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SDRP Journal of Aquaculture, Fisheries & Fish Science

COMPARATIVE BIOTIC QUALITY ASSESSMENT OF TWO TROPICAL RESERVOIRS USING FISH BASED INDEX OF BIOTIC INTEGRITY

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September 2017

Received Date: 23th Aug 2017
Accepted Date: 15th Sep 2017
Published Date:18th Sep 2017

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CONFLICTS OF INTEREST
There are no conflicts of interest for any of the authors.

ABSTRACT
A Fish-based Index of Biotic Integrity (FIBI) was applied to assess the biotic health of two small, tropical West African reservoirs at the Kpong and Oyun reservoirs in Ghana and Nigeria respectively between September, 2014 and August, 2016. The study aims to evaluate the index's response to changes in environmental quality of the two reservoirs. Twelve metrics were selected for the FIBI in three categories: (i). Species richness and composition; (ii). Trophic composition and (iii). Fish abundance and condition. The FIBI was found to be appropriate for the biotic assessment on basis of its sensitivity to non-source perturbations in the two reservoirs. The expected IBI decrease at the impacted station held true only for Kpong reservoir but slightly increased for Oyun, signifying better biotic quality at the latter than the former. By comparison, the FIBI indicated the Oyun reservoir to be in the good class of index classification while the Kpong reservoir fell in the fair class. Further studies to prove the veracity of the FIBI in other tropical freshwater bodies are recommended to enhance its application in future biotic assessments.

Key words: Biotic integrity, IBI, FIBI, Nigeria, Ghana

1.0 Introduction
Globally, aquatic ecosystems face increasing destruction with the biological components being the most impacted (Allan & Flecker, 1993). As a result, biological assemblages in aquatic ecosystems have been used as key indicators of degradation inherent in such systems (Frissell, 1993). For instance, effects of anthropogenic perturbations such as effluents discharged into aquatic environments have be measured using fish assemblages due to a variety of reasons which includes but not limited to their ability to provide a relatively long term record of environmental stress, and the ease with which they integrate the effect of varied stressors on their prey (Moyle & Leidy, 1992). Thus, the abundance or otherwise of species within fish assemblages could be indicative of the physical, chemical and biological conditions of their habitat (Ganavan & Hughes, 1998). In effect, there is growing use of fish assemblage data to describe the status of aquatic resources (Karr & Chu, 1999).
Biological integrity refers to the ability of a biological system to function effectively by maintaining itself and evolving to accommodate the ever changing environmental conditions (Kay, 1991; Anermeir & Karr, 1994). It is the capability of supporting and maintaining a balanced community comparable to that of the natural habitat of the region (Karr & Dudley, 1981). Systems with high biological integrity can withstand or recover from most perturbations either natural or anthropogenic in contrast to systems with low integrity which are often in degrad-

ed state already and further perturbations would rapidly accelerate their degradation causing more undesirable consequences.

The Index of Biological Integrity (IBI) was developed in 1981 as a tool to monitor biological integrity of rivers and streams, originally for those located in the United States of America and subsequently modified to be used extensively in other places (Simon & Lyons, 1995). USEPA (2002) describes IBI as an assessment method that quantifies the biological integrity of a habitat by using a combination of biological indicators that respond to a range of different stressors that may impact a system. It is the synthesis of varying information on the biotic components of the aquatic system that numerically shows the relationship between the biological attributes and anthropogenic perturbations. These attributes which are referred to as 'metrics', are sensitive to fluctuations in the biological integrity of the system arising from human influences. The application of multi-metric (combination of metrics) compares the status of the biotic integrity at the site being sampled with expected status in similar site within the same region that has little or no anthropogenic influences (Karr, 1996).

Biological indices for the evaluation of aquatic systems are numerous but the Index of Biological Integrity (IBI) has recorded comparatively significant success in assessing conditions of freshwater bodies (Karr & Chu, 1999). The IBI takes into consideration key components of the system including trophic guild composition, habitat composition, taxonomic richness and individual abundance (Ganasan & Hughes, 1998). These indices are region specific, as an effective index for particular region might perform poorly for other regions.

Quite a few published works on biotic quality assessment of African tropical reservoirs have been published with Aboua *et al*., (2012); Goore Bi (2009); Hugueny (1990); Hugueny *et al*., (1996) all reporting on the IBI of West African water bodies. However there is paucity of published work on comparative biotic quality assessment of any two West African tropical reservoirs. This chapter presents an attempt to determine the biotic quality of the two studied reservoirs based on Fish based Index of Biotic Index (FIBI) in order to provide their respective managers with information to enhance sustainable exploitation.

2.0 Materials and Methods

2.1 Study Areas:

The work was conducted at two geographically separated West African reservoirs in Ghana and Nigeria at the Kpong and Oyun respectively (Fig. 1a & 1b respectively).

2.1.1 Study Area1: 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.

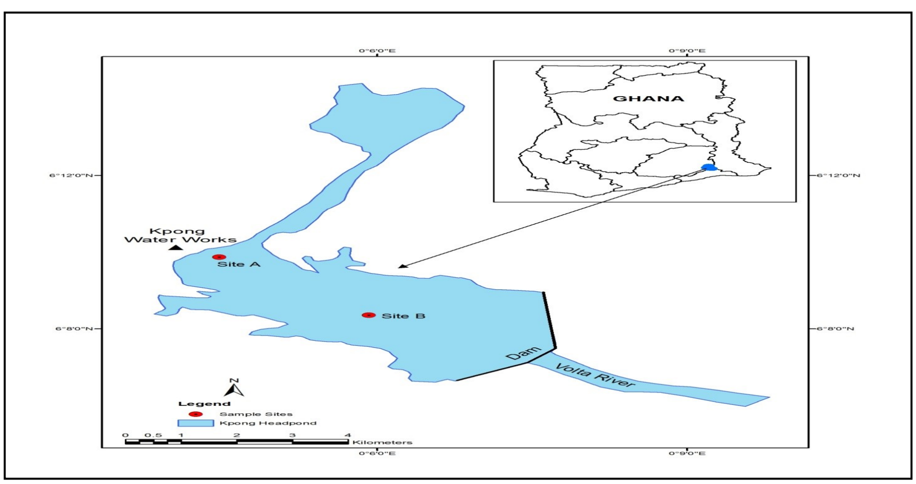

Fig. 1a: Kpong Head pond, Ghana showing Sampling Sites

2.1.2 Study Area2: 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).

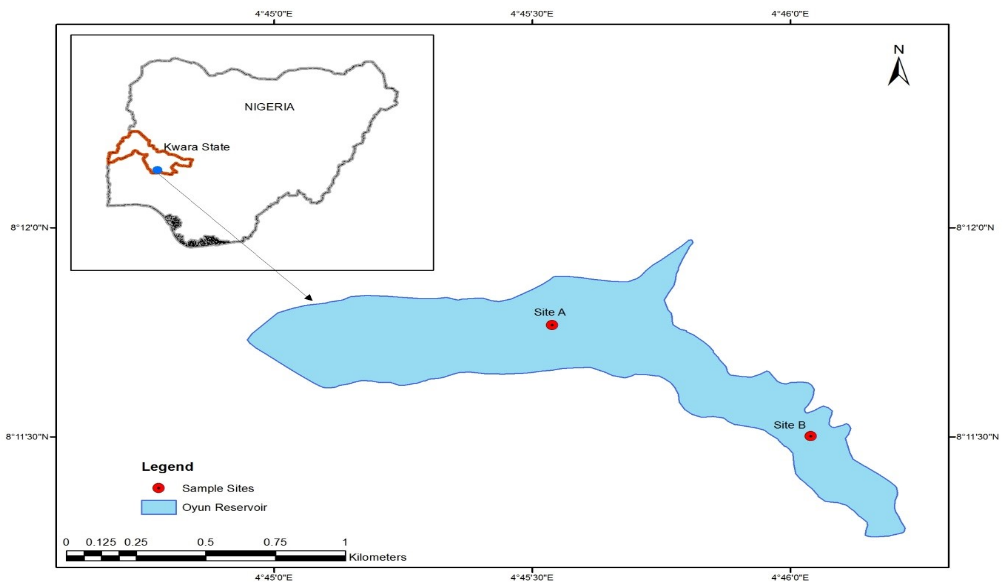

Fig 1b: Oyun Reservoir, Nigeria showing Sampling Sites

Two sampling stations each were chosen for both reservoirs based on anthropogenic activity levels with Site A being portions with more activites compared to Site B with less activites. 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.

2.2 Sampling

Three broad sources of data were adopted namely: i. Data for fish sampling; ii. Data for benthic sampling; and iii. Data for plankton sampling. For all three, sampling was monthly for a period of twenty four (24) months between September, 2014 to August, 2016.

2.2.1 Biological sampling

Data from Fish Sampling

Fish were sampled monthly using experimental fishing with a hired local fisherman fishing for an hour between 6am – 7am 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. The samples were stored immediately in iced containers and transported to the laboratory. In the laboratory, the fishes were sorted according to species using identification keys by Olaosebikan and Raji (2004) and Leveque *et al*., (1992) with numbers of each recorded. All samples were measured using a wooden measuring board for total length and standard length to the nearest 0.1 cm and total weigh to the nearest 0.1 g using an electronic scale. All fish samples were observed for visible signs of disease and anomalies and recorded.

Data for Benthic fauna sampling

For benthic fauna, three successful hauls of benthic samples were taken from each station monthly using a 15 cm x 17 cm Ekman-Birge grab sampler from a boat with an out-board motor monthly during the early morning hours between 8am-10am. The contents of the grab were backwashed through a 1 mm sieve to separate the benthos from mud, 4% formaldehyde solution buffered with Sodium borate (Borax) was added for preservation while a few drops of rose Bengal solution was added to stain the specimens light pink for easy identification. They were then emptied into labelled polythene bags and stored in iced containers for onwards conveyance to the laboratory for sorting and analysis. In the laboratory, the samples were further passed through a 1 mm sieve in order to remove fine sediments and any other extraneous material. The samples were then passed through 0.5 mm mesh sized sieves to collect the macro benthos in them following the methods presented by Esenowo & Ugwumba (2010). Identification was done under light and stereo dissecting microscope and counted. The identification was carried out using keys by (George, *et al*., 2009).

Data for plankton sampling

Phytoplankton samples collection were done at all sampling sites in the early morning hours between 8 am-10 am. A 0.5 m diameter phytoplankton net with 35 μm mesh size was towed for 100 m from a non-motorized canoe. Samples collected were preserved with 1% Lugol solution. An inverted Axiovert S100 microscope was used to view the samples and species identification done using Needham and Needham (1962). Zooplankton samples were collected in same pattern to phytoplankton but with a 55 μm mesh size net and preserved in 4% formaldehyde.

2.3 Adoption of descriptors and metrics

Modification of IBI from Karr, (1981) pioneer Index to different ecological regions requires adequate information on the fish species assemblage to be used for the construction of the Index. Knowledge on the origin of the fish (whether native or non-native), their trophic status, habitat and their relative tolerance to perturbations both natural and anthropogenic are essential as posited by Ganasan and Hughes (1998). Due to the fact that the two water bodies under study are found within the West African sub region, metrics from already existing IBIs from some African water bodies were used as baselines for selecting metrics for this study. Indices for a Guinean water body (Hugueny *et al*., 1996), Cote D' Ivore (Goore Bi, 2009; Aboua *et al.*, 2012), Cameroon (Toham & Teugels, 1999), and Namibia (Hocutt, *et al*., 1994; Hay *et al*., 1996) were considered. Three descriptors, namely, i. Species richness and composition, ii. Trophic composition and iii. Fish abundance and health were chosen in line with Hocutt *et al*., (1994) Index. This was further modified to reflect the peculiarities of tropical African waters and a total of twelve different metrics were then selected under those three descriptors as shown in Table 5.1.

2.4 Adaptation of metrics for Kpong and Oyun reservoirs

Metric I: Karr (1981) original metrics of 'total number of species' was adopted without modifications. Since this metric was predicated on the hypothesis that only tolerant species to perturbations will survive and be present in waters with little or no disturbances, this was retained as it holds true for tropical reservoirs which typically has high species diversity (Jackson & Marmulla, 2001).

Metric II: A new 'number of fish families' was introduced which wasn't part of the original metrics by Karr (1981). The choice of this metric was because of its measure of biodiversity at the family taxonomic level as reported by Noss (1992). Families have been reported to be threatened in environments with intensive human activities and hence decreases as the activities of humans increases (Witkowski, 1992).

Metric III: Cichlid species from the Cichlidae family was used to replace the sunfish species (*Centrarchus macropterus*) from the Centraechidae family which are not found in the two tropical reservoirs under study. Mustapha (2009) reported Cichlid as the most abundant species in Oyun reservoir while Antwi & Ofori-Danson (1993) reported same for Kpong reservoir further making this metrics appropriate for the development of the IBI for these reservoirs. Hocutt *et al*., (1994) on Namibian water bodies and Oberdorff & Hughes (1992) also submitted that water column species like the cichlids are suitable replacements for the sunfish species owing to their abundance.

Metric IV: the metrics 'number of darter species' that belongs to the family Percidae was modified to number of Mormyrid species belonging to the Mormyridae family due to their relatively high abundance in Oyun and Kpong reservoirs respectively (Mustapha, 2009, Antwi & Ofori-Danson; Quarcoopome *et al*., 2011).

Metric V: the 'total number of sucker species' proposed by Karr (1981) was replaced with total number of benthic species as suggested by Oberdorff & Hughes (1992) so as to retain the association with the benthic zone of the reservoir same as the suckers.

Metric VI: the "percentage individuals as Greensunfish" (*Lepomis cyanellus*) proposed in the original IBI metrics was replaced with the third most abundant species in the two reservoirs under consideration. Bagrids for Kpong reservoir, and Mockokids for Oyun as suggested by Hugueny *et al*., (1995).

Metric VII: the ‘percentage of species as omnivores’ was adopted without modification. The hypothesis from Karr (1981) was that omnivores are meant to increase in numbers as the deterioration of the water increases since that condition limits the availability of specialized food material thus aiding their proliferation. Abua *et al*., (2012) and Hocutt *et al.*, (1996) both adopted same for the African water bodies they studied while Ganasan & Hughes (1998) and Pinto & Araujo (2007) both followed similar patterns for tropical rivers in India and Brazil respectively.
Metric VIII: the ‘Percentage individuals that are piscivores’ was also retained without modification. Piscivores abundance in large water bodies is indicative of its good health as it reflects the availability of food for this group of fishes. This metric is common feature in most IBI across regions.
Metric IX: the ‘percentage of individuals that are invertivores’, that is, those fishes feeding on invertebrates i.e. insects and benthic organisms were adopted unchanged from Karr (1981) metrics. Hocutt *et al.*, (1994), Hay *et al*., (1996), Hugeny *et al*., (1996) and Kamdem Toham & Taugels (1999) all adopted same for their respective African water bodies.
Metric X: percentage of individuals that are herbivores was also adopted without adjustments. Hocutt *et al*., (1994) and Hay *et al*., (1996) both argued on the propriety of the inclusion of this metric in the IBI in reservoirs in southwestern Africa. Infact, according to Bayley & Li (1992) the greater abundance of herbivores in healthy waters appears to be the fundamental difference between temperate and tropical fish fauna. Herbivores are sensitive to any physical or chemical perturbation on the habitats that adversely affect vegetation composition.
Metric XI: total number of individuals was adopted and selected without changes. It is a measure of total fish production / catch and serves as a measure of toxic sensitivity and total degradation. Most IBI for both water bodies both in the United States of America and outside it have this metric as an integral part of their IBI (Karr *et al*., 1986; Hughes & Oberdorff, 1998) as it is expected to be less in the less perturbed reference site.
Metric XII: since diseases and anomalies can be induced or exacerbated by the deterioration of the environment, the metric ‘percentage of individuals with anomalies or diseases’ was adopted and maintained unchanged. Since no data on diseases was available, this metrics was not evaluated but retained for future investigation on tropical reservoirs in Nigeria and Ghana. This practice was also used by Ganasan & Hughes (1998) where he posited that this metrics has been used as a key indicator of degradation in various rivers and reservoirs.

2.5: Calculations of the FIBI metrics

Metric scoring criteria for the FIBI were based on the highest metric scores observed between the test site (present study areas) and reference site (Data from Antwi & Ofori-Danson (1993) for Kpong and Mustapha (2009) for Oyun). The choice of Antwi & Ofori-Danson as reference for Kpong reservoir was premised on the fact that work of Dankwa (1982) a year after the reservoir’s impoundment was at the early life of the reservoir and still evolving, while those of Quarcoopome *et al*., (2011) and Nunoo & Asiedu (2013) 25 years and 31 years after impoundments respectively were with reduced fish abundance outcomes that could be related to increase perturbations, among other factors. Hence, that of Antwi & Ofori-Danson (1993) 8 years after the impoundment is the available published work that shows indication of a minimally impacted period of the reservoir. For Oyun, similar pattern was obtainable, Omotosho (1993) study on the reservoir 8 years after impoundment recorded on 14 species while that of Mustapha (2009) recorded 18 species with indications of minimal impact of perturbation hence its choice as reference site. No other detailed study on Oyun was found and the author personal experience during 24 months of data collection shows a reservoir that is still minimally impacted. This approach of using a minimally impacted site data as reference sites was suggested by Karr *et al*., (1986) and employed by Hughes & Gammon (1987) and Ganasan & Hughes (1998). This study adopted the traditional scoring criteria approach to score each metric versus the reference site.

2.6 Data Analysis

The radar chart in Excel data analysis toolpac 2007 was used to compare metrics categories in each reservoir. The values of IBI Index scores for the respective metrics at both reference and study site were compared for both reservoirs using t-test at $p < 0.05$ significance level.

Table 1: Metrics of fish community from original IBI by Karr (1981) and the corresponding ones adapted for Kpong and Oyun reservoirs

Catego-ry	Metric num-ber	Original metrics (Karr, 1981)	Adapted metrics (Present study)
Species richness & com-position	I	Number of species	Number of species
	II	Absent in Karr (1981) metrics	Number of fish families (following Noss (1992) and Witkowski, (1992))
	III	% number of Cichlid species	Retained
	IV	Number of intolerant species	Adapted to % number of Bagrid species (Kpong) Mockokid species (Oyun) respectively
	V	% number of darter species	Adapted to % number of Mormyrid species
	VI	% number of sucker species	Adapted to % number of benthic species
Trophic compo-sition	VII	% number of individuals that are omnivores	% number of individuals that are omnivores
	VIII	% number of individuals that are piscivores	% number of individuals that are piscivores
	IX	% number of individuals that are invertivores	% number of individuals that are invertivores
	X	% number of individuals that are herbivores	% number of individuals that are herbivores
Fish abun-dance & condi-tion	XI	Number of individuals	Number of individuals
	XII	% of individuals with anomalies	% of individuals with anomalies

3.0 Results

3.1 Scoring criteria and scores

The traditional scoring criteria and respective scores of metrics for both Kpong and Oyun reservoirs are shown in Tables 2a & 2b. Oyun recorded the highest total FIBI Index score of 48 from 12 metrics while Kpong had 42 from the same number of metrics. The Kpong reservoir recorded better IBI Index for three metrics (metrics III, VI and X) compared to the references site. Conversely, the metrics for the number of Bagrid species and the number of Mormyrid species recorded significantly reduced indexes compared to the reference site. This shows a reduction in piscivores and omnivores (Bagrids and Mormyrids) with a resultant increase in herbivores (Cichlids) compared to the reference site which is indicative of trophic level realignment (Table 2a).

Compared to the reference site, Oyun reservoir show improved Index for five metrics (metrics II, IV, V, VI and VII). The reservoir demonstrated a balance cascade of adjustments to the Indices of the major feeding levels compared to the reference sites. There was an increase (Good scores) in the ominivory feeding level as seen in the scores for metric IV, V and VII; slight decrease (fair scores) in the piscivores, invertivores and herbivores as seen in metrics V, IX, X and III (Table 2b).

Table 2a: Traditional IBI scoring criteria and scores for Kpong reservoir

Category	Metrics	*5 (best)	*3 (fair)	*1 (worst)	Present study result	Score
Species richness and composition	Number of species	>21	7-15	<6	17	3
	Number of fish families	>15	8-10	<5	5	3
	% number of Cichlid species	>35%	15-20%	<5%	77.7%	5
	% number of Bagrid species	>35%	15-25%	<10%	5.6%	1
	% number of Mormyrid species	> 13%	6-12%	< 5%	8.7%	1
	% number of benthic species	>51.5 %	21-50%	<20%	52.94%	5
Trophic composition	% number of individuals that are omnivores	>25%	10-20%	< 5%	15.8	3
	% number of individuals that are piscivores	>30%	10-25%	< 5%	12.1	3
	% number of individuals that are invertivores	>17%	6-12%	< 3%	6.6%	3
	% number of individuals that are herbivores	>25%	10-20%	< 5%	65.7%	5
Fish abundance and condition	Number of individuals	>1850	1001-1500	< 1000	1415	3
	% of individuals with anomalies	<50	51-99	>100	45	5
Total						**42**

**** Scores of 5, 3 or 1 are assigned to each metric according to whether its value approximates, deviates somewhat from or deviates strongly from the value at the least disturbed / reference site in this study.**

3.2 Functional and trophic groups

Tables 3a & 3b show the functional and trophic groups of fishes found at both Kpong and Oyun reservoirs. Oyun reservoir recorded a trophic level range of between 2.0 (*Tilapia zilli* and *Oreochromis niloticus*) to 4.0 (*Mormyrus anguilloides*) (Table 5.3a) while that of Kpong ranged between 2.0 (*Tilapia zilli* and *Oreochromis niloticus*) to 3.93 (*Hemichromis bimaculatus*) (Table 3b)

The composition of fish habitats types in both Kpong and Oyun reservoirs shows dominance by benthic species with 52.94% and 66.67% respectively with Benthopelagic species the next in dominance at both reservoirs. In terms of diet, Kpong reservoir demonstrated higher percentage of omnivores and piscivores while Oyun recorded marginally higher percentage number of herbivores and invertivores (Tables 5.3a&b).

Figure 2 presents a radar chart show the similarities between the three metric categories in both reservoirs. Oyun reservoir demonstrated wider metrics base compared to that of Kpong. The spread of metrics for both tropic composition and fish abundance at both reservoirs were however the same with the former recording cumulative Index score of 11 and the latter recording 8 respectively. T-test analysis show that there was significant difference between the IBI scores of Oyun and Kpong reservoirs with a p value of 0.0298.

Table 2b: Traditional IBI scoring criteria and scores for Oyun reservoir.

Category	Metrics	*5 (best)	*3 (fair)	*1 (worst)	Present study result	Score
Species richness and composition	Number of species Number of fish families Percentage number of Cichlid species % number of Mochokid species % number of Mormyrid species % number of benthic species	>20 >8 >60% >5% >5% >66%	7-19 5-7 16-55% 3-4% 3-4% 21-65%	<6 <5 <15% <2% <2% <20%	18 9 46% 5.2% 12.2% 66.67%	3 5 3 5 5 5
Trophic composition	% number of individuals that are omnivores % number of individuals that are piscivores % number of individuals that are invertivores % number of individuals that are herbivores	>10% >5% >16% >65%	5-8% 3-4% 6-15% 16-55%	< 3% < 2% < 5% < 15%	36.8 4.2 7.5% 51.5%	5 3 3 3
Fish abundance and condition	Number of individuals % of individuals with anomalies	>7713 <50	1501-7712 51-99	<1500 >100	1598 35	3 5
Total						**48**

****Scores of 5, 3 or 1 are assigned to each metric according to whether its value approximates, deviates somewhat from or deviates strongly from the value at the least disturbed / reference site in this study.**

Table 2c: Karr (1981) Index score classification

Class	Index number
Excellent (E)	57-60
Excellent to Good (E-G)	53-56
Good (G)	48-52
Good to Fair (G-F)	45-47
Fair (F)	**39-44**
Fair to Poor	36-38
Poor (P)	28-35
Poor to Very Poor (P-VP)	24-27
Very Poor (VP)	≤ 23

Table 3a: Classification of fish species at Oyun reservoir into functional and tropic groups

Families	Species	Diet	Habitat		Trophic level
Cichlidae	*Tilapia zilli*	Herbivore[1]	Benthic[1]		2.0[1]
	Oreochromis niloticus	Phytoplanktivore[1]	Benthic[1]		2.0[1]
	Sarotherodon galilaeus	Phytoplanktivore[1]	Benthic[1]		2.05[1]
	Hemichromis fasciatus	Piscivores[1, 3]	Benthopelagic[1]		3.18[1]
Mormyridae	*Mormyrus anguilloides*	Omnivore[2]	Benthic[1]		4.0[1]
	Gnathonemus cyprinodes	Omnivore[2]	Benthic[1]		3.0[1]
	Hyperopisus bebe	Omnivore[6]	Benthic[1]		3.60[1]
	Momyrus rume	Invertivore[1]	Benthic[1]		2.48[1]
Mochokidae	*Synodontis gambiensis*	Omnivore[1]	Benthopelagic[1]		2.9[1]
	Synodontis schall	Herbivore[1]	Benthopelagic[1]		2.92[1]
Cyprinidae	*Barbus occidentalis*	Invertivores[1]	Benthopelagic[1]		3.0[1]
	Labeo coubie	Phytoplanktivore[1]	Benthopelagic[1]		2.04[1]
Claridae	*Clarias gariepinus*	Omnivore[2]	Benthic[1]		3.15[1]
	Clarias anguillaris	Omnivore[1]	Benthic[1]		3.35[1]
Channidae	*Channa obscura*	Piscivores[1]	Benthic[1]		3.4[1]
Osteoglossidae	*Heterotis niloticus*	Planktivore[1]	Benthic[1]		2.93[1]
Schilbeidae	*Schilbe mystus*	Piscivore[2]	Benthic[1]		3.45[1]

[1]Fishbase (www.fishbase.org. January 2017), [2]Aboua (2012) [3]Hugueny *et al*., (1996) [4]IUCN Red List of Threathened Species, 2016-3 [5]Ipinmoroti, (2013) [6]Adeyemi (2012)

Table 3b: Classification of fish species at Kpong reservoir into functional and tropic groups

Families	Species	Diet	Habitat	Trophic level
Cichlidae	*Tilapia zilli*	Herbivore[1]	Benthic[1]	2.0[1]
	Oreochromis niloticus	Phytoplanktivore[1]	Benthopelagic[1]	2.0[1]
	Sarotherodon galilaeus	Phytoplanktivore[1]	Benthic[1]	2.1[1]
	Hemichromis fasciatus	Piscivores[1, 3]	Benthopelagic[1]	3.5[1]
	Pelmatochromis guntherii			
	Hemichromis bimaculatus	Herbivore[1]	Benthopelagic[1]	3.93[1]
	Tilapia aureus	Phytoplanktivore[1]	Benthopelagic[1]	2.0[1]
Mormyridae	*Hyperopisus occidentalis*	Omnivore[2]	Benthic[1]	3.3[1]
	Gnathonemus cyprinodes	Omnivore[2]	Benthic[1]	3.0[1]
	Hyperopisus bebe	Omnivore[5]	Benthic	3.6[1]
	Mormyrus rume	Omnivore[5]	Benthic[1]	2.48[1]
Mochokidae	*Synodontis eupterus*	Insectivore[1]	Benthopelagic[1]	2.65[1]
	Synodontis nigrita	Omnivore[1]	Benthopelagic[4]	3.4[1]
Claroteidae	*Chrysichthyes auratus*		Benthic[1]	3.65[1]
	Chrysichthyes walker	Carnivore [1]	Benthic[1]	3.20[1]
Claridae	*Clarias gariepinus*	Omnivore[2]	Benthic[1]	3.15[1]
	Clarias aureus	Omnivore[1]	Benthopelagic[1]	2.0[1]

[1]Fishbase (www.fishbase.org. January 2017), [2]Aboua (2012) [3]Hugueny *et al*., (1996) [4]IUCN Red List of Threathened Species, 2016-3 [5]Ipinmoroti, (2013) [6]Adeyemi (2012)

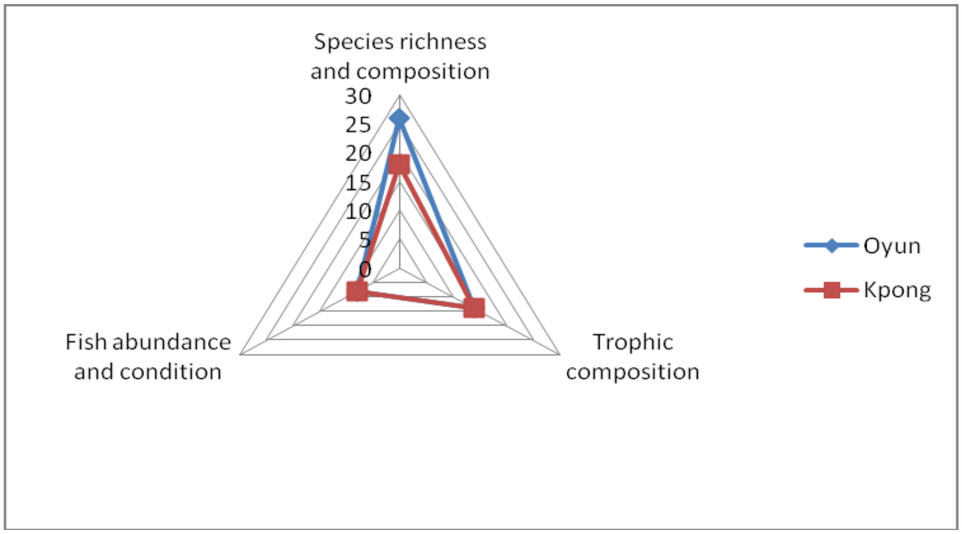

Fig. 2: Radar chart showing similarities among metrics category at Kpong and Oyun reservoirs

4.0 Discussions

On the basis of the FIBI, Oyun reservoir indicated significantly better biotic quality than Kpong reservoir. Most of the metrics considered recorded index scores of 5 and 3 at Oyun reservoir indicating a close or somewhat close relationship to the minimally impacted reference site metrics. Fewer closely related scores of 5 and somewhat related scores of 3 were recorded for Kpong. Metrics scores are indicators of the biotic health of the reservoir or water body. The total number of species is a direct index of the community diversity with Oyun reservoir recording a higher number than Kpong with 18 species compared to 17 species for Kpong reservoir. Reduced proportion of trophic specialists (invertivores and piscivores), increased proportion of trophic generalists (omnivores) and increasing incidence of externally evident disease signs on fishes are indicative signs of a compromised biotic quality as enumerated by Fausch *et al*., (1999). Oyun demonstrated clear signs of good biotic health with increased invertivores percentage (7.5% compared to 6.6% at Kpong) in line with Fausch *et al*., (1990) assumption that proportion of trophic specialists like invertivores declines when the biotic health is bad. Both reservoirs recorded maximum index scores for fish health as very few fishes (<50) were found with externally evident bad health which are measures of deformities. These are often in form of lesions or tumours and are caused by diseases or overcrowding.

5.0 Conclusion

The total FIBI Index score for Oyun was 48 which falls under Good class using Karr (1981) classification range for Index scores while Kpong fall under the Fair class with a total Index score of 42. There was remarkable sustenance of the biotic quality of Oyun reservoir as there was no deterioration of biotic health from the reference site over time unlike at Kpong where the percentage of piscivores sharply over time compared to Oyun. This could be ascribed in large parts to the management of the reservoirs as alterations in habitat and water quality due to land use practices often result in food resource fluctuations in aquatic systems, which are reflected in the structural changes in trophic composition (Karr, *et al*., 1986). Large expanse of aquatic weeds blanket could be seen at Kpong especially around the landing sites with little or no attempts at removing them; this could in the long run further deplete the dissolved oxygen which affects fish abundance.

Expectedly the reference sites have significantly higher IBI scores than sample site which indicates that the biological metrics of the IBI adopted accurately reflects the biotic condition of the reservoirs.

6.0 Recommendations

Being the first documented attempt at using FIBI on the two studied reservoir, the breadth of the sensitivity of the IBI to a variety of types of disturbances should be tested by conducting studies that modifies the Index to cover other disturbances like organophosphates and adapting the outcome to general usage if successful thus conserving more endangered species living in such environments that require unperturbed habitats for survival.
In terms of enforcement, the establishment of long-term monitoring posts to regulate human activities that lead to the compromise of both water and the fish species will be quite beneficial.

Acknowledgements
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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