POTENTIAL HEALTH IMPACTS OF PHYTOPLANKTON COMPOSITION IN WATARI DAM, KANO - NIGERIA

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ABSTRACT
Phytoplankton composition as bioindicators of water quality was determined for six months in Watari Dam, Kano between March and August, 2016. Water samples for phytoplankton and physicochemical parameters were collected and analyzed fortnightly between 8:00 – 10:00AM using standard methods. Four sampling sites (A, B, C and D) were chosen on the Dam based on the ecological setting and impact of anthropogenic activities. The mean range of physicochemical parameters studied were, water temperature (22 – 27.8 $^{\circ}$C), pH (5.9 – 9.3), DO (4.6 – 6.9mg/L), BOD (2.1 – 4.1mg/L), turbidity (28 – 42 NTU), electrical conductivity (630 – 860µS/cm), TDS (470 - 860 mg/L), phosphate (2.0- 3.8mg/L) and nitrate (13.6 -23.3mg/L). Total dissolved solids, turbidity and nitrate recorded significant difference between wet and dry season ($P<0.05$) while no significant difference was observed in DO, BOD, phosphate, temperature and pH. Sixteen (16) phytoplankton species were identified in which Cyanophyta had 25%, Chlorophyta (37.5%), Bacillariophyta (25%) and Euglenophyta (12.5%). Cholorophyta was the dominant group contributing 39.9% of the total floral composition of 286.7org/L. With regards to Palmer Pollution Index (P.P.I) 32 score was recorded from the 11 phytoplankton pollution indicator genera. The presence of pollution indicator phytoplankton species such as *Microcystis* sp., *Oscillatoria* sp., *Scenedesmus* sp., *Euglena* sp. and *Phacus* sp. indicates high degree of organic pollution in the Dam. Shannon-Wiener Index and Evenness Index showed high phytoplankton composition and abundance during wet season than the dry season. The present study revealed that the water body is impacted with various anthropogenic activities which affect the water quality negatively. It is therefore recommended that uncontrolled discharge of agrochemicals around the Dam through irrigation and other human activities should be controlled in order to curtail degradation of the aquatic biota over a period of time.

Keywords: Phytoplankton, Physicochemical parameters, Water Quality, Seasonal Variation, Watari Dam.

INTRODUCTION

Phytoplankton are the primary producers forming the first trophic level in the food chain (Khattak *et al.,* 2005). According to Khatri (2014), based on the distribution pattern of the phytoplankton the water quality of the environment can be assessed. Drinking water supply, recreational activities and fisheries can be impaired by high phytoplankton biomass (Khatri, 2014). The use of phytoplankton as biological indicators of pollution has been studied by rating pollution tolerant algae in a water body based on the report of Palmer (1969). Phytoplankton populations are highly dynamic and in many environments, they experience episodes of rapid biomass increase (blooms), often due to the recurrent changes of the environmental variables (Cloern, 1991). Phytoplankton has long been used as effective bioindicators of eutrophic water that is sensitive to environmental changes (Chekryzheva, 2014). The rate of production of phytoplankton is determined by a host of environmental parameters like physicochemical properties of water and soil, meteorological characteristics of the region and hydrographic features of the water body (Dahl and Wilson, 2000). According to Sanet *et al*. (2006), the distribution, abundance, species diversity and composition of the phytoplankton are used to assess the biological integrity of a water body. In view of the foregoing, this research aimed at assessing the potential health impacts of Watari Dam, Kano using phytoplankton composition.

MATERIALS AND METHODS

Study Area

Watari Dam impounded in 1977 is situated about 47 km away from Kano city along old Bichi-Gwarzo road in Bagwai and Bichi Local Governments Area of Kano 2 km from Bagwai town and 8km south west of Bichi, Kano, Nigeria. It has 1,959 hectares surface area and active storage capacity of 92.74million litres. The dam is located between latitude 12°9'24"N and 8°8'12"E with two distinct seasons (wet and dry). The rainy season which last from May to October and the dry season last from November to April. The mean annual temperature is between 16 – 41^{0}C and the mean annual rainfall range from 700 – 813mm (MANR, 1982 and Adamu *et al.,* 2014).

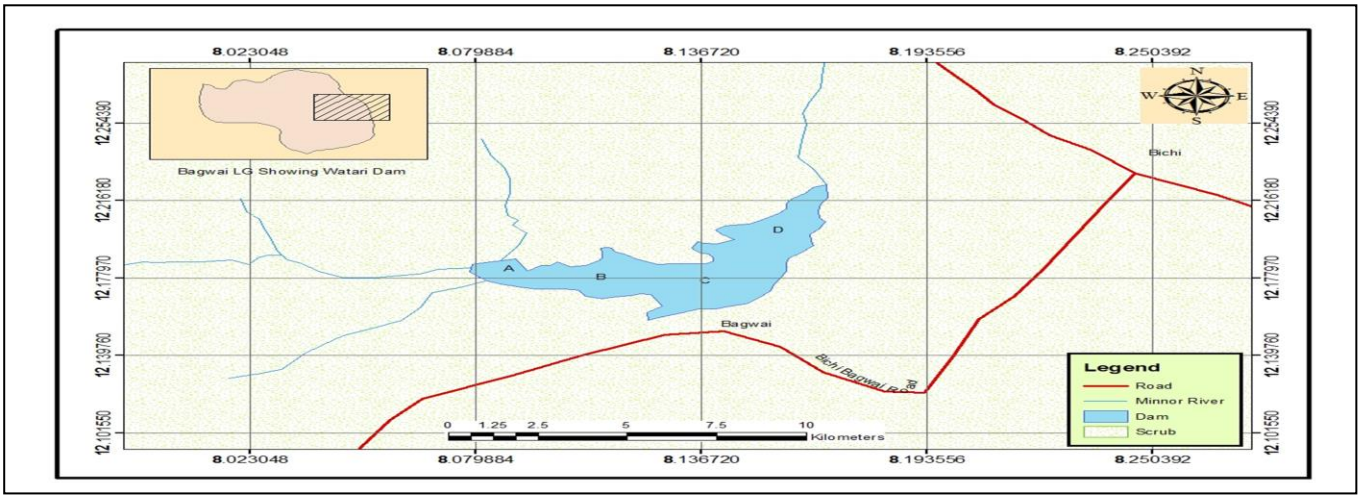

Fig. I: Map of Watari Dam Showing the Sampling Sites (Source: Cartography Lab. Geography Dept. Bayero Univesity Kano, 2017)

Sampling sites

Site A: In this site (12˚18’ 70’’N - 8˚ 07’84’’) the Dam forms a confluence with small rivers.

Site B: (12˚17'70'' - 8˚7'84'') is at the upper point of the dam where there are less human activities apart from fishing.

Site C: This site (12˚17'97'' - 8˚13'20'') is where Watari water treatment plant is located with an estimated capacity of 104.55 million cubic meters serving a total population of about 117,000 people of Bichi, Bagwai and Northern Districts of Kano.

Site D: (12˚ 21'80'' - 8˚13'20'') the spillway point of the reservoir where there is a lot of human activities such as irrigation, sand collection, washing of clothes among other activities.

Determination of Physico-Chemical Parameters

Water samples were collected fortnightly for a period of six months (March – August, 2016). The samples were collected from four sampling stations (Site A, B, C and D) between the hours of 8:00 am -11:00am. The following physiochemical parameters were determined as described by APHA (2005): Surface water temperature Total Dissolved Solids, pH, Dissolved Oxygen, Biochemical Oxygen Demand$_5$, Turbidity, Electrical Conductivity, Nitrate – Nitrogen and Phosphate – phosphorus**.**

Collection and Identification of Phytoplankton Sample

Samples of phytoplankton were collected using plankton net of 15cm diameter and mesh size 70µm according to the procedure described by Verlencar and Desai (2004). The samples were immediately preserved with 1.0ml Lugol's solution (Wetzel and Likens, 2000). The volume of water that passed through the net was estimated by using the formula described by Goswami (2004). The collected samples were condensed to 10mI, and 1ml of the phytoplankton subsample was withdrawn for sorting and counting using light microscope (Olympus) and camera microscope (LEICA DM 2500 model). Identification of the phytoplankton to species level was done using keys described by Palmer (1980) and Lynne (2004). Counts were made in triplicates and their averages were taken and expressed as org/L. Phytoplankton abundance was estimated using the formula as described by Nlewadim and Adeyemo (1998).

$V = \pi r^2 d$ Where V = volume of water filtered through the net,

r = radius of the mouth of the net and

d = length of the haul (Goswami, 2004)

$A = {}^{YZ}/_{ax}$; Where, A = Average plankton per litre, Y = Average plankton per sample, Z = Concentrate volume (ml), a = original volume of sample per liter, x = Volume of sample or counting chamber examined (ml).

Shannon-Weaner (1949) diversity index (H) and species richness was used to determine the phytoplankton species composition and abundance. Shannon-Weaner's Index (H) is commonly used to characterize species diversity in aquatic community. Shannon-Weaner's Index accounts for both abundance and evenness of the species present: Shannon Index (H) = -Σ1ln pi ln pi

Where pi = the proportion of the ith species in the sample ($\frac{No.of\ individual\ species}{total\ number\ of\ samples}$)

H = the Shannon – wiener` index of diversity S= number of species or species richness

H_{max} =Maximum diversity E = Eveness = ${}^{H}/_{Hmax}$

Palmer pollution indices (P.P.I) according to Palmer (1969) based on algal genus and species was used in rating water samples for high or low organic pollution. Twenty (20) most

frequent genera of algae were taken into account. A pollution index factor was assigned to each genus by determining relative number of total points scored by each phytoplankton. The range of palmer index values indicative of organic pollution are 0 - 14: Organic pollution is absent, 15 - 20: Presence of organic pollution and > 20: Presence of high level of organic pollution.

Statistical Analyses

Analysis of variance (ANOVA) was used to compare the means of seasonal variations of phytoplankton species composition and physico chemical parameters during wet and dry seasons to find out if there is significant difference or otherwise. Duncan Multiple Range Test was used to separate the means. All the analyses were carried out using SPSS software (16.0 version).

RESULTS

Physicochemical Parameters

The mean range of the water temperature recorded was between 22.0^{o}C and 27.8^{o}C with the lowest value recorded in July and the highest in May. Similarly, mean water temperature during dry season (March – May) was 28.9± 1.99°C while higher value of 27.8±2.81°C was recorded during wet season (June – August) as presented in Table 2. Temperature variations between seasons indicated no significant difference ($p<0.05$). The range of pH values was pH 5.9 – 9.3) with the lowest value recorded in June and the highest in March. The seasonal variation of pH indicated that the mean pH of dry season was 8.0± 1.66 while that of wet season was 8.9±1.03. There was no significant difference recorded between the two seasons ($P< 0.05$). The seasonal difference for TDS indicates mean dry season values of 416.3mg/L and 763mg/L in the wet season (Table 2). It revealed significant differences between the two seasons at $P< 0.05$.

The DO ranged between 4.6 mg/L in March and to 6.9mg/L in August. Seasonally, the highest mean DO value during dry season was 5.0±1.25mg/L while wet season had the least value of 6.9±1.00mg/L (Table 2). The seasonal variations in the mean BOD values indicated that dry season had 2.7±0.20mg/L while wet season recorded 3.9±0.81mg/L. Statistically, there was no significant difference in DO and BOD between the two seasons ($p<0.05$). Mean monthly values of turbidity ranged between 28NTU and 42NTU. The mean value recorded during the dry season was 27.5±1.00NTU while 38.0±1.80NTU was recorded during the wet season (Table 2). Mean turbidity values revealed significant difference between the seasons ($p< 0.05$).

Mean monthly values of Electrical Conductivity ranged from 630µS/cm to 860µS/cm. Phosphate – phosphorus concentration was observed to be higher in wet season with 2.67±0.61mg/L and low in the dry season with 2.2±0.0.6mg/L. Statistically, no significant difference was observed between the seasons ($P<0.05$). There was high concentration of Nitrate- nitrogen in wet season with 13.7±2.10 mg/L than that of dry season with 9.78±1.90 mg/L which was significantly different at $P<0.05$ (Table 4).

Table 1: Mean Values of Physico-chemical Parameters and Phytoplankton Density in Watari Dam, Kano (March - August, 2016)

Parameters/Sampling Sites	A	B	C	D	Standard limits
Water temperature (°C)	22±1.9[a]	24.6±3.2[b]	27.8±2.7[bc]	26.7±2.1[a]	<40°Cmg/L*
DO (mg/L)	6.9±0.8[a]	6.0±1.1[a]	4.6±0.7[a]	6.4±0.3[a]	5.0-9.0mg/L**
BOD (mg/L)	3.7±0.7[c]	2.1±0.12[b]	3.4±0.2[ab]	4.1±0.6[a]	3.0-6.0mg/L**
TDS (mg/L)	562±23.6[ab]	679±34.2[a]	860±19.6[a]	470±29.8[a]	<600mg/L*
Electrical Conductivity (µS/cm)	860±32.1[ab]	709±24.3[bc]	951±36.1[a]	630±22.6[c]	<1000µ/Scm***
Turbidity (NTU)	27.4±1.5[a]	26.7±1.9[a]	42±2.5[c]	28±1.4[bc]	<25 NTU***
pH	9.3±1.1[a]	8.2±0.8[a]	5.9±.01[a]	8.7±0.7[a]	6.0-9.0*
Phosphate (mg/L)	2.98±0.1[bc]	2.0±0.0[a]	3.8±0.1[a]	2.5±0.1[b]	0.1 mg/L**
Nitrate (mg/L)	12.61±1.6[a]	20.02±1.9[b]	13.6±1.4[a]	23.3± 2.1[a]	5mg/L**

*FEPA (1991), **FME (2001), ***WHO (1999)
Means followed by same letter(s) superscripts in the same row are not significantly different using DMRT at 5%

Table 2: Seasonal Variation of Physicochemical Parameters in Watari Dam, Kano (March - August, 2016)

Parameters	**Dry season (January – May)**	**Wet season (June – October)**
Water temperature (°C)	28.9 ± 1.99	27.8 ± 2.81
DO (mg/L)	5.0 ± 1.25	6.91 ± 1.80
BOD (mg/L)	2.7 ± 0.20	3.90± 0.81
TDS (mg/L)	416.3 ± 9.46	762 ± 12.08
Electrical Conductivity (µS/cm)	791.8 ± 11.58	717.3 ± 9.01
Turbidity (NTU)	27.5 ± 1.00	38.0 ± 1.80
pH	8.0 ± 1.66	8.9 ± 1.03
Phosphate (mg/L)	3.22 ± 0.06	2.67 ± 0.61
Nitrate (mg/L)	9.78 ± 1.90	13.7 ± 2.10

Biological Parameters

Sixteen (16) species of phytoplankton belonging to the following classes: Cyanophyta (25%), Chlorophyta (37.5%), Bacillariophyta (25%) and Euglenophyta (12.5%) were identified during the study period in which *Spirogyra communis* predominates with 14.4% and *Nostoc* sp. recorded the least with 2.2%. Analysis of the phytoplankton community structure with respect to pollution status of Watari Dam using Palmer Pollution Index (P.P.I), a total of eleven (11) genera out of the sixteen (16) were identified. The pollution tolerant species such as *Microcystis aeruginosa, Oscillatoria chlorina, Cosmarium connatum, Scenedesmus quadricauda, Navicula radiosa, Euglena* sp. and *Phacus pleuronectes* were considered as bio-indicator of pollution. Their values cumulatively were 32 higher than 20 used by Palmer (1969) for assessing level of organic pollution in limnological studies. Seasonal variation of P.P.I indicated that wet season had 19 while dry season had 13 scores (Table 4). Shannon-

Wiener diversity Index (H) and Evenness Index (E) were highest at site A with 1.42,0.86 while the least were at site B with 1.23, 0.68 respectively. Seasonal variation of indicated that Shannon wiener Index and Evennes Index had the highest values in wet season of 1.36 and 0.80 while dry season had 1.20 and 0.69 respectively. Seasonal variation revealed more species richness and abundance during wet season than during dry season.

Table 3: Phytoplankton Species Composition and Palmer Pollution Index in obtained from Watari Dam, Kano (March - August, 2016)

Phytoplankton taxa	Palmer Pollution Index	A	B	C	D	Total	% frequency
Cyanophyta (25%)							
Microcystis aeruginosa	5	7.3	3.7	4.4	4.9	20.3	7
Nostoc sp.		2.2	2.1	0.8	1.2	6.3	2.2
Oscillataria chlorine	5	1.6	5.8	5.1	5.7	18.2	6.3
Phormidium uncinatum	1	5.9	6	4.2	5.7	21.8	7.6
Chlorophyta (37.5%)							
Closterium sp.	1	3.7	2.7	1.7	2.8	10.9	3.8
Spirogyra communis		13.4	6.5	8.8	12.7	41.4	14.4
Pediastrum duplex		3.7	3.1	4.7	1.8	13.3	4.6
Cosmarium connatum	2	2.2	1.4	0.6	3.6	7.8	2.7
Scenedesmus quadricauda	4	3.4	5.6	7.3	6.8	23.1	8
Palmella sp.		3	2.2	4.8	2.8	12.8	4.4
Bacillariophyta (25%)							
Nitzchia sp.	3	4.5	2.5	2.9	1.9	11.8	4.8
Navicula radiosa	3	6.8	10.2	9	6.8	32.8	11.4
Gyrosigma sp.		7.4	4.6	6.7	5.8	24.5	8.4
Cyclotella sp.	1	2.6	3	3.4	2.6	11.6	4
Euglenophyta (12.5%)							
Phacus sp.	2	2.7	1.4	1.8	3.8	9.7	3.3
Euglena acus	5	5.8	4.8	4.6	5.2	20.4	7.1
Total no. of individuals per site	**32**	**76.2**	**65.6**	**70.8**	**74.1**	**286.7**	**100**
Shanno-diversity (H)		**1.42**	**1.23**	**1.3**	**1.39**		
Evenness (E)		**0.86**	**0.68**	**0.72**	**0.78**		

Table 4: Seasonal Variation of Phytoplankton Taxa and Palmer Pollution Index of Watari Dam, Kano (March - August, 2016)

Diversity indices	Wet season (June- Aug.)	Dry season (March- May)
Phytoplankton Total count(org/L)	176	110
Shannon - wiener index(H)	1.36	1.2
Evenness index (E)	0.8	0.69
Palmer indices	19	13

Discussion

Dallas (2004) pointed out that various physicochemical and biological circumstances must be simultaneously taken into consideration for understanding fluctuation of biological population in water body. In Watari Dam, limnological parameters were observed to fluctuate slightly during the study period. The mean water temperature of the dam fluctuates between 22 – 27.8°C. The relatively high water temperature in May could be due to characteristic of hot weather in Kano. This trend of temperature variation is in tandem with the findings of Ibrahim (2009) in Challawa River, Kano State and Kefas *et al*. (2015) in Lake Geriyo, Adamawa State. The pH value recorded in this study (7.5 -8.9) was observed to increase slightly from January to October. The pH recorded fall within the acceptable limits of 5.9 - 9.3 for fresh water bodies set FEPA (1991). TDS in water consist of inorganic salts and dissolved materials and high values of TDS may lead to change in water taste (Pandey, 1997). The TDS values recorded in the dam varied from 470mg/L to 860mg/L. The value is higher than the maximum limit of 600mg/L set by FEPA (1991). In the present investigation, Dissolved Oxygen ranged between 4.6 - 6.9mg/L, which is quite satisfactory to support aquatic life perhaps due to good aeration rate and photosynthetic activity as reported by Jaji *et al*. (2007). The distribution of Dissolved Oxygen in water body has been reported to be governed by a balance between input from the atmosphere, rainfall, photosynthesis and losses by the chemical and biotic oxidations (Adesalu and Nwankwo, 2010). Turbidity of the water body also varied significantly according to the season it ranged from 28NTU - 42NTU during dry and wet season respectively. The water turbidity during wet season might be related to cloudiness of water body as a result of particulate matter being suspended within it (Kutama *et al.*, 2013). Phosphates- phosphorus ranges between 2.0-3.8mg/L and Nitrate- nitrogen with 13.6 – 23.3mg/L. The values recorded were higher than the standard limit for fresh water set by FEPA (1991).This corroborates with the findings of Umar and Bashir (2014) who recorded higher values of both nitrate and phosphate in their work on seasonal comparison of physicochemical parameters in Thomas Dam, Kano State. The higher values of phosphate and nitrate concentrations could be attributed to the inputs from agricultural activities around the study area. The values recorded were higher than what was reported by Kefas *et al*. (2015) in Lake Geriyo, Adamawa state, Nigeria.

The significance of this study goes a long way to determine the water quality of Watari dam in relation to pollution indicator phytoplankton species and the implication of anthropogenic activities around the water body. The phytoplankton community in the present study is characterized by four phyla: Cyanophyta (25%), Chlorophyta (37.5%), Bacillariophyta (25%) and Euglenophyta (12.5%). Sixteen genera identified in which eleven (11) have been reported as indicators of organic pollution by Palmer (1969) who specified the range of organic pollution by the tolerance capacity of the phytoplankton species. The presence of 11 pollution tolerant genera with 32 palmer pollution indices corroborates with the findings of Indabawa and Mukhtar (2002) and Verma *et al*. (2012) who described phytoplankton as rapid detectors of water pollution due to their quick response to changes in environmental variables and produce toxic substances which can accumulate and intoxicate the entire food chain. Similarly Hegde (1988) and Anuja and Chandra (2014) reported the significance of phytoplankton in evaluation of eutrophic potentials and pollution status of an aquatic environment.

Results of P.P.I from all the sampling sites categorized the water as being high of organic pollution with 32 score. Similar observation was raised by Suryakant and Awasthi (2012). The present finding is consistent with work of Nandan and Aher (2005) and Ayodhya *et al*. (2012) and Anuja and Chandra (2014) who recorded Palmer's index of pollution score

greater than twenty in their work on phytoplankton as indicators of water quality. Seasonal variation with respect to Palmer pollution index demonstrates that Watari dam had high organic pollution value of 19 during wet season and absent of organic pollution with 13 score during dry season. Observation at the sampling sites indicated that surface run off into the dam from nearby farm lands and other human activities facilitate the enrichment of dam during wet season which possibly lead the high phytoplankton growth. Similar observation was made by Ayodhya *et al.* (2012) in Mula River, India. The high phytoplankton species diversity recorded may be due to the favourable physiochemical parameters that greatly influenced their growth as reported by Muhammad and Saminu (2012) in Salanta River, Kano. Similar observation was made by Anago *et al.* (2013) who reported that in water body where domestic and agricultural activities persists pollution is accelerated through the growth of Chlorophyta and Cyanophyta. The presence of bloom producing species such as *Microcystis* sp., *Anabaena* sp. and *Oscillatria* sp. is an indication that the Dam is undergoing gradual decrease in water quality.

Shannon Weiner diversity index adopted by Islam (2008) revealed that when the value is < 1, the water body is heavenly polluted; 1 - 3, moderately polluted and > 3, clean water. site A from the present finding had the highest value of 1.42 and the least was site B with 1.23 which indicates a moderately polluted water body. Tanimu *et al.*(2012) made similar observation in Bauchi and Hadejia Nguru wetlands.

Conclusion

The present study identified bioindicator phytoplankton species such as *Microcystis* sp., *Oscillatoria* sp., *Scenedesmus* sp., *Euglena* sp. and *Phacus* which can pose potential health impacts on the inhabitants. Irrigation and other domestic activities close to the sampling sites influenced seasonal variations in the phytoplankton composition. The large number of pollution indicator phytoplankton observed which can tolerate various degrees of organic pollution revealed the need for the continuous bio-monitoring and control of organic pollution in the water body. It is therefore recommended that relevant organizations should encourage continual research on the general biology and physicochemical parameters of inland water bodies with the view to track adverse environmental changes in the aquatic environment like Watari Dam in Kano State.

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