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SPATIAL AND TEMPORAL VARIATION OF ZOOPLANKTONIC FAUNA COMPOSITION AND DISTRIBUTION IN THE JAKARA-GETSI RIVER SYSTEM, KANO, NIGERIA

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ABSTRACT
This study aimed at assessing the spatial and temporal variation of zooplanktonic fauna composition and distribution in the Jakara-Getsi River system, Kano. Sampling was conducted monthly for 12 months (January, to December, 2009). Three sampling sites were selected, they are: Sampling Site A: Jakara River, Sampling Site B: Getsi River and Sampling Site C: Magami (Confluence). Zooplankton Samples were collected using plankton net by vertical haul. Samples were put into labeled 100mL bottle. Water physicochemical parameters determined were temperature, pH, transparency, dissolved oxygen (DO) and 5-day biochemical oxygen demand. Electrical conductivity (EC) were conducted according to standard operating procedures, readings obtained were recorded and consequently analysed. Results showed highest species richness of 20 spp recovered at site A, with higest zooplankton density of 691.28 org/L, while lowest species richness was recorded at site C, 13 species with zooplankton density of 443.19 org/L. Species richness accrdig to taxa showed highest was highest among the Protozoa with 12 spp., with lowest species richness of one specie each among the Rotifera, and nematode. There is observed bimodal fluctuation in zooplankton density at the three sites. At site A, double maxima were recorded in the months of February and December, 199.3 org/L and 109.77org/L respectively. At site B, there were observed maxima in the months of February and April, 138.22 org/L and 60.97 org/L respectively. Kendall's tau-b correlation between physico-chemical parameters was positive between DO and transparency at P≤0.05 (2-tailed). There was negative Kendall's tau-b correlation EC and pH at P≤0.05 (2-tailed). There was also positive correlation in zooplankton density between sites A and B at P≤0.05 (2-tailed), likewise between sites A and C at P≤0.05 (2-tailed).

Keywords: Jakara-Getsi, physico-chemical, spatial, temporal, zooplanktonic fauna

INTRODUCTION

Zooplankton refers to the animal potion of plankton; the animal community in marine and fresh-water situations which floats free in the water, independent of shore and bottom, moving passively with the currents (Verna and Agarwal, 2007). Zooplanktonic fauna are the major mode of energy transfer between the phytoplankton and the fish (Howick and Wilhm, 1984). The diversity of an aquatic system refers to the richness of biological variation in terms of the number of species found herein. Study of zooplanktonic fauna composition and distribution could serve as very useful indices of water quality. Zooplankton have long been used as indicator of water quality, because they respond to environmental factors such as water chemistry, shoreline disturbances and watershed land use, as well as levels of vertebrate and invertebrate predation Zooplankton composed of the protozoa, the crustaceans especially the cladoceran and copepods, the nematodes together with the eggs, larvae and pupae of aquatic insects as well as the annelids (Imam, 2010).

Jakara-Getsi River systems is part of the north-eastern watershed of the Kano metropolis, which carries urban domestic wastewater as well as industrial efflents from the Bompai industrial estate. Studies have shown that the river system is highly contaminated with both organic and inorganic pollutants (Imam, 2010; Binns *et al.*, 2003; Bichi and Anyata, 1999).

Empirical evidence from the Kano city suggests that there is currently much reason for concern as industrial and domestic toxins are reaching dangerously high levels, thus, affecting the biodiversity in terms of aquatic species richness and diversity. During the dry season, flow of Jakara-Getsi river system is almost entirely made-up of sewage and industrial wastewater discharges (1978; Bichi, 1993).

There is paucity of information on zooplankton composition and distribution based on spatial as well as temporal variation of the river system despite its high levels of pollution. This study aimed at assessing the spatial and temporal variation of zooplanktonic fauna composition and distribution in the Jakara-Getsi River system, Kano.

MATERIALS AND METHODS

Study Area and Sampling sites

Kano metropolis (12^0N, 8^0 5-8^0 75E) is an urban closed settle zone made up of tripartite urban centers of Kano city only, capital of Kano state (Figure 1), Kano township and Waje district with its various sub-divisions.

It is a key area of modern Nigeria, and one of the largest rural-urban complexes in Africa (Mukhtar *et al*., 2010). Sampling was conducted monthly for 12 months (January, 2009 to December, 2009). Three sampling sites were selected, they are:

Sampling Site A: Jakara River

This is located on Jakara River, at Nomansland off Zungeru road (11^0 58.822N,008^0 28.412E) in a high density residential area. Substantial vegetable production takes place on both banks of Jakara River, and crops are irrigated by water from the Jakara channel, which forms northern watershed of Kano, which flows through the Kano old city (Birni), specifically starting from Aminu Kano Way, Municipal, Gwale, Dala, Fagge, Sabon Gari and Gwagwarwa. The Jakara River serves as the main drain for built up areas along the way. Most of the wastewater entering the irrigation channel comes from residential sources (Figure 2).

Sampling Site B: Getsi River

This site is located 100m away from Kwana Hudu Bridge on the River Getsi (12^0 05.930N, 008^0 37.807E). The river receives effluents from the Bompai industrial Estate. A significant proportion of the factories in operation at the industrial estate are tanneries and textile mills. Field observations revealed that PVC pipes used underground for supplies of domestic potable water in the settlements surrounding Bompai which passes across the Getsi river (Figure 2).

Sampling Site C: Magami (Confluence)

The site is located within 5 meters away from the confluence of Jakara and Getsi rivers Getsi (12^0 03.159N, 008^0 32.689E). Where industrial effluents from the River Getsi and domestic wastewater from the Jakara River mix (Figure 2).

Water Physico-chemical Determination

- **Surface Water Temperature:** was determined using mercury-in glass thermometer by dipping it into water for 5 seconds, removed and reading conducted immediately and recorded (APHA, 2005).
- **pH, and Elecrical Conductivity**: were measured using pH/EC/TDS meter HANNA 3100 Model by dipping the probes into the water untill the screen showed a fixed reading (HANNA Instruments,2004)
- **DO**: was determined using DO meter, in which the probe was inserted into the water until DO reading in ppm (mg/L) was recorded, then Oxygen saturation was read off in percentage (HANNA Instruments,2004).
- **BOD5:** was measured after collecting the samples into a labeled 250mL brown bottle, kept in incubator at Research laboratory at 21°C for 5-days, then DO was measured again. BOD5 was obtained by subtracting the 5-day Do reading from the 0-day DO reading (APHA, 2005).
- **Transparency:** was measured using 20cm diameter Secchi disc, which was dipped into the water till the disc visibly disappeared, the depth was then recorded, and as it was removed, the depth at which it first appeared was also recorded, actual reading was obtained by taking the average of the two readings(APHA,2005).

Zooplankton Samples Collection

Zooplankton Samples were collected using plankton net by vertical haul. Samples were put into labeled 100mL bottle (APHA, 2005). Some samples were preserved by dropping 4% Formalin for identification and photomicrograph.

Concentration Technique: Sedimentation

The obtained sample from the plankton net was kept undisturbed for sedimentation to take place at 1hr settling per mm of column depth according to the protocol of APHA (2005). The advantage of sedimentation method over filtration and centrifugation are that it is non selective as compared to filtration and it is non destructive as in centrifugation. The supernatant was decanted in order to obtain desired volume. The concentrated sample was stored in a closed labeled vial bottle for identification and counting of zooplanktons (APHA,2005).

Zooplankton Enumeration and Density Estimation

Obtained using the following formula:

No. of Orgs/m3: C x VI/ VII x VIII; Where: C= No. of organisms counted

VI= concentrated sample (mL); VII= Volume counted(mL); VIII= Volume of water of the grab sample(m3)

To obtain Viii: the following formula was used: VIII=πr2d; Where: π=22/7; r= radius of plankton orifice(12.5CM); d=depth at which grab sample was obtained (APHA,2005).

Biodiversity Indices

Saprobic Index: S= Σ(s.h)/ Σh (Zladaçek and Tuçek,1975); Where: s=saprobity class(1-4), h= abundance of spp(1-9). NB: It estimates level of organic loading of the water.

Jaccard Similarity Index(JSI): J= C/N1+N2-C (Allaby,1999)

Where:C=No. of taxa shared between a pair of site; N1 and N2: No. of spp in each of the two sites. NB:It corelates two sites in terms of evenness.

Margalef Index: D=(S-1)/lnN (Margalef, 1958; SDR-IV, 2010)

Where:S=No. of spp, lnN= Natural log of Total No. of Individuals. NB: It increases with increase in No. of spp.

Berger-Parker Dominance Index: CDI= Y1 + Y2/ Y (Maiti, 2004); Where: Y1= abundance of the most dominant spp; Y2= abundance of the 2nd most dominant spp; Y= total abundance of all spp at the site.

Statistical Analysis

SPSS statistical software version 15 was employed in the analysis of data obtained, which include variables of zooplanktonic fauna. Student T-test was used to test for significant difference between the variables, likewise Kendall's tau-b correlation was also utilised in the case of testing for any significant correlation between the variables.

Figure 1a: Map of Nigeria and the Study Area: Kano

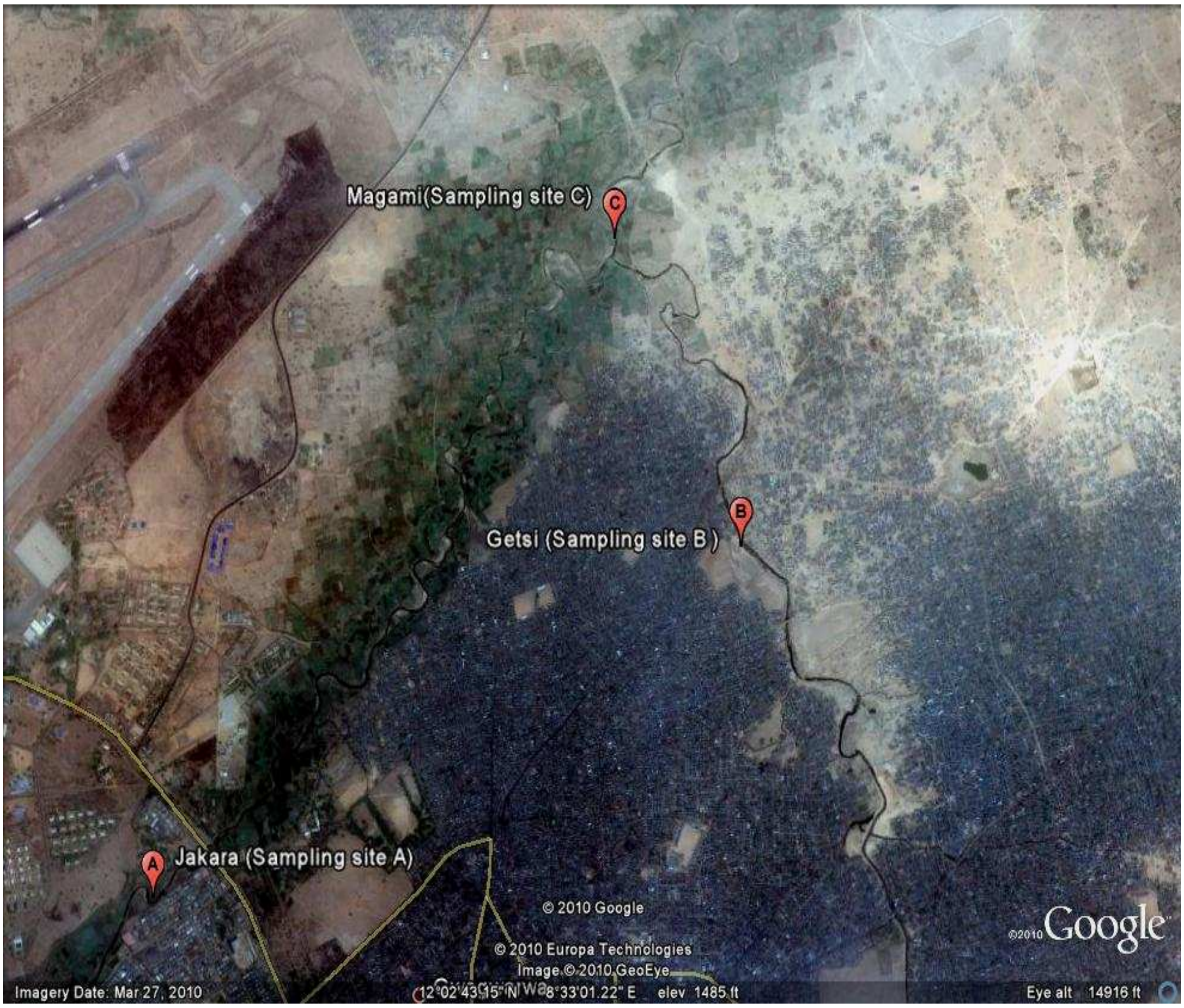

Figure 2: Sampling sites A, B and C (Source: Google Earth)

RESULTS AND DISCUSSION

Results obtained in the study on spatial and temporal variations of zooplanktonic fauna in Jakara-Getsi River systems showed. Highest species richness of 20 at site A, with 13 as the least species richness observed at site C (Table 1). Sarcodina sp. Showed highest distribution and abundance of 1016.34 org/L, which was recovered at sites A, B, and C. Species richness according to taxa showed highest species richness of 11 among the Protozoa, with lowest richness of one species each among the Rotifera, and Nematoda (Table 1).

These results are in line with the discourse by Verma and Agarwal 2007), whereby organisms at the lowest trophic status have greater abundance (i.e. pyramid of numbers). Site A had the overall highest zooplankton density of 691.28 org/L and the lowest record of 443.19 org/L was observed at site C (Table 2). Highest mean monthly zooplankton density was observed at in the month of February, 199.22 org/L at site A, 134.17 org/L at site B and 138.22 org/L at site C. Lowest mean monthly zooplankton density was observed in different months at different sites at site A, 12.2 org/L was observed in the month of July, whereas at site B, 16.26 org/L was recorded to be the lowest in the month of October. In the case of site C, 12.2 org/L was recorded in the months of June, August and October (Tables 2 and 3).

There is an observed bimodal fluctuation in zooplankton density at the three sites. At site site A, double maxima were recorded in the months of February and December, 199.3 org/L and 109.77 org/L respectively. At site B, there were observed maxima of in the months of February and April, 138.22 org/L and 60.97 org/L respectively (Tables 2 and 3). Highest distribution is observed among four zooplanktonic taxa which are the Protozoa, Insecta, Annelida and Cladocera recovered at all the three sites (Table 1; Figure 3).

Percent composition of zooplanktonic fauna based on their species richness, Protozoa predominated (37.9%), with lowest percent composition among the Rotifer, Trematoda and Nematoda, with 3.5% (Figure 3). Physicochemical analysis showed varying degrees of fluctuations along the temporal scale, where highest recorded mean monthly temperature was 32.0^{0}C at sites A and B, and 31.0^{0}C at site C in the month of March (Table 2). Lowest mean monthly temperature was recorded in the month of December. With highest annual mean monthly temperature at site B, 25.0^{0}C, and lowest at site C, 24.3^{0}C (Table 2). Despite the fluctuations temperature values obtained in this study period are within the FEPA (1991) regulation limit for effluent discharge into surface water, which is below 40.0^{0}C. the observed highest temperature in the month of March indicates seasonal variation in which is one of the driest characterized by high temperature, while coolest month was December, that falls within the Harmattan (Ezra, 2000; Kabiru, 2007).

The result of pH showed that the month of December had the highest pH at sites B and C, 8.4 and 8.6 respectively, but least pH was recorded during the month of January. With pH of 6.1, 6.2 and 6.3 at sites A, B, and C respectively (Table 2). The result falls within the FEPA (1991) and Ragnar (2004) limits range of 6.0-9.0. mean annual pH was highest at sites B and C, 7.7 each, and lowest pH of 7.5 recorded at site A (Table 2). The water clarity (i.e. transparency) recorded at three sites was very low, while highest mean transparency was 24cm, 21cm and 27cm at sites A in the month of June, B and C respectively. Lowest mean monthly transparency readings were obtained in the month of January at sites A and B with 3.5cm and 5.5cm respectively and lowest at site C in the months of April and May of 1.0cm (Table 2). All these readings are below the recommended range of 3.0-3.5cm necessary effective growth, reproduction and distribution of zooplanktons (Hart, 1986). Annual mean transparency was highest at site C, 15.9cm and lowest at site A, 14.6cm (Table 2).

Annual mean dissolved oxygen (DO) of 5.3mg/L was the highest recorded at site A, with lowest annual mean of 4.3mg/L observed at site B (Table 3). Highest monthly means were recorded in the months of March, where 5.mg/L, 10.5mg/L and 6.0mg/L were recorded at sites A, B and C (Table 3). While lowest readings of 1.1mg/L, 1.0mg/L and 1.0mg/L were recorded during the month of July at sites A, B and C Table 3). The overall annual 5-day Biochemical oxygen demand (BOD_5 mean showed water quality within the beta-mesosaprobic class, which is the type of water body with a moderate amount of organic loading (Zlacedek and Tucek, 1975). It is also worthy of note that highest BOD monthly mean was observed in the month within the dry season (i.e. March and December), this is line with the observations made by Bichi and Anyata (1999) and that Jakara River during the dry season is almost composed of sewage water. Electrical conductivity (EC) results showed highest monthly means of 3890µS/cm recorded in the month of March at site A, 3600 µS/cm was recorded during the months of February and May at site B and 3850 µS/cm observed at site C in the month February. Highest annual mean of 2748.3 µS/cm was obtained at site A (Table 3). All the overall means, both monthly and annually are beyond the FEPA (1991) and Lenntech (2008) recommended limit of <2000µS/cm. This result is in agreement with the work of Mustapha (2008), conducted in the basin where all the recorded EC results were above 2000 µS/cm. table 4 illustrates seasonal abundance of zooplanktons, in which dry season is recorded to have higher mean zooplankton density as compared with the wet season, 5.62org/l and 28.0org/L respectively, with site A having the highest mean annual zooplankton density of 71.37org/L. reason to this discrepancy could be deduced to the fact rain water dilute the overall aquatic system, and thus abundance of the zooplankton community in a given volume will lower as such. Also the fact that the study area is a river system, the surface runoff during and after rainfall would increase the water volume and consequently flow, bearing in mind that zooplankton are floating organisms, thus they go with flow (Maiti, 2004; Imam, 2010). Kendall's tau-b correlation between physico-chemical parameters showed positive correlation between Electrical conductivity and Total dissolved solid at P≤0.01 (2-tailed), there was also positive correlation between Dissolved oxygen and transparency, likewise between Oxygen saturation and transparency, at P≤0.05 (2-tailed). There was negative correlation between Electrical conductivity and pH, and also between Total dissolved solids and pH at P≤0.01 (2-tailed). There was positive Kendall's tau-b correlation of zooplankton density between sites A and B [r=0.836, P≤0.01 (2-tailed)]. Likewise between sites A and C [r=0.783, P≤0.01 (2-tailed)].

Table 1: Zooplankton Abundance and Distribution in the Jakara-Getsi River System, Kano, Nigeria.

S/N0.	TAXON	SITE A	SITE B	SITE C	Total (Org/L)
	PROTOZOA				
1	*Arcella vulgaris*	4.07	12.21	-	16.28
2	*Bodo caudatum*	4.07	-	-	4.07
3	*Chroomonas caudata*	4.07	-	-	4.07
4	*Euglena* spp.	24.41	-	4.07	28.48
5	*Glaucoma scintillans*	40.65	16.26	12.2	69.11
6	*Gonium pectorale*	4.07	-	-	4.07
7	*Paramecium* spp.	-	-	8.14	8.14
8	*Sarcodina* spp.	365.92	349.59	300.83	1016.24
9	*Spirostonum ambiguum*	60.99	24.39	20.34	105.72
10	*Stentor* spp.	-	4.07	-	4.07
11	*Stylonychia mytilus*	4.07	-	-	4.07
	INSECTA				
12	*Anopheles* spp. Larva	-	4.07	8.14	12.21
13	*Anopheles* spp. Pupa	4.07	-	-	4.07
14	*Chironomus* spp. larva	-	4.07	-	4.07
15	*Simulium* spp. Larva	4.07	-	-	4.07
16	*Triaenodes* spp. Larva	-	-	4.07	4.07
17	*Culex* spp. Pupa	-	-	4.07	4.07
18	*Leptocerus* spp. Larva	-	4.07	-	4.07
	ROTIFERA				
19	*Brachionus urceus*	4.07	-	-	4.07
	NEMATODA				
20	*Hemicycliophora* spp.	-	4.07	-	4.07
	ANNELIDA				
21	*Haplotaxis gordoides*	40.66	36.61	36.59	113.86
22	*Herpobdella octoculata*	12.21	16.27	16.26	44.74
23	*Rhabdolaimus aquaticus*	24.4	-	4.07	28.47
	CLADOCERA				
24	*Daphnia pulex*	20.34	20.34	20.34	61.02
25	*Bosmina longinostris*	8.13	-	-	8.13
26	*Polyphemus pediculus*	-	4.07	-	4.07
	TREMATODA				
27	*Planaria gonocephala*	8.13	-	4.07	12.2
	COPEPODA				
28	*Cyclops* spp.	4.07	-	-	4.07
29	*Metanauplius larva*	8.14	16.27	-	24.41
	Total (Org/L)	691.28	520.43	443.19	1654.9
	Spp Richness	20			

Table 2: Temperature, pH, Transparency and Zooplankton Density of Jakara-Getsi River System, Kano, Nigeria.

Month	Temperature (°C)			pH			Transparency(cm)			Zooplankton density (Org/L)		
	Site A	Site B	Site C	Site A	Site B	Site C	Site A	Site B	Site C	Site A	Site B	Site C
January	22	21	23	6.1	6.2	6.3	3.5	5.5	11	16.3	24.4	16.27
February	22.2	22.3	21.5	7.6	8.1	7.8	10	12.5	13	199.3	134.13	138.22
March	32	32	31	6.5	6.6	6.5	12	21	27	52.88	20.33	24.4
April	31	30	27	7.4	8	8	14	14	9	60.99	23.2	60.97
May	25	27	24	7.6	7.8	7.9	11	10	9	81.32	36.6	56.99
June	22	23	23	7.5	7.7	7.6	24	12	14	44.74	24.4	12.2
July	23	25	24	7.7	8	7.7	18	17	17	12.2	36.6	20.33
August	24	24	24	7.5	7.6	7.5	20	20	18	20.33	20.33	12.2
September	26	27	26	8	8	8.5	19	18	20	40.66	24.4	32.53
October	24	24	24	7.9	7.9	7.9	7.6	19.6	13	16.26	16.26	12.2
November	24	24	24	7.9	8	8	14.6	15.7	15.9	36.6	48.8	16.27
December	18.8	20.6	19.6	8	8.4	8.6	109.77	60.99	36.59	109.77	60.99	36.59
Mean	24.5	25	24.3	7.5	7.7	7.7	57.7	39.2	36.6	57.7	39.2	36.6

Table 3: Dissolved Oxygen, Biochemical Oxygen Demand, Electrical Conductivity and Zooplankton density of Jakara-Getsi River System, Kano, Nigeria.

Month	Dissolved Oxygen (Org/L)			5-Day BOD (mg/L)			El.conductivity(uS/cm)			Zooplankton density (Org/L)		
	Site A	Site B	Site C	Site A	Site B	Site C	Site A	Site B	Site C	Site A	Site B	Site C
January	5	4.2	3	3	1.8	2.2	2440	3390	3460	16.3	24.4	16.27
February	4	4.7	2.8	2.9	2	1	3180	3600	3880	199.3	134.13	138.22
March	5.9	10.5	6	3.9	4.9	3.6	3890	3260	3850	52.88	20.33	24.4
April	4.5	3.9	3.8	4.2	2.7	3	3330	3710	1575	60.99	23.2	60.97
May	4	3.6	2.8	3.4	2.3	1.3	2750	3600	3000	81.32	36.6	56.99
June	5.3	2.3	2.2	1.4	1	1.1	1580	1860	1930	44.74	24.4	12.2
July	4	1.7	4.9	1.1	1.3	1.9	2250	1140	1670	12.2	36.6	20.33
August	5.6	3	5	3	2	2.2	1880	1000	1400	20.33	20.33	12.2
September	6	5	5.6	2	2	3	1750	980	1350	40.66	24.4	32.53
October	4.5	4	4.2	2.5	2	2	3100	2100	2940	16.26	16.26	12.2
November	5.3	4.2	4.2	2	2.9	2.3	3220	2990	2990	36.6	48.8	16.27
December	10	4.3	4.5	4.6	3	2.4	3610	2520	3000	109.77	60.99	36.59
Mean	5.3	4.3	4.4	2.8	2.3	2.2	2748.3	2512.5	2587.08	57.7	39.2	36.6

Table 4: Seasonal Zooplankton Abundance of Jakara-Getsi River System, Kano, Nigeria.

Site	Dry Season Zooplankton density (Org/L)			Wet Season Zooplankton density (Org/L)			Annual Zooplankton density (Org/L)		
	Mean	**Std Dev**	**Maxi**	**Mean**	**Std Dev**	**Maxi**	**Mean**	**Std Dev**	**Maxi**
A	71.8	65.4	199.12	35.91	25.89	81.2	71.37	168.38	516.19
B	58.27	46.18	138.2	24.39	11.21	36.59	53.4	125.64	386.8
C	48.91	46.91	138.2	23.71	18.43	56.9	45.64	110.17	337.53
Mean	59.62	52.83	158.51	28.0	18.51	58.23	56.8	134.73	413.51

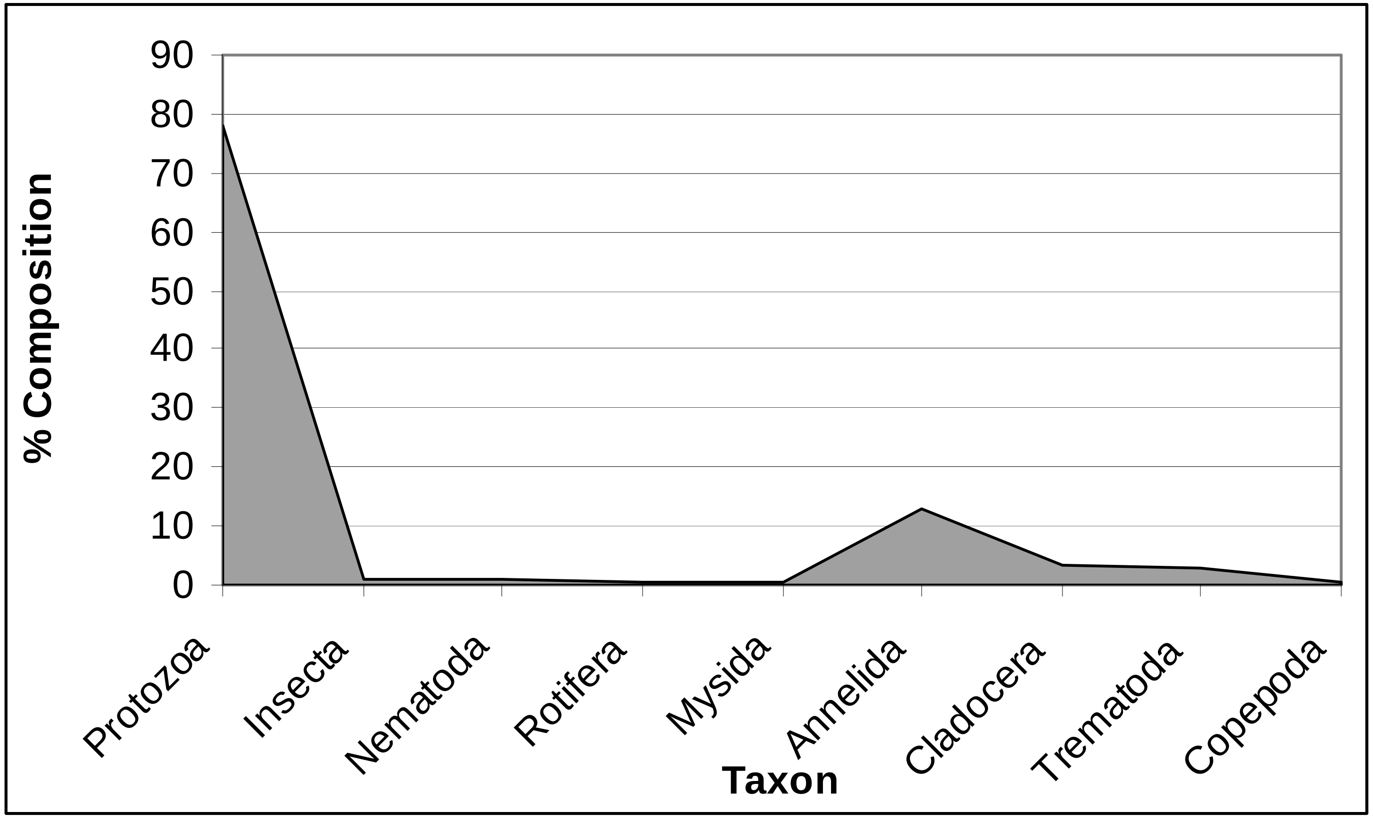

Figure 3: Zooplankton Percent Composition according to Species Richness

Conclusion and Recommendations

This study highlights the state of Jakara-Getsi river system in terms of zooplanktonic fauna composition and distribution. The overall abundance of zooplanktons was observed to be low both spatially and temporally. There is the prolem of maintaining the balance of the aquatic ecosystem bearing mind that the study area is part of the Bompai-Jakara catchment basin, where fishing is notably practised, and the fact that trophic status of zooplanktons cannot be substituted. Thus, effort of monitoring as well as government enforcement of FEPA effluent and sewage discharge regulation limits need to effected. This is in order to improve the health of the aquatic biodiversity which is will be ecologically and socio-economically beneficial to Kano populace and the nation in general.

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