



## Effects of Monthly Variations of Limnological Parameters on Phytoplankton Distribution in Kalgo River, Kebbi State

Ja'afar, U., Salisu, N., and Tsayyaba, A

Department of Biology, Federal University, Birnin Kebbi

### ABSTRACT

The present study investigate the effects of monthly variation on limnological parameters on phytoplankton's distribution in Kalgo River of Kebbi State. Water samples was collected in three stations (upstream, midstream and downstream) with a planktons net by scooping at 20cm depth. Part of the samples was preserved with 4% formalin for analysis of physicochemical parameters and the other part was preserved using Lugos Iodine for analysis of phytoplanktons using standard methods. Temperature ranges from  $20.10 \pm 0.67^\circ\text{C}$  to  $28.40 \pm 0.40^\circ\text{C}$ , pH from  $6.20 \pm 0.21$  to  $7.17 \pm 0.07$ , dissolved oxygen (DO), biological oxygen demand (BOD) ranges from  $3.33 \pm 0.15\text{mg/l}$  to  $6.20 \pm 0.12\text{mg/l}$  and  $14.40 \pm 0.26\text{mg/l}$  to  $16.07 \pm 0.46\text{mg/l}$  respectively. Electric conductivity (EC) ranges from  $46.60 \pm 32.7\mu\text{s/l}$  to  $805.4 \pm 24.9\mu\text{s/l}$ ,  $\text{NO}_2$   $0.27 \pm 0.03\text{mg/l}$  to  $0.48 \pm 0.13\text{mg/l}$  and  $\text{PO}_4$  ranges from  $0.15 \pm 0.03\text{mg/l}$  to  $0.20 \pm 0.02\text{mg/l}$ . the results of phytoplanktons indicated that twenty two species belonging to six classes was identified, class Cyanophyceae had 36.52%, followed by Bacillariophyceae with 33.04%, Chlorophyceae 21.74% and the least individuals was observed in Fragilariophyceae and Trebouxiophyceae each with 2.61%. Species composition was found higher in midstream (43.48%), followed by upstream (29.57%) and least species was recorded in downstream (26.96%). February (27) recorded the highest phytoplanktons species, followed by January and December each with (14) species while the least species was observed in May, June and July each had (4) species and August recorded (3) species. Monthly physicochemical parameters was significantly ( $P < 0.05$ ) affected phytoplankton distribution. Physicochemical parameters and human activities such as fishing, swimming, washing and farming activities affect the distribution and abundance of phytoplanktons. Further studies should be conducted on the phytoplankton's diversity.

**Keywords:** Limnology, Physicochemicals, Phytoplankton and Kalgo River

### INTRODUCTION

Limnology is the study of physical, chemical and biological characteristics of the freshwater ecosystem. It concern with the study of functional relationship and productivity of freshwater ecosystems as they are regulated by the dynamics of their chemical, physical and biotic environment (Boyd, 1982). Therefore, the quality of a given water body is controlled by its physical, chemical and biological factors, which interact with one another to influence its productivity. In order to assess the productivity of such aquatic ecosystem for their essential management and effective utilization, there is need to study these parameters with a view of controlling and maintaining them within optimum range (USEPA, 1989). Environmental quality directly or indirectly affects species abundance, composition and diversity (Balarabe, 2001).

Water bodies meet the requirement of human being, irrigation, hydro electrical powers, flood control, storage of water for drinking purpose and suitable development of fisheries for the purpose of human food. Water is one of the most important compounds required for very existence of life. Without water neither human nor the environment, which sustain them, can survive (Lokhande, 2013).

Nigeria is blessed with over 15 million hectares of inland freshwater bodies hence, the need for limnological studies (FISON, 2001). Furthermore, Nigeria's population of about 170 million people means that there must be a good readily available animal protein source to the teaming population. The Food and Agricultural Organization F.A.O (2003) projected that Nigeria requires 13.0 kg/head of animal protein; it thus becomes imperative to study the limnological characteristics of our water bodies so as to improve on their fisheries potentials.

In recent years there have been increase concerns about the rate at which inland waters are polluted through human activities, such as agriculture, organic and inorganic manure, fertilizers and pesticides. These find their way through run-offs into streams and lakes thereby enriching the water bodies, leading to eutrophication (Adekole *et al.*, 2003). The present study was aimed at determine the effects of monthly variation on limnological parameters on phytoplankton's distribution in Kalgo River of Kebbi State.

### MATERIALS AND METHODS

#### Study Area

Kalgo River is located in Kalgo Local Government Area of Kebbi State in the Northwest of Nigeria. A tributary of Anka River from Zamfara State which in turn feeds the Niger River. Its coordinates are  $12^\circ 19' 0''$  N and  $4^\circ 12' 0''$  E in DMS (Degrees Minutes Seconds) or 12.3167 and 4.2 (in decimal degrees) (Muhammed, 2002).

#### Sample Collection

Three sampling sites were selected as station 1, 2 and 3 (each was replicated three times) for the study. Station 1 downstream where a lot of human activities such as washing, bathing and fish landing take place. Station 2 was at the midstream of the reservoir which represents the area of lentic water, it is the transition zone between the Riverine and lentic sections of the River. Station 3 was located at the upstream of the river which represents the lotic section and inflow of the river (Mustapha, 2010). Surface water samples were collected between 6-8 am with aid of plankton net (55 $\mu\text{m}$  mesh size) and transferred into well labelled (station number, date and time for collection) clean plastic bottles (2 liter) with a lid and preserved with few drop of 4% formalin. All collected

samples was transported to the Agricultural science laboratory of Usmanu Danfodiyo University, Sokoto for determination of physicochemical parameters (Aguigwo, 1998; Dan-Kishiya *et al.*, 2012).

#### Determination of Physicochemical Parameters

Physicochemical parameters such as temperature, pH, electric conductivity (EC), dissolved oxygen (DO) and total dissolved solid TDS were analyzed *in-situ* according to the methods described by APHA (1998). Temperature and pH were recorded using thermometer and digital pH meter respectively. TDS values were measured using TDS meter, EC using EC meter and DO were determined by Winkler's method. Biological oxygen demand (BOD) was measured based on oxygen consumed in a 5-day incubation test period (5-d BOD or BOD<sub>5</sub>) at 20°C after arrival of sample to the laboratory (APHA, 1998).  $BOD = DO_1 - DO_5$ . Hardness of water was determined using titration methods according to the procedure described by Andrew *et al.* (2005). Twenty 20-mL of water sample were pipetted into a conical flask and 5-mL of buffer solution were added followed by 3 drops of Eriochrome black indicator and then titrated with 0.01 M EDTA. Phosphate determination involved two 2-mL of the water sample that were poured into 50-mL of flask and 2-mL of phosphorus extraction solution were added with 2-mL of ammonium molybdate and 35-mL of distilled water was also added with 1 mL of fresh diluted stannous chloride (Bartram *et al.*, 2000).

#### Phytoplankton Sampling

Plankton net were used for collection the water samples. The samples were transferred and stored in the sample bottle, and then preserved with 10% Lugol Iodine. The species were identified and counted using binocular microscope with the aid of identification book (Davis, 1955; Yamaji, 1979).

#### Data Analysis

Significant differences in the means of physicochemical parameters of the River were determined using Analysis of Variance (ANOVA) and separation of significantly different means was performed using the DNMRT

## RESULTS

### Monthly Physicochemical Parameters of Kalgo River Water

The results presented in Table 1 indicated the variation among the monthly physicochemical parameters of Kalgo river water. Highest mean temperature of 28.40°C was observed in March followed by April with 26.67°C. The lowest temperature of 20°C was recorded in January (Table 1). Water transparency was found to be higher at 1.97m in May and lowest values was recorded at 1.13m in September (Table 1). In terms of pH, ranges from minimum value of 6.20 in March to the maximum value of 7.17 in July, followed by 7.00 in August. Regards to the dissolved oxygen (DO) and Biological oxygen demand (BOD), table 1 showed variation among the months. The lowest values of DO was recorded in January with 3.33mg/l and the highest values was obtained in August with 6.20mg/l. BOD ranges from minimum value of 14.40mg/l in July to a maximum value of 16.07mg/l in April (Table 1). Table 1 revealed that maximum electrical conductivity (EC) of 805.40 µs/cm was recorded in August and the minimum value of 46.60µs/cm was recorded in November, 2017. In this study, the hardness of

water throughout the study ranged from 0.51mg/l in January and February to the highest value of 1.09 mg/l in August 2018. Maximum mean value of Nitrate content was recorded in October with 0.48mg/l, followed by August and September 2018 each with 0.43mg/l (Table 1). A minimum mean value of nitrate was recorded in February and March each with 0.2 mg/l. The phosphate had its maximum monthly mean value of 0.22mg/l in May, while the lowest value of 0.15mg/l was observed in February (Table 1). The higher value of phosphate in month of May might be due to leaching of it from soil through inflow of water and rainfall.

**Table 1:** Mean± Standard deviation of Monthly Physicochemical Parameters of Kalgo River, From October, 2017 to September, 2018

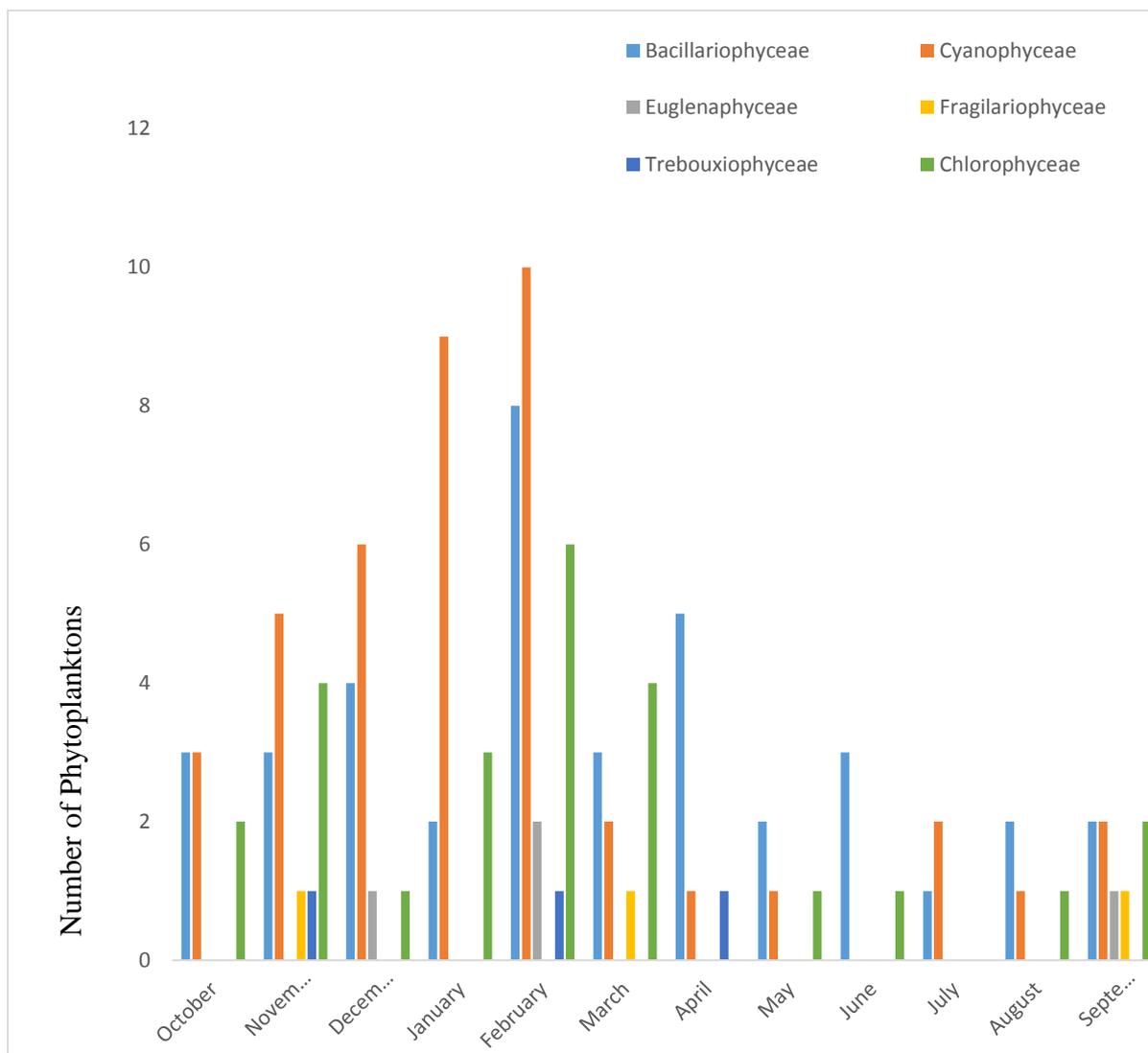
Months	Temp. °C	Transp. (m)	pH	DO (mg/l)	BOD (mg/l)	EC (µs/l)	Hard (mg/l)	NO <sub>2</sub> (mg/l)	PO <sub>4</sub> (mg/l)
October	26.43±1.10 <sup>a</sup>	1.50±0.15 <sup>a</sup>	6.53±0.32 <sup>a</sup>	4.43±0.19 <sup>a</sup>	15.43±0.07 <sup>a</sup>	57.10±57.3 <sup>a</sup>	0.69±0.06 <sup>a</sup>	0.48±0.13 <sup>a</sup>	0.19±0.02 <sup>a</sup>
November	25.03±0.60 <sup>b</sup>	1.53±0.12 <sup>a</sup>	6.33±0.12 <sup>b</sup>	4.07±0.20 <sup>b</sup>	15.23±0.62 <sup>b</sup>	46.60±32.7 <sup>b</sup>	0.59±0.07 <sup>b</sup>	0.37±0.88 <sup>b</sup>	0.19±0.02 <sup>a</sup>
December	22.37±1.40 <sup>c</sup>	1.57±0.15 <sup>b</sup>	6.45±0.17 <sup>a</sup>	3.53±0.15 <sup>c</sup>	15.53±1.01 <sup>a</sup>	120.90±42.9 <sup>c</sup>	0.59±0.11 <sup>b</sup>	0.35±0.87 <sup>b</sup>	0.17±0.03 <sup>b</sup>
January	20.10±0.67 <sup>d</sup>	1.77±0.07 <sup>c</sup>	6.40±0.35 <sup>a</sup>	3.33±0.15 <sup>c</sup>	15.37±1.02 <sup>a</sup>	124.30±4.1 <sup>c</sup>	0.51±0.04 <sup>c</sup>	0.35±0.14 <sup>b</sup>	0.16±0.05 <sup>c</sup>
February	21.10±0.90 <sup>d</sup>	1.77±0.24 <sup>c</sup>	6.37±0.13 <sup>b</sup>	3.53±0.43 <sup>c</sup>	14.97±0.32 <sup>c</sup>	138.8±28.9 <sup>d</sup>	0.51±0.06 <sup>c</sup>	0.27±0.07 <sup>c</sup>	0.15±0.03 <sup>c</sup>
March	28.40±0.40 <sup>a</sup>	1.67±0.17 <sup>c</sup>	6.20±0.21 <sup>c</sup>	3.47±0.42 <sup>c</sup>	15.03±0.46 <sup>d</sup>	67.4±44.5 <sup>e</sup>	0.59±0.10 <sup>b</sup>	0.27±0.03 <sup>c</sup>	0.17±0.01 <sup>b</sup>
April	27.67±0.67 <sup>a</sup>	1.87±0.22 <sup>d</sup>	6.27±0.32 <sup>c</sup>	3.67±0.44 <sup>c</sup>	16.07±0.46 <sup>e</sup>	98.5±24.3 <sup>f</sup>	0.87±0.09 <sup>d</sup>	0.37±0.03 <sup>b</sup>	0.19±0.15 <sup>a</sup>
May	26.43±0.20 <sup>a</sup>	1.97±0.33 <sup>d</sup>	6.40±0.27 <sup>a</sup>	4.13±0.26 <sup>b</sup>	15.70±0.78 <sup>d</sup>	124.5±5.5 <sup>c</sup>	0.78±0.08 <sup>d</sup>	0.37±0.09 <sup>b</sup>	0.22±0.07 <sup>d</sup>
June	26.30±0.80 <sup>a</sup>	1.53±0.29 <sup>a</sup>	6.90±0.32 <sup>d</sup>	6.03±0.55 <sup>d</sup>	14.73±0.42 <sup>c</sup>	132.0±60.2 <sup>d</sup>	0.76±0.13 <sup>d</sup>	0.39±0.11 <sup>b</sup>	0.20±0.02 <sup>d</sup>
July	26.13±0.37 <sup>a</sup>	1.30±0.45 <sup>e</sup>	7.17±0.07 <sup>d</sup>	5.80±0.44 <sup>d</sup>	14.40±0.26 <sup>c</sup>	114.9±34.1 <sup>c</sup>	0.80±0.07 <sup>d</sup>	0.39±0.12 <sup>b</sup>	0.19±0.03 <sup>a</sup>
August	26.37±0.37 <sup>a</sup>	1.30±0.40 <sup>e</sup>	7.00±0.26 <sup>d</sup>	6.20±0.12 <sup>d</sup>	15.67±0.84 <sup>a</sup>	805.4±24.9 <sup>g</sup>	1.09±0.25 <sup>e</sup>	0.43±0.67 <sup>c</sup>	0.18±0.03 <sup>a</sup>
September	26.43±0.20 <sup>a</sup>	1.13±0.12 <sup>f</sup>	7.13±0.09 <sup>d</sup>	6.17±0.17 <sup>d</sup>	14.67±0.67 <sup>d</sup>	264.9±21.4 <sup>h</sup>	0.84±0.08 <sup>e</sup>	0.43±0.12 <sup>c</sup>	0.18±0.04 <sup>a</sup>

Values represent means and standard deviation of physic-chemical parameters of the River. Mean in a column with the same superscript are not significantly different (P<0.05).

**Key:** Temp (0°) = Temperature; Transp (m) = Transparency; DO (mg/l) = Dissolved Oxygen; BOD (mg/l) = Biological Oxygen Demand, EC (µs/cm) = Electrical Conductivits

**Monthly Composition and Distribution of Phytoplanktonsin Kalgo River, 2017**

Figure 1 shows the monthly distribution of phytoplanktons among the six classes identified in Kalgo River. Phytoplanktons was found to be higher in February, followed by January and December while the least number of individuals was observed in May, June, July and August.



**Figure 1.** Monthly Distribution of Phytoplanktons in Kalgo River

**Distribution and Abundance of phytoplankton in Kalgo River, 2017**

Table 2 shows the phytoplanktons identified in Kalgo River during the study period. A total of one hundred and fifteen (115) species distributed over twenty two (22) genera and belonging to six (6) classes was determined. Cyanophyceae recorded the highest number of species (9) with 36.52% relative frequency, followed by Bacillariophyceae with 33.04%, chlorophyceae had 21.74% and Euglenaceae with 3.48%, while Fragilariophyceae and Trebouxiophyceae recorded the least number of species each with 2.61% relative frequency. Regards to the sampling stations, phytoplanktons was found to be higher in midstream which accounted 43.48%, followed by upstream with 29.57%. The least number of species was recorded under

downstream which accounted for 26.96%. The species *Navicula digitoradiata* the highest percentage frequency of 16.65%, followed by *Oscillatoria agrdhi* with 10.43% while *Westellabo tryoiden* and *Microcystis sp.* each had 7.83% percentage distribution. The least number of individuals was recorded in *Melosira varians*, *Scenedesmus sp.*, *Gloeocapsa punctata* and, *Aphanocapsa rivularis* each had 0.87% relative frequency (Table 2). The highest composition and distribution of phytoplankton species was observed in midstream which accounted 43.48%, followed by upstream with 29.57% and downstream recorded 26.96.

**Table 2:** Distribution and Abundance of Phytoplanktons in River Kalgo, 2017

Class	Species	Stations			Total	RF (%)
		Upstream	Midstream	Downstream		
Bacillariophyceae	<i>Nitzschia acicularis</i>	3	3	0	6	5.22
	<i>Navicula digitoradiata</i>	4	9	5	18	15.65
	<i>Pseudonitzschia fraudulentata</i>	3	3	2	8	6.96
	<i>Paralia sculcata</i>	0	2	0	2	1.74
	<i>Melosira varians</i>	1	0	0	1	0.87
	<i>Rhopodia gibberula</i>	0	2	1	3	2.61
Cyanophyceae	<i>Westella botryoides</i>	2	3	4	9	7.83
	<i>Lyngbya sp.</i>	1	3	0	4	3.48
	<i>Rivularia sp.</i>	2	0	0	2	1.74
	<i>Scenedesmus sp.</i>	0	1	0	1	0.87
	<i>Microcystis sp.</i>	3	4	2	9	7.83
	<i>Gloeocapsa punctata</i>	0	0	1	1	0.87
	<i>Aphanocapsari vularis</i>	0	1	0	1	0.87
	<i>Oscillatoria agrdhii</i>	3	5	4	12	10.43
	<i>Ankistrodesmus fusiformus</i>	0	2	1	3	2.61
Euglenapyceae	<i>Euglena sp.</i>	2	0	2	4	3.48
Fragilariophyceae	<i>Tabellaria fenestrata</i>	1	2	0	3	2.61
Trebouxiophyceae	<i>Crucigenia sp.</i>	0	0	3	3	2.61
Chlorophyceae	<i>Ulothrixva riabilis</i>	1	1	0	2	1.74
	<i>Ulothrix zonata</i>	1	0	2	3	2.61
	<i>Spirogyra sp</i>	3	7	3	13	11.30
	<i>Volvox</i>	4	2	1	7	6.09
<b>Total</b>		<b>34</b>	<b>50</b>	<b>31</b>	<b>115</b>	<b>100.00</b>

RF (%) = Relative Frequency

## DISCUSSION

The present study showed that physicochemical parameter varies significantly among the months and have a great effects on phytoplankton distribution. The pH results indicate that river Kalgo is moderately acidic from October to June (6.20) and slightly alkaline from July to September (7.17) and was found within the recommended limits (5-9.5) WHO (1997) suitable for aquatic life. Abohweyere, (1990) gave a pH range of 6.5-8.5 as suitable for productive waters and these values are within the permissible limit of WHO, (2008) and FAO (Ayers and Westcot, 1994) set for drinking and irrigation purposes. Maximum concentration of nitrate and phosphate recorded may be due to the addition of nutrients as a result of the decomposition of organic matter that are deposited into the aquatic environment by wind at the onset of rainy season and terrestrial runoff. The element normally originate from agricultural input e.g. fertilizers and its increase in the wet season could be attributed to farming activities and the use of fertilizers in the gardens, which is leached or transported by run off Abohweyere (1990). The highest temperature (28.4°C) recorded in March and April may possibly be due to the increase in surface water absorption of solar heat radiation since it was the beginning of rainy season. Thus, the average temperature of the river is favourable for aquatic ecosystem. The variations in mean monthly temperature of this study tallied with the recorded values obtained by Mustapha (2010) and Boyd (1982).

There was significant difference between the monthly transparencies, this may be due to the accumulation of high-suspended organic into the water bodies by surface run off and human activities which light penetration. This result is in lined with the findings of Abohweyere, (1990). The monthly variation of dissolved oxygen at three stations of reservoir showed its maximum value of 6.2mg/l in August, the minimum 3.33mg/l in January appeared cleaner compared with station other months possibly due to less human activities such as washing, bathing and domestic sewage and this agreed with Aguigwo, (1998). The highest value (805.40µs/cm) of EC recorded in August, indicated that the river receives high amount of dissolved inorganic substances in ionized form from their surface catchments. Maximum DO (6.20±0.12mg/l) value recorded in August and the lowest value of 3.33±0.15mg/l recorded in January indicate aquatic pollution. Concentration levels of DO below 5.0 mg/L adversely affect aquatic life (Kidu *et al.*, 2015). The highest BOD value (16.07±0.46mg/l) recorded in April may be an indication of organic pollution due to the accumulation of organic matter. Other findings also showed that a high level of BOD causes to decrease the value of dissolved oxygen in the river (Kidu *et al.*, 2015; Aguigwo, 1998).

Phytoplankton composition and distribution of Kalgo River in this study showed that one hundred and fifteen (115) species distributed over twenty two (22) genera and belonging to six (6) classes was determined. Cyanophyceae recorded the highest species with 36.52%, followed by Bacillariophyceae with 33.04%, and Chlorophyceae had 21.74% relative frequency. These results are agreed with finding of Ayodele, (2003) that reported class Bacillariophyceae, Cyanophyceae and Chlorophyceae dominated most tropical African Lakes and rivers. The result of this study is differ from the finding of Adeyemi *et al.* (2008) which reported 1,302

species of phytoplankton distributed over four (4) classes viz: Chlorophyta, Bacillariophyta, Cryptophyta and Euglenophyta from Gbedikere Lake, Bassa, Kogi State Nigeria. Chlorophyta had the highest percentage dominance of (77.74%), followed by Bacillariophyta with (18.81%) while Cryptophyta, and Euglenophyta accounted for (3%) each. Among the species identified *Navicula digitoradiata* had the highest percentage frequency of 16.65%, followed by *Oscillatoria agrdhii* with 10.43% while *Westella botryoiden* and *Microcystis sp.* each had 7.83% distribution. Composition and distribution of phytoplankton species was found higher in midstream which accounted 43.48%, followed by upstream with 29.57% and downstream recorded 26.96%. The variation among sampling stations could be due human activities and midstream have favorable environmental condition for the growth of phytoplanktons. The results of this study is in lined with the finding of Carvalho *et al.* (2010) which reported that high density of phytoplankton is associated with favorable environmental condition, and also, lesser activities of grazers and predators (Ghosh *et al.*, 2012). Some phytoplankton species are sensitive to environmental changes when the water become polluted may disappear while the tolerant species that could survive pollution stress remained (Ghosh *et al.*, 2012).

## CONCLUSION

The present study revealed monthly variation of physicochemical parameter and significantly affect the distribution of Phytoplanktons in Kalgo River. One hundred and fifteen (115) belonging to six (6) classes was determined. Cyanophyceae had the highest species with 36.52%, followed by Bacillariophyceae with 33.04%, Chlorophyceae had 21.74% and Euglenaceae with 3.48%, while Fragilariophyceae and Trebouxiophyceae recorded the least number of species each with 2.61% relative frequency. February recorded the highest phytoplanktons species, followed by January and December while the least species was observed in May, June, July and August. This result indicated that Kalgo River was moderately rich with the phytoplanktons which can support consumer species.

## REFERENCES

- Abohweyere, P. O. (1990). Study of limnological parameters and potential fish yield in Kigera Reservoir in Kainji, New Bussa, Nigeria *Journal of Aquatic Science* 5:53-58
- Adekole, A., Mbab, C.E. and Dalla, M.A. (2003). A paper presented at 29<sup>th</sup> International conference on Millennium Development Goals, Abuja, Nigeria. Pp 14-15.
- Adeniyi, H. A. (1998). Diurnal vertical distribution of zooplankton during stratification in Kainji Lake, Nigeria. *International Journal of Limnology*, 20: 1677-1689.
- Adeyemi, S. O., Bankole N. O., Adikwu I. A. and Akombu, P. M. (2008). Phytoplankton community of Lake Gbedikere, Bassa, Kogi State Nigeria (Open Source). Pp 1-15.
- Aguigwo, J. N. (1998). Studies on the physicochemical parameters and plankton productivity of a

- productive Stream. *Journal of Aquatic Sciences*. **13**: 9-13
- Andrew, O., Eaton, H., Lenore, S., Clescerl, T., Arnold, E., Greenberg, G.Y. and Eugene, W. (2005). *Quality criteria for water*. United States of Environment, Protugal Agency. E.P.A. – 440/9 –76023, Washington D.C
- APHA (American Public Health Association). (1998). *Standard method for the examination of water and waste water* (19th ed), New York. Pp 223-25.
- Ayers, R. S., and Westcot, D. W. (1994). *Water Quality for Agriculture*, FAO Irrigation and Drainage Paper Water: Romep. Pp 5-19.
- Balarabe, M. L. (2001). Effect of Limnological characteristics of zooplankton composition and distribution in Dumbi and Kwangila pond, Zaria, Nigeria. Unpublished Ph.D.
- Bartram, J. and Rees, G. (2000). *Monitoring Bathing Waters—A practical guide to the design and Implementation of Assessments and Monitoring Programmes*. World Health Organization. P 34-42.
- Boyd, C. E. (1982). *Water quality management for pond fish culture*. Elsevier science publishers. Pp 318.
- Carvalho, A. P., Zhonghua, T. M., Correia, M. F. and Neto, J. P. (2010). Study of physical chemical variables and primary productivity in Bacanga River estuary dam, Sao Luis, Maranhao, Brazil. *Researcher* **2**(2): 15-24.
- Dan-kishiya, A. S. and Chiaha, N. O. (2012). Physico-chemical parameters of some selected manmade lakes & river basins. *The proceeding of the international conference on Kainji Lake & River Basins Development in Africa* **3**. 12-14.
- Davis, C. C. (1955). *The marine and fresh water plankton*. USA. Michigan State University Press. Pp 23-59.
- F A O. (2003). The state of World Fisheries and Aquaculture. A revised classification of lakes based on mixing. *Canadian Journal of Fisheries and Aquatic Science* **40**: 1779-1787.
- FISON (2001). The significance of Limnology on the development of fisheries in manmade lakes & river basins. *The proceeding of the International Conference on Kainji Lake & River Basins development in Africa*. 135 – 143.
- Ghosh, S., Barinora, S. and Kesh, J. P. (2012). Diversity and seasonal variation of phytoplankton community in the Santragachi Lake, West Bengal, India. *Journal of Natural Sciences Research* **2** (8):2224- 3186.
- Lokhande, M.V. (2013). Limnological studies on Dhanegaon reservoir, Dhenagaon, Dist-osmanabab, Maharashtra, India. *Indian Stream Research Journal*. **(2)**:1-4
- Muhammed, K. Y. (2002). Development and challenges of Bakolori irrigation project in Sokoto state Nigeria. *Nordic Journal of African Studies* **11**(3): 411–430.
- Mustapha, M. K. (2010). Seasonal influence of limnological variables on plankton dynamics of a small, shallow, tropical African reservoir. *Asian Journal of Experimental Biological Sciences*. **1**(1): 60-79.
- U.S.E.P.A. (1989). *Quality criteria for water*. United States of Environment, ProtugalAgency. E.P.A. – 440/9 –76023, Washington D.C.
- World Health Organization (WHO). (1997). *Guidelines for drinking water quality*. 2<sup>nd</sup> edition. World Health Organization. Geneva, 249.
- World Health Organization (WHO). (2008). *Guidelines for Drinking Water, WHO Criteria and Other Supporting Information*, World Health Organization: Geneva.
- Yamaji, I. (1979). *Illustrations of the freshwater plankton of Japan*. Japan: Hiokusha Publishing Company limited. Pp 45-56.