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ZOOPLANKTON AS BIOINDICATORS OFWATER QUALITY IN JAKARA DAM, KANO STATE, NIGERIA

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ABSTRACT
The study of zooplankton as bioindicators of water quality in Jakara Dam was carried out for a period of 12 months (March,2013-February 2014). Zooplankton and water samples were collected and analyzed using standard methods. Sampling sites designated as A, B,C,D, and E were chosen. Result of physico-chemical parameters analysed showed that temperature, secchi disk transparency, pH and electrical conductivity ranged between 25.3-23.9, 10.7-57.9 cm, 7.9-7.7 and 856.7- 817.9 µS/cm respectively, so also dissolved oxygen, biochemical oxygen demand, nitrate and phosphate ranged between 4.5-3.3 mg/l, 2.5-1.7 mg/l, 23.8-14.3 mg/l, and 15.8-12.5mg/l respectively. Among the zooplankton, Rotifers were the dominant, contributing 27.10% of the total fauna composition. Cladocerans constituted 26.99%, Cyclopoida 16.15%, Calanoida 15.08%, and Protozoans 14.68%. However, a combined total of 36 zooplankton species were encountered, Rotifers had 10, Cladocerans 10, Cyclopoida 6, Protozoans 6, and Calanoida 4. The total fauna composition recorded was 2606.58 Org/l with the highest zooplankton density recorded at site D (631.64 Org/l) and lowest at site A (384.31 Org/l). Bosmina longirostris had the highest total species count of 250.88 Org/l while Afrocyclops monodi had 7.02 Org/l. Rotifers are signs of deteriorating condition of the water quality. Pearson's correlation existed between zooplankton, nitrate, phosphate and electrical conductivity at P<0.01. During the period of this study, site A had low secchi disk transparency,high level of nitrate and phosphate. This is due to human activities taking place at the site.In a bid to providing safe water for domestic and industrial uses, water treatment plant should be provided to help in water treatment especially at site A (Bela community) of this research area.
Key words: Bela community, Deteriorating, Zooplankton, Water Quality, Jakara Dam

INTRODUCTION

The use of living organisms to determine the presence, amounts, changes in and effects of physical, chemical, and biotic factors in the environment is termed biological monitoring (Baker,1976). Biological monitoring is a valuable method used in conservation studies to protect natural ecosystems, which include preservative measures. Bioindicators of pollutants are useful in predicting the level and degree of pollutants before the effect of the pollutant starts. Study of these organisms is generally linked to the use of mathematical distribution of these organisms in a community to which bioindicator species belong (Singh and Singh, 2002). Imam (2011) studied the state of Jakara-Getsi River system in terms of zooplanktonic fauna composition and distribution. He observed bimodal fluctuation in zooplankton density. However, despite the numerous works carried out in the study of zooplankton fauna composition, it is still desirable to carry out more of such study due to global environmental changes that may lead to appearance and disappearance of some species in the area.

This study was aimed at investigating the species composition of zooplankton to the existing water quality in Jakara Dam and their seasonal fluctuation. It also studied nitrate and phosphate in addition to the physicochemical parameters studied by Imam (2011).

MATERIALS AND METHODS

Study Area: Jakara Dam

Jakara Dam was constructed in 1976 and situated in Minjibir Local Government Area in North – Eastern part of Kano metropolis about 41.5km from Kano city centre (Duwa and Oyeyi 2009). The Dam was constructed for irrigation, recreation and wildlife conservation. The reservoir was designed to contain 54.34 million cubic metres of water with surface area of 1,659ha (WRECA, 1974). The maximum depth of the dam was 14.3 metres (Ministry of Water Resources Kano State). Study has shown that the river system is highly contaminated with both organic and inorganic pollutants (Imam, 2010).

Sampling Sites

Five sampling sites selected for this study were based on differences in their anthropological condition (Figure 1). GPS 12 model (GARMIN, USA) was used in marking the global position of the site. Depth measurements were done using graduated lines (Welcomme, 1985).

SITE A: This site is located on latitude 12° 08' 49.29" N and longitude 8°41' 19.40" E**,** the inlets where irrigation farming, fishing and human activities are taking place with mean depth of 1.2m.

SITE B: This is located on latitude 12°08' 36.46" N and longitude 8°41' 44.84" E, the midpoint of the water with mean depth of 8.6m.

SITE C: This is located on latitude 12°08' 35.86" N and longitude 8°41' 15.84" E, the mid point of the water with mean depth of 7.4m

SITE D: This is located on latitude 12°08' 41.26" N and longitude 8°41' 24.54" E, where irrigation farming is taking place with mean depth of 5.0m.

SITE E: This is located on latitude 12°08' 27.97" N and longitude 8°41' 11.98" E, the outlets with mean depth of 2.3m.

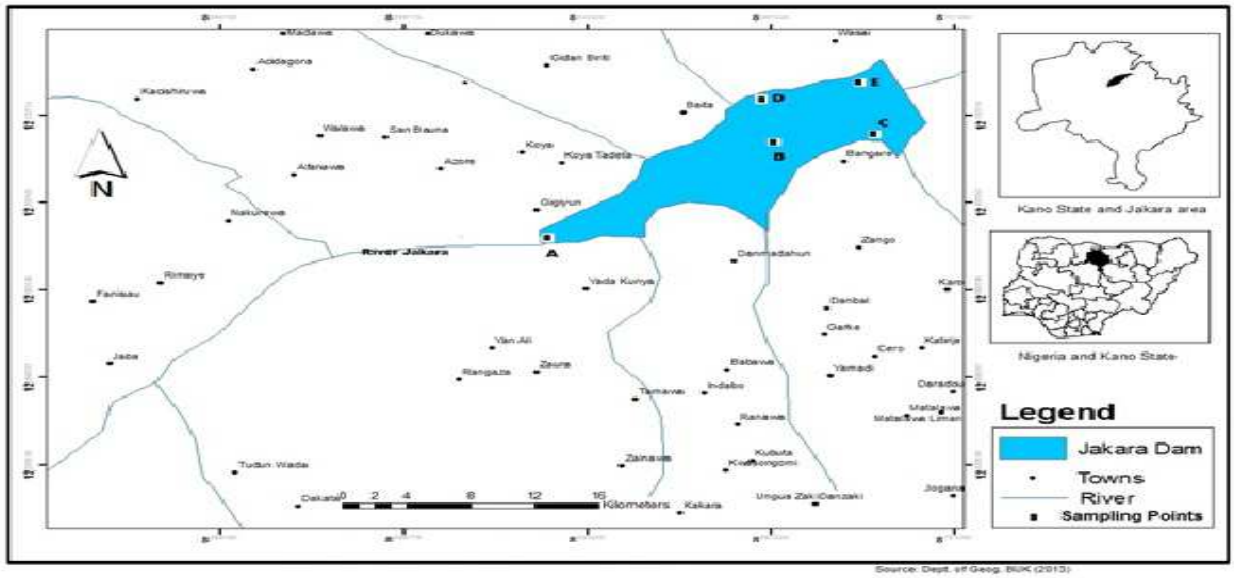

Figure 1: Map of Jakara Dam Showing Sampling Sites

Physical Analyses of Water Samples

Measurement of Temperature

This was determined using mercury- in -glass thermometer, by dipping it into the water and allowed to stabilize for 5 seconds, removed and reading recorded immediately (APHA, 2005).

Determination of Transparency

Water transparency was determined using secchi disk with black and white paints. The disk was lowered until it disappeared from view and the depth recorded. The disk was raised until it just appeared and the depth was recorded. The disk visibility was estimated by taking the average of the two readings while viewing the disc directly from above and backing the sun (Abdullahi, 1990).The depth at which it disappeared in the water ($_1$) and reappeared ($_2$) were noted. The transparency of the water body was computed as follows:

Transparency (Secchi Disk Transparency) = $\frac{(x + x_2)}{2}$

Where;

$_1$ = Depth at which Secchi disk disappeared.

$_2$ = Depth at which Secchi disk reappeared.

Determination of Electrical Conductivity

Conductivity was measured using conductivity meter with model HI 76310 manufactured by Hanna (APHA, 2005).

Determination of pH

The pH values were obtained using a digital pH meter model HI 1131 manufactured by Hanna (APHA, 2005).

Chemical Analyses

Determination of Dissolved Oxygen

The sample of the water was treated with manganous chloride tetrahydrate ($MnCl_2 .4H_2O$), potassium iodine (KI) and potassium hydroxide (KOH) under highly alkaline condition.One hundred and twenty five millilitre (125ml) of the water sample was measured into BOD bottles. Two millitre (2ml) of manganous chloride was added. [Fifty gram (50g) of manganous chloride tetrahydrate was dissolved into a volume of 100ml of distilled water and 2ml of Winklers reagent (100g of KOH was dissolved in 20ml of distilled water, 60g of (KI) was added and cooled. The solution was diluted to 500ml mark]. They were carefully added in order to prevent air bubbles at the site. All the solution was carefully inverted several times after closing it tightly. The precipitate was allowed to settle and mixed again. Two millitre (2ml) of concentrated sulphuric acid was added with a measuring pipette stopper. The bottle was inverted several times to dissolve the precipitate. Ten millitres (10ml) of the treated sample was measured into 250ml beaker and titrated against standard sodium thiosulphate solution ($Na_2S_2O_2.5H_2O$).[Three point one gram (3.1g) of $Na_2S_2O_2 \cdot 5H_2O$ was dissolved in distilled water and then made to 1000ml mark]. The end point was marked by a pale stew colour.

Four (4) drops of starch indicator are added and titrated until the colour disappeared and the total volume of sodium thiosulphate was recorded as

described by Bryan (1974).

$$DO\ (mg/L) = \frac{ml\ of\ titrants\ x\ (N)\ X\ 8\ X\ 1000}{sample\ volume\ in\ ml}$$

$Na_2S_2O_2 \cdot 5H_2O$ and N/8 = 0.0125.

Determination of Biochemical Oxygen Demand

This was done by incubating the bottles with the water samples at room temperature (25) for 5 days. Then DO was measured again. BOD_5 was obtained by subtracting the 5 days DO reading from the 0 - day reading (APHA,2005). The BOD_5 was expressed in milligram per litre of DO using the following equation.

BOD_5 (mg/L) = DO (0-day) (mg/L) initial – DO (5-day) (mg/L)

Determination of Nitrate

Ten millilitre (10ml) of the sample was added into distillation tubes and 10ml of 40% sodium hydroxide (NaOH) was also added into the distillation tube. One gram (1g) of devardas alloy power was added into the distillation tube. Ten millilitre (10ml) of 2% boric acid was placed into a conical flask and 5 drops of mixed indicator (Methyl red 10g 1-1 and bromocresol green in 95% ethyl alcohol) was added. Distillation starts when the steam coming from the kjadahl flask and 50ml of the distillate was collected in the conical flask containing 2% boric acid. The content was titrated against 0.025mol-l standard solution of H_2SO_4.

Calculation

$$NO_3^- = \frac{0.014\ X\ 0.025\ X\ 100\ X\ titrants}{A.T}$$

Where:

A.T = Aliquot taken = 10ml

To convert % into mg/l the values obtained was multiplied by 10000.

Determination of Phosphate

Five milliliter (5ml) of a clear sample was added into 50ml Erlenmeyer flask, 20ml of distilled water was added into the flask. Eight millilitre (8ml) of ascorbic acid molybdate was added into the sample and distillated water was added up to 50ml mark. Zero point two (0.2) ,0.4 ,0.6, 0.8 and 1ml of standard potassium dihydrogen phosphate (KH_2PO_4)was diluted into 1, 2, 3, 4, and 5ml of distillated waterrespectively in 50ml Erlenmeyer flask.Eight millilitres(8ml) of colour developer (ethanoate) was then added into each and made up to 50ml mark. Both standard and the sample were measured after 5minutes spectrophotometrically at 690nm wavelength. The concentration of the sample was estimated from the calibration curve.

Calculation

$$Phosphorus\ mg/L = \frac{sample\ absorbance}{slope} X\ Vol.\ of\ extract$$

To convert phosphorus to phosphate (PO_4^{-3}) (Orthophosphate) the values obtained was multiplied by 2.291.

BIOLOGICAL ANALYSIS OF WATER SAMPLE

Collection of zooplankton

Zooplankton were collected by using plankton net of 27cm in diameter and 70µ mesh-sized with a small plastic bottle container of 20ml attached to it narrow end. The net was tied to a metal rod, towed horizontally for a fixed distance of 1metre, hauled out of water. The water (containing plankton) was collected in the plastic bottle at the end of the net was emptied into plastic bottle of 20ml and immediately fixed with 4ml of 4% formalin to preserved the zooplankton (Goswani,2004). Five samples were collected at each sampling site in the early hours of the morning (8.00am – 11.00am) for a period of twelve months (Abdullahi, 1990).

Plankton Identification and Enumeration

Two (2) of the five (5) samples collected at each of the sampling site were analyzed immediately while the other three (3) samples were allowed to settle for 48 hours, the average was used (Abdullahi, 1990). Each sample was homogenized after decanting $^2/_3$ of it. One mililitre of the concentrated sample was taken using pipette dropped onto a watch glass and picked with a dropper on a glass slide and viewed under a compound microscope and viewed using x 40 and x10 objectives for identification (Goswani, 2004).

Counting

The species were directly counted under microscope. The Zooplankton were identified based on taxonomical classification to species level using the identification keys by Scourfield and Harding (1958), Durand and Lèvèque (1980), Shield and Green (1995), Lynne(2004).

Volume of water filtered

The volume of water that passed through the net was then estimated by using the following formula:

$$V = \pi r^2 \mathrm{d}$$

Where:

V = volume of water filtered.

r = radius of the mouth of the net.

d = length of the haul.

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

$$Org/L = \frac{Total\ count\ of\ the\ specimens\ (average\ count)}{volume\ of\ water\ filtered}$$

Statistical Analysis

Pearson's Product Moment Coefficient Correlation was carried out to determine the relationship between the physicochemical parameters, phytoplankton and zooplankton density using Statistical Package for Social Sciences (SPSS) version 20 (Lead Technology, 2002). Biodiversity was calculated using Shannon-Weiner (H), Evenness index (E), and Simpson's (Ds) Indices.

Table 1: Zooplankton Abundance and Distribution in Jakara Dam (March 2013, - February, 2014)

Site /Species	A		B		C		D		E			
	TC	FC (Org/l)	TC	FC (Org/l)	TC	FC (Org/l)	TC	FC (Org/l)	TC	FC (Org/l)	TFC (Org/l)	Frequency (%)
Protozoa												
Euglena spp.	2.4	42.11	1	17.54	0.8	14.04	2	35.09	1.6	28.07	136.85	5.25
Paramecium spp.	2.2	38.60	0.4	7.02	0.2	3.51	2	35.09	1.4	24.56	108.78	4.17
Stentor caudatus	0.2	3.51	0.2	3.51	0.2	3.51	0.2	3.51	0.6	10.53	24.57	0.94
Euplotes spp.	0.4	7.02	0	0.00	0.6	10.53	0.2	3.51	0	0.00	21.06	0.81
Vorticella spp.	0.8	14.04	0.8	14.04	0.4	7.02	0.8	14.04	0.4	7.02	56.16	2.15
Prorodon spp.	0.4	7.02	0.4	7.02	0.2	3.51	0.4	7.02	0.6	10.53	35.1	1.35
											382.53	**14.68**
Rotifera												
Brachionus caudatus	2.4	42.11	0.4	7.02	1.4	24.56	0.6	10.53	0.4	7.02	91.24	3.50
B. dimidiatus	0.6	10.53	1	17.54	0.8	14.04	0.8	14.04	1.2	21.05	67.2	2.58
B. falcatus	0	0.00	0.8	14.04	0.4	7.02	0	0.00	0.2	3.51	14.57	0.56
B.calyciflorus	0	0.00	0.2	3.51	0.6	10.53	0	0.00	0.6	10.53	24.57	0.94
Keratella serrulata	0.2	3.51	1.4	24.56	0	0.00	0.4	7.02	0.4	7.02	42.11	1.62
K. cochlaris	0.4	7.02	0	0.00	2	35.09	2.2	38.60	2.6	45.61	126.32	4.85
K. quadrenticus	0.6	10.53	1	17.54	0.8	14.04	0.2	3.51	0.2	3.51	49.13	1.88
K. tropica	0.4	7.02	0.8	14.04	0.8	14.04	3.8	66.67	0.6	10.53	112.3	4.31
K. valga	0.4	7.02	0	0.00	1.8	31.58	1.6	28.07	1.6	28.07	94.74	3.63
K. cruciformis	1.4	24.56	0.2	3.51	0.6	10.53	0.2	3.51	2.4	42.11	84.22	3.23
											706.4	**27.10**

Table 1 (continued)

Site / Species	A		B		C		D		E			
	TC	**FC (Org/l)**	**TC**	**FC (Org/l)**	**TC**	**FC (Org/l)**	**TC**	**FC (Org/l)**	**TC**	**FC (Org/l)**	**TFC (Org/l)**	**Frequency (%)**
CRUSTACEA												
Cladocera												
Diaphanosoma sarsi	0.2	3.51	0.2	3.51	0	0.00	0.4	7.02	0.2	3.51	17.55	0.67
Moina micrura	0.2	3.51	2.2	38.60	2.8	49.12	1	17.54	0.4	7.02	115.79	4.44
Bosmina.longirostris	3.9	68.42	2.6	45.61	2.4	42.11	1.8	31.58	3.6	63.16	250.88	9.62
B. pellucida	0.2	3.51	0.4	7.02	0	0.00	1.2	21.05	0.2	3.51	35.09	1.35
B.freyi	0.2	3.51	0	0.00	0	0.00	0.4	7.02	0	0.00	10.53	0.40
B.rostrum	0	0.00	0.4	7.02	0.6	10.53	0	0.00	0.6	10.53	28.08	1.08
Daphnia pulex	0.4	7.02	0.4	7.02	1.8	31.58	1.4	24.56	1.8	31.58	101.78	3.90
D. retrocurva	0.2	3.51	1.6	28.07	1.6	28.07	0.2	3.51	0.6	10.53	73.69	2.83
Leptodora kindti	0.2	3.51	0	0.00	0	0.00	0.6	10.53	0.2	3.51	17.55	0.67
Sida crytalina	0	0.00	0.6	10.53	0.2	3.51	2.2	38.60	0	0.00	52.64	2.02
											703.58	**26.99**
Calanoida												
Tropodiaptomus incognitus	2.4	42.11	1.6	28.07	2.4	42.11	1.8	31.58	2	35.09	178.96	6.87
Tropediaptomus lateralis	0.4	7.02	3	52.63	0.8	14.04	2	35.09	0.8	14.04	122.82	4.71
Leptodiaptomus sicilis	0	0.00	0.8	14.04	1.2	21.05	0.4	7.02	1.6	28.07	70.18	2.69
Nauplius larva	0	0.00	0.2	3.51	0.6	10.53	0.4	7.02	0	0.00	21.06	0.81
											393.02	**15.08**
Cylopoida												
Mesocylops spp.	0.2	3.51	0.6	10.53	1.8	31.58	0.6	10.53	1.2	21.05	77.2	2.96
Tropocylops confinis	0	0.00	0	0.00	1	17.54	0	0.00	0	0.00	17.54	0.67
Neocylops affinis	0.2	3.51	0.8	14.04	0	0.00	2.2	38.60	0.2	3.51	59.66	2.29
Afrocyclops monody	0	0.00	0	0.00	0.2	3.51	0.2	3.51	0	0.00	7.02	0.27
Macrocyclops spp.	0	0.00	1.2	21.05	0	0.00	0.4	7.02	1.2	21.05	49.12	1.88
Mesocyclops leukarti	0.4	7.02	2.6	45.61	3	52.63	3.4	59.65	2.6	45.61	210.52	8.08
		384.31		**487.75**		**561.46**		**631.64**		**561.44**	**421.06**	**16.15**
Total (Org/L)											**2606.58**	**100**

KEY: TC= Total count, FC=Fauna count, TFC= Total fauna count

Table 2: Mean Monthly Values of Physicochemical Parameters and Zooplankton Density in Jakara Dam (March, 2013- February, 2014)

Sampling Sites	A	B	C	D	E
Temperature (	25.3	23.9	24.0	24.0	25.3
Secchi disk Transparency(cm)	10.7	54.7	57.9	38.6	33.4
Dissolved Oxygen(mg/l)	4.5	3.3	3.7	4.9	3.9
Biochemical Oxygen Demand (mg/l)	2.5	1.7	1.5	2.4	2.1
Electrical Conductivity (µS/cm)	856.7	818.1	817.9	844.5	838.2
pH	7.2	7.8	7.8	7.8	7.7
Nitrate (mg/l)	23.8	16.2	14.3	21.1	19.5
Phosphate (mg/l)	15.8	13.3	12.5	14.6	14.3
Zooplankton Density (Org/l)	12.7	36.8	42.4	47.7	40.0

Table 3: Mean Values of Physico-Chemical Parameters in Jakara Dam During Wet and Dry Seasons (March, 2013- February, 2014)

Parameters / Season	**Wet season**	**Dry season**
Temperature ()	24.9	22.8
Secchi disk transparency(cm)	41.5	37.9
Dissolved oxygen (mg/l)	3.3	2.3
BOD (mg/l)	1.8	1.2
EC(µS/cm)	747.5	880.2
pH	7.7	7.9
Nitrate (mg/l)	11.3	28.9
Phosphate (mg/l)	7.8	22.2

Table 4: Zooplankton Structure and Biological Indices at Five Sampling sites in Jakara Dam (March, 2013- February, 2014)

Biological Index /Sites	**A**	**B**	**C**	**D**	**E**
Zooplankton Total Count (Org/l)	383.31	487.75	561.46	631.64	561.44
Shannon-Wieners Index (H)	2.77	3.03	3.1	3.13	3.09
Evenness Index (E)	0.47	0.49	0.49	0.49	0.49
Simpson's Index (Ds)	0.09	0.057	0.050	0.059	0.056

Table 5: Zooplankton Fauna Composition during Wet and Dry season in Jakara Dam (March, 2013- February, 2014)

Taxon	**Wet Season Total (Org/l)**	**Frequency (%)**	**Dry Season Total(Org/l)**	**Frequency (%)**
Protozoa	161.31	19.99	157.77	15.54
Rotifera	196.36	24.34	329.70	32.48
Cladocera	214.00	26.53	267.82	26.39
Calanoida	161.44	20.01	172.03	16.95
Cyclopoida	73.69	9.13	87.70	8.64
Total (Org/L)	806.8	100	1015.02	100

Table 6: Zooplankton Structure And Biological Indices of Water Quality during Wet and Dry Season (March, 2013- February, 2014)

Biological Indices / Season	**Wet Season**	**Dry Season**
Zooplankton total fauna count(Org/l)	747.19	878.31
Shannon- Weiner Index	3.03	3.01
Evenness Index	0.46	0.44
Simpson's Index	0.056	0.057

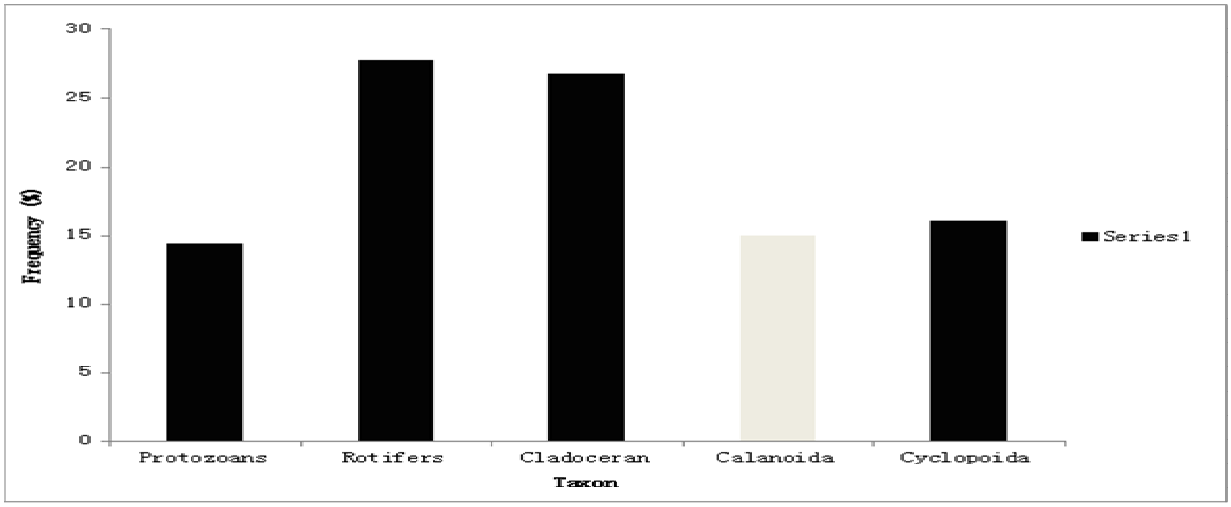

Figure 2: Frequency of Zooplankton Against Taxon in Jakara Dam (March, 2013- February, 2014)

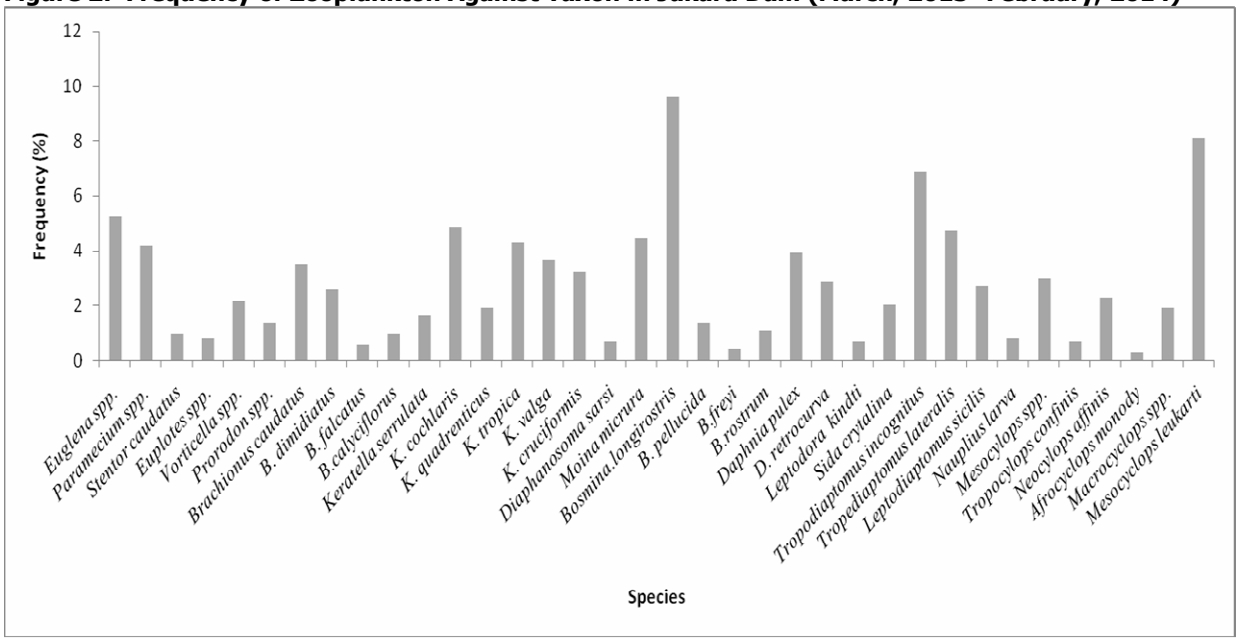

Figure 3: Frequency Against Zooplankton Species (March, 2013- February, 2014)

RESULTS AND DISCUSSIONS

The result obtained showed that zooplankton highest species richness was recorded at site D (631.64 Org/l) followed by sites E, C, and B with 561.44 Org/l, 561.46 Org/l, and 487.75 Org/l respectively. Site A had the least number of species (384.21 Org/l). Zooplankton species richness according to taxa showed highest value of 10 species of Rotifers, Cladocerans 10, Protozoa 6, Cyclopoida 6, and Calanoida 4 species. *Bosmina longirostris* showed highest distribution and abundance of 250.88 Org/l, *Afrocyclops monodi* had the least of 7.02 Org/l (Table 1and Figure 3).

Rotifers are being considered as the most important soft bodied invertebrates. They play a significant role in aquatic food chain and thereby constitute an important food items to fish. The composition of rotifers communities responds to environmental factors and therefore can be used as biological indicator of trophic condition of aquatic ecosystem (Huchtchinson, 1967). In the present study, rotifers had 27.10% of the total zooplankton species identified (Table 1 and Fig. 2). This agrees with the findings of Lamai and Kolo (2003) in Rabiu *et al.* (2011) who studied the zooplankton of Dan-Zaria Dam and observed 40 taxa dominated by the rotifers. Similar observation was made by Thirupathaniah *et al.*(2011). The present study is in agreement with the findings of Imoobe and Adeyinka (2010) who stated that the zooplankton community structure was dominated by numerous species of rotifers in tropical forest river.

Cladocera are popularly called 'water flea' and prefers to live in deep water and constitute a major item in food chain and energy transformation (Uttangi, 2001). During the present study 10 species were recorded which formed 26.99% of the total collection (Table 1 and Figure 2).

Protozoa are an important food source for micro invertebrates thus, the ecological role of protozoa in the transfer of bacterial and algal production to successive trophic levels is important. As predators, they prey upon unicellular or filamentous algae, bacteria and micro fungi. They control bacteria population (Alcamo and Warner 2009). Six (6) species of protozoa were recorded which made up 14.44%. *Euglena* spp were 142 Org/l out of the total count of 397.4 Org/l (Table 1and Figure 2).

Cyclopoida and Calanoida had 16.14% and 15.00% respectively (Table 1 and Figure 2). The total number of zooplankton species in the dry season (878.31 Org/l) was greater than the values obtained in the wet season 747.19 Org/l (Table 5 and 6).

From the calculated result, the values of Shannon-Weiner's, Evenness index and Simpson's index were between 2.7 - 3.13, 0.47 - 0.49 and 0.09 - 0.54 respectively (Table 4). Shannon-Weiner's and Evenness indices were high in the wet season than in the dry season. Simpson's index is higher in the dry season than in the wet season (Table 6) . This result was similar with the findings of Thirupathaniah *et al.* (2001). The relationship between species diversity and pollution status of aquatic ecosystem are classified as follows; >3 = clean water, 1-3 = moderately polluted < 1 = heavily polluted (William *et al.,* 2002). This indicated that the Dam is moderately polluted.

The mean monthly range of temperature was 25.3-23.9 (Table 2). These values were within the National Environmental Standard and Regulation Enforcement Agency (NESREA) (1991) emission standard of 30 for discharge of effluents into river (Ibrahim, 2009). The mean values of temperature in the rainy season were 24.9 and 22.8 and in the dry season (Table 3). Differences in water temperature may be due to the timing of collection and influence of season (Adeniji, 1993). Similar reasons were given by Ibrahim (2009).

Transparency enables the sun rays to penetrate to a certain depth, enabling photosynthetic flora to perform productive activities, which is very important in aquatic ecosystems (Huchtchinson, 1967). The annual mean of transparency was low at site A (10.7cm) and high at site C (57.9cm) (Table 2). The mean transparency was slightly higher in the rainy season (Table 3).

Dissolved Oxygen is one of the most important parameters that indicate water purity. It is essential in maintaining a variety of forms of biological life in water. According to Department for International Development (DFID) (1999), DO provides a broad indicator of water quality and that DO concentration in unpolluted water is normally about 8-10 mg/l at 25. The annual mean DO of 4.5 mg/l was the highest recorded at site A, with lowest value of 3.3mg/l observed at site B (Table 2).The highest monthly mean of 3.9 mg/l was recorded in the month of May in the early rainy season and lowest of 2.4 mg/l in late rainy season. In the wet season, the DO mean value was 3.3mg/L while the value of 2.3mg/l was recorded in the dry season (Table 3). This result was in agreement with the values of DO observed by Imam (2010) in the same water. Ibrahim (2009) stated that river that contained higher level of inorganic and organic pollutants tents to have low dissolved oxygen.

The annual mean values of BOD ranged between 1.7 and 2.5mg/l (Table 2). Low values of BOD were obtained in the months of dry season (Table 3). This agreed with the finding of Awanda (1987) that studied the effect of industrial effluents on biota of River Kaduna. He reported that BOD was higher in the dry season than the rainy season during the period of oxygen consumption by decomposers (bacteria and fungi) on biogenic materials. Based on classification of aquatic bodies, unpolluted water BOD < 1.0 mg/l, moderately polluted BOD < 10.00 mg/l and heavily polluted BOD > 10.00mg/l (Maria, 1983). BOD above 1 mg/l is associated with waste water contamination (UNESCO, 1991). The result of electrical conductivity showed that annual monthly mean value was highest at site A (856.7µScm$^{-1)}$ and lowest (817.9 µScm^{-1}) at site C (Table 2). The higher electrical conductivity observed at site A may be attributed to the intensive irrigation farming because of fertilizer application, such activity was lacking at site C, which is the mid-point of the water. This agrees with the observation made by Sebastain *et al.* (2004) that the higher the ionic concentrations in water the greater the conductivity. The average mean value of EC in the dry season was slightly greater than the value obtained in the rainy season (Table 3). This could have been due to the high level of nutrient in the site.

During the present study, highest mean pH was recorded at site A (7.9) and lowest at site E (7.7) (Table 7). The result fall within the acceptable limit of 6.5 -8.5 and 6 - 9 recommended by the WHO (1999) and (NESREA) (1991) respectively for inland and drinking water.

The concentration of nutrient in water body is strongly influenced by the nature of the sediment. Wetzel (2001) reported that the rate of phosphorus released into water body can be doubled when the sediments are frequently disturbed. The highest annual mean value of nitrate was recorded at site A (23.8mg/l) and lowest at site C (14.3mg/l). Consequently, the mean value of phosphate obtained at site A of 15.8mg/l was the highest and lowest at site C was 12.5mg/l (Table 2). The values of nitrate obtained from this study were below WHO and FEPA tolerance limit of 45mg/l for drinking water (Mahre *et al.* 2007). The mean values of nutrients obtained in the dry season were significantly higher than the respective values recorded in the months of the rainy season (Table 3). This could have been attributed to the dry season irrigation farming and concentration of these nutrients due to evaporation. This was in agreement with the findings of Mohammad and Saminu (2012) that studied the effect of physico- chemical factors on seasonal dynamics in Nguru Lake.In the wet months of the rainy season, Pearson's Coefficient analysis showed that there was positive relationship between temperature and nitrate and BOD at P< 0.05, likewise between DO and phytoplankton and zooplankton, BOD and nitrate and phosphate at P< 0.01.

Similarly, negative correlation was recorded between Secchi disk transparency and BOD at P< 0.05, and Secchi disk transparency and phosphate at P< 0.01 were observed. In the dry season, positive correlation existed between secchi disk transparency and zooplankton, DO versus phosphate at P< 0.01. Likewise between DO versus BOD, BOD versus nitrate and phosphate, nitrate and phosphate at P < 0.01, also negative correlation existed between zooplankton and nitrate, temperature and EC and nitrate at P< 0.01 so also between zooplankton and phosphate, secchi disk transparency and pH at P < 0.05.

CONCLUSION

Zooplankton diversity and abundance could be used as an important tool in monitoring changes in Jakara Dam. During the period of this study, site A had very low secchi disk transparency and high level of nitrate and phosphate in the whole sampling sites. This is due to the suspended matter resulting from the runoff from the surrounding farmland that uses the water for irrigation, and fishing activities especially at site A where these activities was high. Zooplankton as bioindicators of both pollution and trophic condition of water system.

RECOMMENDATIONS

In a bid to providing safe water for domestic and industrial uses, water treatment plant should be provided to help in water treatment especially at site A (Bella community) of this research area.

Government should provide the farmers with modern means of irrigation, for this will help to control and regulate agricultural activities around the area, hence checking entry and exit of water through water channels.

The need for government to provide a means for treating effluents from the source (origin) cannot be over emphasized

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