Original article

Impact of Climate Change on the Plankton Community of Kainji Lake, Nigeria

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ABSTRACT

The world is undergoing extinction crisis – the most rapid loss of biodiversity in the planet's history – and this loss is likely to accelerate as the climate changes. Climate change is believed to have major implication on agricultural production and food security especially in the aquatic ecosystem of the tropical and subtropical regions. Climate data spanning 20 years period (1994 - 2013) of Kainji Lake obtained from national institute of freshwater fisheries research (NIFER) New-Bussa, Nigeria were utilized for the present study. Climate data and physicochemical parameters obtained showed a general rising trend, with maximum temperature mean value range between 36.30^{0}C in 2013 – 41.22^{0}C in 1999 and minimum 19.10^{0}C in 1996 – 24.83^{0}C in 2013 respectively. Plankton community obtained from four stations (Fakun, Tarda, Garafini and Malale) of the lake include zooplankton such as Ostracoda, ostracoda, maxillopoda, amphipoda, cephalopoda, trematoda, bdelloida, branchiopoda, while the phytoplankton were the bacillariophyceae, dinophyceae, zygnematophyceae, florideophyceae and fragilariophaceae. While the Phytoplankton were the Bacillariophyceae, Dinophyceae, Zygnematophyceae, Florideophyceae and Fragilariophaceae. (*Daphnia sp. Rotaria sp. Spirogyra sp. Fragillaria sp. Latotalla curifa, Cascino discus, Ceretium sp. Odentella sp, Biddelphia sp.* There were significant relationship of the plankton community with weather elements and physicochemical parameters. In conclusion, Kainji Lake plankton community is responding to the threat of climate change and efforts should be made towards adaption and mitigation of this menace both in the short and long run.

Keyword: Climate change, Physicochemical, Phytoplankton, Zooplankton, Kainji Lake, Nigeria

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INTRODUCTION

The world is undergoing an extinction crisis, the most rapid loss of biodiversity into accelerate as the climate changes. The effects of global warming and climate change have become important contemporary issues in Nigeria (NIMAT, 2012). Climate change has been defined as any change in climate over time, whether due to natural variability or as a result of human activity (Parry *et al.*, 2007). Limnologists are concerned about the vulnerable effect of climate change on physical, biological and properties of streams, and lakes which are habitat for fish and other aquatic organisms. The major challenge that climate change presents for Nigeria is an increase in air temperature over the entire country, leading to flooding around the coastal areas and drought in the grass savannah zone (NESAT, 2011). Easterling *et al.* (2007) reported that climate change will increase water stress throughout Africa but more so in eastern and western Africa. Climate change is modifying the distribution and productivity of marine and freshwater fish species and is already affecting biological processes and altering the aquatic food webs. The consequences for lack of sustainable management of aquatic ecosystems, fisheries, and aquaculture on the people could be devasting and may present significant negation socio-economic impact to Nigeria. The present study was designed to determine the effect of climate change on primary productivity of the Kainji Lake and it effect on plankton abundance of Kainji Lake

MATERIALS AND METHODS

Kainji Lake, is located between longitude 4°21' and 4°25' East and latitude 9°5' and 10°55' North. The study covered southern basin of Kainji Lake in Borgu local Government area of Niger State; four sampling stations were located at: (A) Fakun (Dam-site) (B) Tarda (C) Garafini and Malale which are important fish landing sites of Kainji Lake.

Twenty (20) year climate data was collected from National Institute of Freshwater Fisheries Research, New-Bussa and National Hydropower Station Kainji, data including rainfall and temperature data.

Phytoplankton and zooplankton population examination were carried out to determine primary productivity of Kainji Lake. Plankton net was used to collect samples in the respective station. And sampling was based on a simple random sampling, where plankton net was towed horizontally few centimeters below the water surface and the sample collected was emptied into sample bottle and fixed with 4% of buffered formalin and analyzed with the aid of Olympus XSZ-N 107 photomicroscope. A taxonomic key according to Jeje and Fernado (1986) was used for identification. The sampling was carried out quarterly (April, August and December, 2013) respectively. Physico-chemical parameters were determined by monthly water sampling from January to December 2013, temperature, Dissolved Oxygen, pH Alkalinity, Electrical Conductivity and total hardness were determined using the standard methods.

RESULTS

Climatic data spanning 20 years period (1994-2013) of Kanji Lake analyzed showed variation in temperature and rainfall, highest average temperature (40°C) record in 1999 and lowest average temperature (36.2 °C) recorded in 2007 and 2013 respectively.

The temperature fluctuates from year to year and showed great variability and sharp fluctuation of rainfall values from year to year. The rainfall did not only vary but generally increased linearly. The highest rainfall value (1,295.00mm) was recorded in 1993, while the lowest value (735.33mm and 823.25mm) were recorded in 2002,1996, 2003 and 2013 respectively (Table 1)

Table 1: Rainfall, **Temperature, In/out flow** and Fish Yield of Kainji Lake (1994-2013)

Year	Maximum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)
1994	37.62	20.09	1227.59
1995	38.29	19.53	1098.00
1996	38.87	19.1	823.25
1997	38.80	20.4	1117.19
1998	39.38	20.64	1349.79
1999	41.22	19.90	1295.00
2000	38.49	22.16	971.02
2001	39.65	19.98	982.47
2002	38.85	22.11	735.33
2003	37.09	24.18	846.90
2004	38.83	21.54	1183.06
2005	37.34	23.71	1049.63
2006	38.68	22.78	1140.59
2007	36.41	23.11	939.60
2008	37.00	23.3	1079.64
2009	37.48	22.0	1124.64
2010	38.20	24.4	1325.50
2011	37.10	21.2	1182.55
2012a	36.30	23.6	1090.74
2013a	36.30	24.83	853.87

Analysis of variance (ANOVA) of physico-chemical showed that in both years, mean monthly temperature value varied significantly (32.55°Ce and 40.85°Ce) ($p< 0.05$) from each other, the pHPh. Value (6.73-8.02) differed significantly for each month ($p< 0.05$), electrical conductivity value (54.00-204.25) differed significantly for each month ($p< 0.05$), dissolved oxygen value (6.25-10.50mg/1) differed significantly for each month. Biochemical oxygen demand value (2.00-7.00mg/1) differed significantly for each month ($p< 0.05$), total hardness values differed significantly from each other ($p< 0.05$). Alkalinity value (24.50-47.00mg/1) also differ significantly ($p< 0.05$) in the month of January, February, April, June, July and August respectively, Table 2. Sub-seasonal variation in physic-chemical.

Table 2: The monthly mean values of physicochemical measured from January December 2013 in Kainji Lake

	Temperature (0C)	Ph	Conductivity (µmhos/sec)	DO (mg/l)	BOD (mg/l)	Total Hardness (mg/l)	Alkalinity (mg/l)
January	[illegible]	6.73 ± 0.41^{a}	130.25 ± 14.17^{c}	10.50 ± 1.15^{b}	5.00 ± 1.15^{bcd}	31.25 ± 8.54^{a}	9.50 ± 1.00^{a}
February	[illegible]	6.80 ± 0.22^{a}	102.25 ± 7.41^{bc}	6.25 ± 0.50^{a}	2.00 ± 0.82^{a}	42.50 ± 3.00^{b}	16.50 ± 4.12^{a}
March	[illegible]	6.74 ± 0.16^{a}	188.00 ± 5.89^{d}	8.00 ± 1.63^{ab}	2.83 ± 0.85^{ab}	45.00 ± 8.87^{b}	20.00 ± 1.63
April	[illegible]	7.05 ± 0.12^{ab}	204.25 ± 47.60^{d}	7.75 ± 1.71^{ab}	3.50 ± 1.29^{abc}	25.25 ± 2.87^{a}	34.00 ± 3.65
May	[illegible]	7.04 ± 0.12^{ab}	204.25 ± 47.60^{d}	7.75 ± 1.71^{ab}	4.00 ± 1.41^{abc}	24.50 ± 3.70^{a}	35.00 ± 2.58
June	[illegible]	8.02 ± 0.94^{c}	87.50 ± 15.26^{ab}	7.25 ± 1.89^{a}	4.00 ± 1.63^{abc}	28.50 ± 7.00^{a}	37.50 ± 1.91
July	[illegible]	7.76 ± 0.11^{c}	104.50 ± 16.66^{bc}	7.00 ± 0.98^{a}	2.37 ± 0.98^{ab}	29.50 ± 1.91^{a}	29.00 ± 1.15
August	[illegible]	7.78 ± 0.11^{c}	105.50 ± 12.29^{bc}	6.50 ± 1.00^{a}	5.50 ± 1.00^{cd}	35.00 ± 1.90^{a}	25.00 ± 2.58
September	[illegible]	6.80 ± 0.31^{a}	95.00 ± 26.94^{bc}	5.75 ± 1.25^{a}	3.75 ± 1.26^{abc}	47.00 ± 8.80^{b}	7.50 ± 1.91^{a}
October	[illegible]	7.54 ± 0.08^{bc}	58.75 ± 15.26^{a}	8.50 ± 2.65^{ab}	2.50 ± 1.29^{a}	32.50 ± 2.25^{a}	9.75 ± 2.06^{a}
November	[illegible]	6.70 ± 0.41^{a}	54.00 ± 5.48^{a}	14.00 ± 2.83^{c}	7.00 ± 3.16^{d}	32.50 ± 2.52^{a}	11.00 ± 2.58^{a}
December	[illegible]	6.73 ± 0.41^{a}	130.25 ± 14.17^{c}	10.50 ± 1.91^{c}	5.00 ± 1.54^{bcd}	28.75 ± 8.54^{a}	9.50 ± 1.00^{a}

Values as Mean ± S.E. Mean values with the same letter in a column are not significantly different ($p < 0.05$)

The monthly mean value of sub-seasonal Variations in Physicochemical Parameters (38.84±2.38 ^{0}C and 33.88 0.80^{0}C respectively) were not significantly different from each other ($p > 0.05$); while the early and late dry seasons values (37.47 1.71 ^{0}C respectively) also did not differ significantly from each other ($p > 0.05$). The pH value in the early and late sub-seasons, early (7.37±0.70) and late (7.44±0.51) were not different significantly from each other, but were both significantly different from that of the late dry season sub-season (6.76 0.31) at $p < 0.05$. The electrical conductivity of early wet (165.33 67.85$\mu mhos/sec$) and late (101.67±8.42 $\mu mhos/sec$) wet seasons were significantly different and so was that of early (81.00±38.13$\mu mhos/sec$) and late (140.17 ± 38.34 μmhos/sec) dry seasons sub-season ($p<0.05$). The DO for early and late wet sub-season (7.58±1.62 and 6.42±1.08mg/l respectively) and late dry (8.25±2.26mg/l) sub-seasons differed significantly from that of early dry (11.00 ±3.28mg/l) ($p<0.05$). There was no significant in the sub-seasons value of BOD for the duration of the study ($p>0.05$). Total hardness of the water for early (26.08±4.76mg/l) and late (38.25±10.82mg/l) wet seasons were significantly different from each other; a similar observation was made for the early (31.25 ±5.17mg/l) and late (39.58±9.10mg/l) dry sub-seasons value ($p<0.05$). All the sub-seasons values for alkalinity differed significantly from one another ($p<0.05$). (Table 3)

Table 3: The values of physicochemical parameters of Kainji Lake measured at different sub-seasons in year (2013)

Parameters	Early wet season	Late wet season	Early dry season	Late dry season
Temperature (^{O}C)	34.84±2.38^a	33.88±0.8^a	37.47±1.71^b	38.74±2.05^b
pH	7.37±0.70^b	7.44±0.51^b	7.02±0.45^{a,b}	6.76±0.31^a
Conductivity ($\mu mhos/sec$)	165.33±1.62^a	101.67±18.42^a	81.00±38.13^a	140.17±38.34^b
DO (mg/L)	7.58±1.62^a	6.42±1.08^a	11.00±3.28^b	8.25±2.26^a
BOD (mg/L)	3.833±1.34^a	4.00±1.53^a	4.83±2.69^a	3.28±1.58^a
Total hardness (mg/L)	26.08±4.76^a	38.25±10.82^b	31.25±5.17^a	39.58±9.10^b
Alkalinity (mg/L)	35.5±2.97^d	20.50±9.91^c	10.08±1.93^a	15.33±5.14^b

Mean values with same letter in rows are not significantly difference ($p>0.05$)

Plankton population examination indicated the occurrence of ten of ten taxa of zooplankton (Ostracod, Calanoid, Amphido, Copepod, Cypris larve, Sicula, Nictychia, Nauplius, Rotaria, Daphnia) and six taxa of phytoplankton (Diatom, Dinoplagellate, Ceratium, Spirogyra, Bactrachospermum, Fragillaria). The class maxillopoda had the highest percentage (95%) among the zooplankton while bacillariophyceae had the highest percentage (95%) abundance among the phytoplanktons. The second quarter sampling had the highest population abundance of phyton taxa, while third quarter sampling had the least abundance. (Table 4).

Table 4: List of plankton recorded in Kainji Lake (2013)

A. ZOOPLANKTON

	Taxa	Class	No	%
1.	Ostracod	Ostracoda	7	3.72
2.	Calanoid	Maxillopoda	136	72.34
3.	Amphipod	Amphioda	1	0.53
4.	Copepod	Maxillopda	28	14.89
5.	Chironomus larvae	Ostracoda	2	1.06
6.	Sepia	Cephalopoda	2	1.06
7.	Nectyclina	Trematoda	2	1.06
8.	Nauplius	Maxillopoda	8	4.26
9.	Rotaria	Bdelloida	1	0.53
10.	Daphnia	Branchiopoda	1	0.53
	Total		188	99.98

B. PHYTOPLANKTON

	Taxa	Class	No	%
1.	Diatom	Bacillariophyceae	39	66.10
2.	Dinoplagellate	Dinophyceae	8	13.56
3.	Ceratium	Dinophyceae	3	5.08
4.	Spirogyra	Zygnematophyceae	5	8.47
5.	Bactrachospermum	Floridaphyceae	3	5.08
6.	Fragillaria	Fragillariophyceae	1	1.69
	Total		59	99.98

The weather elements (rainfall and temperature) greatly influence physico-chemical parameters which in turn interact with plankton composition and abundance. The analysis of Plankton abundance and interaction with physico-chemical parameters showed a positive relationship between plankton and temperature, pH and Ec, while DO, BOD, Total Hardness and Alkalinity shows negative relationship (figure 1 to 7)

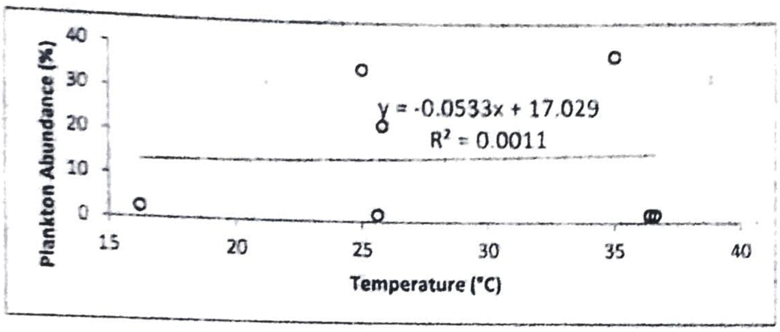

Figure 1: Effect of temperature on plankton abundance of Kainji Lake in year (2013)

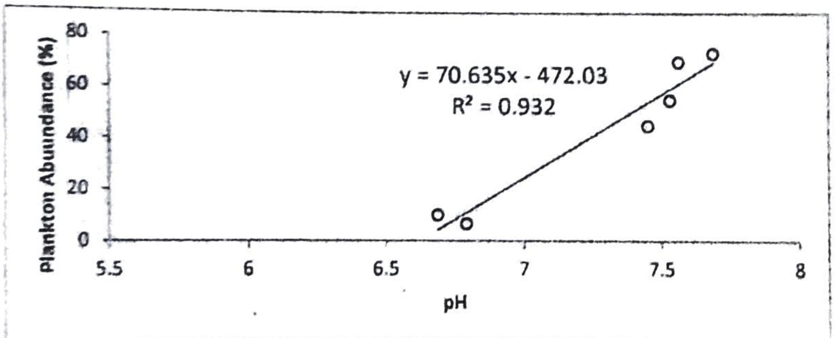

Figure 2: Effect of pH on plankton abundance of Kainji Lake in year (2013)

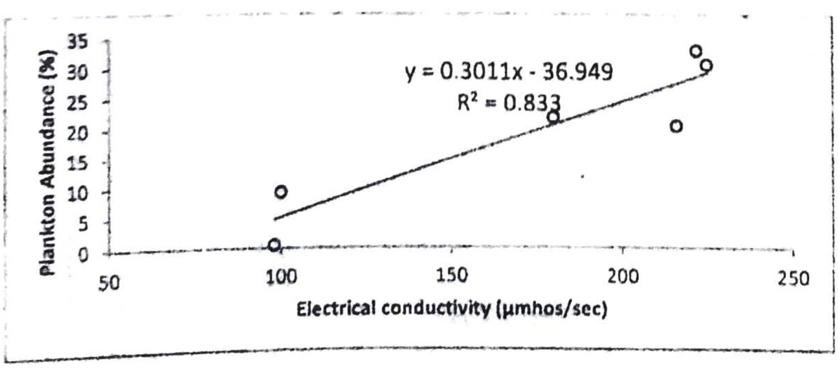

Figure3: Effect of electrical conductivity on plankton abundance of Kainji Lake in year

(2013)

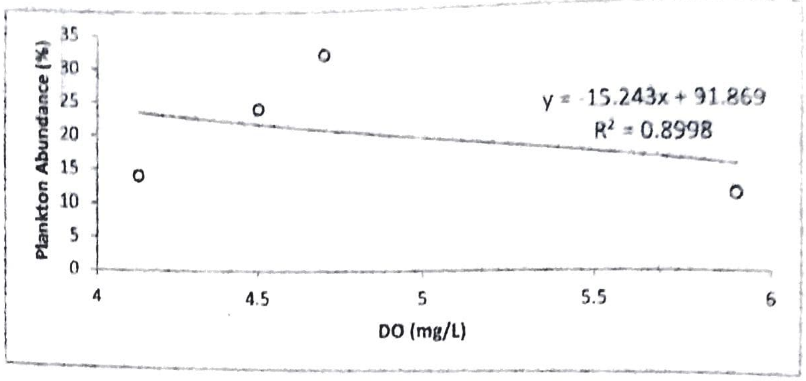

Figure 4: Effect of DO on plankton abundance of Kainji Lake in (2013)

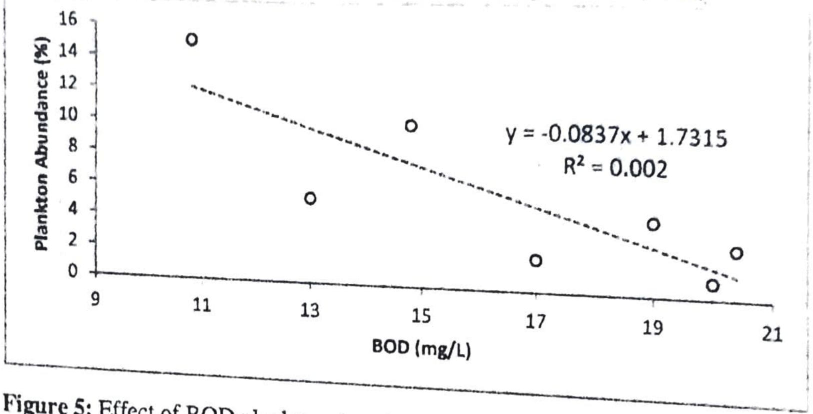

Figure 5: Effect of BOD plankton abundance of Kainji Lake in (2013)

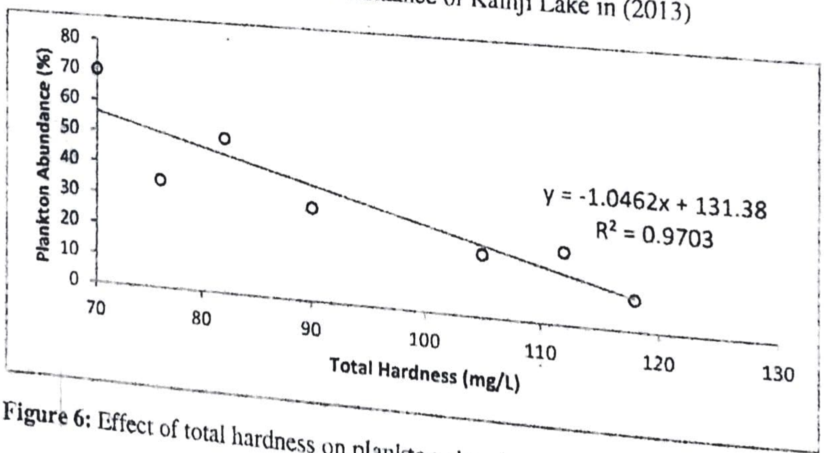

Figure 6: Effect of total hardness on plankton abundance of Kainji Lake in (2013)

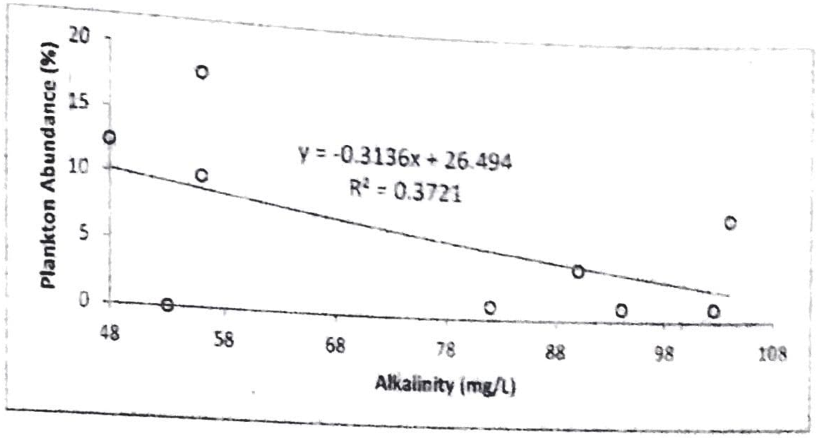

Figure 7: Effect of alkalinity on plankton abundance of Kainji Lake in (2013)

DISCUSSION

The climatic data spanning 20 year, the temperature mean value range fell within the upper limit range for tropical water bodies, this temperature range might influence the current species planktons status of the Kainji lake and agreed with findings of Allison *et al*, (2006). On potential impacts of climate change on fisheries, this deviated from the findings of Fafioye *et al.* (2005) who recorded ranges of 26.5- 31.5^{0}c in Imo water body kanji lake ecological parameters were influenced by temperature and precipitation. These temperature ranges was within the upper limit for tropical lakes, which is an indication of a shift in previous temperature ranges recorded. The variability and fluctuating weather pattern might be due to natural phenomenon and anthropogenic activities which were on the increase in the lake (IPCC, 2007). Linear regression analysis of physico-chemical parameters with plankton abundance revealed high level of interaction with rainfall and temperature being the key driving forces. This further suggest increase variability and changing weather pattern with negative consequences which is similar with the reports of NESAT (2003), Odjugo (2005) and IPCC (2007). The result of air temperature, mean value for all stations, months and sub sub-seasons followed similar patterns of variation. This finding is consistent with the reports of Sule (2011) who worked on the Subsistence farmers to climatic Change and Variability in Niger State. The highest air temperature value recorded (39^{0}C and 41^{0}C) in February and March were due to dry season intensive high solar radiation. The decreased temperature from April to September was due to the precipitation, which lowered the temperature. The least mean value (32^{0}C and 33^{0}C) recorded in April and July might be due to the onset of rains.

Increased in temperature argument the productivity of a body of water by increasing algal growth (phytoplankton), bacterial metabolism and nutrient cycle rates (Klapper 2001). The linear relationship recorded between temperature and plankton abundance might to be due to the fact that higher temperature promote algal growth as reported by Zakariya *et al.* (2011 and Mironga *et al.* 2011).

The temperature affect the amount of Dissolved Oxygen the water column can hold at a given time. Dissolved oxygen in water is an important factor that determine the occurrence and abundance of aquatic organism. This is because for all the aquatic aerobes, Oxygen is a prerequisite for life.

thus the more the oxygen available, the more the organisms present (WHO, 1996).

The negative relationship between plankton abundance and Alkalinity may be due to biological process that used up the solutes ($CaCO_3$). Zooplankton are free living aquatic animals. They are natural fish food organisms and are important in many food webs taking energy from phytoplankton and algae and repackaging it for consumption by higher trophic organisms (Omoreige, 2005). The Bacilariophycae were the dominant family of phytoplankton identified in this study. This finding is similar with the works of Jeje and Fernado (1986), Olele and Ekelemu (2008), Zakariya *et al* (2011) and Mironga *et al*. (2011). The maximum occurrence of plankton species was in second quarter, May-August 2013. This might be due to available rains nutrients and other physical and chemical factors which promote growth of Phytoplankton and Zooplankton. The difference in the number of tax and number of individuals between stations and months for each class of plankton might be due to difference in temperature and pH as a different species obtain nutrient at different pH and temperature (Zakariya *et al* 2011).

The presence of these families and classes of phytoplankton and zooplankton indicated that the productivity of Kanji lake was moderate compared to the tropical Africa lakes. The zooplankton identified in this study correspond with those of previous studies carried out by Jeje and Fernado 1986, Adeniji *et al* 2001 and Adeniji (1993). Although only few species and families where identified in the studies compared to earlier work carried out, which is an indication of a change in species composition status of the lake.

CONCLUSION

This studies reveals great interaction between the weather elements (rainfall and temperature), physic-chemical parameters and planktons status of Kainji Lake, hence influences the species composition and plankton abudnace which are responding to the effect of climate change that needed to be checked to manage the negative consequences of unpredicted weather pattern in Kainji area.

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