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Limnological Studies of Gombe Abba River, Dukku Local Government Area of Gombe State, Nigeria

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ABSTRACT

Phytoplankton and Zooplanktons species constitute an important step of food chain in Lake Ecosystem but the increase in the use of excessive agricultural chemical possess a thread to their availability. This thus necessitates the need to study the occurrence and distribution of plankton species in Gombe-Abba River with a view to determine their relationship with physicochemical parameters. Four sampling stations were chosen for the study. Phytoplankton and Zooplankton were sampled from the reservoir with the aid of plankton net. Physicochemical characteristics of the water were measured *in situ* fortnightly. These parameters include air Temperature, water temperature, pH, Electrical conductivity, Total dissolved solid, Turbidity, Dissolved Oxygen and their various results were found to be at ranged between 32.62-33.33^{0}C, 25.55-26^{0}C, 7.13-7.67, 114.3-116.6, 61.51-63.46mg/L, 5.01-5.27mg/L, 4.69-4.76mg/L respectively, while Biological oxygen Demand, Nitrates, and Phosphates ranged between 2.05-2.12, 14.73-15.19mg/L, 10.95-11.63 mg/L respectively. A total of 2546 phytoplankton were identified consisting of four genera which are *Baccillariophyta Chlorophyta, Cyanophyta* and *Euglenophyta* occurring as the dominant phytoplankton species observed during the study time. *Baccillariophyta* has 1037 individuals accounting for 40.73% of the total population of phytoplankton followed by *Chlorophyta* 28.40% *Cyanophyta* 19.17% *Euglenophyta* with 11.7%. The Simpson's species diversity index for the four phytoplankton taxa *Baccillariophyta, Chlorophyta, Cyanophyta* and *Euglenophyta* were found to be 0.1658, 0.0805, 0.0367 and 0.0134 respectively while the Margalef indexes of genera richness were 6.3605, 4.2404, 3.5336 and 1.4134 respectively. A total of 1058 zooplankton encompass of 15 numbers of genera amongst the three zooplankton taxa of *Cladocera, Copepoda* and *Rotifers* were determined. The *Rotifers* were the most abundant zooplankton taxon comprising 43.67% of the zooplankton abundance followed by *Copepoda* with 31.29% and *Cladocera* with 25.05%. The Simpson's species diversity index for the three zooplankton taxa of *Cladocera, Copepoda* and *Rotifera* were, 0.0626, 0.0977 and 0.1905 respectively while the Margalef index of genera richness of *Cladocera, Copepoda* and *Rotifera* were 2.5508, 2.5508 and 5.1016 respectively. Study of composition and abundance of plankton were found to vary with the variation in the physicochemical parameters suggesting that the river is moderately polluted.

Keyword: Limnological, Gombe Abba River.

INTRODUCTION

Water is a fundamental human need and most important in shaping the land and regulating the climate. It is one of the most important compounds that greatly influence life and two thirds of the earth's surface is covered by water. The quality of water is usually described according to its physical, chemical and biological characteristics. The availability of water determines the location and anthropogenic activities has put water bodies under pressure (Li *et al.*, 2009).Rapid industrialization and indiscriminate use of chemical fertilizers and pesticides in agriculture are causing heavy and varied pollution in aquatic

environment leading to deterioration of water quality and depletion of aquatic biota. Physical, chemical and biological factors of a given water body interact and influence its productivity (Balarabe, 2000). The interaction of physical, chemical and biological properties of water most often lead to the production of phytoplankton, while their assemblages are influenced by these factors. Thus any change in these factors may affect the diversity and distribution of plankton (Mustapha, 2011).Several factors usually contribute to the establishment of plankton communities in a reservoir, among which are good water quality, presence of nutrients, physicochemical factors of water, hydrological characteristics of the reservoirs and reservoir ageing. Phytoplankton are the most important factor for production of organic matter in aquatic ecosystem reservoirs will require significant amount of plankton to be reproductive.

Limnological studies provide baseline for proper decision making on biological problems associated with water quality (Ajuzie, 2012).

Gombe Abba River has not been an exception. Been that the area is located in Dukku local government; it serves as a measure source of water for irrigation, farming activities and other domestic usage to the local inhabitant. Such intense irrigation during the annual draw down period has accelerated the rate of gradual silting up of the River, thereby threatening the livelihood of the people as well as the life of the aquatic biota. Also, increase in human population growth coupled together with the activities taking place around that stream has led to habitat destruction, leaving many species isolated on fragments of land and water. This has severely affected the macro-fauna thriving around that region. For the purpose of conserving the microbial community, it is thus crucial to determine the abundance of these indigenous species with the potential factors affecting their distribution and composition.

This study therefore provide and promote information on water quality and macro invertebrate potentials of Gombe Abba River as well as sustainable use of the reservoir resources for benefit of both human and livestock in the community. The species composition, distribution, diversity and relative abundance of the river could have significant impact on public health of the inhabitant of the vicinity of the river (Mustapha, 2011).

MATERIALS AND METHODS

STUDY SITE

Sample collection was conducted at Gombe-Abba River in Dukku local government area of Gombe State. The area is located at latitude 14^0N and longitude 14^0E. This area is characterized by mean annual rainfall range (1200mm- 1500mm) and the temperature characteristics are typical of West African savanna climate. Agricultural activities are carried out along the river bank. The river channel supplied the neighboring community with drinking water and use in household.

SAMPLING PROCEDURE

Sampling was carried out monthly from each sampling station. Water samples were collected in the morning and were sampled at surface of level by dipping 1 liter plastic sampling bottle sliding over the most upper surface of the water dragging it against the water current to permit undisturbed passage of the water in to the bottle.

SAMPLING AND ANALYSIS OF PHYTOPLANKTON

Phytoplankton was sampled from the reservoir with the aid of plankton net (Made of bolting cloth with a fine aperture of 0.0lmm, 25cm long, and small bottle container attached to the narrow end of the net) it has an opening, of about 20cm diameter. At each station, the net was sunk just beneath the water surface and towed for a distance of 1 meter. Collected water samples were transferred to small plastic

bottles and preserved in 4% neutral formalin and 3 drops of lugol iodine. The collection from each station was taken to the laboratory for identification as described by Vuuren*et al.,* 2006.

SAMPLING AND ANALYSIS OF ZOOPLANKTON

Zooplankton were collected using a silk plankton net of 20cm diameter and 70 meshes/cm attached with a 50ml capacity bottle at base. At each station, collection was done by sinking the net and towed through a distance of 1 meter. The sample was then poured into plastic bottle of 70ml capacity and preserved in three drop of iodine. Counting was done using drop method and then mounted on a microscope for identification. Identification was carried out using various keys described by Witty, (2004).

Water samples were then transported to the laboratory for the analysis of physico-chemical and biological parameters. The research covered a period of six months (April, 2019-September, 2019).

ANALYSIS OF SURFACE WATER PHYSICOCHEMICAL PARAMETERS

Determination of Temperature

Water temperature was determined by lowering the thermometer into the water in an inclined Position for about 5 minutes to allow for equilibrium before recording as described by APHA (1998).

Determination of Water pH

The pH was determined with Hanna 420 pH meter; it was calibrated according to instructional manual provided by the manufacturer. The electrode of the pH meter was dipped into the water sample for 2-3 minute and readings were recorded (APHA, 1998).

Determination of Transparency

A Secchi disc of 25cm diameter was used in the determination of transparency. The transparency was taken by lowering the Secchi disc into the water until it became invisible. The depth of disappearance and reappearance was measured to the nearest centimeter this was repeated three times and the average was taken.

Determination of Conductivity

Conductivity was measured with WTW 320 conductivity meter. Water samples were placed into clean beakers, conductance cell of the meter was immersed in μs/cm then readings were obtained, the cell is rinsed in a beaker with distilled water after each reading.

Determination of Biological Oxygen Demand

For the determination of Biochemical oxygen demand, 100ml of water samples were incubated at room temperature (25°C) for a period of four days; in the dark after addition of 2ml manganese chloride solution the resultant precipitate was then dissolved by the addition of 2ml concentrated H_2SO_4. The difference obtained between the initial dissolved oxygen and the final dissolved oxygen concentration obtained after four days. The BOD is expressed in milligrams per liter of the sample (APHA 1998; Mohan *et., al*, 2000).

BIOLOGICAL ANALYSIS

Slides Analysis were prepared and observed under a binocular microscope with various magnifications. The identification of phytoplankton was carried out by the use of taxonomic keys and identification guides as described in (van Vuuren *et al.,* 2006 and Witty, 2004.). The phytoplankton and zooplankton were counted from left top corner of the slide to the right corner by moving the slide horizontally.

Data Analysis

The results obtained were subjected to analysis of variance to test significance between Physico-chemical parameters among the stations. Simpson's biodiversity index Margalef was employed to determine the species diversity of the samples in river. Correlation was employed to test the

relationship between the physico-chemical characteristics and phytoplankton and zooplankton abundance and distribution at P<0.05 level of significance.

RESULTS

The physicochemical parameters such as air temperature, water temperature, water pH, electrical conductivity, turbidity, dissolved oxygen, biological oxygen demand, nitrates, and phosphates and were analyzed for the water samples collected from Gombe Abba River. These parameters were taken at the four stations (in replicates). All parameters with the mean value of the data and standard error were calculated as shown in Tables 1 below.

Table 1: Mean variation of physicochemical parameters of Gombe Abba River among four stations.

	Station A	Station B	Station C	Station D	Mean	F-Stat	P-Val.
	Mean±SE	Mean±SE	Mean±SE	Mean±SE			
Air temp. (^{0}C)	32.91±0.92	33.22±0.92	33.33±0.96	32.62±0.91	33.02±0.93	0.342	0.269
Water tem. (^{0}C)	26±0.73	25.82±0.67	25.85±0.68	25.55±0.78	25.81±0.72	0	0.001
Water pH	7.52±0.46	7.67±0.49	7.24±0.2	7.13±0.29	7.39±0.36	0	0
E.C(µS/cm)	118.1±5.39	114.3±5.52	118.4±6.05	116.6±6.2	116.8±5.79	0	0
TDS (mg/L)	62.67±3.54	63.46±3.53	62.54±4.36	61.51±3.78	62.55±3.8	0.276	0.365
Turbidity (cm)	5.13±0.72	5.27±0.72	5.01±0.69	5.24±0.72	5.16±0.71	0.123	0
DO(mg/L)	4.7±0.43	4.76±0.41	4.74±0.48	4.69±0.49	4.72±0.45	0.114	0
BOD(mg/L)	2.12±0.25	2.05±0.28	2.07±0.22	2.1±0.26	2.09±0.25	0.023	0
Nitrate (mg/L)	14.73±0.94	15.19±0.87	15.08±0.85	14.89±0.98	14.97±0.91	0.001	0
Phosphate (mg/L)	11.63±0.67	11.08±0.53	11.17±0.55	10.95±0.43	11.21±0.55	0.033	0
Note: E.C: Electrical conductivity, TDS: Total Dissolved Solid, D.O: Dissolve oxygen, BOD: Bioch. Oxygen Demand							

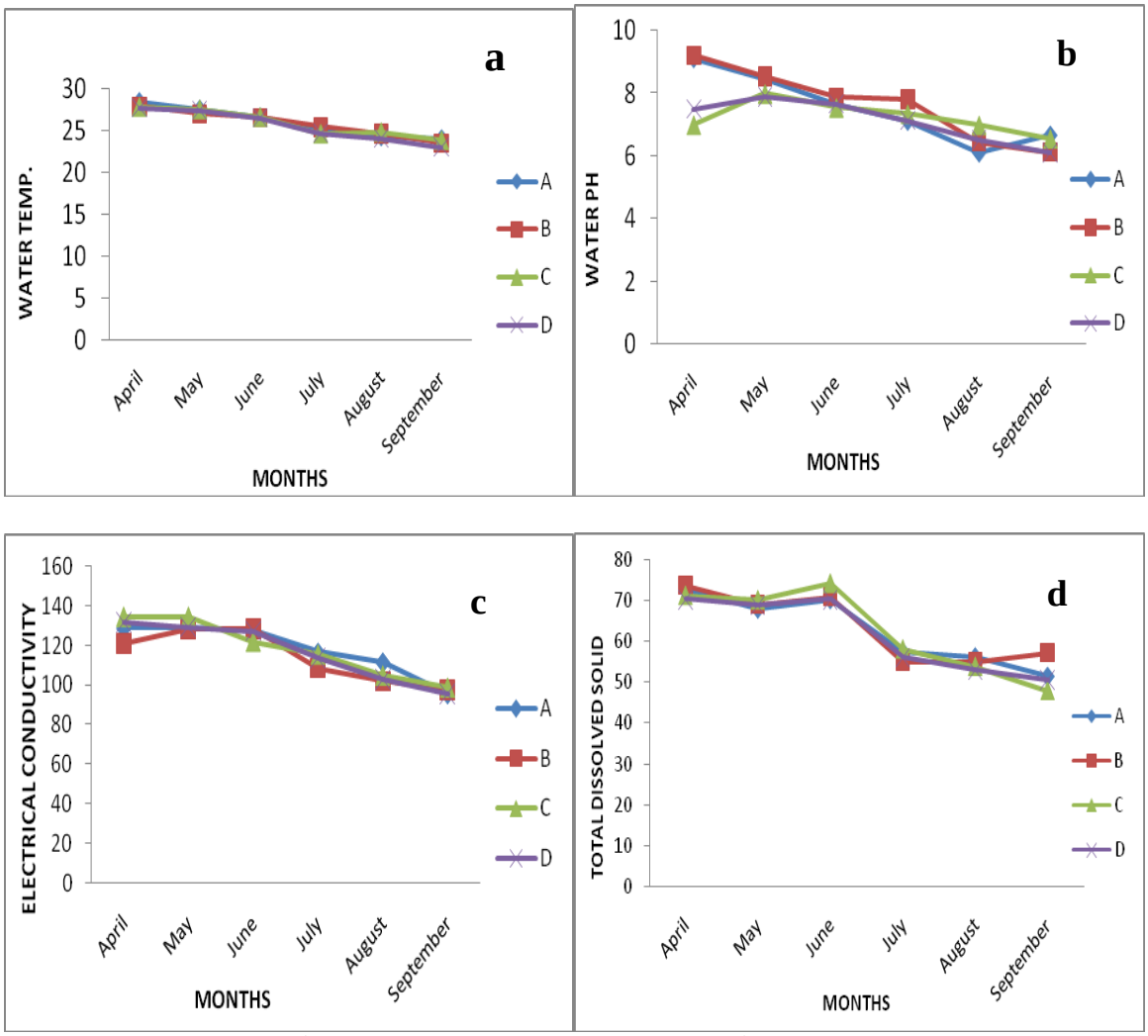

Figure 1: Mean Monthly Variation of Physicochemical parameters at various Stations of Gombe Abba River. (a) Temperature (b) pH (C) Electrical conductivity (d) Total dissolve solid

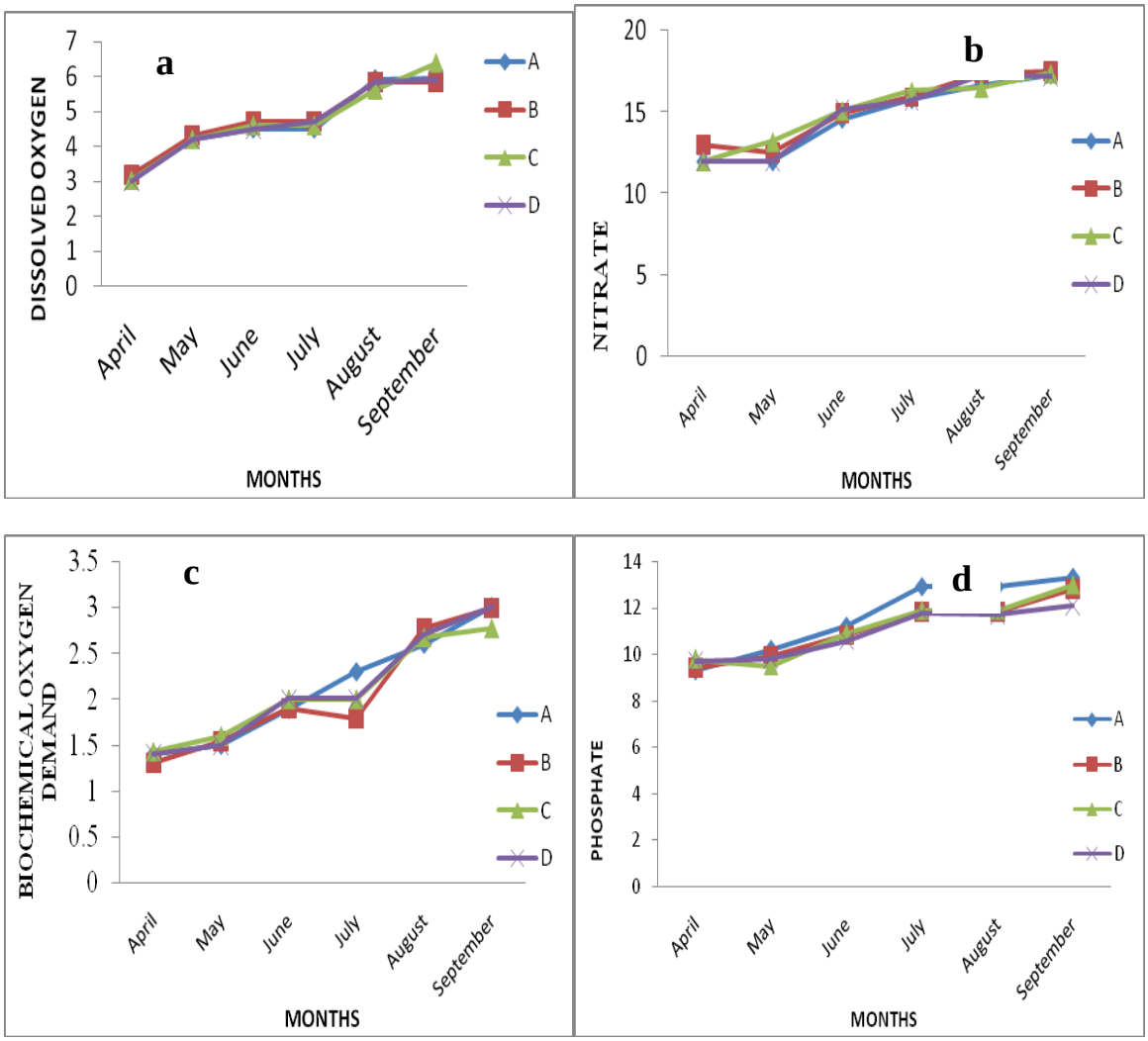

Figure 2: Monthly variation of physicochemical parameters (a) Dissolved oxygen (b) Nitrate (c) BOD (d) Phosphate

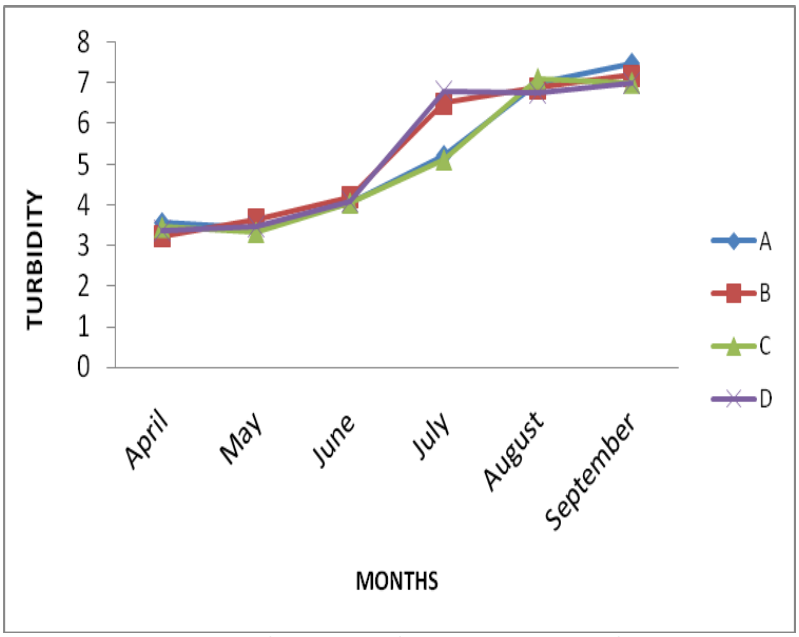

Figure 3: Monthly variation of Turbidity at four sampling stations of Gombe Abba River

ABUNDANCE AND DISTRIBUTION OF ZOOPLANKTON IN GOMBE ABBA RIVER

Table 2: Abundance and distribution of Zooplankton in Gombe Abba during the month of April, 2019

Zooplankton Taxa	Station A	Station B	Station C	Station D	Total
Rotifera					
Keratella S.	3	2	3	0	8
Platylas spp	2	3	3	1	9
Brachianus spp	3	5	2	2	12
Kellicottia spp	6	5	2	4	17
Trichocerca spp	4	3	2	2	11
Philodina spp	3	6	2	1	12
Rotaria spp	2	4	6	1	13
Cladocera					
Daphnia spp	5	4	4	5	18
Alona spp	2	1	0	2	5
Eurycercus spp	2	2	2	1	7
Chydonus spp	2	0	1	1	4
Copepoda					
Diaphtamus spp	5	4	6	4	19
Cyclopoids spp	4	2	4	5	15
Calanoida spp	3	1	2	4	10
Nauplius spp	2	5	2	3	12
Grand Total	48	47	41	36	172

Table 3: Abundance and distribution of Zooplankton in Gombe Abba during the month of May, 2019

Zooplankton Taxa	Station A	Station B	Station C	Station D	Total
Rotifera					
Keratella spp.	2	3	5	3	13
Platylas spp	2	1	3	1	7
Brachiumus spp	2	2	0	1	5
Kellicottia spp	6	5	6	3	20
Trichocercas spp	1	0	3	2	6
Philodina spp	3	3	2	4	12
Rotaria spp	3	4	2	2	11
Cladocera					
Daphnia spp	7	6	2	5	20
Alona spp	3	3	2	1	9
Eurycercus spp	2	2	4	1	9
Chydonus spp	2	4	2	2	10
Copepoda					
Diaphtamus spp	8	4	5	4	21
Cyclopoides spp	2	2	4	3	11
Calanoida spp	2	4	1	3	10
Nauplius spp	4	3	4	2	13
Grand Total	49	46	45	37	177

Table 4: Abundance and distribution of Zooplankton in Gombe Abba River during the month of June, 2019.

Zooplankton Taxa	Station A	Station B	Station C	Station D	Total
Rotifera					
Keratella S.	2	4	4	3	13
Platylas spp	3	2	2	1	8
Brachiumus spp	2	4	3	2	11
Kellicottia spp	7	5	4	2	18
Trichocercas spp	0	4	3	2	9
Philodina spp	4	5	2	2	13
Rotaria spp	4	2	3	2	11
Cladocera					
Daphnia spp	6	5	3	5	19
Alona spp	2	1	2	0	5
Eurycercus spp	3	1	2	2	8
Chydonus spp	2	0	1	1	4
Copepoda					
Diaphtamus spp	7	4	5	4	20
Cyclopoides spp	4	2	4	3	13
Calanoida spp	4	2	2	1	9
Nauplius spp	4	3	2	3	12
Grand Total	54	44	42	33	173

Table 5: Abundance and distribution of Zooplankton in Gombe Abba River during the month of July,2019

Zooplankton Taxa	Station A	Station B	Station C	Station D	Total
Rotifera					
Keratella s.	2	1	3	3	9
Platylas spp	2	2	1	0	5
Brachiumus spp	3	3	2	3	11
Kellicottia spp	6	5	2	4	17
Trichocercas spp	0	2	2	0	4
Philodina spp	2	3	3	1	9
Rotaria spp	3	4	4	2	13
Cladocera					
Daphnia spp	6	5	6	3	20
Alona spp	4	4	2	3	13
Eurycercus spp	2	2	1	2	7
Chydonus spp	3	2	2	1	8
Copepoda					
Diapthtamus spp	7	5	4	5	21
Cyclopoides spp	3	3	2	2	10
Calanoida spp	2	2	3	1	8
Naupluis spp	4	4	3	4	15
Grand Total	49	47	40	34	170

Table 6: Abundance and distribution of Zooplankton in Gombe Abba River during the month of August, 2019

Zooplankton Taxa	Station A	Station B	Station C	Station D	Total
Rotifera					
Keratella S.	3	1	2	2	8
Platylas spp	2	1	3	2	8
Brachianus spp	3	2	2	1	8
Kellicottia spp	7	6	4	3	20
Trichocercas spp	0	2	1	1	4
Philodina spp	3	2	3	2	10
Rotaria spp	3	4	1	3	11
Cladocera					
Daphnia spp	6	7	5	2	20
Alona spp	3	2	2	1	8
Eurycercus spp	3	3	4	1	11
Chydonus spp	2	4	2	2	10
Copepoda					
Diaphtamus spp	8	7	4	5	24
Cyclopoides spp	4	3	2	3	12
Calanoida spp	2	2	1	3	8
Nauplius spp	4	4	2	4	14
Grand Total	53	50	38	35	176

Table 7: Abundance and distribution of Zooplankton in Gombe Abba River during the month of September, 2019

Zooplankton Taxa	Station A	Station B	Station C	Station D	Total
Rotifera					
Keratella S.	3	2	4	3	12
Platylas spp	4	2	3	1	10
Brachianus spp	3	2	1	3	9
Kellicottia spp	7	5	6	3	21
Trichocercas spp	1	2	2	3	8
Philodina spp	4	3	2	2	11
Rotaria spp	4	3	3	3	13
Cladocera					
Daphnia spp	6	7	5	4	22
Alona spp	2	4	3	2	11
Eurycercus spp	2	3	2	3	10
Chydonus spp	2	4	2	1	9
Copepoda					
Diaphtamus spp	7	8	5	3	23
Cyclopoides spp	3	2	2	4	11
Calanoida spp	4	2	1	0	7
Nauplius spp	4	4	2	3	13
Grand Total	56	53	43	38	190

Table 8: Checklist of Abundance and distribution of Zooplankton in Gombe Abba River altogether throughout the study period.

Zooplankton Taxa	Station A	Station B	Station C	Station D	Total
Rotifera					
Keratella S.	15	13	21	14	63
Platylas spp	15	11	15	6	47
Brachiumus spp	16	17	10	14	57
Kellicottia spp	39	31	24	19	113
Trichocerca spp	6	14	13	10	43
Philodina spp	19	22	14	12	67
Rotaria spp	19	21	19	13	72
Cladocera					
Daphnia spp	36	34	25	24	119
Alona spp	16	15	9	9	49
Eurycercus spp	14	13	15	10	52
Chydonus spp	13	14	10	8	45
Copepoda					
Diaphtamus spp	42	32	29	25	128
Cyclopoides spp	20	14	18	20	72
Calanoida spp	17	13	10	12	52
Nauplius spp	22	23	15	19	79
Grand Total	309	287	247	215	1058

Table 9: Margalef species richness and Simpson diversity index of Zooplankton in Gombe Abba River

	Station A	**Station B**	**Station C**	**Station D**	**Total(%)**	**Simpson**	**Margalef**
Rotifera	129	129	116	88	462.0	0.1905	5.1016
					43.67		
Cladocera	79	76	59	51	265.0	0.0626	2.5508
					25.05		
Copepoda	101	82	72	76	331.0	0.0977	2.5508
					31.29		

ABUNDANCE AND DISTRIBUTION OF PHYTOPLANKTON IN GOMBE ABBA RIVER

Table 10: Abundance and distribution of Phytoplankton in Gombe Abba River during the month of April, 2019

Phytoplankton Taxa	Station A	Station B	Station C	Station D	Total
Baccillariophyta					
Cocconeis spp	2	1	3	3	9
Navicula spp	3	1	4	2	10
Diatom spp	4	5	4	1	14
Fragillaria spp	1	2	1	4	8
Nitschia spp	3	3	2	1	9
Synedra spp	5	2	1	4	12
Pinnularia spp	3	1	0	1	5
Coscinodiscus spp	6	3	2	1	12
Actinella spp	4	3	3	2	12
Anphora spp	2	1	1	2	6
Chlorophyta					
Actinastrus	7	5	4	2	18
Coelastrum spp	1	3	2	3	9
Scenedesmus spp	3	5	2	5	15
Ulothrix spp	2	2	1	2	7
Spyrogera spp	8	6	7	3	24
Oetogenium spp	5	4	2	2	13
Cosmarium spp	3	2	2	2	9
Cyanophyta					
Anabaena spp	4	3	4	4	15
Arthrospira spp	5	4	3	2	14
Oscillatoria spp	2	1	2	1	6
Spinilla spp	2	0	3	2	7
Nodularia spp	1	1	0	1	3
Trichodesmium spp	1	1	1	0	3
Eugleunophyta					
Euglena spp	5	3	2	4	14
Phacus spp	6	7	4	1	18
Trachelominas spp	1	2	3	2	8

Table 11: Abundance and distribution of Phytoplankton in Gombe Abba river during the month of May, 2019

Phytoplankton Taxa	Station A	Station B	Station C	Station D	Total
Baccillariophyta					
Cocconeis spp	4	6	4	6	20
Navicula spp	5	6	5	2	18
Diatom spp	7	5	7	1	20
Fragillaria spp	7	6	6	3	22
Nitschia spp	4	3	4	4	15
Synedra spp	5	2	3	2	12
Pinnularia spp	3	2	2	1	8
Coscinodiscus spp	3	4	4	3	14
Actinella spp	7	4	6	1	18
Anphora spp	4	3	3	2	12
Chlorophyta					
Actinastrus	2	3	7	1	13
Coelastrum spp	8	7	6	2	23
Scenedesmus spp	4	5	4	3	16
Ulothrix spp	5	3	3	1	12
Spyrogera spp	6	4	4	2	16
Oetogenium spp	3	5	3	1	12
Cosmarium spp	4	5	4	2	15
Cyanophyta					
Anabaena spp	2	1	1	1	5
Arthrospira spp	1	2	1	0	4
Oscillatoria spp	2	1	3	2	8
Spinilla spp	2	1	3	2	8
Nodularia spp	1	1	2	1	5
Trichodesmium spp	2	1	2	2	7
Eugleunophyta					
Euglena spp	2	3	2	1	8
Phacus spp	1	2	1	2	6
Trachelominas spp	2	2	3	1	8

Table 12: Abundance and distribution of Phytoplankton in Gombe Abba River during the month of June, 2019

Phytoplankton Taxa	Station A	Station B	Station C	Station D	Total
Baccillariophyta					
Cocconeis spp	5	4	7	6	22
Navicula spp	3	4	4	5	16
Diatom spp	5	5	4	4	18
Fragillaria spp	8	6	3	7	24
Nitschia spp	7	6	4	5	22
Synedra spp	6	4	6	8	24
Pinnularia spp	4	3	5	3	15
Coscinodiscus spp	5	6	6	6	23
Actinella spp	2	5	8	5	20
Anphora spp	2	3	2	3	10
Chlorophyta					
Actinastrus	6	5	6	4	21
Coelastrum spp	4	5	4	5	18
Scenedesmus spp	6	5	8	4	23
Ulothrix spp	2	3	3	3	11
Spyrogera spp	5	4	5	5	19
Oetogenium spp	6	5	5	4	20
Cosmarium spp	6	2	5	3	16
Cyanophyta					
Anabaena spp	4	5	4	6	19
Arthrospira spp	5	6	5	2	18
Oscillatoria spp	4	4	4	4	16
Spinilla spp	4	5	4	5	18
Nodularia spp	3	5	3	2	13
Trichodesmium spp	3	3	3	4	13
Eugleunophyta					
Euglena spp	4	3	4	5	16
Phacus spp	5	3	6	3	17
Trachelominas spp	3	3	2	2	10

Table 13: Abundance and distribution of phytoplankton in Gombe Abba River during the month of July, 2019

Phytoplankton Taxa	Station A	Station B	Station C	Station D	Total
Baccillariophyta					
Cocconeis spp	7	8	9	7	31
Navicula spp	7	5	6	5	23
Diatom spp	7	6	5	5	23
Fragillaria spp	4	3	4	5	16
Nitschia spp	9	6	9	8	32
Synedra spp	5	6	4	5	20
Pinnularia spp	3	5	5	4	17
Coscinodiscus spp	6	8	6	6	26
Actinella spp	6	5	6	3	20
Anphora spp	4	6	5	6	21
Chlorophyta					
Actinastrus	4	5	6	3	18
Coelastrum spp	6	2	3	6	17
Scenedesmus spp	5	5	4	4	18
Ulothrix spp	6	3	3	3	15
Spyrogera spp	6	8	5	6	25
Oetogeniums spp	4	3	2	1	10
Cosmarium spp	3	1	2	3	9
Cyanophyta					
Anabaena spp	2	4	3	2	11
Arthrospira spp	5	6	3	4	18
Oscillatoria spp	6	5	3	3	17
Spinilla spp	4	4	3	5	16
Nodularia spp	2	2	3	2	9
Trichodesmium spp	3	4	4	4	15
Eugleunophyta					
Euglena spp	6	5	5	6	22
Phacus spp	4	6	7	4	21
Trachelominas spp	4	5	6	5	20

Table 14: Abundance and distribution of Phytoplankton in Gombe Abba River Abba during the month of August

Phytoplankton Taxa	Station A	Station B	Station C	Station D	Total
Baccillariophyta					
Cocconeis spp	6	8	6	8	28
Navicula spp	5	6	3	7	21
Diatom spp	6	6	4	6	22
Fragillaria spp	5	2	6	5	18
Nitschia spp	6	3	8	6	23
Synedra spp	5	4	3	4	16
Pinnularia spp	3	4	7	7	21
Coscinodiscus spp	6	4	6	5	21
Actinella spp	4	4	2	4	14
Anphora spp	3	3	2	3	11
Chlorophyta					
Actinastrus	5	6	6	4	21
Coelastrum spp	6	3	5	6	20
Scenedesmus spp	5	5	4	3	17
Ulothrix spp	4	3	4	4	15
Spyrogera spp	8	7	8	6	29
Oetogenium spp	5	4	6	7	22
Cosmarium spp	4	5	5	3	17
Cyanophyta					
Anabaena spp	8	8	4	6	26
Arthrospira spp	3	3	3	2	11
Oscillatoria spp	6	5	4	7	22
Spinilla spp	6	4	7	6	23
Nodularia spp	4	3	4	3	14
Trichodesmium spp	4	4	5	4	17
Eugleunophyta					
Euglena spp	2	4	6	8	20
Phacus spp	4	3	6	8	21
Trachelominas spp	8	4	3	10	25

Table 15: Abundance and distribution of phytoplankton in Gombe Abba River during the month of September

Phytoplankton Taxa	Station A	Station B	Station C	Station D	Total
Baccillariophyta					
Cocconeiss spp	7	6	5	5	23
Navicula spp	5	4	4	4	17
Diatom spp	3	5	6	5	19
Fragillaria spp	4	3	6	7	20
Nitschia spp	2	4	5	6	17
Synedra spp	2	4	3	2	11
Pinnularia spp	4	2	6	7	19
Coscinodiscus spp	3	6	4	5	18
Actinella spp	7	5	4	3	19
Anphora spp	8	3	3	2	16
Chlorophyta					
Actinastrus	4	5	4	5	18
Coelastrum spp	5	4	6	5	20
Scenedesmus spp	4	3	4	4	15
Ulothrix spp	6	8	7	2	23
Spyrogera spp	8	7	6	4	25
Oetogenium spp	7	4	5	5	21
Cosmarium spp	6	6	2	4	18
Cyanophyta					
Anabaena spp	5	4	3	3	15
Arthrospira spp	4	5	2	6	17
Oscillatoria spp	4	6	4	5	19
Spinilla spp	7	6	4	5	22
Nodularia spp	3	3	6	4	16
Trichodesmium spp	2	4	8	4	18
Eugleunophyta					
Euglena spp	5	7	5	6	23
Phacus spp	4	4	6	7	21
Trachelominas spp	6	6	4	4	20

Table 16: Checklist of Abundance and distribution of Phytoplankton in Gombe Abba River altogether throughout the study period.

Phytoplankton Taxa	Station A	Station B	Station C	Station D	Total
Baccillariophyta					
Cocconeis spp	31	25	34	27	117
Navicula spp	28	26	26	25	105
Diatom spp	32	32	30	22	116
Fragillaria spp	29	22	26	31	108
Nitschia spp	31	25	32	30	118
Synedra spp	28	22	20	25	95
Pinnularia spp	20	17	25	23	85
Coscinodiscus spp	29	31	28	26	114
Actinella spp	30	26	29	18	103
Anphora spp	23	19	16	18	76
Chlorophyta					
Actinastrus	28	29	33	19	109
Coelastrum spp	30	24	26	27	107
Scenedesmus spp	27	28	26	23	104
Ulothrix spp	25	22	21	15	83
Spyrogera spp	41	36	35	26	138
Oetogenium spp	30	25	23	20	98
Cosmarium spp	26	21	20	17	84
Cyanophyta					
Anabaena spp	25	25	19	22	91
Arthrospira spp	23	26	17	16	82
Oscillatoria spp	24	22	20	22	88
Spinilla spp	25	20	24	25	94
Nodularia spp	14	15	18	13	60
Trichodesmium spp	15	17	23	18	73
Eugleunophyta					
Euglena spp	24	25	24	30	103
Phacus spp	24	25	30	25	104
Trachelominas spp	24	22	21	24	91
Grand Total	686	627	646	587	2546

Table 17: Margalef species richness and Simpson diversity index of phytoplankton in Gombe Abba River

	Station A	Station B	Station C	Station D	Total(%)	Simpson	Margalef
Baccillariophyta	281	245	266	245	1037	0.1658	6.3605
					40.73%		
Chlorophyta	207	185	184	147	723	0.0805	4.2404
					28.40%		
Cyanophyta	126	125	121	116	488	0.0367	3.5336
					19.17%		
Euglenophyta	72	72	75	79	298	0.0134	1.4134
					11.7%		
Grand Total	686	627	646	587	2546		
Distribution	**26.94%**	**24.63%**	**25.37%**	**23.06%**			

DETERMINATION OF THE RELATIONSHIP BETWEEN PHYSICO-CHEMICAL PARAMETERS AND ZOOPLANKTON AND PHYTOPLANKTON SPECIES FOUND IN GOMBE ABBA RIVER.

The results showed that phytoplankton and zooplankton taxa are correlated with certain physico-chemical characteristics.

Table 18: Correlation matrix showing relationship between Physico-chemical parameters, phytoplankton and Zooplankton in Gombe Abba River throughout the study period.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
A	1																
B	**0.96**	1															
C	**0.89**	**0.97**	1														
D	**0.9**	**0.97**	**0.99**	1													
E	**0.88**	**0.95**	**0.95**	**0.96**	1												
F	**-0.92**	**-0.98**	**-0.98**	**-0.99**	**-0.97**	1											
G	**-0.98**	**-0.92**	**-0.87**	**-0.89**	**-0.84**	**0.89**	1										
H	**-0.95**	**-0.95**	**-0.95**	**-0.96**	**-0.88**	**0.95**	**0.96**	1									
I	**-0.94**	**-0.97**	**-0.94**	**-0.93**	**-0.88**	**0.95**	**0.91**	**0.95**	1								
J	**-0.95**	**-0.99**	**-0.95**	**-0.94**	**-0.93**	**0.96**	**0.89**	**0.92**	**0.98**	1							
K	0.22	0.19	0.11	0.16	0.37	-0.3	-0.16	-0	-0.2	-0.2	1						
L	**-0.79**	**-0.75**	**-0.65**	**-0.71**	**-0.83**	**0.73**	**0.76**	**0.67**	**0.6**	**0.69**	**-0.5**	1					
M	0.07	0.05	-0.07	-0.11	-0.09	0.14	0.06	0.09	-0	-0.1	-0.4	0.01	1				
N	**-0.71**	**-0.63**	-0.47	-0.46	**-0.54**	**0.56**	**0.61**	0.49	**0.69**	**0.69**	**-0.5**	**0.51**	-0.3	1			
O	**-0.89**	**-0.82**	**-0.79**	**-0.79**	**-0.67**	**0.79**	**0.94**	**0.93**	**0.88**	**0.79**	0.01	**0.52**	0.1	**0.5**	1		
P	**-0.83**	**-0.84**	**-0.84**	**-0.81**	**-0.69**	**0.84**	**0.83**	**0.88**	**0.95**	**0.87**	-0.1	0.35	0.1	**0.6**	**0.9**	1	
Q	**-0.74**	**-0.87**	**-0.92**	**-0.89**	**-0.86**	**0.91**	**0.69**	**0.81**	**0.91**	**0.89**	-0.2	0.44	0.1	**0.5**	**0.7**	**0.9**	1

Note:- A: air temp., B: Water temp., C:pH, D: E.C., E:TDS, F:Turbidity, G: DO, H:BOD, I:Nitrate, J: Phosphate, K:Rotifera, L: Cladocera, M: Copepoda, N: Baccillariophyta, O: Chlorophyta, P: Cyanophyta, Q: Euglenophyta. The bold fonts implies correlation is significant at P≤0.05

DISCUSSION

Physical and chemical conditions of aquatic ecosystem determine the occurrence, distribution and diversity of flora and fauna which may change with season of the year. These variations in the physico-chemical parameters is associated with temperature, rainfall and water usage (Atobale and Ugwumba, 2008; Ayoade et al 2006, Oso and Fagbauro, 2008 and Idowo *et al*., 2013).

PHYSICOCHEMICAL PARAMETERS

Temperature

Temperature play a significantly role in determining the distribution aquatic ecosystem which has certain range for their survival, growth and reproduction. The highest and lowest mean air and water temperature are 33.33^0C and 26^0C and 32.62^0C and 25.55^0C respectively. This agreed with the findings of Ayoade *et al*., 2006 that temperature varies with optimum range between 21^0C and 32^0C.Air and water temperature showed a positive correlation with pH, Electrical conductivity, and total dissolve solids and negatively with turbidity, Dissolved Oxygen, Biological oxygen Demand, Nitrate and Phosphate (Table 18).

pH

The pH of Gombe Abba River ranged between 7.13-7.67 which is alkaline and it agrees with the findings of Sharma *et al*., 2016. Alkaline is common in most fresh water ecosystem promotes high productivity (Kumar and Prabhahar, 2012). Low pH

indicates acidity possibly due to the presence of nitrate and sulphate ions in water. The level of pH could support many fish and other benthic organism. Similar report was observed by Edema, *et.al;* (2002). There was increase in algal bloom due to the trophic state of the phytoplankton community this also coincides with the findings of (Balogun 2001).pH is positively correlated with E.C., TDS. And negatively correlated with turbidity, DO., BOD., Nitrate and Phosphate (Table 18).

Electrical Conductivity

Electrical conductivity during the study period was highest during the month of April and continues to decrease as the volume of water increase(Figure 4). The highest mean value of 118.4±6.05 was recorded in station C and least mean value of 114.3±5.52 was recordedin station B and the overall mean 116.8± 5.59. High evaporation and increase in nutrients due to run off from inorganic fertilizer from adjacent land may be the reason for increase electrical conductivity during dry season. Decrease in conductivity during the rainy season might be due to increase in rain water which dilutes the dissolved solids in the reservoir. This was similar to the observation of Usman *et al*., 2017 and Gadzama and Mondo 2011).

Total Dissolved Solids

Solid refers to the suspended and dissolved matter in water which are very useful describing the chemical constituents of the water and can be considered as edaphically relation to contribute to productively within the water body. The total dissolved solids in the sampled water ranged from 61.51±3.78 to 63.46±3.53 with the mean of 62.55±3.8 (Stable 1). The highest TDS reported during the month of April in station A, B and C and June in station C and D while lowest was observed in September across all stations (see Figure 5). This differences in values of TDS between dry season (highest) and wet season (lowest) may be due to decaying of vegetation and rate of evaporation (Atobatele and Ugwumba 2008). TDS is negatively correlated with dissolved oxygen may be due to flow of substance during rainy season and colonizing effect of the substance in dry season. This agrees with findings of Usman *et al*., 2017 and Araoye, 2008).

Dissolved Oxygen

Dissolved oxygen, is an important environmental parameter that decides ecological health of a stream and protects aquatic life (Chang, 2002).The value for dissolved oxygen concentration of the water samples in all the four sampling stations fall within the range of 4.69 to 4.76mg/l. There was high dissolved oxygen September and lowest in April which could be attributed to the peak time of biochemical oxygen demand due to bacteria and other decomposers uptake. This was similar to the findings of Sharma *et al*., 2016. Dissolved oxygen in water depends on some factors such as temperature, depth, wind and extent of living organisms such as decomposition (Indabawa, 2009) and its changes affect growth of many organisms (Charles, 2003).

Biological Oxygen Demand (BOD)

The biological oxygen demand of the water samples in all the four sampling stations fall within the range of 2.04-2.09 mg/l. This agrees with the findings of (Mustapha, 2011). Biological oxygen demand (BOD) was higher in the dry season than in the rainy season (see figure 8). BOD shows a positive correlation with turbidity, DO, Nitrate and phosphate and negatively with water temperature, pH, EC and TDS,

Nitrates

The result of nitrogen obtained throughout the period of this research has the overall mean of 14.97mg/l. It was observed that concentration of nitrogen begin to increase from dry season to rainy season (April to September) as shown in figure 7. This could be due to run-off through discharge of sewage and from agricultural fields in the catchment area (Kemdirim, 2000; Solanki, 2012). The highest amount of nitrates concentration was known to support the formation of bloom (Uduma, 2014). Nitrates is positively

correlated with Turbidity, BOD, DO and Phosphate and negatively correlated with water temperature, pH, EC, TDS, T

Phosphates

The highest mean value of Phosphate of was recorded in the month of September while the lowest mean value recorded in April (Figure 9). The highest mean value of 11.63±0.67 mg /l was recorded in Station A and lowest mean value of 10.95±0.43 mg/l in station D (Table 1). Phosphate-phosphorus values obtained during raining season period was higher than that of dry season this might be due to run-off from nearby farmlands, since phosphate fertilizer application is common in the farmland around the catchment area. Reduction in water volume also has impact of altering the physical and nutrients condition of water bodies (Mustapha, 2011; (Sharma et al., 2009), Phosphate is positively correlated with Turbidity, DO, BOD and Nitrates and negatively with water temp. pH, EC and TDS.

ZOOPLANKTON

A total of 1058 individuals' organisms of zooplankton encompass of 15 numbers of genera amongst the three zooplankton taxa of Cladocera, Copepoda and Rotifers each with 4, 4 and 7 species respectively. The Rotifers were the most abundant zooplankton taxon comprising 43.67% of the zooplankton abundance followed by Copepoda with 31.29% and Cladocera with 25.05% which agrees with the findings of Ahmad *et* al., 2012. Cladocera have widely been used as biological indicators in studies due to their sensitivity to various levels of water quality characteristics (Radix*et al.,* 2002). The Simpson's Species diversity index for the three zooplankton taxa of Cladocera, Copepoda and Rotifera were, 0.0626, 0.0977 and 0.1905 respectively (Table 9). Simpson value ranges from 0 to 1 and the greater the value, the greater the sample diversity (Simpson, 1949). The Margalef index of genera richness of Cladocera, Copepoda and Rotifera were 2.5508, 2.5508 and 5.1016 respectively (Table 9) and according to Margalef (1956), the higher diversity values reflect the suitability of habitat for the organism.

Relationship between Physicochemical Characteristics and Zooplankton Abundance

In freshwater bodies, oxygen fluctuations could be due to close relationship between the free water and the bottom where organic matter accumulates. Kramer (1987) reported that variation of oxygen could be vertical, horizontal or temporal due to diurnal alternation of the predominance of photosynthesis and respiration.

Cladocera shows positive correlation with Turbidity, Dissolved oxygen, Biochemical oxygen demand, Nitrate and Phosphate while negatively correlated with Air temperature, Water temperature, pH, Total Dissolved Solid. High dissolved oxygen concentration conforms to increase in zooplankton productivity during that period (Kemdirim, 2000). The occurrence of Copepoda and Rotifera showed no correlation with the physico chemical parameters. Ewa *et al.,* 2017 reported significant correlation between the occurrence Zooplanktons and some physicochemical characteristics in coastal Vistula lagoon.

PHYTOPLANKTON

A total of 2546 individuals' organisms of phytoplankton were observed among the four genera. Baccillariophyta Chlorophyta, Cyanophyta and Euglenophyta were the dominant phytoplankton species observed during the study time. This agrees with the findings of Renuka *et al*., 2014; Meng *et al.,* 2018. Baccillariophyta is the most abundant and is similar with finding of Ogbuagu and Ayoade 2012 Imo River, Nigeria. It has 1037 individuals accounting for 40.73% of the total population of phytoplankton with station A having 281, B 245, C 266 and D 247, followed by Chlorophyta with 723 (28.40%) with station A having 207, B 185, c 184 and D 148, Cyanophyta 488 (19.17%) with station A having 126, B 125, C121 and D 116 and

Euglenophyta with 298 (11.7%) with A having 72, B 72, C 75 and D 79. This agrees with the finding of Olele and Ekelemu, 2008. The Simpson's species diversity index for the four phytoplankton taxa Baccillariophyta, Chlorophyta, Cyanophyta and Euglenophyta were 0.1658, 0.0805, 0.0367 and 0.0134 respectively (Table 17) and the greater the value, the greater the diversity of phytoplankton where the value ranged between 0 and 1 as described by Simpson (1949). The Margalef indexes of genera richness were 6.3605, 4.2404, 3.5336 and 1.4134 respectively (Table 17) which according to Margalef (1956), the higher diversity values indicate that the habitat is suitable for the organism and vice versa.

Relationship between Physico-Chemical Characteristics and Phytoplankton Abundance

Phytoplankton community was excellent indicators of environmental conditions and aquatic health within ponds because it is sensitive to environmental changes both in biomass and density ((Usman, 2016; Li *et al*., 2009) mainly caused by different tolerance ability to the environment (Farinas *et al*., 2015). Density of *Bacillariophyceae* has negative correlation with water temperature. Similar relationship was also reported Suresh *et al*., 2013. Cyanophyta, Chlorophyta and Euglenophyta were negatively correlated with temperature. Growth of phytoplankton composition is governed by the temperature (Rajkumar *et al*., 2009; Suresh *et al*., 2013). Phytoplanktons observed were all positively correlated with dissolved oxygen, nitrate, turbidity and phosphate. Dissolved oxygen indicates a good relationship with phytoplankton a community which shows high productivity (Sharma, *et al*., 2016), turbidity favors their growth (Harsha and Malammanavar, 2004) and total nitrogen and phosphates were positively correlated with the presence of phytoplankton which are used as indicators of eutrophication (Renuka *et al*., 2014).

CONCLUSION

The phytoplankton and zooplankton abundance and distribution observed in this study was very much and make the River potential for wider ecological studies. The zooplankton has 15 genera under three taxa which are Cladocera, Copepoda and Rotifera. The highest was Rotifera with 43.67% followed by Copepoda and Cladocera. Phytoplankton has 16 genera from four taxa (Baccillariophyta, Chlorophyta, Cyanophyta and Euglenophyta). Baccillariophyta is the highest with 40.73% followed by Chlorophyta (28.40%), Cyanophyta (19.17%) and Euglenophyta (11.7%).

The result showed that all the taxa of Phytoplankton and Zooplanktons distribution and abundance are influenced by physicochemical parameters.

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