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PLANKTON ABUNDANCE AND DIVERSITY IN DADIN KOWA DAM IN GOMBE STATE, NIGERIA

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ABSTRACT
Plankton biodiversity serves as ecological indicator of aquatic environment due to their response to environmental changes. Study was carried out for of 6 months (May – October) in Dadin Kowa dam, Gombe state Nigeria. Samples collected using plankton net into a bottles preserve in 5% formalin then transported to the laboratory for identification, counting and for further analysis. SPSS (v.11.0.1) was used for data analysis. Phytoplanktons group recorded *Chlorophyta* highest (1,960) and lowest (860) in May and July. *Bacillariophyta* maximum (990) and minimum (450) number in June and September, *Cyanophyta* maximum (450) in July and Minimum (20) in September. *Euglenophyta* was only recorded in September (30), *Cryptophyta* observed only in June (20) and September (20), *Dinophyta* highest in May and September (40) minimum (10) in August. *Xantophyta* minimum (10) in August and maximum (30) in October. The Zooplanktons include *Brightwellii* highest (428) in June lowest (121) in October, *Monia* highest (97) and lowest (30) in June and September, *Diaptomuus* highest (112) in May and the lowest (30) in September. *Philodina* highest (550) in June while lowest (195) in September, *Daphnia* highest (43) and lowest (26) in May and September. *Cyclops* highest (70) in July while lowest (35) in September and October, *Bdelloid* highest (402) in May and lowest (116) in October. *Camtocerus* highest (76) in May and lowest (35) in September and October, *Bidentata* highest (331) in May and lowest (49) in October. Torrential rains, characteristic trade winds of the dry season, human activities and other environmental factors might have contributed to the variation of the plankton richness and diversity.

Keywords: Dadin kowa, Phytoplankton, Zooplankton, Diversity, Richness.

INTRODUCTION
The availability of Plankton as food for larval fish is thought to be one of the key factors that strengthen commercial fisheries (Kane,1993). Plankton forms an important aspect of limnology, which tend to constitute the intermediate level between the primary producers and secondary consumers. The plankton community is comprised of the primary producers or phytoplankton and the secondary producers or zooplankton (Battish, 1992). This utilization of the aquatic resources depends upon their limnological, hydrobiological and ecological knowledge to augment fish production by adopting the scientific approach. Blockeel *et al*., (1999) suggested that physical and chemical properties give a specific picture of water quality in freshwater at a particular point in time, while the biota (biological property) act as a continuous monitor and give more general pictures of water quality over a while. Plankton, particularly phytoplankton, has long been used as indicators of water quality and because of their short life spans, planktons respond quickly to environmental changes (Pradeep *et al*., 2014). Zooplankton species succession and spatial distribution result from differences in ecological tolerance to abiotic and biotic environmental factors (Marneffe *et al.*, 1998). Plankton serves as an important food item of many fishes. Phytoplanktons are at the basis of the food web and provide the nutritional base to zooplankton and other invertebrates (Emmanuel and Onyema, 2007). Phytoplanktons are microscopic single-celled algae which are capable of moving through the use of flagella or floats on the upper surface of the water column where they are dependent on sunlight for photosynthesis (Verlencar and Desai, 2004). The use of living organisms to determine the presence, amount, changes in and effects of physical, chemical, and biotic factors in the environment is termed biological monitoring (Pedrozo and Rocha, 2005). An important aspect of biological monitoring is the use of species diversity. According to Ogbeibu and Edutie, (2002) species diversity is a reliable parameter in biology to determine how healthy an environment. Physico-chemical parameters are important factors controlling the abundance of Plankton in lakes and also play a paramount role in the reproductive rhythm of zooplankton populations (Pedrozo and Rocha, 2005).However, despite their considerable potential as effective indicators of environmental change and their fundamental importance in the transfer of energy and nutrient cycling in aquatic ecosystems, the zooplankton has been widely used as ecosystem condition indicators Pedrozo and Rocha, (2005). Phytoplankton composition changes with nutrient fluxes because individual taxa have different requirements (Kilham and Kilham 1984). The Planktons are in constant change within the environment due to the different activities that occur in the environment. Planktons quickly respond to nutrient changes in water which can have repercussions throughout both pelagic and benthic food web and thus serve as a good indicator of water quality (Emmanuel, *et al*., 2008). Reports of several studies on Plankton species in both experimental and field area have been well documented (Radwan, 1976; Gannon and Stemberger, 1978; Mäemets, 1983; Blancher, 1984; Berzins and Pejler, 1989; Swadling *et al*., 2000; Pedrozo and Rocha, 2005). Pedrozo and Rocha, (2005) worked on the physicochemical condition and seasonal variation of Plankton. The diversity of a community depends on the species richness and species evenness. Species richness is the aspect of diversity that bothers on the number of species present in the community (Emmanuel *et al*., 2008). The distribution and density of Plankton species are influenced by several physical and chemical factors of the pond environment (Aarti *et al.,* 2013). This present study was conducted to determine the abundance and diversity of Planktons in Dadin Kowa Dam, Gombe State Nigeria by identify the species, composition and distribution in each sampling site, and also to evaluate monthly variations in the abundance of Plankton species among sampling sites.

MATERIALS AND METHODS
Study Area
Dadin Kowa Dam is located 5km North of Dadin Kowa village (about 37km from Gombe town, along Gombe-Biu road) in Yamaltu Deba Local Government Area of Gombe State Nigeria. The Dam lies within Coordinates 10°19′19″N 11°28′54″E / 10.32194°N 11.48167°E of the equator (Gombe State University, 2016). The reservoir has a surface area of 300 square kilometres and has potential as a source of fish (William, 2001). Dadin-Kowa Dam is a multipurpose dam which impounds a large reservoir of water from Gongola River. It has a storage capacity of 1.77 billion cubic meters for irrigation to 950 km^2 area of farmland and its flood spillway has a discharge capacity of 1.1110 m^3/s and the climate of Dadin Kowa is characterized by a dry season of eight months, alternating with a four months' rainy season (Ibeje *et al.,*2013). The dam has a

single outflow channel where the water level is controlled.

Sampling Station

Sampling stations were selected based on preliminary surveys of the dam on factors such as the volume of water, accessibility, fishing activities and other domestic activities taking place in and around the dam. Three sample stations selected were Station A (10 19'25" N, 11 28'30"E), Station B (10 27'15" N, 11 27'15" E) and Station C (10 31'45" N, 11 28'10"E) (Gombe state University,2016).

Sample collection

The samples were collected monthly in the morning hours (between 7:00 am and 9:00 am) for a period of six months from each sampling station using plankton net of mesh size 55µm by hauling the sampler horizontally for five meters according to the method of Anene (2003). Samples were transferred into a label collecting bottles and preserved in 5% formalin and then transported to the laboratory for identification, counting and further analysis.

Laboratory Sample Analyse

In the laboratory, the collected samples were allowed to settle for 24 hours and then decanted carefully to 10 ml from which a drop of the concentrated Plankton was examined under a microscope. Dropping pipette was used to place the concentrated plankton on a glass slide, covered with a cover slit and view under the microscope. The Plankton were systematically identified and counted in all the microscopic fields from the left top corner of the slide to the right corner by moving the slide horizontally. The next consecutive field row was then adjusted using the mechanical device of the stage. Three sub-samples were examined and the total number of cells/drop was sum up the plankton numbers of all the microscopic fields. Three such sub-samples were taken from each concentrate (the second and subsequent subsamples were taken after the previous sub-sample is put back into the bottle), as described by Boyd, (1981).

The mean number of plankton per ml was computed as follows:

$$\text{Organism/l of water} = \frac{\text{organism per ml of concentrate x 1000}}{\text{Filtered water /litres of concentrate}}$$

Planktons were counted and identified using Plankton identification manual and other relevant texts. Phytoplankton identification guides was according to the method of (Verlencar and Desai, 2004; Perry, 2003) and Practical guide on Nigeria Zooplankton identification (Jeje and Fernado, 1986) were used for Phytoplankton and Zooplankton identification respectively.

Statistical Analysis

SPSS (v.11.0.1) was used for graphical illustrations and analysis of Plankton diversity and abundance.

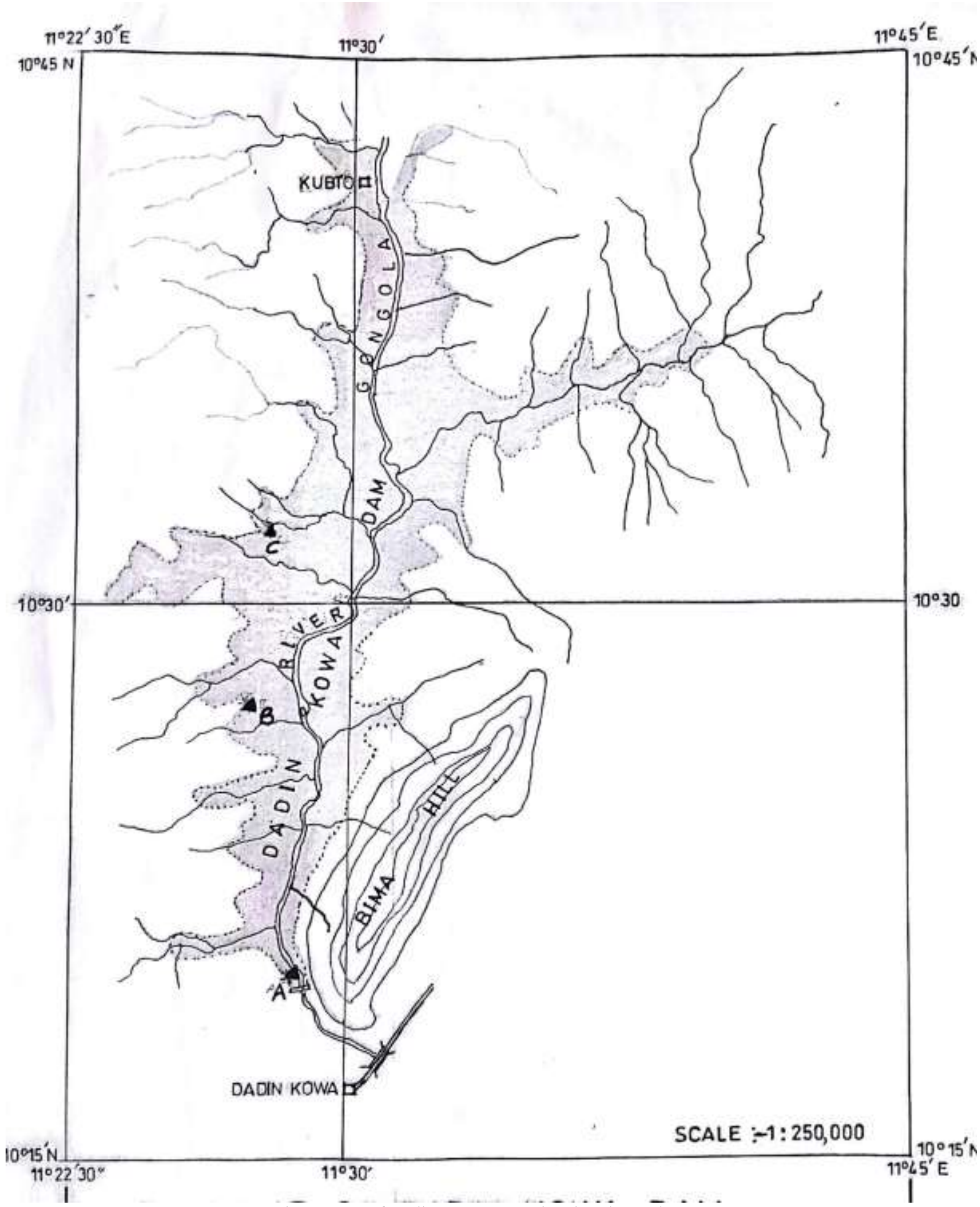

Fig. 1: Map of Dadin Kowa Dam showing the study area
Source; Gombe State University, 2016

RESULTS AND DISCUSSIONS

The Gussian species packing of phytoplankton richness in Dadin Kowa Dam are presented in Table 1. Bacillariophyta where the optimum (410.191), tolerance (134.555) and maximum (330) levels were recorded. Cyanophyta optimum (348.33), tolerance (5) and maximum (6.67) levels were determined. Euglenophyta gives the optimum, tolerance and maximum levels of 343.33, 0.01 and 10 respectively. Cryptophyta recorded 348.33, 5 and 6.67 as optimum, tolerance and maximum levels respectively. Dinophyta 498.515, 146.142 and 13 were recorded as optimum, tolerance and maximum levels. Xantophyta with optimum (387.746), tolerance (131.416) and maximum (10) levels. Species Richness in an area gives the number of species per unit area which increase of species contributed to increase in biodiversity and give the idea of the productivity of the water body. According to Vallina *at el.,* (2017) the best adapted species to each particular environment or ecological niche tend to dominate the community. The phytoplankton displayed an optimum level for Dinophyta (498.515) while Bacillariophyta shows the high level maximum species richness. The interaction of the species with the environment and the different species determine the various level of the species richness level in which it can tolerate. species richness can be a simple measure to quantity and express the complexity of an area (Nabout *et al*., 2007). The phytoplankton community composition of the positive and negative sides is mostly dominated by slow-growing nutrient specialists and fast-growing nutrient opportunist species, respectively (Vallina *at el.,* 2014). The phytoplankton richness in the water is influence by various factors which varies with the ecosystem. Species richness has been recognized over the dynamics and functioning of the community in relation to stability and productivity, essential to understand the factors that drive the phytoplankton richness (Geovani *at el.,* 2014).

Table 1: Gussian Species Packing of Phytoplankton Richness in Dadin kowa Dam

	Ba	*Cy*	*Eu*	*Cr*	*Di*	*Xa*
Optimum	410.191	404.295	343.33	348.33	498.515	387.746
Tolerance	134.555	143.801	0.01	5	146.142	131.416
Maximum	330	150	10	6.67	13.33	1

Bacillarophyta (Ba), Cyanophyta (Cy), Euglenophyta (Eu). Cryptophyta (Cr), Dinophyta (Di), Xantophyta (Xa).

The phytoplankton diversity indices are shown in table 2 with the highest values (6) of Taxa recorded in Chlorophyta, Bacillarophyta,Cyanophyta and Xantophyta while the in Euglenophyta. The Simpson Index for phytoplankton was found to be the highest in Bacillarophyta (0.8252) and lowest in Euglenophyta (0.0). The Simpson Index value ranges between 0 and 1, the greater the value, the greater the sample diversity (Simpson,1949). The Shannon Index (H) for phytoplankton was found to be the highest in Bacillarophyta (1.763) and lowest in Euglenophyta (0.0). The Shannon Index (H) takes a value between 0 and 1 (Robiu *at el*.,2017). Shannon Diversity Index is a commonly used diversity index which consider both abundance and evenness of species present in the community and commonly used to characterize species diversity in a community (Abu Sayeed *at el*.,2017). The high value of Shanno Index in Bacillarophyta indicates that the species are more evenly distributed in the study area. The higher diversity values of Margalef reflect the suitability of habitat for the organism and correlated with longer food chain and complex food web of the ecosystems and also more stable community (Margalef,1956). Margalef Richness Index for the study was found to be the highest in Cyanophyta (0.7714) and lowest in Euglenophyta (0.0). The Margalef Richness Index shows a variation depending upon the number of species. The Equitability index takes a value between 0 and 1. The lower values indicate more diversity while higher values indicate less diversity (Robiu *at el*.,2017). The Equitability Index for phytoplankton was found to be the highest in Cryptophyta (1) and lowest in Euglenophyta(0). Fisher alpha index measure the diversity within a population (Sandhya,2013). The Fisher's alpha index recorded highest in Xantophyta (1.957) and lowest in Euglenophyta (0.2766).

Table 2: Phytoplankton Diversity Indices

0	Ch	Ba	Cy	Eu	Cr	D	Xa
Taxa_S	6	6	6	1	2	3	6
Simpson_1-D	0.8158	0.8252	0.7922	0	0.5	0.5925	0.8194
Shannon_H	1.743	1.763	1.616	0	0.6931	0.9649	1.748
Margalef	0.6414	0.6708	0.7714	0	0.386	0.5881	1.355
Equitability_J	0.9726	0.9842	0.9017	0	1	0.8783	0.9756
Fisher_alpha	0.7411	0.7787	0.9125	0.2766	0.6524	0.83	1.957

Chlorophyta(Ch), Bacillarophyta(Ba), Cyanophyta(Cy), Euglenophyta(Eu), Cryptophyta(Cr), Dinophyta(Di), Xantophyta(Xa)

Representatives species of zooplankton found in the study include Brightwellii, Philodina, Bdelloid, Moina, Daphnia, Camtocerus, Diaptomus, Cyclops, Bidentata and Caudatus were recorded in all the months (Fig 4) during the study. 10 zooplankton species were identified Brightwellii was having the highest value (428) in June while lowest value (121) in October, Monia recorded the highest (97) and lowest value (30) in June and September, Diaptomuus recorded highest value (112) in May and the lowest value (30) in September respectively. Philodina was having the highest value (550) in June while lowest value (195) in September. Daphnia recorded the highest (43) and lowest value (26) in May and September. Cyclops was having the highest value (70) in July while lowest value (35) in September and October. Bdelloid recorded the highest value (402) in May and lowest value (116) in October. Also during the study Camtocerus recorded the highest value (76) in May and lowest value (35) in September and October and Bidentata species recorded the highest value (331) in May and lowest value (49) in October. Generally, the high number of zooplanktons were recorded around May, June and July which are related the early raining month season. The nutrient concentrations increased the spatial stability and increasing the average total biomass (Wang,2017). This higher zooplankton population density in summer might be due to the temperature increase (Lampert and Sommer, 1997). This defer to study conducted by Roy *et al.*, (2014) that stated the accumulation of zooplankton biomass coincides with the onset of the rainy season from July to September while Ahmed *et al*., (2011) reported a low amount of zooplankton during the month of May to July which associated with high water temperature. However, it was observed a decrease of the number of zooplankton taxa in the period of lowest temperatures by Pedrozo & Rocha (2006), also detected by Güntzel (1995) in the Emboaba and Caconde Lakes. High number was recorded at early raining months of May, June and July (Figure 4). The clustering of the species in Dadin Kowa ecology shows higher value in the early set of rain. At the early set of the raining season, the nutrients are wash in to the water which boost the growth of Phytoplankton thereby making food available for the Zooplankton. Nutrient loading may support the high phytoplankton production which can ultimately support to zooplankton abundance/population (Manickam *et al.,* 2014).

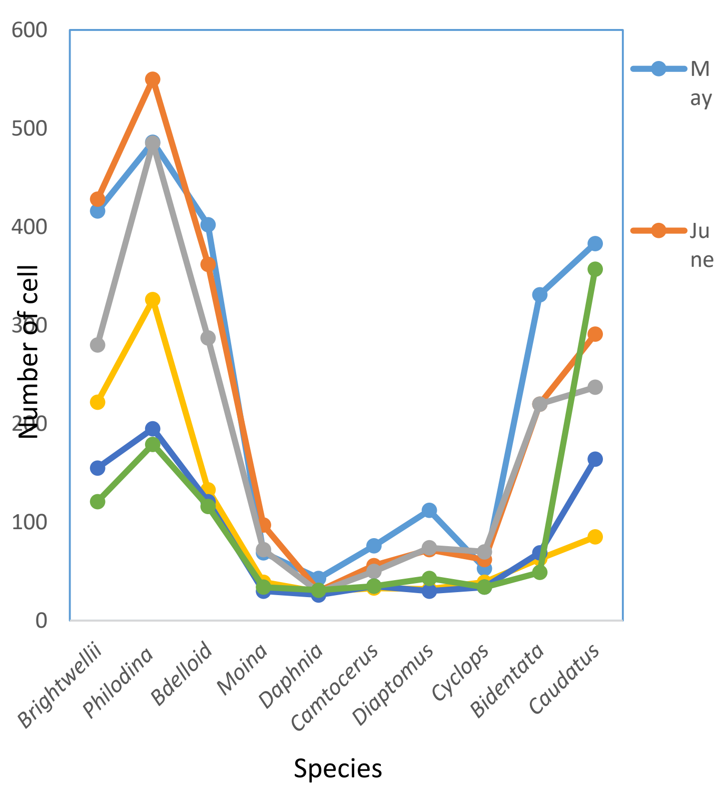

Figure 2: Monthly variation of Zooplankton in Dadin Kowa Dam.

The Zooplankton diversity indices are shown in table 3. The Zooplankton diversity indices are shown in table 3 indicate the same value (6) of Taxa species recorded. The Simpson Index value ranges between 0 and 1, the higher the value, the greater the sample diversity (Simpson,1949). The Simpson Index shows the highest in Daphnia (0.8283) and lowest in Bidentata (0.76). The Shannon Index (H) for Zooplankton indicated to be the highest in Daphnia (1.778) and lowest in Bidentata (1.567). The Shannon Index ranges a value between 0 and 1 (Robiu *at el*., 2017). The high value of Shanno Index in indicates that the species are more evenly distributed. Margalef Richness Index for the Zooplankton study was found to be the highest in Daphnia (1.208) and lowest in Philodina (0.757). The Margalef Richness Index shows a variation base on the number of species. The lower values in Equitability Index indicate more diversity while higher values indicate less diversity (Robiu *at el*.,2017). The Equitability Index for the Zooplankton indicate highest value (0.992) in Daphnia and Bidentata with the lowest value (0.875). The measure of the diversity within a population is shown in Fisher alpha index (Sandhya,2013). The Fisher's alpha index indicate highest in Daphnia (1.957) and lowest in Philodina (0.893). Species richness and biodiversity in this study is found to be lower compared to similar work done on River Benue by Okayi (2001). This may attribute to influences such as climate change, physical, chemical and biological factors within the water body and may also be associated with tropic state as well as geographical factors observed vertical migration with the suspect to change in temperature can also be considered as limiting factor for zooplankton occurrence for the variation in their distribution concerning depth and stations.

Table 3: Zooplankton Diversity Indices

	B	Ph	Bd	Mn	Dp	Cm	Dp	Cy	Bd	Ca
Texa_S	6	6	6	6	6	6	6	6	6	6
Simpson_1-D	0.8014	0.8074	0.7916	0.803	0.8283	0.8159	0.795	0.820	0.76	0.805
Shannon_	1.694	1.709	1.665	1.701	1.778	1.742	1.681	1.751	1.567	1.697
Menhinick	0.258	0.221	0.275	0.563	0.758	0.616	0.545	0.608	0.336	0.267
Margalef	0.795	0.757	0.811	1.057	1.208	1.098	1.043	1.092	0.868	0.803
Equitabil.	945	0.954	0.929	0.950	0.992	0.973	0.938	0.977	0.875	0.947
F. alpha	0.945	0.893	0.969	1.35	1.634	1.423	1.326	1.413	1.05	0.957

Brightwellii (B), Philodina (Ph), Bdelloid (Bd), Moina (Mn), Daphnia (Dp), Camtocerus (Cm), Diaptomus (Dp), Cyclops (Cy), Bidentata (Bd), Caudatus (Ca).

A higher number of Plankton taxa were observed during the period of research. Group of phytoplankton recorded include Chlorophyta, Bacillariophyta, Cynophyta, Euglenophyta, Cryptophyta and Dinophyta. Chlorophyta was observed in all the stations during the research with the highest (1,960) and lowest (860) number recorded in May and July respectively. Bacillariophyta was also recorded in all the stations with the maximum value (990) and minimum (450) number in June and September respectively, Cyanophyta was recorded in all the station with the maximum value (450) recorded in July and the Minimum value (20) in September. Euglenophyta was only recorded in September (30). Cryptophyta was only observed in June (20) and September (20). Dinophyta was observed in May, August and September only with the minimum value (10) in August. Xantophyta was observed in all the stations with the minimum value (10) recorded in August and maximum value (30) in October.

Seasonal variation of phytoplankton community structure is generally understood to be driven by the water circulation dynamics, which varies mainly in accordance to the dry and wet periods in tropical waters (Jeje and Fernando, 1986). A higher number of phyoplankton was observed during the research period (chlorophyta, bacillariophyta, cyanophyta, Euglenophyta, Cryptophyta, Dinophyta and Xantophyta.). The Chlorophyta recorded the highest value and it was higher in May which is associated with the dry season. Generally, the sequence of annual phytoplankton dominance is Chlorophyceae > Cyanophyceae > Bacillariophyceae (Khan, 2010). This sequence was similar to what is existing in Dadin kowa dam. The numbers tend to decline during the raining months. According to Pradeep (2014) increase in the amount of water during wet season and high turbidity has adverse effect on phytoplankton abundance and cause a sharp fall in their abundance. The chlorophyta is a group of algae having their photosynthetic pigments localized in chromatophores which are grass-green because of the predominance of chlorophyll. Dhakar, (1979) also observed that the green algae prefer water with higher concentration of dissolve oxygen. Monthly variation of chlorophyta shows bimodel distributions with one peak during the dry season and other peak during wet season. Bacillariophyta, group includes a large number of unicellular and colonial genera which differ from other algae in the shape of their cells. Bacillariophyta recoded shows a little stability in their number in the months of May to August which is associated with high temperature. A number of factors influenced the distribution of Bacillariophyta in water body such as change in water temperature light and irradiance of water. Pradeep, (2014) also suggested that high temperature favours the growth of Bacillariophyta but Venkatesharaju *et al.,* (2010) observed an inverse relationship between diatoms and temperature.

A unique feature of cyanophyceae is the primitive type of nucleus, which lack nucleolus and nuclear membrane. These algae can tolerate very high range of temperature and form the dominant group (Pradeep, 2014). Cyanophyta was recorded maximum during the dry season although in little amount and tend to decline. Enkateshwarlu (2010) observed in Chandlodia Lake the Blue green algal growth is dominated over Chlorophyceae, Bacillariophyceae and Euglenophyceae and concluded that absence of large number of blue green algae is an indication of clean water. Swadling *et al.,* (2000) reported that the polluted water zone constituted a heavy cyanophyta growth. In the study Cyanophyta was recorded lower than Chlorophyta and Bacillariophyta, this indicate low pollution as stated by Swadling *et al.,* (1990). In some systems, stability induces their growth allowing fluctuation under optimal light conditions and re-suspension inhibition of the no-floating competitive species (Viner, 1985). Water bodies with large drainage area or which receive domestic sewage effluents are the most conducive to luxuriant growth of Cyanophyta. Blue green algae mainly contribute the nuisance blooms. (Dadi-mamud, 2012).

Euglenophyta are free-swimming algal flagellates found in a variety of freshwater.The phytoplankton was only observed in September which is associated with late raining month. Pradeep (2014) indicated that high amount of phosphate; Nitrate and low content of dissolve oxygen favoured the growth of euglenophyta. In general, the members of euglenophyta have shown poor distribution but in some lake its numbers are high which might be due to efflux of domestic sewage. Singh (1989) recorded that the factor like temperature, organic matter and albuminoid ammonia influenced the growth and development of Euglenophyta
Cryptophyta was recorded in June and September, Dinophyta recorded only May, August and September and Xantophyta were recorded in little number during all the months of the study.

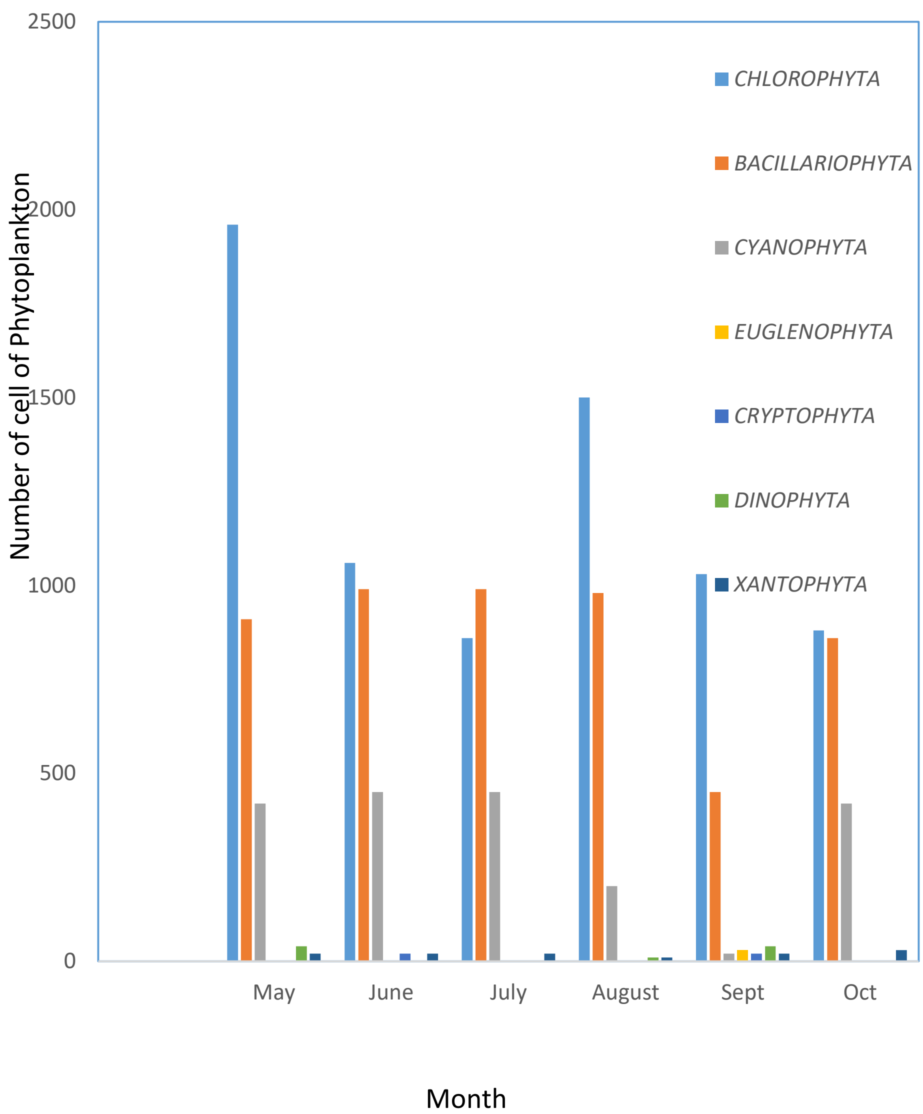

Figure 3: Monthly Variation of Phytoplankton in Dadin Kowa Dam.

The Principle Component Analysis (Figure 4) shows Chlorophyta, Euglenophyta, Crytophyta, Dinophyta and Xantophyta shows positive number in their population but indicate a negative component in terms of their interaction with the ecosystem which indicating a negative number in the component 2. Bacillariophyta and Cyanopyhta show a positive position in terms of their population and growth in number in relationship to the ecosystem. The PCA of phytoplankton indicate ecological system where chlorophyta indicate a negative in the component 2 area indicating a decline in their number in relationship to the ecosystem despite its high number compared with the other Phytoplankton. Bacillarophyta and Cyanophyta shows positive increase and Cryptophyta, Dinophyta and Xantophyta were cluster at the negative at component 2 and positive at the component 1 which indicate their availability. The changes in physical and chemical conditions in the dam enables the coexistence of a high number of phytoplanktonic species, opportunistic and with high growth rate (Bovo-Scomparin and Train, 2008).

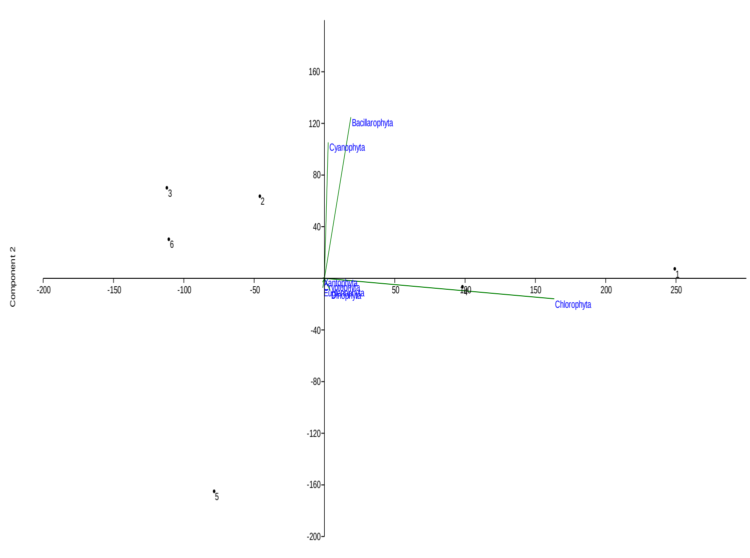

Figure 4: Principle Component Analysis of Phytoplankton

CONCLUSION AND RECOMMENDATIONS

The Plankton identified in Dadin Kowa Dam by cluster analysis reveals that different species associations occur among them and their ecosystem.

The distribution and density of plankton species is influenced by several physical and chemical factors within the ecosystem. More intensive study of the plankton diversity in Nigerian water bodies in order to document other species and wider distribution of many others than those that were recorded in the study.

It is therefore recommended that further study should be carried out on the continuous monitoring of the dam ecosystem to know the future impact of climate change on distribution of plankton which can help to identify different species to formulate the effective conservation strategies

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