SPATIO-TEMPORAL ASSESSMENT OF ZOOPLANKTON OF WUSHISHI (WUSHISHI) LAKE, NIGER STATE

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Abstract

The trophic status of Wushishi Lake Niger State was determined using zooplankton and also to provide a baseline data of its composition. The lake was sampled monthly for two years (2013 to 2014) and the physico-chemical parameters and the zooplankton were studied using the techniques described by APHA 2010. Temperature, pH, Electrical conductivity, BOD and Nitrate, and Total Solids were higher in site 1 whereas Secchi disc transparency, Dissolved oxygen, Water hardness, Alkalinity Phosphate and Magnesium were highest in site 3. Similarly the Temperature, pH, BOD, Hardness, Nitrate, Phosphate, Magnesium, Total dissolve oxygen were higher in the wet season while in the dry seasons, Electrical conductivity, Secchi transparency, dissolved oxygen and alkalinity were higher in the dry season. A total of 39 zooplankton species were recorded, with 14 species of the rotifers, 10 of the copepods and 15 species of the Cladoceran. The zooplankton population was in the following order of dominance, copepods > cladoceran > and the rotifers. The Shannon Wiener diversity index, mergalef's and the evenness have shown a fairly rich diversity of zooplankton supported by a nutrient status of the water body. 84 percent of the zooplankton is recorded in the wet season especially from august to September with site 2 having the highest.

Key words: physico-chemical parameters, oligotrophic, Shannon Wiener diversity index, mergalef's diversity index.

Introduction

The assessment of the population of different organisms at any particular time may form a basis for determining the trophic state that biological community (Hamed *et al.*, 2018).The Zooplankton based on their size can response to changes in nutrient conditions can be modified by other factors such as seasons, grazing and depths.

The use of zooplankton to assess the trophic state of a water body is becoming a novel practice in the maintenance of the water for both aqua-culture and managers of portable water, (Offem et al., 2011). Zooplankton in ecological studies appears in between the phytoplankton and the nekton. This may be applied to predict the activities and abundance of the phytoplankton which serve as food to them and predict the well being of the nekton and productivity of the water body in question by merging the study with physicochemical studies (Robarts et. al 1992).

Physical and chemical parameter changes with seasons and alters the standing crop of the zooplankton, (Shivashankar, & Venkataramana, 2013; Nwinyimagu, 2018) and may not give the actual picture of the interaction between zooplankton and the physico-chemical, Dabhade and Chhaba (2019).

The phytoplankton and both the nekton have different tolerance to different environmental factors to survive, Emir, (2018). The use of zooplankton as indicators of water quality is gaining acceptance in Nigeria, with the work of researchers Like Arimoro and Ogannah (2010), and other parts of the world Saksena, (1987), Ramachandra *et al.* (2006), *Pramila* et al. (2008), Dabhade and Chhaba (2019) forms the link behind the assessment of the trophic status of each water body. Standing crop of each community at a particular time is paramount in the determination of the trophic state. Wushishi (Wushishi) Lake was constructed to avert the seasonal flooding of the about of 900 hectares and drainage control works of 1,215 hectares, Upper Niger River Basin Development Authority (UNRBDA, 1989). Wushishi (Wushishi) Lake have not received attention from researches and large amount of subsistence farming is common in the area. With change in the use of chemical for farming in most part of Nigeria (WHO/UNEP (1997), bathing fishing and domestic activities, the lake is vulnerable to anthropogenic domestic activities which may impact on the quality of the water which will translate to zooplankton standing crop. Monthly data on the lake water quality of the environmental variables may help in assessing interference of lake indicators. Environmental factors and anthropogenic activities are the variables that cause changes in zooplankton populations. In this research the record of environmental factors were used to infer the changes on the community structure of the zooplankton and the trophic state of the lake as a whole.

MATERIALS AND METHODS

Study Area

This research was conducted in Wushishi Lake with coordinates 9° 40 °0' and 6° 3' 0'. It is located 7.50 kilometres away from Wushishi town of Wushishi Local Government in Niger state. It was constructed to avert the seasonal flooding of 900.00 hectares and used for the Irrigation of 1215 hectares. It was built across River Ubandawaki and River Bankogi and completed in 1988.

It is situated in the woodland savanna. The mean annual rainfall stands at 125.00 mm, decreasing from east to west (Chima et al. 2011) with a single peak of rainfall in September. Mean maximum temperature of the area is 85.00°F the hottest months of the year are March and April, though high day temperature persists throughout the year.

Sample collection: Samples were collected at the surface of the water for physico-chemical and zooplankton. The first site (A) was at the bank which varies with seasons. At this area washing of domestic cloth and plates, boat landing area, processing of fish catches was done. This sampling site has sparse vegetation and it slopes in to lake carrying run off from long distance of about 50.00 meters into the lake during raining season. Samples were collected from the surface of the water, at 5.00 meters away from the bank in the dry season.

The second site (B) is 75.00 meters away from the site 1 into the Lake. The third site is 150.00 meters away from site 2 (C) into the Lake which is about the middle of the lake.

Sampling and Analysis:

Samples are collected monthly from February 2013 to January 2015. Samples are collected at about 9.00am to 11.00am at the three sites. Subsurface water samples were collected in 5.0 litres sampling bottles in triplicates at all the three sampling sites. These are used for the analysis of the physico-chemical character of the water. Temperature and Secchi transparency were determined in situ with Mercury in glass thermometer while the Secchi transparency was measured using a 25.0cm diameter black and white alternately painted disc. Conductivity is measured using a conductivity meter with a model number LF90 (0.N) 0 300210) after calibrating it with the buffers. Other physico-chemical parameters measured were Dissolved Oxygen, Biological Oxygen Demand, Hardness, Alkalinity, nitrate, phosphate, magnesium and total dissolved solids were determined according to the techniques described by APHA. (2009).

The zooplankton were samples were collected using a plankton net with mesh size of 20.0µm on a manual powered canoe by towing through a time of about 5.00 minutes. Collected samples were concentrated to a volume of 60.00 cm^{-3}. Samples were fixed with 4% buffered formalin and stored for 24.00 hours to settle. The volume is further reduced by decanting the top 50.00 cm^{-3}.

Exactly 1.0 cm^{-3} of the sample poured on a microscope slide drop by drop and the zooplankton encountered were enumerated. A camera with the model number HCDE10C is fitted in the eyepiece of a binocular microscope (Mag X40) with model number XSZ-107E is connected to the computer is used to count. Zooplankton encountered were identified using the keys of Jeje and Fernando (1986) and Haney et al., 2013.

Relative abundance was calculated as number of individuals per litre of the filtered water through the net.

Margalef's and shannon wiener diversity indices were determined using the PAST 4, statistical package. From the data generated the seasonal distribution of the zooplankton was determined and relationship between the physico-chemical parameters and the zooplankton were determined using canonical correspondence analysis of the Past 4 software.

RESULTS

Table 1.0 describes the spatial distribution of physico-chemical parameters recorded in the sampling sites. The temperature ranged from 19.50^{0}C to 32.00^{0}C with the highest mean value of 27.88±3.71 in site 1. The lake water showed a weak buffering capacity throughout the sampling period with alkalinity values ranging from 12.11 to 24.00mg/l with a highest mean value of 15.70mg/l and the corresponding pH value ranges from 6.35 – 8.40 in site 3. Transparency, Dissolved oxygen, Hardness, Alkalinity and Magnesium were lower while Electrical conductivity, Biological Oxygen Demand, Nitrates and Total Dissolved Solids was highest in site 1. The Transparency of the water is low with values ranging from 8.30-24.60cm and a mean value of 17.85cm. The Phosphate concentration ranged from 0.04-0.8 mg/l with a mean value of 0.04±0.01 while that of Nitrate had a mean value of 0.28±06 and it ranged from (0.17-0.63) mg/l. The Dissolved Oxygen value ranged from 5.15 to 7.80mg/l with a mean value of 6.21mg/l where as Total Dissolved Solid ranged from 13.06 to 40.05mg/l with a mean value of 4.90mg/l. The Electrical conductivity values ranged from 247.50 to 399.00 µS/cm with a mean value of 299.75 µS/cm. the BOD values recorded ranged from 2.00 to 6.05mg/l with a mean value of 3.85mg/l.

The seasonal distribution of the physical and the chemical parameters of the water body in figure 1.0 showed that total dissolved solids was more prominent of the physical and the chemical parameters

studied. And the wet season values were higher compared to the dry season. Generally the wet season was more than that of the dry season. The wet and dry season distribution of zooplankton (Table 3.0) recorded have shows that the wet seasons have more of the zooplankton, with *Moina* topping the list. *Filinia* and *Allonelidae* were not recorded in the wet season.

The total number of monthly distribution of zooplankton through the two years sampling period was described in Figure 3.0. The monthly distribution has shown that organism population stats to reduce from the month of February up to May, and by the month of June they start to increase generally in the two sampling sessions. May values were the lowest in all the three sites. In 2014, site 1 values were highest from October to January, while in 2015 it was site 2 values that were higher from September to December 2015. Though the lowest values were recorded from site 1 consistently, the higher values revolve around site 2 and site 3.

More of the organisms were recorded during the 2013/2014 (6972) season compared to the 2014/2015 (4573) sampling season (Table 4.0). Highest numbers of the organisms were recorded in site 1(1342.5) (Table 3.0) while the least was observed in site 3(2290), and Cladoceran were more while the copepods were the least. A total of 39 different taxa with 2674 individuals were recorded in site 2 while the least recorded was in site 1 with 35 different taxa having 1342.5 individuals.

The Shannon Weiner diversity index of the community shows that community is even and rich in organisms. The dominancy of a particular organism will be unlikely. The diversity of the zooplankton in the lake is very high (Shannon Wiener diversity index) this shows that the organisms in the lake is even, rich and very diverse in all the three sites. This means that dominance of a specific organism is low.

The physico-chemical parameters of the wet seasons (Table 2.0) were more than that of the dry seasons except Electrical Conductivity, Transparency Dissolved Oxygen and Alkalinity.

Table 1.0 Mean (±SD) values of some physical and chemical parameters in Wushishi Lake 2013 to 2015. (maximum and minimum in parenthesis).

	Site 1	Site 2	Site 3
Temperature °C	27.88±3.71 (19.50-32.00)	27.88±3.70 (21.00-31.00)	27.85± (20.33-31.00)
pH	7.19±0.24 (6.75-7.60)	7.11±0.34 (6.35-7.65)	7.18±0.26 (6.80-7.75)
Conductivity (µS/cm)	310.46±14.67 (273.50-344.00)	298.5±18.30 (247.50-399.00)	278.3±8.35 (251.00-303.50)
Secchi (cm)	15.68±4.52 (8.30-24.60)	18.57±2.73 (15.25-24.25)	19.31±3.88 (15.35-23.60)
Dissolved Oxygen (mg/l)	5.92±0.40 (5.15-6.85)	6.15±0.50 (5.35-7.35)	6.55±0.66 (5.65-7.80)
BOD (mg/l)	4.09±0.99 (2.52-6.05)	3.86±0.96 (2.20-5.55)	3.61±0.91 (2.00-5.50)
Hardness (mg/l)	34.14±5.49 (27.75-43.50)	35.93±4.60 (28.20-43.50)	39.18±6.64 (28.00-54.00)
Alkalinity (mg/l)	15.31±2.51 (12.26-22.70)	15.42±2.65 (12.16-22.90)	15.70±2.94 (12.11-24.00)
Nitrate (mg/l)	0.29±0.11 (0.17-0.58)	0.28±0.09 (0.16-0.48)	0.28±0.11 (0.16-0.63)
Phosphate (mg/l)	0.11±0.01 (0.04-0.8)	0.07±0.03 (0.04-0.13)	0.19±0.01 (0.04-0.13)
Magnesium (mg/l)	6.75±2.13 (2.72-9.90)	7.06±1.83 (2.68-9.44)	7.22±1.94 (2.67-8.98)
Total solids (mg/l)	25.35±1.90 (13.0-40.05)	23.25±1.82 (13.0-36.95	24.95±1.81 (15.25-39.80)

Values are means and standard deviation with rage in brackets.

Table 2.0 Mean seasonal distribution of physico-chemical parameters recorded in Wushishi Lake 2013/2015

	Wet	Dry
Temperature (°C)	25.13833	23.945
pH	7.22	7.101667
Electrical Conductivity µs/cm	111.8033	121.64
Transparency (cm)	16.73333	18.97833
Dissolved Oxygen (mg/l)	8.895	9.516667
B.O.D. mg/l	4.263333	3.45
Hardness (mg/l)	39.44333	33.38167
Alkalinity (mg/l)	15.15167	15.80333
Nitrate (mg/l)	0.28	0.27
Phosphate (mg/l)	0.605	0.585
Magnesium (mg/l)	7.015	6.396667
Total Dissolved Solids (mg/l).	311.75	182.4

Table 3.0: Mean Seasonal Distribution of Zooplankton in Wushishi Lake 2013/2015

	Wet	Dry
Asplanchna spp	9.30	4.91
Brachionus spp	1.77	0.73
Keratella spp	10.58	9.02
Filinia spp	0.00	2.38
Ptygyra spp	0.33	1.53
Testudinella spp	4.42	0.90
Trocosphaere spp	10.96	8.75
Cyclops spp	7.69	7.56
Diacyclops spp	12.21	7.61
Limnocalanus spp	6.90	0.98
Leptodiaptomus spp	6.32	5.84
Skistodiaptomus spp	5.50	2.83
Tropocyclops spp	2.23	1.61
Allonelldae spp	0.00	0.083
Nauplius spp	5.31	2.63
Microcyclops spp	7.05	4.54
Ceriodaphnia spp	12.81	5.13
Moina spp	17.5	6.66
Diaphanosum spp	8.27	6.15
Total	129.15	80.57

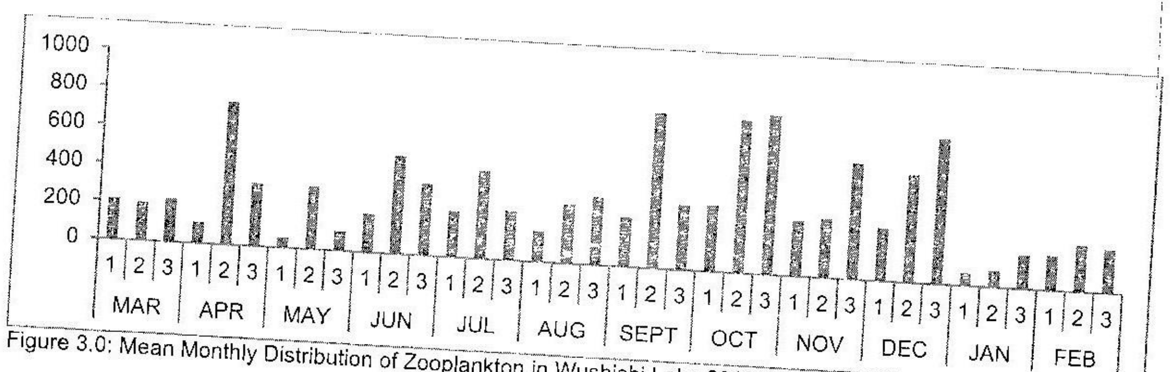

Figure 3.0: Mean Monthly Distribution of Zooplankton in Wushishi Lake 2013/2015.

Table 2.0: Mean Values of Zooplankton Recorded in Wushishi Lake 2013 to 2015.

Taxa	SITE 1	SITE 2	SITE 3	% Abundance
Rotifera				
Asplanchna herricki (de Guerne, 1888)	47	59	53.5	2.5
Asplanchna perodonta (Gosse, 1850)	32.5	89.5	100	3.5
Anuraeops racenensi, Gosse, 1851)	61.5	133.5	127	5.1
Brachionus angularis, Gosse, (1851)	4	8.5	0.5	0.2
Brachionus calyciflorus, Pallas,(1776)	16	14.5	11.5	0.7
Brachionus fulcatus, Zacharias, (1898)	2.5	15.5	7.5	0.4
Brachionus quadridentatus, Hermanns, (1783)	7	17	6.5	0.5
Brachionus variabalis, Hampel, (1896)	0	1	0	0
Filinia terminalis,Plate, (1886)	7	21	0.5	0.5
keratella choachlearis (Gosse, 1851)	111	173.5	171.5	7.2
Ptygyra melicarta (kellicott, 1882)	22	23.5	37	1.3
Testudinella caeca (Parson 1892)	59	73.5	64.5	3.1
Testudinella patina, Hermann, (1783)	4	3	1	0.1
Trochosphaera aequatorialis (semper1892)	15.5	97.5	60	2.7
Copepoda				
Limnocalanuus macrurus, Sars, (1863)	13.5	10.5	21.5	0.7
Trophocyclops prasinus mexicanus, Kiefer, (1938)	1	5.5	4	0.2
Leptodoaptomus ashlandi (Marsh, 1893)	57.5	110	72.5	3.8
Leptodoaptomus coloradensis (Marsh, 1911)	87	143.5	140	5.9
Trophocyclops prasinus mexicanus (kiefer, 1938)	37.5	30.5	40	1.7
Leptodoaptomus novomexicanus (Herrick, 1895)	30	48	50.5	2
Leptodoaptomus sicilis (S. A. Forbes, 1882)	40	83.5	121.5	3.9
Leptodoaptomus signicaudata (Lilljeborg in Guerne and Richard, 1889)	28	61	45.5	2.1
Leptodoaptomus tyrelli (Lilljeborg in Guerne and Richard, 1889)	50.5	98.5	78	3.6
Skistodiaptomus reighardi (Marsh, 1895)	24.5	30	17	1.1
Cladocera				
Allona exigua, Lilljeborg, (1853)	0	8.5	10	0.3
Eubosmania tubicen; (Brehm,1953)	21.5	54	102	2.8
Cyclops strenuous, Fischer, (1851)	75	87	86	3.9
Diacyclops Thomasi (S. A. Forbes, 1882)	47	83	84	3.4
Microcyclops albidus, Jurine, (1820)	29.5	95	54.5	2.8
Microcyclops varicans, Sars, (1863)	79.5	295.5	156.5	8.4
Mycrocyclops fuscus (Jurine, 1820)	0	5	0	0.1
tropocyclops equitorialis, (kiefer, 1938)	30.5	62.5	62.5	2.5
Ceriodaphnia reticulata Jurine 1820	83.5	97	70.5	4
Macrochaetus colinsi (Norman & Brady, 1867)	0	3.5	2	0.1
Moina macrocopa (Straus, 1820)	38.5	65.5	79.5	2.9
Moina macrura (Kurz, 1874)	51	162	134	5.5
Diaphanosum birgei (Korinek, 1981)	31	79.5	72.5	2.9
Diaphanosum excisum, Sars, (1885)	57.5	85	94	3.8
Diaphanosum sarsi (Richar 1894)	39.5	139.5	50.5	3.6

Table 3.0: Diversity Indices and the Number of Individual Taxa Recorded.

0	SITE 1	SITE 2	SITE 3
Taxa_S	35	39	37
Rotifers	389	730.5	641
Copepods	332	590.5	550.5
Cladocera	621.5	1353	1098.5
Individuals	1342.5	2674	2290
Shannon_H	3.302	3.291	3.284
Evenness_e^H/S	0.7763	0.6893	0.7209
Margalef	4.721	4.815	4.653

DISCUSSION

Spatial Distribution of physico-chemical Parameters.

The temperatures recorded in the three sites do not show much variation and the value observed is a typical of African lakes, (Arimoro *et al.*, 2008; Adebisi, 1981; Ovie and Adeniji, 1993). The Secchi transparency, observed may be due to the depth of the water, where site 3 was deeper than site 1. The low value of the Secchi disc transparency is site 1 could be due to decreased depth, increased boating activity that could cause more rowdiness causing increased conductivity. Generally the transparency of the water was very poor. This is a direct opposite of the report of Imoobe and Adeyinka (2010). The values they recorded ranged from 0 to 1.2NTU, which is equivalent to more than 85.0 Centimeters and it was conducted in the rain forest in Ovia River, 25.0 kilometers from Benin City.

The dissolved oxygen was high and within the range (7.80-5.15 mg/l) required for aquatic growth and the values increase from site 1 to site 3, may be indicating level of purity of water. While the BOD values were high and decrease from site 1 to site 3 with a range from 6.05 to 2.0 mg/l.

The value of nitrate in the lake water was very low with a value ranging from 0.63 to 0.16 mg/l while phosphate was very high with values ranging from 0.80 to 0.04 mg/l. The farming activity, washing of cloths and plates around the area could be a reason (Ubwa, 2013; Chimuriwo, 2016). Nitrate is a product of decomposition of organic matter where the highest of BOD was in site 1, and it translates higher levels of nitrate. This was similar to the report of Arimoro and Ogana 2010 who reported High values of and BOD in a site that received higher load of waste water from a slaughter house in Agbor in the Niger Delta, Nigeria. The buffering capacity of the water was low with alkalinity values that ranged from 24.00 to 12.22 mg/l with a corresponding pH range of slightly acidic to neutral value. The productive nutrients like, nitrates, phosphates, BOD of site 1were most dominant than all the other three sites.

Seasonal Distribution of Physico-Chemical Parameters

The physico-chemical parameters of the wet seasons (Table 2.0) were more than that of the dry seasons except Electrical Conductivity, Transparency Dissolved Oxygen and Alkalinity.

This correlates with the increase of zooplankton population in the wet season and shows that wet season that brings in more nutrients into the lake directly influences the population of the zooplankton, this is in agreement with the report of Arimoro and Ogana (2010) and Egborge (1984) who also reported increase physico-chemical parameters in the rainy season which tallies with increase zooplankton population.

Secchi transparency was found to be higher in the dry season this was true all lakes in Northern Nigeria due reduced influx of runoff into the water shade, Kemdrim, (1990), Ibrahim et al. (2009) and Zahraddeen et al. 2019. Lower transparency may translate to low productivity in the wet season.

Seasonal Distribution of Zooplankton

Mustapha (2010) also reported that the wet season (November to April) zooplankton were more ubiquitous than that observed in the dry season months (May to October), this similar to that observed in this report. Also the general composition of the zooplankton were observed in all the season, except that their abundance were not the same and for a few species like *Filinia spp, Allonelldae spp* that were not observed in the wet season. Most abundant in the wet season were *Diacyclops spp*, and *Ceriodaphnia spp*, while in the dry season, the highest organism observed was the keratella. The dry seasonal distribution show that the population of the zooplankton have reduced compared to the wet season. The spatial population of the individuals in the sites (table 3.0) were in this order, 3>2>1. The zooplankton (table 3.0) indicated higher species diversity and evenness, lower dominance, lack of quantitative importance of individual species, low densities and equitable abundance of the majority of species in both seasons Sharma 2011.

It was observed that more zooplankton were encountered in the wet seasons of the two years, from the months of June to February (figure 3.0) after which the population starts to drop. Increase in the population from the month of could be attributed to the influx nutrients (table 2.0) into the lake water from tributaries in the lake (Noris and Laws 2017).

Zooplankton Composition

The composition of the zooplankton observed in this study is in the following order Cladocera > Rotifers > Copepods. The zooplankton composition recorded in this study was similar to that observed by Ikhuoriah et al (2015), Neves et al. (2003), Sharma, et al (2010). The Shannon Wiener diversity index, Margalef's and the evenness have shown a fairly rich diversity of zooplankton supported by a nutrient status of the water body. Therefore, the lake is not under a serious threat to pollution during the study period. Shannon diversity index showed that site 1(3.302) was more diverse than site 2(3.291) and site 3 (3.284) was the least. The high diversity in site 1 could be due to increase in the physico-chemical parameters which the run off transports into in site 1. The zooplankton population recorded in the lake varied monthly and more were recorded in the wet season. This was in consonance with the report of Mustapha (2010) who reported that the rainy and dry season are the drivers of changes observed in the lakes. The total zooplankton recorded during the study were 11545, with the Cladoceran having a population of 4292, the copepods were 4833 and the rotifers were 2420.

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