JFLS | 2017 | Vol 2(2) | Pp 40-49

OPEN ACCESS

Journal of Fisheries and Life Sciences
International Peer-Reviewed Biannual Journal
www.fishlifesciencejournal.com

Research Article

Community dynamics of the fishes and some aspects of the limnology of two West African reservoirs

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ISSN: 2456-6268

ARTICLE INFO
Received: 24 August 2017
Accepted: 01 November 2017
Available online: 31 December 2017

KEYWORDS
Limnology
Reservoir
Potential fish yield
Diversity

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ABSTRACT

The ichthyofaunal diversity and limnology of Kpong and Oyun reservoirs located in Ghana and Nigeria respectively were studied with the main aim of gathering useful information to support the development, management and sustainable use of their respective fisheries to enhance the socio-economic status of riparian communities. Experimental fishing with a battery of gill nets of various mesh sizes was used to sample for fishes monthly (September 2014 to August 2016) were individually identified, weighed and measured for standard and total lengths. Water samples were taken monthly and analyzed for physico-chemical parameters. Cichlidae and Mormyridae were the most abundant families in Kpong reservoir accounting for 77.7% and 8.7% respectively and Mochokidae was the least occurring with 2.0% while Oyun recorded Cichlidae, Claridae and Mormyridae as the most important families encountered with 45.99%, 25.41% and 12.2% respectively with Channidae (0.5%) the least occurring. In the Kpong Reservoir, 17 species belonging to 5 families were encountered with *Oreochromis niloticus* (28.94%) and *Sarotherodon galilaeus* (25.98) the most abundant and *Gnathonemus cyprinniodes* (0.43%) the least. In the Oyun Reservoir, 18 species, representing 9 families, were obtained. *Tilapia zilli* (22.78%) and *Oreochromis niloticus* (14.14%) were the dominant species with *Channa obscura* (0.50%) the least. The fish diversity of the Kpong Reservoir was lower than that of the Oyun reservoir recording a species diversity (H') of 2.14 compared to 2.45 for Oyun. Herbivorous fishes were dominant in the two reservoirs while carnivorous ones were the least dominant. The Forage-Carnivore (F/C) ratios of 1.21 (by number) and 2.13 (by weight) for Oyun and 3.49 (by number) and 1.72 (by weight) for Kpong suggest a suitable ecological balance between carnivorous fishes and their prey populations. The estimated potential fish yield per year for the Oyun Reservoir (97.61kg/ha/yr) was higher than that of the Kpong Reservoir (60.69kg/ha/yr) possibly due to its shallower nature and higher productivity. Both reservoirs were well oxygenated all year-round with Oyun exhibiting a weakly acidic pH to Kpong's weakly basic trend. The key physico-chemical parameters in both reservoirs were within ranges for fish survival and production with Oyun being characterized by a comparatively higher ionic and nutrient content. Nutrients displayed greater impact on fish abundance hence the inference by the study that nutrient levels fluctuations are factors that play crucial roles in fish abundance in both reservoirs. Granted the adoption of appropriate management measures, both reservoirs are considered highly productive and possess the potential to optimize their fish production.

INTRODUCTION

Reservoirs are typically purposed for hydroelectric power generation, domestic water provision and often times for irrigation purposes, however in most tropical reservoirs, fish production forms a significant part of the services derived from them. This key service contributes substantially to the domestic fish production of several developing countries (Dan-kishiya, 2012) and to their respective food, nutrition and Gross Domestic Product (GDP). The management of the fisheries of the reservoir impacts on the fish assemblage / composition there and hence on their percentage contribution to the GDP of the respective coastal States. The understanding of and the

effectiveness of the management approaches of the fisheries in reservoirs is vital in this regard, owing to the variation in physiology, morphology and adaptation of individual species to their environment. Fish populations are limited by varying factors such as water quality, habitat structure, which in turn set the framework in which biotic interactions occur, such as growth, reproduction, trophic dynamics, and competition (Karr *et al*., 1986). Both Kpong and Oyun reservoirs were both classified as small, tropical reservoirs by size and retention rates following Kalff, (2003).

The diversity and composition of fish resources in both Nigeria and Ghana have been observed and documented by many authors such as Olaosebikan & Raji, 1998; Idodoh-Umeh, 2003; Balogun, 2005; Komolafe & Arawomo, 2008; Ibrahim *et al*., 2009; Mustapha, 2009; Lawson & Olusanya, 2010; Avoaja, 2011 for Nigerian waters while Vanderpuye, 1982; Dankwa, 1982; Antwi & Ofori-Danson, 1993; Quarcoopome *et al*., 2007; Quarcoopome *et al*., 2011, Nunoo & Asiedu, 2013 for Ghanaian waters. However, comparative assessment of the fish diversity, composition and limnology of reservoirs from both countries is nonexistent. Comparative studies are significant among other things, in identifying effective management practices that could be adopted between entities that are spatially apart from one another, particularly when they share similitude of characteristics. This study aims to bridge that gap in research by comparatively assessing the ichtyofaunal composition and diversity of two West African reservoirs, Kpong in Ghana and Oyun in Nigeria.

MATERIALS AND METHODS

Study areas

The work was conducted at both Kpong reservoir in Ghana and Oyun reservoir in Nigeria (Plate 1 & 2 respectively).

Study Area: The Kpong Reservoir

The Kpong Reservoir, in Ghana is a product of the Kpong Hydroelectric project, which was completed in 1982 is located on 06^0 08' N and 0^0 07' E with a total surface area of 38 km^2 and a mean depth of 5 m. According to Vanderpuye (1982), mean annual flow of water through the reservoir is 1183 m^3/s and water retention time is 5 days.

Kpong is a typical commercial town located about 70 km east of Tema which is southeastern part of Ghana. The Kpong reservoir was the second created on the Volta River after Akosombo Dam, primarily as a source of hydroelectric power generation and potable water supply. The Kpong reservoir created at about 25 kilometers below the Akosombo Dam was formed after the closure of the Volta Dam and it created the potential for two additional industries, agriculture by irrigation and fishing. The reservoir is also the main source of water supply to the Accra-Tema Metropolitan Area.

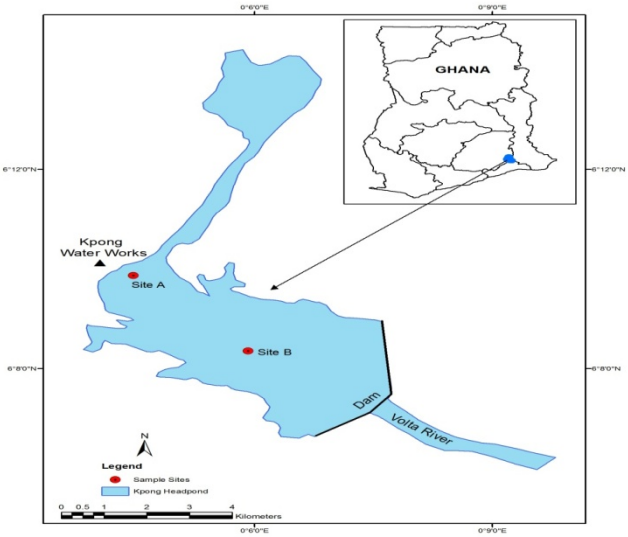

Plate 1: Kpong Head pond, Ghana showing Sampling Sites

Study Area: The Oyun Reservoir

Oyun Reservoir, on the other hand is located at Offa, Kwara State, Nigeria, longitude 08°30' N and latitude 08°15' E. It was created on the Oyun River to primarily provide potable water for domestic and industrial use to the estimated 300,000 people (Mustapha, 2009). Subsistence and commercial fishing activities are secondary activities engaged in by the populace around the reservoir. It has a maximum length of 128 m, maximum width of 50 m and maximum depth of 8 m, mean depth of 2.6 m. The surface area is 6.9 x 10^5 m^2 while the water volume is 3.50 x 10^6 m^3. The net water storage capacity is 2.9 x 10^6 m^3. The water retention time is between 3 - 4 months in the raining season, while the water residence time in the dry season is few days due to high evaporation. This reservoir is located in the tropical Guinea savannah zone having two marked seasons of rain (April–October) and dry (November–March) and where there is high rate of evapo-transpiration. Subsistence fishing activities are carried out on the reservoir. The reservoir is eutrophic with diverse species of littoral plant occupying the shoreline length (Mustapha, 2009).

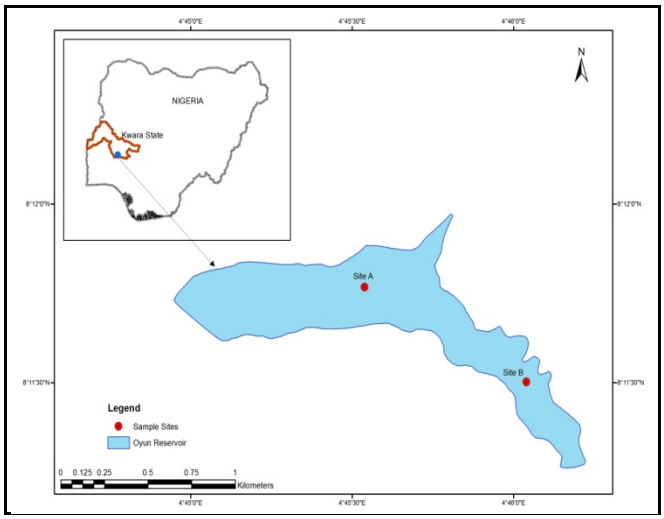

Plate 2: Oyun Reservoir, Nigeria showing Sampling Sites

Two sampling stations each were chosen for both reservoirs based on anthropogenic activity levels with Site A being portions with more activities compared to Site B with less activities. For Kpong reservoir, each site was about 120 m in breadth with a distance of about 3.0 river kilometers between them while for Oyun reservoir, each station was about 150 m in breadth with a distance of about 4.0 river kilometers between them.

Fish sampling

Fish were sampled monthly using experimental fishing deployed by a hired fisherman fishing for an hour between 6 am – 7 am with a set of multifilament gill nets of laterally stretched mesh sizes that ranged between 12.0 and 35.0 mm, and a set of monofilament gill nets of large meshes between 6 am – 7 am with a set of multifilament gill nets of laterally stretched mesh sizes that ranged between 12.0 and 35.0 mm, and a set of monofilament gill nets of large meshes ranging from 55.0 to 185.5 mm. Fish samples were stored in iced containers and transported to the laboratory where they were sorted according to species using identification keys by Olaosebikan and Raji (2004) and Leveque *et al*., (1992) with number of each recorded. All samples were measured using a wooden fish measuring board for total length and standard length to the nearest 0.1cm and total weight to the nearest 0.1g using an electronic scale.

The following parameters were computed for fish analysis:

Fish species composition and diversity

Fish species composition of both reservoirs was estimated from the checklist of fishes obtained from identification of monthly samples. A number of indices were used to describe and compare the diversity of the fish communities in the two reservoirs (Naik *et al.,* 2013, 2014, Kumar *et al.,* 2015; Dwivedi, *et al.,* 2017).

(i) Margalef's Index (D) for species richness:

$$D = (S-1)/\text{Ln } N$$

where S = number of species and N = number of individuals.

(ii) The Shannon-Wiener's Index (H') of species diversity:

$$H' = -\sum Pi \text{ Ln } Pi$$

where Pi is the proportion of the total number of individuals occurring in species i.

(iii) Pielou's Index (J) for species evenness:

$$J = H'/\text{Ln } S$$

where H' is the species diversity index and S is the number of species.

(iv) Jaccard's Measure of Similarity was used to calculate the similarity of the species of the fish community of the two reservoirs: $Cj = j / (a + b – j)$

where Cj is the similarity between zone a and b; j is the number of species common to both zone a and b; a is the number species at zone a while b is the number of species at zone b. Kpong reservoir was represented as zone a while Oyun reservoir was represented as zone b. A Cj value equals to 1 would indicate complete similarity while a value of 0 would mean complete dissimilarity

(v) The ecological balance of the community was estimated by the ratio of forage fishes to carnivore fishes (i.e. forage-carnivore or F/C ratio) in terms of number and weight using the formula: F/C = Herbivores / (Carnivores + Omnivores) Ipinmoroti (2013)

(vi) Potential fish yield estimates were obtained using abiotic variables based on the chemical composition of the reservoirs and the relationship:

$$Y = 23.281 \text{ MEI}0.447 \text{ (Marshall, 1984)}$$

where Y is the potential fish yield in kg ha-1, MEI is morpho-edaphic index, which is given in µm/hos and is estimated by dividing the mean conductivity by the mean depth (Ryder *et al.,* 1974).

Physicochemical analyses

Physicochemical parameters linked to organic production and pollution indicators such as temperature, transparency, salinity, Dissolved Oxygen (DO), pH, conductivity, total alkalinity, Chemical Oxygen Demand (COD) and Total Dissolved Solids (TDS) were measured in-situ following Mustapha (2009) using a HACH Electronic multiparameter probe. 500 ml plastic bottles were used to collect water samples for nutrients analysis covering Nitrate, Phosphate and Sulphate in the laboratory following the standard methods for the examination of water and waste water (APHA, 1998). Water samples collection and probe readings were taken at 20 cm below the water surface in triplicates with the average recorded for the respective months at each sampling station.

Data Analysis

Correlation coefficient was used to determine relationships between limnological parameters at the two reservoirs using Excel spreadsheet. This statistical tool was also used for two sample t-test to identify significant differences in physico-chemical parameters within and between years and season at both reservoirs at 95% confidence level ($p < 0.05$). Relationship between measured physico-chemical parameters and fish abundance was analyzed using Paleontological Statistics Software (PAST) 3.15 to identify physico-chemical parameters with the most influence on fish abundance. Same tool was used to compare seasonal fish abundance within and across years at both reservoirs at $p < 0.05$ using Shannon Weiner and Simpson diversity indices.

RESULTS

Fish species composition

The checklist of fishes (Fig. 1a & 1b) in the Kpong reservoir show 5 taxonomic families and 17 species while that of the Oyun reservoir show 9 taxonomic families and 18 species. The percentage fish species composition in terms of number for the Kpong reservoir indicated that the dominant species were *Oreochromis niloticus* (28.94%), *Sarotherodon galilaeus* (25.98%), and *Hemichromis fasciatus* (12.04%). *Pelmatochromis guntherii*, *Clarias gariepinus* and *Tilapia zilli* followed next in importance with 4.49%, 4.05% and 3.98% respectively with *Hemichromis bimaculatus* recording the least abundance representing just 0.58% of total samples. For Oyun reservoir, the percentage fish species composition in terms of number indicated that the dominant species were *Tilapia zilli* (22.8%), *Oreochromis niloticus* (14.1%) and *Clarias*

gariepinus (13.0%) while *Channa obscura* (0.5%) recorded the least abundance by number.

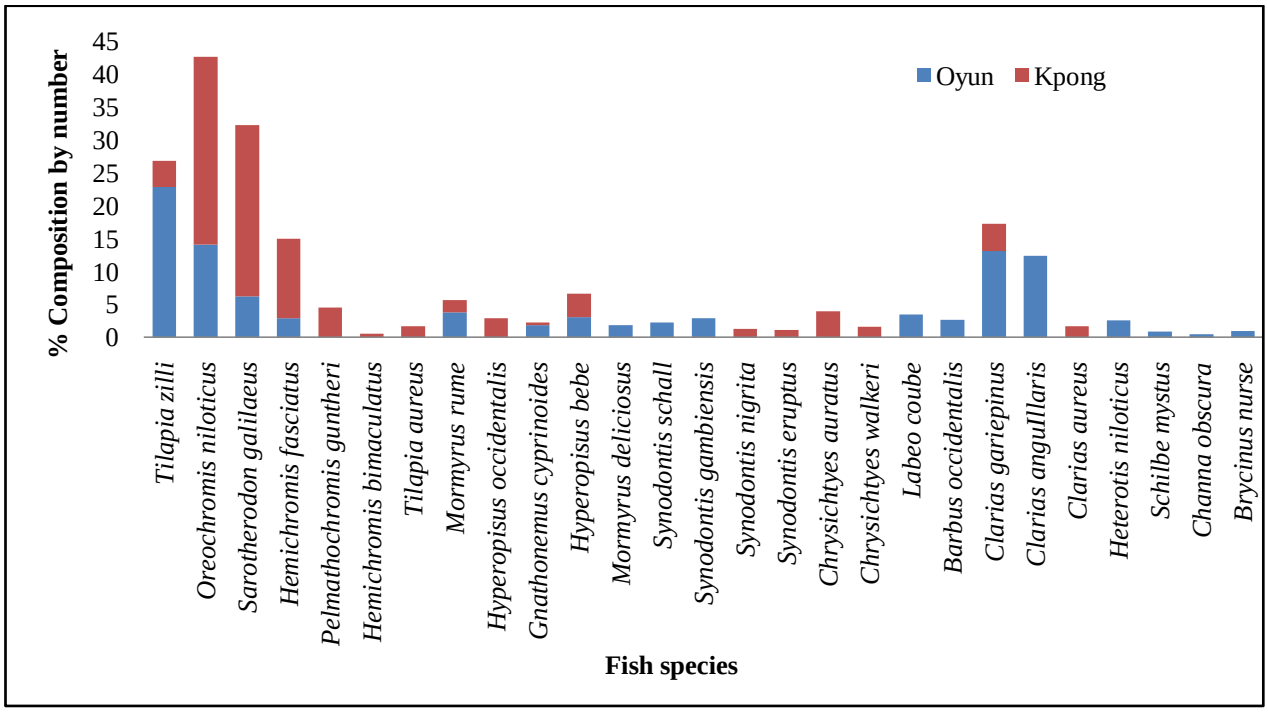

Fig. 1a: Comparative fish species percentage composition by number at the two reservoirs

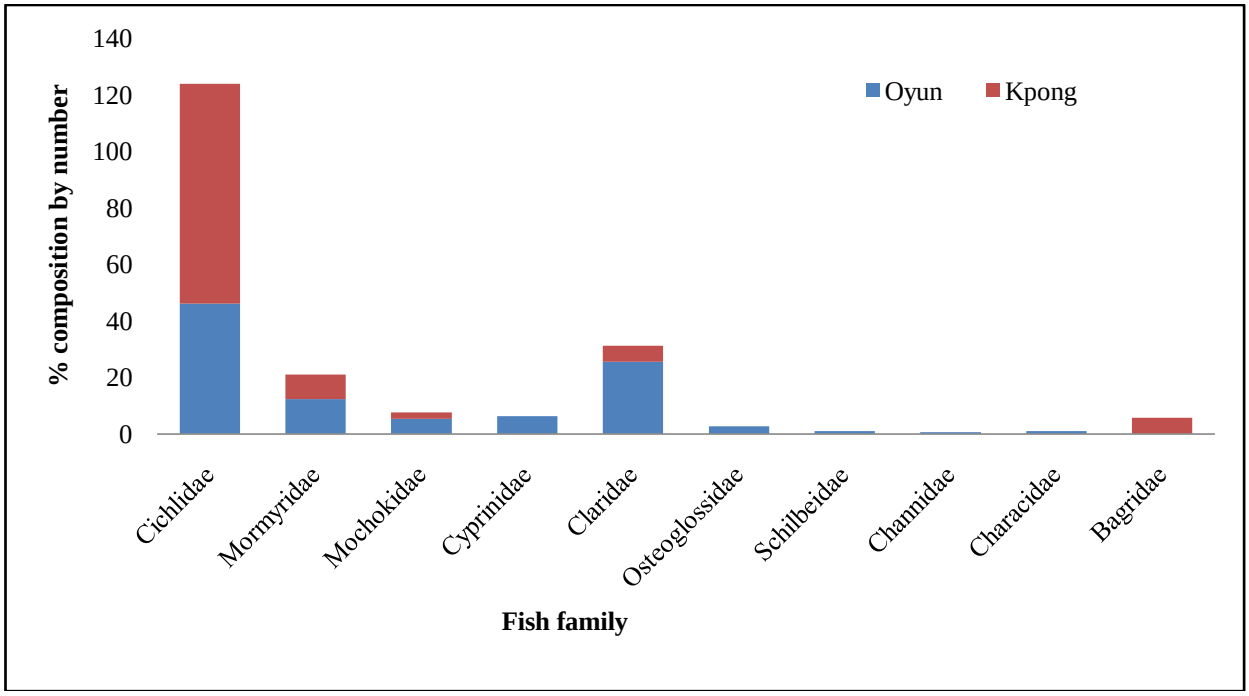

Fig. 1b: Comparative Fish family percentage composition by number at the two reservoirs

In both Kpong and Oyun Reservoirs, fish family composition in terms of number was dominated by Cichlidae with Oyun recording 45.99% while Kpong recorded a higher figure of 77.71%. Claridae and Mormyridae were the second most important fish families at Oyun and Kpong reservoirs respectively. The least important family at Oyun was Channidae and mochokidae for Kpong.

Fish species diversity Indices

The estimated diversity indices for the two reservoirs (Fig. 2) showed that the values of all the diversity indices, namely species richness (D), species diversity (H') and species evenness (J), were higher for Oyun reservoir (D = 2.30, H' = 2.45 and J = 0.85) compared to Kpong reservoir with D = 2.30, H' = 2.45 and J = 0.85 respectively. The

similarity measure (Cj) for the two reservoirs show just a 30% similarity in fish species similarity among them.

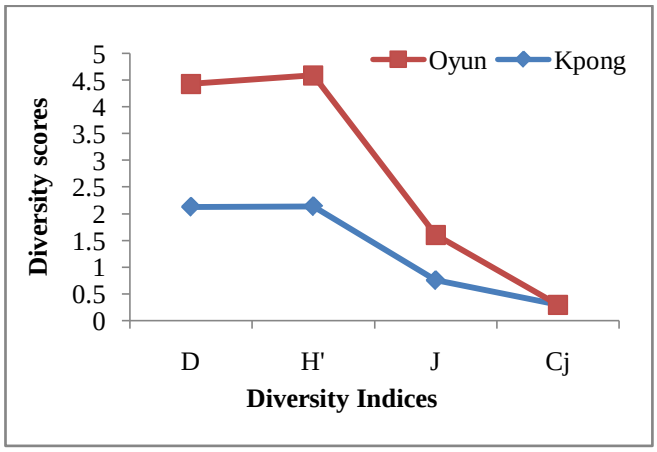

Fig. 2: Diversity Indices scores for the two reservoirs

Estimated Potential fish yield

An estimated potential fish yields of 60.67kg/ha and 97.61kg/ha were determined for Kpong and Oyun reservoirs respectively from the Morphoedaphic Indices (MEI) (Fig. 3a). The estimated MEI range for Kpong reservoir was between 6.97 – 10.68 with annual mean of 8.60 while that of Oyun ranged betwwen 19.19 – 32.98 with an annual mean of 25.16.

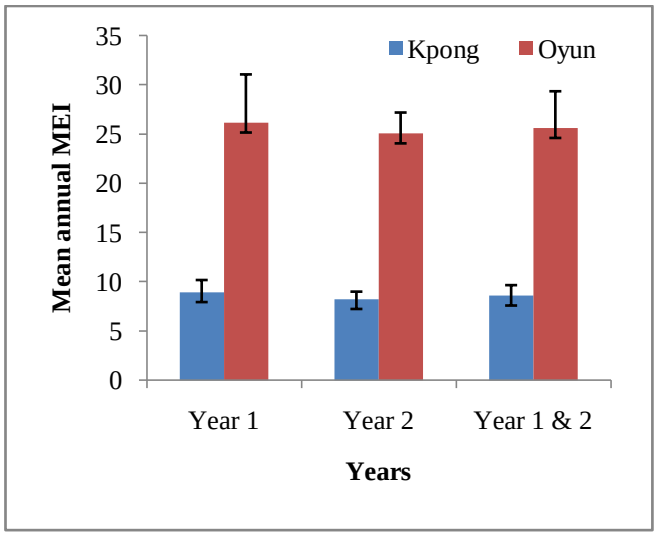

Fig. 3a: Mean Annual MEI computed for the two reservoirs
* Year 1 (September 2014 – August, 2015)
** Year 2 (September, 2015 – August, 2016)

Ecological balance

Kpong reservoir recorded relatively higher values for the Forage / Carnivore (F/C) ratio by number compared to Oyun reservoir. The former recorded F/C ratio of 4.96, 2.51 and 3.49 for year 1 (September, 2014 to August, 2015), year 2 (September, 2015 to August, 2016) and Year 1 & 2 combined respectively while the latter recorded 1.26, 1.17 and 1.21 for year 1, year 2 and Year 1 & 2 combined respectively (Fig 4a). On the other hand, Oyun reservoir recorded higher of F/C ratio values by weight compared to Kpong reservoir. Oyun recorded 1.69, 2.46 and 2.13 F/C ratio by weight for year 1, year 2 and Year 1 & 2 combined respectively while Kpong had 1.81, 1.64 and 1.72 for the same periods (Fig. 4b).

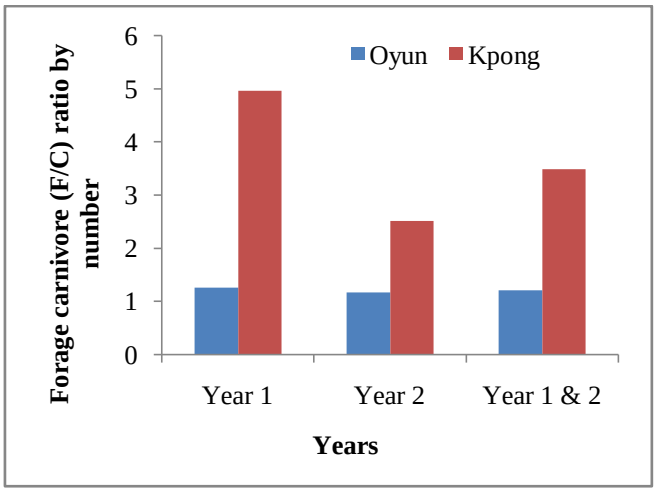

Fig. 4a: Forage / Carnivore (F/C) ratio by number for Oyun and Kpong reservoirs

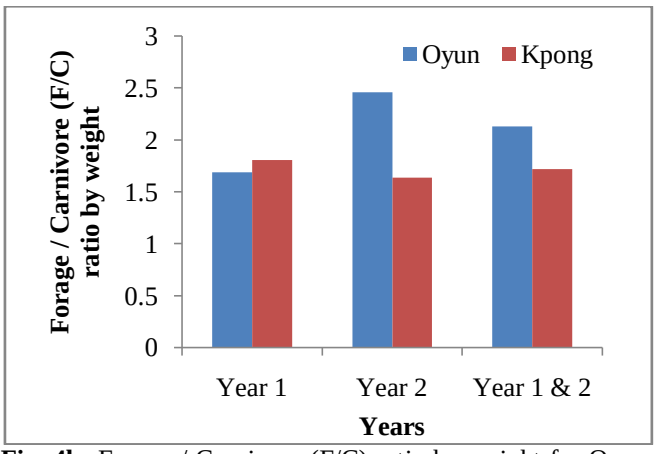

Fig. 4b: Forage / Carnivore (F/C) ratio by weight for Oyun and Kpong reservoirs

Physicochemical parameters

The mean annual surface temperatures for the Kpong and Oyun reservoirs were 28.04ºC ± 1.68 and 26.88ºC ± 0.96, respectively (Fig. 5). The Kpong Reservoir attained its highest surface temperature (31.6^{0}C) during the study in February, 2016 while Oyun recorded its own highest surface temperature (28.65 ºC) during the study in March, 2016. The lowest temperatures of 26.1 ºC and 24.75^{0}C were recorded for Kpong and Oyun reservoirs respectively in August 2015. The pH values recorded for Kpong Reservoir ranged between 6.45-8.0 with a mean of 7.14 ± 0.39 while a range of 6.35-7.4 was recorded for Oyun Reservoir with a mean of 6.85. Dissolved oxygen (DO) recorded a mean value of 4.41 mg/l ± 0.64 in Kpong and 6.86 mg/l ± 0.34 in Oyun. The water at Oyun showed a better transparency (less turbid) compared to that of Kpong with 1.17 m recorded for Oyun as against 0.78 m for Kpong. Both conductivity and Total Dissolved Solids were higher at Oyun than at Kpong, mean values of 93.29 µS/cm and 62.79 mg/l were recorded for conductivity and TDS respectively at Oyun compared to 67.80 µS/cm and 40.46 mgl at Kpong (Table 3.4). Mean annual salinity was higher at Kpong (0.68

ppt) compared to Oyun (0.05 ppt). Same trend was recorded for Phosphate, Nitrate and Sulphate where Oyun had 1.59 mg/l, 3.5 mg/l and 11.85 mg/l respectively while Kpong recorded 1.07 mg/l, 1.11 mg/l and 3.30 mg/l.

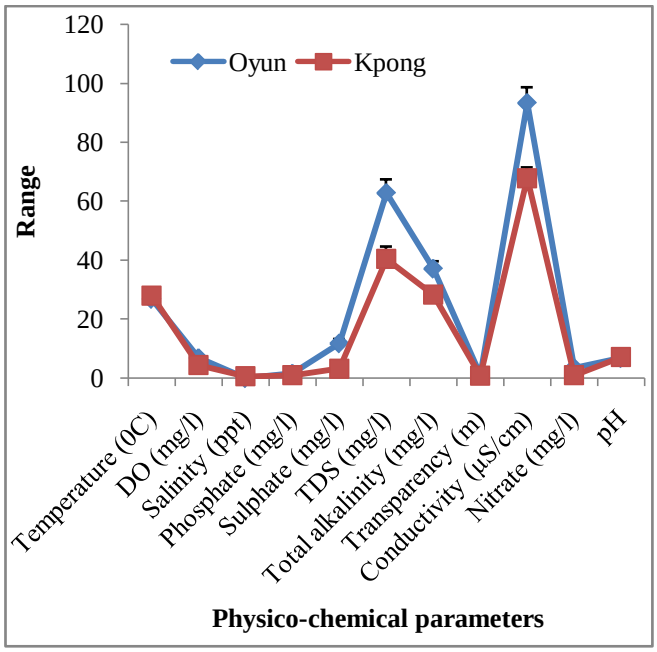

Fig. 5: Mean Annual Physico-chemical Parameters for the two reservoirs

Relationship between physico-chemical parameters

Table 3.5b presents the correlation between the physico chemical parameters at Kpong. Nitrate and temperature correlated positively (r=0.5536). Total Dissolved Solids (TDS) correlated negatively with the trio of Dissolved Oxygen (DO) (r = -0.5612), temperature (r = -0.5612) and nitrate (r = -0.5909). Sulphate also correlated negatively with pH (r = -0.6889). This negative relationships imply that one variable decreases as the other incereases and vice versa. In Oyun, transparency showed the strongest positive relationship in the reservoir with temperature (r = 0.8978) indicating that as one of them increases the other increases too and vice versa. DO correlated negatively with temperature (-0.5011) while Total Alkalinity (TA) correlated with DO in same way (r = -0.5930). Nitrate showed a negative relationship with both Chemical Oxygen Demand (COD) (r = -0.7243) and temperature (r = -0.5153) while showing a positive relationship with DO (r = 0.6393). pH correlated negatively with COD (r = -0.5287) and positively with nitrate (r = 0.6391) and phosphate (r = 0.6691). A strong positive relationship was exhibited between phosphate and nitrate (r = 0.7241). Salinity demonstrated similar relationship with temperature (r = 0.7102) and transparency (r = 0.6389) while showing a negative one with nitrate (r = -0.5531). Conductivity and pH demonstrated a negative correlation (r = -0.5614) and a positive one with temperature (r = 0.5315). Sulphate demonstrated negative relationship with COD (r = -0.5776) and a strongly positive one with the trio of nitrate (r = 0.7597), phosphate (r = 0.7569) and pH (r = 0.6727) (Table 3.5a).

Table 1: Major Physico-chemical Parameters correlation for both Oyun and Kpong reservoirs

LOCATION	CORRELATION	PARAMETERS
Oyun	Highest	Temperature vs Transparency (0.8971) Nitrate vs Sulphate (0.7599) Phosphate vs Sulphate (0.7568)
	Least correlation	DO vs Temperature (- 0.5011)
Kpong	Highest	Sulphate vs pH (- 0.6882) Nitrate vs TDS (- 0.5901) TDS vs Temperature (- 0.5612)
	Least correlation	Nitrate vs Temperature (0.5536)

The relationships between fish abundance and physic-chemical variables are shown in figures 5.1a and 5.1b. Using the PAST software, the environmental data (physico-chemical parameters) were normalized by transforming them with (x-mean)/standard deviation to take care of parameters with standard deviation of 1 and mean of zero. The biological data (species) were also transformed with ln (x+1) to reduce the influence of very abundant species so that the rarest species do have some influence too on the path observed. At Kpong reservoir, the strongest explanatory factors to fish abundance were TDS, nitrate, salinity, conductivity, pH and DO. About 63.47% of the variation in the fish species abundance data was explained by physic- chemical parameters measured in this study. *Tilapia zilli*, *Tilapia aureus* and *Hyperopisus occidentalis* show moderate sensitivity to salinity and nitrate while having low sensitive for transparency and temperature. *Hemichromis fasciatus* also recorded moderate sensitivity to COD and pH. *Clarias aureus* show high sensitivity to TDS while *Pelmatochromis guntherii* show moderate sensitivity to phosphate. *Oreochromis niloticus* demonstrated mild sensitivity to phosphate. *Hemichromis bimaculatus* demonstrated high sensitivity for DO while *Chrysichthyes auratus* also show high sensitivity to sulphate (Fig 5.1b).

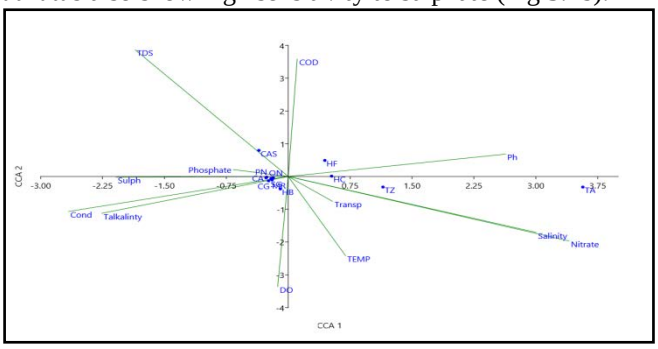

Fig. 5.1a Relationship between physico -chemical parameters and fish abundance for Oyun reservoir

Legend
SG-*Sarotherodon galillaeus*
ON-*Oreochromis niloticus*
HF – *Hemichromis fasciatus*
HB – *Hyperopisus bebe*
TZ – *Tilapia zilli*
HC - Hyperopisus *occidentalis*
CA – *Chrysichtyes auratus*
CAS – *Clarias anguillaris*
PN – *Pelmatochromis guntherii*
TA – *Tilapia aureus*
CG – Clarias gariepinus

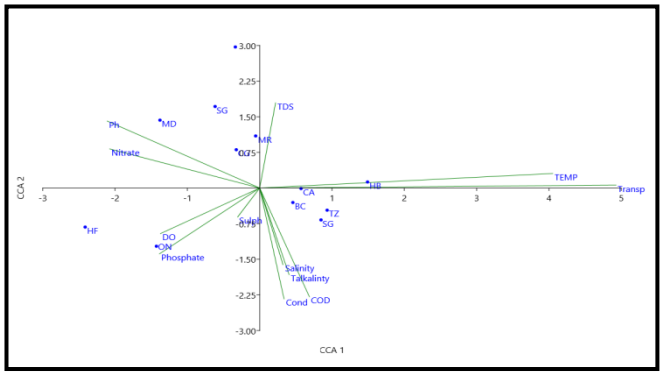

Fig. 5.1b Relationship between physico -chemical parameters and fish abundance for Kpong reservoir

Legend
SG-*Sarotherodon galillaeus*
MR-*Mormyrus rume*
ON-*Oreochromis niloticus*
HF – *Hemichromis fasciatus*
HB – *Hyperopisus bebe*
TZ – *Coptodon zilli*
MD – *Mormyrus deliciosus*
BC – *Barbus occidentalis*
CA – *Chrysichtyes auratus*
CG – *Clarias gariepinus*

For Oyun reservoir, the strongest explanatory power to fish abundance by physico-chemical variables were by Total Alkalinity (TA), COD, DO, TDS, phosphate and nitrate. About 52.29% of the variations in fish abundance were accounted for by the physico chemical variables at this reservoir. *Coptodon zilli* demonstrated high sensitivity to TA, COD, temperature, salinity, conductivity and transparency in that order. A moderate sensitivity to conductivity was observed for *Hemichromis fasciatus*. *Mormyrus anguilloides* was associated with low levels of TDS while the trio of *Clarias gariepinus*, *Sarotherodon galilaeus* and *Hyperopisus bebe* were sensitive to low levels of DO. *Mormyrus rume* exhibited high sensitivity for both phosphate and nitrate. *Labeo coubie* and *Oreochromis niloticus* were however extremely positioned (Fig 5.1a).

Seasonality

Seasonal difference in fish abundance within Year 1 at Kpong reservoir indicated significant difference between dry and wet season in both the Shannon Weiner and Simpson diversity Indices (p = 0.0081 for Shannon Weiner and p = 0.0034 for Simpson). There was however no significant difference observed between the two seasons in Year 2 with Shannon Weiner Index recording p = 0.096 while Simpson Index recorded p = 0.058. Conversely, there was significant difference in fish abundance between the two years at Kpong with p = 0.029 and p = 0.0122 recorded for Shannon Weiner and Simpson Index respectively.

Seasonal difference in fish abundance within Year 1 at Oyun reservoir indicated significant difference between dry and wet season in both the Shannon Weiner and Simpson diversity Indices (p = 0.0000181 for Shannon Weiner and p = 0.0000256 for Simpson). There was however no significant difference observed between the two seasons in Year 2 with Shannon Weiner Index recording p = 0.351 while Simpson Index recorded p = 0.290. The between years relationship in fish abundance in Oyun show no significant difference with p = 0.27039 and p = 0.41574 recorded for Shannon Weiner and Simpson Index respectively.

The two sample t-test for Kpong reservoir indicating significant differences between physico chemical parameters within year shows temperature, transparency, COD, Nitrate, pH, TDS, conductivity, salinity and sulphate as being significantly different at $p < 0.05$ for Year 1 while DO, COD, nitrate, phosphate, pH, TDS and sulphate recorded significant difference in Year 2. Differences between years (Year 1 and 2) indicated there was significant difference between the years (Year 1 & 2) with p = 0.00.

For Oyun, the difference between physico-chemical parameters within the first year using two sample t test recorded temperature, nitrate and conductivity as being significantly different at $p < 0.05$. In the second year, only conductivity (p = 0.0046) exhibited significant difference. The comparison of differences between years indicated significant differences at $p < 0.05$ with a p = 0.00 value.

DISCUSSION

In the Oyun Reservoir, 9 fish families with 18 species were encountered while Kpong recorded 5 families and 17 species. The Cichlidae family dominated in both reservoirs with *Tilapia zilli* the most dominant at Oyun reservoir and *Oreochromis niloticus* for Kpong reservoir. *Gnathonemus cyprinoides* and *Channa obscura* were the least dominant in both Oyun and Kpong respectively. The higher fish species and family richness for the Oyun reservoir compared to Kpong reservoir could be as a result of its higher Total Dissolved Solids (TDS) values. This parameter is a proxy to reservoir productivity (Reid & Wood, 1976) and hence increased TDS within the 1500 mg/l recommended levels by Weitzman *et al.*, (1996) would result in corresponding improved productivity.

Species richness (D), species diversity (H') and species evenness (J) were higher for Oyun reservoir compared to Kpong reservoir. Oyun reservoir recorded D = 2.30, H' = 2.45 and J = 0.85 compared to D = 2.13, H' = 2.14 and J = 0.76 at Kpong reservoir. These were quite higher than the D = 0.70, H' = 1.52 and J = 0.80 reported by DanKishiya *et al.*, (2013) for a tropical reservoir in Nigeria and even further higher than what was reported by Quarcoopome *et al.*, (2008) for two Ghanaian tropical reservoirs where Bontanga reservoir recorded species richness (D) of 1.11, species diversity (H') of 1.55 and species evenness (J) of 0.40 while Libga reservoir recorded 2.4, 2.36 and 0.52 for species richness (D), diversity (H')

and evenness (J) respectively. The two reservoirs indicated intermediate similarity in species composition shown by the 0.30 recorded for the Jarcard's Measure of similarity (Cj).

The most important feeding group in the two reservoirs was herbivores belonging to the family Cichlidae specifically *Tilapia zilli* at Oyun and *Oreochromis niloticus* at Kpong reservoir. This agrees with previous findings by Quarcoopome *et al*., (2011) where they reported *Oreochromis niloticus* as an ever present important species in Kpong reservoir right from pre impoundment up to 25 years after impoundment. Mustapha (2009) equally reported *Tilapia zilli* as the most abundant species of the Cichlidae family in Oyun.

The estimated F/C ratios of 1.21 (by number) and 2.13 (by weight) in Oyun reservoir and 3.49 (by number) and 1.72 (by weight) for Kpong reservoir all fall within the acceptable range of 1.4–10.0 for balanced fish populations (Ofori-Danson *et al.*, 1993; Ofori-Danson & Antwi, 1994), indicating a balanced fish community status and a suitable ecological balance between carnivorous fishes and their prey.

The potential fish yields of the two reservoirs in this study are comparable to even some large and medium tropical reservoirs, this is because estimates of potential fish yields of 60.67 kg/ha and 97.61 kg/ha for Kpong and Oyun reservoirs respectively, from this study were high and within the 30 – 150kg/ha fish productivity range for shallow reservoirs suggested by Marshal & Maes (1995). Abban *et al*., (1994) reported Achubunyo and Busunu reservoirs recording potential fish yields of 75.05kg/ha and 82.62 kg/ha respectively in Ghana. In Nigeria, Adeniji (1980) reported between 25-40 kg/ha for Bakolori reservoir and Balogun & Aduku (2005) gave the potential fish yield of Kubani reservoir as 38kg/ha. The shallower nature of Oyun reservoir and the availability of nutrients could be the reason why the Morpho Edaphic Index (MEI) of the reservoir was higher than that of Kpong, with Oyun recording 25.16 against Kpong's 8.60. The annual pH mean of Kpong reservoir was 7.14 which was slightly basic while that of Oyun (6.85) was weakly acidic but both were within acceptable range of 6.5 – 9.0 (Boyd & Lichtkopper, 1979) for the production of fishes. Both Kpong and Oyun Reservoirs were both well oxygenated (4.41 mg/l and 6.89 mg/l for Kpong and Oyun, respectively). While they both fall within the recommended range for fish survival of 5 mg/l or more (Hanna, 2003) and not less than 3 mg/l (Biney, 1974), the difference in the values between them could possibly be as a result of Kpong having more algal blanket covering stretches of its banks which exacerbate oxygen depletion due to decomposition. Although DO in reservoirs are produced during photosynthesis by aquatic plants including algae, their high concentration can also be oxygen draining. This dimension could also be attributed to the lower transparency at Kpong (0.78 m) compared to 1.18 m at Oyun.

At both reservoirs, temperature show greater correlation with other physico-chemical parameters. Transparency and temperature exhibited the strongest correlation at Oyun while sulphate and pH showed the strongest at Kpong. Overall at the two reservoir, nutrients displayed greater impact on fish abundance with nitrate, phosphate, sulphate, showing significant influence at Oyun while nitrate and phosphate dominated at Kpong. The study therefore inferred that nutrient levels fluctuations are factors that play crucial roles in fish abundance in both reservoirs. This is in agreement with the conclusions of Antwi & Ofori-Danson (1993) for Kpong reservoir seven years after impoundment, Ansa-Asare & Asante (1998) for Weija reservoir, Ghana and Moshood (2009) for Oyun reservoir, Nigeria. However, Alhassan *et al*., (2011) reported homogeneity in the Dawhenya reservoir in Ghana with nutrients not playing significant influence there.

CONCLUSIONS

Both reservoirs have key physico-chemical parameters being within recommended ranges for fish survival. The limnochemistry of Oyun is however characterized by its high ionic content as reflected in the high conductivity and Total Dissolved Solids (TDS) values recorded. The ionic content could possibly be attributed to the advanced weathering of rocks and soils in the Oyun Reservoir as submitted by Mustapha (2009). Conversely, Antwi & Ofori-Danson (1993) submitted that the Volta system on which Kpong reservoir is situated is characterized by low ionic content with typically low conductivity and TDS values.

Generally in terms of seasonality, both reservoirs recorded high productivity during their respective rainy seasons with Oyun recording slightly higher due to increased TDS and nutrients levels. Productivity however dropped slightly during the dry season when the water levels are lower and flow was naturally slower hence ineffective nutrients distribution.

Despite both reservoirs being impounded in the same year, the Kpong Reservoir had lower fish species richness than the Oyun Reservoir as expected due to the latter having a shallower depth and a higher productivity. Estimates of Forage-Carnivore (F/C) ratio gave indications of a suitable ecological balance between foragers and carnivores in both the Kpong and Oyun reservoirs. The estimated annual harvestable fish from the two reservoirs were comparable with that for tropical reservoirs of same, medium and bigger sizes. Granted the adoption of appropriate management measures, both reservoirs are considered highly productive and possess the potential to optimize their fish production.

RECOMMENDATIONS

In order to maximize yields in both reservoirs, management approaches that covers habitat protection by preventing sedimentation and aquatic plants cover / regular removal and social approaches that include consistent education of the communities living around the reservoirs. Stricter monitoring and enforcement of non-compliance is also essential to the sustainability of these reservoirs. However, as posited by Marshall & Maes (1995) the choice and combination of approaches to be deployed should be dependent on reservoir status (productivity) as well as other social and economic factors

ACKNOWLEDGMENT

Profound gratitude to the University of Maiduguri, Nigeria for granting the lead author study leave for the period of this study.

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