant difference between the hydrogen ion concentration of the marine waters and brackish waters ($p< 0.05$). pH did not correlate (r) at $p< 0.05$ with any other physico-chemical variables measured across the water bodies (Tables 2 and 3).

The salinity of the coastal waters during the period of sampling ranged from 0.9‰ to 37 ‰. Marine waters had higher salinity (mean 29.06 ± 0.68‰) than the brackish waters (mean 7.38 ± 0.48‰). Higher values were recorded between December 2010 and February 2011 at the peak of dry season and lower values were recorded during the rainy season in the two water bodies (Fig. 4).

The dissolved oxygen content of the coastal water varied from 5.0 mg/l to 8.08 mg/l (mean = 7.0 ± 0.08) (LC 5.3 -8.08 mg/l, mean 6.88 ± 0.24 mg/l; LLC 5.0 – 8.5 mg/l, mean 7.11 ± 0.24 mg/l). The lowest dissolved oxygen concentration was recorded in December 2009 in LC. The dissolved oxygen content was highest in October, 2010 in the same water body at 8.5 mg/l (Fig. 5). There was no significant difference between the DO of the LC and LLC ($P< 0.05$). The DO of the LC correlated negatively with conductivity (r = -0.5208) and positively with TDS (r = 0.7467) while DO of LLC correlated negatively with conductivity (r = -0.5761) and positively with TDS (r = 0.5856).

Values for transparency ranged between 0.17m and 0.44m in all the stations with mean value of 0.29 ± 0.45m. The water transparency was lower 0.17 m - 0.32 m (mean 0.28 ± 0.12m) in August -November, 2009, while the higher water transparency (mean 0.4± 0.13m) was between November 2010 and February 2011 in the two water bodies with the highest value of 0.44m recorded in December 2010 in LC. Water transparency was relatively higher in marine waters than brackish waters (LC 0.2 - 0.44m (mean 0.31±0.07m); LLC 0.17 m - 0.39 m (mean 0.27±0.07m) (Fig. 6). There was significant difference between the water transparency of the LC and LLC ($p<0.05$). Transparency correlated positively with salinity (r=0.5732) and temperature (r= 0.6022) in marine waters and also with salinity (r=0.5243) in brackish waters.

Alkalinity ranged from 71.0 - 180.2 mg $CaCo_3$ /l with mean value of 116.62±0.47 mg $CaCo_3$ /l (LC, mean value 109.74 ±0.22 mg $CaCo_3$ /l and LLC, 123.5 ± 1.12 mg $CaCo_3$ /l). The highest value of 180.2mg$CaCo_3$/l was recorded in March 2011 in LLC while the lower values were recorded in December 2009 to March, 2010 with the lowest value of 71.0 mg$CaCo_3$/l in December, 2010 in LLC (Fig. 7). There was significant difference between the total alkalinity of the marine and brackish waters ($p< 0.05$). Total alkalinity did not correlate with other physico-chemical parameters in marine waters but correlated negatively with temperature (r= -0.5790) and salinity (r= -0.5813) in brackish waters.

Conductivity of water ranged from 22.05 to 48.41 µS/cm across the sampling station, with a mean value of 36 .0 ± 0.12 µS/cm.The lowest value was recorded in December 2009 in LC (22.08 µS/cm) while the highest value was recorded in March 2010 in the same water body. Conductivity values from brackish waters ranged from 23.0 to 47.4 µS/cm with a mean value of 34.23± 0.19 µS/cm and LC conductivity ranged from 22.05- 48.41 µS/cm with a mean value of 35.18± 0.21 µS/cm (Fig. 8). There was no significant difference between the conductivity of the LC and LLC ($P < 0.05$). Conductivity correlated negatively with dissolved oxygen of marine waters (r = -0.5762) and TDS (r = -5296).

The total dissolved solids ranged between 6.45 mg/l and 38.45 mg/l, with a mean of 25.30 ± 0.09 mg/l. Wet season values (mean: 29.58 ± 1.20mg/l) were higher than dry season values (mean 18.85 ± 0.14mg/l). The highest value of 38.45 mg/l was recorded both in marine and brackish waters in September and October 2010 respectively, and least value of 6.45 mg/l was recorded in marine waters in February 2010. (Fig.9).

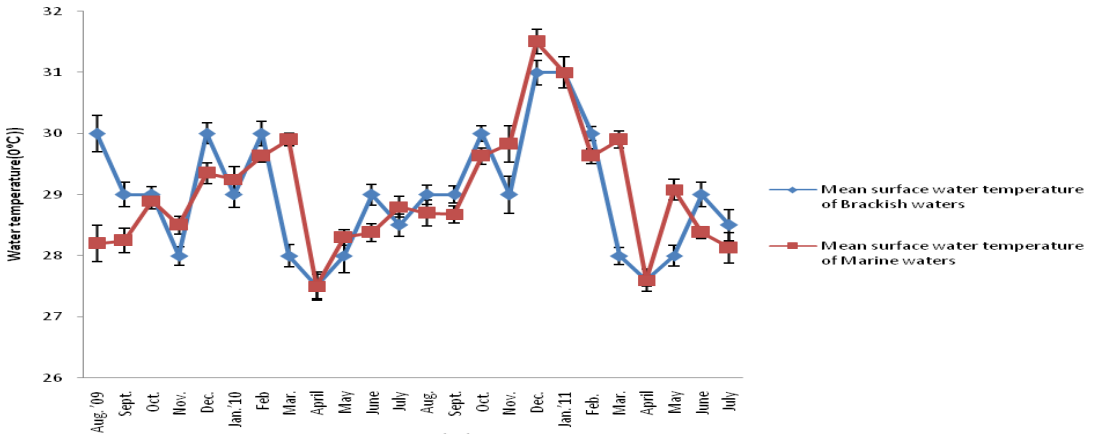


Fig.2: Monthly variation in surface water temperature of coastal waters of Lagos state

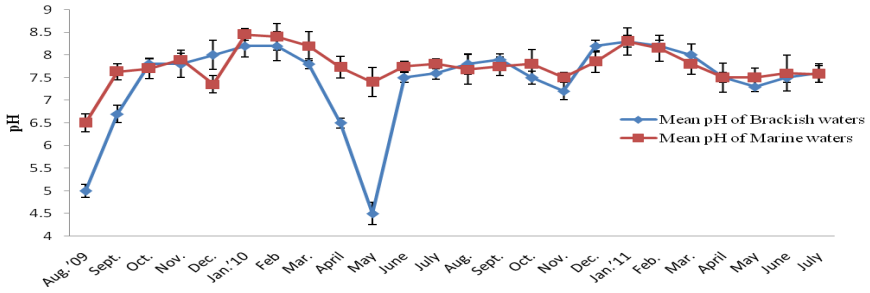


Fig. 3: Monthly variation in hydrogen ion concentration of coastal waters of Lagos state

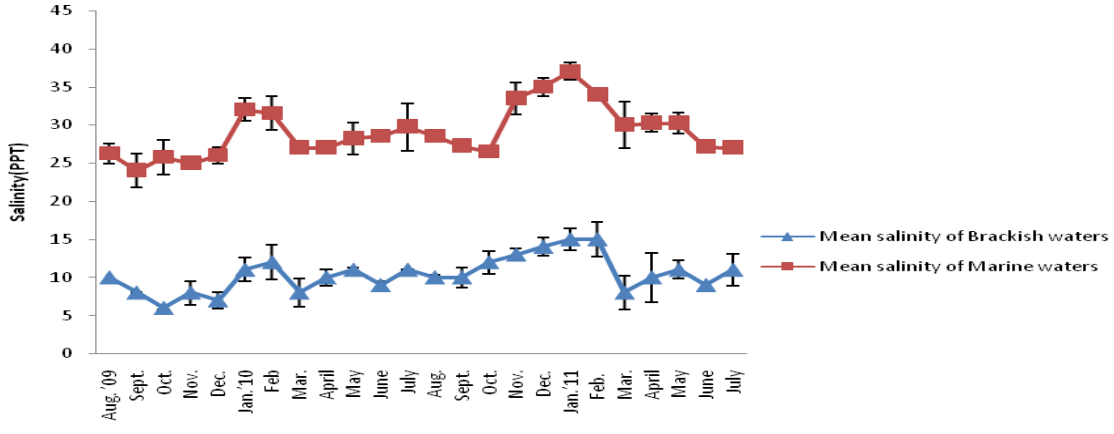


Fig.4: Monthly variation in salinity of coastal waters of Lagos state

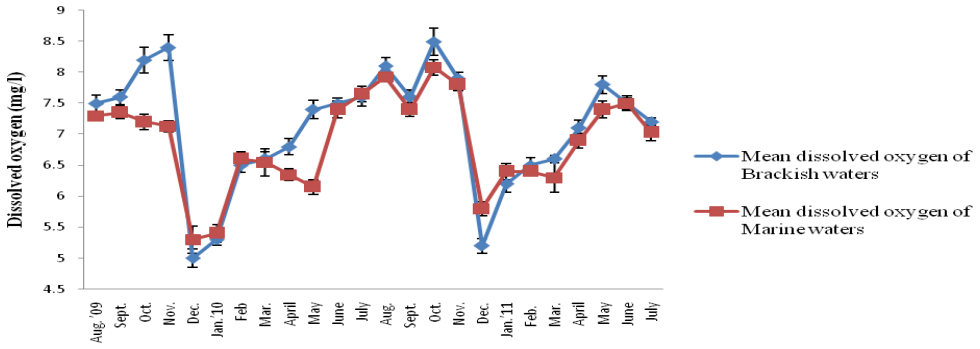


Fig. 5: Monthly variation in dissolved oxygen in coastal waters of Lagos state

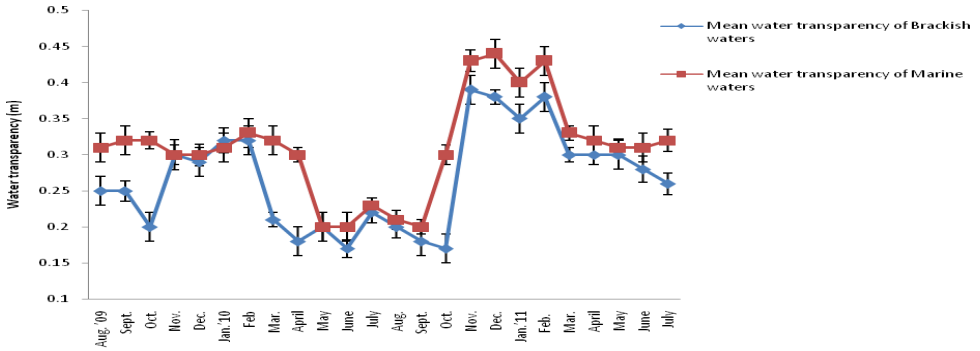
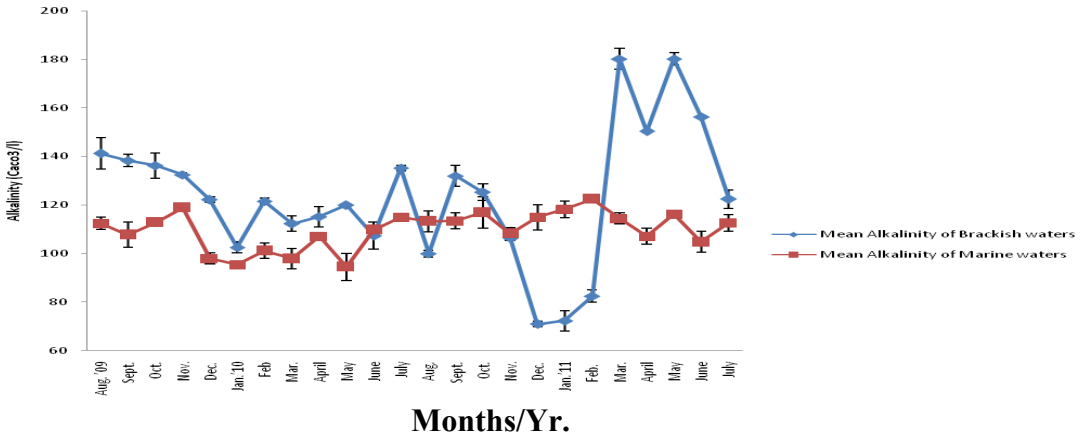


Fig. 6: Monthly variation in water transparency in coastal waters of Lagos state



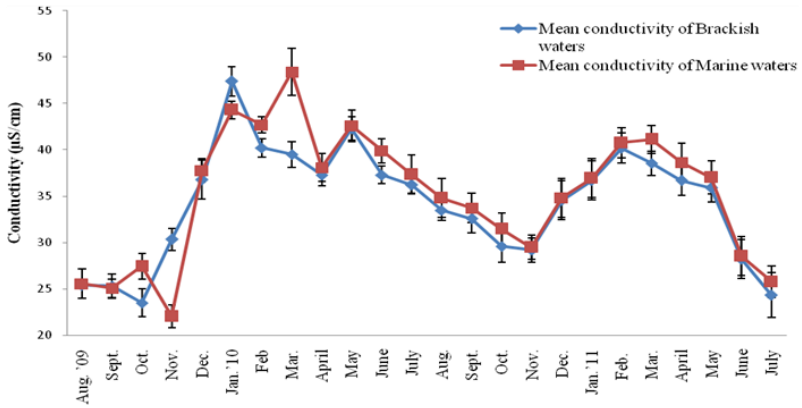


Fig. 8: Monthly variation in surface water conductivity in coastal waters of Lagos state

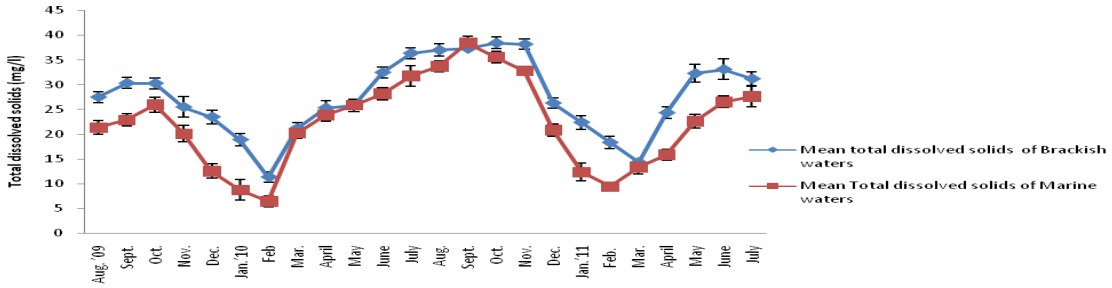


Fig. 9: Monthly variation in total dissolved solids of coastal waters of Lagos state.

Table 2: Correlation coefficient (r) values of physico-chemical parameters of marine water, Lagos state.

	Salinity(°/₀₀)	DO(mg/l)	Transp.(m)	Alka.(Caco3/g)	Cond.(µS/cm)	TDS(mg/l)	Temp.(°C)	pH
Salinity	1.0000							
DO	-0.3011	1.0000						
Transparency	**0.5732**	-0.2788	1.0000					
Alkalinity	0.1909	0.4505	0.2523	1.0000				
Conductivity	0.4198	**-0.5208**	-0.0853	-0.4426	1.0000			
TDS	-0.4064	**0.7467**	-0.4755	0.2446	-0.4599	1.0000		
Temp	**0.6723**	-0.3138	**0.6022**	0.1873	0.2717	-0.3019	1.0000	
pH	0.4446	-0.2941	0.2156	-0.0315	0.4878	-0.3698	0.4666	1.0000

Table 3: Correlation coefficient (r) values of physico-chemical parameters of brackish waters, Lagos state

	Temp(°C)	pH	Salinity(°/₀₀)	DO(mg/l)	Transp.(m)	Alka($Caco_3$/l)	Cond.(µS/cm.)	TDS(mg/l)
Temp	1.0000							
pH	0.2712	1.0000						
Salinity	0.4983	0.1117	1.0000					
DO	-0.3693	-0.3165	-0.2257	1.0000				
Transparency	0.3743	0.3557	**0.5243**	-0.4774	1.0000			
Alkalinity	**-0.5790**	-0.2259	**-0.5813**	0.4041	-0.2439	1.0000		
Conductivity	-0.0930	0.1631	0.2722	**-0.5761**	0.1701	-0.2471	1.0000	
TDS	-0.0793	-0.0865	-0.1513	**0.5856**	-0.3631	0.0812	**-0.5296**	1.0000

KEYS: DO – Dissolved oxygen; Trans- Transparency; Alka – Alkalinity; Cond – Conductivity; TDS – Total Dissolved solid

Discussion

The rainfall followed the pattern of tropical rainforest with distinct rainy season (April to October) and dry season (November to March) when rainfall was reduced. Higher value recorded in the months of April, June and July with peak in July 2011 and one month recorded no rain (January 2011) during the sampling period showed variation in the persistence of rainfall throughout the study period. The relative humidity was generally high throughout sampling period in the coastal waters of Lagos State and the lower values recorded in dry season than the rainy season could be associated to the thicker cloud cover during raining season. Temperature variation is one of the factors in the coastal and estuarine system which may influence other physico-chemical characteristics, the distribution and abundance of flora and fauna (Soundarapandian *et al.,* 2009). Values obtained for water temperatures in the two water bodies were within the acceptable levels for survival, metabolism and physiology of aquatic organism. This result agreed with previous reports that the temperatures in tropics vary between 21^0C and 32^0C (Ugwumba and Ugwumba, 1993; Ayodele and Ajani, 1999, Kamran *et al.,* 2003). Solarin (1998) recorded air and water temperatures of 25.0- 33.0 ºC and 25.0- 32.4ºC over a period of three years in Lagos Lagoon, temperature range of 27 – 31 was also recorded by Onyema (2009) in Lagos Lagoon and Ayoola and Kuton (2009) reported temperature range of 26.6 ºC and 31.0 ºC in Lagos Lagoon. Nwoji *et al.,* 2010 who recorded relatively uniform temperature for both water and air in the Lagos Lagoon, attributed this to the conservative nature of these parameters in the lagoon. Water temperature was generally low during the period of heavy rainfall in both marine and brackish waters probably due to cloudy sky and rainfall which reduced the heating effect of the sun and brought down the temperature to the minimum level. Higher water temperature recorded during the dry season can be attributed to high radiation from the sun resulting from clear atmosphere and low humidity. Similar observations have been reported by Sundaramanickan *et al,* (2008).

The variation in pH was very small for most of the sampling period. 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 both brackish and marine environment, this is in agreement with Ajao (1990) who reported that the relatively small pH range in the brackish water would depend largely on the salinity regime in the brackish environment. The pH concentration gets changed with time due to the changes in temperature, salinity and biological activity. Moyle (1993) reported that a livable pH value is from 5.5 to 10 and less than 6 can result in marked decrease in some fish oogenesis, egg fertility or growth of fry, or egg hatchability and growth (Mathews, 1998). The most productive waters, however are those that slightly alkaline (pH 8) (Moyle, 1993).

The seasonal variation in pH values observed in this study is in agreement with result of previous studies conducted by Dublin- Green (1990) in Bonny River where the highest pH values were recorded in the dry season and lower values in the rainy season. High pH during the dry season may be attributed to the chemical removal of free dissolved carbon dioxide through CO_2, HCO_3, CO_3 link and increase in photosynthetic activity during this period could result in the withdrawal of the carbon dioxide which would otherwise buffer the pH (Egborge, 1977). Similar report was given by Ekeh and Sikoki (2003) in the New Calabar River and Ansa (2005) in Andoni flats of the Niger Delta area. Ikomi *et al.* (2003), Idowu and Ugwumba (2005) also reported that the pH values were alkaline during the dry season and slightly acidic during the raining season.

Salinity is one of the important factors which profoundly influence the abundance and distribution of the animals in estuarine environment and inshore waters. The low values recorded during March to October is due to heavy rainfall and large quantity of freshwater inflow. Highest value recorded in the January 2011 in marine water is due to low rainfall, decreased freshwater inflow and rise in temperature. Salinities observed in the brackish waters were slightly brackish and fell within the range reported by Edokpayi *et al.,* (2008 and 2010). The findings in this study agrees with research works carried out by different authors on salinity of sea surface water, harbor and main lagoon system in Nigeria and West Africa (Ajao, 1990; Dublin – Green, 1990; Oyewo 1998; Ayoola and Kuton, 2009; Abowei, 2010 and Lawanson, 2011). Dilution or low salinity values, recorded in the month of April to October in West Africa, usually coincide with the rainy season when high volumes of freshwater are

discharged into coastal or estuarine waters.

Dissolved oxygen in water is a very important parameter in water analysis as it serves as an indicator of the physical, chemical and biological activities of the water body. The highest value of 8.3 mg/l recorded in the month of August, 2010 is an indication of low water temperature and increased aeration because of heavy rainfall. This report agreed with work of Ayoade *et al.,* (2006) that the DO concentration at Asejire Lake attained its peak at the height of raining season. A DO of not less than 5.0 mg/l is required to sustain fish and other aquatic lives (Ayodele and Ajani, 1999). It also has the tendency of improving the water quality by oxidizing poisonous gases. UNESCO/WHO (1978) reported that coastal water requires a minimum of 4.0mg/l and perform better with 5.0 mg/l of DO to provide for option ecosystem.

Low water transparency recorded during the raining season (August and November, 2009) in both marine and brackish water could be attributed to influx of turbid water and runoffs into the coastal waters thereby decreasing light penetration and decrease in sunlight intensity due to presence of heavy cloud in the atmosphere which in turn reduced the quantity of light reaching the water (Anetekhai, 1986). High alkalinity above 500 mg/l is usually associated with high pH values, hardness and high dissolved solid. Water with alkalinity less than 7.5 mg/l especially some surface waters and rainfall is subject to changes in pH due to dissolved gases that may be corrosive. Alkalinity values reported during the study period were beyond the range of 20 – 150 mg/l considered to contain suitable quantities of carbon dioxide (CO_2) to permit plankton production for fish culture (Fagade and Olaniyan, 1973).

Total dissolved solids affect metabolism and physiology of fish and other aquatic organisms. Higher values of TDS recorded during the rainy season months than dry season months with peak in September and October 2010 in both marine and brackish waters could be due to erosion over flooding of the season; when particulate matters from the neigbouring of the coastal water course were carried into the water bodies. Values recorded in this study for both water bodies (6.45mg/l – 38.45mg/l) were still within the acceptable limit. According to Boyd, 1997 most aquatic ecosystems involving mixed fish fauna can tolerate TDS levels of 1000mg/l. Conductivity estimate the amount of total dissolved salts (TDS) or the amount of dissolved ions in the water and it's the measure of water capability to pass electrical flow which is directly related to the concentration of ions in the water. Conductivity values recorded in this study for marine and brackish waters (22.08- 48.41µs/cm) were within the acceptable limit. Werner *et al*. (2012) reported the permissible of conductivity at 1000 (micro mhos/cm).

Conclusion

Variations in the physico-chemical parameters of water quality of coastal waters of Lagos State, Nigeria has been carried out. In this study the water quality parameters of marine and brackish waters were assessed to determine the health status and suitability of the environments for fish production. The result revealed that the water parameters favoured the survival and production of fish from both the brackish and marine water despite the differences in the salinity gradient of the two environments. The temperature, pH, salinity, dissolved oxygen, transparency, total alkalinity and conductivity values obtained in this study were within the recommended values of world health organization (WHO) and United State Environmental Protection Agency (USEPA) for survival, metabolism and physiology of aquatic organisms. High TDS values recorded during the study was as a result flood and anthropogenic activities within the catchment area. In addition, it was noted that high dissolved oxygen content revealed that the coastal water of Lagos state can successfully support aquatic life including fish. It is therefore recommended that measures be put in place to reduce the release of waste into the water bodies, and also, flooding should be checked to ensure healthier aquatic environment.

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References

Abowei, J.F.N. (2010): Salinity dissolved oxygen, PH and surface water temperature conditions in Nkoro River, Niger Delta, Nigeria. *Adv. J. Food Sci. Technol.,* 2(1): 16 – 21.

Ajao, E.A. (1990): The influence of domestic and industrial elements on populations of sessile and benthic organisms in Lagos lagoon. Ph.D. Thesis, University of Ibadan, Nigeria.

Anetekhai M.A. (1986). Aspects of the bio ecology of the African river prawn *Macrobrachium vollenhovenii* (Herklots) in Asejire Lake, Oyo State, Nigeria. PhD Thesis, University of Ibadan, p. 225.

Ansa. E.J. (2005). Studies of the benthic Macrofauna of the Andons flats in the Niger Delta area of Nigeria. Ph.D. Thesis University of Port Harcourt, Port Harcourt, Nigeria. pp 242.

Ayoade, A.A., Fagade, S.O. and Adebisi, A.A. (2006). Dynamics of limnological features of two – made lake in relation to fish production. *Afr. J. Biotechnology*, 5: 1013 – 1021.

Ayodele, I.A. and Ajani, E.K. (1999). Essentials of fish farming (Aquaculture) Odufuwa press, Ibadan 46p.

Ayoola, S.O. and Kuton, M. P. (2009). Seasonal variation in fish abundance and physicochemical parameters of Lagos lagoon, Nigeria. *African Journal of Environmental Science and Technology* 3 (5): 149-15.

Boyd, C.E. 1997. Water Chemistry and Plankton in unfertilized ponds in Boyd pastures and in woods. *Transaction of the American Fisheries Society*, 105, 634-636.

Cornell L.P. 2007. Patterns of Dissolved oxygen, Productivity and Respiration in Old woman Creek Estuary, Report Submitted to: ODNR Div. of Wildlife. June 2007.

Dublin – Green, C.O. (1990). Seasonal variations in some physio-chemicals parameters of the bony estuary, Niger Delta. NIOMR. Tech. paper 591:5.

Egborge, A.B.M. (1977). The Seasonal variation and distribution of phytoplankton of the lake Asejire. A new impoundment in Nigeria. *Proceeding of International conference on Kainji Lake. University of Ife. The Ecology of Lake Kainji. University of Ife., Ile-Ife Nigeria.* Pp.136-145.

Edokpayi, C.A. 2005. Variation of chemical constituents of a brackish water prawn habitat in southern Nigeria. *Acta SATECH*, 2 (1): 11-18.

Edokpayi, C.A., Olowoporoku, A.O. and R.E. Uwadiae (2010): The hydrochemistry and microbenthic fauna characteristics of an urban drawing Greek. *International J. Biodiversity and conservation,* 2(8): 196 – 203.

Edokpayi, C.A., Uwadiae, R.E., Asoro A.O. and A.E. Badril (2008): Phytomacro invertebrates' arthropods associated with the roots of *Eichorrnia crassipes* (water hyacinth) in a tropical West African Lagoon. *Ecology, Environment and conversation*, 14 (2 – 3): 241 – 247.

Ekeh, I. B. and Sikoki, (2003). The state and seasonal variability of some physio-chemical parameters in the new Calabar River, Nigeria *Supp ad Acta Hydrobiol*., 5.45-60.

Fagade, S.O. and Olaniyan C.I.O. (1973). The food and feeding interrelationship of the fishes in the Lagos lagoon. *J. Fish Biol*. 5(2):205-225.

Idowu, R.B. and Ugwumba, A.A.A. (2005). Physical, chemical and benthic fauna characteristic of a southern Nigerian reservoir. *The zoologist* 3:15 – 25

Ikomi. R.B., Iloba K.I. and Ekure, M.A. (2003). The physical and chemical hydrology of River Adofi at Utagbo – Uno Delta state. Nigeria. *The zoologists*, 2: 84 – 95.

Kamran, T., Mohammed, A., Abdus, S., Mohammed, L. and Tasveer, Z. 2003. Study of the seasonal variation in the Physico- chemical and biological aspects of Indus River Pakistan. *Pakistan Journal of Biological Science* 6. 21: 1795-1801.

Lawanson (2011). Physico – chemical parameters and heavy metal contents of water from the mangrove swamps of Lagos lagoon, Lagos Nigeria. *Advances in biological research* 5 (1): 08 – 21.

Marshall, S. and M. Elliot, 1998. Environment influences on the fish assemblage of the Humber estuary, U.K. *Estuary Coastal Shelf Sci*., 46(2): 175-184.

Mathews, W. (1998). Patterns in freshwater fish ecology. Kluwer Academic publishers, New York. Pp 365

Moyle, P. (1993). Fish; An Enthusiast's Guide, Barley. University of California Press.

Nkwoji, J.A., Yakub, A., Ajani, G.E., Balogun K. J., Igbo J.K., Renner, K.O., Ariyo, A.A. and Bello, B.O. 2010. Seasonal variation in the water chemistry and benthic macroinvertebrates of a south Western Lagoon, Lagos, Nigeria. *J. Am. Sci.,* 6: 85-92.

Nwankwo, D.I. (1996). Phytoplankton diversity and succession in Lagos lagoon, Nigeria. *Archiv Fur Hydrobiologie.* 135 (4): 529-542

Onyema, I.C., (2009). The water chemistry, phytoplankton biomass (Chlorophyll a), Episaammic and Periphytic Algae of the Apese Lagoon, Lagos. *Rep. Opin.,* 1(5): 31-40.

Oyewo. E.O. (1998): Industrial sources and distribution of heavy metals in Lagos lagoon and their biological effects on estuarine animals. PhD. Thesis, University of Lagos, Nigeria 279 pp.

Solarin, B.B. (1998). The hydrobiology, fishes and fisheries of the Lagos lagoon Nigeria. Ph.D. Thesis. University of Lagos. P.235

Soundarapandian, P., Premkumar, T. and Dinakaran, G.K. (2009). Studies on the physico-chemical characteristic and nutrients in the Uppanar estuary of Cuddalore, South east coast of India. *Curr. Res. J. Biol. Sci.*, 1(3): 102-105.

Sundaramanickam A., Sivakumar T., Kumaran R., Ammaiappan V., Velappan R. (2008). A comparative study of physico-chemical investigation along Parangipettai and Cuddalore coast. J. Environ. Sci. Technol., 1 (1): 1-10.

Ugwumba, A.O. and Ugwumba, A.A.A. (1993). On the biology of the black jaw tilapia, *Sarotherodon melanotheron* (Ruppell) in a tropical freshwater lake. *Nig. J. Res. Rev. Sci* 1: 12 – 25.

UNESCO/WHO (1978): Water quality survey. Studies and reports in hydrology, No 23. Paris: United Nation Educational scientific and cultural organization and world health organization.

Werner, A.D., Bakker, M., Post, E.A.V., Vandenbohede, A., Lu, C., Ashtiani, B., Simmons, T.C., and Barry, D.A. (2012): seawater intrusion processes, investigation and management: Recent advances and future challenges", *Advances in Water Resources*, Elsevier, 51, pp. 1-26.