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SPATIAL AND TEMPORAL LIMNOLOGICAL STATUS OF ERELU RESERVOIR, SOUTHWESTERN NIGERIA

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ABSTRACT

Water quality monitoring is essential for determining the current condition and long-term trends of a reservoir for effective management. The spatio-temporal dynamics of the trophic lake is crucial in defining its water quality as well as biodiversity. Hence, the physico-chemical parameters and primary productivity of Lake Erelu were monitored for twenty-one months (July 2013 - March 2015) to determine its suitability for sustainable fish production. The study area was temporally and spatially stratified. Temporal stratifications covered wet (April to October) and dry (November to March) seasons. Spatially, the lake was divided into lower (LZ), middle (MZ) and upper (UZ) zones based on geographical locations. Four sampling points were randomly selected in each zone. Water samples were collected monthly from each of the sampling points following standard methods and analyzed for variables such as biological oxygen demand (BOD), Nitrate (NO_3^-), Lead (Pb) and primary productivity (NPP). Mean value obtained for BOD in UZ (2.62 ± 0.25 mgL^{-1}) and LZ (2.59 ± 0.26 mgL^{-1}) were significantly different from MZ (2.42 ± 0.41 mgL^{-1}), whereas no significant difference exists between wet (2.56 ± 0.28 mgL^{-1}) and dry (2.51 ± 0.39 mgL^{-1}) seasons. NO_3^- in wet (0.66 ± 0.07 mgL^{-1}) and dry (0.70 ± 0.05 mgL^{-1}) differ significantly but between UZ (0.67 ± 0.07 mgL^{-1}), MZ (0.68 ± 0.06 mgL^{-1}) and LZ (0.67 ± 0.06 mgL^{-1}) no significant differences occurred. Pb in LZ and UZ (1.46 ± 0.44 and 1.19 ± 0.53 mgL^{-1}) and wet (1.07 ± 0.63 mgL^{-1}) and dry (1.41 ± 0.52 mgL^{-1}) were significantly different. NPP did not differ significantly between seasons and between spaces. The physico-chemical parameters revealed seasonal and spatial variations which fall within desirable limits for fish production. Also, the lake was more productive during the dry season than rainy season.

Key words: Water quality, Heavy metals, Erelu lake, Desirable limits.

INTRODUCTION

Water is the basis of life and one of the most precious commodities required for survival of any forms of life (Dirican, 2015). Its resources are of critical importance to both ecosystem and human development. They provide habitat, sanctuary and food for many species of fish and wildlife and are also a source of process water to a myriad of industries (Kareem, 2017). The quality of surface water is largely affected by natural processes (weathering and soil erosion) and anthropogenic inputs (municipal and industrial waste water discharge). According to Olanrewaju *et al*., (2017), the anthropogenic discharge represent a constant polluting source, whereas surface run offs is a seasonal phenomenon, mostly affected by climatic conditions. Effluent discharges from industries contribute a serious environmental threat to water quality and aquatic resources, including biodiversity. However, declining water quality in freshwater lakes and reservoirs is an increasing problem that threatens the ecosystem services to the riparian communities especially, in developing countries.

Water quality monitoring is essential for determining the current condition and long-term trends of a reservoir for effective management. The free style way of disposing agricultural, industrial and domestic effluent into natural water bodies in many communities may cause serious contamination (Olanrewaju *et al.* 2017). Major activities that can impact on the quality of water includes: chemical and pesticides released by agricultural activities, effluents discharged from aquaculture, solid wastes dumped from residential areas and fishing of juvenile fishes by local fishermen (Kareem, 2017). The quality of water in any ecosystem provides significant information about the available resources for supporting life in that ecosystem.

Erelu lake is one of the dam built by the then Western region government in 1962 to supply portable water to Oyo town and its environs. However, secondary activities that followed in the area include lowland farming activities along the edges of the dam, irrigation of arable crops by the farmers and migration of fishermen into the area (Kareem, 2017). According to Daka and Moslen (2013), multi stressors including rapid siltation of the lake from sediments discharged by the main inflow rivers, run off from the surrounding agro-based farms and huge irrigation water demands for agriculture poses a significant threat to the sustainability of many Nigerian lakes. Hence, such an ever increasing intensity of the exploitation of the Erelu lake catchment and resources require monitoring of the water quality variables to obtain insight into the temporal and spatial variations associated with its prevailing trophic state. Studies have been carried out on several lakes and reservoirs within the same geographical catchment as Erelu lake on the physico-chemical characteristics, fauna and flora distribution, trace metal load, plankton and benthic macro invertebrates abundance (Olanrewaju *et al.*, 2017; Falaye *et al.*, 2015; Jenyo-Oni *et al.*, 2014; Ayoola and Ajani, 2009) but, there has been no documented information on the physico-chemical parameters and productivity level of Erelu lake. This study, investigates spatial and temporal patterns in physico-chemical parameters and primary productivity of Erelu lake.

MATERIALS AND METHODS

Study area

Erelu Lake lies in the southwestern region of Nigeria, between Latitudes 7°53'0"- 7°55'30" N and Longitudes 3°53'30" - 3°56'0" E. The climate is characterized by distinct dry and rainy season. The reservoir, formed from the impoundment of Awon River in 1961, is located 6.4 km from the heart of Oyo town (Figure 1). It is about 315.86 km in catchment area and has a maximum depth of 5.1 m, covering an area of 161.07 ha with maximum height of 13.106 m (Kareem, 2017). The lake is fed by several tributaries such as Isuwin, Oroki, Ogbagba, Oloro, Elesin, Awon and Abata. Erelu lake supports a rich biodiversity, offers livelihood and nutritional security to both artisanal fishermen and the riparian community. Settlers around the dam are from various states of Nigeria including Oyo, Ogun, Osun, Ondo, Kogi, Benue and Delta states.

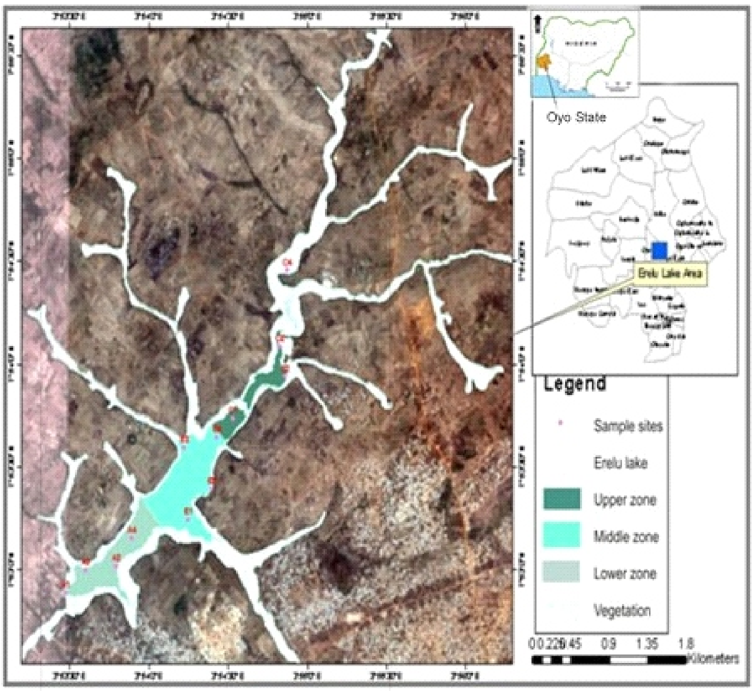

Figure 1. Map of Erelu Lake, Oyo, Nigeria

Field Sampling

Erelu lake was spatially stratified into upper, middle and lower zones (UZ, MZ and LZ respectively) based on geographical location and four sampling points were randomly selected in each zone for water sampling. Water sampling was carried out monthly for a period of 21 months covering July 2013 to March 2015, from 0800 to 0930 h. Surface temperature, pH and transparency were determined *in situ*. Temperature was measured using mercury in glass thermometer accurate to 0.1 °C, pH was measured with a pH meter (Hanna model H1-98107) while transparency was determined by a standard Secchi disc having a diameter of 20 cm with black and white quarters. The water samples after collection with well labeled plastic containers (1 litre) was put into plastic buckets covered with ice blocks and laboratory analysis for other parameters commenced within 5 h of sample collection. Water sample for dissolved oxygen were collected in 250 ml bottles with glass stoppers and fixed immediately at the point of collection with Winkler I and II solution. In each sample eleven parameters including dissolved oxygen, conductivity, biological oxygen demand, nitrite, nitrate, ammonia, phosphate, lead, zinc, iron, and cadmium were analysed. Dissolved oxygen was determined by Winkler's titrimetric method, while conductivity was measured using Intelligent meter (model AD. 33915). Nitrate, nitrite, phosphate and ammonia were determined using the corning Flame Photometer (Model 400). Determination of biological oxygen demand (BOD) was carried out by using the procedure of APHA (1985). Heavy metals (lead, zinc, iron, and cadmium) were determined in water samples using a Perkin Elmer model 306 Atomic Absorption Spectrophotometer. Primary productivity was estimated by *in situ* incubation method using the light and dark bottle oxygen method (Strickland and Parsons, 1972).

Data analysis

Data generated were subjected to both descriptive (means and standard deviations) and inferential statistics (ANOVA) at $\alpha_{0.05}$. One-way analysis of variance was carried out to test the significant difference between three sampling zones (i.e. spatial), while paired t-test was used to evaluate seasonal differences in the values of the physico-chemical variables. Duncan New Multiple Range Test was employed to ascertain the difference between means of parameter with significant difference between zones. Statistical analysis was performed using SPSS (version 20.0, SPSS Inc., Chicago, Il, USA) for Windows.

RESULTS

Climatical variables

The results obtained from the climatic data within study area (Figure 2) showed the average monthly air temperature, humidity and rainfall data. The highest air temperature of 33.4 °C in 2013 was recorded during the month of December while the lowest (27.1 °C) was realized in August. Rainfall of 128.5 mm (highest) was obtained in September while 7.2 mm (lowest) was achieved in December. However, for the sampling period covering January to December, 2014 the highest mean air temperature (33 °C) was realized in December while the lowest of (27.8 °C) was recorded in August. The highest humidity (91%) and rainfall (161.4 mm) were recorded in August and October, respectively.

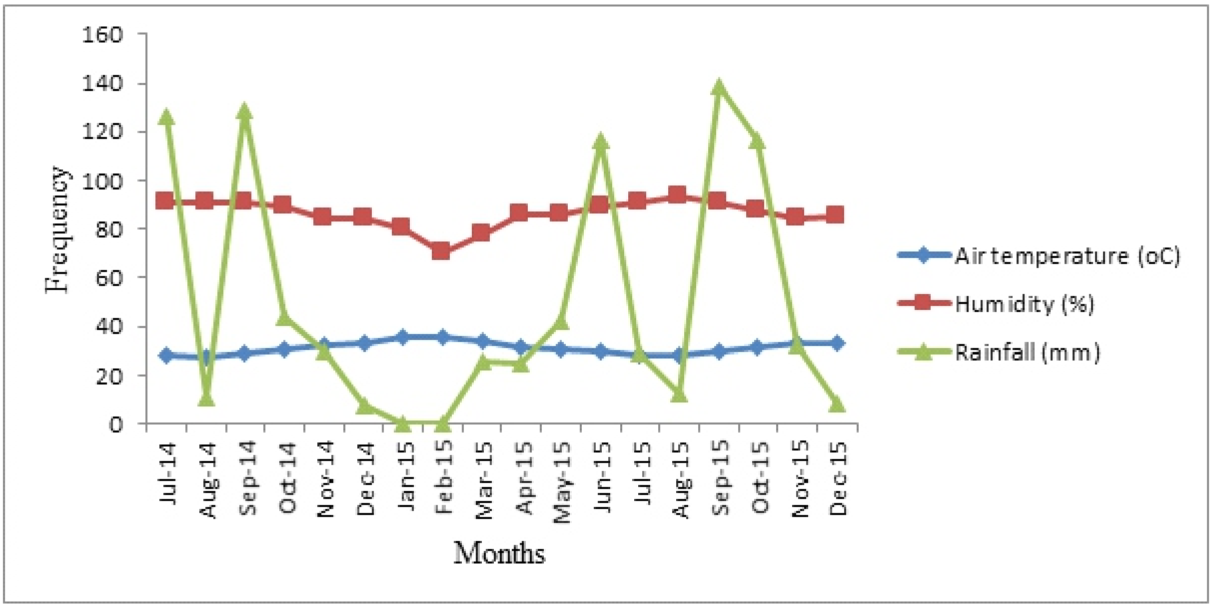

Figure 2. Meteorological data revealing Air temperature, Humidity and Rainfall pattern around Erelu Reservoir between July, 2013 and December, 2014. Source: NIMET, Oyo State, Nigeria.

Table 1. Spatial (Zone) Variation in Physico-Chemical parameters of Erelu Reservoir from July, 2013 to March, 2015

Variables	Upper Zone	Middle Zone	Lower Zone	Mean ± SD
DO (mgL^{-1})	7.33±0.88[a]	7.20±0.94[a]	7.14±0.96[a]	7.22±0.93
BOD (mgL^{-1})	2.62±0.25[a]	2.42±0.41[b]	2.59±0. 26[a]	2.54±0.33
Transparency (m)	1.11±0.43[a]	1.05±0.41[a]	1.02±0.40[a]	1.06±0.42
Temperature (°C)	27.41±1.55[a]	27.37±1.35[a]	27.31±1.45[a]	27.36±1.45
Conductivity (μScm^{-1})	158.18±21.72[a]	158.86±18.98[a]	160.27±19. 25[a]	159.10±19.94
pH	7.11±1.27[a]	7.42±0.93[a]	7.50±0.71[a]	7.34±1.00
Nitrate (mgL^{-1})	0.67±0.07[a]	0.68±0.06[a]	0.67±0.06[a]	0.67±0.06
Nitrite (mgL^{-1})	0.23±0.02[a]	0.23±0.02[a]	0.23±0.03[a]	0.23±0.02
Ammonia (mgL^{-1})	0.23±0.18[a]	0.23±.02[a]	0.22±0.02[a]	0.23±0.02
Phosphate (mgL^{-1})	0.29±0.02[a]	0.28±0.04[a]	0.29±0.02[a]	0.29±0.03
Lead (mgL^{-1})	1.19±0.53[ab]	0.96±0.72[b]	1.46±0.44[a]	1.20±0.61
Zinc (mgL^{-1})	0.23±0.03[a]	0.22±0.03[a]	0.23±0.02[a]	0.22±0.02
Iron (mgL^{-1})	0.13±0.06[a]	0.12±0.05[a]	0.15±0.07[a]	0.13±0.06
Cadmium (mgL^{-1})	0.03±0.01[a]	0.04±0.01[a]	0.04±0.01[a]	0.04±0.01

Different superscript in a row (a, b and c) indicates significant difference between the zone means at $p < 0.05$

Physico-chemical variables

The spatial variation patterns in the physico-chemical water quality of the lake are shown in table 1. Most of the investigated parameters were not statistically significant ($p > 0.05$) spatially except BOD and lead. The mean dissolved oxygen value across zones was 7.22 ± 0.93 mgL^{-1} with the highest mean dissolved oxygen (7.33 ± 0.88 mgL^{-1}) obtained in upper zone. BOD was significantly lower at middle zone (2.42 ± 0.41 mgL^{-1}) while upper (2.62 ± 0.25 mgL^{-1}) and lower (2.59 ± 0.26 mgL^{-1}) zones revealed no significant difference. The mean transparency value ranged from 1.02 ± 0.40 m in lower zone to 1.11 ± 0.43 m in upper zone indicating little variability. There was slight variability in the mean water temperature values obtained at the study zones. The highest mean value 27.41 ± 1.55 °C was recorded in upper zone. Mean conductivity values varied between 158.18 ± 21.72 and 160.27 ± 19.25 μScm^{-1} with a progressive increase from upper to lower zone. Lowest ionic content of the lake water was recorded in upper zone (158.18 ± 21.72 μScm^{-1}), while the highest record was for lower zone (160.27 ± 19. 25 μScm^{-1}). A weak mean alkaline pH value of 7.34 ± 1.00 was observed for the lake. While across zones, 7.11 ± 1.27, 7.42 ± 0.93 and 7.50 ± 0.71 were recorded for upper, middle and lower zones respectively.

The essential primary productivity nutrient, nitrate was comparatively higher in middle zone (0.68 ± 0.06 mgL^{-1}) than upper and lower zones (0.67 ± 0.07 mgL^{-1}), though not significant. The lake had 0.23 ± 0.02 mgL^{-1} for mean nitrite and ammonia concentration while the mean phosphate value ranged from 0.28 ± 0.04 mgL^{-1} to 0.29 ± 0.02 mgL^{-1} indicating little variability. The highest lead was found in lower zone (1.46 ± 0.44 mgL^{-1}). Lead differed significantly ($p < 0.05$) between the zones. However, zinc, iron and cadmium contents did not differ significantly ($p > 0.05$) between zones.

Table 2 shows the seasonal statistics of physico-chemical parameters of Erelu reservoir measured during the study period. Some of the investigated parameters were significantly high ($p < 0.05$) in the dry season than in the wet season, i.e. DO, transparency, conductivity, pH, nitrate, lead and iron. However, BOD, conductivity, nitrite, ammonia, phosphate, zinc, iron and cadmium content showed no significant variation ($p > 0.05$) between seasons.

Table 2. Seasonal Physico-Chemical Parameters of Erelu Reservoir between July, 2013 and March, 2015

Variables	Wet season Mean±SD	Dry season Mean±SD	P value
DO (mgL^{-1})	7.03±0.97	7.53±0.77	0.01*
BOD (mgL^{-1})	2.56±0.28	2.51±0.39	0.06
Transparency (m)	0.88±0.31	1.36±0.39	0.00*
Temperature (°C)	27.71±1.00	26.81±1.82	0.00*
Conductivity (μScm^{-1})	157.79±20.48	161.12±19.01	0.32
pH	7.06±1.06	7.80±0.70	0.00*
Nitrate (mgL^{-1})	0.66±0.07	0.70±0.05	0.00*
Nitrite (mgL^{-1})	0.23±0.02	0.23±0.02	0.21
Ammonia (mgL^{-1})	0.23±0.02	0.23±0.02	0.21
Phosphate (mgL^{-1})	0.29±0.04	0.29±0.02	0.30
Lead (mgL^{-1})	1.07±0.63	1.41±0.52	0.00*
Zinc (mgL^{-1})	0.23±0.02	0.22±0.03	0.26
Iron (mgL^{-1})	0.13±0.06	0.14±0.06	0.09
Cadmium (mgL^{-1})	0.04±0.01	0.04±0.01	0.06

*P<0.05

Table 3. Spatial variations in Primary Productivity in Erelu Reservoir from July, 2013 to March, 2015

Parameters	Zones			Mean±SD
	Upper	Middle	Lower	
Net Primary Productivity ($gC/m^2/d$)	$0.38±0.02^a$	$0.30±0.11^a$	$0.21±0.12^b$	0.30±0.18
Gross Primary Productivity ($gC/m^2/d$)	$1.04±0.10^a$	$1.01±0.14^a$	$0.85±0.33^b$	0.97±0.43
Community Respiration ($gC/m^2/d$)	$0.32±0.05^a$	$0.31±0.06^a$	$0.22±0.18^b$	0.28±0.11

Different superscript in a row (a, b and c) indicates significant difference between the zone means at p<0.05

Table 4. Seasonal variations in Primary Productivity in Erelu Reservoir from July, 2013 to March, 2015

Parameters	Seasons		P-value
	Wet	Dry	
Net Primary Productivity ($gC/m^2/d$)	0.54±0.03	0.42±0.12	0.33
Gross Primary Productivity ($gC/m^2/d$)	0.69±0.06	0.84±0.29	0.00*
Community Respiration ($gC/m^2/d$)	0.21±0.06	0.30±0.28	0.00*

*P<0.05

Biological variables

The spatial variations of primary productivity investigated during the study period are shown in table 3. There were no significant variations ($p > 0.05$) in primary productivity among zones. Mean daily respiration rate was higher in upper zone (0.32 ± 0.05 $gCm^{2-1}d^{-1}$) compared to the middle and lower zones which had 0.31 ± 0.06 and 0.22 ± 0.18 $gCm^{2-1}d^{-1}$ respectively. Net primary productivity ranged between 0.21 ± 0.12 and 0.38 ± 0.02 $gCm^{2-1}d^{-1}$ throughout the study period with the mean value of 0.30 ± 0.18 $gCm^{2-1}d^{-1}$ recorded. Gross primary productivity varied from a minimum of 0.85 ± 0.33 $gCm^{2-1}d^{-1}$ (lower zone) to a maximum of 1.04 ± 0.10 $gCm^{2-1}d^{-1}$ (upper zone). Generally, the mean GPP of the lake was 0.97 ± 0.43 $gCm^{2-1}d^{-1}$. The average mean values of net primary productivity (NPP), gross primary productivity (GPP) and community respiration (CR) during different seasons is given in table 4. The mean CR values varied between 0.21 ± 0.06 and 0.30 ± 0.28 $gCm^{2-1}d^{-1}$, and showed distinct significant seasonal variation ($p < 0.05$). Maximum average value was observed in the dry season. However, the average NPP was 0.54 ± 0.03 $gCm^{2-1}d^{-1}$ for wet season and 0.42 ± 0.12 $gCm^{2-1}d^{-1}$ for dry season and there exist no significant variations between seasons ($p > 0.05$). Similarly, seasonal average of GPP was significantly higher (0.84 ± 0.29 $gCm^{2-1}d^{-1}$) in dry season whereas, the least value was 0.69 ± 0.06 $gCm^{2-1}d^{-1}$ in wet season.

DISCUSSION

There are two distinct seasons in Erelu reservoir, wet and dry seasons. The wet season spans from April to October while the dry season extends from November to March. The rainfall data showed a seven month wet season period with five months dry season cycle. This rainfall pattern has similarly been reported in southern Nigeria lake by Deekae *et al.* (2010). The highest ambient air temperature and least relative humidity were recorded in the middle of the dry season due to the characteristic cool dry tropical wind and intense sunlight between November and February. This type of observation has been reported by Mustapha (2008).

Spatial variations among the investigated parameters were not statistically significant ($p > 0.05$) except for BOD and lead. However, most of the studied parameters were significantly higher in the dry season. In the present study, dissolved oxygen concentration varied between 4.86 mgL^{-1} –8.95 mgL^{-1} with spatial mean values of 7.22 ± 0.93 mgL^{-1}. These values were within the acceptable levels for survival, metabolism and physiology of aquatic organisms (Olanrewaju *et al.*, 2017). Similarly, oxygen concentration recorded in the present study compares well with findings of Mustapha (2008) in Oyun reservoir. There was higher mean DO value at the upper zone than in the middle and lower zone, though this was not significant but could mean the most productive area supporting diverse organisms. The result is in agreement with the observations of Etim and Obot (2014) on Stubbs creek, Niger Delta, Nigeria. The observed significant seasonal variation in DO concentration favoured dry season. This is in consonance with the observations of Olele and Ekelemu (2008) in Onahlake, Asaba, Nigeria. Contrarily, Etim and Obot (2014) recorded higher wet season mean DO concentration than dry season mean in Stubbs creek.

The BOD concentrations varied from 1.02 to 2.84 mgL^{-1}, though there were variations across the zones that were not significantly different ($p > 0.05$). The values were within the Boyd (1998) regulated limit and that of FEPA (1991) of < 4 mgL^{-1}. Moreover, the concentrations of BOD were found to be higher (2.62 ± 0.25 mgL^{-1}) in upper zone of the lake as well as wet season (2.56 ± 0.28 mgL^{-1}). The results found in the current study also agreed with the findings of Imam and Balarabe (2012) conducted in Bompai-Jakara catchment Basin. Water transparency was higher during the dry season than the rainy season. According to Mustapha (2009) and Ibrahim *et al.* (2009), the lower transparency observed during the rains and flood could be due to high water run-off from the water shed into the reservoir causing dilution. Similarly maximum mean value in dry season and minimum mean value in wet season was also recorded by Mustapha (2009) from Oyun Reservoir Nigeria. However, the range of Secchi disc transparency of 0.59 to 2.68 m reflects the depth of light penetration which enhances photosynthesis and hence primary productivity

(APHA, 1992).

The Erelu lake with surface temperatures ranging from 23.3 °C to 31.0 °C is typical of tropical lakes and reservoirs (Olanrewaju *et al*., 2017; Hassan *et al*., 2014; Ayoola and Ajani, 2009). In the present study, water temperature was significantly higher from March to April which marked the end of the dry season. Several investigations have revealed that surface water temperatures closely follow the ambient air temperatures (Welcome, 1979). Sometimes, this period also encompassed the wet season. Similar observation has been reported by Manikannan *et al*. (2011) and Jayabhaye (2009) from different wetlands. The range of conductivity in Erelu lake (123.45 – 190.02 μScm^{-1}) was optimum (Boyd, 1998) and it could be compared to other lakes in Nigeria including Oyun reservoir (Mustapha, 2009) and Eleyele wetlands (Ayoola and Ajani, 2009). There is slight variation of conductivity observed spatially, which could be due to utilization of the ions by flora and fauna. Similarly, the lower zone which had the highest conductivity (160.27 ± 19. 25 μScm^{-1} could be linked to high flood water which contains a lot of suspended and dissolved materials as revealed by Mustapha (2009). The content of the electrical conductivity was highest with 161.12 ± 19.01 μScm^{-1} in dry season. Similar trend in conductivity was reported by Ibrahim *et al*. (2009) from Kontagora reservoir, Nigeria. Olanrewaju *et al*. (2017), however, reported higher conductivity in the wet season in Eleyele reservior.

The hydrogen ion concentration (pH) ranged from alkaline (9.36) to acidic (5.53) condition throughout both season, and it was within the range for inland waters (pH 5.0–10.0), as reported by Tepe *et al*. (2005). Erelu lake however exhibits more neutral than alkaline conditions within the study period as reflected from mean values recorded both spatially and seasonally. This result was in agreement with the reports of several authors including Hassan *et al*. (2014) on lower Ogun river wetlands, Mustapha (2009) on Oyun reservoir. In contrast to the findings of Mustapha (2009), higher pH values were recorded in the dry season. The range of nitrate recorded for the present study was (0.46-0.85 mgL^{-1}) and is optimum for highly productive lake as revealed by Boyd (1998), though higher than the value (0.02-0.03mgL^{-1}) reported by Medudhula *et al*. (2012) in lower Manair reservoir but lower than the value (3.84 ± 1.95 mgL^{-1}) reported by Olanrewaju *et al*. (2017) in Oyun reservoir. According to Mustapha (2009), the variation in nitrate concentration reflects the effects of human activities on various sections of the reservoir. Also, higher nitrates were observed during dry season and lower during wet season. Similar trend was also noted by Bade *et al*. (2009). This result however, contradicts the finding of Olanrewaju *et al*. (2017) who studied physico-chemical status of Eleyele reservoir, Ibadan, Nigeria. These authors found nitrate concentration to be significantly ($p < 0.05$) higher in wet season.

The nitrite concentration of the lake varied from 0.18 to 0.28 mgL^{-1} over twenty-one months period of investigation. These range recorded could be considered as being within the permissible limit standard of Boyd (1998) and FEPA (1991) for aquatic life survival. The result of mean ammonia concentration obtained in this study was 0.23 ± 0.02 mgL^{-1}, which fell within the tolerable range documented by Boyd (1998) and FEPA (1991). This is an indication of pollution free and good water quality status for fish production. Furthermore, the monthly variations in phosphate values range from 0.03 mgL^{-1} to 0.35 mgL^{-1} and found within the range recorded in Oyun reservoir (Mustapha, 2009). Zinc and cadmium were high during the wet season period which coincided with the period of high run-off into the reservoir. Although, there was no variation spatially but little variation was recorded between seasons. The mean zinc (0.22 ± 0.02 mgL^{-1}) and cadmium (0.04 ± 0.01 mgL^{-1}) were within the optimum range for aquatic flora and fauna (Boyd, 1998). A similar observation was reported by Akindele *et al*. (2013) in Lake Tiga. According to Mohamed (2005), domestic sewages and industrial effluents generated from adjacent residential and industrial areas could be the prime sources for Cd and Zn in river water and lakes. The Pb and Fe concentrations in water significantly varied between seasons with highest value in dry season during the study period. Lower zone is imperative recipient of Pb and Fe, which is responsible for seasonal difference especially along the downstream stretch. It is evident that anthropogenic source are predominantly responsible for Pb and Fe input into Erelu lake. These results are in conformity with the findings of Raju *et al.* (2013), who studied spatio-temporal variation of heavy metals in Cauvery river basin, India. The authors reported significantly high Pb and Fe concentration in dry season. Moreover, the heavy metal levels found in this study were within the tolerable limit for aquatic lives (Boyd, 1998).

The average gross primary productivity (GPP) of Erelu lake was in the range of 0.21 ± 0.12 - 0.38 ± 0.02 gC/m^2/d. This is low compared with most Nigerian lakes, Lake Kainji (average: 2.19) (Karlman, 1973) and NIFFR reservoir (average: 3.17) (Bwala *et al*., 2010). However, the GPP was significantly higher than the findings of Ovie and Ajayi (2009) in Dadinkowa (0.16) and Kiri (0.08) reservoirs. It is also greater than the value (0.63) reported by Ovie *et al.* (2004) in Ojirami reservoir. Meanwhile, the respiration varied from 0.22 ± 0.18 to 0.32 ± 0.05 gC/m^2/d and these results inferred that throughout the study period, respiration never exceeded the GPP. Twenty-one months average of NPP, GPP and CR during the different seasons showed that fluctuations over different seasons and across the different zones were insignificant during all the seasons.

CONCLUSIONS

The results obtained from the study showed that investigated physico-chemical parameters were within desirable limits for growth, survival and production of fish. Values obtained for most parameters were higher in the dry season than in the wet season, whereas no significant variations were obtained between zones. Generally, Erelu reservoir is more productive in the dry season than rainy season and higher productivity were obtained in upper zone than middle and lower zones during both seasons. The primary productivity value is however, low and stable like most oligotrophic system.

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