https://dx.doi.org/10.4314/dujopas.v11i1b.28
ISSN (Print): 2476-8316
ISSN (Online): 2635-3490
Dutse Journal of Pure and Applied Sciences (DUJOPAS), *Vol. 11 No. 1b March 2025*

Water Quality Assessment of Dutsin-Ma Dam, Katsina State, Nigeria

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Abstract
Maintenance of healthy aquatic environment and production of sufficient food in reservoirs are primarily linked with successful reservoir culture operations. To keep the aquatic habitat favorable for existence of living organisms, physical and chemical factors like temperature, turbidity, pH, odor, dissolved gases (Oxygen and CO_2), salts and nutrients as well as presence of heavy metals must be monitored regularly, individually or synergistically. The aim of this research was to assess the quality of water in Dutsin-Ma dam. During the study, physico-chemical parameters, Phytoplanktos diversity as well as heavy metals presence of Dutsin-Ma Dam were studied for the period of four months, July, 2021 to September, 2021 (rainy season). Water temperatures, Water pH, were measured. Dissolved oxygen, Turbidity and Total dissolved solids were determined Spectrophometrically. Results of the determination of physico-chemical parameters showed that temperature, pH, dissolved oxygen, biological oxygen demand, turbidity, nitrate, phosphate, zinc and chromium were varied. Similarly, Phytoplanktons were collected using small sampling bottles and identified. Five (5) species grouped into Four (4) classes of phytoplankton comprising of Chlorophyta, Charophyta, Cyanophyta and

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Chrysophyta were recorded. Species identified includes Characium sp, Gleotrichia sp, Mallomonas sp, Closterium sp and Chlorella sp. Heavy metals were analyzed by digestion and analysis using Palintest Spectrophotometer (7100). The results of heavy metal analysis showed the presence of zinc and chromium which varies between July to August. The value of Chromium was high in August (5.39±2.20) while lowest in the month of September (1.65±0.77). Correlation matrix showed that there were significant positive correlations between phytoplanktons diversity and physico-chemical parameters of the dam water. This suggests that the dam water is not fit for drinking during this season.

Keywords; water quality**,** physico-chemical parameters, phytoplanktons, heavy metals, Dutsin-Ma Dam

INTRODUCTION

The quality of water is governed by its physical, chemical and biological parameters status in comparison with international inland and drinking water standard (Yakubu, 2000). Phytoplanktonic species have different physiological requirements and thus show diverse responses to physical and chemical parameters such as light, temperature and nutrient regime, their sensitivity and variations in species composition are often a reflection of significant alteration in ambient condition within an ecosystem (Ekelemu and Olele, 2008). Reservoir communities of phytoplankton constitute the basis of the aquatic food chain. This is because they are primary producers which sustain populations of primary consumers that include zooplankton, some macro invertebrates and fishes. The composition and abundance of plankton communities may provide a hint on the health status of a reservoir (Watson, 2004). Freshwater phytoplanktons communities are important indicators of environmental changes. Since they integrate the effects of increased nutrient loads, and they can be more sensitive to the combined impacts of stressors than a single stressor (Sagert, 2008). They are important water quality indicators because of their short life cycles, and ability to respond to environmental changes, hence, their standing crop and species composition indicate the quality of water (Tiseer, 2008). The change in abundance species diversity and community composition of Phytoplanktons indicates environmental changes like pH, temperature; nitrate, phosphate total dissolved salt, nutrient levels, and alkalinity are sensitive indicators of pollution in comparison with phytoplankton (Tiseer, 2011). Phytoplanktons are producers, transforming sunlight into food energy. Producers provide food for many different primary consumers. The species composition of the plankton when observed can provide an indication of environmental health, (Yahaya, 2004). The classic example is algal blooms associated with eutrophication, especially during large phytoplankton blooms known as red tides (Hassan *et al*., 2011, 2013).

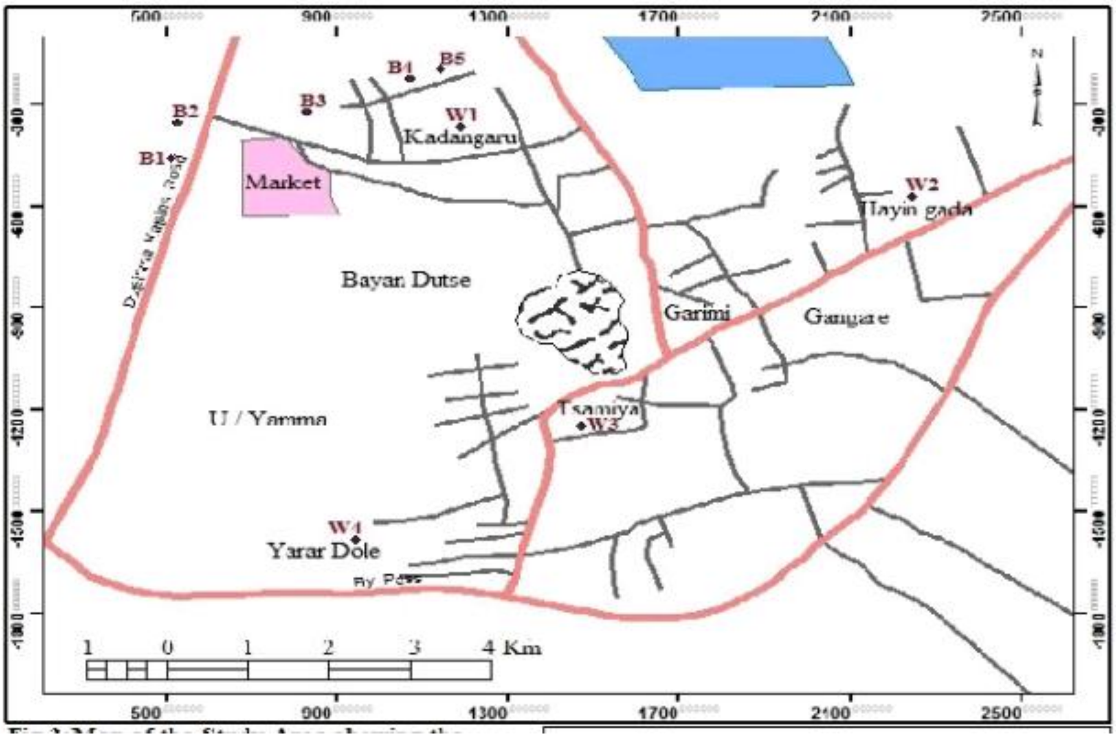
The relationship between the physico-chemical parameters and planktons production of water bodies are of great importance in management strategies of aquatic ecosystem (Dam, ponds, rivers and ground waters are used for domestic and agricultural purpose. The quality of water may be described according to their physico-chemical and plankton characteristics (Yakubu, 2000; (Hassan *et al*., 2011, 2013a and b). The phytoplanktons in dam are an important biological indicator of the water quality. While phytoplanktons are important primary producers and are the at the base of food chain in open water, some species on the other hand can be harmful to human and other animals by releasing toxic substances (hepatotoxins or neurotoxins etc.) into the water (Potts and Whitton, 2000).

In recent years, there has been increasing concern about the rate at which inland waters are polluted through run offs into streams and dams, as in Dutsin-Ma Dam therefore leading to euthrophication which affect the specific diversity of planktons and variation of physico-chemical parameters as well as changing the qualities of these water bodies (Chapman and Romberg, 2008). The quality of a given water is governed by its physical, chemical and biological parameters status in comparism with international inland and drinking water standard (Yakubu, 2000).Changes may had happened over a period of time in Dutsin-Ma Dam because of how the neighboring communities use the Dam .The neighboring communities resort to the use of the dam for agriculture, recreation, livestock and human consumption due to insufficient supply of pipe borne water. These activities of the communities of Dutsin-Ma Dam may affect the physico-chemical parameters and biological composition in relation to season as well as the quality of the water, which is the focus of the study. The aim of this study is to assess the quality of water in the Dutsin-Ma Dam, Katsina state, Nigeria.

Materials and Methods

Study Area

The study was conducted in Dutsin-Ma Local Government Area, Katsina State and samples were collected from three different sampling stations within the dam. Dutsin-Ma local government is located on Latitudes 12° 27′18″N to 12° 27′47″N and Longitudes 7° 29′29″E to 7° 30′11″E and has its headquarters in the town of Dutsin-Ma. It has an estimated area of 527km² and a population of 169,671 as at 2006 census (NPC, 2006). The people are predominantly farmers, cattle rearers and traders.



Sampling Dam

Fig. 1. Map of Dutsin-Ma (Ones/Spot Image, 2014)

Three sampling points (A, B, C) were chosen within the dam. These points cover the various human activities occurring within the study area.

Sampling methods

From each sampling station, water samples were collected bi-weekly starting from July, 2021 to September, 2021. The sampling was accomplished between 7:00am to 1:00pm and sampling bottle were used in collecting water samples. These samples were transported to the laboratory, Bayero University, Kano, for physico-chemical analysis and phytoplanktons identification. The physico-chemical parameters evaluated were pH, temperature, dissolved oxygen, turbidity, Total dissolved oxygen and biological oxygen demand

Determination of physico-chemical parameters

Temperature
Liquid in glass thermometer was used to determine environmental temperature by exposing the thermometer to the air, for five seconds until it stabilized and the temperature was read. This was followed by immersing the thermometer into the water surface in an inclined position for five seconds and allow until stabilized. The temperature reading was also taken (Ahmad, 2015)

pH
Water was collected in sampling bottle and was taken to the laboratory for pH analysis. The pH was determined with Hanna multi-parameter (The pH meter was calibrated before taking the pH measurement as described by APHA (1999).

Dissolved Oxygen
Water was collected in sampling bottle and taken to the laboratory for DO analysis. The DO was determined with palin test (Photometer, 7100) as described by Ahmad (2015)

Total dissolved solid
Water was collected in sampling bottle and were taken to the laboratory for TDS analysis. The TDS was determined with palintest (Photometer7100). The probe was zeroed with distilled water between sample readings to avoid errors (Ahmad, 2015).

Turbidity
Water was collected in sampling bottle and was taken to the laboratory for turbidity analysis. The turbidity was determined with a portable dataloging spectrophotometer (2010,Hach spectrophotometer) .The probe was zeroed with distilled water between sample readings to avoid errors (Yahaya, 2013).

Biological Oxygen Demand (BOD)
This test was done by the use of Hach (2010) model spectrophotometer to measure the DO (Dissolved oxygen) initially and then after incubation for 5 days at 25^{o}C; the difference between the two values being the BOD (APHA, 1999).

Phytoplanktons Sampling
Phytoplankton samples were collected with one litter plastic bottle by dipping the container bottle, sliding over the upper surface of water body with it mouth against the water current to permit undisturbed passage of the water into the bottle (Tanimu, 2011). Samples were preserved with Lugol's solution and brought to the laboratory. Slides were prepared and observed under a binocular microscope. Each sampled was dropped on a slide and it was viewed on the microscope with the aid of identification guide as described by American Public Health Authorities (1999).

Heavy Metal Analysis

Sample digestion

Digestion of samples for analysis of heavy metals were carried out prior to the sample analysis 100 ml of sample was introduced into 250 cm^3 beaker, anti-bumping granules and 1.5 cm^3 beaker,. HNO_3 were added. The samples were then heated until it evaporated to about 20 cm^3. It was then cooled and diluted to 100 cm^3 and kept for analysis.

Determination of Heavy metal

Palintest spectrophotometer (Photometer7100) was used to measure the concentration of nitrate-nitrogen, phosphate-phosphorous, chromium and zinc from the sample collected.
The spectrophotometer was put on and set based on the heavy metal to be analyzed and blank sample which contain distilled water was placed in the sample cell and introduced in the spectrophotometer in order to zero the machine. The concentration of the heavy metal measured was obtained and the instrument was zeroed to the blank sample concentration for subsequent measure (Yahaya, 2013). Ten mills of the digested samples were then introduced into the sample cells and run at different wave length. The concentration of heavy metals was determined at different wavelength using data logging spectrophotometer and the concentrations were recorded. Same instrument and procedure was followed to determine the concentration for zinc at wavelength of 620nm as described by Yahaya, (2013).

Statistical Analysis

Pearson correlation was used to determine the relationship between phytoplankton and physico-chemical parameters of the Dam. Alongside this, one way Analysis of variance (ANOVA) was used to determine the monthly mean variation and standard deviation using SPSS version 16.0 software.

RESULTS

Monthly Physico-chemical Parameters

Between July to August, the values of temperature was high in August (24.36±1.63) while lowest in the month of September (21.63±0.94), the highest value of pH was recorded in the month of September (7.60±0.61) while lowest in the of month of August (6.55±0.23), Turbidity has it highest values in the month of August (4.17±105.44) while lowest values in the month of September (1.14±31.61) ,Dissolved oxygen has the highest values in the month of September (4.70±1.40) while the lowest values in the months of July (2.18±0.59), Biological Oxygen Demand was found with the highest value in August (2.62±0.74) while the lowest value in July (0.94±0.52) and Total Dissolved Solid was found with the highest values in the months of (55.55±19.38), while lowest in the month of July (49.76).

Table 1: Monthly Mean ± SD of the physico–chemical parameters recorded in Dutsin-ma Dam

Parameters	July	August	September	P-value
Temperature °C	21.96±0.96	24.36±1.63	21.63±0.94	0.003
pH	7.01±0.40	6.55±0.23	7.60±0.61	0.004
TB NTU	2.59±62.67	4.17±105.44	1.14±31.61	0.000
DO mg/l	2.18±0.59	4.43±1.17	4.70±1.40	0.002
BOD mg/l	0.94±0.52	2.62±0.74	1.79±0.69	0.002
TDS ppm	48.48±17.79	55.55±19.38	69.98±21.39	0.187

Monthly Trace Elements

Between July to August, the values of Nitrate was high in August (6.16±2.24) while lowest in the month of September (1.13±0.42), the highest value of Phosphate was recorded in the month of August (2.79±1.17) while lowest in the month of September (1.13±0.42).

Between July-August, the Trace element determined shows that, Phosphate had the highest p-value (0.006), and Nitrate has (0.003).

Table 2: Monthly Mean ± SD of some Trace Element recorded in Dutsin-Ma Dam

Trace Element	July	August	September	P-value
NO_3-N	4.05±1.40	6.16±2.24	2.19±0.91	0.003
PO_4-P	1.60±0.48	2.79±1.17	1.13±0.42	0.006

Monthly Phytoplanktons Diversity

Between July to August, the values of *Characium* sp was high in August (6.83±3.18) while lowest in the month of July (3.33±2.25),(Table 3). The highest value of *Closterium* sp was recorded in the month of August (5.00±2.09) while lowest in the of month of July (3.17±1.94), *Gleotrichia* sp has it highest values in the month of September (1.33±1.03) while lowest values in the month of July (0.83±1.32). *Mallomonas* sp has the highest values in the month of August (5.83±2.48) while the lowest values in the months of July (3.00±1.78), *Chlorella sp* was found with the highest value in August (4.50±1.872.50±1.04) .

Table 3: Monthly Mean ± SD of some Phytoplanktons species recorded in Dutsin-ma Dam

Phytoplankton	July	August	September	P-value
Characium sp	3.33±2.25	6.83±3.18	3.53 ±1.87	0.048
Closterium sp	3.17±1.94	5.00±2.09	4.33±2.16	0.326
Gleotrichia sp	0.83±1.32	0.83±1.32	1.33±1.03	0.727
Mallomonas sp	3.00±1.78	5.83±2.48	5.83±1.47	0.036
Chlorella sp	2.50±1.04	4.50±1.87	2.67±1.21	0.051

Physico-chemical Parameters

Between Sampling stations A to C, the values of temperature was high in A (23.78±1.80ºC) while lowest in B (21.31±1.04ºC), the highest value of pH was recorded in A (7.49±0.66) while lowest in C (6.99±0.55), Turbidity has it highest values in A (3.11±176.15) while lowest values in B (2.20±115.90) ,Dissolved oxygen has the highest values in A (4.77±1.60) while the lowest values in B (2.69±0.88), Biological Oxygen Demand (Table 4**)** was found with the highest value in A (2.28±0.89) while the lowest value in B (1.31±0.89) and Total Dissolved Solid was found with the highest values in B (80.91±12.92), while lowest in A (41.98±6.71)

Table 4: Mean ± SD of the physico–chemical parameters recorded in Dutsin-ma Dam by sampling points (stations).

Parameters	Station A	Station B	Station C	P-value
Temperature °C	23.78±1.80	21.31±1.04	22.86±1.32	0.027
Ph	7.49±0.66	6.67±0.34	6.99±0.55	0.053
TB NTU	3.11±176.15	2.20±115.90	2.59±147.08	0.575
DO mg/l	4.77±1.60	2.69±0.88	3.84±1.54	0.061
BOD mg/l	2.28±0.89	1.31±0.89	1.76±0.91	0.207
TDS ppm	41.98±6.71	80.91±12.92	51.11±15.21	0.000

Trace Element

Between Sampling stations A to C, the values of Nitrate was high in A (5.62±2.417) while lowest in B (2.58±1.22), the highest value of Phosphate was recorded in A (2.63±1.30) while lowest in B (1.26±0.49).

Between sampling stations A to C, the Trace element determined shows that, Nitrate had the highest p-value (0.055), and Phosphate has (0.046)

Table 5: Mean ± SD of some Trace Element recorded in Dutsin-Ma Dam with respect to sampling station

Trace Element	Station A	Station B	Station C	P-value
Nitrate-nitrogen mg/l	5.62±2.417	2.58±1.22	4.19±2.09	0.055
Phosphate-phosphorous mg/l	2.63±1.30	1.26±0.49	1.66±0.63	0.046

Phytoplanktons Diversity

Between Sampling station A to C, the values of *Characium sp* was high in A (7.16±2.78) while lowest in B (2.33±1.21), the highest value of *Closterium sp* was recorded in A (6.50±1.37) while lowest in (2.33±0.82), *Gleotrichia sp* has it highest values in B (2.50±0.54) while lowest values in C (0.16±0.40) ,*Mallomonas sp* has the highest values in the month of A (7.00±2.00) while the lowest values in B (3.17±1.47), *Chlorella sp* was found with the highest value in A (4.67±1.50) and lowest value in B (1.83±0.75).

Table 6: Mean ± SD of some Phytoplankton diversity of Dutsin-ma Dam with respect to sampling station

Phytoplankton	Station A	Station B	Station C	P-value
Characium sp	7.16±2.78	2.33±1.21	4.16±2.13	0.005
Closterium sp	6.50±1.37	2.33±0.82	3.67±1.21	0.000
Gleotrichia sp	0.33±0.51	2.50±0.54	0.16±0.40	0.000
Mallomonas sp	7.00±2.00	3.17±1.47	4.50±1.64	0.005
Chlorella sp	4.67±1.50	1.83±0.75	3.17±1.16	0.003

Relationship between some Phytoplanktons and physico-chemical parameters

Table 7 shows correlation relationship between phytoplanktons and physico-chemical parameters .*Characium* sp (CH) shows a positive correlation with temperature, Turbidity, DO, TDS, BOD and it shows a negative correlation with pH. *Closterium* sp (CM) shows a positive correlation with temperature, pH, Turbidity, DO, BOD and shows a negative correlation with TDS. *Gleotrichis* sp shows a positive correlation with temperature, *TDS* and shows a negative correlation with pH, Turbidity, DO. *Mellomonas sp* (MS) shows a negative correlation with *TDS* and it shows a positive correlation with temperature, BOD DO, Turbidity. *Chlorella sp* shows a positive correlation with temperature, pH, Turbidity, BOD and shows a negative correlation with TDS.

Table 7: Correlation coefficient (r) showing relationship between some Phytoplanktons and some physico-chemical parameters

Parameters	Temp	pH	Turbidity	DO	TDS	BOD	CH	CS	GL	MS	CL
Temp	**1**										
Ph	-.145	**1**									
Turbidity	.833**	-.492	**1**								
DO	.513*	.402	.136	**1**							
TDS	-.597**	-.206	-.427	-.190	**1**						
BOD	.742**	.002	.531*	.806**	-.177	**1**					
CH	.868**	-.004	.632**	.571*	.567*	.611**	**1**				
CS	.738**	.441	.406	.718**	-.511*	.732**	.697**	**1**			
GL	.634**	-229	-.397	-.323	.752**	-.340	-.603**	-520*	**1**		
MS	.608**	.403	.249	.854**	-.370**	.623**	.776**	.774**	-.431	**1**	
CL	.933**	.113	.718**	.633**	-.614	.728**	.877**	.816**	-.638**	.761**	**1**

**. Correlation is significant at the 0.001 level (2-tailed)*. *. Correlation is significant at the 0.005 level (2-tailed)

Monthly Heavy Metals

Between July to August, the values of Chromium was high in August (5.39±2.20) while lowest in the month of September (1.65±0.77), the highest value of Zinc was recorded in the month of August (4.05±2.52) while lowest in the month of September (1.95±1.41).

Between July-August, the Heavy metal determined shows that, Zinc had the highest p-value (0.195), and Chromium has (0.002).

Table 8: Monthly Mean ± SD of some Heavy metals recorded in Dutsin-ma Dam

Heavy metals	July	August	September	P-value
Chromium mg/l	4.50±1.39	5.39±2.20	1.65±0.77	0.002
Zinc mg/l	3.63±1.95	4.05±2.52	1.95±1.41	0.195

DISCUSSION

Physico-Chemical Parameters

Temperature is an important factor that influences primary production in lakes and it depends on the climate, Sunlight and depth (Lewis, 2000; Abolude, 2007). Aquatic organisms (from microorganisms to fish) depend on certain temperature range for optimal growth (APHA, 1999). The normal range to which fish is adapted in the tropics is between 8°C and 30°C (Mustapha, 2011). Temperatures were relatively higher in August and in December (Atobatele and Ugumba, 2008).

The hydrogen ion concentration (pH) of water is important because many biological activities can occur only within a narrow range of pH. Thus, any variation beyond acceptable range could be fatal to aquatic organisms. The pH range observed during the study period was 6.55-7.60 throughout July to August, and it was within the range for inland waters (pH6.5 - 8.5), as reported by (Mahar, 2003). Boyd and Tucker, (1998), reported pH range of 6.09 - 8.45 as being ideal for supporting aquatic life including fish. Thus, the pH range obtained in this study is within the acceptable level of 6.0 to 8.5 for culturing tropical fish species and, for the recommended levels for drinking water (WHO, 2006). (Federal Environmental Protection Agency FEPA, 1991) recommended pH 6.5 - 8.0 for drinking and 6.0-9.0 for aquatic life (Ibrahim, 2009). High mean value of pH recorded during wet season could be due to combined effects of run-off from agricultural lands (with high concentration of lime) and photosynthetic activity of macrophytes. (Mustapha, 2008) observed that there was increase in pH with photosynthesis. The onset of the rains caused increase in pH, this dilution effect of rains ameliorates biological conditions in lakes (Unohia, 2001; Baijot, 1997). The pH range obtained in this study compares well with those of Lake Chad (7.6-8.0), Tiga Lake (6.9-7.6), Shiroro Lake (6.7-7.0) and Volta Lake (6.8-8.06) as reported by (Kolo,1996).

Turbidity was high during the early part of rainy season could be due to increase in surface run-off, water flood from the catchment area which bring dissolve substance and re-suspension of dissolve materials. This was observed also in the stations. It reduced light penetration into water columns as a result of turbidity affects the aquatic environment and plant life with consequent secondary effects on food chain.

The dissolved oxygen in the Dam was significantly higher during the dry season than the rainy season. The high oxygen value for the dry season coincides with periods of lowest turbidity and temperature. The amount of dissolved oxygen in water has been reported not to be constant but fluctuates, depending on temperature, depth, wind and amount of biological activities such as degradation (Adeniji, 1991; Ibe, 1993).

The Total dissolved solids which usually consists of organic and inorganic substances dissolved and washed into the lake by runoffs (Bala and Bolorunduro, 2011) are essential in the life of aquatic bio-community. Dissolved solids determination are important in water quality studies, though no serious health effect has been associated with dissolved solids ingestion in water but some regulatory agencies (FME, 2001; NAFDAC, 2001) recommended a maximum dissolved solids value of 500mg/l in drinking water supplies.

Biochemical oxygen demand (BOD) indirectly depicts the amount of organic matter degradable by microbial metabolism on the assumption that the water medium has no bacteriostatic effects. (Adakole, 1999; Abolude 2007; Idowu and Gadzama, 2011 and Abolude, 2012) reported that BOD is a fair measure of cleanliness of any water on the bases that values of less than 2 mg/l are clean, 3 -5 mg/l, fairly clean and 10 mg/l definitely bad and polluted. The results show that the Dam water. This contradicts the work of Ahmad, (2015) in his study on Determination of physico-chemical parameters and planktons composition of Wawan-rafi Lake in Kazaure, Nigeria which shows that the Lake water was fairly clean. BOD was significantly higher at the peak of the rainy season (August) than in the other months used for sampling in the present research. This could be attributed to higher organic matter washed into the lake due to runoffs from surrounding lands in the rainy season.

Phosphate and nitrate levels are a measure of level of eutrophication of a given lake (Kolo, 2010). Phosphate levels in the present study were significantly higher during the months of the rainy season (August) than the other months during the sampling period. Similar report was observed by (Ahmad, 2015). The concentration of nitrate during the sampling months was significantly different. This contradicts the work of (Ahmad, 2015) on his study on Determination of physico-chemical parameters and plankton composition of Wawan-rafi Lake in Kazaure, Nigeria. High values of phosphate and nitrate support algal growth and hence good plankton bloom (Ude, 2011). (FEPA, 1991) recommended a maximum of 20mg/litre. The importance of soluble phosphorous transport in agricultural run-off as an immediate source of phosphorus for biological uptake and thereby accelerating the eutrophication of surface waters has been well reviewed (Matagi, 1996). Mohammed and Saminu, (2012) highlighted that in most water bodies, phosphate appears to be the ultimate limiting factor for biological productivity. (Karikar, 2007) in their study on water quality in Angaw River concluded that phosphorus is the limiting factor for algal growth. The concentration of nutrients (phosphate and nitrate) in a water body is strongly influenced by the nature of the sediment. Wetzel (2001) and Hassan *et al.* (2013), stated that the rate of phosphorus release into the water can double, when sediments are frequently disturbed. The phosphate level in Dutsin-ma dam may be a result of release from disturbed sediment, anoxic conditions as a result of decaying macrophytes and washing of phosphate fertilizer from nearby farmlands.

Phytoplankton Diversity

The phytoplanktons were characteristically dominated by five groups. The phytoplanktons diversity observed in Dutsin-ma dam throughout the sampling month were dominated by Chlorophyta (*Characium sp* and *Chlorella sp*), Chrysophyta (*Mallomonas sp*), Cyanophyta (*Gleotrichia sp*) and Charophyta (*Closterium sp*). The dominating presence of Chlorophyta shows gradual deterioration of the water quality. This could be as a result of anthropogenic activities, such as chemicals and wastes washed into it, washing of clothes and bathing done sometimes around the lake. Hassan *et al*. (2010) and Anago, (2013) reported that in lakes where domestic, agricultural and industrial pollution is accelerated, growth of Chlorophyta and Cyanophyta results.. According to Tanimu (2011) the increase in abundance of the Cyanophyta is an indication of organic pollution. Chlorophyta (*Chlorella sp*) showed significant negative correlation with total dissolved solids and significantly correlated positively with temperature. These contradict the work of (Ahmad, 2015) in which chlorophyta showed a positive significance with total dissolved solids.

CONCLUSIONS

i. The physico-chemical parameters of Dutsin-Ma dam were optimal for aquatic organisms within the period of study, however high phosphate concentration and nitrate concentration can posed threat of pollution to the Dam.
ii. The Phytoplankton diversity of Dutsin-Ma Dam during the period of study was dominated by Chlorophyta, Cyanophyta, Charophyta and Chrysophyta.

Recommendations

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

1. Farming activities very close to the reservoir should be discouraged, in order to reduce the runoffs of inorganic fertilizers and pesticides into the reservoir.
2. Farmers around the reservoir 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 when the water level recedes.

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