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FLORA COMPOSITION OF PHYTOPLANKTON AS BIOINDICATORS OF WATER QUALITY IN JAKARA DAM, KANO STATE, NIGERIA

Abubakar, A. and Abdullahi, B.A
Department of Biological Sciences Bayero University, Kano.
Email:abdulrahmanabubakar96@yahoo.com

ABSTRACT
A study on phytoplankton as bioindicators of water quality in Jakara Dam was carried out for a period of 12 months (March, 2013-February 2014). Phytoplankton and water samples were collected and analyzed using standard methods. Sampling sites designated as A, B, C, D, and E were chosen. Physico-chemical parameters showed 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- 817.9µs/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. Cyanophyceae were the most dominant contributing 56.8% of the total flora composition, followed by Bacillariophyceae (23.2%) and Chlorophyceae (23.0%). A combined total of 23 species of phytoplankton were encountered. Cyanophyceae 9, Bacillariophyceae 7 and Chlorophyceae 7. The total flora count obtained was 3255.93 Org/l. The highest phytoplankton density was recorded at site D (870.18 Org/l) and lowest at site A (454.39 Org/l). Oscillatoria spp. had the highest total species count (1131.58) org/l while Anthophysa vegetans had the lowest (10.53 Org/l). High percentages of organic pollution indicators Oscillatoria spp and Microcystis aerogenosa were signs of deteriorating condition of the water quality. Shannon - Weiner's and Evenness Indices values were higher in the months of wet season than in dry season, while the Simpson's Index values were low. The total flora counts were higher in dry season. In the wet 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, BOD and nitrate and phosphate 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. Shannon - Weiner's Index value indicated that the site is more polluted. Government and stakeholders should strengthen their legislation against indiscriminate and improper waste disposal along water-ways, dams inclusive. This will ease inflow and check contamination to a large extent.
Keywords: Bioindicators, Indicies, Jakara Dam, Physico-chemical parameters, Phytoplankton

INTRODUCTION

Bioindicators are species used to monitor the health of the environment or ecosystem. They are biological species or group of species whose function, population or status can be used to determine ecosystem or environmental integrity (Karr, 1981). 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). Phytoplankton has long been used as effective bioindicators of eutrophic water (APHA, 1989) that is sensitive to environmental changes. Tanimu *et al*. (2011) studied phytoplankton of Saminaka Reservoir, Northern-Nigeria**.** He discovered a number of phytoplankton species, and class abundance showed the order Bacillariophyceae > Cholorophyceae > Cyanophyceae > Euglenophyceae. The physico-chemical characteristics (Nitrate-nitrogen, phosphate-phosphorus, total hardness, total alkalinity, electrical conductivity, dissolved oxygen, biochemical oxygen demand and secchi disk transparency) of the water in the reservoirs showed significant relationship with phytoplankton.

However, despite the numerous works carried out in the study of phytoplankton 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 certain species in the area.

This study was aimed at investigating the species composition of phytoplankton to the existing water quality in Jakara Dam and their seasonal fluctuation. It examines whether phytoplankton of Jakara Dam could be considered as bioindicators.

MATERIALS AND METHODS

Study Area: Jakara Dam

Jakara Dam was constructed in 1976 and situated in Minjibir Local Government Area (L.G.A) 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 sites. 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 site is located on latitude 12°08' 35.86" N and longitude 8°4' 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.

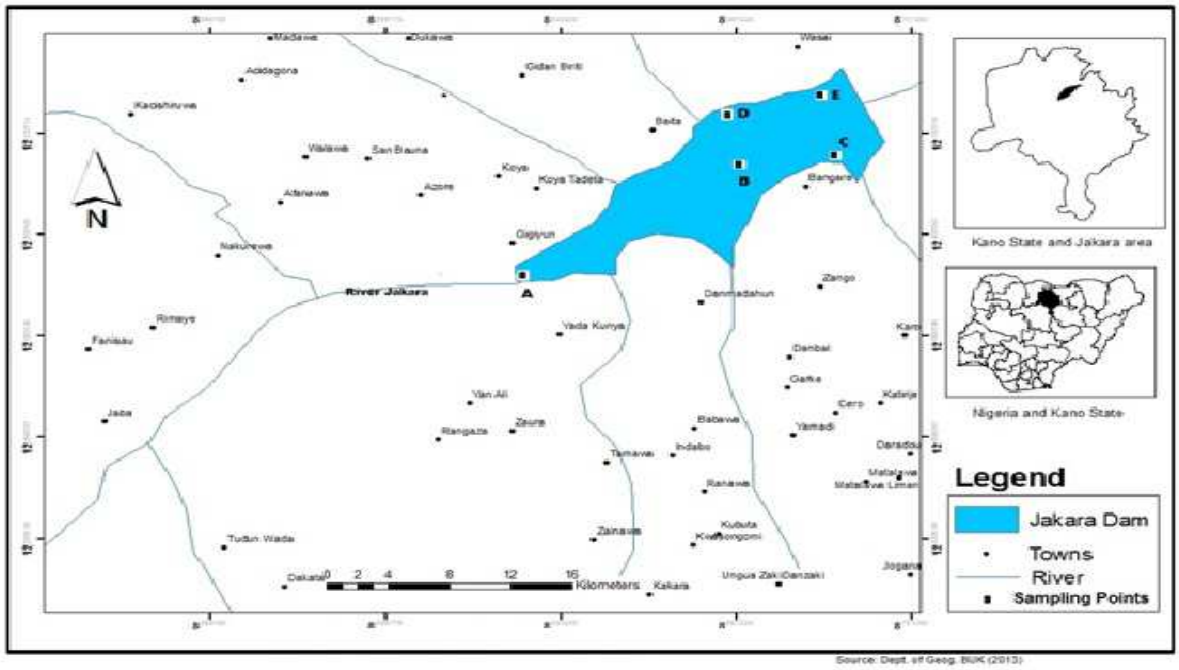

Figure 1: Map of Jakara Dam Showing Sampling Points

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;

x_1 = Depth at which Secchi disk disappeared.

x_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 (DO)

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 millitre (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 (BOD)

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 powder 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 started when the steam coming from the kjaedahl 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 millilitre (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 water respectively in 50ml Erlenmeyer flask. Eight millilitre (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 Plankton

Phytoplankton were collected 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) that was collected in the plastic bottle at the end of the net was emptied into plastic bottle of 20ml and immediately fixed with 1ml of Lugol's iodine solution to preserve the phytoplankton (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 sites were analyzed immediately while the other three (3) samples were allowed to settle for 48 hours. The average was used in computation of the result (Abdullahi, 1990). Each sample was homogenized after decanting $^2/_3$ of it. One mililitre (1ml) 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 phytoplankton were identified based on taxonomical classification to species level using the identification keys by Botes (2001), Dietrich (1979), Durand and Lévéque (1980), and Edward and Ugwumba (2010).

Volume of water filtered

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

$$V = \pi r^2 d$$

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 and phytoplankton 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.

Table1: Phytoplankton Abundance and Distribution in Jakara Dam (March, 2013- February, 2014)

Site/ Species	A		B		C		D		E			
	TC	FC (Org/)	TC	FC (Org/l)	TC	FC (Org/l)	TC	FC (Org/l)	TC	FC (Org/l)	TFC (Org/l)	Frequency (%)
Chlorophyceae												
Oscillatoria Spp.	14.9	261.40	18	315.79	4.6	80.70	13.6	238.60	13.4	235.09	1131.58	34.8
Microcystis aerogenosa	1.6	28.07	0.6	10.53	1.4	24.56	3.4	59.65	1	17.54	140.35	4.3
Aphanizomenon flos- aquae	1	17.54	1.6	28.07	0	0.00	2	35.09	0.6	10.53	91.23	2.8
Merismopodia glauca	0.6	10.53	1.8	31.58	1.8	31.58	3	52.63	0.8	14.04	140.36	4.3
Rivularia spp.	0.4	7.02	1	17.54	1.6	28.07	0.6	10.53	0.8	14.04	72.20	2.4
Anabaena flos-aquae	1.6	28.07	0.4	7.02	0.2	3.51	0.4	7.02	1	17.54	63.16	1.9
Merismopedia elegans	0	0.00	0.2	3.51	2	35.09	1.4	24.56	0.2	3.51	66.67	2.0
Coelosphaerium confernis	0	0.00	0.2	3.51	0.6	10.53	0	0.00	0.4	7.02	21.06	0.7
Calothrix brevissima	0	0.00	0	0.00	0	0.00	1.2	21.05	0	0.00	21.05	0.7
											1752.66	**53.8**
Bacillariophyceae												
Navicula sp.	0.8	14.04	4.4	77.19	2.4	42.11	10	175.44	3.6	63.16	371.94	11.4
Stauronesis phoenicenteron	0	0.00	0.2	3.51	0.4	7.02	0.6	10.53	0.6	10.53	31.59	1.0
Nitzchia spp.	0	0.00	1.8	31.58	5	87.72	4	70.18	2	35.09	224.57	6.9
Synedra spp.	0	0.00	0.8	14.04	1	17.54	0.8	14.04	0.6	10.53	56.15	1.7
Anthophysa vegetans	0	0.00	0	0.00	0.2	3.51	0	0.00	0.4	7.02	10.53	0.3
Cyclotella spp.	0.8	14.04	0.6	10.53	0.2	3.51	0	0.00	0.4	7.02	35.10	1.1
Pinnularia spp.	0	0.00	1	17.54	0	0.00	0.2	3.51	0.2	3.51	24.56	0.8
											754.44	**23.2**
Chlorophyceae												
Volvox aureus	1	17.54	1.4	24.56	1.6	28.07	1.6	28.07	1.6	28.07	126.31	3.9
Ulothrix zonata	1.8	31.58	1.2	21.05	1.8	31.58	1	17.54	2.4	42.11	143.86	4.4
Cosmarium spp.	0.4	7.02	1	17.54	1.2	21.05	0.4	7.02	0	0.00	52.63	1.6
Spirogyra spp.	0	0.00	0.2	3.51	0.2	3.51	0.2	3.51	2.5	43.86	54.09	1.7
Pediastum spp.	0	0.00	2.8	49.12	1.8	31.58	4	70.18	2.2	38.60	189.48	5.9
Pediastrum simplex	0.8	14.04	2	35.09	0.4	7.02	1.2	21.05	1.2	21.05	98.25	3.0
Bodo caudatus	0.2	3.51	0	0.00	4.6	80.70	0	0.00	0	0.00	84.21	2.6
											748.83	**23.0**
Total (Org/L)		**454.39**		**722.81**		**578.95**		**870.18**		**629.82**	**3255.93**	**100.0**

Key: TC= Total count of the species, FC= Floral count of the species, TFC= Total floral count of the species

Table 2: Mean Monthly Values of Physico-chemical Parameters and Phytoplankton 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	7.9	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
Phytoplankton Density (Org/L)	37.9	60.2	48.3	72.5	43.3

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

Parameters	**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: Phytoplankton Structure and Biological Indices at Five Sampling Sites in Jakara Dam (March, 2013- February, 2014)

Sites/Biological Index	**A**	**B**	**C**	**D**	**E**
Phytoplankton Total Count (Org/l)	454.39	722.81	578.95	870.18	629.82
Shannon-Wieners Index (H)	1.67	2.49	2.02	2.63	2.33
Evenness Index (E)	0.27	0.33	0.41	0.34	0.36
Simpson's Index (Ds)	0.35	0.23	0.089	0.14	0.17

Table 5: Phytoplankton Floral Composition in Wet and Dry Season in Jakara Dam (March, 2013- February, 2014)

	Wet Season		**Dry Season**	
Taxon	**Total(Org/l)**	**Frequency (%)**	**Total(Org/l)**	**Frequency (%)**
Cynophyceae	452.43	42.773	1037.88	62.80
Bacillariophyceae	336.92	31.853	323.64	19.60
Chlorophyceae	268.40	25.374	291.23	17.60
Total (Org/L)	1057.75	100.00	1652.75	100.00

Table 6: Phytoplankton Structure and Biological Indices of Water Quality in Jakara Dam during Wet and Dry Seasons (March, 2013- February, 2014)

Diversity Indices/ Season	Wet Season	Dry Season
Phytoplankton total flora count (Org/l)	1057.75	1656.25
Shannon- Weiner index	2.93	2.79
Evenness Index	0.4	0.38
Simpson's Index	0.067	0.088

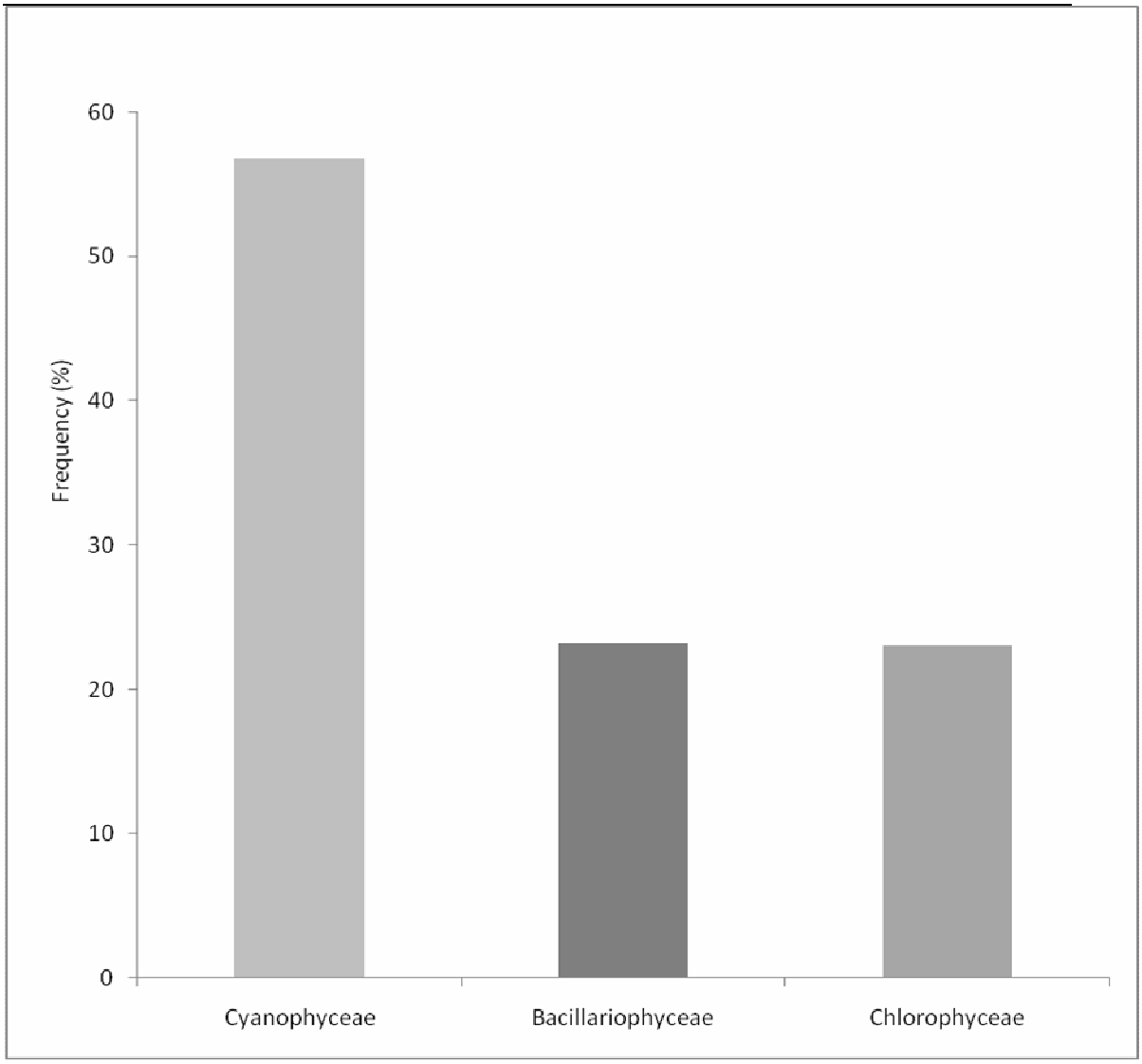

Figure 2 : Frequency of Phytoplankton Against Taxon in Jakara Dam (March 2013 – February, 2014)

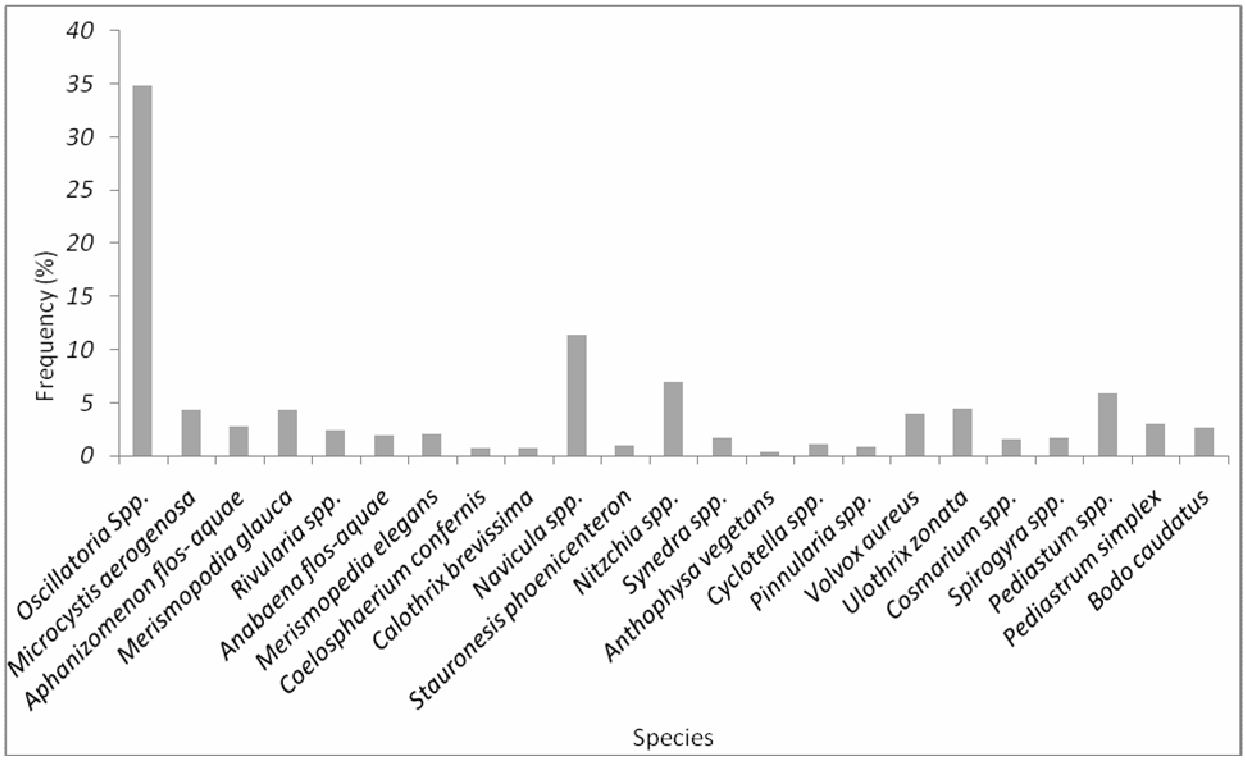

Figure 3 : Frequency of Phytoplankton Species in Jakara Dam (March 2013 – February 2014)

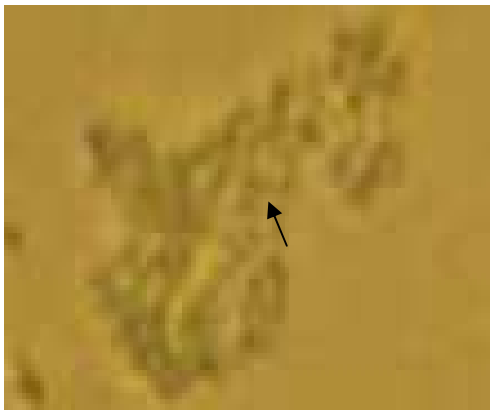

Plate i: *Microcystis aerogenosa* x400

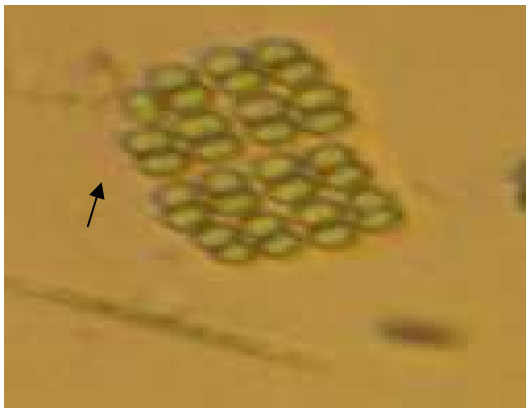

Plate ii : *Merismopedia glauca* x400

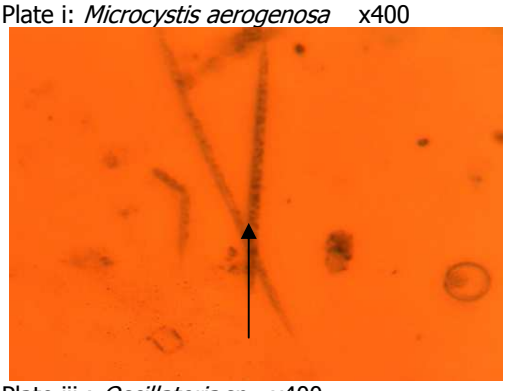

Plate iii : *Oscillatoria* sp. x400

Plate iv: *Ulothrix zonata* x100

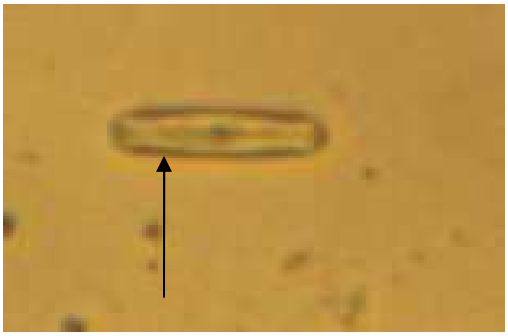

Plate v: *Pinnularia* sp. x400

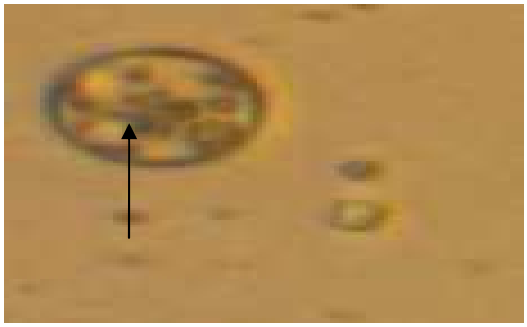

Plate vi: *Cyclotella* sp. x400

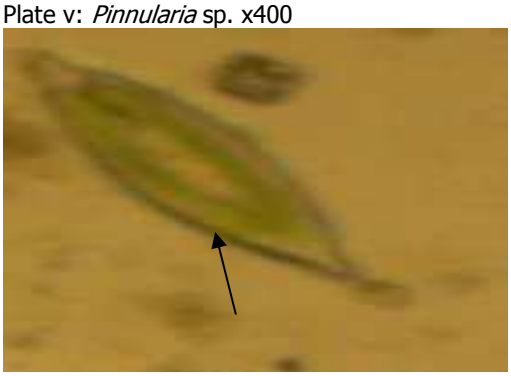

Plate vii : *Navicula* sp. x400

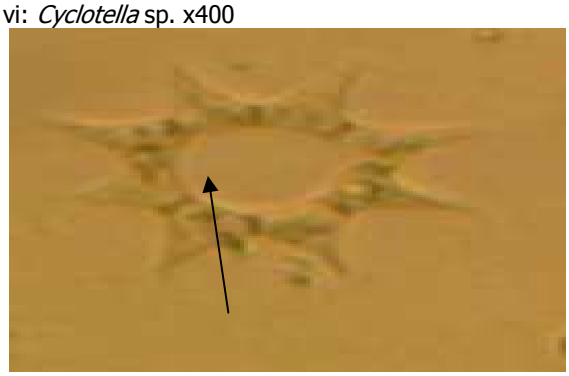

Plate viii : *Pediastrum* sp. x400

Plates: This Shows Some of the Species Identified in Jakara Dam (March, 2013- February, 2014).

RESULTS AND DISCUSSION

The result obtained showed that phytoplankton had the highest species richness at site D with flora composition of 870.18 Org/l and 722.81 Org/l, 629.82 Org/l and 579.65 Org/l at site B, E and C respectively. The least at site A (454.39 Org/l). *Oscillatoria* spp. showed highest distribution and abundance of 1131.58 Org/l and *Anthophysa vegetans* with the least of 10.53 Org/l. The study revealed the occurrence of 23 species of phytoplankton; among which 9 were Cyanophyceae, 7 were Bacillariophyceae and 7 were Chlorophyceae (Table 1). Cyanophyceae had 53.8 % out of the total number of phytoplankton identified. According to Tanimu *et al.* (2011) and Mohammad and Saminu (2012), the increase in the abundance of Cyanophyceae and Euglenophyceae is an indication of organic pollution. Higher number of *Oscillatoria* spp. and high percentage of Cyanophyceae is an indication of pollution in the water (Figure 3 and Plates). This was in agreement with the findings of Pramila *et al.* (2008). This research finding corroborates with that of Odhiambo and Gichuki (1998) that the algae of Lake Baringo were dominated by the Cyanophyta and Chlorophyta and that the lake is in a state of gradual deterioration of water quality.

Bacillariophyceae had 23.2% of the total flora composition. This was not in agreement with the findings of El-Sherif and Ibrahim (1993) who reported that Bacillariophyceae constituted the dominant algal groups in terms of cell numbers and taxa. Chlorophyceae had 23.0% (Table 1 and Figure 2). This contradicts with the work of Khan *et al.* (1983) and Kemdirim (2001) who reported chlorophyceae as the most abundant group in Nigeria fresh waters.

The total number of flora count in dry season of 1652.75 Org/l was greater than that of wet season, 1057.75 Org/l (Table 5). This contradicts with the findings of Abowei *et al.* (2008) that recorded more species of phytoplankton in wet season in the lower Sombreiro river, Niger Delta, Nigeria.

From the calculated result, the values of Shannon-Weiner's Index are 1.67 - 2.67. Evenness Index and Simpson's Index were 0.27 - 0.41 and 0.089 - 0.36 respectively (Table 4). Shannon-Weiner's and Evenness Indices value were high in the wet season than in the dry season. Simpson's Index is high in the dry season than in the wet season (Table 6). This result was in agreement with the findings of Muhammad and Saminu (2012). 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 Jakara Dam is moderately polluted.

The mean monthly range of temperature was 25.3-23.9 (Table 3). 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 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 that are very important in aquatic ecosystem (Huchtchinson, 1967). The annual mean of transparency was low at site A (10.7cm) and higher at site C (57.9cm) (Table 2). The mean transparency was slightly higher in the rainy season (Table 2).

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 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 tent 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 electrical conductivity is the ability of water to conduct electric current and is affected by the total amount of salt (ions) dissolved in water Boyd and Frobish (1998). The result of electrical conductivity showed that annual monthly mean value was highest at site A (856.7$\mu Scm^{-1)}$ 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 is 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 2).

An important parameter which is very significant in evaluating the acid – base balance of water is the pH. During the present study, highest mean pH was recorded at site A (7.9) and lowest at site E (7.7) (Table 2). 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 double 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 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, BOD and nitrate and phosphate at $P< 0.01$, also negative correlation between Secchi disk transparency and BOD at $P< 0.05$, and Secchi disk transparency and phosphate at $P< 0.01$. In months of the dry season, positive correlation existed between secchi disk transparency, DO and phosphate at $P< 0.01$. Likewise positive correlation existed between DO versus BOD, BOD versus nitrate and phosphate at $P < 0.01$.

CONCLUSION

Phytoplankton 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. However, these favour the growth of *Oscillatoria* spp., *Microcystis* and *Anabaena* which are pollution indicators. The presence of these species indicate an organic pollution, reflecting human interference to pollute the water over a period of time

RECOMMENDATIONS

Government and stakeholders should strengthen their legislation against indiscriminate and improper waste disposal along water-ways, dams inclusive. This will ease inflow and check contamination to a large extent.

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