PRODUCTIVITY STATUS OF DADIN KOWA RIVER CONTINUUM, GOMBE STATE, NIGERIA

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ABSTRACT

Assessment of Physico-chemical parameters, occurrence and distribution of Aquatic biota in Dadin-Kowa River Contiuum Gombe State were carried out for a period of Eighteen month. Three sampling stations were chosen and standard methods and identification guide were used to determine physicochemical and biological parameters. Result of Physicochemical parameters showed that Temperature, pH, Alkalinity, Transparency and Conductivity ranged between 21 - 27°C, 6.3-7.8, 28.1-46.2mg/L, 48.5-76.7cm, 54.0-397.5µs/cm respectively, while Dissolved oxygen concentration, Biochemical Oxygen Demand, Calcium, Magnesium, Hardness, Iron, Nitrate-Nitrogen, Phosphate-Phosphorus ranged between l.l-3.4mg/L, 2.2-39mg/L, 11.3-23.2mg/L, 4.5-8.9mg/L, 40.0-88.5mg/L, 0.1-3.3mg/L, 0.3-1.5mg/L, 0.3-2.0mg/L respectively. A total of sixteen (16) phytoplankton species were recorded of which four classes of algae were identified. These are chlorophyta (25.9%), cyanophyta (23.9%), bacillariophyta. (48.9%) and dinophyta (15. 7%).Three major classes of zooplankton were recorded rotifera (36.9%) cladocera (35.5%) and copepoda (27.4%). Distribution of planktons varied with the variation in the physico-chemical parameters. The findings of the study revealed that the water body of Dadin-Kowa was moderately polluted.

Key word: Physicochemical parameters, Phytoplankton, Zooplankton, Dadin kowa,

INTRODUCTION

Limnology is the study of physical, chemical as well as biological processes/factors occurring in fresh water environment. It highlights the factors influencing the survival or the composition, abundance and distribution of diverse species of organisms in water. Information from limnological studies are basic ingredients needed for proper decision making on fishery management and planning as well as other biological problems associated with water quality (Abubakar *et al*., 2018). The most important contribution of limnology to fisheries is the ability to objectively evaluate the yield in fish, which can be expected from individual water bodies (Balarabe, 2015).

The quality of a given water body is controlled by its physical, chemical and biological factors, all of which interact with one another to influence the productivity of the water. (Abubakar *et al.*, 2018). In order to assess the potentials of such aquatic ecosystems for their essential management and effective utilization, there is the need to study these influences with a view to controlling and maintaining them within optimum range, therefore the need for comprehensive studies of the various man-made lakes is needed (Abdullahi and Indabawa, 2017).

Nigeria is richly blessed with a vast area of inland waters. The total surface area of water bodies in Nigeria is estimated to be 550,000 hectares (13,000km^2) and this constitutes about 15.9% of the total area of Nigeria (Ekiye and Zejiao, 2010). These include both natural and man-made lakes, reservoirs, Floodplains and cattle ponds, rivers and streams; but exclude deltas, estuarine and miscellaneous wetlands suitable for rice cultivation. This implies that composition and density of aquatic organisms depends on the geographical and water quality of the aquatic life which habitat can be adversely affected by human activities (Izah, 2015).

Several factors usually contribute to the establishment of plankton communities in a river, among which are good water quality, presence of nutrients, physicochemical factors of water, hydrological characteristics of the reservoirs and river ageing. The productivity of water depends on composition of phytoplankton which are usually at the base of aquatic food web and are the most important factor for production of organic matter in aquatic ecosystem. Most river will require significant amount of plankton to have productive and sustainable fisheries. The interplay of physical, chemical and biological properties of water most often lead to the production of phytoplankton, while their assemblages are structured by these factors. Thus any perturbations in these factors may affect their assemblage which could have a significant impact on water quality and fisheries of river (Mustapha, 2014).

MATERIALS AND METHODS

Study Area

Dadin Kowa river lies through three Local Government Area of Gombe State namely: Yamaltu Deba, Kwami and Funakaye local Government area of Gombe State in north eastern Nigeria, the river is about 60 kilometers to the east of Gombe town and 5 kilometers north of Dadin Kowa town, it provides drinking water to Gombe metropolis and some parts of the state. (Figure 1). The area lies within latitude 10^{o}17 '18" N and longitude 11^{o}30'32 "E of the equator (UBRDA, 2010).

The major activities taking place around the river are irrigation farming, mostly rice, maize, tomatoes, onions among others, also, activities of inhabitants are dominantly farming, fishing rearing animals which include cattle, sheep and goat among others, the type of fishing activities taking place are artisanal, commercial which are not controlled by government officials, the types of effluent into the river are both industrial and domestic materials.

Three sampling stations were identified for the study across the three Local Government Area, Station 1 at the upstream landing site of the river namely Almakashi town in Funakaye Local

Government Area, where human activities like washing, bathing, are taking place. Station 2 is at the midstream which is the middle point of the river at Malleri town in Kwami Local Government Area where there are less human activities due to its distance from entrance, Station 3 is at the downstream which is the deepest part of the river around 30meters deep at the Dammed site at Dadin Kowa town in Yamaltu Local Government where irrigation farming is taking place, the distance between each stations is approximately 15kms. Three landing centers were used for fish sampling from local fishermen at each of the landing sites.

Sampling Procedure

Sampling was carried out monthly from each sampling station. Water samples were collected between the hours of 8:00am and 1:00 pm as described by (Wetzel, 2016). In this method, water was sampled at surface level by dipping 1-liter plastic sampling bottle sliding over the upper surface of the water with their mouth against the water current to permit undisturbed passage of the water in to the bottle. Water samples were transported the Regional Water Quality Laboratory Gombe (Federal Ministry Water Resources) for the analysis of physico-chemical and biological parameter. The research covered a period of eighteen months (18 month) with a view to make observation during the dry and rainy seasons.

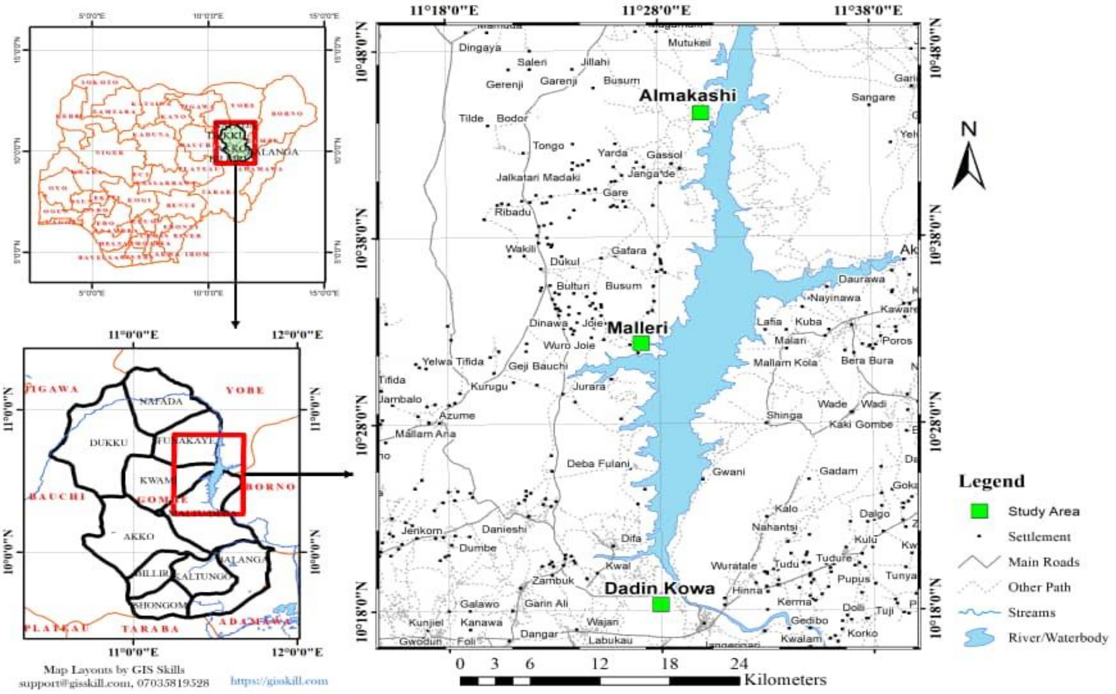

Figure 1: Map of the study area showing various sampling stations and settlement areas

Determination of physicochemical parameters

Physico-chemical characteristics of the water body were taken monthly from three (3) stations for the period of eighteen months (18 month). Triplicate surface water samples were collected in 1L plastic bottles and analyze for dissolved oxygen, nitrate, phosphate, iron, total hardness, alkalinity and magnesium according to the standard methods for the examination of water APHA, (2017) procedures.

Temperature, pH, conductivity and total dissolved solids were measured *in-situ* using Hanna portable combo waterproof pH/ EC/TDS/Temperature Tester model HI 98130. Transparency was evaluated using a standard 20cm diameter Secchi disc having black and white quarters.

Determination of temperature

Water temperature was determined by lowering the thermometer into the water in an inclined Position for about 5 minutes to allow for equilibrium before recording as described by APHA (2017).

Determination of water pH

The pH was determined with Hanna 420 pH meter, It was calibrated according to instructional manual provided by the manufacturer. The electrode of the pH meter was dipped into the water sample for 2-3 minute and readings was recorded (APHA, 2017).

Determination of transparency

A Secchi disc of 25cm diameter was used in the determination of transparency. The transparency was taken by lowering the Secchi disc into the water until it became invisible. The depth of disappearance and reappearance was measured to the nearest centimeter this was repeated three times and the average was taken.

Determination of conductivity

Conductivity was measured with WTW 320 conductivity meter. Water samples were placed into clean beakers, conductance cell of the meter was immersed in µS/cm then readings were obtained, the cell was rinsed in a beaker with distilled water after each reading. The calibration measurement was performed in 0.0072 Nacl solutions.

Determination of water hardness

10ml of sample was taken into conical flask with the help of pipette, 0.5mg of buffer table (Erchrome Black-T) and 1ml of concentrated ammonium hydroxide (NH_4OH) was added as indicator and then titrated with 0.1N (EDTA) solution, color change to pale blue (end point) indicate the hardness of water.

Determination of biological oxygen demand

For the determination of Biochemical oxygen demand, 100ml of water sample was incubated at room temperature (25°C) for a period of five days; in the dark after addition of 2ml manganese chloride solution the resultant precipitate was then dissolved by the addition of 2ml concentrated H_2SO_4. The difference obtained between the initial dissolved oxygen and the final dissolved oxygen concentration obtained after five days was taken. The BOD is expressed in milligrams per liter of the sample (APHA 2017).

Determination of dissolved oxygen

This was determined by the modified Winkler azide method (Lind 1979 and APHA, 2017). Duplicate water samples were collected in 250ml BOD stopper bottles, they were then fixed in the field with 2ml manganese sulphate ($MnSO_4$) this was followed by the addition of 2ml alkaline - iodide-azide and 2m1 conc. H_2SO_4.The samples were then transported to the laboratory. 100ml of the prepared solution was measured and 2ml of concentrated H_2SO_4 was added to the solution and titrated with 0.0021N sodium thiosulphate solution until it turned to a pale yellow colour. One milliliter of freshly prepared starch solution was then added as indicator which turned to blue colour. The titration continued until the blue colour disappeared. The volume of the thiosulphate titrant used is equivalent to the milligram of dissolved Oxygen per liter (APHA, 2017).

Determination of calcium

The procedure applied for the determination of calcium ion concentration was the one described by APHA (l995). 50ml of water samples was measured into a conical flask and 2ml of NaOH solution was added and a pinch of murexide indicator and titrated with 0.1M Na_2EDTA solution until the colour change from purple to violet. Calcium ion was obtained using the formula;
Milligram per litre of Calcium A x B x 400.8= Volume of sample

Where A = MI of titrant (EDTA) B = I.0m1. APHA (2017)

Determination of Iron

In this method, 100ml of water sample was mixed with 10ml acid solution (mixture of 3:1 conc. HCl and cone. HNO_3) and was immersed in water bath (90°C) for 30 minutes followed by analysis with atomic absorption spectrophotometer (A.A.S), model A.A.S. 2010. (APHA 2017).

Determination of Magnesium

This was determined by using spectrophotometer model Hatch 2010 as described by APHA (2017).

Determination of Nitrate- nitrogen

100ml of water sample was poured into a clean dry metallic crucible, it is then dried, evaporated and cooled, 2ml of phenoldisulphonic acid was added and smeared around the crucible, after 10miutes, 10ml of distilled water was added followed by 5ml strong ammonia solution. Setting the spectrophotometer at the wave length 430nm, absorbance of nitrate-nitrogen was obtained, using distilled water as blank. The concentration of nitrate-nitrogen was obtained from the calibration curve in mg/L (APHA 2017).

Determination of Phosphate-phosphorus

This was determined using the Deniges method APHA, (2017), 1ml of Dennigs reagent (Ammonium Molybdate) and 5ml stannous chloride was added to 100ml water sample. Absorbance at

690nm was measured with spectrometer, model S101 using distilled water as blank. The phosphate-phosphorous concentration of water sample was read from the calibration curve in mgl/L.

Determination of Total alkalinity

In this method, I00ml of water sample was measured in 250ml conical flask, and 3-drops of methyl orange indicator and bromocresol green solution was added and titrated with sulphoric acid until colour changes from red to yellow.
Total alkalinity in $CaCO_3$ mg/L= Titer value ×10.

Biological Analysis

Slides Analysis were prepared and observed under a binocular microscope with various magnifications. The identification of phytoplankton was carried out by the use of taxonomic keys and identification guides as described. The phytoplankton were counted from left top corner of the slide to the right corner by moving the slide horizontally, furthermore, counting of biota were e done in drops/L, ml/L and cells/L (Moncheva, 2012).

Depth Determination

The depth of water at each sampling station were measured using calibrated tape in meter and was weighted with heavy metal at the bottom. The tape was lowered from the boat into the water until it reached the bottom of the reservoir, the point at which it reached the bottom was marked and then removed; the value was then recorded as the depth of water in meters (m).

Sampling and analysis of phytoplankton

Phytoplanktons were sampled from the reservoir with the aid of plankton net. (Made of bolting cloth with a fine aperture of 0.0lmm, 25cm long, and small bottle container attached to the narrow end of the net) it has an opening, of about 20cm diameter. At each station, the net was sunk just beneath the water surface and towed for a distance of 1 meter. Collected water samples were transferred to small plastic bottles and preserved in 4% neutral formalin. The collections from each station were taken to the laboratory for identification. Slides were prepared and observed under a binocular microscope with various magnifications. The identification of phytoplankton was carried out by the use of taxonomic keys and identification guides such as (Moncheva 2012). The phytoplankton were counted from left top corner of the slide to the right corner by moving the slide horizontally.

Sampling and analysis zooplankton

Zooplankton were collected using a silk plankton net of 20cm diameter and 70 meshes/cm attached with a 50ml capacity bottle at base. At each station, collection was done by sinking the net and towed through a distance of 1 meter. The sample was then being poured into plastic bottle of 70ml capacity and preserved in 4% formalin. Counting were done using drop method and then mounted on a microscope for identification. Identification will be carried out using various keys described by (Imoobe, 2012).

Data Analysis

The results obtained was subjected to analysis of variance to test significance between physico-chemical parameters and number of seasonal variation. Also Shannon Weanner Diversity Index was used to test the distribution and abundance of the phytoplankton, zooplanktons and fisheries community in the river. Correlation analysis was used to test relationship between physico-chemical and biological parameters.

RESULTS AND DISCUSSION

Physicochemical Parameters

Temperature

There is a significant different between the month where high temperature was recorded in the month of February (27.98^{o}C) whereas lower temperature was recorded in November (21.10^{o}C) (Table 1a). Analysis of variance revealed that higher significant variation existed between the months, Temperature plays a vital role in determining the occurrence, specie composition of fresh water organisms.

The result showed low water temperature was recorded between the months of November to January in response to seasonal changes in temperature. This affects the occurrence and distribution of zooplankton as reported by Dimowo, (2013). The relatively very low temperature recorded during this period might be due to the cool dry winds (harmattan) effect that was severe at that time of the year. A similar effect was observed by Kolo and Oladimeji (2014), in their studies of some water bodies in Nigeria. This supports the findings as shown by the result of the analysis of variance which showed significant difference between seasons. Temperature affects the distribution of plankton. There was high algal bloom at the beginning of rainy season this corresponds with high temperature during that period. This also influences the distribution of macro benthic invertebrates that migrates, and becomes more active when there is high temperature (Mustapha, 2010). This corresponds with the findings of Abdullahi and Indabawa, (2017) in their study of the ecology of fresh water phytoplankton of River Hadejia, Jigawa State.

Water temperature also showed positive and significant correlation with dissolved oxygen, transparency, conductivity, BOD. This also correlated with secchi transparency, dissolved oxygen and temperature. This is supported by similar report carried out on Shiroro Lake by (Kolo and Oladimeji 2014).

Alkalinity

The mean monthly variations for alkalinity in month showed that there is no significant different between the months (Table 1a). The range of alkalinity in the river was 28.05 to 42.20mg/l, whereas the lowest was in January (28.05mg/l); also there is a higher significant difference between months. The wet season mean (37.41) was higher than rainy season mean (34.29mg/l) (Table 2). Correlation co-efficient analysis showed a significant analysis showed a significant positive correlation between hardness, copepod, cladocera, baccillariophyta, cyanophyta, chlorophyta and pH (Table 4).

pH

The monthly variation of water pH of Dadin Kowa River was presented on (Table 1a), where the pH range between 6.38 to 7.85, the river was acidic during rainy season while slightly alkaline at dry season throughout the study period (Table 2). Analysis of variance reveals a non-significant variation between month and seasons.It was found to have increased with the onset of the rainy season, and slightly decrease in dry season. Low pH indicates acidity possibly due to the presence of, nitrate and sulphate ions in water. The level of pH could support many fish and other benthic organism like molluscs. Similar report was observed by Alam *et al*., 2014).

Transparency

Table 1a shows the mean monthly variation of transparency between month and the result reveal that highest transparent water was recorded in month of September whereas lowest was recorded in July, and the range across month lies between 48.50 to 73.75cm (Table1a). Decrease in transparency from June to September could be attributed to increase flooding which washes earth materials in to the water body. Transparency was in the increase during dry season from November to April. Transparency was between the ranges of 25cm to 75cm. This corresponds with algal bloom that leads to depress oxygen concentration of water as reported by (Babatunde, and Raji, 2017).

The turbidity was high during the early part of rainy season could be due to increase in surface run-off, flood water from the catchment area, which bring dissolve materials and course re-suspension of dissolved materials. That is why it affects station. Increase in total dissolve solid result to increase in turbidity but decrease of the benthic fauna and increase in the algal bloom.

This agrees with the observation of Adakole (2014). The result from the analysis of variance (ANOVA) showed no significant difference between stations and seasons interaction. In general, all the month recorded high values secchi disc transparency during a dry season. This could be attributed to the absence of floodwater, surface run-off and silting effect of suspended materials that followed the cessation of rainfall. Low secchi visibility recorded between June to September agree with the finding of (Mustapha, 2014) who observed that on set of rain decreased the secchi-disc visibility in two mine lake around Kano, Nigeria.

Electrical conductivity

The electrical conductivity showed highly significance variation between months and season where relatively higher conductivity was recorded in during the month of September 203.80 and 397.50 (µS/cm) respectively (Table 1a and 2). The gradual decrease in electrical conductivity from October to March could be attributed to the decreases in water volume because there was increase in water volume from rain fall. This decreases concentration of about 10uohms^{1-} in the water. There was positive, significant correlation between conductivity with BOD, calcium, and chloride, but no significant correlation with phosphate (PO_4-P) this was in line with the work of Akpan, 2018) reported similar result. In their Limnological study of Gallocanta Aragon northern observed revealed high level of evaporation lead to reduction in water volume and increase in salt concentration. Increases in total dissolve organic matter result to increase in conductivity and turbidity but a decrease of the benthic fauna, this agrees with observation made Adakole (2015) in his limnological study of river Kubanni, Zaria. Ovie and Adeniji observed a similar trend in Shiroro Lake that there was higher dry season mean in conductivity during dry season attributed to higher concentration effect due to reduce water volume from their main tributaries. High electrical conductivity of the water surface indicated trophic status and productivity (Akphan 2016).

Transparency

Table 1a shows the mean monthly variation of transparency between month and the result reveal that highest transparent water was recorded in month of September whereas lowest was recorded in July, and the range across month lies between 48.50 to 73.75cm (Table1a). Variation between month and season was not significant (Table 2). The correlation co-efficient analysis (Table 4) showed that a positive correlation exist between transparent, cyanoplyta, and Baccillanoply.

Conductivity

The electrical conductivity showed highly significance variation between months and season where relatively higher conductivity was recorded in during the month of September 203.80 and 397.50 (μS/cm) respectively (Table 1a and 2). There is positive correlation between Conductivity and Hardness and negative with Calcium (Table 4).

Hardness

The seasonal and monthly values of water hardness for Dadin Kowa River was presented in table 1a.

.Table 1a: Monthly Variation of Physico-chemical Parameters of Dadin Kowa River, Gombe State (October, 2019 to March, 2021)

Months	Temperature (°C)	Alkalinity (mg/L)	pH	Transparency (cm)	Conductivity (µS/cm)	Hardness (mg/L.CaCO₃)
October	24.78±0.38[ab]	33.20±1.80b[cd]	7.75±0.45[a]	63.38±6.52[a]	96.75±1.96[b]	88.50±4.11[ab]
November	24.85±0.45[ab]	46.20±2.10[a]	7.85±0.46[a]	48.50±7.23[a]	95.25±5.69[b]	79.50±4.11[ab]
December	24.93±0.57[ab]	45.45±1.75[a]	7.30±0.13[a]	68.00±3.63[a]	307.50±8.46a	285.75±7.66[a]
January	22.98±0.98[b]	31.38±3.28[cd]	6.30±14.90[a]	73.75±1.14[a]	397.50±3.28[a]	86.50±12.17[ab]
February	23.23±0.83[b]	30.83±2.73[cd]	7.23±0.09[a]	59.00±5.26[a]	350.00±2.66[a]	87.00±3.89[ab]
March	21.10±1.00[b]	30.15±0.06[cd]	7.80±0.61[a]	76.75±8.93[a]	130.00±15.81[b]	65.00±1.41[b]
April	22.85±1.75[b]	39.98±1.33[ab]	6.80±0.40[a]	57.25±1.37[a]	87.50±2.50[b]	57.75±8.39[b]
May	21.65±2.45[b]	28.05±3.65[d]	7.15±0.06[a]	53.75±9.07[a]	108.25±9.16[b]	52.25±2.05[b]
June	27.98±0.68[a]	37.10±1.00[bc]	6.53±0.53[a]	54.75±9.95[a]	76.25±5.33[b]	40.00±2.92[b]
July	27.55±1.15[a]	36.15±1.95[bc]	6.58±0.19[a]	58.55±4.82[a]	54.05±1.92[b]	44.50±6.77[b]
August	27.98±0.68[a]	37.10±1.00[bc]	6.53±0.53[a]	54.75±9.95[a]	76.25±5.3[b]	40.00±2.92[b]
September	27.55±1.15[a]	36.15±1.95[bc]	6.58±0.19[a]	58.55±4.82[a]	54.05±17.92[b]	44.50±9.77[b]
October	23.23±0.83[b]	30.83±2.73[cd]	7.23±0.09[a]	59.00±5.26[a]	350.00±2.66[a]	87.00±3.89[ab]
November	21.10±1.00[b]	30.15±0.06[cd]	7.80±0.61[a]	76.75±8.93[a]	130.00±15.81[b]	65.00±1.41[b]
December	22.85±1.75[b]	39.98±1.33[ab]	6.80±0.40[a]	57.25±1.37[a]	87.50±2.50[b]	57.75±8.39[b]
January	21.65±2.45[b]	28.05±3.65[d]	7.15±0.06[a]	53.75±9.07[a]	108.25±9.16[b]	52.25±2.05[b]
February	27.98±0.68[a]	37.10±1.00[bc]	6.53±0.53[a]	54.75±9.95[a]	76.25±5.33[b]	40.00±2.92[b]
March	27.55±1.15[a]	36.15±1.95[bc]	6.58±0.19[a]	58.55±4.82[a]	54.05±1.92[b]	44.50±6.77[b]
P value	**0.003****	**0.004****	**0.440ns**	**0.506ns**	**0.001****	**0.001****

The value ranged from (4.0.00 to 58.50mg/l). The result reveal that month of October recorded high value whereas lowest value was recorded in February (Table 1a)The river was moderately hard during the rainy season and very hard in the dry season and rich for fish production. Analysis of variance (ANOVA), revealed significant difference between the seasons. The relatively harder water during the rainy season could be attributed to the leaching of artificial fertilizer in to the dam which originated from the catchment area due to farming activities during the period of July to August similar observation was made by Balarabe (2014) in study of makwaye lake of Ahmadu Bello University Zaria; he observed that between July to October is the period of fertilizer application that increases water hardness.

Biological Oxygen Demand

Biological Oxygen Demand (BOD) values range between 2.23 to 3-95mg/l, across month, highest value was obtained in January 3.95mg/l and the lowest in November 2.23mg/l (Table 1b). The biological oxygen demand of the water samples in all the month fall within the range of 2.1-3.3 mg/l. This agrees with the findings of (Mustapha, 2014). Biological oxygen demand (BOD) was higher in the dry season than the rainy season. This coincided with the period of oxygen consumption by decomposers (Fungi and Bacteria) on the biogenous materials as reveled by negative correlation with oxygen.

Dissolved oxygen

Higher mean value of DO was obtained the month of February (3.48 mg/l) (Table 1b). The value of seasonal variation of dissolve oxygen for the two seasons showed that dissolve oxygen concentration was higher in dry season than in wet season (Table 2).The values for dissolved oxygen concentration of the water samples in all the month fall within a range of 1.48-3.38 mg/l. There was significant difference between the seasons in dissolved oxygen with the dry season showing higher concentration than the rainy season. Lowest concentration during rainy season could be attributed to the peak time of biochemical oxygen demand due to bacteria and other decomposers uptake. Highest concentration coincided with the minimum water temperature in December and January due to harmattan wind that cause cooling period. The higher the temperature the lower the dissolved oxygen and the lower the temperature the higher dissolved oxygen. High dissolved oxygen concentration in November conform to increase in zooplankton productivity during that period. This conforms to the findings of Mageed *et al*., (2015). In freshwater bodies, oxygen fluctuations could be due to close relationship between the free water and the bottom where organic matter accumulates.

Nitrate-Nitrogen

The highest nitrate-nitrogen concentration value of 2.35mg/l was recorded in February and lowest value of 0.35mg/l was recorded in October (Table 1b).

The results of nitrate-nitrogen ions obtained throughout the period of this research ranged between 0.33-2.35mg/l. It was observed that concentration of nitrate-nitrogen was higher in the rainy season from July to September. This could be due to run-off from the farmland in to the reservoir, and also application of fertilizer by the farmers from the catchment area as observed. Another reasons for this variations could also be as a result of nitrates released from sediments during decomposition of organic matter observed that the peak nitrate seem to be related to input from agricultural lands. Low nitrate-nitrogen values indicate period of extreme dry season or early onset of rains and the period preceding the first upsurge of phytoplankton growth (Lymer *et al.*, 2014) observed that concentration of nitrate could be reduced by plankton and macrophytes uptake during the period.

Iron

The value of Iron concentration across the month of Dadin Kowa River showed slightly variation. The highest value was obtained during the wet season than dry season (1.18 and 0.75mg/l) respectively (Table 2). Iron concentration of Dadin Kowa River showed slight variation between months. Highest values were obtained during rainy season and lowest value during dry season this could be due to a lot of farming activities and pollution from the surrounding communities. A similar finding was reported by (Balogun *et al.*, 2015) in his study of some ponds in Zaria, Kaduna Nigeria**.**

Magnesium

The monthly variation in magnesium ion concentration of the river revealed that there was low magnesium Iron in January (4.58mg/l) and highest in October (8.90mg/l) (Table 1b), There was no significant difference between month with respect to magnesium irons concentration the result revealed that there was low concentration during rainy season and higher concentration value during dry season. The analysis of variance revealed no significant difference with in the stations and season ($P \geq 0.05$).

Phosphate-phosphorus

The value of phosphate ranged from (0.72 to 2.03mg/l) The maximum phosphate Iron concentration was observed during dry season (1.18mg/l) and lowest is wet season (0.68mg/l), the lowest value of (0.73mg/l) in the month of July was recorded while highest value of (2.03mg/l) was recorded in the month of January (Table 1b). Phosphate-phosphorus values obtained during raining season period was higher than that of dry season this might be due to run-off from nearby farmlands, since phosphate fertilizer application is common in the farmland around the catchment area. Relatively higher dry season mean values of phosphates observed could be attributed to concentration effect because of reduction in water volume.

Table 1b: Monthly Variation of Physico-chemical Parameters of Dadin Kowa River, Gombe State (September, 2019 to February, 2021)

Months	Biochemical Oxygen Demand (mg/L)	Dissolved Oxygen (mg/L)	Calcium (mg/L)	Iron (mg/L)	Mg (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)
October	3.23±0.05[a]	2.15±0.58[a]	17.15±0.06[bc]	0.80±0.27[b]	5.15±0.10[ef]	0.88±0.25[def]	0.68±0.18[c]
November	2.33±0.05[a]	2.63±0.71[a]	19.10±0.04[abc]	1.00±0.35[b]	6.23±0.11[de]	1.53±0.17[bc]	0.73±0.17[c]
December	1.13±0.05[a]	1.03±0.71[a]	14.28±0.18c[d]	0.50±0.13[b]	5.83±0.28[def]	1.33±0.23[bcd]	0.93±0.21[c]
January	1.35±0.06[a]	2.30±0.28[a]	11.30±0.19[d]	3.33±0.78[a]	6.30±0.90[de]	1.75±0.25[b]	0.33±0.23[c]
February	1.43±0.09[a]	2.05±0.55a	18.55±0.17[abc]	0.28±0.09[b]	8.90±0.30[a]	0.35±0.10[f]	0.75±0.37[c]
March	1.23±0.14[a]	3.38±0.43[a]	21.73±0.58[ab]	1.30±0.90[b]	8.30±0.11[abc]	1.43±0.09[bcd]	0.50±0.04[c]
April	2.53±18.16[a]	2.78±0.53[a]	18.30±4.87[abc]	0.10±0.00[b]	7.15±1.05[bcd]	1.45±0.13[bcd]	1.03±0.18[bc]
May	1.95±12.36[a]	1.50±8.50[a]	19.60±1.40[abc]	0.90±0.70[b]	4.58±0.48[f]	0.75±0.29[ef]	2.03±0.29[a]
June	0.38±0.25[a]	2.48±0.26a	18.75±0.25[abc]	0.38±0.11[b]	6.80±0.51[cd]	2.35±0.10[a]	1.63±0.24[ab]
July	1.15±0.10[a]	1.18±0.51[a]	23.23±1.08[a]	1.08±0.26[b]	8.48±0.18[ab]	1.10±0.04[cde]	0.73±0.13[c]
August	2.38±0.25[a]	1.48±0.26[a]	18.75±0.25[abc]	0.38±0.11[b]	6.80±0.51[cd]	2.35±0.10[a]	1.63±0.24[ab]
September	1.15±0.10[a]	1.18±0.51[a]	23.23±1.08[a]	1.08±0.26[b]	8.48±0.18[ab]	1.10±0.04[cde]	0.73±0.13[c]
October	3.23±0.05[a]	2.15±0.58[a]	17.15±0.06[bc]	0.80±0.27[b]	5.15±0.10[ef]	0.88±0.25[def]	0.68±0.18[c]
November	2.33±0.05[a]	2.63±0.71[a]	19.10±0.04[abc]	1.00±0.35[b]	6.23±0.11[de]	1.53±0.17[bc]	0.73±0.17[c]
December	1.13±0.05[a]	1.03±0.71[a]	14.28±0.18c[d]	0.50±0.13[b]	5.83±0.28[def]	1.33±0.23[bcd]	0.93±0.21[c]
January	1.35±0.06[a]	2.30±0.28[a]	11.30±0.19[d]	3.33±0.78[a]	6.30±0.90[de]	1.75±0.25[b]	0.33±0.23[c]
February	1.43±0.09[a]	2.05±0.55a	18.55±0.17[abc]	0.28±0.09[b]	8.90±0.30[a]	0.35±0.10[f]	0.75±0.37[c]
March	1.23±0.14[a]	3.38±0.43[a]	21.73±0.58[ab]	1.30±0.90[b]	8.30±0.11[abc]	1.43±0.09[bcd]	0.50±0.04[c]
P value	**0.473ns**	**0.363ns**	**0.001****	**0.005***	**0.005***	**0.008ns**	**0.005***

Means with different alphabet(s) along columns are not significantly different.
** significant at P≤0.01, ns – not significant at P≥0.05.

Table 2: Seasonal Variation of Physico-chemical Parameters of Dadin Kowa River, Gombe State

Physicochemical Parameters	Season		P value
	Wet	Dry	
Temperature (°C)	24.15±0.34[a]	24.23±0.91[a]	0.939ns
Alkalinity (mg/L)	37.41±1.85[a]	34.29±1.30[a]	0.175ns
pH	10.49±2.98[a]	6.97±0.20[a]	0.246ns
Transparency (cm)	62.53±3.47[a]	60.21±4.80[a]	0.698ns
Conductivity (µS/cm)	249.40±36.89[a]	91.21±7.90[b]	0.000**
Hardness (mg/L.$CaCO_3$)	125.45±41.31[a]	51.90±4.21[b]	0.002**
Biochemical Oxygen Demand (mg/L)	2.69±0.12[a]	3.45±4.30[a]	0.125ns
Dissolved Oxygen (mg/L)	1.63±0.29[a]	2.66±1.73[a]	0.253ns
Calcium (mg/L)	16.08±0.67[a]	20.32±1.02[b]	0.005*
Iron (mg/L)	1.18±0.30[a]	0.75±0.23[a]	0.264ns
Mg (mg/L)	6.48±0.34[a]	7.06±0.39[a]	0.273ns
Nitrate (mg/L)	1.17±0.14[a]	1.42±0.14[a]	0.210ns
Phosphate (mg/L)	0.68±0.11[a]	1.18±0.15[a]	0.008ns

** - Highly significant at $P \leq 0.01$, ns – not significant at $P \geq 0.05$.
*- Significant

Phytoplankton
Chlorophta

The monthly values variations on Table 3 showed that there was higher algal count value in the month of September, July and May 140(20,89%), 123(18.90%), and 157(21.08%) respectively, where March and April has the lowest 45(9,24%) and 34(6.98%) respectively.
Correlation results reveal that there is positive correlation between chlorophyta and cyanophyta, cladocera, copepod, transparency, and hardness while negative correlation exists with BOD, DO, and phosphate (Table 4).

Cyanophyta

Cyanophyta (blue - green algae) accounted for 207(32.75%) algal count in Dry season and 428(67.25%) in Wet season out of the total 683 number of phytoplankton identified during the study period (Table 3). The Seasonal variation revealed that there was higher algal count during wet season between July to October, while low algal count were obtained during dry season between January to March (Table 3).

The correlation coefficient showed that there was positive correlation between Cyanophyta with Bacillariophyta, Cladocera, Copepoda, pH, and Conductivity but there was negative correlation with Calcium and Phosphate. (Table 4).

Bacillariophyta

The monthly Abundance of Bacillariophyta of Dadin Kowa river revealed that there was a total of 518(38.74%) and 819(61.10%) algal count in Dry and Wet Season respectively, constituting a total of 1337 (Table 3). The highest algal count of 202(24.66%) and 185(22.58%) were obtained in June and August respectively whereas lowest count of 69 and 59 were recorded in October and May respectively (Table 3). It was also observed that there was high population density during Wet season period from June to September and low count from January to March in dry seasons. Bacillariophyta have positive Correlation with Cladocera, Copepoda, pH, Conductivity, Hardness, and Iron while negative correlation exists with Calcium and Magnesium (Table 4).

Dinophyta

The monthly Abundance shown in (Table 3) revealed that there was high algal count of 135(29.22%) in October and July has the lowest, There was high algal count during Wet season in August and September with range between 47 and 135 algal counts respectively. Dry season month from January to March recorded the lowest algal count between 10 to 50 algal counts respectively (Table 3). The correlation coefficient (Table 4) revealed that there was positive correlation between Dinophyta and Copepoda with Conductivity but negative correlation exist with Calcium (Table 4).

The result of biological analysis has indicated the presence of twenty five species of phytoplankton belonging to four major classes these include chlorophyta, bacillariophyta, cyanophyta and dinophyta. The occurrence of phytoplankton also varied with the study period. The phytoplankton identified were found throughout the study period except in some months were some were not identified. The abundance phytoplankton could be related to availability of nitrates - nitrogen and other nutrients in the reservoir as a result of run-off and situation from the surrounding catchments. Similar result was reported by Kolo and Oladimeji (2014) in their study of Shiroro and Dan Zaria Dam Niger State respectively.

The result also showed that higher density of algal count was obtained betweeen June and November. Cyanophyta were represent by *Anabaenia* sp., *Microcystis* sp., *Oscillatoria* sp. among others. Where *Anabaenia* sp. recorded highest number of individual throughout the year. The bacillariophyta include *Navicular* sp., *Fragilaria* sp., *diatoma* sp. *and Melosira* sp. respectively, and *Navicular* sp. recorded highest number of occurrence in all the stations. Chlorophyta recorded the following number individuals as follows; *Spirogyra* sp., *Oedogonium* sp., *Closterium* sp., *Volvox* sp. among others. Where *Spirogyra* sp. showed highest number of occurrence.

The Dinophyta genera comprises of *spirotaenia* sp, *ceratium* sp. *and ceracium* sp. respectively, where *spirotaenia* sp. showed highest number of occurrence.

The Bacillariophyta and Chlorophyta revealed a higher occurence between months. Bacillariophyta count for (133) individual (23.54%) and Chlorophyta total count of (98) individual (17.35%) respectively. Cyanophyta being third in population of phytoplankton population identified with a total of (86) individual of the total (15.22%) of the phytoplankton.

Zooplankton

The number of zooplanktons recorded during the study period was sixteen species, belonging to three major classes were identified in all the five months. They include Cladocera, Copepoda and Rotifera (Table 4).

Cladocera

The cladocera accounted for 1263 number of the total population count of zooplankton with a total of six (6) . different species identified during study period. The monthly Abundance values revealed that there was higher cladocera in August 284 (27.22%) and it was low in May 63(14.15%) (Table 3). The Wet season showed higher population count between the month of July - October and low population count in dry season (November to March). There was positive correlation between the cladocera and Copepoda, Alkalinity, Conductivity and Hardness; there was negative correlation with BOD, DO, Calcium and Phosphate (Table 4).

Copepoda

The monthly Occurence of copepoda in Dadin Kowa River revealed that there was high algal count in the month of August 176(31.59%) while the lowest was recorded in February 34(14.10%) of total zooplankton population (Table 3). Wet seasons recorded higher count of copepoda 556(56.01%) between June to October and low population count of copepods was obtained during the dry season 421(43.09%) between the month of November-March (Table 3). Correlation coefficient (Table 4) revealed that there was position correlation between copepoda with Conductivity and Hardness, but there was a negative correlation of copepoda with BOD, DO and Phosphate (Table 4).

Table 3: Monthly Occurrence of Phytoplankton and Zooplankton in Dandin Kowa River, Gombe State

Month	Chlorophyta	Cyanophyta	Bacillariophyta	Dinophyta	Protozoa	Cladocera	Copepoda	Total
October	8 (11.27)	8 (9.30)	11 (8.27)	6 (6.12)	3 (9.09)	7 (9.21)	5 (7.35)	**48 (8.50)**
November	10 (14.08)	14 (16.28)	17 (12.78)	7 (7.14)	3 (9.09)	11 (14.47)	10 (14.71)	**72 (12.74)**
December	12 (16.90)	13 (15.12)	21 (15.79)	13 (13.27)	4 (12.12)	13 (17.11)	10 (14.71)	**86 (15.22)**
January	7 (9.86)	13 (15.12)	23 (17.29)	14 (14.29)	3 (9.09)	10 (13.16)	10 (14.71)	**80 (14.16)**
February	5 (7.04)	9 (10.47)	9 (6.77)	15 (15.31)	5 (15.15)	8 (10.53)	9 (13.24)	**60 (10.62)**
March	12 (16.90)	9 (10.47)	12 (9.02)	9 (9.18)	3 (9.09)	6 (7.89)	6 (8.82)	**57 (10.09)**
April	2 (2.82)	7 (8.14)	10 (7.52)	17 (17.35)	3 (9.09)	6 (7.89)	5 (7.35)	**50 (8.85)**
May	3 (4.23)	5 (5.81)	15 (11.28)	4 (4.08)	2 (6.06)	3 (3.95)	3 (4.41)	**35 (6.19)**
June	5 (7.04)	3 (3.49)	9 (6.77)	6 (6.12)	2 (6.06)	6 (7.89)	3 (4.41)	**34 (6.02)**
July	7 (9.86)	5 (5.81)	6 (4.51)	7 (7.14)	5 (15.15)	6 (7.89)	7 (10.29)	**43 (7.61)**
August	12 (16.90)	13 (15.12)	21 (15.79)	13 (13.27)	4 (12.12)	13 (17.11)	10 (14.71)	**86 (15.22)**
September	7 (9.86)	13 (15.12)	23 (17.29)	14 (14.29)	3 (9.09)	10 (13.16)	10 (14.71)	**80 (14.16)**
October	5 (7.04)	9 (10.47)	9 (6.77)	15 (15.31)	5 (15.15)	8 (10.53)	9 (13.24)	**60 (10.62)**
November	12 (16.90)	9 (10.47)	12 (9.02)	9 (9.18)	3 (9.09)	6 (7.89)	6 (8.82)	**57 (10.09)**
December	2 (2.82)	7 (8.14)	10 (7.52)	17 (17.35)	3 (9.09)	6 (7.89)	5 (7.35)	**50 (8.85)**
January	3 (4.23)	5 (5.81)	15 (11.28)	4 (4.08)	2 (6.06)	3 (3.95)	3 (4.41)	**35 (6.19)**
February	5 (7.04)	3 (3.49)	9 (6.77)	6 (6.12)	2 (6.06)	6 (7.89)	3 (4.41)	**34 (6.02)**
March	7 (9.86)	5 (5.81)	6 (4.51)	7 (7.14)	5 (15.15)	6 (7.89)	7 (10.29)	**43 (7.61)**
Total	**71 (12.57)**	**86 (15.22)**	**133 (23.54)**	**98 (17.35)**	**33 (5.84)**	**76 (13.45)**	**68 (12.04)**	565

Table 4 Correlation of Biological Parameters against the Physico-Chemical Parameters of Dadin Kowa River

	Chloro	*Cyano*	*Bacill*	*Dino*	*Rotif*	*Clad*	*Cope*	*Temp*	*Alk*	*pH*	*Transp*	*EC*	*Hard*	*BOD*	*DO*	*Ca*	*Fe*	*Mg*	*N*	*P*
Chloro	1																			
Cyano	0.6*	1																		
Bacill	0.4	0.8*	1																	
Dino	-0.1	0.4	0.2	1																
Rotif	0.2	0.2	-0.2	0.4	1															
Clado	0.6*	0.9*	0.6*	0.4	0.3	1														
Cope	0.5*	0.9*	0.6*	0.5*	0.6	0.9*	1													
Temp	0	-0.3	-0.3	-0.3	0.2	0.2	0	1												
Alk	0.3	0.4	0.2	0.2	0.1	0.7*	0.4	0.5*	1											
pH	0.1	0.5*	0.7*	0.3	-0.1	0.3	0.4	-0.2	-0.2	1										
Transp	0.5*	0.3	0.4	0.3	0.1	0.2	0.3	-0.4	-0.3	0.5*	1									
EC	0.2	0.6*	0.6*	0.6*	0.3*	0.6*	0.7*	-0.3	-0.1	0.6*	0.5*	1								
Hard	0.6*	0.6*	0.6*	0.3	0.3	0.8*	0.5*	0	0.5*	0	0.3	0.5*	1							
BOD	-0.8*	-0.4	-0.2	0.1	-0.4	-0.5*	-0.6*	-0.3	0	-0.2	-0.4	-0.4	-0.3	1						
DO	-0.3	-0.3	0.2	-0.4	-0.6	-0.5*	-0.5*	-0.4	-0.3	-0.2	-0.3	-0.2	-0.1	0.5*	1					
Ca	-0.1	-0.6*	-0.8*	-0.5*	0.2	-0.6*	-0.4	0.1	-0.1	-0.7*	-0.4	-0.7*	-0.5*	0.1	0.1	1				
Fe	0.2	0.4	0.6*	0	-0.1	0.2	0.4	-0.2	-0.3	0.9*	0.5*	0.4	-0.1	-0.4	-0.1	-0.5*	1			
Mg	0.1	-0.1	-0.5*	0.4	0.7	-0.1	0.2	0.1	-0.1	-0.1	0.2	0.1	-0.2	-0.3	-0.6*	0.5*	-0.1	1		
N	0.1	0	0.2	-0.1	-0.5	0.2	-0.1	0.4	0.4	0.3	0.1	-0.2	-0.1	-0.1	-0.1	-0.2	0.2	-0.1	1	
P	-0.6*	-0.6*	-0.2	-0.4	0.5*	-0.5*	-0.7*	0.1	-0.1	-0.5*	-0.6*	-0.4	-0.2	0.6*	0.8*	0.2	-0.5*	-0.4	0	1

* = positive correlation (-*)=negative.

CONCLUSION

Dadin Kowa River revealed that there was an indication of some physicochemical pollution in the water body although some values of these parameters are within acceptable range.
Both planktonic composition and abundance were increased during rainy season and decreased with dry season, also it showed the river is productive and will support a diverse species and population of fishes.

Recommendation

Water quality of the river is influenced by anthropogenic activities as runoffs of inorganic fertilizers and pesticides. Therefore, it is recommended that-

1. Farming activities very close to the river should be discouraged, in order to reduce the runoffs of inorganic fertilizers and pesticides into the reservoir.
2. More studies should be carried out to identify the zooplankton composition using using molecular identification methods that are not used during this work.
3. Farmers and students around the river should be enlightened on the effects of their activities into the body of the water, especially application of inorganic fertilizers and pesticide during period of rainy season farming and irrigation and washing when the water level recedes.

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