ENVIRONMENTAL CORRELATES OF ZOOPLANKTON COMMUNITY STRUCTURE IN DOWNSTREAM KADUNA RIVER, NIGERIA.

BY

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ABSTRACT

Assessment of water quality a water body can be done using resident biota. Zooplankton has been adjudged to give true picture of anthropogenic activities occurring in any water body. Zooplankton samples were collected for a period of four month from the river receiving water from the Shiroro dam, Nigeria. The physico-chemical and the anthropogenic effect on the distribution of the zooplankton were studied. Mean and standard deviations of physiological parameters ranged from; Temperature 24.5±1.73 to 25.5±3.70^{0}C, Transparency 0.18±0.09 to 0.36±0.03, pH 6.4±0.93 to 6.73±1.13, Conductivity 90.3±24.00 to 93.85±16.83µs/cm, D.O 2.66±0.21-3.21±0.54mg/L and BOD 2.75±0.50±4.00±0.82mg/L from site 1, 2, and 3 respectively. Monthly mean and standard variations of Temperature, Transparency, pH, Conductivity, DO, ranged from 22.67±1.53 to 27.00±3.00^{0}C, 18.00±2.65 to 22.67±11.01m, Transparency range from 18.00±2.65 to 22.67±11.01m, 5.82±0.02 to 7.19±0.01, 80.37±22.41 to 106.80±0.98µs/cm, 2.43±0.21 to 3.29±0.57 to 4.00±1.00mg/L from March to June respectively. Physicochemical parameters correlated positively with most species of zooplankton encountered. A total of 237 zooplankton belonging to 16 different families comprising rotifer cladocera and copepods were recorded. *Leptodiaptomus coloradensis* was the highest and the least recorded was *Daphnia magna*, *Cerodaphnia reticulata*, *Eucylops elegance* and *Anthocyclops robustus* least recorded. It is confirmed that downstream part of Shiroro dam is a good community that support an assemblage of Zooplankton species with sampling station B.

Keywords: physicochemical parameters, anthropogenic activities, spatial and temporal variations, zooplankton.

INTRODUCTION

Zooplankton is a generic term describing animals that have limited locomotive ability relative to the water bodies they inhibit. They vary in size, ranging from 2 nm (micro-zooplankton) to 2m in diameter (some jelly fish), constitute an important food source for many species of aquatic organisms (Guy, 1992). Zooplankton communities are highly divers, containing representative of at least a dozen phyla (Richardson *et al*., 2009). Almost all marine animals,

weather they live in the water column or on the sea floor, occur in the zooplankton at some stage of their life history, such as the egg or larvae of lobsters, sea star most fish and corals.
Fish prefers to eat the larger and more visible kind of zooplankton, therefore zooplankton that coexist with fish are typically small (less than 1 to 1.5 millimetres) and transparent (Anonymous, 2007). They consist of Protozoans, Cladocera, Copepod, Rotifera and serves as indicators of water quality(Jeje and Fernando, 1966). Their communities are highly sensitive to environmental variation, such as water temperature, light, PH, oxygen, salinity, toxic contaminant, food availability (algae and bacteria), and predation by fishes and invertebrate (Paterson2001). In that way changes in their abundance, species diversity, or community composition can provide potential indication of environmental changes or disturbance (Paterson, 2001).

Zooplankton constitute an important component of lake ecosystem and their central position in food web allows transferring energy and matter from primary producers (algal biomass) to higher tropic levels such as fish, (Keda r*et al.,* 2008). Moreover, by grazing on phytoplankton and bacteria they help in improving water quality (Pinto-coelho *et al*., 2005).

The most important role of zooplankton is as grazers in ocean food web, providing the principal pathway of energy for primary producers to consumers at higher tropic levels such as tuna, seals, and sharks. The copepods are the most abundant multi-cellular animals on earth, out numbering insect by possibly three orders of magnitude (Schminke, 2007).
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Zooplankton plays an important role in shaping the extent and pace of climate change (REF). The ocean’s ability to act as a sink for CO_2 relies partially on the biological pump. By this process much of the CO_2 that is fixed by phytoplankton is used by the zooplankton and is subsequently exported to deeper layer through sinking of faeces and carcasses. Zooplankton also migrates each day in to the ocean depth to avoid near-surface predatory fish thus aiding the export of carbon to deeper waters. Without the diverse role performed by zooplankton, our ocean will be devoid of almost all the large fish, mammals, and turtles that are of such immense aesthetic and financial value to society. Zooplankton also play a key role as an efficient filter feeder on phytoplankton, and as a source of food for other invertebrate, fish larvae and fish, (Deksne*et al*. 2011).
The short life time of zooplankton makes them suitable indicators to assess the ecosystem health due to their ability to respond quickly to environmental stress (Gannon and Stemberger, 1978). It is well known that there is an inverse relationship between zooplankton richness and abundance and the concentration of total dissolved solid (Ivanova and kazantseva, 2006). Due to the increasing environmental stress produced by the increase in salinity (Herbst, 2001), but in saline lakes, biomass tends to be higher due to the occurrence of large-sized zooplankton specie that can thrive since the environmental stress causes lack of fish (Evans*et al*, 1996). In Nigeria the study of zooplankton has been developed mostly in large river and lakes. Such studies have focused on descriptive ecology emphasising faunal composition, spatial and temporal distribution and plankton succession in newly-formed reservoirs (Segers, 1993). There is little or no information on the zooplankton diversity of

downstream Shiroro Lake in Niger State. There is the need for baseline information on the diversity of zooplankton in this end of the Lake.

MATERIALS AND METHODS

Study Area

Shiroro Reservoir was created in May, 1984 by damming the Kaduna River at Shiroro village, Niger, Nigeria. Its coordinate is: Latitude =9.9724, Longitude=6.83532. The reservoir has an estimated surface area of 312 km2 and a mean depth of 22.4 meters and continues to grow. It is now the second largest man-made lake in Nigeria followed by Jebba and Tiga. The Shiroro Hydropower Reservoir, like most other newly created large man-made lakes in Nigeria and throughout the tropics, was expected to provide favourable conditions for large scale fish production and fishery development, (www.fao.org/DOCREP/005/T1230E07.htm//em.wikipedia.org/wiki/list of dams and reservoirs in Nigeria).

The area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30.2^0C, 61.00% and 1334.00mm, respectively. The climate presents two distinct seasons: a rainy season between May and October, and a dry season (November - April). The vegetation in the area is typically grass dominated savannah with scattered trees. Though, a heterogeneous community, residency in Minna is dominated by three major tribes namely, Gwari, Nupe and Hausa, with reasonable presence of Yoruba and Igbos, (The Nigerian Congress, 2009).

Sampling Sites

Samples were collected in such a way that it will cover the study area. Three sampling sites were selected.

Site 1. This is the area that is completely isolated from interference of the people, and it is far up to turbine effluent.

Site 2. This is an area through which the ferry boat passes by.

Site 3.This is an area which has a slight rowdiness. And it has a slight interference by the canoe.

Zooplankton Collection

Samples were collected twice monthly for four months from march to June 2013.The collection of zooplankton was carried out with the aid of plankton net with mesh size of 0.025µm.The zooplankton were collected by taking vertical hauls and concentrating it in to a 60.0mls bottle. Collected samples were preserved by adding formalin to make 4% (i.e. the final concentration). The samples were taken to the laboratory for analysis.

Zooplankton Analysis

Samples were kept for 24 hours for specimen to settle. Samples were concentrated by discarding the top 40.0mls by siphoning with a dropper. 1.0 mls of the sample was dropped on the slide and mounted on the microscope (with the model number XSZ-107E-049327) for analysis. Zooplankton observed were enumerated and recorded.

Physicochemical Analysis

Determination of pH

The pH was measured using a pH meter with model number jenway 3305.The temperature was measured using 100.00 graduated mercury in glass thermometer, transparency was determined using a 25.cm diameter Secchi disc, conductivity was determined using conductivity meter with model number LF 90(0.N0 300210), Dissolved Oxygen and Biological Oxygen demand was determined according to the method of APHA (2009). Result obtained was analysed using SPSS 20.0 version. ANOVA was used to test for significant difference, Duncan Multiple Range Test was use to separate their means and Pearson correlation was used to test for association between the variables.

RESULT AND DISCUSSION

Results

Mean spatial distribution of physicochemical parameters in Shiroro Lake (downstream), Niger State.

Table 4.1.1 highlighted the mean spatial distribution of physicochemical parameters in downstream of Shiroro dam of Niger State. All the physicochemical parameters varied significantly ($P < 0.05$) between the sites though variation is very slim, except pH that shows no significant difference ($P > 0.05$) between the sites. The mean physicochemical parameters ranged as follows; temperature from 24.5 to 25.3^oC, transparency from 0.18 to 0.36m, pH from 6.41 to 6.73 for site 3 and 1 respectively, conductivity from 90.00 to 93.85μS/cm for site 2 and 3 respectively, D.O from 2.60 to 3.21mg/l for site 2 and 1 respectively, and B.O.D from 2.75 to 4.00mg/l for site 1 and 3 respectively. However, temperature, transparency and dissolve oxygen (D.O) were significantly higher ($P < 0.05$) in site 1. More so, Temperature and D.O were not significantly different ($P > 0.05$) in site 2 and 3, while Transparency, conductivity and Biological oxygen demand (B.O.D) were significantly different in site 2 and 3.

Table 4.1.1: **Mean spatial distribution of physicochemical parameters in Shiroro Lake (downstream), Niger State.**

Site	Temperature (^oC) Mean ±S.D	Transparency (m) Mean ±S.D	pH Mean±S.D	Conductivity (μS/cm) Mean ±S.D	D.O (mg/l) Mean±S.D	B.O.D (mg/l) Mean±S.D
1	25.5±3.70^b	0.36±0.30^c	6.73±1.13^a	92.25±10.41^{ab}	3.21±0.54^b	2.75±0.50^a

2	24.8±3.86^{a}	0.24±0.06^{b}	6.50±0.89^{a}	90.30±24.00^{a}	2.60±0.21^{a}	3.25±1.50^{b}
3	24.5±1.73^{a}	0.18±0.09^{a}	6.41±0.93^{a}	93.85±16.83^{b}	2.7±10.40^{a}	4.0±0.82^{c}

Mean values followed by the same superscript alphabets in the same column are not

PARAMETERS (Units)	MARCH Mean±SD	APRIL Mean±SD	MAY Mean±SD	JUNE Mean±SD
Temperature (^{o}C)	26.67±3.51^{b}	23.33±1.52^{a}	27.00±3.00^{b}	22.67±1.53^{a}

significantly different (P > 0.05)

Mean monthly physicochemical parameters of Shiroro Lake (downstream), Niger State.

Mean monthly physicochemical parameters of downstream Shiroro dam are highlighted in table 4.1.2. All the parameters showed monthly variation during the study period. Mean temperature ranged from 22.67^{0}C to 27.00^{0}C in June and May respectively. Statistically temperature recorded in the month of March and May were not significantly different (P > 0.05), and also April and June follow the same trend. Mean transparency ranged from 0.18 to 0.23m for April and March respectively, March and May showed the highest significant variation in transparency. pH recorded during the study also varied significantly between March and June and ranged from 5.82 to 7.19 in March and April respectively. Mean water conductivity ranged from 81.00 to 106.80µS/cm in April and June respectively, and only March and June show significant variation. Dissolved Oxygen recorded during the study period ranged from 2.43 to 3.29mg/l for April and June respectively and they also show significant variation while other months do not. Lastly Biological Oxygen Demand recorded ranged from 2.67 to 4.00mg/l for April and May, though it shows significant variation between all the months during the study period.

Table 4.1.2: **Mean monthly physicochemical parameters of Shiroro Lake (downstream), Niger State in 2013**

Transparency (m)	0.23+0.11[c]	0.18±0.03[a]	0.20±0.11[b]	0.18±0.09 [a]
pH	5.82±0.02[a]	7.19±0.01[c]	6.94±1.39[c]	6.21±0.87[b]
Conductivity µS/cm	99.33±7.56[b]	81.00±11.21[a]	80.37±22.41[a]	106.80±0.98[c]
D.O (mg/l)	2.90±0.56[ab]	3.29±0.47[b]	2.68±0.15[ab]	2.43±0.21[a]
B.O.D (mg/l)	3.00±1.00[ab]	2.67±0.57[a]	3.67±1.52[b]	4.00±1.00[c]

Means follow by the same super script alphabets in the same row are not significantly different at ($P > 0.05$)

Correlation coefficient of physicochemical properties of Shiroro Lake (downstream), with abundance of Zooplankton species during the study period.

Physicochemical parameters recorded during the study period correlated positively with most species of zooplankton encountered, few of them correlated negatively while only *Leptodiaptomus minutus* show no correlation with Biological Oxygen Demand (B.O.D). Out of the 12 Zooplankton species recorded, 7 species correlated negatively with Temperature, pH and Dissolved Oxygen; 5 species with Transparency and 4 species with Conductivity and 3 species with B.O.D.

Table 4.1.3: **Correlation coefficient of physicochemical parameters of Shiroro Lake (downstream), with abundance of Zooplankton species during the study period.**

Zooplankton species	Temperature (°C)	Transparency (m)	pH	Conductivity (µS/cm)	D.O (mg/l)	B.O.D (mg/l)
Leptodiaptomus coloradensis	-0.28	-0.33	0.64	-0.62	0.94*	-0.78*
Meagacyclops viridis	-0.92*	0.87*	-0.46	0.05	-0.37	0.49
Moina macrura	-0.75*	-0.51	-0.41	0.81*	-0.59	0.17
Daphnia longiremus	-0.58	-0.35	-0.54	0.88*	-0.73*	0.30
Eucyclops elegance	0.52	0.87*	-0.76*	0.37	0.14	-0.37
Daphnia magna	0.52	0.87*	-0.76*	0.37	0.14	-0.37
Daphnia pulex	0.76*	0.34	0.47	-0.76	0.07	0.44
Leptodiaptomusminutus	0.13	-0.30	0.96*	-0.97*	-0.51	0.00
Ceratodaphnia reticulate	0.62	0.17	0.42	-0.58	-0.27	0.73*

Ceriodaphniacornuta	-0.04	-0.30	0.06	0.15	-0.86*	0.95*
Bominopsisdietersis	-0.67	-0.52	-0.35	0.75	-0.72*	0.37
Anthocyclopsrobustus	-0.67	0.52	-0.35	0.75*	0.72	0.37

* = significantly correlated (P = 0.05)

Means partial abundance of Zooplankton species in Shiroro Lake (downstream), Niger State.

Mean spatial distribution of Zooplankton species are presented in figure I. The species showed spatial distribution in the same trend according to sites. In each site, seven different species were encountered; though site 3 record significantly higher species than the other two sites. *Leptodiaptomus coloradensis, Megacyclops viridis, Moinama crura* and *Daphnia pulex* showed significantly higher density in site 3, followed by site 1, and site 2 record the least though,*Moina macura* and *Daphnia pulex* record zero species in site 2. *Leptodiaptomus minutes* and *Daphnia longiremus* showed similar trend in their distribution at site 3 record zero Zooplankton species with higher abundance in site 1, followed by 2. However, *Eucyclops elegance* was not found in site 1, with highest recorded in site 3 and lowest in 2. *Bominopsis detersis*, *Daphnia magna*, *Anthocyclops robustus*, *Ceratodaphnia reticulate and Ceriodophnia cornuta* were the only species encountered in site 1, 2, 2, 3 and 3 respectively.

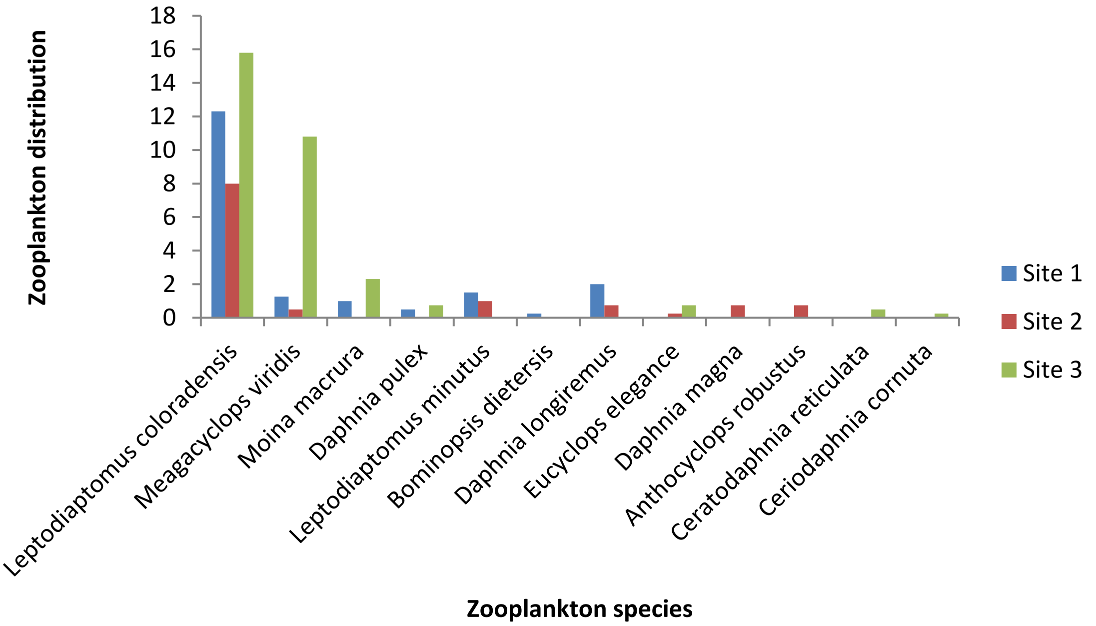

Figure I: Mean Spatial distribution of Zooplankton species in Shiroro Dam (down stream), Niger State.

Mean monthly abundance of zooplankton species in Shiroro Lake (downstream), Niger State

Mean monthly distribution of Zooplankton species are presented in figure II. *Leptodiaptomus coloradensis* and *Megacyclops viridis* were the common species recorded throughout the four months of study, though *Leptodiaptomus coloradensis* were significantly higher in April, followed by March, May and June recorded the least, however the abundance trend was not similar as higher species were recorded in May followed by March, June and April record the least. *Eucyclops elegance*, *Daphnia magna*, *Ceriodaphnia reticulata*, *Bominopsis dietersis*, and*Anthocyclops robustus* were singly found in March, April, May June. However, *Moina macrura, Daphnia longiremus, Daphnia pulex*, *Leptodiaptomus minutus* and *Ceriodaphnia cornuta* were not encountered in the following months March, April May June.

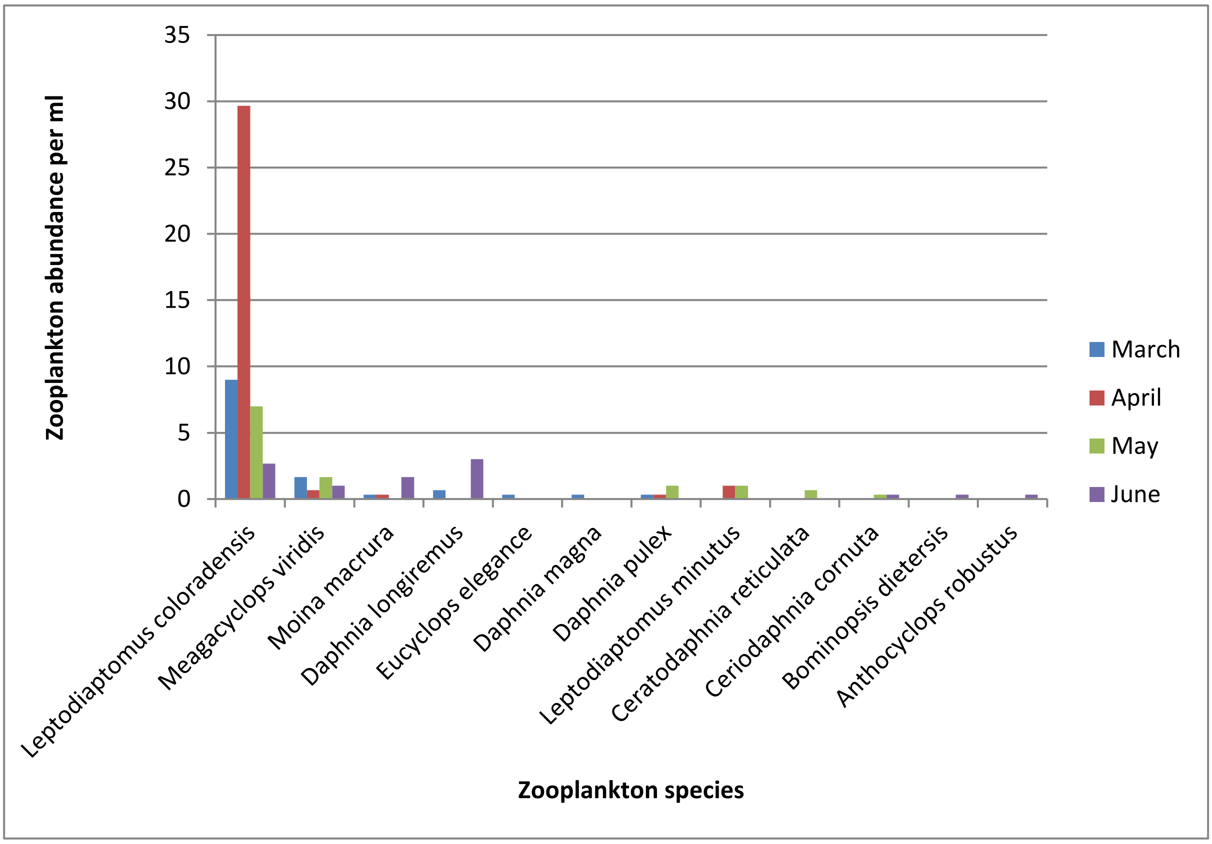

Figure II: Mean monthly abundance of zooplankton species in Shiroro Dam (down stream), Niger State

Discussion

Spatial distribution of physicochemical parameters in Shiroro dam (down stream) Niger State.

All the physicochemical parameters varied significantly ($P < 0.05$) between the sites though variation is very slim, except pH that shows no significant difference ($P > 0.05$) between the sites though the pH ranged from slightly acidic to neutral and may favour the primary productivity of zooplankton and this is in agreement with the report of Kawo *et al*. (2004), who stated that pH range of slightly acidic to neutral favours primary productivity of aquatic invertebrate. More so, the pH also falls within the maximum limit recommended by FEPA (1990) of 6-9. Mean temperature 24.5 to 25.3ºC, recorded fall within the maximum limit of 40.0^{0}C recommended by FEPA (1990) for aquatic life. Transparency value recorded during the study (0.18 to 0.36m), was far higher than that recorded by Adekole *et al.* (2003) of 27.27±18.40cm, for a lake water. Dissolved Oxygen recorded during the study ranged from 2.60 to 3.21mg/l and was far less than that recorded at Kubanni Lake which was 2.70mg/l which is low and the highest was 9.40mg/l of dissolve oxygen concentration as recorded by the former author. While Biochemical Oxygen Demand recorded during the study from 2.75 to 4.00mg/l was far less than that recorded by the same author of 1.00 to 3.90mg/l.

Monthly physicochemical parameters of Shiroro Dam (downstream), Niger State

Mean monthly physicochemical parameters of downstream Shiroro dam showed monthly variation during the study period. All the parameters investigated were within the limit recorded by Adekole *et al.* (2003) and were within the range required for aquatic growth. And therefore it can be concluded that the parameters recorded during this study influence zooplankton distribution and variation in Shiroro dam.

Correlation coefficient of physicochemical properties of Shiroro Dam (downstream) with abundance of Zooplankton species during the study period.

Physicochemical parameters recorded during the study period correlated positively with most species of zooplankton encountered, few of them correlated negatively while only *Leptodiaptomus minutus* show no correlation with Biological Oxygen Demand (B.O.D). Out of the twelve Zooplankton species recorded, seven species correlated negatively with Temperature, pH and Dissolved Oxygen; five species with Transparency and four species with Conductivity and three species with B.O.D. The negative correlation recorded for temperature, pH, Dissolved Oxygen, transparency, conductivity and B.O.D against some species of zooplankton indicated that as these parameters are increasing the associated zooplankton are decreasing, and may also influence their variation of zooplankton species during the study. This result is in agreement with the reserach of Arimoro and Oganah (2010), who reported that physicochemical parameters such as temperature, flow velocity, depth, dissolved oxygen, alkalinity and conductivity accounted for 69% of variation in zooplankton assemblages using canonical correspondence analysis (CCA).

Spatial abundance of Zooplankton species in Shiroro Dam (downstream), Niger State.

Spatial distribution of Zooplankton were investigated and the result revealed that species showed spatial distribution in the same trend according to sites. In each site, seven different species were encountered, though site 3 record significantly higher species than the other two sites. *Leptodiaptomus coloradensis*, *Megacyclops viridis*, *Moina macura* and *Daphnia pulex* showed significantly higher density in site 3, followed by site 1, and site 2 record the least though *Moina macura* and *Daphnia pulex* record zero species in ste 2. *Leptodiaptomus minutes* and *Daphnia longiremus* showed similar trend in their distribution as site 3 record zero Zooplankton species with higher abundance in site 1, followed by 2. However, *Eucyclops elegance* was not found in site 1, with highest recorded in site 3 and lowest in 2. The higher density recorded in site 3 may be attributed to less activities taking place in the site and the least recorded in site 2 may be due to the human activities taking place in the site. This is similar to the findings of Kolo *et al*. (2010), who reported that cladocerans were abundant at all stations. However, *Moina micrura*, and *Thermocylops neglectus* were the only members of this group recorded in station 2, and attributed the low fauna diversity experienced in station 2 throughout the period of sampling showed strong evidence of impact arising from the abattoir waste discharge and heavy human activities at that station.

Monthly abundance of zooplankton species in Shiroro Dam (down stream) Niger State.

Monthly distribution of Zooplankton species recorded during this study revealed that *Leptodiaptomu scoloradensis*(copepod) and *Megacyclopes viridis*(Cladoceran) were the only species recorded throughout the four months of study, though *Leptodiaptomus coloradensis* were significantly higher in April, followed by March, May and June recorded the least, however the abundance trend was not similar with *Megacyclopes viridis* (Cladoceran) as higher species were recorded in May followed by March, June and April record the least. *Eucyclops elegance* (Cladoceran), *Daphnia magna* (Cladoceran), *Ceriodaphnia reticulate* (Cladoceran), *Bominopsis dietersis* (Cladoceran), and*Anthocyclops robustus*(Cladoceran) were singly found in March, April, May June. However, *Moina macura*, *Daphnia longiremus* (Cladoceran), *Daphnia pulex* (Cladoceran), *Leptodiaptomus minutes* (Copepod) and *Ceriodaphnia cornuta* (Cladoceran) were not encountered throughout the months. These result indicated that zooplankton species showed monthly variation in downstream of Shiroro dam and this variation may be as a result of fluctuation of monthly physicochemical parameters recorded during the study. This is not in agreement with the work of Hashemzadeh and Venkataramana (2012), who collected Zooplanktons and macro invertebrate’s monthly from two sampling stations at River Kapila, Nanjangud, Karnataka State, India. Prior to sampling, temperature of surface water, pH, dissolved oxygen concentration was evaluated. The result revealed higher percentage of cladoceran compared to copepods Rotifera (62.00%), Copepoda (12.00%), Cladocera (19.50%), Diptera (4.00%) and Nematoda (4.50%).

CONCLUSION AND RECOMMENDATIONS

Conclusion

A total of 237 Zooplankton made up of Cladoceran and Copepods were collected. It was observed that both the physicochemical parameters and the zooplankton have varied throughout the months and the sites. *Leptodiaptomuscoloradensis* was the dominant species monthly and spatially. *Cereodaphniacornuta*was the least recorded in the sites, while the least recorded in the months was *Daphnia magna.*The organisms encountered are diverse this is confirmed by the Shannon wiener diversity index with a value of -0.35297.The interpretation is that organisms are almost equally distributed. Strong negative and positive correlation was observed among some of the physicochemical parameters and Zooplankton. Therefore, it can be concluded that variation in physicochemical parameters influence Zooplankton distribution and abundance in downstream Shiroro dam.

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