JEBAT, 2023, Vol 6, No 2, 1-10
https://doi.org/10.54987/jebat.v6i2.977

HIBISCUS PUBLISHER

JOURNAL OF ENVIRONMENTAL BIOREMEDIATION AND TOXICOLOGY

Website: http://journal.hibiscuspublisher.com/index.php/JEBAT/index

JEBAT VOL 6 NO 2 2023
Jebba Lake, Nigeria
Malapterurus electricus

Assessment of the Physicochemical Parameters and the General Wellbeing of *Oreochromis niloticus* in Dadin Kowa Reservoir, Gombe State

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HISTORY

Received: 15th July 2023
Received in revised form: 23rd Nov 2023
Accepted: 29th Dec 2023

KEYWORDS

Oreochromis niloticus
Physicochemical parameters
Weight
Condition factor
Dadin Kowa reservoir

ABSTRACT

The maximum sustainable yield of aquatic biota of a reservoir is maintained by periodic monitoring of its water quality and the ecological conditions. Physicochemical parameters and the general wellbeing of *Oreochromis niloticus* in Dadin Kowa reservoir were investigated. Water samples were collected from the three sampling stations (upper reaches, lower reaches and water midways) on biweekly basis for physicochemical analysis. Air temperature, water temperature, pH, transparency, electric conductivity, Dissolve Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Phosphates, nitrate were measured and monitored. A total of 240 (120 male and 120 females) *O. niloticus* samples were obtained fortnightly for the period of 6 months (March – August, 2019) from Dadin kowa dam. Weight-length relationship and fish condition factor were determined. Negative allometric growth pattern was observed in both sexes of *O. niloticus* (b-values <3) with good condition factor (k-value >1). The physicochemical parameters of the reservoir varied with months, and stations which may be due to change in weather cycle during the study period that occurs in the environment. Anthropogenic activities such as farming and cattle rearing, washing and fishing that are taking place around the reservoir had some impact on the water quality of the reservoir, especially during the rainy season which in turn may stress the life of fishes and thus reduce the degree of their wellbeing and thus, slowed the rate of growth. Despite the fact that this research found that the reservoir is fit to support the life of *Oreochromis niloticus*, there is need to check the physicochemical parameters and condition factor of the reservoir regularly for over a long period of time and across different seasons of the year, so as to ascertain the health status of the reservoir.

INTRODUCTION

Freshwater ecosystems have been used for the investigation of factors controlling the abundance and distribution of aquatic organisms [1]. It is well established that the productivity of a reservoir depends on its ecological conditions and by monitoring the water quality; productivity can be increased to obtain maximum sustainable yield of aquatic biota[2,3]. Maintenance of healthy aquatic environment and production of sufficient food in reservoir are primarily linked with successful reservoir culture operations. Various studies conducted on changes brought about by biotic and abiotic factors of river as a result of damming. However, responses of rivers and its ecosystem to damming are complex and varied as they depend on local sediment supplies, geomorphic constraint, climate, dam structure and operation [4,5]. Reservoir ecosystems are fragile and can undergo rapid environmental changes, often leading to significant declines in their aesthetic, recreational and aquatic ecosystem functions [6]. Maintenance of healthy aquatic environment and production of sufficient foods in reservoir are primarily linked with successful reservoir culture operations. To keep the aquatic habitat favourable for existence of living organisms, physical and

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https://doi.org/10.54987/jebat.v6i2.977

chemical factors like temperature, turbidity, pH, dissolved gases, salts nutrients must be monitored regularly, individually or synergistically, activity of living organisms is influenced by the seasonal and diurnal changes of these parameters[7],Changes in the physico-chemical parameters may positively or negatively affect the biota of water bodies in a number of ways such as their survival and growth rates and these may eventually result in disappearance of some species of organisms or its reproduction [8]. Life in aquatic environment is largely governed by physico-chemical characteristics and their stability.

The physico-chemical study of water could also help in understanding of the structure and function of a particular water body in relation to its inhabitant. The chemical elements found in water have an effect on biological processes which lead to interconversion of energy, production of organic materials and ultimately to production of aquatic resources such as fisheries and other biological components found in water ecosystem [2]. The proper balance of physical, chemical and biological properties of water in lakes, ponds, reservoirs, and rivers is an essential ingredient for successful production of fish and other aquatic resources. The presence or absence of a particular chemical element in a water body might be a limiting factor in the productivity of such water body [9].

The Nile tilapia is mostly herbivorous animal that feed on plants, with omnivorous tendencies, especially when young[10] .They mostly feed on phytoplankton and algae, and in some cases feeds on other macrophytes also are important[11] .The Nile tilapia is primarily a diurnal animal that typically feeds during the hours of daytime. This suggests that, light is a main factor that contributes to feeding activity [12]. A recent study found evidence that, contrary to popular belief, size dimorphism between the sexes usually results from differential food conversion efficiency rather than differential amounts of food consumed [13].

Changes in the physico-chemical parameters may positively or negatively affect the biota of water bodies in a number of ways such as their survival and growth rates and these may eventually result in disappearance of some species of organisms or its reproduction [14]. *Oreochromis niloticus* is very important commercial species in Gombe state, despite its enormous importance, little information since the last study in 2020 is known concerning its survival and growth rate in Dadin Kowa reservoir, Gombe State [15]. Hence the need for an update on this research. Therefore, the aim of this study was to update some of the physicochemical parameters and relate it to general wellbeing of *Oreochromis niloticus* in Dadin Kowa reservoir.

MATERIALS AND METHODS

Study Area

Dadin Kowa Dam is located 5km North of Dadin Kowa village (about 37 Km from Gombe town, along Gombe-Biu road) in Yamaltu Deba Local Government Area of Gombe State. The area lies within longitude 11◦ 30' E and 11o 32'E, and latitude 10◦ 17′ and 10 18 N of equator. The Dam is part of River Gongola; its drainage basin is situated in North-Eastern Nigeria, with water capacity of 800million cubes and surface area of 300 kilometers square and has potential as a source of fish. Irrigation farming, cattle rearing, washing and bathing are some of the activities that takes place around the reservoir.

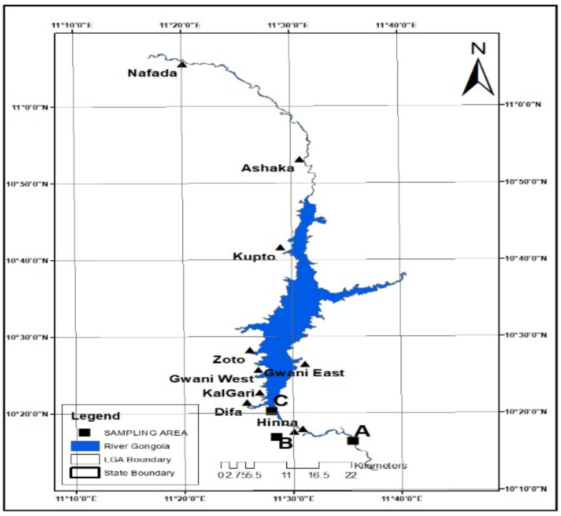

Fig. 1. Dadin Kowa Dam indicating sampling stations.

Sampling Stations

Three sites (A, B, C) were selected along the course of the river for the study. Site A is the Dam site; fishing is the major human activity on this site. Site B is the point where there are high human activities such as irrigation, washing and bathing. While site C is where irrigation and cattle rearing take place.

Water sampling and regime

Water samples were collected from the three different stations on the lake and mean values of the three stations were worked out and recorded. The sampling was conducted fortnightly between the months March to August, 2019.

Determination of Physico-chemical Characteristics

Air temperature

Temperature (°C) of the air was determined in situ by exposing a bulb mercury in glass thermometer in the air at each sampling station for about 1-2 min and the readings were recorded in degree Celsius [15].

Water temperature

Water temperature was determined in situ by dipping bulb mercury in glass thermometer into the water at each station for about 1-2 min and readings were recorded [16].

pH

pH was measured using pH meter, the tip of the pH meter was immersed into the 100 mL beaker containing water sample for 2-3 min and readings were recorded [15].

Electrical Conductivity

Electrical conductivity was measured with conductivity meter, the Water samples was drawn in a wide mouthed beaker and the tip of the conductivity meter was dipped into a beaker for a period of 2-3 minute to permit constant reading.

Transparency

Transparency was measured with black-white Secchi disc. Transparency was measured by gradually lowering the Secchi disc at respective sampling points. The depth at which it disappears in the water (X1) and reappears (X2) was noted and estimated as the average of points of disappearance and reappearance [17].

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Dissolved Oxygen

Hanna Dissolved Oxygen microprocessor HI 98186 was used to determine the dissolved oxygen. Sample of the water was collected in 100 mL beaker; the electrode of dissolved oxygen microprocessor was dipped into the beaker that contains the sample water for about 2-3 min. The reading was recorded in mg/L [18].

Biochemical oxygen demand (BOD)

Hanna Dissolved Oxygen microprocessor HI 98186 was used to determine the biochemical oxygen demand, 100 mL part of the sample collected was incubated for five days in dark cupboard at room temperature and dissolved oxygen was determined after five days of incubation, the difference between the initial value of dissolved oxygen and the value after five days of incubation was used as value of biochemical oxygen demand in the water sample.

Nitrate- NO_3

The Palintest multiparameter model 7100 colorimeter was used to determine the nitrate using the Nitra ver. 5 nitrate reactive reagent. The reagent was added to the sample collected in a 20 mL colorimeter vial and placed in a colorimeter compartment and then closed with the colorimeter cover and allowed for a period of time sufficient to permit constant reading. The value obtained was recorded in mg/L [2].

Phosphate-PO_4

The Palintest multiparameter model 7100 colorimeter was used to determine the phosphate using the armstrong reagent. The reagent was added to the sample collected in a 20 mL colorimeter vial and placed in a colorimeter compartment and then closed with the colorimeter cover and allowed for a period of time sufficient to permit constant reading. The value obtained was recorded in mg/L.

Biological parameters

Fish Sampling

Fish were obtained from the local fishermen and transported to the laboratory for measurement. Total length, Standard length and weight of the fish were measured as described by Olatunde [19]. Total length was measured from the tip most part of the mouth to the tip of the caudal fin. Standard length was measured from the tip of the mouth to hypural bone. All measurements were done in centimetres.

Weight of the fish species was taken using electronic weighing balance (model: TE620), after removing water and other unwanted substances on the fish with the help of filter paper. All measurements were done in grams.

All measurements of the sizes were used to determine the length-weight relationship and condition factor of fish.

Sex determination

Sexing of the fish was done manually done. The sex of male fish was determined by the presence of two openings situated just in front of the anal fin, of which one is the anus. The other is the opening of the urethra, at the end of the genital papilla (an oval-shaped lobe just rearward of the anus), from which milt and urine are discharged. The female possesses three body openings, of which one is the anus, the urethra and the opening of the oviduct (a crescent-shaped slit), from which eggs are released [20].

Data Analysis

One-way Analysis of variance was used to test the significant differences in mean of physico-chemical characteristics among stations and Least Significance Difference (LSD) was used to separate the means of significant differences where exist. Correlation was employed to test the relationship between the physico-chemical characteristics and the *Oreochromis niloticus* at $P<0.05$ level of significance.

Length-weight relationship

Linear transformation of length and weight of the fish was made using natural logarithm at the observed lengths and weights. The length-weight relationship (LWR) was calculated following Pauly [21]. The LWR was used to calculate the regression coefficient (slope of regression line of weight and length). The parameter "b" of the length weight relationship were estimated using the formula W= aLb. Where: W = the weight of the fish in grams, L = the total length of the fish in centimetres a = exponent describing the rate of change of weight with length b = weight at unit length. The expression of the relationship was represented by the following formula:

$$\text{Log } W = b \log L + \log a$$

Condition factor (K) would be determined using conventional formula described by Le Cren [12].

$$K = \frac{W}{L^3} \times 100$$

Where:
K = Condition factor,
W = Weight in grams,
L = Standard length in cm.

RESULTS

Water samples were collected from the three sampling stations (upper reaches, lower reaches and water midways) biweekly basis for physicochemical analysis. Air temperature, water temperature, pH, transparency, electric conductivity, Dissolve Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Phosphates, nitrate were measured and monitored. A total of 240 (120 male and 120 females) *O. niloticus* samples were obtained fortnightly for the period of 6 months (March – August, 2019) from Dadin Kowa dam. Weight-length relationship and fish condition factor were determined. Negative allometric growth pattern was observed in both sexes of *O. niloticus* (b-values <3) with good condition factor (k-value >1).

Physicochemical parameters

The monthly mean variation of physicochemical parameters of Dadin Kowa Dam is shown in **Table 1**. The mean value of air temperature, water temperature, water pH, electric conductivity, dissolved oxygen, transparency, Biological Oxygen Demand, Chemical Oxygen Demand, phosphate and nitrate were all recorded.

Air Temperature

There was no significant difference at $P\leq0.05$ level of significant among the three stations. Station C had the highest mean temperature value of 32.32±1.18 °C, while station A had the lowest mean temperature value of 30.61±1.22 °C.

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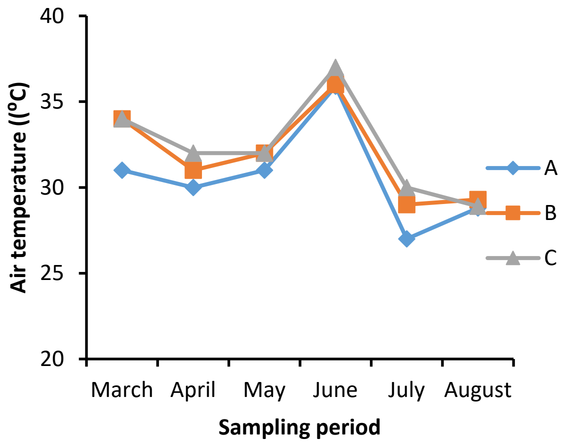

Fig. 2. monthly mean variation of Air Temperature (°C) among the three stations in Dadin Kowa reservoir (March-Aug 2019).

Water Temperature

The lowest mean water temperature value of 24.00±0.99 °C was recorded in the month of August, while the highest temperature value of 28.00±0.58ºC was recorded in the months of March, April and May (**Table 1**). A significant variation existed in water temperature between the three stations, with station C having the highest mean temperature value of 27.58±0.55 °C and station A having the lowest mean temperature value of 26.33±0.92 °C

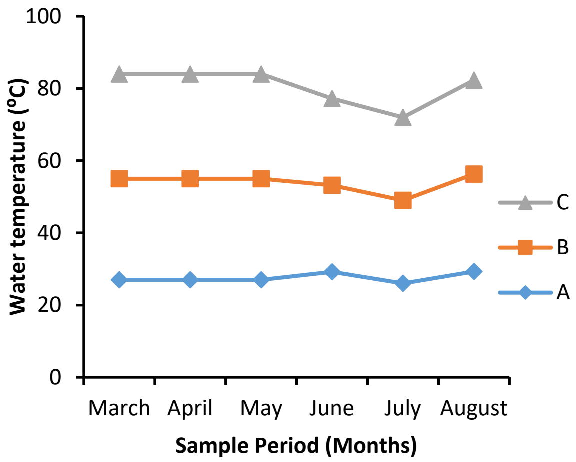

Fig. 3. Monthly mean variation of Water Temperature (ºC) among the three stations in Dadin Kowa reservoir (March-Aug 2019).

pH

Highest pH value of 8.54±0.08 was recorded in the month of August, while the lowest value of 7.53±0.03 was recorded in the months of March (**Table 1**). There was no significant difference at p≤0.05 level of significant among the three stations, station A had the highest mean pH value of 8.06±0.22 and station C had the lowest mean pH value of 7.92±0.21 (**Table 2**).

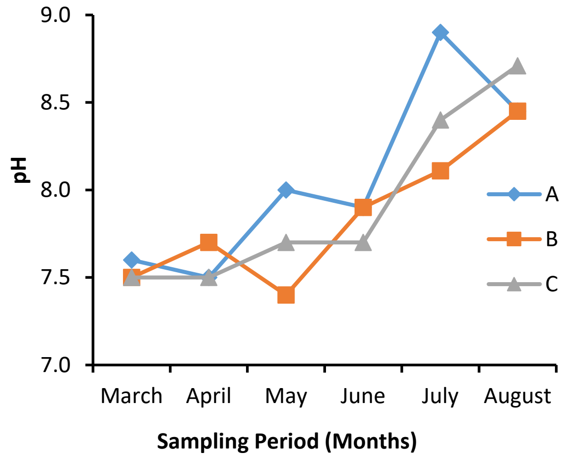

Fig. 4. Monthly mean variation of pH among the three stations in Dadin Kowa reservoir (March-Aug 2019).

Transparency

Highest transparency value of 10.0±0.28 cm was recorded in the month of March, while the lowest value of 6.86±0.87 cm was recorded in the month of August (**Table 1**). There was no significant difference at p≤0.05 level of significant among the three stations, station B had the highest mean transparency value of 8.9±0.31cm and station C had the lowest mean transparency value of 8.6±0.58 cm (**Table 2**).

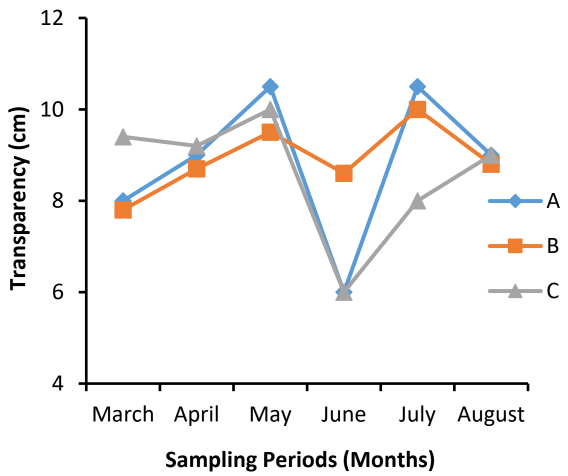

Fig. 5. Monthly mean variation of Transparency (cm) among the three stations in Dadin Kowa reservoir (March-Aug 2019).

Electrical conductivity

The highest conductivity value of 122.67±1.67µS/cm was recorded in the month of June, while the lowest value of 54.00±1.45µS/cm was recorded in the month of August (**Table 1**). Station C had the highest mean conductivity value of 91.83±10.54µS/cm and station A had the lowest mean conductivity value of 83.00±9.91µS/cm (**Table 2**).

https://doi.org/10.54987/jebat.v6i2.977

Table 1. Mean monthly variation of physicochemical parameters of dadin kowa dam march-august 2019.

	March	April	May	June	July	August
Air temp (ºC)	33±1.0	31±0.58	31.67±0.33	36.3±0.35	28±0.88	29.00±0.15
Water temp (ºC)	28.00±0.58	28.00±0.58	28.00±0.58	25.73±1.73	24.00±0.99	27.43±0.98
Water pH	7.53±0.03	7.57±0.06	7.70±0.17	7.83±0.06	8.47±0.23	8.54±0.08
Transparency (cm)	10.0±0.28	9.50±0.76	8.97±0.07	8.93±0.67	8.40±0.61	6.86±0.87
Conductivity (µS/cm)	97.00±9.64	92.33±4.33	88.33±2.73	122.67±1.67	66.33±1.45	54.00±1.53
DO (mg/L)	4.97±0.15	6.97±1.27	5.07±0.15	7.21±0.26	9.07±0.42	4.08±0.29
BOD (mg/L)	3.04±0.03	2.86±0.06	2.66±0.13	2.34±0.07	2.15±0.08	2.05±0.07
COD (mg/L)	3.85±0.13	3.66±0.18	4.49±0.37	4.20±0.17	3.77±0.24	4.13±0.47
Phosphate(mg/L)	3.51±0.17	3.67±0.18	3.97±0.09	3.93±0.09	3.92±0.03	3.92±0.03
Nitrate (mg/L)	7.50±0.06	7.43±0.23	7.97±0.12	8.93±0.47	9.66±0.43	10.20±0.21

$P \geq 0.05$ Key: pH: Percentage of hydrogen ion concentration; EC: Electrical conductivity; DO: dissolved Oxygen; BOD: Biological Oxygen Demand; COD: Chemical Oxygen Demand

Table 2. The mean variation of physicochemical parameters between the three stations of Dadin Kowa Dam March-August 2019.

	Station A Mean±SE	Station B Mean±SE	Station C Mean±SE	p-value
Air temperature (ºC)	30.61±1.22[a]	31.88±1.11[a]	32.32±1.18[a]	0.322
Water temp.(ºC)	26.33±0.92[b]	26.67±1.11[a]	27.58±0.55[a]	0.000
pH	8.06±0.22[a]	7.84±0.16[a]	7.92±0.21[a]	0.267
Transparency (cm)	8.83±0.68[a]	8.90±0.31[a]	8.60±0.58[a]	0.281
Conductivity (µS/cm)	83.00±9.91[a]	85.50±9.91[b]	91.83±10.54[c]	0.000
DO (mg/L)	5.75±0.71[a]	7.29±0.93[b]	6.32±0.85[c]	0.000
BOD (mg/L)	2.47±0.08[a]	2.88±0.15[b]	2.51±0.17[a]	0.000
COD (mg/L)	3.98±0.24[a]	4.1±0.24[a]	3.96±0.17[a]	0.747
Nitrate(mg/L)	8.28±0.44[a]	8.53±0.47[b]	9.03±0.56[c]	0.000
Phosphate(mg/L)	3.70±0.13[a]	3.81±0.08[b]	3.94±0.05[c]	0.000

The same superscript across the column indicates that there is no significant difference while different superscript across the column indicates significant difference at $P \leq 0.05$.

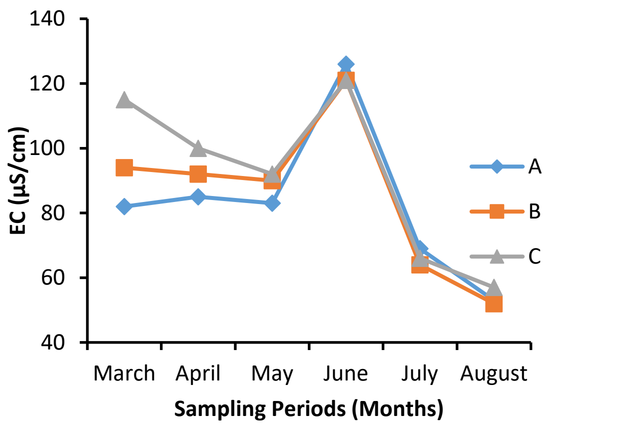

Fig. 6. monthly mean variation of Conductivity (µS/cm) among the three stations in Dadin Kowa reservoir (March-Aug 2019).

Dissolved Oxygen

The highest dissolved oxygen value of 9.07±0.42 mg/L was recorded in the month of July, while the lowest value of 4.08±0.29 was recorded in the month of August (**Table 1**). Station B had the highest mean dissolved oxygen value of 7.29±0.93 mg/L and station A had the lowest mean dissolved oxygen value of 5.75±0.71 (**Table 2**).

Biological Oxygen Demand

The highest biological oxygen demand value of 3.04±0.03 mg/L was recorded in the month of April, while the lowest value of 2.05±0.07 mg/L was recorded in the month of August (**Table 1**). Station B had the highest mean biological oxygen demand (BOD) value of 2.88±0.15 mg/L while station A had the lowest mean oxygen value of 2.47±0.08 mg/L (**Table 2**).

Chemical Oxygen Demand

The highest chemical oxygen demand value of 4.49±0.37 mg/L was recorded in the month of May, while the lowest value of 3.66±0.18 mg/L in the month of April (**Table 1**). There was no significant difference at p≤0.05 level of significant among the three stations, station B had the highest mean chemical oxygen demand (COD) value of 4.1±0.24 mg/L and station C had the lowest mean value of 3.96±0.17 mg/L (**Table 2**).

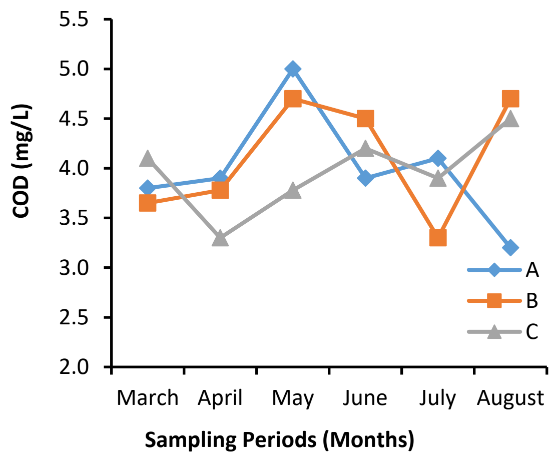

Fig. 7. monthly mean variation of Chemical Oxygen Demand (COD) (mg\L) among the three stations in Dadin Kowa reservoir (March-Aug 2019).

Table 3. Mean condition factor of Male *Oreochromis niloticus* in Dadin Kowa Dam March-August, 2019.

Months	March	April	May	June	July	August	Mean±SE
No. of fish	20	20	20	20	20	20	
Weight (g)	53.3	64.5	68.1	82.5	65.8	64.5	66.45±3.83
Length (cm)	15	14.2	14.9	16.4	14.6	14.2	14.8±0.33
Condition Factor	1.57	2.25	2.05	1.87	2.11	2.25	2.01±0.10

Table 4. Mean condition factor of Female *Oreochromis niloticus* (Nile tilapia) in Dadin Kowa Dam March-August, 2019.

Months	March	April	May	June	July	August	Mean±SE
No. of fish	20	20	20	20	20	20	
Weight (g)	51.9	45.1	45.5	51	46.4	45.1	47.45±1.23
Length (cm)	14.4	13.4	14.2	13.7	14.2	13.4	13.88±0.18
Condition Factor	1.73	1.87	1.58	1.98	1.62	1.87	1.77±0.06

Nitrate

The highest nitrate value of 10.20±0.43 mg/L was recorded in the month of August while the lowest value of 7.43±0.23 mg/L in the month April (**Table 1**). Station C had the highest mean nitrate value of 9.03±0.56 mg/L, while station A had the lowest mean nitrate value of 8.28±0.44 mg/L (**Table 2**).

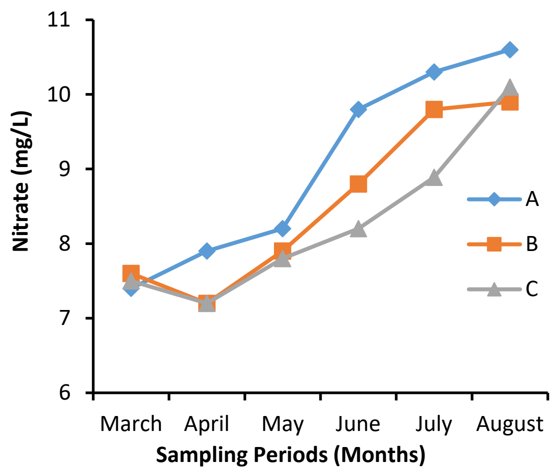

Fig. 8. Monthly mean variation of Nitrate (mg/L) among the three stations in Dadin Kowa reservoir (March-Aug 2019).

Phosphate

The highest phosphate value of 3.96 mg/L was recorded in the month of May while the lowest value of 3.5 mg/L was recorded in the month of March (**Table 1**). Station C had the highest mean phosphate value of 3.94±0.05 mg/L, while station A had the lowest mean phosphate value of 3.70±0.13 mg/L (**Table 2**).

Condition Factor

Mean condition factor of *Oreochromis niloticus* in Dadin Kowa Dam March-August, 2019

The lowest mean condition factor value of 1.57 for male *Oreochromis niloticus* (Nile tilapia) was recorded in the month of March, while the highest value of 2.25 was recorded in the month of August (**Table 3**).

The lowest mean condition factor value of 1.58 for female *Oreochromis niloticus* (Nile tilapia) was recorded in the month of May, while the highest value of 1.98 was recorded in the month of June (**Table 4**).

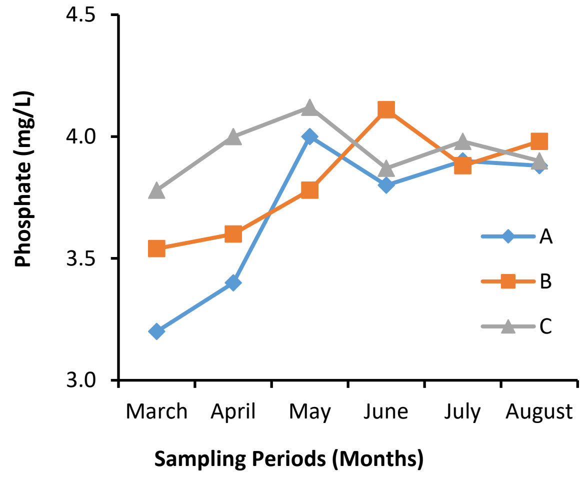

Fig. 9. Monthly mean variation of Phosphate (mg/L) among the three stations in Dadin Kowa reservoir (March-Aug 2019).

Length-Weight and regression co-efficient of *Oreochromis niloticus* of Dadin Kowa Dam March-August 2019

At the end of the experiment the results of length-weight relationship are presented in **Tables 5** and **6**. The mean length for male *Oreochromis niloticus* was 13.88±0.1 cm while the mean weight was 47.5±0.6 g, the mean length and weight for the female *Oreochromis niloticus* were12.04±0.11cm and 66.45±1.42g respectively. The value of regression co-efficient 'b' obtained for the LWR for male *Oreochromis niloticus* 2.56 (**Fig. 10**) while that of female *Oreochromis niloticus* was 2.99 (**Fig. 11**).

Table 5. Length-Weight and regression co-efficient of *Oreochromis niloticus* of Dadin Kowa Dam March-August 2019.

Sex	Mean Weight±SE	Mean Length±SE	N	Log a	B	Coefficient of correlation
Male	47.5±0.6	12.04±0.11	120	1.40	2.56	0.22
Female	66.45±1.42	13.88±0.1	120	1.20	2.99	0.46

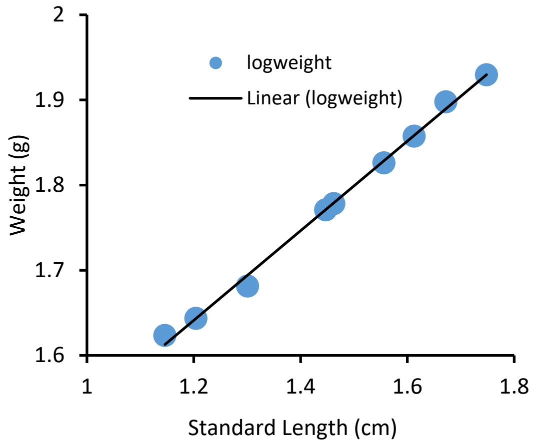

Fig. 10. Length-weight relationship of male *Oreochromis niloticus* in Dadin kowa Dam (March-August 2019).

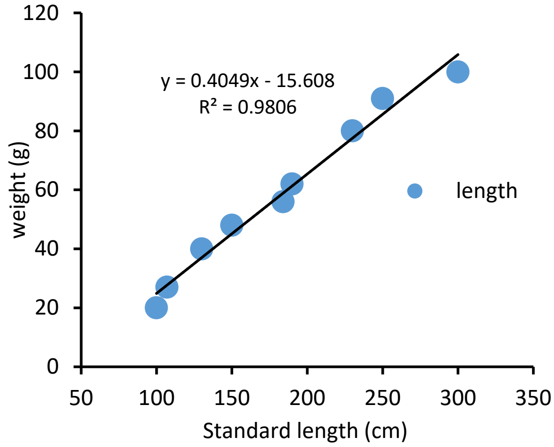

Fig. 11. Length-weight relationship of female *Oreochromis niloticus* in Dadin Kowa Dam (March-August 2019).

DISCUSSION

Physico-Chemical Characteristics

Physico-chemical characteristics refer to the physical and chemical attributes that signifies water quality and productivity of both lentic and lotic ecosystems. The recorded monthly variation and significance difference in physico-chemical characteristics of the dam is attributed to variation in environmental conditions. This finding is similar to the research conducted by several researchers [15,22], who revealed that differences in physicochemical characteristics of the dam may be associated to patterns of water usage, changes in temperature and rainfall.

Water Temperature

Temperature is the most vital factor that significantly affects productivity in lentic ecosystem and it depends on the climate, sunlight and depth [23]. Generally, aquatic organisms depend on certain water temperature range for its survival, growth and reproduction. The highest mean water temperature of 28.0±0.58 °C was recorded in the months of March, April and May while the lowest water temperature 24.0±0.99 °C was recorded in July, these fall within the normal range of 8-30 °C that fish adopt in the tropics [24,25]. This result agreed with previous report that the temperature in tropics vary between 21 °C and 32 °C [15,26]. Temperatures between 20 and 36 °C have been reported by various researchers as being suitable for tilapia. Ayoade et al., [26] for instance reported that the temperature ranges of 20-30 °C for optimum fish growth including *Oreochromis niloticus* and. FAO [27] reported the preferred temperature ranges of between 31 and 36 °C. This implies that Dadin Kowa Dam is suitable for the growth of fish and other aquatic organisms. Water temperature affects the rate of photosynthesis and solubility of oxygen in water [28]. The result shows that the higher the temperature, the lower the dissolved oxygen which agreed with the statement of Umar et al. [29]; that when water temperature increases, the evaporation and volatization of chemical substances also increases, but conversely the solubility of gases such as oxygen decreases.

pH

The pH range recorded during the study period was 7.5-8.5 i.e the Dam is slightly alkaline (basic). The highest mean pH of 8.54±0.08 was recorded during the month of August and the least mean pH of 7.53±0.03 was recorded during the month of March (**Fig. 3**). Therefore, the water pH of Dadin Kowa Dam is within the required range of good water quality similar to the report of Umar et al. [30] that water pH values range 6.5-8.5 mostly point out good water quality. These recorded values fall within the recommended values of 6-9 in most tropical natural water [25]. Boyd and Lichkoppler, [31] also reported pH values of 6-9 as ideal for supporting aquatic life including *Oreochromis niloticus.* Bryan et al. [32]concurs that most fish would do better with a pH near 7.0, while a pH of less than 6.0 may result in stunting or reduced fish production. Fish have an average blood pH ranging from 4.0-6.5, and therefore a little deviation from this value generally falls within 7.0-8.5 is more optimum and conducive to fish life. However, fish can become stressed in water with a pH ranging from 4.0-6.5 and 9.0-11.0 and death is almost certain at a pH less than 4.0 or greater than 11.0 [33].

Electrical conductivity (EC)

Electrical conductivity had its highest mean value of 122.67±1.67µS/cm during the month of June and lowest mean value of 54.00±1.53µS/cm during the month of August (**Fig. 4**). The highest mean value of 91.83±10.5453µS/cm was recorded in station C and least mean value of 83.00±9.9153µS/cm was recorded in station C. The highest conductivity in station B resulted may be due to high concentration of contaminants of conducting materials, the range of mean value of conductivity (264.5-321µS/cm) suggest that the conductivity level is within the desired range or intermediate. Conductivity levels below 50µS/cm are regarded as low; those between 50-600µS/cm is medium while those above 600µS/cm are high conductivity [34].

Transparency

Transparency is a measure of water clarity, the more materials suspended in water the less light can pass through the water column**.** Highest transparency value of 10.0±0.28 cm was recorded in the month of March, while the lowest value of 6.86±0.87 cm was recorded in the month of August (**Table 3**) (**Fig. 4**)**.** The highest mean value of 8.9±0.31cm was recorded at station B and lowest mean value of 8.6±0.58cm was recorded at station B (**Table 3**). Transparency ranges from 6.86±0.87 cm to 10.0±0.28 cm, the highest value of 10.0±0.28 cm in the month of March might be attributed to the lack of the rainfall which is related to increase in debris load by water run-off. This agrees with Abubakar [35]; Abubakar et al. [25] reported that reduced activity and lack of rains accounted for higher transparency.

Dissolved Oxygen

Dissolved oxygen is an essential factor that facilitates the survival, growth and reproduction of aquatic organisms. The dissolved oxygen concentrations ranged between 4.08 mg/L to

https://doi.org/10.54987/jebat.v6i2.977

7.2 mg/L, and hence, the concentrations were within the required range, similar to the report of Abubakar et al. [25], Its falls within the recommended values of Kolo and Tukura [36] who reported that many species of fish can survive in dissolved oxygen concentrations well below 6 mg/L. But it is lower than that of Abubakar [35] who reported values from 12.02 to 19.50 mg/L. The low amount of DO observe during the period of research might be due to high phosphorus and decomposition of organic matter resulting in use of oxygen. The amount of dissolved oxygen in water has been reported not static but dynamics, depending on temperature, depth, wind and extent of living organisms such as decomposition [37]. Low dissolved oxygen affects the growth of many organisms and enhances the rate of metabolic activities [38]; therefore, adequate dissolved oxygen is essential for all living organisms. The lower the dissolved oxygen the poorer will be the water quality [30].

Biological Oxygen Demand

The highest biological oxygen demand value of 1.8 mg/L was recorded in the month of August, while the lowest value of 1.47 mg/L was recorded in the month of March (**Table 1**). Station B had the highest mean biological oxygen demand (BOD) value of 1.88±0.15 mg/L while station A had the lowest mean oxygen value of 1.47±0.08 mg/L (**Table 2**). This study showed consistency in the BOD (2.6-5.4 mg/L) of the water body over the months of the study. This BOD range makes the reservoir to be slightly polluted. It is estimated that water bodies with BOD in the range of 2-8 mg/L are moderately polluted [39]. Important factor influencing BOD include organic matter content, pH, reduction in organic matter, nitrification and types of microorganisms [40]. Higher level of BOD could be as a result of increase in phosphate from anthropogenic activities such as washing and high organic load from cattle using the reservoir as water drinking points.

Nitrate-Nitrogen

The highest nitrate value of 10.2 mg/L was recorded in the month of august while the lowest value of 7.43 mg/L in the month April (**Table 1**). Station C had the highest mean nitrate value of 3.94±0.05 mg/L, while station A had the lowest mean nitrate value of 3.70±0.13 mg/L (**Table 2**). High amount of nitrate recorded during the month of August could be as a result of build-up of nitrate from farming activities during the raining season. Thilaga et al. [41] and Garg et al. [42] made similar observation. Run-off water from agricultural activities from nearby farms might have elevated the concentration of nitrates in Dadin Kowa Dam. Nitrate-nitrogen is required in aquatic and terrestrial ecosystem in a moderate quantity.

The amount of nitrate in solution at a given time is determined by metabolic processes in water; that is production and decomposition of organic matter [43]. Nyilitya et al. [44] reported the increased level of nitrates leached into African lakes from the excessive use of nitrogen fertilizers. High amount of nitrogen in the water can cause overstimulation of growth of aquatic plants and algae. Excess growth of these organisms, in turn, can clog water intakes, use up dissolved oxygen as they decompose, and block light to penetrate to deeper water, these can lead to decrease in animals and plants diversity [45].

Phosphate-phosphorus

The highest phosphate value of 3.96 mg/L was recorded in the month of May while the lowest value of 3.5 mg/L was recorded in the month of March (**Table 1**, **Fig. 10**). Station A had the highest mean phosphate value of 9.03±0.56 mg/L, while station C had the lowest mean phosphate value of 8.28±0.44 mg/L (**Table 2**), which is not in agreement with Kolo and Yisa [36] who reported 0.04 to 0.05 mg/L in river Suka. The high level of phosphorus recorded in this study could be as of surface ruff-off, sewage, and other decomposing matter. All this additional phosphorus feeds and promotes toxic cyanobacteria, which in turn, can deplete oxygen from the environment and bock sunlight from reaching past the surface and this threatened plant and aquatic life [46]. Artificial sources of phosphorus include fertilizers, detergent, waste water, industrial effluent and animal excreta among others [47]. With increase in rains and accumulation of run-off water in river, it was observed that concentration of phosphorus increased, this is in agreement with the findings of this study because the concentration of phosphorus is not within safety limit of about or less than 1 mg/L [48].

Length-weight relationship and condition factor of *Oreochromis niloticus*

The mean length for male *Oreochromis niloticus* was 12.04±0.11 cm while the mean weight was 47.5±0.6 g. The mean length and weight for the female *Oreochromis niloticus* were 13.88±0.1 cm and 66.45±1.42 g, respectively. The value of regression co-efficient 'b' obtained for the LWR for male *Oreochromis niloticus* was 2.56 while that of female *Oreochromis niloticus* was 2.99 (**Table 5**) which were all less than 3. These negative growth trends could be attributed to the multiple degradation factors such as dumping of domestic wastes, overfishing, introduction of invasive exotic fishes, uses of chemical fertilizers (which could be the reason for the high levels of phosphorus and nitrite observed) and pesticides in agriculture occurring in Dadin Kowa Dam.

This result is in agreement with several works [49,50] who reported low values of 'b' for *Clarias gariepinus,* when 'b' < 3, is indicative of negative allometry in growth pattern. It also agrees with findings of Abowei et al. [51] who reported a negative allometric growth pattern function from Amassoma River flood plains. Also, a similar finding was reported by Thomas et al. [52] from lower River of Benue, Nigeria. According to Lagler et al. [53], such variations in growth parameters documented for different fish species could be attributed to sex, maturity, developmental stage, season and harsh environmental conditions.

Froese [11] opined that length-weight parameters of fish are influenced by both intrinsic and extrinsic factors such as diet, season, stomach fullness, health, habitat, sex, gonad maturity and annual variation in environmental conditions. Also, "b" value in fish can be affected by sample size, habitat suitability, fishing activities, individual metabolism, age and maturity [54,55]. Both males and females *Oreochromis niloticus* had b-values lower than 3 indicating negative allometry of growth pattern. These means that *Oreochromis niloticus* of Dadin Kowa Dam does not grow fatter as the length of the fish increases.

Negative allometry in growth pattern has been reported for juvenile cichlids, *Chromidoptilapia guntheri* and *Hemichromis fasciatus* in Lake Eleiyele, Ibadan Southern Nigeria [56], *Clarias gariepimus*, *Illesha Africana* and *Heterobranchus longifilis* from River Idodo, Nigeria [57]. Weatherly and Gill [58,59] reported that allometric growth pattern could be negative or positive and that in "isometric growth pattern", when the growth exponent 'b'= 3, the body form maintains a constant proportion to length but when 'b' ≠ 3 a positive or negative allometry is indicated with 'b' < 3 as negative and 'b' > as positive allometry. This study follows the cube law which according to Froese [11] uses the Fulton's Condition Factor and attributes of length-weight exponential of b-value equals 3 for isometric fish growth.

https://doi.org/10.54987/jebat.v6i2.977

Condition factor

Condition factor is an important index used in fisheries science to ascertain the relative wellbeing of fish species. Condition factor which could be used to reflect the health status of water bodies is influenced by factors such as age, sex, food availability, and environmental conditions. Low condition factor in fish may be attributed to poor environmental conditions and reduced availability of food and prey items [22,51]. The lowest mean condition factor value of 1.57 for male *Oreochromis niloticus* (Nile tilapia) was recorded in the month of March, while the highest value of 2.25 was recorded in the month of August (**Table 3**). The lowest mean condition factor value of 1.58 for female *Oreochromis niloticus* (Nile tilapia) was recorded in the month of May, while the highest value of 1.98 was recorded in the month of June (**Table 4**).

The mean condition factor of *Oreochromis niloticus* (Nile tilapia) in this study was observed to be good which agrees with Lagler [53] and Abubakar et al. [25] who reported that the condition factor values are not constant for individual species or populations, but is subject to wide variations. Lagler [53] observed that sexual differences, ages, changes in the season, length and weight of fish, nutritional level of fish or stomach fullness and maturity level of the fish can influence the values of the condition factor. Variation in *O. niloticus* condition factor affected by seasons and pollution has also been documented by Khallaf et al. [60] in a drainage canal in Egypt. Stewart [61] observed stress as a result of the reduction in the breeding and nursery ground of *O. niloticus* in Lake Turkena, Kenya. Olatunde [19] observed that there was fall in condition factor of *Clarias gariepinus* in Zaria from October to February during the dry season. The condition factor should be equal to 1.0, while <1 or >1 indicate below and average conditions respectively [62,63]. Wade [64] stated that condition factor of fishes greater or equal to 1.0 is good.

CONCLUSION

It can be concluded that most of the physicochemical parameters were within the recommended values of most tropical water bodies. The amount of Dissolved Oxygen, Nitrate-nitrogen and phosphate-phosphorus are not within the recommended values. Run-off water from agricultural activities from nearby farms might have elevated the concentration of nitrates and phosphorus in Dadin Kowa Dam. The condition factors of both *Oreochromis niloticus* found in this study are within the normal range. Both Males and females analysed samples exhibit negative allometric growth pattern. Therefore, the reservoir is suitable to support the life of Tilapia particularly *Oreochromis niloticus*. Based on the findings of this research, it is recommended that anthropogenic activities taking place around the Reservoir should be regulated so as to maintain and improve the proper management of the water as well as the aquatic organisms which might increase the weight of the *Oreochromis niloticus*. Physicochemical analysis and condition factor examination should also be checked regularly over a long period of time, so as to ascertain the health status of the reservoir. Agricultural activities along the riparian forest should be regulated because increases run-off and siltation of water bodies.

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