ASSESMENT OF PHYSICOCHEMICAL PARAMETRS OF DADIN KOWA DAM, NIGERIA

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Abstract

The assessment of the water quality criteria of Dadin Kowa reservoir based on some selected physicochemical parameters were carried out over a period of twelve months. Five sampling stations were chosen for the study. Water sample for analysis was collected from reservoir of Dadin Kowa Dam and analyzed insitu for physicochemical parameters based on standard methods. These parameters include water temperature, pH, transparency, nitrate, hardness, biochemical oxygen demand, phosphate, calcium, iron and magnesium. All the physicochemical parameters revealed monthly and seasonal variations. The result of the physicochemical parameters obtained from this study was compared with standard values set by World Health Organization (WHO). Overall assessment revealed that, the results of the physicochemical parameters were within the standard safe limit set by WHO. Moreover, some sampling stations that showed slight increase in value of parameters was reported to be influenced by anthropogenic activities such as washing of clothes and application of fertilizers and pesticides. This study showed that the reservoir of Dadin Kowa is suitable for irrigational and domestic purposes. In order to improve the sustainable use of the reservoir, appropriate suggestions were provided on how to safeguard the healthy status of the reservoir for wider scope of usage.

Key words; Physico-chemical parameters, Dadin Kowa reservoir, degradation, anthropogenic

Introduction

The quality of given water body is governed by its physical, chemical and biological factors all of which interact with one another and greatly influence its productivity. Environmental conditions are reported to be the key factors affecting the development of aquatic life (flora and fauna) in surface waters as well as well as the physiological performance of individual organisms (Tessema *et al*., 2014). The survival of aquatic flora and fauna found in specific water body depends on the combined effects of various hydrological, physical and chemical factors (Rahmanian *et al*., 2015). Consequently, these are the factors controlling the dynamic state of aquatic environment vis-à-vis their tropical state. In order to assess the potential of such aquatic ecosystem for their essential management and effective utilization, it is necessary to monitor and evaluate the physicochemical parameters of the water body with a view to developed a control system for maintaining them within the optimum range.

The increase of human population which brought about fishing activities, irrigation, and farming activities has been reported to offer massive pressure on the quality state of water in the reservoir (Tepe *et al*., 2005). The impact of anthropogenic activities within and outside the surrounding of the water reservoir felt either directly or indirectly on the physical and chemical properties of the water, and this determined the survival and the availability of the aquatic biota within a given water body.

Most of the agents causing severe deterioration of water quality in a given reservoir comprise of high level of nutrients input (such as nitrate, phosphate, chemical oxygen demand and biological oxygen demand) which often causes eutrophication. The occurrence of eutrophication in water body creates a shading effect which prevents maximum penetration of light thereby affecting the growth of autotroph (Ajuzie *et al*., 2012). Heavy metal contamination and organic pollution such as pesticide are also listed as measure activities affecting the quality of water supply. The measure concern on the occurrence of these water pollutants in water body is the strong negative effect on the structural biodiversity of the reservoir (Shiva, 2016). Assessing the physicochemical parameters of water body provide a good signal on the healthy status of a particular water body as well as its sustainability. Any slight increase and decrease in the level of physic chemical parameters such as temperature, transparency, dissolved oxygen, chemical oxygen demand, nitrate and phosphate could provide important information on the quality of the water body as well as any potential source(s) of the variations.

The water of Dadin Kowa reservoir has long been known for its usage as sources of water supply to the local community around the region. About eleven government areas including neighboring state of Gombe depend on Dadin Kowa reservoir for their livelihood. Since it constructions, human interference has been sported as the major factor affecting the quality of water in the reservoir. For instance, a lot of farming activities have been going around its surrounding catchments especially its banks. The intense irrigation during the annual draw down period has accelerated the rate of gradual silting up of the reservoir, thereby threatening the livelihood of the people. Since clean drinking water is now seen as a fundamental right of every human beings, it is imperative to assess the physicochemical parameters of Dadin Kowa reservoir in order to determine its healthy status. Therefore the main aim of this research is to determine the mean monthly and seasonal variation of the physicochemical parameters of Dadin Kowa reservoir in relation to possible damage caused by anthropogenic activities going on around the region.

Methodology

Study Area

Dadin Kowa reservoir is located 5 km North of Dadin Kowa town in Yamaltu-Deba Local Government Area of Gombe State (Figure 1). The area lies within latitude 10^o17 ‘18”N and longitude 11^o30’32 “E of the equator (Aliyu and Abubakar, 2015). It occupied an area of about 30 km^2.

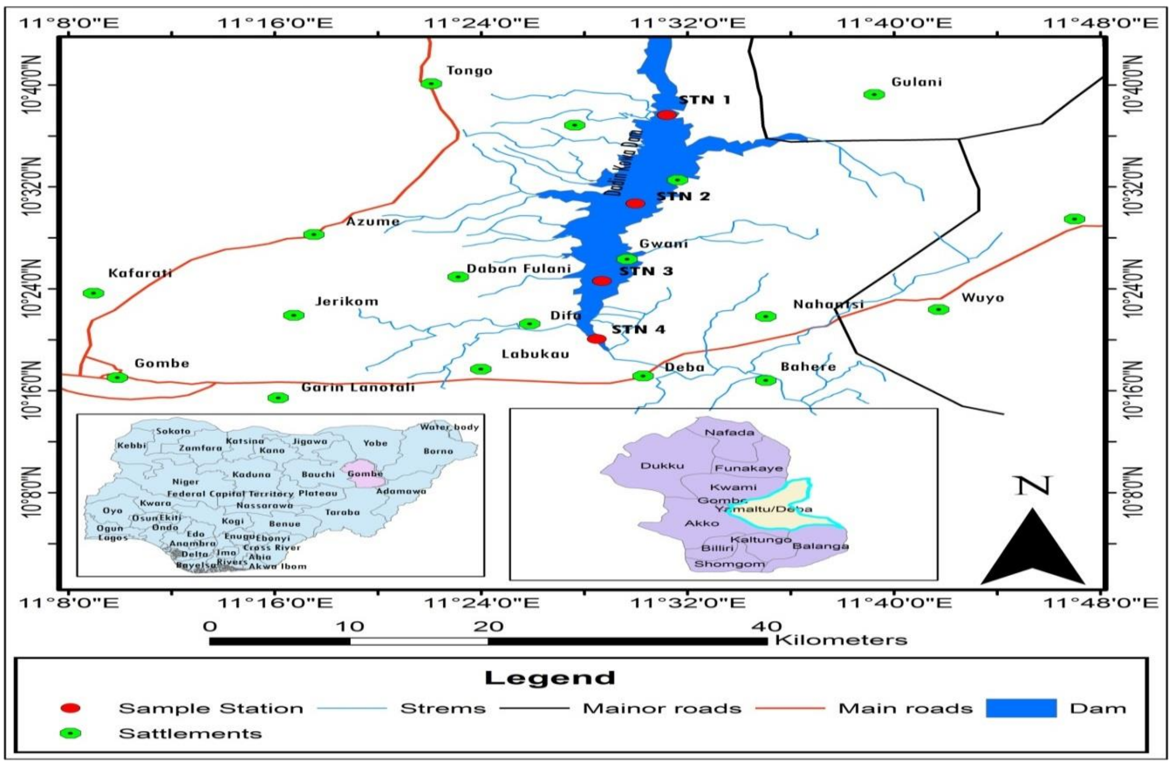

Figure 1: Map of Dadin Kowa Dam showing the study area

Irrigation, washing of clothes, farming and cattle rearing are some of the activities around the reservoir.

Sampling Stations

Five sampling stations were chosen for the study. Station 1 is where human activities including washing of clothes and bathing are been done regularly. Station 2 is located at the tower point where less human activities take place. Station 3 is at the deepest part of the reservoir where agricultural materials are been washed and station 4 is located near the middle of the Dam where no human activities are been carried out there. Station

5 is at the entrance point of river associated with farming activities.

Sampling Method

Sampling was carried out monthly for a period of one year from each sampling station. Water samples were collected between the hours of 8:00 am and 1:00 pm as described by (Yohanis and Mondol, 2010). In this method, water was sampled at surface level by dipping 1 liter plastic sampling bottle, sliding it against the water current to permit undisturbed passage of the water into the bottle. Water samples were then transported to the laboratory for physico-chemical analysis.

Determination of physico-chemical parameters

Temperature

Water temperature was determined by lowering the thermometer into the water in an inclined position for about 5 minutes before recording as described by American Public Health Association (APHA, 1992).

pH

The pH was determined using Hanna 420 pH meter after calibration. The electrode of the pH meter was dipped into the water sample for 2-3 minutes and readings were recorded (APHA, 1999).

Transparency

The transparency reading was taken by lowering Secchi-disc of 25 cm in diameter into the water until it become invisible. The depth of the instrument was then measured as described by (Saidu *et al*., 2015).

Hardness

Hardness of the water body was measured using titration method as described by (Kumaz *et al*., 2016).

Biological Oxygen Demand

BOD was measured by incubating sample at 20°C for a period of five days in the dark after addition of 2 mL each of manganese chloride solution and Winkler reagent as described by (APHA, 1999).

Calcium

Calcium content of the water sample was determined titration method according to the procedure described by APHA (2005).

Iron

Concentration of iron was obtained by mixing 100 mL of water sample with 10 mL acid solution (mixture of HCl and $HN0_3$ 3:1) and was immersed in water bath (90^oC) for 30 minutes followed by analysis with Atomic Absorption Spectrophotometer (A.A.S, model 2010).

Magnesium

This was determined by using spectrophotometer model Hatch 2010 as described by APHA, 2005).

Nitrate

Nitrate was determined according to the method described by APHA with spectrophotometer at 430 nm wavelength (APHA, 2005).

Phosphate

The phosphate content of water was determined using Deniges method as described by (APHA, 1999) using spectrophotometer at 690 nm absorbance with spectrophotometer (model S101).

Total Alkalinity

100 mL of water sample was measured and placed in 250 mL conical flask. 3 drops of methyl orange indicator and bromocresol green solution was added and titrated with H_2SO_4 until colour changes from red to yellow. Total alkalinity in $CaCO_3$ mg/L= Titer value ×10.

Results and discussion

Temperature

The mean monthly variations of physicochemical parameters (temperature) for all the sampling stations are presented in Table 1. The temperature readings obtained from station 1, 2, 3, 4 and 5 are 23.19±0.85°C, 23.11±0.82°C, 3.20±0.85°C, 27.25±0.69°C and 27.00±0.7°C respectively. The highest temperature was found to be recorded in station with the temperature value of 27.25°C while the lowest temperature was recorded at station 2 with a temperature value of 23.11°C. Results of the analysis of variance revealed that there is a significant difference in the temperature reading between the sampling stations ($P \leq 0.05$). The range of the temperature recorded between the months of January–December was 27.98±0.68-21.10±0.98°C (Table 2). Overall, the high temperature was recorded in the month of February (27.98^{o}C) whereas lower temperature was recorded in November (21.10^{o}C). The mean value of the temperature recorded during wet season is 24.15±0.34^{o}C whereas during the dry season, the mean temperature was found to be 24.23±0.91^{o}C (Table 3).

Temperature plays a vital role in determining the occurrence, species composition and density of fresh water organisms. The results obtained from this study showed low water temperature recorded between the months of November to January in response to seasonal changes. This may have an effect on the occurrence and distribution of zooplankton (Mahadevan, 2016). A relatively very low temperature recorded during this period might be due to the cool dry winds (harmattan) at the time of the year. Similar

Table 1: Variation of Physico-chemical Parameters of Dadin Kowa Reservoir, Gombe State

Physicochemical Parameters	Station One	Station Two	Station Three	Station Four	Station Five	Mean±SE	P value
Temperature (°C)	23.19±0.85b	23.11±0.82b	23.20±0.85b	27.25±0.69a	27.00±0.7a	**24.19±0.48**	**0.001****
Alkalinity (mg/L)	34.99±2.58	34.87±2.64	34.93±2.61	38.60±1.08	37.33±1.03	**36.85±1.14**	**0.603ns**
pH	7.33±0.29	7.27±0.25	7.30±0.27	7.01±6.00	7.11±2.00	**7.73±1.50**	**0.451ns**
Transparency (cm)	56.07±6.85	62.00±6.06	56.70±5.44	70.70±4.49	66.38±2.11	**61.37±2.93**	**0.267ns**
Hardness (mg/L.$CaCO_3$)	57.40±5.83	65.70±9.24	51.10±84.39	80.50±5.71	84.61±1.80	**67.68±21.2**	**0.40ns**
Biochemical Oxygen Demand (mg/L)	2.36±8.38	3.75±0.34	3.05±0.35	2.11±0.37	3.11±2.11	**2.27±2.19**	**0.108ns**
Calcium (mg/L)	16.80±1.83	18.68±1.30	18.74±1.26	18.57±1.18	18.11±0.71	**18.20±0.69**	**0.729ns**
Iron (mg/L)	0.74±0.39	0.98±0.38	0.78±0.37	1.36±0.40	0.91±0.19	**0.97±0.19**	**0.662ns**
Mg (mg/L)	6.87±0.52	6.63±0.54	6.75±0.53	6.83±0.58	6.88±0.11	**6.77±0.26**	**0.990ns**
Nitrate (mg/L)	1.42±0.14	1.03±0.22	1.21±0.18	1.50±0.23	1.28±0.31	**1.29±0.10**	**0.337ns**
Phosphate (mg/L)	1.09±0.22	0.72±0.19	0.87±0.20	1.04±0.19	0.41±0.53	**0.93±0.10**	**0.557ns**

Means with different alphabet(s) along rows are significantly different
** Significant difference at $P \leq 0.01$, ns – not significant at $P \geq 0.05$.

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Table 2: Monthly Variation of Physico-chemical Parameters of Dadin Kowa Reservoir, Gombe State

Months	Temperature (°C)	Alkalinity (mg/L)	pH	Transparency (cm)	Hardness (mg/L.$CaCO_3$)
January	21.65±2.45b	28.05±3.65d	7.15±0.06	53.75±9.07	52.25±2.05b
February	27.98±0.68a	37.10±1.00bc	6.53±0.53	54.75±9.95	40.00±2.92b
March	27.55±1.15a	36.15±1.95bc	6.58±0.19	58.55±4.82	44.50±6.77b
April	27.98±0.68a	37.10±1.00bc	6.53±0.53	54.75±9.95	40.00±2.92b
May	27.55±1.15a	36.15±1.95bc	6.58±0.19	58.55±4.82	44.50±9.77b
June	24.78±0.38ab	33.20±1.80bcd	7.75±0.45	63.38±6.52	88.50±4.11ab
July	24.85±0.45ab	46.20±2.10a	7.85±0.46	48.50±7.23	79.50±4.11ab
August	24.93±0.57ab	45.45±1.75a	7.30±0.13	68.00±3.63	285.75±7.66a
September	22.98±0.98b	31.38±3.28cd	6.30±14.90	73.75±1.14	86.50±12.17ab
October	23.23±0.83b	30.83±2.73cd	7.23±0.09	59.00±5.26	87.00±3.89ab
November	21.10±1.00b	30.15±0.06cd	7.80±0.61	76.75±8.93	65.00±1.41b
December	22.85±1.75b	39.98±1.33ab	6.80±0.40	57.25±1.37	57.75±8.39b
Mean±SE	**24.19±0.48**	**35.85±1.14**	**7.73±1.50**	**61.37±2.93**	**66.68±1.32**
P value	**0.003****	**0.200****	**0.440ns**	**0.506ns**	**0.348****

Table 2: cont'd: Monthly Variation of Physico-chemical Parameters of Dadin Kowa Reservoir, Gombe State

Months	BOD (mg/L)	Calcium (mg/L)	Iron (mg/L)	Mg (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)
June	3.23±0.05	17.15±0.06bc	0.80±0.27b	5.15±0.10ef	0.88±0.25def	0.68±0.18c
July	2.33±0.05	19.10±0.04abc	1.00±0.35b	6.23±0.11de	1.53±0.17bc	0.73±0.17c
August	1.13±0.05	14.28±0.18cd	0.50±0.13b	5.83±0.28def	1.33±0.23bcd	0.93±0.21c
September	1.35±0.06	11.30±0.19d	3.33±0.78a	6.30±0.90de	1.75±0.25b	0.33±0.23c
October	1.43±0.09	18.55±0.17abc	0.28±0.09b	8.90±0.30a	0.35±0.10f	0.75±0.37c
November	1.23±0.14	21.73±0.58ab	1.30±0.90b	8.30±0.11abc	1.43±0.09bcd	0.50±0.04c
December	2.53±18.16	18.30±4.87abc	0.10±0.00b	7.15±1.05bcd	1.45±0.13bcd	1.03±0.18bc
January	1.95±12.36	19.60±1.40abc	0.90±0.70b	4.58±0.48f	0.75±0.29ef	2.03±0.29a
February	0.38±0.25	18.75±0.25abc	0.38±0.11b	6.80±0.51cd	2.35±0.10a	1.63±0.24ab
March	1.15±0.10	23.23±1.08a	1.08±0.26b	8.48±0.18ab	1.10±0.04cde	0.73±0.13c
April	2.38±0.25	18.75±0.25abc	0.38±0.11b	6.80±0.51cd	2.35±0.10a	1.63±0.24ab
May	1.15±0.10	23.23±1.08a	1.08±0.26b	8.48±0.18ab	1.10±0.04cde	0.73±0.13c
Mean±SE	**1.07±2.19**	**18.20±0.69**	**0.67±0.19**	**6.77±0.26**	**1.29±0.10**	**0.93±0.10**
P value	**0.473ns**	**0.001****	**0.003****	**0.100****	**0.200****	**0.100****

Means with different alphabet(s) along columns are not significantly different.
** significant at P≤0.01, ns – not significant at P≥0.05.

Table 3 Seasonal Variation of Physico-chemical Parameters of Dadin Kowa Reservoir, Gombe State

Physicochemical Parameters	Season		Mean±SE	P value
	Wet	**Dry**		
Temperature (°C)	24.15±0.34	24.23±0.91	24.19±0.48	0.939ns
Alkalinity (mg/L)	37.41±1.85	34.29±1.30	35.85±1.14	0.175ns
Ph	10.49±2.98	6.97±0.20	8.73±1.50	0.246ns
Transparency (cm)	62.53±3.47	60.21±4.80	61.37±2.93	0.698ns
Hardness (mg/L.$CaCO_3$)	125.45±41.31	51.90±4.21	88.68±21.32	0.085**
Biochemical Oxygen Demand (mg/L)	2.69±0.12	3.45±4.30	7.07±2.19	0.125ns
Calcium (mg/L)	16.08±0.67	20.32±1.02	18.20±0.69	0.001**
Iron (mg/L)	1.18±0.30	0.75±0.23	0.97±0.19	0.264ns
Mg (mg/L)	6.48±0.34	7.06±0.39	6.77±0.26	0.273ns
Nitrate (mg/L)	1.17±0.14	1.42±0.14	1.29±0.10	0.210ns
Phosphate (mg/L)	0.68±0.11	1.18±0.15	0.93±0.10	0.010**

** significant at $P \leq 0.01$, ns – not significant at $P \geq 0.05$.

The effect was observed in some related studies as reported by (Ojeh *et al*., 2016). The seasonal variation of water temperature obtained from this study varied in accordance with the findings of research of Sa'ad and Abbas (1985). The moderate temperature which favors high algal bloom at the beginning of rainy season corresponds with the findings of (Abdullahi and Indabawa, 2005) in their study of the ecology of fresh water phytoplankton of River Hadejia, Jigawa State. Positive correlation of water temperature with dissolved oxygen, transparency, conductivity, BOD at stations correspond to similar report carried out on Shiroro Lake by Kolo and Oladimeji (Kolo and Oladimej, 2004). In terms of comparison with standard regulatory limit set by WHO, all the temperatures reported in the 5 sampling stations were in line with the approved standard of 27-29^{o}C recommended by WHO (WHO, 2004).

Alkalinity

The alkalinity value recorded for station 1, 2, 3, 4 and 5 was found to be 34.99±2.58, 34.87±2.64, 34.93±2.61, 38.60±1.08 and 37.33±1.03 mg/L respectively. Highest alkalinity value was recorded at station 4 with alkalinity value 38.60 mg/L whereas the lowest alkalinity was recorded at station 2 with the alkalinity value of 34.87 mg/L. Statistical analysis showed that there is no significant different between the sampling stations with high Alkalinity recorded in station 4 (Table 1). The alkalinity value recorded between the month of January – December was found to be at the range of 46.20 – 28.05±3.65mg/L. The lowest value of alkalinity was observed in January (28.05 mg/L).

While the highest was recorded in July (46.20 mg/L) (Table 2). The mean alkalinity value recorded during wet and dry season was found to be 37.41±1.85 and 34.29±1.30 respectively (Table 3).

Alkalinity is considered as an important factor for fish and aquatic life because it protects buffers against rapid pH changes (Ajuzie, 2012). Living organisms, especially aquatic life, function best in a pH range of 6.0 to 9.0. Higher alkalinity levels in surface waters will buffer acid rain and other acid wastes and prevent pH changes that are harmful to aquatic life (Ajuzie, 2012). The standard permissible limit set by WHO for alkalinity is within the range of 98-276 and the various alkalinity values determined in all the sampling stations is within the specific range set by WHO (WHO, 2004).

pH

The monthly variation of water pH of Dadin Kowa reservoir was presented on Table 2. The pH value recorded for station 1, 2, 3, 4 and 5 was found to be 7.33±0.29, 7.27±0.25, 7.30±0.27, 7.01±6.00 and 7.11±2.00. Station 1 of pH value 7.33 was tagged as the station recorded with the highest pH whereas station 4 was found to present the pH value of 7.01. The pH value values recorded across months (January - December) was reported to be at range of 6.30±14.90 - 7.85±0.46. The mean pH value measured during wet and dry season are 10.49±2.98 and 6.97±0.20 respectively. This obviously indicated that the reservoir was acidic during rainy season while slightly alkaline at dry season throughout the study period. Analysis of variance reveals a non-significant variation between stations, months and seasons.

The pH of Dadin Kowa reservoir ranged between 6.4-7.4 were found to have increased with the onset of the rainy season, and slightly decrease in dry season. Low pH indicates acidity possibly due to the presence of nitrate and sulfate ions in water. The level of pH could support many fish and other benthic organism like molluscs. Similar report was observed by Edema *et al*., (2002). A water sample is said to be acidic when the pH level is below 7. Meanwhile it is neutral at 7 and acidic above 7. The measure problem of acidic water is corrosion of metal pipe, while that of alkaline is disinfection in water (Sharna *et al*., 2017). For that reason, World Health Organization (WHO) has set a guideline for permissible limit for drinking water to be within the range of 6.5 - 8.5 (WHO, 2011). Moreover, the pH range obtained from this study is between 7.01-7.33 which falls within the set range approved by WHO).

Transparency

Table 1 and 2 shows the mean monthly variations of transparency between month and stations and the result reveal that the transparency value of station 1, 2, 3, 4, and 5 obtained was 56.07±6.85, 62.00±6.06, 56.70±5.44, 70.70±4.49, 66 and 38±2.11cm respectively. The highest transparent water was recorded at station 4 whereas the station with the lowest transparent value of 38cm. The value of transparency across the months was found to be at range of 76.75±8.93 - 48.50±7.23, with November been the month where the water present in the researvoir is much more clearerer than that observed in the month of July (Table 2). The transparent value recorded during wet season is 62.53±3.47cm, which is relatively higher than 60.21±4.80cm recorded during dry season (Table 3).

Decrease in transparency from June to September could be attributed to increase flooding which washes earth materials into the water body. Transparency was in the increase during dry season from November to April at the ranges of 25 cm to 75 cm. This corresponds with algal bloom that leads to depress oxygen concentration of water as reported by Lawson (2011). The turbidity was high during the early part of rainy season which could be due to the increase in surface run-off, flood water from the catchment area, which bring dissolve materials and course re-suspension of dissolved materials. Increase in total dissolve solid result to increase in turbidity but decrease of the benthic fauna and increase in the algal bloom. The result from the analysis of variance (ANOVA) showed no significant difference between stations and seasons interaction. In general, all the five sampling stations recorded high values transparency during a dry season. This could be attributed to the absence of floodwater, surface run-off and sitting effect of suspended materials that followed the cessation of rainfall. Low visibility recorded between June to September agree with the finding of Wade who observed that on set of rain decreased the visibility in two mine lake around Jos, Nigeria (Wade, 1985). A water body is said to be transparent when it does not has too much turbidity cause as a results of the presence of free suspended material. Turbidity determined the cloudiness of a water body. It is within that context that the WHO set the standard recommend maximum turbidity level of 5 nephelometric unit (NTU) (WHO, 2011; Hasbiyana, 2008).

Hardness

The seasonal and monthly mean of water hardness for Dadin Kowa reservoir was presented in Table 2. The hardness of water measured in station 1, 2, 3, 4 and 5 was found to be 57.40±5.83, 65.70±9.24, 51.10±84.39, 80.50±5.71 and 84.61±1.80 respectively. Station 5 contained the highest value of hardness whereas station 3 reported the lowest value of hardness (Table 1). The amount of the hardness of the water determined across the months was found to be at a range of 88.50±4.11 - 28.75±7.66 with June been the month where high level of water hardness was observed (Table 2). The hardness value recorded during the wet season and dry season was found to be 125.45±41.31 and 51.90±4.21mg/L respectively (Table 3). Also, there is no significant different between stations, months and seasons.

The reservoir was moderately hard during the rainy season and very hard in the dry season. Analysis of variance (ANOVA) revealed significant difference of hardness observed between the seasons. The relatively harder water during the rainy season could be attributed to the leaching of artificial fertilizer into the dam which originated from the catchment area due to farming activities during the period of July to August. However, WHO has set standard limit of the hardness of water to be 0-60 (WHO, 2004). Therefore all the sampling stations except station 1 and 3 which has the hardness level above the permissible discharge limit set by WHO.

Biological Oxygen Demand

Biological Oxygen Demand (BOD) values of all the sampling stations was reported to be 2.36±8.38 for station 1, 3.75±0.34 for station 2, 3.05±0.35 for station 3, 2.11±0.37 for station 4 and 3.11±2.11 for station 5. It was observed that the highest level of BOD was detected in station 2 whereas the lowest was found in station 4 (Table 1). The COD value at range between 3.23±0.05 - 1.13±0.05mg/L was recorded across months. The highest value was obtained in June of about 3.23 mg/L and the lowest in February of 0.38 mg/L (Table 2). Also the ranges of BOD observed during wet and dry season was 2.69±0.12 - 3.45±4.30. There was no significant different between month, station and season.

The biological oxygen demand of the water samples in all the five sampling stations fall within a range of 2.1-3.3 mg/L. This agrees with the findings of Kendrim, (2001). Biological oxygen demand (BOD) was higher in the dry season than the rainy season. This coincided with the period of oxygen consumption by decomposers (Fungi and Bacteria) on the biogenic materials. The potential of utilizing the water of Dadin Kowa reservoir for drinking and other domestic purposes also depend of nature of BOD of the water. Increase in BOD, increases the biodiversity of microorganism of a particular water zone.

Calcium

The calcium concentrations found in all the three station are 16.80±1.83, 18.68±1.30, 18.74±1.26, 18.57±1.18, 18.11±0.71 mg/L for station 1, 2, 3, 4 and 5 respectively (Table 1). Monthly range value of calcium ion concentration was found to be at range of 11.30 to 23.23 mg/L (Table 2). The highest value of 23.23 mg/L in the month of March and lowest value in September of 11.30 mg/L was observed (Table 3). The result showed that the value of calcium ion concentration were higher during the dry season (20.32±1.02 mg/L) than in wet season (16.08±0.67 mg/L). Analysis of variance revealed highly significant difference between months and seasons while no significant between stations.

The result of the research findings has revealed that the dam contains dissolved chemical substances of calcium. The presence of this substance could be derived from application of fertilizer, insecticides garbage and herbicides into the reservoir. The result showed that the value of calcium is high in the dry season than in the rainy season. Results of calcium content found in all the sampling stations revealed that, the highest concentration of calcium was 18.74 mg/L is relatively within the standard limit set by WHO (WHO, 2004).

Iron

The value of Iron concentration across the sampling stations of Dadin Kowa reservoir showed slightly variation. The concentration of iron reported in station 1, 2, 3, 4 and 5 are 0.74±0.39, 0.98±0.38, 0.78±0.37, 1.36±0.40 and 0.91±0.19 mg/L respectively (Table 1). Interms of distribution across the months, the highest value of 3.33±0.7 mg/L was obtained during the month of September while the lowest value of 0.28±0.09 mg/L was obtained during the month of October. The iron content measured during wet season and dry season are 1.18 and 0.75 mg/L respectively. The result of analysis of variation revealed that there was higher significant differences on the monthly occurrence of Iron, but not significant across stations and seasons.

The concentrations of iron in Dadin Kowa reservoir showed slight variation between stations. Highest values were obtained during rainy season and lowest value during dry season. This could be due to a lot of farming activities and pollution from the surrounding communities (Kokac *et al*., 2017). Availability of heavy metals in drinking water exceeding the permissible concentration could cause many severe problems to human health. Therefore analysis of heavy metal ion such as iron becomes necessary in water body. In the present study, the iron content of reservoir of DadinKowa was measured and compared with permissible limit set by WHO. The highest concentration of iron was reported in station 4 of about 1.36 mg/L which is slightly higher than 0.3 mg/L standard permissible limit set by WHO.

Magnesium

Table 1 showed that, the magnesium content found in station 1, 2, 3, 4, and 5 are 6.87±0.52, 6.63±0.54, 6.75±0.53, 6.83±0.58, 6.88±0.11 mg/L. Water content of station 3 contained the highest amount of magnesium content than station 1 which has the lowest amount of magnesium content (Table 1). Monthly variation in magnesium ion concentration of the reservoir revealed low magnesium content in January of 4.58 mg/L and highest in October of 8.90 mg/L, seasonal variation of magnesium ion showed that there was high concentration in dry season of about 7.06 mg/L and low during wet season of about 6.48 mg/L (Table 3). One way ANOVA showed no significant different across stations and seasons, but high significant different was obtained across months.

There was no significant difference between stations with respect to magnesium ion concentration. The result revealed that there was low concentration during rainy season and high concentration value during dry season. The analysis of variance revealed no significant difference with the stations and season ($P \geq 0.05$). Although WHO has not set the standard permissible limit for magnesium, but Habiyana, 2008 reported that, a water body fit for drinking should have magnesium content not exceeding 150 mg/L. The ranges of magnesium content determine for all the sampling stations in this study were 6.87-6.63 mg/L which concluded that they fall below the standard permissible limit (WHO, 2011).

Nitrate

Nitrate concentration throughout the study period obtained was 1.42±0.14, 1.03±0.22, 1.21±0.18, 1.50±0.23, 1.28±0.31 mg/L for station 1, 2, 3, 4 and 5 respectively. The highest and lowest values were recorded at station 1 and station 2 of about 1.50 and 1.03 mg/L respectively. The monthly variations of nitrate concentration were found to be at range of 0.35 to 2.35 mg/L (Table 2). The highest nitrate concentration value of 2.35 mg/L was recorded in February and the lowest value of 0.35 mg/L was recorded in October. Result of ANOVA revealed that there was no significant different of nitrate concentration between stations and seasons but highly significant different between month.

Nitrate concentrations obtained throughout the study period was at range of 0.33-2.35 mg/L. It was observed that concentration of nitrate was higher in the rainy season from July to September. This could be due to the surface run-off from the farmland into the reservoir and also application of fertilizer by the farmers from the catchment area as observed by Kemdirim (2001). Another reason for this variation could also be as a result of nitrates released from sediments during decomposition of organic matter (Kolo and Oladimej, 2004). Low nitrate values indicate period of extreme dry season or early onset of rains and the period preceding the first upsurge of phytoplankton growth. The presence of excess amount of nitrate in water causes methaemoglobinaemia (WHO, 2008). The standard regulatory limit set for drinking water by WHO is 50 mg/L (WHO, 2008). The nitrate content measured in all the sampling stations of the reservoir of Dadin Kowa were below the standard limit set by WHO, therefore indicating it fitness for drinking.

Phosphate

The values of the phosphate concentrations measured in this study were 1.09±0.22 mg/L for station 1, 0.72±0.19 mg/L for station 2, 0.87±0.20 mg/L for station 3, 1.04±0.19 mg/L for station4 and 0.41±0.53 mg/L for station 5. In terms of monthly variation, high concentration of phosphate was recorded during the month of 2.35 mg/L whereas the lowest concentration of 0.35 mg/L was recorded during the month of October (Table 2). The maximum phosphate concentration was observed during dry season of 1.18 mg/L while the lowest was in wet season of 0.68 mg/L (Table 3). There is significant different between months and seasons while no significant difference exist within stations.

The phosphate values obtained during raining season was higher than that of dry season. This might be due to run-off from nearby farmland; since phosphate is a major constituent of fertilizer and it application is common to farmland around the catchment area. Relatively, higher dry season mean values of phosphates observed could be attributed to concentration due to reduction in water volume. Reduction of water volume alters the physical and nutrients concentration of water bodies (6). Because phosphate has less potential hazard to human, WHO have not set a standard limit for phosphate (WHO, 2008).

Conclusion

The results of the physicochemical parameters of the reservoir indicated that the reservoir was more productive during the rainy season than dry season. Anthropogenic activities such as farming, cattle rearing, washing of clothes and fishing was reported to be the major activity affecting the quality of the water especially during the rainy season. The physico-chemical parameters of Dadin Kowa reservoir studied revealed that the water body is not much polluted, moreover, some values of these parameters are within standard acceptable limit set by WHO. This implies that, the reservoir is suitable for irrigational and other domestic purposes. Further study should investigate other potential water pollutants such as microbial and radiological materials so as to have the overall understanding of the water quality of Dadin Kowa reservoir.

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