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Research Article

Studies on Some Aspects of Physico-Chemical and Planktonic Distribution and Abundance in Biu Reservoir, Borno State, Nigeria

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Abstract

Biu Reservoir located on latitude 10.038'00"N and longitude 12.005'31"E in Biu Local Government area of Borno state, Nigeria, is an abandon project built to supply drinking water to Biu Township and its environments, having threatened by increased land use and urbanization within the catchment area. A critical appraisal of Some aspects of limnology of the reservoir were investigated for the period of nine months (September, 2019 to May, 2020) from five sampling stations (A, B, C, D and E) using Physico-chemical parameters and Planktonic compositions, distributions and abundance are formidable to sustaining of the Reservoir is essential, hence this study. The mean values of Physico-chemical parameters were temperature (31.5 ± 0.08oC), Dissolved oxygen (8.7 ± 0.09 mg/L), pH (9.0 ± 0.11), Alkalinity (37.4 ± 0.680mg/L), Biochemical Oxygen Demand (5.1 ± 0.09 mg/L), Turbidity (49.8 ± 0.11 cm), Conductivity (49.4 ± 0.18µs/cm), Nitrite-nitrogen (0.16 ± 0.04 mg/L), Nitrate-nitrogen was (1.36 ± 0.05 mg/L), Phosphate-phosphorus (2.42 ± 0.46 mg/L), and Ammonium 0.82 ± 0.08 mg/L). The planktonic in the reservoir were significantly abundant in composition; the Phytoplankton was dominated by Chlorophyta (36%), followed by Baccilariophyta (24.7%), Cyanophyta (22%), Dinophyta (10%), and Euglenophyta (8%). Zooplankton; the Rotifers having the highest abundance with 33%, Cladocerans 30%, Copepods 21% and Nauplii 16%. The study revealed that almost all the Physico-chemical parameters investigated were within the observed ranges in common unpolluted water bodies and also consistent with desirable limits for aquatic life and drinking. There were no variations between the five stations for Physico-chemical parameters. The Plankton was influenced by interaction of a number of Physico-chemical and biological factors acting simultaneously. The plankton distribution and abundance studied can be presumed adequately enough to sustain the balance in the food web in Biu Reservoir. Hence, their importance cannot be overemphasized.

Keywords: Biu Reservoir; Physico-chemical Parameters; Plankton; Phytoplankton; Zooplankton

Introduction

Water is a natural resource essential to all living things and basic need of humans, thus water is as considered pretty good national asset. With growing demands in various sectors, water needs appropriate planning, development, and management [15]. Bodies of water such as Dams, Reservoirs and Ponds are important part of aquatic ecosystems, though some are relatively small in size, they perform significant environmental, social and economic functions, ranging from being a source of drinking water, recharging groundwater, and acting as sponges to control flooding, supporting biodiversity and providing livelihoods. The biodiversity is primarily needed for ecological balance and human survival but it is largely influenced by the climate change and that its conservation is necessary for inclusive and sustainable development [39,47].

Reservoirs and manmade dams are of the most important surface water resources for the living beings. During rainy season rainwater is stored in reservoirs which are used by the local communities for domestic use. It is mainly used by the animals for the drinking purpose therefore it is necessary to check its water quality. According to [47], study of physico-chemical parameters is useful to know the water quality.

Water quality holds an overall indent of the relative position, productivity and sustainability of any aquatic environment for monitoring water quality which is the opening move for management and conservation of aquatic ecosystems. The periodical changes of Physico-chemical parameters like temperature, transparency, dissolved oxygen, chemical oxygen demand, nitrate, phosphate etc., of any water body may provide valuable information on its biological production in any aquatic body. For instance, Phytoplankton is vital and important organisms which act as producer to the primary food supply in any aquatic ecosystem. Water quality deteriorates when its properties and composition are changed due to the release of pollutants so that it becomes less suitable for drinking, domestic uses, fish production and other purposes, than would otherwise be in its unpolluted state.

According to [40] the Physico-chemical parameters are the major factors that control the dynamics and structure of the phytoplankton of aquatic ecosystem. Changes in Physico-chemical parameters of ecosystems have a substantial impact on the species that live within them. Seasonal variations in these parameters have an important role in the distribution, periodicity and quantitative and qualitative composition of freshwater biota.

According to [20], life in aquatic environment is largely governed by physico-chemical characteristics and their stability. These characteristics have enabled the biota to develop many adaptations that improve sustained productivity and regulate Lake Metabolism. [35] also opined that growth, health, food and reproduction of fish and other aquatic animals are primarily dependent on adequate supply of nutrient both in terms of quantity and quality, irrespective of the natural or culture system in which they are grown. In view of such occurrences, before an attempt to protecting any water body and fisheries resources, it is admirable to have an idea of the water quality status, types of plankton diversity, and overall productivity of the water. Biu Reservoir like every other water bodies may face a host of serious threats, all of which are caused primarily by land use and anthropogenic activities which can pollute the water resources. This study therefore was conducted to determine the Physico-chemical parameters of Biu reservoir and to evaluate the composition, distribution and diversity of plankton species.

Materials and Methods

This study was carried out at Biu reservoir in Biu Local Government of Borno state, Nigeria. The Reservoir is located on latitude 10.038'00" N and longitude 12.005'31" E. The construction work of the Reservoir was initiated in 1984 by then Governor Goni administration to supply drinking water to Biu community but was abandoned by successive governments. Today, the reservoir is primarily used for the purpose of irrigation, fishing and domestic [41]. Biu has a Subtropical steppe climate situated at an elevation of 762.32 meters above sea level. The district's yearly temperature is 32.16ºC and it is said to be 2.7% higher than Nigeria's averages. Biu has Three and half months rainy annually and it typically receives about 36.38 millimetres (1.43 inches) of precipitation [8].

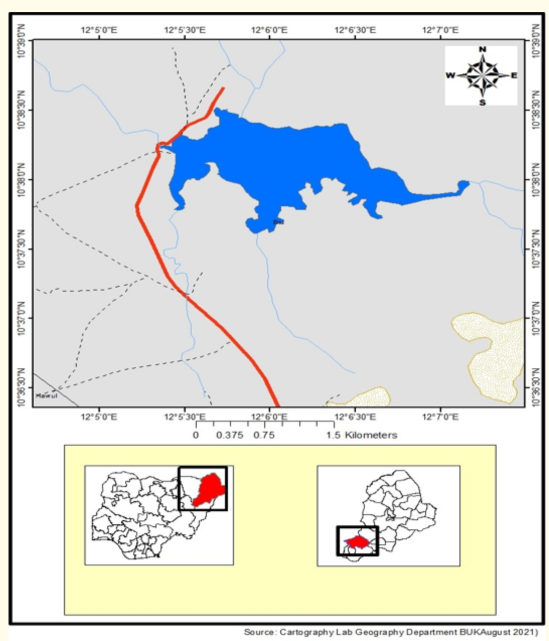

Figure 1: The Map of Biu Reservoir.

Sampling stations

The five sampling stations of the study area were randomly selected (Figure 1): Station A was the area round the water inlet where dry season farming or/and more animal activities are taking place. Station B was the point between the water inlets from the right to the water outlet point where most fishing folks are stationed. It is also where the villagers fetch water; household washing, dry season farming and fish processing activities take place. Station C was point at the water outlet where less or no human activities take place except for animals coming to drink water. This is where the management office is located. Station D was the centre of the reservoir. The sampling was within the depth of 300cm and above and Station E is the point between the water outlet and the water inlet point where small plantation, dry season farming and irrigation are intensively operated.

Sample collection

The research involved monthly sampling for all Physico-chemical parameters and plankton variables throughout the period of the research. Water samples were collected between the morning hours. Sample collections lasted for a period of nine months from September, 2019 to May, 2020 from the reservoir. The readings were taken twice every month (fortnightly).

Determination of physico-chemical parameters

Water quality parameters of Biu reservoir such as dissolved oxygen; pH, conductivity, nitrate, nitrite and temperature required for growth and other biological processes were monitored and recorded biweekly.

Determination of temperature

The Hannan instrument model H198129 was used to measure the water temperature. This was done by inserting the electrode into the water for 2-3 minutes. The measurement was recorded when the stability symbol O in the top left of the secondary ICD disappears suddenly.

Determination of total alkalinity

Total alkalinity was determined as described by [43]. 50ml of water sample will be measured and transferred into conical flask; 2 to 3 drops of methyl orange indicator were added. The sample was then titrated with standard 0.01m H_2SO_4 from a 10ml burette and shaken until the colour changed from blue to pale pink. The total alkalinity was then calculated; thus

, Where, n = normality of standards H_2SO_4

V 1 = Volume of the sample, V2 = Volume of acid used.

Determination of turbidity

Turbidity of the experimental water was taken with the aid of fabricated Sechi disc. The turbidity thus, was measured by lowering the disc into the water gradually and a depth reading (L1) was taken at the point the instrument just disappeared from sight. The instrument was then gently raised and another reading (L2) was taken at the point the disc re-appeared. The average of the two readings ( ) was the correct Secchi disc reading for the water.

Determination of hydrogen ion concentration (pH)

The hydrogen ion concentration (pH) of the experimental water was determined directly by titration using reagent 1, 2, and 3 of Aqua test kit and compared the colour with the colour chart to determine the actual pH [16].

Determination of dissolved oxygen

Dissolved oxygen (DO) of the experimental water was determined directly using Jenway DO meter model 9500 (range 0.2 to 20 mg/l) by dipping the sensor into the experimental water and the reading was taken and recorded.

Determination of biochemical oxygen demand (BOD)

Water sample was collected in one litre airtight sampling bottle. Initial dissolved oxygen (Do1) was recorded on the first day at the site and subsequently the water sample inside the sampling bottle was wrapped or covered in a black sheet and placed in dark room for incubation to take place. After five days, dissolved (Do2) was recorded; hence the biochemical oxygen demand (BOD) was calculated using the following formula described by [11]: BOD = DO1 – DO2 (mg/l).

Where: DO1 = initial dissolved oxygen, DO2 = dissolved oxygen after days.

Determination of conductivity

Conductivity values of the experimental water were routinely monitored at different stations using digital Hatch conductivity meter model, EC500. This is done by dipping the sensor into the water after which result will be taken and recorded. It is expressed in µs/cm.

Determination of ammonia (NH_4)

Ammonia contents of the experimental water was determined directly by titration using reagent 1 and 2, of Aqua test kit and by comparing the colour of the test with the colour chart to determine the actual ammonia content of the water.

Determination of nitrate (NO_3)

Nitrate contents of the experimental water was determined directly by titrating/adding 6 drops each of reagent 1, 2, 3 and 4, of Aqua test kit to the 10ml of the experimental water and shake vigorously and compare the colour with the colour chart to determine the actual Nitrate content of the water.

Phosphate phosphorus (PO_4)

To 10 ml of experimental water add 6 drops of reagent 1 and 2, and shake until liquid was evenly distributed. One spoon of heaping measurement (white) was added to reagent 3 and shaken. The colour was compared after 5 minutes.

Plankton collection/analysis

Water samples for plankton analysis were collected across the five stations in 1 litre bottle samplers about 10cm below the water surface [11]. Samples collected for plankton were preserved in situ by adding 3ml Lugol, s iodine solution. Plankton numerical analysis was carried out using the method by [22].

In the laboratory sample was concentrated by centrifuging. The supernatant was siphoned to obtain the concentrated sample (50ml). About 1ml of the concentrated sample (sub sample) was transferred onto Neuber model 10EC Nephelometric counting cell for plankton enumeration under a compound microscope. The relative abundance for zooplankton and phytoplankton were calculated as follows: Number/ml = C,

Where $C = 1000mm^2/L \times D \times W \times S$

Where, C = Number of organisms counted, L = Length of each strip(S-R) cell length in mm,

D = Depth of a strip(S-R) cell depth, W = Width of the strip, (mm),

S = number of traverses counted.

The number of plankton in a litre (No/l) of water sample is given by: No/l = No/ml ×1000.

Identification of planktons is based on the keys provided by [29].

Data analysis

Data obtained from heavy metal analysis and water quality parameters of all the sampling stations were subjected to statistical analysis. One-way analysis of variance (One-way ANOVA), using SPSS 23. While mean values were compared for significant differences at ($p < 0.05$) using Fisher LSD. Microsoft Excel (2007) was used to calculate mean and standard deviation, percentages and also to plot graph

Result and Discussions

In all aquatic ecosystems, the water temperature is an important factor to controlling all the rate of chemical reactions, fish growth, reproduction, and immunity. Temperature changes can be fatal to fish if it is outside the normal ranges. The monthly mean temperature variation of Biu reservoir from September, 2019 to May, 2020 fluctuated between 14.8 ± 0.5°C and 31.5 ± 0.08°C (Table 1). The minimum temperature was observed at station C in January, 2020 and the maximum temperature was observed in April and May, 2020 respectively. There was significant and strong negative correlation between temperature and dissolved oxygen (r = - .887), pH (r = - 696), and also positive correlation between temperature and Alk (r = -.757), PO_4(r = 635), NH4(r = 411) Table 2. This means that as water temperature increases, dissolved oxygen and pH decreases and vice versa. However, other compounds especially phosphate, nitrite and ammonia increase with increased temperature. Statistically there were significant differences in the mean temperature values between all the months at $p < 0.05$ significance level (Table 1). In this study, the maximum temperature recorded was in May and April and these could probably be due to low relative humidity, high atmospheric temperature with little or no cloud cover, low water level and reduction in the amount of suspended particles among others. This corroborated with [35] who reported that ambient air temperature; sunshine and duration of the day modify water temperature. The water temperature in the months of September, October and March was moderately high, December to February was the months which record low temperature. The lowest temperature values recorded in January otherwise could

MONTH/P	TEMP (oC)	DO (mg/L)	PH	Alk (ppm)	BOD (mg/L)	TUB (cm)	EC (µS/cm)	NO_2 (mg/L)	PO_4 (mg/L)	NO_3 (mg/L)	NH_4 (mg/L)
Sept.2019	24.6 ± 0.4e	7.4 + 0.06d	6.7 ± 0.09d	28.5 ± 0.00f	4.5 ± 0.08c	31.2 ± 0.05i	41.9 + 0.48c	0.15 ± 0.00a	2.42 ± 0.25a	0.96 ± 0.77de	0.64 ± 0.05bc
Oct.2019	25.8 ± 0.19c	7.3 + 0.05e	6.3 ± 0.09g	28.1 ± 0.05f	4.3 ± 0.04d	35.1 ± 0.07g	41.6 + 1.14c	0.12 + 0.00b	1.60 ± 0.22b	0.80 ± 0.00f	0.52 ± 0.08de
Nov.2019	23.4 ± 0.04f	7.8 + 0.07c	6.8 ± 0.04d	30.5 ± 0.10d	5.1 ± 0.08a	35.6 ± 0.05f	39.6 + 0.11d	0.01 + 0.00d	1.14 ± 0.21d	1.12 + 0.04bc	0.64 ± 0.11bc
Dec.2019	16.5 + 0.07h	8.2 + 0.20b	7.2 ± 0.05c	37.8 ± 0.68a	4.4 ± 0.05c	32.5 ± 0.08h	26.6 + 0.10e	0.03+ 0.01c	0.77 ± 0.07e	1.22 + 0.11b	0.60 ± 0.10cd
Jan.2020	14.8 – 0.05i	8.7 + 0.09a	9.0 ± 0.11a	32.2 ± 0.21c	4.6 +0.04b	37.5 ± 0.09e	19.0 + 0.19g	0.03 ± 0.00cd	0.64 ± 0.95e	1.36 ± 0.09a	0.46 ± 0.07cd
Feb.2020	18.1 ± 0.07g	7.4 + 0.12d	7.2 ± 0.08c	34.4 ± 0.21b	5.1 ± 0.08a	37.8 ± 0.05d	22.7 + 0.13f	0.03 ± 0.00cd	0.85 ± 0.28e	0.90 ± 0.07ef	0.72 ± 0.13ab
Mar.2020	24.8 ± 0.05d	7.7 + 0.04c	7.4 ± 0.13b	31.8 ± 0.40c	5.1 ± 0.09a	42.3 ± 0.19c	26.6 + 0.16e	0.02 ± 0.00cd	1.32 ± 0.27cd	0.90 ± 0.00ef	0.44 ± 0.05e
Apr-2020	31.5 ± 0.08a	6.1 + 0.05f	6.67 ± 0.08d	29.8 ± 0.26e	3.6 ± 0.09f	49.8 ± 0.11b	49.4 + 0.18a	0.16 ± 0.04a	1.64 ± 0.46b	1.06 ± 0.05g	0.82 ± 0.08a
May-2020	30.12 ± 0.05b	6.2 + 0.12f	6.5 ± 0.11f	27.5 ± 0.40g	3.8 ± 0.14e	51.4 ± 0.41a	46.6 + 0.56b	0.16 ± 0.02a	1.48 ± 1.11bc	1.08 ± 0.13cd	0.78 ± 0.04a

Table 1: Monthly mean values and standard deviation (± SD) of Physico-chemical parameters of Biu Reservoir.

Tempt	1										
DO	-.887**	1									
pH	-.696**	.684**	1								
Alk	-.757**	.596**	.433**	1							
BOD	-.587**	.678**	.337*	.410**	1						
TUR	.662**	-.747**	-.137	-.374*	-.572**	1					
EC	.896**	-.797**	-.776**	-.752**	-.666**	.419**	1				
NO_2	.741**	-.782**	-.560**	-.688**	-.810**	.435**	.809**	1			
NO_3	-.678**	.689**	.603**	.387**	.289	-.363*	-.529**	-.488**	1		
PO_4	.635**	-.487**	-.560**	-.670**	-.315*	.024	.685**	.703**	-.508**	1	
NH_4	.411**	-.638**	-.412**	-.180	-.477**	.443**	.487**	.498**	-.343*	.169	1

Table 2: Pearson correlation of the physico-chemical parameters of Biu Reservoir.

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

The mean values with the same superscript on the same raw are not significantly different from each other at P < 0.05%.

likely be influenced by the environmental temperature as well as other climatic conditions prevailing in the study area at the time of collecting the samples. For instance, the cooling effect of harmattan and high relative humidity and usually air temperature can seriously influence surface water temperature. This result agrees with [23], who also reported that temperature in the tropic may range between 14 to 30°C. The temperature values of Biu reservoir throughout the period of the study were acceptable for aquatic life and household activities, including drinking purposes. The temperature variations may not act as a limiting factor for the survival of aquatic populations and the biotic community [30]. However, in polluted water, water temperature can have a profound effect on DO [45,48].

Critical to every aquatic environment is Dissolved oxygen. The monthly mean Dissolved Oxygen (DO) concentration of the water of Biu reservoir ranged from 6.1 ± 0.09 mg/l to 8.7 ± 0.05 mg/L (Table 1). The highest value was recorded in January, 2020 and least value in the April and May, 2020 respectively. There was strong negative correlation between dissolved oxygen and NO_2 (r = - 786), PO4 (r = -487), NH4 (r = -487) and Strong positive correlations between Dissolved oxygen and pH (r = .684), Alk (r = 596), Tur (r = 717) and BOD (r = .678) (Table 2). This showed that Dissolved Oxygen decreases with increased in water temperature, Nitrite phosphate and ammonia. Results from analysis of variance showed that Dissolved Oxygen varied significantly between all the months ($P < 0.05$) except November, 2019 and March 2020 (Table 1). The amount of Dissolved Oxygen (DO) in water has been reported as not being constant but fluctuates, depending on the temperature, depth, wind and amount of biological activities such as degradation, photosynthesis among others. Depending upon water temperature saturation rate DO varied between 5 – 9 mg/l [45]. The sanitary significance 6.1mg/l is safe for the survival of all aquatic organisms especially, the (fish) and pleasing for most other beneficial uses and of good ecological status [48]. In this study, the recorded value for dissolved oxygen fell within the acceptable limit stipulated by [48]. The reported lowest mean value observed in this study according to similar study by [31] do not cause stress to aquatic organisms and ecosystems and can rarely result in changes in the communities through direct organisms' mortality and reduction in the population growth of sensitive species. The high value may be due to the cool and dry seasons with steady wind which increases wave action, and decrease in surface run offs and alternatively the cause of decrease in dissolved oxygen may be due to increase in turbidity during torrential rainy season [23]. It can be stated that the monthly DO concentrations in Biu reservoir were moderate.

The pH is a measure of the intensity of acidity or alkalinity and measures the concentration of hydrogen ions in water. The present study revealed that monthly mean pH values ranged from 6.3 ± 0.09 in October, 2019 to 9.0 ± 0.11 in January, 2020 (Table 1). The maximum value was observed in the month of January, 2020 at stations B while the minimum values were recorded in October, 2019 at station D and May, 2020 at station B (Figure 3). Statistically, there was strong and significant negative correlation between pH and Nitrite (r = - 560) and PO_4 (r = - 560) and weak correlation between pH and alkalinity (r = 410), NO_3 (r = 603) table 1. The ANOVA revealed that there was no significant difference ($p < 0.05$) between the months of December, 2019 and February, 2020 (Table 1). As pH increases Nitrite and Phosphate decrease whereas alkalinity increases with increased pH. This, it has been noted during the study periods that the reservoir has almost maintained the prescribed limit by Federal environmental protection agency (FEPA). The pH range of 6.7 - 8.9 reflected a slightly acidic to a slightly alkaline aquatic environment and was within the acceptable range (6.5 – 8.5) for a healthy aquatic life [49]. The variation in pH observed in this study may be due to the high rainfall and flow through from the tributaries. Similar findings were also recorded by [36], reflecting neutral to slightly alkaline conditions. According to the authors optimal pH range below 6.5 influences the slow growth of some aquatic species while pH value greater than 6.5 affects the capacity of some organisms to preserve their salt equilibrium and can cause a stoppage in reproduction. The reported pH 8.9 range is conducive and quite suitable for fish production and for domestic uses.

Primarily, alkalinity and hardness contribute to the buffering capacity of water and the ability of the water to resist change in pH when small amount of acid, base or alkaline is added to the water. The mean monthly alkalinity of Biu reservoir from September, 2019 to May, 2020 fluctuates between 27.5 ± 0.40 mg/L and 37.8 ± 0.68 mg/L (Table 1). The lowest mean value was recorded in May, 2020 at station D and September and October, 2019 at stations A and B respectively while, the highest mean value was observed in December, 2019 at station A and E (Figure). Pearson correlation indicated that there was significant positive correlation between al-

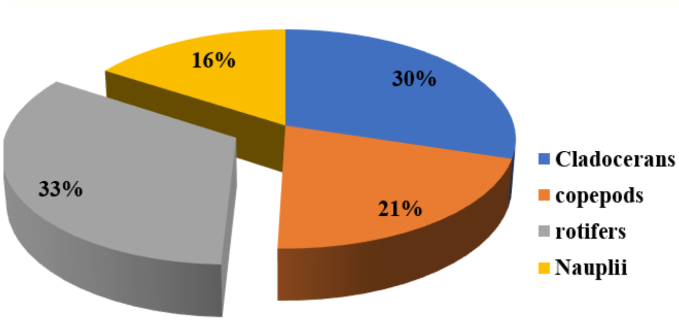

Figure 2: Percentage distribution of Zooplankton in Biu Reservoir from Sept. 2019 - May, 2020.

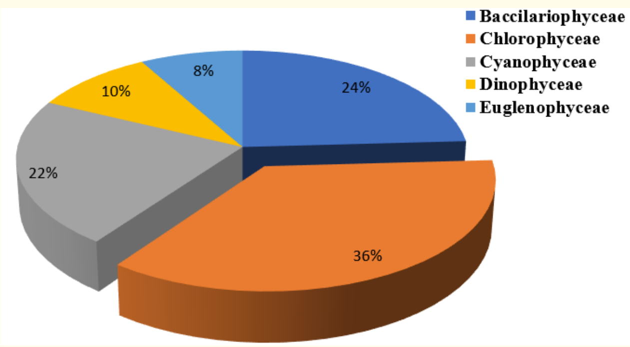

Figure 3: Percentage distribution of phytoplankton in Biu Reservoir from Sept. 2019 - May, 2020.

kalinity and BOD (r = .410) while the rest of the parameter showed all negatively (Table 2). The ANOVA result showed that there were significant variations between all the months ($p < 0.05$) (Table 1). A suitable range of alkalinity is 20 to 300 ppm [39]. These values fell within the permissible limit of the standards [39]. This might be attributed to the low bicarbonate content leaching from the soil in the catchment [3]. Thus, the reservoir with regards to alkalinity level is quite suitable to support aquatic organisms and domestic purposes.

BOD represents the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter under aerobic conditions at a specified temperature. It indicates biochemically degradable organic matter present in a sample. In Biu reservoir, the five days mean monthly BOD recorded ranged between 3.6 ± 0.09 mg/L and 5.1 ± 0.08 mg/L throughout the study periods (Table 1). The maximum was observed in January, 2020 at stations A and February, 2020 at station C. while, the minimum was observed in September, 2019 at station D, November same year at station A (Table 1). Result from correlation showed that there was weak positive correlation between BOD and NO3 (r = 289) and weak negative correlation between NO2(r = - 810), PO4(r = - 315), NH4(r = - 477). This means that as BOD decreases the mentioned parameters increases and vice versa. The ANOVA showed that there were no significant differences between the months ($P < 0.05$) of November, 2 019 and February and March, 2020 (Table 3). In this study, high Biochemical Oxygen Demand was recorded in these aforementioned months; this may be due to huge load of chaff used as means of luring the fish into the traps by fishermen and possibly sewage from nearby villages. The result obtained in this study fell within permissible limit by [48]. This result is similar to the by findings of [49], who reported that the Biochemical Oxygen Demand from 5.0 – 6.9 mg/l falls within the acceptable value or range of standard for drinking water.

Water turbidity, which reflects transparency, is the measure of light penetration in water. It is an important criterion for assessing the quality of water. When the water is cloudy and contains a lot of particles, light cannot penetrate deeply into the water column which may limits primary productivity or photosynthesis. The mean turbidity of Biu reservoir ranged between 31.2 ± 0.05 and 51.4 ± 0.41cm (Table 1). The minimum values were recorded in the Month of September, 2019 at station B while, the maximum value was recorded in May, 2020 at stations C and E respectively. The transparency pattern varied with change in Climatic condition of the area from January to May. Result from ANOVA revealed that significant variations ($p < 0.05$) were observed between all the months (Table 1). The increase in turbidity following rainfall is clearly a common limnological feature of the lake especially those whose catchment has intensive agricultural activities. According to the WHO, the turbidity of drinking water should be less than 5 nophelometric turbidity unit (NTU) or 20 – 80cm seechi disc reading. The least transparency value obtained for Biu reservoir in September, 2019 may be as a result of human activities, high amount of rainfall and increase in debris load by water run-off which is characteristic of the wet seasons. This agrees with a previous study by [38], who reported that reduced activity in Lake Geriyo and complete lack of rains accounted for high transparency.

Conductivity is a measurement of the ability of an aqueous solution to carry an electrical current. The sources of conductivity may be abundance of dissolved salts due to poor irrigation, minerals from rain water run-offs, or other discharges. The monthly mean conductivity of Biu reservoir hovered between 19.0 ± 0.19 and 49.4 ± 0.18μS/cm (Table 1). The maximum value was found to be in April, 2020 at stations C while, the minimum values were recorded in January, 2020 at stations B and D (Table 1). Strong and significant correlations were observed between EC and NO_2 (r = 809), NH_4 (r = 487), and PO_4 (r = 649). This showed that as these parameters increase EC also increases over time. The result showed that there were significant differences (P < 0.05) between the EC mean values recorded for all the months from September, 2019 - May, 2020 (Table 1). The variation was associated with change in seasons from dry to wet. The mean variation of conductivity for Biu reservoir falls within the recommended values of 20 - 1000 μS/cm [48]. The low conductivity levels observed in Biu reservoir suggested that there were low dissolved salts in the study area. The highest could be as a result of dissolved solutes from decaying organic materials raised in temperature. This concords similar report by [2,23], that positive correlation was found to exist between conductivity and temperature values in Dadin Kowa Dam.

Nitrites- nitrogen as a rule is found together with nitrates and ammonia nitrogen in surface waters but their concentrations are usually low because of their instability. They are readily oxidized to nitrate or reduced to ammonia, both chemically and biochemically by bacteria. The monitored mean monthly nitrite of Biu reservoir throughout the period of study fluctuated between 0.01 ± 0.00 mg/L and 0.16 ± 0.04mg/L (Table 1). The minimum mean values were observed in the month of November, 2019 at stations A and D while, the maximum value was obtained in May, 2020 at all stations. Statistically, nitrite correlated positively and significantly with temperature (r = 741), PO4(r = 635) and NH4(r = 411) It also indicated negative correlations between NO3 (r = - 678) and pH (r = -560). This means that as water temperature increases nitrite phosphate and ammonia increase. This shows that temperature influences Nitrite concentrations. The ANOVA showed that there were significant differences (P < 0.05) between all the months except September, 2019 and April and May, 2020 and also January, February and March 2020 (Table 1). The levels of nitrite in Biu reservoir were reportedly lower but falls within the recommended values of 0.00 to 2mg/L for fish production [48]. This is similar studies reported by [5], who recorded 3.5mg/l. Low level of nitrite recorded in the study period might be attributed to minimal human and agricultural activities, and low discharges of waste water around the study area.

Nitrate-nitrogen is a form of nitrogen, which is found in several different forms in terrestrial and aquatic ecosystems. Nitrate is less toxic than the other forms of nitrogen in the aquatic environment, such as nitrite and ammonia. It also emphasized that when the dead organic matter decomposes in water, it forms complex proteins which get converted into nitrogenous organic matter and finally to nitrate by bacterial activity. The monthly mean minimum and maximum value of nitrate ranged between 0.80 ± 0.0 mg/L and 1.36 ± 0.09 mg/L (Table 1). The lowest value was obtained in April, 2020 at all stations while, the highest value was recorded in December, 2019 and January, 2020 at station E and C (Table 1). Pearson correlation revealed that there was negative and significant correlation between Nitrate (NO3) and temperature (r = -.678). The statistical variations between the months were significant at (P < 0.05) between all the months (Table 1). The permissible limit for Nitrate – Nitrogen is 45 mg/l (Bastian and Dan, 2012). The nitrate concentration of Biu Reservoir in surface water was normally low, but can reach high levels from agricultural runoff, or from contamination by human or animal wastes. The values obtained in this study collaborates the finding of [3] who reported that unpolluted natural water usually contain only small amounts of nitrate source and in case of increased level, nitrates might be leached into African lakes from the excessive use of nitrogen fertilizers. These variations in nitrate concentration throughout the period of this study may be due to microbial utilization as well as varying agricultural inflows.

A small amount of phosphorus is essential nutrients for all aquatic plants and algae but in high levels can be considered pollution. Phosphate may occur in surface water as a result of domestic sewage, detergents and agricultural effluents with fertilizers. Figure 1 below shows the monthly mean values of Phosphate (PO_4) in Biu reservoir. The monitored mean values fluctuated between 0.64 ± 0.95 mg/L and 2.42 ± 0.25 mg/L (Table 1). The maximum value was observed in the month of September, 2019 at stations A and the minimum value was recorded in January, 2020 at station D. Statistically there was a strong and significant positive correlation between PO4 and temperature (r = 635) and negative relationship between PO4 and pH (r = -.565). The result showed significant differences (P < 0.05) between the months throughout the study periods except for the months of December, 2019 and January, 2020 respectively (Table 1). Phosphorus can also be used to measure eutrophication of ecosystems with only concentration of 0.1mg/L. The values obtained in this study were slightly higher but still falls within the required permissive level of 2 mg/l as recommended by

WHO. The low concentration of phosphorus can be attributed to minimal anthropogenic activities and the influence of fluctuating temperature. On the contrary, high temperatures allow the mineralization of organic matter in the bottom by bacteria and zooplankton [14]. The result of this study agrees with the findings [19], who asserted that high value phosphate can easily be linked to inputs from the nearby terrestrial surfaces in the rainy season, thereby increasing their concentrations.

The monthly mean of ammonia of Biu reservoir varied between 0.44 ± 0.05 and 0.82 ± 0.08 mg/L. The lowest mean value was recorded in March, 2020 in and highest mean was observed in April Table 1). Ammonia correlated significantly with NO3(r = 169) and temperature (r = 411). This means that nitrate and ammonia are influenced by the water temperature. ANOVA result indicated that there was significant difference ($P < .0.05$) between the months except December, 2019, January, 2020 April and May 2020 (Table 1). In this study, the observed NH4-N concentrations was very low, this may be due to the reduced animal waste released and poor management of agricultural irrigation and run off to the water or the demineralization of submerged macrophytes. This is similar to the work of [24] in Lake Alau who reported that low level concentration of phosphate in Lakes could be attributed to less release of Animal waste living near or in the water or reduced agricultural waste- fertilizer containing high level of Phosphate through run off. Herewith, the recommended limit for freshwater environments beyond which, it acts as toxic to freshwater organisms.

Phytoplankton is a prime producer of all aquatic ecosystems and possibly influences some of the ecological changes in the environment. Plankton in Biu Reservoir was confirmed in their ubiquitous distribution and abundance to some environmental changes especially in water quality and nutrient concentrations. This scenario was also witnessed by [34]. There distribution and abundance in Biu Reservoir equally may depend on various physical and chemical properties of the environment as reported by [27]. Figure 3 presents the percentage compositions and distributions of phytoplankton according to families in Biu reservoir throughout the period of the study. The study showed that five (5) families and thirty three (33) species of Phytoplankton were identified in Biu reservoir (Figure 3). The Families are: Bacillariophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae and Euglenophyceae. The result of this investigation is similar to those of [10,13,28,34] who all reported that Chlorophyta, Bacillariophyta, Cyanobacteria and Dinophyta are most dominant in fresh water communities.

Result from Biu Reservoir indicated that out of the species studied Chlorophyceae emerged the highest 36% with twelve species and the most diverse family throughout the period of the study (figure 3). The highest monthly mean value was recorded in September, 2019 followed by the month of May, 2020 while; the least was indicated in December, 2019. The high mean value may be as a result of nutrients drift from agricultural activities during raining season and/or increased transpiration and absence of runoff during dry season which may increase concentration. This finding is similar to reports of [34] who reported that the family Chlorophyceae ranked higher in abundance over other families especially Cyanophyceae and Bacillariophyceae [5]; also reported that Chlorophyceae was the most dominant family in the composition of the phytoplankton in most tropical communities, [7] that the phytoplankton abundance of Ikere-gorge is dominated by the Chlorophyta. [21] who also reported that the Chlorophyta had the highest number of species in some water bodies in Kaduna Metropolis, Nigeria. Statistically chlorophyceae correlated positively with temperature (r = 801) NO2(r = 798), PO_4(r = 316) and pH (r = 543) Table 3. This shows that Biu reservoir favoured Chlorophyceae abundance is quite productive and linked to nutrient availability as alluded by [42] especially nitrate and phosphate. Generally, the role of Chlorophyceae in the ecosystem's balance worldwide is outstanding. They are among the significant groups of photosynthetic microorganisms and also one of the most abundant in micro-phytoplankton and that they comprise a wide diversity of freshwater, marine, and even terrestrial green algae [50].

The Bacillariophyceae (diatoms) comprises a ubiquitous, highly successful and distinctive group of unicellular algae which serve as the most valuable food to the aquatic organisms. Its occurrence in Biu reservoir ranked the second in abundance (24%) with ten (10) species identified throughout the period of the study (Figure 3). The highest monthly mean was recorded in the month of October, 2019 and the least mean value was recorded in December 2019. Baccilariophyceae correlated positively with temperature (r = .753), PO_4(r = 519), NO2 (r = 791), and with NO_3 (r = .649), pH (r = 568). This indicated that Baccilariophyceae thrive well with increased in all the parameters mentioned above especially the regular supply of key nutrients Nitrate and Phosphate. This agreed with the report by [44] who opined that Bacillariophyceae communities thrive very well in healthy and favourable conditions and that high

Tempt	**1**												
DO	.885**	1											
pH	.689**	.679**	1										
Alk	.749**	.579**	.419**	1									
NO_2	.735**	781**	.552**	.680**	1								
NO_3	.706**	.740**	.621**	.407**	.505**	1							
PO_4	.642**	.499**	.561**	.676**	.706**	.512**	1						
NH_4	.390**	.622**	.398**	-.153	.486**	-.363*	.167	1					
Baccilo	.753**	.762**	.568**	.749**	.791**	.649**	.519**	.360*	1				
Chloro	.801**	.650**	.543**	.880**	.798**	.454**	.711**	.316*	.783**	1			
Cyano	.778**	.698**	.706**	.474**	.572**	.506**	.404**	.428**	.601**	.723**	1		
Dino	.589**	.582**	.450**	.551**	.538**	.698**	.436**	.202	.728**	.558**	.500**	1	
Eugleno	.637**	.606**	-.167	.388**	.492**	.418**	.303*	.485**	.450**	.558**	.622**	.404**	1

Table 3: Pearson correlation of Phytoplankton and some Physico-chemical parameters of Biu Reservoir.

biological diversity usually shows that the water quality is good. It has been documented that the occurrence of rich algal flora takes place generally at the places where there are high levels of nutrients, together with favourable environmental conditions [32].

[9,30] also reported that regular supply of phosphate, nitrate, silicate and total hardness encouraged the growth of Bacillariophceae (diatoms). This could be opined that Biu reservoir is a moderately pollution free environment thereby creating little stress free environment for Bacillariophyceae species to flourish. This assertion was also reported by many researchers [9,17,46].

The family Cyanophyceae emerged third in abundance 22.9% throughout the period of study in Biu reservoir. Cyanophyceae are (blue-green algae) algal-like bacteria with photosynthetic capabilities that can contaminate surface water supplies mostly during warm seasons from the months of March to April in the tropical regions [42]. In harmony with this study, the Maximum monthly mean of Cyanophyceae was in the month of April and May, 2020 and moderately in October, 2019. In these months the water temperature is usually high if not worm. Statistically there was strong positive correlation between Cyanophyceae and temperature (r = 778), NO_2 (r = 506), NH4(r = 428), PO4(r = 404) with pH (r = 706) (Table 3). This means that cyanophyceae members increase with increased in temperature and Phosphate and apparently with increased in pH. The occurrence of the members of Cyanophyceae in Biu reservoir is a characteristic feature of nutrient rich environment which have high concentrations of phosphate or nitrate and Optimal temperature [34]. This was also in tune with the positive correlations of Cyanophyceae members to temperature, pH, Nitrate, phosphate, and ammonium among others. This is corroborated the report of [6] that even at low ratio either of nitrogen and phosphorus concentrations may favour the development of cyanobacteria blooms. It can be said that Cyanophyceae can out-compete other phytoplankton under low levels of phosphorus or nitrogen especially, Nostoc, and Gleocapsa as the most flourished species in the family of Cyanophyceae studied in Biu Reservoir. [6] further reported that high phytoplankton density leads to high turbidity and low light availability, and cyanobacteria are the group of organisms which can grow best under these conditions.

In this present study, maximum population of Cyanophyceae was observed during the months of April when the temperature was recorded higher and October when the temperature was moderate. This result is also similar to the previous study by [3]. Moreover, Microcystis spp., Oscillatoria spp and Gloeotrichia spp. are among phytoplankton identified by WHO [9] as most common toxic cyanobacteria in freshwater. Their excessive intake and health impairments through drinking-water are seen through such symptoms as abdominal pain, nausea, vomiting, diarrhoea and skin and eye irritations; these symptoms are likely to have diverse causes, with several classes of toxin and genera of cyanobacteria involved. Therefore, anthropogenic activities that are fuelling the abundance of these phytoplankton species should be put under control for the safety and proper function.

Dinophyceae accounted the fourth 8% in distribution and abundance in Biu reservoir. This result is similar to the report by [13,28], who reported Dinophyta as one of the most common and dominant phytoplankton species in the fresh water communities. The highest monthly mean of Dinophyceae was recorded in April, 2020 and October, 2019. There was strong positive correlation between Dinophyceae and NO_3(r = 698), temperature (r = 589), PO4(r = 436) and correlated with Table 3.

The peak abundance observed in April and slightly lower in the month of October, 2019 is a validation of the fact that Dinophyceae presence and survival is linked to nutrients availability especially nitrates and phosphate and that the environment was conducive for their proliferation. This corroborates with the finding of [18] in respect to dinophyceae distribution who reported that the regional effect of high temperature, wind conditions alongside nutrient are among the evident on their distribution and abundance Dinophyceae members. The relative contribution of autotrophic and heterotrophic dinoflagellates cyst species can be particularly useful, since the two trophic groups have different environmental requirements related to their nutrition. The species Peridinium was observed to be least compared to Ceratium in the study area.

The minimum monthly value of Euglenophyceae was reported in the month of April followed by May, 2020 and November, 2019 and the least in February, 2020. There was relatively low fluctuation in abundance from the month of September and October, 2019 and December 2019 to March, 2020.

Euglenophyceae was reported to be the least 7% throughout the period of the study. Two (2) genera; Euglena and Phacus species were identified in Biu reservoir (Table 5). They are facultative heterotrophs and are generally abundant in water rich in organic matter. Statistically Euglenophyceae correlated significantly with temperature (r = 637), NO3(r = 418), PO4(r = 303).

Their low distribution and abundance might be a sign that Biu Reservoir is an unpolluted and good abundance of Euglenophyceae was recorded in the month of April, 2020 which was also characterized by moderate concentration of nitrate. Generally, Euglenophyceae is observed to be associated with organic matter contamination and a distinctively well typified group in most still water bodies; and their occurrence may likely be affected by anthropogenic influence. This means that they are good indicators of water quality. Studies on freshwater environments by [10] also showed that moderate phosphate and nitrate concentration favours the growth of euglenoid cells. It was observed in the present study that the values of physico-chemical parameters fluctuate notably during different months and seasons while Euglenophyceae cells flourished well throughout the period of the study. This may be associated with available nutrients throughout the period of the study.

Figure 2 presents the monthly mean distribution of Zooplankton studied in Biu Reservoir from September, 2019 to May 2020. There were 11 species of zooplankton from three families Cladoceran, Rotifers, Copepods and Nauplii studied in Biu reservoir (Table 4).

Tempt	**1**												
DO	.885**	1											
pH	.689**	.679**	1										
Alk	.749**	.579**	.419**	1									
NO3	.706**	.740**	.621**	.407**	1								
PO4	.642**	.499**	.561**	.676**	.512**	1							
NH4	.390**	.622**	.398**	-.153	-.363*	.167	1						
BOD	.647**	.727**	-.105	-.345*	.398**	.017	.416**	1					
Tur	-567**	.653**	.315*	.384*	.320*	-.320*	.453**	.540**	1				
Clado	.627**	.508**	-.335*	-.326*	.404**	.472**	.200	.389**	.421**	1			
Copep	.658**	.584**	.533**	.563**	.567**	.747**	.290	.188	.413**	.626**	1		
Rotifers	.773**	.691**	.581**	.632**	.435**	.691**	.340*	.365*	.612**	.642**	.696**	1	
Nauplius	.802**	.776**	.528**	.547**	.709**	.431**	.307*	.597**	.513**	.613**	.539**	.630**	1

Table 4: Pearson correlation of Zooplankton and some Physico-chemical parameters of Biu Reservoir.
** Correlation is significant at the 0.01 level (2-tailed).* Correlation is significant at the 0.05 level (2-tailed).
The mean values with the same superscript on the same raw are not significantly different from each other at P < 0.05%.

The Rotifers was the dominant family (42.4%). It consists of four species namely; Branchionus spp, Bosminia spp, Keratella spp and Filinia spp (table). The maximum monthly mean was observed in October, 2019 and the lowest value obtained was in the months of January, 2019 and February, 2020. The study also showed a fluctuating density pattern of Rotifer cells across some months throughout the study period. There was significant strong positive correlation between Rotifers and temperature ((r = .773), pH (= 581), PO_4(r = 691), NO3 (r = .435), Cladocera (r = .404), and Copepods(r = 696) (Table 4). Rotifers may increase with increase in the water quality parameters. The dominance of Rotifer species in Biu reservoir was highly expected as various reports showed that rotifers are the most dominant zooplankton group in Nigerian and tropical aquatic ecosystems [1,4,9,31]. Additionally, their dominance could also be attributed to a few number of fish grazing on rotifers as observed in a similar report by [37] in the Kontogora Reservoir and with similar studies by [12] possibly due to the food sufficiency enhancing their reproductive capacity as opined by [19] Rotifers have been known to thrive and flourish under quiet and near stagnant condition [37]. The superiority of rotifers to dominate any aquatic environment has been indicted as pollution indices as observed in this study by [31]. Among the species studied are Keletella spp, Bronchionus spp, Euchlanus spp and Filinia spp (Table 4).

The result of monthly mean distribution of copepod is presented in Figure. The monthly mean distribution undulated between the Month of September, 2019 and May, 2020. The least value was obtained in the months of January, 2020 while, the highest value was observed in the months of September, 2019 and the moderate in the month of March and April, 2020 respectively. Pearson correlation indicated that Copepods correlated positively with temperature (r = .658), pH (r = .533), PO_4(r = .747) and dissolved oxygen (r = .584). The Copepods: recorded the least (21%) in abundance in this study. This finding is not in consonant with other studies where they were found to be the dominant taxon. [25], observed that copepods dominate most aquatic ecosystems because of their resilience and adaptability to changing environmental conditions and ability to withstand varying environmental stresses. Copepod population dropped at unfavourable conditions. It can be noted in this study that the low abundance of copepod was unique, thus their reduced number or non-utility role in Biu Reservoir. The numbers could not be reported as absent or disappearance since no previous information exists. However, the only genus (Cyclops and Diatom spp) identified in this study are known for their ability to survive varieties of trophic and water temperature. The composition and abundance of zooplankton in any aquatic ecosystem are crucial in water quality monitoring. They could be threatened or impacted on due to anthropogenic activities such as domestic or sewage disposal, agricultural as noted in the present study [49]. Zooplankton is thus important in the structuring of dynamics of aquatic environments and productivities.

The mean monthly distribution of the Cladocerans studied in Biu reservoir was recorded highest in September, 2019 and lowest in January, 2020 with irregularly fluctuating low patterns/density throughout the other months of the study periods. Pearson correlation (Table 3) showed that there was strong significant positive correlation between Cladoceran and NO_3(r = .404), PO4(r = .427) temperature (r = .627) and dissolved oxygen (r = .508) (Table 4). The temperature as a master abiotic factor may have influenced their abundance and survival in Biu reservoir probably. Cladocerans ranked the second in abundance and diversified order studied in Biu Reservoir after rotifers at 30%. The vigorous number of Cladocerans in Biu Reservoir could also be attributed to the fact that Biu Reservoir is a healthy environment with associated food sources or energy for these individuals. This finding is similar to the study [24] in Ogbei Stream of Anambra whose found Cladocerans to be the second dominant zooplankton species. [26] also reported that Cladocerans are of great importance in the aquatic food chain as food for both young and adult fish. In addition, [19] listed Cladocerans among choice food items important in the energy cycles of fish conservation. The author further opined that the success of Cladocerans is known for much enhanced survival in serene and stable habitat. Therefore, with similar environmental condition, it may be said that Biu Reservoir is a quite stable water body. The consequential presence of Cladocerans has further confirmed the floristic nature of Biu reservoir. The presence of Cladocerans also suggested that they possess a wide range of environmental variables.

The monthly mean distribution of nauplius being the first larval stage of many crustaceans studied in Biu reservoir is presented in (Table 5). The nauplius larva showed its highest densities in October, 2019 while, lowest mean values across months of December, 2019 and January, 2020. Result also showed that Naupli correlated positively with Temperature (r = 802), Dissolved Oxygen (r = .776), pH(r = .528), and Cladocerans (r = .613). This means that the larval stage could be favoured by those parameters indicated above and believed to be the imminent Cladocerans after hatching. By default, Cladocerans might have outnumbered Rotifers since their larval stage comprised considerable percentage. However, their larval stage may be the most favoured food to fish since their importance in maintaining and sustaining food chain cannot be overemphasized. Once they are not found in an environment it shows that there is potential threat to their existence and it may unravel the natural food chains. In Biu Reservoir equally their presence is evident (16%) of their existence and conducive and flourishing environment.

Conclusion

The study revealed that almost all the Physico-chemical parameters investigated were within the observed ranges in common unpolluted water bodies and also consistent with desirable limits for aquatic life and drinking. There were no variations between the five stations for physico-chemical parameters except nitrate which exhibited significant variations.

From the appraisal to the distribution, abundance of plankton in Biu Reservoir, it was found that the environmental conditions of the Reservoir support a productive diversity of plankton. The Reservoir had a diversified group of plankton of about 33 phytoplankton and 11 zooplankton species including crustacean's larva. The plankton diversity is largely influenced by interaction of a number of physical, chemical and biological factors acting simultaneously. The plankton distribution, diversity and abundance studied can be presumed adequately enough to sustain the balance in the food web in Biu Reservoir. Hence, their importance cannot be overstated.

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