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Plankton Dynamics and Status of Limnological Variables in Kware Lake, Sokoto Nigeria

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Abstract

Kware Lake is the only natural lake and major source of water to Kware inhabitants. Irrigation and other domestic reliance on the water are befits derived from lake. Plankton are good indicator organisms,they influence availability of larger organisms in aquatic systems such as fish. The study was conducted to evaluate plankton dynamics and status of limnological variables. Samples for both plankton and water were collected monthly.Standard procedures were adopted for identification and determination of physicochemical variables. Results revealed that; highest temperature was 25.83°C, while December and January temperatures were uniform compared to other months of study. Nitrate level was higher than phosphate, though they range obtained was; 0.47-0.60 mg/l and 0.12-0.23mg/l respectively.Total number of plankton cells/litre identified were 3150cells for phytoplankton and 544 cells for zooplankton. Phytoplankton cells were more abundant than the zooplankton and chlorophyceae dominated phytoplankton classes, while copepod dominated the zooplankton classes. The following plankton species recorded the highest distribution; Staurastumrotula (phtoplankton) andCopepoditesspp.The few species identified in Kware Lake may reflect the moderate level of nutrient level. There is therefore need for regular monitoring of the lake to avoid excess input of nutrients that could lead to eutrophication.

Keywords: Dynamics, Kware, Limnological, Plankton, Sokoto

1. Introduction

Plankton are tiny drifting plants and animals, which are vital part of the aquatic food chains including;lakes, ponds streams and our waterways. Plankton communities reflect effects and status of water quality and the level of growth nutrients such as phosphate and nitrate which influence their distribution (Farashi et al., 2014).

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In order to manage water quality, there is need to understandplankton and their interaction with abiotic of aquatic ecosytems. Phytoplankton respond to changes in light or nutrients and sediment load, and in response to grazing by larger zooplankton. Different species of plankton present in water are important in determing water quality. Though, few number of phytoplankton species are known to be toxic which can be harmful to their consumers, but can not necessarily be harmful to their vectors such oysters or fish. Knowledge of their diversity, abundance possible causes of blooms is an important study (Suthers andRissik, 2009). The interplay between physical and chemical variables of water usaully lead to production of phytoplankton, while their assemblages are influenced by these factors as well. Perturbations in these factors may affect their plankton assemblage which could have a significant impact on water quality, fisheries and other aquatic large fauna (Carpenter and Kitchell, 1993). Assemblages of plankton species in ecological communities reflect interactions between organisms and the abiotic environment (Hughes, 2000).

Plankton species are valuable indicators of environmental conditions (Beaugrand, 2004; Bonnet and Frid, 2004), since they are known to be indicators of physical, chemical and biological factors.The distribution and abundance of plankton species also influence abundance of fishes species and other auatic fauna (Mc-Namara and Houston, 1987; Hüppop, 2005). This paper aimed to evaulate the variation of physicochemical variables and the diversity of plantkon (Phytoplanton and zooplankton) in Kware Lake.

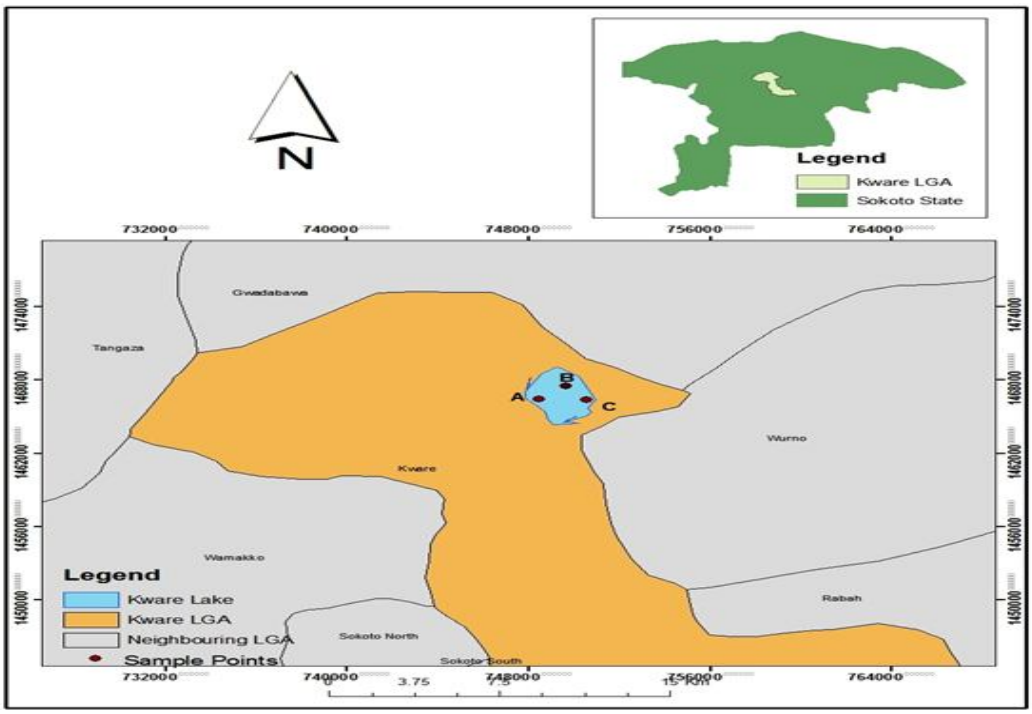
2. Materials and Methods

2.1 Study Area

Kware Lake is naturally occurring freshwater, located at Kware Local Government Area of Sokoto State, its located 20km northeast of Sokoto metropolis. Within longitude 5◦16´N and latitude 13◦15´E. Kware is flanked both sides by bunch of growing eel grass (Vallisneriaamericana).

The vegetation of the area is Sudan savannah, mostly dominated by grasses, and small trees (Figure I). It is characterized by two distinct seasons, the short raining season, which runs from May to September or October depending on the rain fall pattern of the year, and the long dry season that occurs from October or November to April (Itaet al., 1982).

Figure 1: Map of Kware Lake Showing Sapling Stations



2.2 Sample Collection

Water samples were collected from three different stations, A (Outlet of the lake), B (Inlet of the lake) and C (Midstream) between (7–8am) for a period of four months (December 2014 – March, 2015) the water samples were taken immediately to

laboratory for determination of physicochemical parameters, except temperature which was determined in situ.

2.3. Plankton Collection

Plankton net was used for plankton collection which was made of up bolting nylon silk (mesh – size 50µm) and a bottle at the bottom and the net was 25cm in diameter. Plankton samples collectedwere kept in a plastic bottlesand labeled into station A, B, and C, which were also preserved in a 4% of formalin solution prior identification. The collected samples were taken to Hydrobiology Laboratory for identification.

2.4 Identification of planktons and Determination of Physicochemical Variables

Each sample A, B, and C of plankton was transferred into 100ml measuring cylinder and then 1ml of lugol's solution was added to both samples The samples took 24 hours before settling down at the bottom of the sample bottle. After sedimentation, Samples were decanted until each bottle sample remain 10ml and out which 1ml was transferred into counting chamber which comprises of 100 boxes and each box was analyzed quantitatively under the microscope.Species were identified using various authenticated monographs.

After which an accurate identification of each species and density of the plankton were calculated (Janse van et al., 2006; Yamaguchi, and Gould, 2007; Bellinger and Sigee, 2010). Water samples were determinedby adopting the standard methods of UNEP (2004)and Pandayet al.(2005).

2.5 Statistical Analysis

Data obtained both from the field and Laboratory were subjected to statistical analysis, ANOVA statistical tool was employed, LSD was also used for the mean separation, these were adopted according to description of Gelman (2005), Motulsky, (2007).

3.Results

3.1. Level of Physicochemical Variables

Kware Lake is located in sub-Saharan Africa where temperature can exceed 40°C sometimes. The importance temperature for metabolic reactions in biological systems has been well documented. In the present study average monthly temperature are presented (Table 1), March has the highest (25.83°C), while February follows with 22.33°C. The December and January were more or less uniform temperature readings. Hydrogen ion concentration (pH) of the lake demonstrated three classical pH readings (acidic, neutral and alkaline) in which neutral pH was obtained in December 2014. The growth promoters were observed to be vice versa in concentration (that is nitrate and phosphate). Nitrate being higher in the surface water recording a mean of 0.60mg/l in both December 2014 and January 2015 as the highest. The least average value of nitrate was recorded in March though there wasn't statistical significance difference between the monthly means.

Level of phosphate indicated decrease in concentration during the study. Though the concentration might be more as depth increases meaning benthic water have high level of phosphate than the surface water. March 2015 recorded the least concentration (0.12 mg/l) while December has the highest with 0.23mg/l (Table 1).

Concentration of sodium in the surface fluctuated between the months studied, but February and March 2015 were both 1.00mg/l both, while December 2014 and January 2015indicated higher and lower levels of sodium respectively (1.30 and 0.70mg/l). Calcium and Magnesium were the most fluctuated chemical variables studied throughout the study period. Though, calcium indicated a low mean in January (0.17mg/l) while magnesium has 0.32mg/l as the lowest. Both magnesium and calcium indicated statistical significance between the monthly means (Table 1).

Table 1: Level of Physicochemical Parameters in Kware Lake from Dec. 2015 – Mar.2015

Parameter	Months			
	December	**January**	**February**	**March**
Temp (^{0}C)	20.05±0.29^a	20.00±0.00 ^{a}	22.33±0.17^b	25.83±0.17^c
pH	7.00 ±0.06^a	6.77±0.13^a	8.50±0.58^b	7.47±0.15^c
Nitrate (mg/l)	0.60 ±12^a	0.60±0.00^a	0.53±0.67^a	0.47±0.67^a
Phosphate (mg/l)	0.23 ±0.01^a	0.22±0.00^b	0.15±0.00^c	0.12±0.00^c
Sodium (mg/l)	1.30 ±0.00^a	0.70±0.10^b	1.00±0.00^c	1.00±0.00^c
Potassium (mg/l)	0.20±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Calcium (mg/l)	0.38±0.44^a	0.17±0.17^a	2.75±0.14^b	1.85±0.29^c
Magnesium (mg/l)	0.32±0.44^a	0.40±0.29^a	1.86±0.16^a	3.48±1.08^b

Footnote: Alphabet on the same row signified means that are not statistically different, while different alphabets on the row are statistically significant.

3.2. Plankton Diversity and Distribution

Diversity and distribution of plankton of Kware Lake demonstrated how nutrients level was enough to promote their growth and survival. Three Classes of both phytoplankton and zooplankton were identified during the sampling period. Identified plankton cells were collected from three locations of the lake namely; Inletwhich has the distribution of phytoplankton cells (1560 cell and 38.5%) which was followed by Outlet with 1346cells and 33.1%, Midstream recorded the least

distribution of phytoplankton cells of 1156 and a percentage distribution of 28.5% (Table 2).

Table 2: Number of Algal cells/litre at Stations From Dec 2014-March 2015 of Kware Lake

Months	STA (Inlet)	STB (Midstream)	STC (Outlet)	Total
December	180	56	280	**516**
January	200	500	480	**1180**
February	400	480	280	**1160**
March	780	120	306	**1206**
Total	**1560 (38.4)**	**1156 (28.5)**	**1346 (33.1)**	
Footnote: STA Station A, STB Station B, STC Station C, Percentage in parenthesis				

Zooplankton cells distribution differed from what was obtained from phytoplankton cells. However, Inlet has the highest distribution of cells (196) and 36.5% distribution, while Midstream was the second with 192cells and 35.8%. Zooplankton cells were represented with 146cells as the least in Outlet of Kware Lake and a 27.7% distribution (Table 3).

Table 3: Number of Zooplankton cells/litre at Stations of Kware Lake Dec 2014-March 2015

Months	STA (Inlet)	STB (Midstream)	STC (Outlet)	Total
December	61	34	42	137
January	43	77	50	170
February	32	59	29	120
March	60	22	28	110
Total	**196 (36.5)**	**192 (35.8)**	**149 (27.7)**	
Footnote: STA Station A, STB Station B, STC Station C, Percentage in parenthesis				

Phytoplankton were represented by the following classes; Chlorophyceae recorded 392cells in December 2014, 980cells, 220 and 540 in January, February and March 2015 respectively. Bacillariophyceae has 70, 200, 180 and 686cells in December 2014,

January to March 2015 respectively. While Cyanophyceae was the least with distribution of phytoplankton individual cells of 52 and 100cells which were only identified in December 2014 and March 2015 respectively (Figure 2).

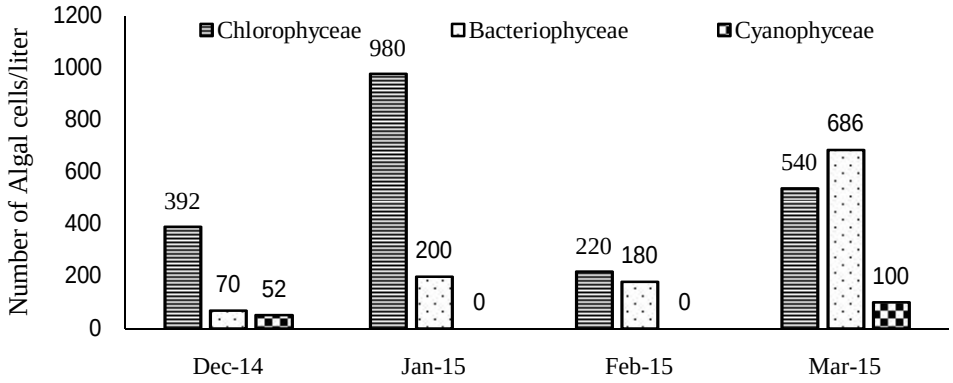


Figure 2: Alagal Cells encountered Base on Clases From Dec. 2014 to March 2015

Zooplankton cells were represented by three classes Cladocera, Rotifera and Copepoda. Although, Copepoda has the highest distribution of 109, 95, 88 and 64cells in December 2014, January to March 2015 respectively. Rotifera has the least with 10, 2, 8, and 2cells in December 2014, January, February and March 2015 respectively (Figure 3). Plankton Species occurrence and distribution varies between phytoplankton and zooplankton, but coincidentally both 16 species were identified in both phytoplankton and zooplankton, but distribution of individual cells varies accordingly.

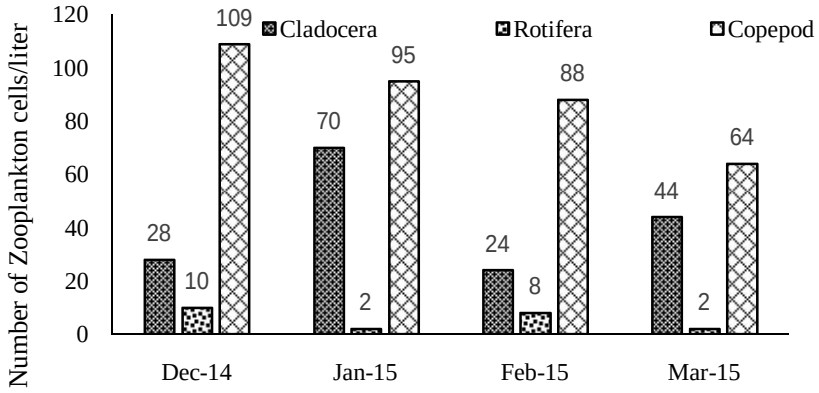


Figure 2: Zooplankton Cells encountered base on Clases at of Kware Lake Dec 2014-March 2015

Phytoplankton recorded a total of 3150 cells within the period of study (Table 4), while zooplankton has 544 cells (Table 5). Straurastrumrotula(26.9%) as the highest mean distribution followed by SpygyraSpp with 14.00% distribution (Table 4). Zooplankton recorded 33.6% for Copepoid copepods as the highest while FiliniasppandTrichecercaspphas theleast percentage distribution of 0.2% each (Table 5).

Table 4: Phytoplankton Species Occurrence and Distribution From Dec. 2014-Mar. 2015 of Kware Lake

Species	Dec. 2014	Jan. 2015	Feb.	Mar.	Total	Mean	(%) Dist.
Staurastumrotula	328	320	60	140	848	212	26.9
Chlorella elipsoidea	52	140	140	20	352	88	11.2
Spirogyra Spp	12	400	-	30	442	111	14.0
SynedraSpp	12	40	40	40	132	33	4.2
NitzchiaSpp	30	40	40	40	150	38	4.8
Melosira granulate	2	-	-	340	342	86	10.9
FragillariaSpp	26	40	40	100	206	52	6.5
Aphanocapsaelachista	28	-	-	-	28	7	0.9
MicrocytisSpp	18	-	-	-	18	5	0.6
OscillatoriaSpp	2	-	-	-	2	1	0.1
Spirulina Spp	2	-	-	100	102	26	3.2
Anabeanaspirodes	2	-	-	-	2	1	0.1
Hormidiumspp	-	20	20	20	60	15	1.9
Closterium simplex	-	100	-	60	160	40	5.0
Diatonellaspp	-	60	60	160	280	70	8.9
Naviculaspp	-	20	-	6	26	7	0.8
Total	**514**	**1180**	**400**	**1056**	**3150**		**100**
Footnote: (%) Dist.= Percentage Distribution, -= Not Detected							

Table 5: Zooplankton Species Occurrence and Distribution Dec. 2014-Mar. 2015 of Kware Lake

Species	Dec. 2014	Jan. 2015	Feb.	Mar	Total	Mean	(%) Dist.
Diaphanosomaexicusm	9	17	-	2	28		5.1
Naupliispp	17	24	17	30	88	22	16.2
Chydorusspp	2	24	4	-	30	8	5.5
Asplanchinaspp	4	-	-	2	6	2	1.1
Brachionusdiversiconis	2	-	-	-	2	1	0.4
Brachionuscalyciflorus	2	-	4	-	6	2	1.1
Lecanedecipens	2	2	-	-	4	1	0.7
Copepoditesspp	67	45	35	26	173	43	31.8
Cyclopoid copepods	42	50	53	38	183	46	33.6
Ceriodaphniacornuta	-	1	1	6	8	2	1.5
Moinamicrura	-	4	-	-	4	1	0.7
Bosminaspp	-	-	-	-	2	1	0.4
Filiniaopoliensis	-	-	-	-	1	1	0.2
Ptygraspp	-	-	2	-	2	1	0.4
Trichocerca cylindrical	-	-	1	-	1	1	0.2
Macrothrixspp	-	-	-	6	6	2	1.1
Total	**147**	**167**	**120**	**110**	**544**		

Footnote: (%) Dist.= Percentage Distribution, -= Not Detected

4.0 Discussion

4.1 Level of Physicochemical Variables

Water quality and overall level of nutrients can give important information on the existing biota (Diersing, 2009). The level of physicochemical variables in freshwater environment is subjected to variations, parameters such as temperature, pH usually influence the distribution of flora and fauna of different freshwater bodies (Regier, 1990). Kware Lake has shown that surface water temperature fluctuated minimally, in which the highest mean temperature recorded was 25.83^{o}C. The rapid increase in temperature was observed during the month of March,likely due to change in the weather and anthropogenic inputs (EPA, 2006). The pH observed indicated a slight fluctuation of parameters with maximum value recorded during the study period.

Generally the physicochemical variables studied were found to vary slightly with statistical significance difference demonstrated at $P<0.05$ as the means were compared. Though, the means were found to be within limits that support life in aquatic systems and also enough to promote growth of plankton and other aquatic organisms (UNEP 2004; WHO, 2004; Weiner, 2007).

4.2 Plankton Diversity and Distribution

Plankton communitydistribution depends on some of the complex factors viz; changeof climatic conditions, physical and chemical parameters andvegetation cover(Rocha et al., 1999; Neves et al.,2003). Sixteen species of phytoplankton were identified in Kware Lake during the study period, Staurastrumrotula has the highest percentage distribution which was followed by Spirogyra spp.The few number of phytoplankton species identified may likely be due sensitivity of phytoplankton species to environmental changes (Hays et al., 2005). Monthly phytoplankton distribution revealed that March and December were months with few phytoplankton species, this could be due to grazing effect by consumers such as Copepods, and other zooplanktons species during the period of study. Sixteen species of zooplankton were identified in Kware Lake during the study period, Cyclopoid copepodsrecorded highest percentage distribution particularly in December, which was followed by Copepoditesspecies. The few number of zooplankton species identified may be attributed to feeding habits of fish species in the lake (Singh et al., 2002). January and March were months with few zooplankton species, which could be due to the dilution factors and its effect leads to less photosynthetic activity by primary producers (Singh et al., 2002). Most of the planktonic organisms are cosmopolitan in distribution (Mukherjee, 1997). Few species identified may likely be related to low chlorophyll-a measured in the lake which usually indicate level of productivity in lakes or reservoirs (Carlson and Simpson, 1996; Jenkerson and Hickman, 2007).

Therefore, the low nutrient of nitrate and phosphate in the present study may have attributed to less number of algal and zooplankton species as reported by Rothhaupt (2000)

4.3 Conclusion

Kware Lake was observed to be moderately enriched with nutrients that could influenced the rapid growth of these plankton (flora and fauna) which could signify the productivity of this lake, particularly the phytoplankton which are the primary and first trophic level of aquatic food chain. Though, chlorophyceae dominated phytoplankton classes, while copepod dominated the zooplankton classes. Therefore availability of food in Kware Lake will depend on how diverse and abundance these phytoplankton species are and their distribution.Though the study was carried for a short time, therefore long time study may give another intriguing results.

4.4 Recommendations

The following are recommended;

- Longtime survey of these plankton study should be carriedout
- Government and research personals which collaborate to monitor this lake regularly
- Laws should be employed to inhabitants(fishers and farmers) to avoid excessive inputs of pesticides, fertilizers and overfishing to conserver the biota in the lake.

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