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FISHERIES POTENTIALS OF CHALLAWA DAM, KANO STATE, NIGERIA

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Abstract

Morpho-metrics and total nutrient input of Challawa dam, Kano State (Nigeria) were applied to estimate the potential fish yield using morpho-edaphic index (MEI). Physico-chemical parameters of the reservoir were sampled monthly from three stations for the period of six months (March to August, 2017) using standard methods. Potential fish yield estimates of the reservoir was determined using the values of the Physico-chemical characteristics of the reservoir with the relationship $Y=23.281\ MEI^{0.447}$, where Y is the potential fish yield in kg/ha, MEI is Morphoedaphic index (given in µS/cm) which was obtained by dividing mean conductivity of the reservoir by mean depth. The values of the mean conductivity and mean depth were 92µS/cm and 3.8m respectfully, with the potential estimate being 96.84kg/ha. The relative yield index (RYI) which is the ratio of estimated yield with angler harvest, was determined using the relationship $RYI= Y_{obs}/Y_{est} \times 0.75$, where Y_{est} is estimated potential yield in Kg/ha and Y_{obs} is anglers harvest in Kg. The estimated yield (Y_{est}) value obtained and anglers harvest were 96.84kg/ha and 35.7kg respectfully, which implied that the relative yield index was 0.27and 27.6%. This result showed that, the reservoir's exploitation level was moderate. Therefore effective management system, implementation of good fishing regulations and practices should be implemented.

Key words: fish potential yield morpho-edaphic index, conductivity, mean depth, dam, Relative Yield Index

Introduction

Fish is an inexpensive source of protein and an important cash crop in many regions of the world (Bhatnagar & Devi, 2013). The natural aquatic systems have witnessed changes in fish stock diversity and abundance, genetic structure and age composition of stocks resulting from structural changes in habitat, food composition and uncontrolled exploitation (Omowumi, 2013). Fisheries resources are fast reducing in Nigeria due to over exploitation; therefore, adequate knowledge of species composition, relative abundance of her water bodies must be understood and actively pursued (Ayamre, 2016).

The morphoedaphic index (MEI; Ryder, 1965), being a model for estimating fish yield, calculated as the concentration of total dissolved solids (TDS) divided by mean depth of the lake. This model indicates that potential fishery yield is proportional to the square root of MEI (Hansen *et al.,* 2010). Several limnological parameters such as conductivity, total dissolved solids, water quality, phytoplankton richness and reservoir morphometry have been used in estimating potential fish yields from reservoirs. However, conductivity is used instead of TDS (Mustapha, 2009). Also; due to its simplicity, the morphoedaphic index had gained enormous popularity among ecologist, fish managers (Downing *et al*, 1991). Despite its simplicity; the MEI was derived empirically (Ryder 1965), which embraced the following conceptual framework and assumptions underlying the model. These assumptions are (i) bedrock geology largely determines the concentration of TDS entering lakes; (ii) TDS is a surrogate for essential nutrients, such as phosphorus, that control lake productivity; and (iii) mean depth is a surrogate for hydrological characteristics such as thermal stratification, nutrient circulation, and dilution, all of which affect how energy is processed within the water column (Hansen *et al*., 2010).

The morphoedaphic index (MEI) has a wide applications which has being applied by many researchers to predict nutrient status and biomass in some Canadian Lakes (Chow-fraser, 1996), fish yield potentials of West African lakes; the morphoedaphic has being in use to determine the productivity of inland impoundments which indeed are more productive than temperate ones (Alhasssan, 2011). The productivity of two Ghanaian lakes Bontanga and Libga were successfully assessed by (Quarcoopome & Amevenku, 2008), Dawhenya reservoir in Ghana after four decades of impoundment by (Alhasssan, 2011). In Nigeria; the same model has being in use for the assessment of potential yields of fish in shallow reservoirs which includes the works of Edward (2013) who evaluated the fisheries potentials of Egbe reservoir, Ekiti State, the fisheries potentials of Kubanni reservoir (ABU, Zaria) was also reported by (Balogun & Aduku, 2004), Eleiyele reservoir fisheries potentials was also reported by Jeje (1997).

The Relative Yield Index (RYI) is the ratio between the observed catch (angler's harvest) and the estimated potential yield. Fisheries management takes into account of "two really different issues: what nature can produce, and what can be done to manage the activities of those who would capture that production (Walters and Martell 2004). Therefore, the determinants of fish productivity and potential yield should be understood and related to management of natural aquatic ecosystem. In line with the above; the model Maximum Sustained Yield (MSY) was developed to check the level of exploitation of fish stock in a natural aquatic ecosystem, the Maximum Sustained Yield is the ratio of estimated potential yield using morphoedaphic index with angler harvest (Baigún *et al.*, 2006).

The study of the Physico-chemical properties of water which is a fundamental part of limnology which diverse usage to the assessment of water quality, biological productivity and trophic status, as well as composition, distribution and abundance of biotic organisms (Mustapha, 2009).

The quality of water parameters such dissolved oxygen (DO); pH, phosphates, salinity and nitrates influence the healthy growth as well as the survival of fish and other integral components such algae, shrimps, and crayfish of both fresh and marine aquatic habitats. The productivity of a given body of water is determined by its physical, chemical and biological properties; therefore these parameters have to be monitored for the survival of fish (Olurin, 2006).

Methodology

The study was conducted in Challawa gorge dam. The dam is located at $8^0 06^{'} 58.04^{''}$E latitude $11^0 41^{'} 21.95^{''}$N longitude (Google Earth, 2016) in Karaye Local Government of Kano State in the Northwest of Nigeria, about 90 km southwest of Kano city. It is a major reservoir on the Challawa River, a tributary of the Kano River, while Kano River is the main tributary of the Hadejia River (Uyigue, 2009). It is 7.8 km in length with a full storage capacity of 904,000,000 m^3. The direct catchment area is 3857 km^2. Apart from irrigation; fishing, and township water supply, the dam was constructed with hydropower potential of around 3MW (Salihi, 2009).

Limnological sampling

Physico-chemical characteristics of the water body were sampled monthly from three stations. Triplicate surface water samples were collected in 1L plastic bottles and analyzed for dissolved oxygen, nitrate, phosphate, total alkalinity, according to the standard methods for the examination of water and waste water (APHA 1998) and Hach (2003) procedures. Analytes requiring photometric measurement were determined using Jenway spectrophotometer (model 6300). Temperature, pH, conductivity and total dissolved solids were measured in-situ using Hanna portable combo waterproof pH/ EC/TDS/Temperature Tester model HI 98130.

Fish weight determination

Fish samples were collected from the catches of artisanal fishermen. Also, total weight of all catches of fishermen were determined using a weighing balance (Sartorius T630) *in-situ* and readings were recorded.

Fish potential yield estimation

Estimates of the potential fish yield were obtained using the Physico-chemical characteristics of the reservoir and the relationship

$Y=23.281\ MEI^{(0.447)}$ ………………… (1)

Where Y is the potential fish yield in Kg/ha, MEI is morpho-edaphic index, which is given in μS/cm and is estimated by dividing the mean conductivity by the mean depth Ryder *et al.*, (1974).

Relative yield index (RYI) determination

As a measure of exploitation level the relative yield index (RYI) defined by Adams and Olver (1977) was used.

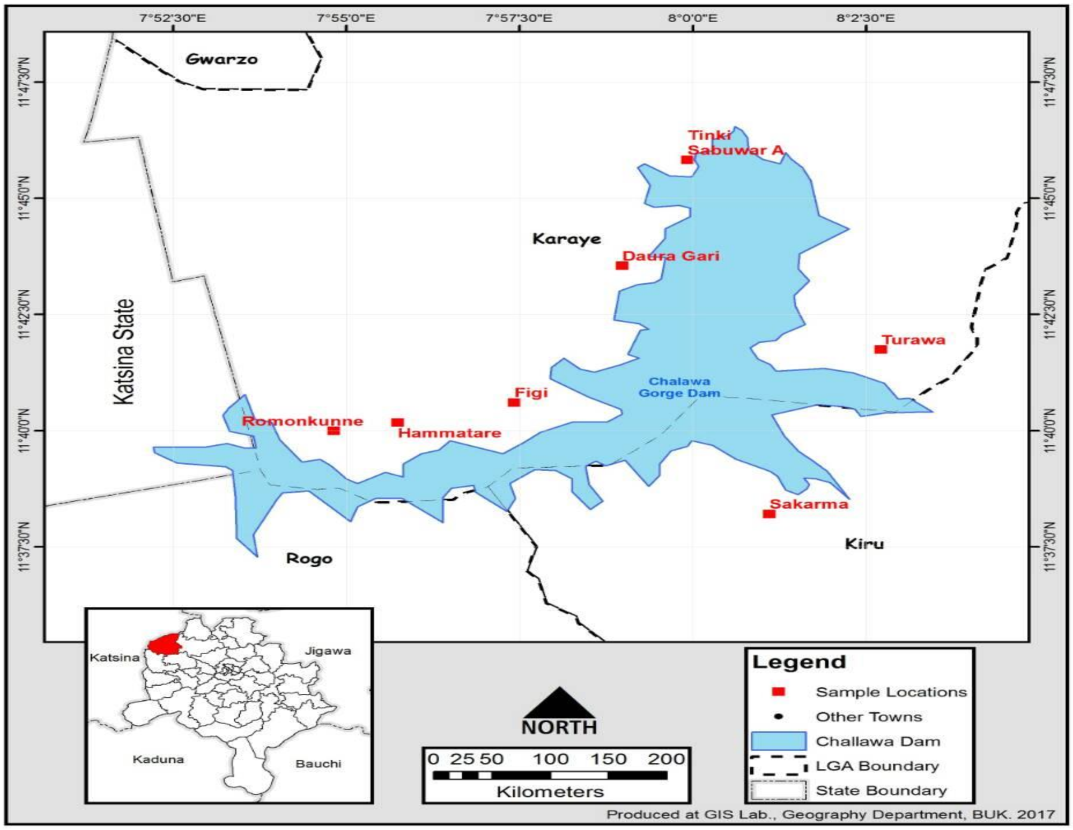

Figure 1: Map of Challawa showing study sites

The RYI is the ratio between the observed catch and the estimated potential yield and thus, RYI = Yobs/Yest x 0.75……………………………….………. (2)

Where;

Yobs = observed yield (which was obtained from the total weighted fish samples obtained in the field),

Yest = estimated potential fish yield (obtained using MEI).

Results and discussion

The data of the Physicochemical parameters of sampling sites during the study period showed that, the mean minimum temperature value of 24.6°C in site 1 and a maximum of 26.2°C in site 2 with a mean value of 25.4 ± 0.56°C (Figure 1). Mean minimal value of 6.35mgl^{-1} was recorded in site 2 and maximum of 7.64mgl^{-1} in site 1 of dissolved oxygen, with a mean of 6.99mgl^{-1}± 0.90mgl^{-1} (Figure 2). Conductivity values revealed that site 2 has the mean maximum value 95.5µScm^{-1}, where site 1 recorded the mean minimum value of 88.8µScm^{-1} and a mean value of 92.2 µScm^{-1} ± 4.7µScm^{-1} (Figure 3). Site 1 recorded the lowest nitrates content of 6.28mgl^{-1}, while site 3 recorded the highest value of 10.19mgl^{-1} with a mean value of 8.24±1.38mgl^{-1} (Figure 4). Mean site values of pH ranged from a minimum of 7.33 in site 1 to a maximum of 7.37 in site 2 with a mean value of 7.35 ± 0.02 (Figure 5).

In the Challawa Dam reservoir, total biomass of fish from catches of fishermen were assessed and recorded from the three sampling sites during the study period, the mean variations of the total biomass revealed that site 1 has the mean minimum total biomass with 8.7 Kg, and maximum of 14.7 Kg in 3 with a mean of 11.7 ± 2.12 Kg (Figure 6).

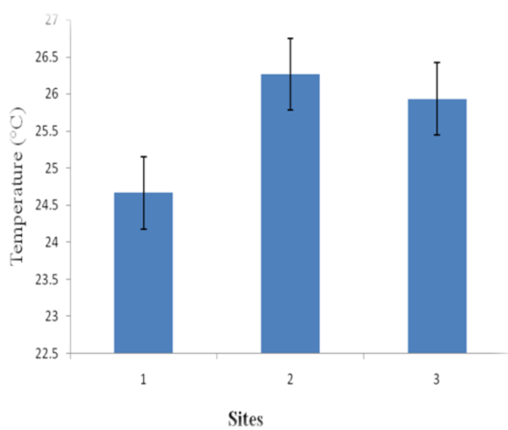

Figure 1: Mean temperature (°C) of the three sites with standard error bars

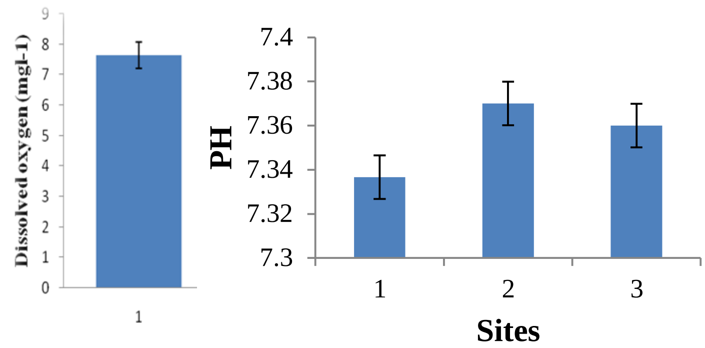

Figure 2: Mean dissolved oxygen (mgl^{-1}) of the sites with standard error bars

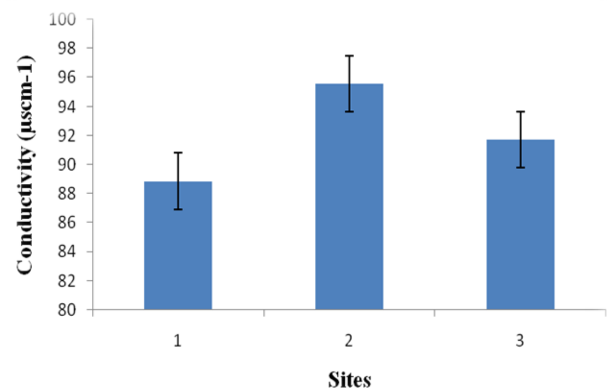

Figure 3: Mean conductivity (µScm^{-1}) of the three sites with standard error bars

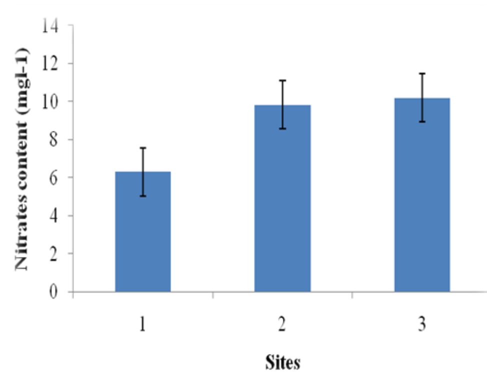

Figure 4: Mean nitrates content (mgl^{-1}) of the three sites with error baars

Figure 5: Mean pH of the three sites with standard error bars

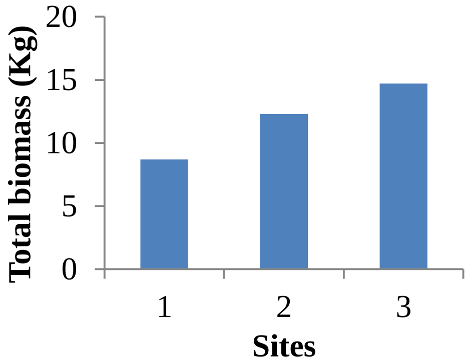

Fig. 6: Mean total biomass (Kg) of the three sampling sites with standard error bars

Potential Fish Yield Estimate

The potential yield of the Challawa dam was obtained from the morphoedaphic index of the dam, and the potential was estimated to be 96.84kg/ha, this was obtained using the expression

$$Y = 23.281 \times \frac{(\text{mean conductivity of the three sites})^{0.447}}{\text{Mean depth}}$$

$$Y = 23.281 \times \frac{92.0^{(0.447)}}{3.8}$$

Y = 96.84kg/ha

Relative Yield Index

In order to check the exploitation level of the fish stock of the dam, the relative yield index (RYI) was calculated, this was achieved using the mean total biomass of fish in field with the potential yield estimates, and thus the expression;

$RYI = Y_{obs} / Y_{est} \times 0.75$,

$RYI = 35.7 / 96.84 \times 0.75$

RYI = 0.276,

Therefore, percentage RYI would be

$RYI = 0.276 \times 100$

RYI = 27.6%

Discussion

The reservoir's fish estimates obtained is 96.84 kg/ha, this yield is within the yield in shallow lakes (Mustapha, 2009) who stated that shallow tropical reservoirs are more productive than deeper lakes, hence the fish yield from Challawa dam obtained is similar to the ones found from the works of other researchers such as Oyun (125.72 kg/ha) Mustapha, (2009) in Nigeria, Botanga (86.98 kg/ha) and Libga (97.19 kg/ha) Quarcoopome, *et al.* (2008) in Ghana.

The yield of the Challawa dam is however higher than the yield of the other tropical reservoirs such as Kubani (38 kg/ha) Balogun, (2005); Kainja (3.5 – 4.7 kg/ha) Balogun, (1995), however, the high potential yield may be as a result of high conductivity with low depth, hence according to Jackson, (2001), shallow reservoirs in the tropics are said to be more productive than those in the temperate regions.

Relative Yield Index

The relative yield intensity (RYI) recorded is 27.6% this upper limit coincides with the findings of Jenkins (1982) in Baigún *et al.*,

(2006) but however, it is lower than the result obtained by Mosa and Regidor (2003) with 80% as cited by (Baigún *et al.,* 2006). Attributable to the dynamics of Relative Yield Index includes the differences in salinity of water, conductivity, species biomass and biomass accumulation, food conversion efficiencies, biomass composition of estimated species, and potential fish yield estimates. The Relative Yield Index of the Challawa dam cannot be expressed as being overexploited (RYI<1). And, indicated that the dam is rich. According to Adams and Olver (1977) RYI value less than 1 indicates moderate exploitation of fish stock.

Physico chemical parameters

Dissolved oxygen is virtually an integral component to life in aquatic environment as it affects the physiology and distribution of the aquatic organisms EPA (2013). Dissolved oxygen is virtually an integral component to life in aquatic environment as it affects the physiology and distribution of the aquatic organisms. In freshwaters, dissolved oxygen at sea level ranges from values of 15mgl^{-1} at 0°C to 8mgl^{-1} at 25 °C. Concentrations in unpolluted waters are usually close to, but less than 10mgl^{-1} (Alhassan, 2011). Concentrations below 2mgl^{-1} may lead to the death of most fish. The dissolved oxygen range of 6.35 to 7.64 mgl^{-1} indicates a good range of dissolved that can support fish and aquatic life in Challawa dam.

As defined by EPA (2012), conductivity refers to the measure of water's capability to pass electrical flow and is usually measured in micro or millisiemens per centimeter. This ability is directly related to the concentration of ions in the water. The highest conductivity value of 93.60µScm^{-1} recorded in June from site 2 (Sakarma), this value recorded may be due to the influx of suspended particles as well as agricultural inputs from the nearby settlement; this will increase the salinity content of the water body. Site 3 (Turawa) recorded the lowest conductivity value with 68.20µScm^{-1} in March; this may be due to the continuous uptake of ionic compounds by phytoplankton in the dry season. However, water with extreme conductivity value decrease species number in aquatic ecosystem according to Dumont (1999) as cited by Mustapha (2002).

Conductivity has been used to estimate potential yield of fish in an inland aquatic ecosystem as it was applied by researchers such as Alhasssan, (2011), Edward (2013) and Mustapha (2009). Challawa dam conductivity range falls within range of acceptable limit for aquatic ecosystem.

No chemical concept, dependent upon a mathematical twist has been received more enthusiastically by ecologists than pH (Talling, 2010). The pH ranges fall within 7.23 to 7.72 throughout in this study. The recommended pH range for most fish is between 6.0 and 9.0 with a minimum alkalinity of 20 mg/L, with an ideal $CaCO_3$ levels between 75 and 200 mg/L (Wurts *et* *al.*, 1992), therefore, these values are favorable for the good growth and survival of fish species.

Dependent upon geomorphic conditions and local climate; temperature is a fundamental factor that influences the distribution of aquatic organisms. Water temperature comes from solar radiation by direct absorption (Berman & Steinman, 1998). In this study, temperature values fall within the range of 25.90 ± 1.19 °C to 26.28 ± 0.94 °C and analysis of variance at 0.05 showed that there was significant difference in the seasons with the wet season having higher temperature values. These findings are in line with the findings of Oyewo (2015). Martinez-Placious *et al.*, (1993) suggested that the temperature range of 20ºC to 30ºC for fish is good; this therefore shows that the temperature values of this studies is good for the survival of fish.

The availability of nitrate in an aquatic ecosystem reflects the characteristic of the surrounding environment and including bedrock. The nitrate range falls within 8.25 ± 3.34 mg/L to as much as 10.13 ± 3.96 mg/L. Sites 1 and 2 (Feginma and Sakarma) recorded the highest value with 13.96 mg/L, these two sites are well surrounded by active farmlands, therefore there is an influx of chemical fertilizers (especially NPK) in the water body. This maybe the possible cause of high nitrates contents. Nitrate is an essential nutrient for land and aquatic plants however excess nitrate can lead to anoxia through eutrophication and subsequent fish kill (Sun & Boyd, 2013) and cause loss of aquatic biodiversity. Effective measures should be applied to stabilize nitrate influx and its related threats.

Conclusion

The Challawa reservoir potential yield was estimated to be 96.84 kg/ha which shows a very good potential yield of fish, it surpasses the yield of many other tropical and temperate lakes; attributable to this high yield is the relatively high conductivity coupled with low depth. The relative yield intensity (Maximum Sustainable Yield) of 0.276 and 27.6%, this implies that the reservoir has a good fish stock potential with a moderate level of exploitation. Also, all the Physico-chemical parameters of the reservoir studied during the sampling fall within the acceptable range with the exception of nitrate which exceeded the recommended limit, this should be addressed to avoid its associated threats. Associated with any ecological changes of a natural reservoir are rainfall, wind and solar energy which served as driving forces (Mustapha, 2009), besides these; nutrient inputs, hydrology and other chemical parameters account for the population dynamic of a natural aquatic ecosystem (Chalar & Tundisi, 1999); as well as human activities such as pollution of aquatic resources, dredging of lakes, overfishing and use of non-selective gears which may account to these changes can be avoided through the efforts of both community level and relevant government agencies.

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