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SEASONAL DYNAMICS OF PHYTOPLANKTON DIVERSITY IN RELATION TO CHLOROPHYLL CONTENTS IN AJIWA RESERVOIR.

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Abstract: Seasonal changes in phytoplankton diversity in relation to chlorophyll contents in Ajiwa reservoir, Katsina State Nigeria was carried out from June 2019 to January 2020 using standard procedures. Three (**3**) sampling stations were chosen. The phytoplankton and chlorophyll content of the water was determined using the standard method (APHA 1999). The results from the three sites indicated mean phytoplankton percentage composition of Chlorophyceae (33.50%), Bacillariophyceae (22.36%), Cyanophyceae (12.57%), Chryptophyceae (12.48%), Chrysophyceae (7.93%), Euglenophyceae (6.58%), and dinophyceae (4.55%). There were significant differences between season and phytoplankton abundance with more diversity of phytoplankton recorded in the wet season than the dry season. The highest was Chlorophyceae it has a total number of 397 individual species which represent 33.50% of the total phytoplankton count during the study period. The least abundant phytoplankton in the reservoir is Dinophyceae it has a total number of 40 individual species which represent 3.57% of the total phytoplankton count during the study period. The result also indicated the mean percentage composition of chlorophyll-a (0.33 mg/L) in dry and (1.09 mg/L) in the wet season, chlorophyll-b (0.30 mg/L) in dry and (0.56 mg/L) in the wet season, and total chlorophyll (0.66 mg/L) in dry and (1.65 mg/L) wet season and in all the three sampling stations. Analysis of variance revealed there was a significant difference in chlorophyll between seasons ($P > 0.05$). More studies should be carried out to identify the plankton composition using advanced techniques such as Polymerase Chain Reaction (PCR).

Key Keywords: Dynamics, Diversity, Phytoplankton, Chlorophyll contents, and Ajiwa reservoir.

Introduction:

Water is one of the most important available substances on the earth. The survival and the quality of human life depend upon the availability of freshwater. The aquatic animal's life directly or indirectly depends on water quality status (Balarabe 2001). Reservoirs are usually the best method of impounding water because it ensures that water is available and help in minimizing obstruction from rivers. Reservoirs have been used for the investigation of factors controlling the abundance and distribution of aquatic organisms (Ugwumba, 2010). Nigeria is blessed with about 853,600 hectares of freshwater capable of producing over 1.5 million metric tonnes of fish annually (FAO, 2009). There is a need to devise means of using these precious resources. It is no doubt reservoirs have contributed to the economic growth of many nations and Nigeria included. Reservoirs built in several parts of the world have played important role in helping communities to harness water resources for several uses. An estimated 30-40% of irrigated land worldwide now relies on reservoir water (Mustapha, 2011). In Nigeria, many researchers have conducted works on limnology, and plankton composition of the Nigerian lake system, Balogun *et al.* (2005) Balarabe (2001), Ibrahim *et al.* (2009), Hassan *et al.* (2010), and Abubakar (2009).

Seasonal variations of phytoplankton composition have long fascinated aquatic ecologists. Plankton is the most sensitive floating community which is being the first target of water pollution thus any undesirable change in an aquatic ecosystem affects diversity as well as biomass of this community. The measurement of plankton's productivity helps to understand conservation ratio at various trophic levels and resources as an essential input for proper management of the reservoir. According to Hassan *et al.* (2010), the plankton study is a very useful tool for the assessment of biotic potential and contributes to the overall estimation of the basic nature and general economic potential of the water body. The use of a variety of agrochemicals in the catchment and human pressure is causing depletion of aquatic biota due to water pollution in the case of lakes and reservoirs.

Phytoplankton is the pioneer of an aquatic food chain. The productivity of an aquatic environment is directly correlated with the density of phytoplankton. The phytoplankton is the base of most of the lake food webs and fish production is linked to phytoplankton. Moreover, the number and species of phytoplankton serve to determine the quality of the water body Ayoade *et al*. (2006).

MATERIALS AND METHODS

Study Area

The secondary purpose of the the dam was for fishing and irrigation activities.

Ajiwa reservoir was constructed in 1975 it's located in a sub-desert area on Latitude 12°98'N, Longitude7°75'E in Batagarawa Local Government Katsina State, Nigeria. The main purpose of the reservoir is irrigation and water supply to the people of Katsina, Batagarawa, Mashi, and Mani local Governments. For the purpose of this research, the reservoir was divided into three stations and samples from each station were taken, measured, and analyzed. Taxonomic identification of plankton was carried out with the help of taxonomic keys such as Emi and Andy (2007); Verlencar (2004); Edward and David (2010) and chlorophyll estimation was done using a spectrophotometer at a wavelength of 630, 647, 664 and 750 respectively.

Figure 1: Map of Ajiwa dam showing the sampling stations (Source : Geography Dept UMYU,2020)

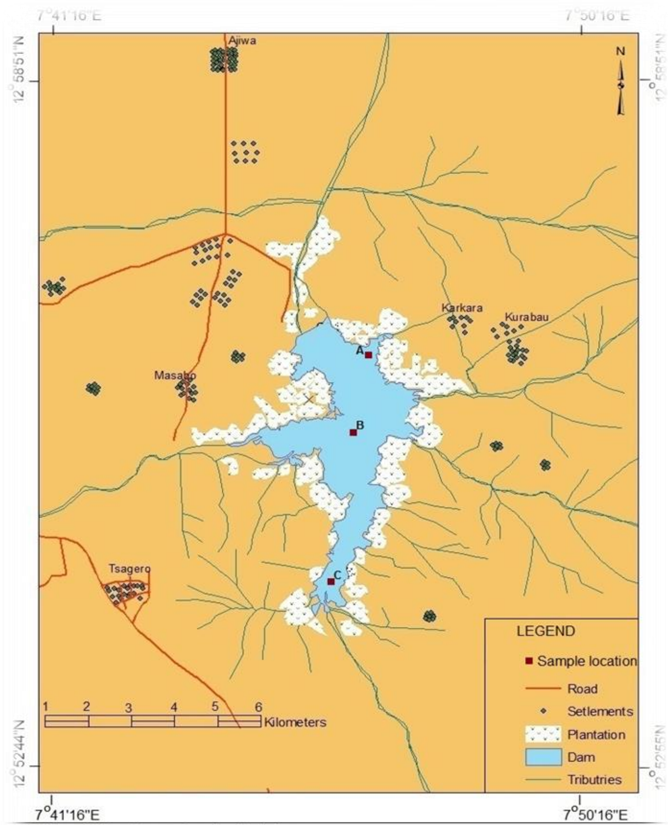

Fig.2: Map of Ajiwa Reservoir as the Study Area
Source:- National Administration and Space Administration Spot Image 2020

Sampling stations

Three sampling stations were selected A, B, and C, for the purpose of this study. Station A was located at the site of the dam where irrigation activities are taking place; station B was located at the site of the dam where human activities like bathing, washing are taking place. Station C was located at the site of the dam where there are fewer agricultural and human activities from June 2019 to January 2020, in which June, November, December, and January are grouped as dry seasons were as July, August, September, and October are grouped as the wet season.

Sampling procedures and preservation

A net of small mesh size of 53µm, used to trawl samples horizontally on the reservoir the net was lowered gently and trawled at a distance of 2m for 3 minutes at constant speed Samples were collected monthly between 8 and 10 am from the reservoir at each station and preserved with Lugol's solution for phytoplankton analyses, (Ayoade *et al*. (2006)). while for the determination of the chlorophyll contents the water was sampled at the surface level by dipping a one-liter plastic sampling bottle sliding over the upper surface of the water with their mouth open against the water current to permit undisturbed passage of the water into the bottle at each station (Tanimu, 2011) The water samples were then transported to the post-graduate laboratory in the Department of Biology, Umaru Musa Yar'adua University Katsina for analysis of plankton abundance and chlorophyll content of the water.

Phytoplankton was analyzed microscopically by taking 1 ml of the sample collected at each station and drops it on a microscopic slide and observed under microscope with various magnifications and the plankton observed ware snap with a camera and the counting of the plankton was done by moving the slides from the top left corner to the top right corner of the slides and identification was done using an identification guide (Tanimu, 2011).

Chlorophyll contents of the water are measured using a spectrophotometer as a method adopted by (Alain Aminot and Francisco Ray, 2009) 100 ml of the water sample from each station were filtered using a Whatman filter paper, after filtration the filter paper was then folded with the algae inside blotted with absorbent paper to remove most of the water and place in a properly leveled clean container the pigment was then extracted by grinding the residue in the filter paper with 90% Acetone and allowed for 5 minutes under subdue sunlight. The mixture was then mixed thoroughly and centrifuge for 10 minutes the sample extracts from the centrifuging tube were then transferred into a cuvette by carefully pipetting and measured using a spectrophotometer at the absorbance of 630nm, 647nm, 664nm, and 750nm.

Statistical analysis

Data obtained from the study were statistically analyzed using the Analysis of Variance (ANOVA) t-test was used to compare the mean between seasons; Pearson's correlation was used to test the relationship between various parameters. A significant level was taken as $P < 0.05$. All the analyses were carried out using SPSS software.

RESULTS

Phytoplankton

Phytoplankton collected from the Ajiwa reservoir were identified up to a generic and specific level, the Phytoplankton composition identified in the three stations belongs to seven groups, which include Bacillariophyceae, Chlorophyceae, Cyanophyceae, Cryptophyceae, Chrysophyceae, Dinophyceae, and Euglenophyceae. Percentage composition of species in the seven identified groups indicated that Chlorophyceae has a total of 397 which represents 33.50% of the total population of the identified species while Dinophyceae represent the seventh texa with a total

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number of 54 individual species with a percentage composition of 4.55% (Table 1).

Chlorophyll has a weak negative correlation with Cryptophyceae (-0.916), Chrysophyceae (-0.757), and dinophyceae (-0.528) in the dry season (Table 4) whereas it has a strong positive correlation with Bacillariophyceae (0.614), Chlorophyceae (0.663), cyanophycean (0.672) and Cryptophyceae (0.995) in the wet season (Table 5).

Table 1 Phytoplankton abundance (%) in Ajiwa reservoir between seasons station combined

Taxon	Bacillariophyceae	Chlorophyceae	Cyanophyceae	Cryptophyceae	Chrysophyceae	Dinophyceae	Euglenophyceae
Dry Season	17.75±6.07[a]	29.25±12.03[a]	12.25±4.78[a]	5.25±2.50[a]	10.25±3.30[a]	3.25±1.50[a]	3.75±1.70[a]
Wet Season	48.50±16.94[b]	70.00±21.21[b]	25.00±5.47[b]	18.25±7.67[b]	26.75±6.99[b]	10.25±4.78[b]	15.75±5.73[b]

Table 2 diversity of phytoplankton (no of individuals) in Ajiwa reservoir between seasons station combined

	Dry season			Wet season			
Taxon/species	A	B	C	A	B	C	Total
Bacillariophyceae							
Diatomella sp	10	7	5	20	15	10	67
Pinmularia sp	9	8	5	15	10	10	57
Navicula sp	12	10	8	23	14	10	77
Cymbella sp	4	7	4	20	15	14	64
Chlorophyceae							
Spirogyra sp	25	12	16	50	30	20	153
Scenedesmu sp	13	10	5	20	18	15	81
Chlamydonana sp	15	13	10	24	20	15	97
Volvox sp	15	8	5	20	10	8	66
Cyanophyceae							
Anabaena sp	6	3	2	15	7	8	41
nostoc sp	8	5	4	14	15	10	56
Chloococcus sp	10	6	5	11	10	10	52

Chryptophyceae							
Cryptomonas sp	15	10	9	30	20	10	94
Chrysophyceae							
Synura sp	21	15	17	40	30	25	148
Dinophyceae							
Ceratium sp	8	5	3	17	13	8	54
Euglenophyceae							
Euglena sp	10	10	8	15	15	10	68

The text with the highest number of phytoplankton species is Chlorophyceae consisting of 397 numbers of phytoplankton species, the texa comprises Sp*irogyra* sp, *Scenedesmu* sp, *Chlamydonana* sp, and *Volvox* sp and the most observed species among the texa was Sp*irogyra* sp it was recorded in the wet season and in station A (Agricultural area). The lowest texa was Dinophyceae consisting of 58 individuals and only one species was observed in this text and are the most observed species which is *ceratium* sp which is also recorded in the wet season in station A (Agricultural area).

Chlorophyll contents

Chlorophyll contents range from (0.45– 1.73) the highest was recorded in the month of August (1.11) and the lowest was recorded in June (0.45). Chlorophyll decreases From August to January. Analysis of variance revealed there was a significant difference in chlorophyll between seasons ($P > 0.05$). Chlorophyll has a weak negative correlation with Cryptophyceae (-0.916), Chrysophyceae (-0.757), and dinophyceae (-0.528) in the dry season (Table 4) whereas it has a strong positive correlation with Bacillariophyceae (0.614), Chlorophyceae (0.663), cyanophycean (0.672) and Cryptophyceae (0.995) in the wet season (Table 5),

$$\text{Chlorophyll } a = \frac{(11.85*(E664 - E750) - 1.54*(E647 - E750) - 0.08\,(E630 - E750))*Ve}{L*Vf}$$

$$\text{Chlorophyll } b = \frac{(-5.43*(E664 - E750) + 21.03*(E647 - E750) - 2.66\,(E630 - E750))*Ve}{L*Vf}$$

Total chlorophyll = sum of Chlorophyll-a and Chlorophyll-b Where:
L = Cuvette light-path in centimeter.
Ve = Extraction volume in milliliter.
Vf = Filtered volume in milliliter.

Table 3 chlorophyll contents (Average of the 3 stations) of Ajiwa reservoir between seasons

Season	Chlorophyll-a (mg/L)	Chlorophyll-b (mg/L)	Total chlorophyll (mg/L)
Dry season	0.33 ± 0.08^a	0.30 ± 0.08^a	0.66 ± 0.14^a
Wet season	1.09 ± 0.02^b	0.56 ± 0.07^a	1.65 ± 0.07^b

Note: the same superscript between seasons indicated no significant difference, different superscript between the seasons indicated there is a significant difference.

Chlorophyll-a and total chlorophyll indicated significant differences between seasons while chlorophyll-b indicated that there is no significant difference between seasons.

Table 4 Correlation between chlorophyll contents and phytoplankton in dry season

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	Bacillariophyceae	Chlorophyceae	Cyanophyceae	Cryptophyceae	Chrysophyceae	Dinophyceae	euglenophyceae
Chlorophyll-a	0.184ns	0.217ns	0.052ns	-0.948*	-0.925*	-0.423ns	0.986ns
Chlorophyll-b	0.994*	0.990*	0.978*	-0.170ns	-0.051ns	-0.283ns	-0.049ns
Total chlorophyll	0.994*	0.884*	0.774*	-0.588*	-0.566*	-0.337ns	0.475ns

*= significant ns= not significant

Table 5 Correlation between chlorophyll contents and phytoplankton in wet season

	Bacillariophyceae	Chlorophyceae	Cyanophyceae	Cryptophyceae	Chrysophyceae	dinophyceae	Euglenophyceae
Chlorophyll-a	0.671*	0.481ns	0.521*	0.957*	0.583*	0.170ns	0.284ns
Chlorophyll-b	0.970*	0.882*	0.973*	0.566*	-0.555*	-0.848*	-0.820*
Total chlorophyll	0.976*	0.907*	0.999*	0.730*	-0.369ns	-0.729*	-0.677*

*= significant ns= not significant

DISCUSSION

The Phytoplankton composition identified in the three sampling stations belongs to seven groups, which include Bacillariophyceae, Chlorophyceae, Cyanophyceae, Chryptophyceae, Chrysophyceae, dinophyceae, and euglenophyceae. In general, Chlorophyceae have a higher abundance than other kinds of algae and the species identified are Sp*irogyra* sp, *Scenedesmu* sp, *Volvox* sp, and *Chlamydonanas* sp this result agrees with the findings of Abdullahi and Indabawa (2005), on the phytoplankton content of Nguru Lake. The dominating presence of Chlorophyta shows gradual deterioration of the water quality. This could be as a result of anthropogenic activities, such as chemicals and wastes washed into it, washing of clothes, and bathing done in some part of the reservoir Balogun *et al.* (2005). The least taxa of phytoplankton recorded during the period of the study are Dinophyceae with a total number of 54 species which accounted for 4.55%. Phytoplankton percentage composition indicated that Chlorophyceae has a total of 397 numbers of individual species which represent 33.50% of the total population of the identified species. Mahar (2003) also observed a phytoplankton community was affected by strong seasonal influence. The monthly and seasonal variation of composition and abundance of phytoplankton may be due to the fluctuations of water and physicochemical parameters in the reservoir. Abubakar (2009) made a similar observation in which he reported that; in tropical regions, the dry and rainy seasons show distinct fluctuations with an abundance of phytoplankton. Abolude (2007) reported that in lakes where domestic, agricultural, and industrial pollution is accelerated, growth of Chlorophyta and Cyanophyta results.

The higher abundance during the wet season could be due to the presence of more nutrients and water levels in the reservoir during the season Balogun *et al.* (2005). The higher phytoplankton count during the rainy season indicated that the reservoir was more productive during the rainy season because phytoplankton is the primary producer in freshwater and determines the link of feeding relationship in the aquatic ecosystem. This corresponds to the observation of Tisser *et al.* (2008) who reported that phytoplankton forms the vital source of energy in the freshwater environment they initiate the freshwater food chain by serving as food to primary consumers which include zooplankton, fish, and others Abolude (2007)

The higher value of chlorophyll content of the reservoir was recorded in the month of August in the wet season this could be due to the high abundance of chlorophyll pigment from the higher algal bloom of phytoplankton in the wet season the result tally with the work of (Francisco Ray 2009) which reported higher concentration of chlorophyll in the wet season then the dry season and this may be due to the fact that more phytoplankton was present in the wet season as a result of the favorable climatic condition and availability of food substances.

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Conclusion

The study has shown that phytoplanktons which include Bacillariophyceae, Chlorophyceae, Cyanophyceae, Cryptophyceae, Chrysophyceae, dinophyceae, and euglenophyceae all varied with seasons. Phytoplankton composition and abundance were increased during the rainy season and decreased with the dry season. The phytoplankton quality of the reservoir is influenced by anthropogenic activities such as runoffs of inorganic fertilizers and pesticides. However, considering that the reservoir is a source of drinking water, the potential of the anthropogenic inputs gains significance. Hence, there is a need for an effective anthropogenic inputs control program in the reservoir.

Recommendations

I. Farming activities very close to the reservoir should be discouraged, in order to reduce the runoffs of inorganic fertilizers and pesticides into the reservoir to avoid eutrophication and pollution

II. More studies should be carried out to identify the plankton compositiosn using polymerase Chain Reaction (PCR) and other Taxonomic identification methods that are not used during this work.

III. There is a need for further study on other planktonic compositions like nano and pico planktons which contribute greatly to primary production in the reservoir

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