TRENDS IN PHYSICO-CHEMICAL PARAMETERS IN DADIN-KOWA RESERVOIR GOMBE, NIGERIA

Supported by tetfund TERTIARY EDUCATION TRUST FUND

R. Yerima[1]*, B. Suleiman[2] and P. I. Bolorunduro[3]

[1]Department of Biological Sciences, Gombe State University, Gombe, Nigeria
[2]Department of Biology, Ahmadu Bello University Zaria, Nigeria
[3]National Agricultural Extension and Research Liaison Services, Ahmadu Bello University, Zaria, Nigeria
*Corresponding author: ymsultan6@gmail.com

Received: December 12, 2017 **Accepted:** February 21, 2018

Abstract: This study was conducted to determine the monthly variation in some physico-chemical parameters in Dadin-Kowa reservoir. The water, electrical conductivity, total dissolved solids, and pH were measured by Hanna conductivity meter model EC 215 and pH meter model H198107. The water temperature, waterdepth**,** transparency, dissolved oxygen (DO), biochemical oxygen demand (BOD), carbon dioxide and water hardness were determined using standard methods. One-Way Analysis of Variance (ANOVA) was used to test for significant differences in means of the physicochemical factors among stations and Duncan's Multiple Range Test (DMRT) was used to separate the means where significant differences exist. Correlation coefficient was used to determine the relationships between physicochemical factors. There was high significant ($P \leq 0.05$) variation in the physico-chemical parameters with months in the reservoir except for water depth, carbon dioxide and hardness. There was high positive association between BOD and DO ($r = 1.00$) and between carbon dioxide with EC and TDS ($r = 0.80$). Temperature showed moderate significant positive relationship with carbon dioxide, BOD and DO. A positive and significant association was observed between TDS and EC. Water depth was found to significant negative association with temperature, EC, BOD, TDS, DO and carbon dioxide.The study revealed marked monthly variation in the physicochemical factorsin the reservoir. It is hereby recommended that regular monitoring of the physicochemical parameters of water and sustainable management of the fisheries resources of the reservoir be encouraged.

Keywords: Dadin-Kowa, Reservoir, physicochemical parameters, variations, correlation

Introduction

Reservoirs are man-made water bodies constructed for domestic use such as irrigation, navigation and hydro-electricity generation. Freshwater ecosystem has been used in the investigation of factors controlling the abundance and the distribution of aquatic organisms (Atobatele and Ugwumba, 2008; Esenowo and Ugwumba, 2010). The creation of a large reservoir in a river environment could affect the socio-economicstatus both at the upstream and the downstream sector on the entire catchment basin (Blackmore, 2000).A healthy reservoir is dependent upon the physico-chemical and biological characteristics (Venkatesharaju *et al.*, 2010). Water quality has been known to play an important role in public health, recreational use and aquacultural capability of reservoir (Ibrahim *et al.*, 2009). Abiotic conditions in reservoirs (temperature, oxygen, pH, presence of toxic substances, fluctuations in water level,among others) may be the most influential factors on either the absence or the presence of certain species (Rodríguez-Ruiz, 1998). The physical and chemical properties of water immensely influence its use and the distribution and richness of the biota (Unanam and Akpan, 2006).

The distribution of fish species is affected by biotic and abiotic factors (Kadye*et al.*, 2008). Water quality has been known to play an important role in public health, recreational useand aquacultural capability of reservoir (Ibrahim *et al.*, 2009). The general desire to protect freshwater fisheries has led to an expansion of researchinto their quality requirements in terms of physico-chemical parameters such as pH, temperature, dissolved oxygen, transparency, salinity and electrical conductivity etc. Thesefactors serve as base for the richness or otherwise biological production of any aquatic environment (Imevbore, 1990). Several of these physico-chemical parameters have been studied on large man-madelakes in Nigeria by Adeniji and Ita (1977) and Adeniji (1981). Other works on physico-chemical parameters include that of Balarabe (1989) on Makwaye Lake, Oniye *et al.* (2002) on ABU reservoir, Ugwumba and Ugwumba (1993) on Awbalake in Ibadan.Kolo andOladimeji (2004) studied water quality and some nutrients level of Shiroro Lake, Niger State.

This study therefore evaluates the variation in the physico-chemical parameters in Dadin-Kowareservoir in relation to the activities associated with the sampling stations, thereby serving as pointers to the magnitude of deleterious anthropogenic activities.

Materials and Methods

Description of study area

Dadin-Kowa Reservoir is located 5 km North of Dadin-Kowa village about 37 km from Gombe Town, along Gombe – Biu Road in Yamaltu Deba Local Government Area of Gombe State in the North East of Nigeria. The area lies within Longitude 11^0E and 11^0E and Latitude 10^0 and 10^0N coordinates of the equator (UBRDA, 1980) (Fig. 1). The reservoir was completed by the Federal Government in 1984 with damming of River Gongola. The reservoir had a capacity of 800 million cubic meters of water and a surface area of 30,000 hectares (William, 2001). The surrounding settlements of Dadin-Kowa majorly depend on agriculture as major source of livelihood. Theflood plains known as Fadamalands, as a result of the Dadin-Kowa River, a tributary to river Benue makes both ground water and surface water available and accessible. It is basically an agrarian society that produces agricultural products such as sorghum, millet, cotton, vegetables, rice, maize, groundnut, banbara-nut, as well as fruits and engaged in activities such as weaving, fishing, hunting among others (Ahmed and Philip, 2012).

Sampling stations

Three sampling stations were selected: Station A was area around the entrance of water into the reservoir. The water movement was relatively obvious due to ingress of large amount of water at this Station compared to other parts of the reservoir. Station B was thearea around the central portion of the reservoir with no obvious sign of water movement. The third Station, C was the part of the reservoir where the water is shallower and with a lot of human activities.

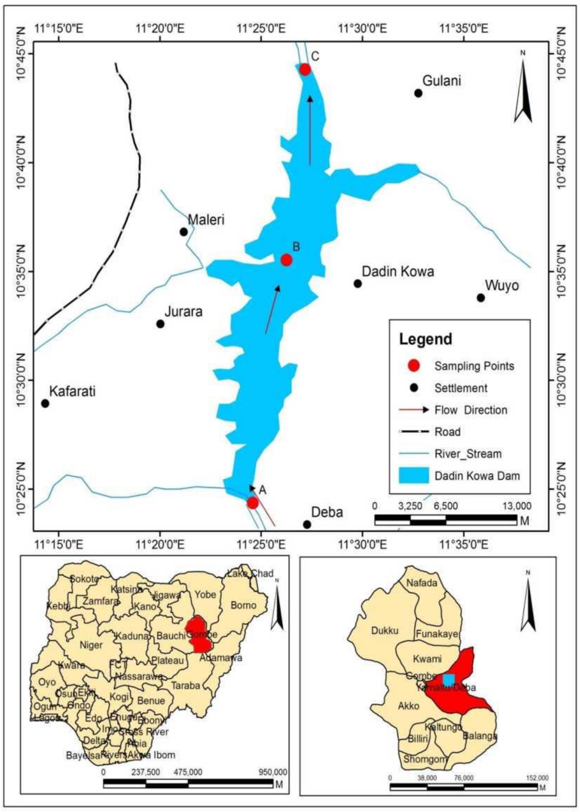

Fig 1: Map showing Dadin-Kowa reservoir and the sampling Stations (A, B and C)

Determination of physico-chemical parameters

Water surface temperature

Thetemperatures were determined using mercury in glass thermometer between 8.00 – 9.00 hours of the day. Thethermometer was submerged into the water at each station for about 3-4 minutes, then thereadings were recorded (^oC) (APHA, 1999).

Water depth

Calibrated rope of known length weighted at one end was used to measure the water depth at eachstation. The rope was dipped down gradually until the weight settled down on the bottomof the reservoir then the water level was marked and recorded in meters.

Transparency

Transparency was determined by the use of a 25 cm diameter Secchi disc. The procedure involved lowering the Secchi disc into the water at each station until it ceased to bevisible. The depth at disappearance and reappearance were measured to the nearest cm and the average was taken.

Hydrogen ion concentration (pH)

The hydrogen ion concentration was measured by the use of Hanna pH meter model H198107. The pH meter was calibrated according to instructional manual provided by the manufacturer. The electrode of the pH meter was dipped into the water sample for about 3 – 4 minutes and the final reading showing on the meter were recorded (APHA, 1999).

Electrical conductivity (EC) and total dissolved solids (TDS)

These parameters were measured by Hanna conductivity meter model EC 215. Water samples from all the sampling stations were placed into clean beakers, conductance cell of the meter was immersed into sample solution. The resistance was measured in µS/cm the readings of conductivity and total dissolved solids were recorded with the conductivity meterby changing the measurement to TDS. The cell was rinsed in a beaker with ionized waterafter each reading.

Water hardness

Hardness was determined by diluting 25 mls of water sample and 25 mls of distilled water making 50 mls. Two (2) mls of buffer solution and 0.1 g of Erichrome black T-dye were then added followed by EDTA -titrant drop until a blue colour end point was observed. Thecalculation was based on the equation by Lind (1979) and APHA (1999).

EDTA hardness as $mgCaCO_3/L$ = 2M/titrant x 40

Dissolved oxygen (DO) and bio-chemical oxygen demand (BOD)

Hanna Dissolved Oxygen meter model H12400 was used to determine dissolvedoxygen. The DO water was calibrated according to the instruction manual provided by themanufacturer. Water samples was collected in 100 ml beaker, the electrode of DissolvedOxygen water was dipped into the beaker that contained the water sample for about 3-4minutes, then the readings were recorded in mgl^{-1}.For biological oxygen demand; 100ml ofthe water sample was incubated for five days in a dark cupboard at room temperature and DissolvedOxygen was determined. The difference between the initial value (at day one) of dissolved oxygen and thefinal value (after day five) that is the value after incubation was used as value of biochemical oxygen demandof the water sample (APHA, 1999).

Free carbon dioxide

The titration method described by Needham and Needham (1975)was used. Ten drops of phenolphthalein indicator being added to 100 mls water sample and titrated against Sodium carbonate until a weak pink colour end point was obtained.

$MgCO_2$ per liter = ml of titration x 10

Data Analysis

One-Way Analysis of Variance (ANOVA) was used to test for significant differences in mean physico-chemical parameters among stations and Duncan's Multiple Range Test (DMRT) was used to separate the means where significant differences exist. Correlation analysis was used to test the level of association among the physico-chemical parameters.Statistical significance was set at $P \leq 0.05$.

Results and Discussion

Physico-chemical parameters

There was high significant ($P \leq 0.05$) variation in the physico-chemical parameters with months in the reservoir except for water depth, carbon dioxide and hardness (Table 1). All of the physicochemical parameters but hardness did not vary significantly ($P > 0.05$) in the sampling stations in the reservoir (Table 2). Water quality is determined by various physico-chemical and biological factors, as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals (El-Nemaki *et al*. 2008). The significant variation in the physical and chemical parameters observed during this study period could be attributed to changes in weather conditions and anthropogenic activities in and around the reservoir.

The highest temperature of 34.40±0.17^oC was recorded in the month of April, while January had the lowest temperature of 24.17°C. There was significant temperature variation among the months of November, December and January from the other months. The monthly temperature variation among the stations is represented in Fig. 2. Water temperature varied from the lowest value of 23.0^oC in January in Station A to the maximum of 34.5^oC in April. The high temperature recorded in April may be as a result of the intense solar radiation that characterized the month. This value exceeds the normal range of temperature (8 – 30^oC) in the tropics for normal physiological adaptation by fish. Such high temperature could impair fish growth and development. Lower temperatures observed in the month of December and January coincided with the harmattan season in the study area, when atmospheric temperature is very low due to reduced sunlight intensity. Sawyer *et al.* (1994) and Adebowale *et al.* (2008) reported that variation in water temperature is related to atmospheric temperature as well as weather conditions of an area. As fish is a cold blooded animal, its body temperature changes according to that of environment affecting its metabolism and physiology and ultimately affecting the production. Higher temperature increases the rate of bio-chemical activity of the micro biota, plant respiratory rate, and subsequent increase in oxygen demand (Bhatnagar and Devi, 2013).

Transparency showed variation among closely followed months. October and November were significantly different from months of December, January and February as well as April and May. Transparency was highest in February with 76.00 µscm-^{1}, followed by January (74.33 µscm-^{1}) and December (73.33 µscm-^{1}), with the least transparency was observed in the month of November (46.00 µscm-^{1}) which was not significantly different from October (49.00 µscm-^{1}).

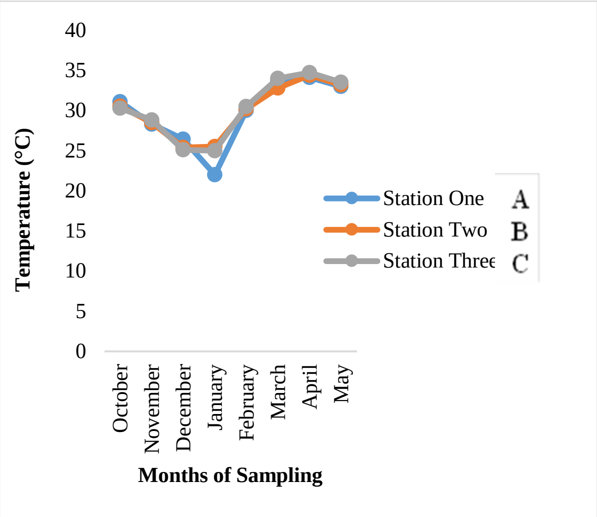

Fig. 2: Mean monthly variation in water temperature of the stations in Dadin-Kowa Reservoir

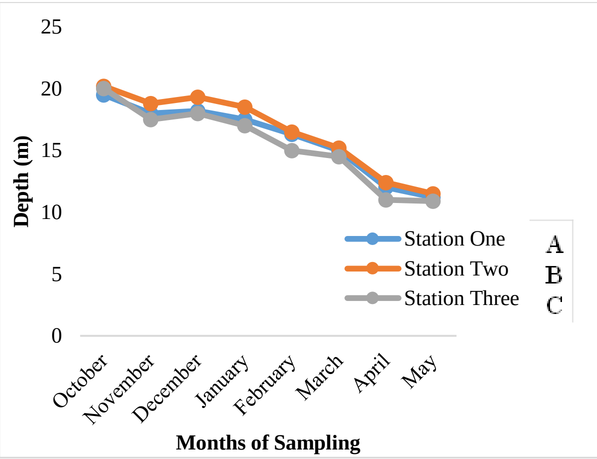

Fig. 3: Mean monthly variation in water depth of the stations in Dadin-KowaReservoir

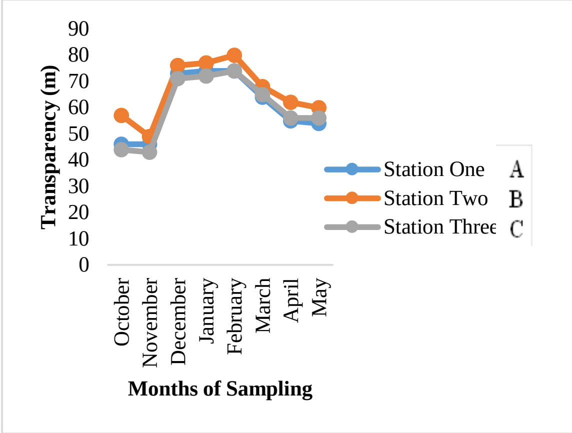

Fig. 4: Mean monthly variation in water transparency of the stations in Dadin-Kowa Reservoir

Figure 4 shows the monthly variation in the transparency of the water in the reservoir in the three stations. The lowest value of 42 m was observed in station C in October with the highest value of 78 m in February in Station B. In all the months, transparency values were highest in Station B. The significant gradual increase in transparency from the months of November to February may be related to onset of the dry season and decreased water current. The transparency values from this study are within the range of 27.71 to 79.70 cm reported for Alau Lake (Usman *et al.*, 2013), in the same ecological zone with Dadin-Kowa reservoir. Transparent water is important as light is an important factor for aquatic organisms to develop. Turbid water that carries suspended matter, soil particles are not suitable for fish culture (Bolorunduro and Abdullah, 1996).

Though there was variation in pH among the months, some similarities were observed in November, December and February and also between October and January. October had the highest pH of 7.67 while April had the least pH of 6.30. There was similarity in the variation of the pH values of the water in the three Stations across the months (Fig. 5). The monthly pH range (6.3 to 7.67) in this study falls within the values of 6.5-9.0 for water pH stipulated by world quality standard for fish production (WHO, 1990; EPA, 2001) outside which may affect fish productivity. The exposure of water body, biological activities, temperature changes (Adebowale *et al.*, 2008) in surface runoff and decaying vegetation could result in water pH variation. Fish have an average blood pH of 7.4, a little deviation from this value, generally from 7.0 to 8.5 is optimal and conducive to fish life (Bhatnagar and Devi, 2013). The pH value between 7 and 8.5 is considered ideal for biological productivity. Water pH in the range of 4.0 to 6.5 and 9.0 to 11.0, can cause stress in fishes and death is almost certain at a pH of less than 4.0 or greater than 11.0 (Ekubo and Abowei, 2011).

Although the depth of the water body did not vary significantly, the highest (18.50 cm) was observed in the month of December while May had the least depth with 11.20 cm. The water depth was observed to gradually decrease with months across the Stations (Fig. 3). The water in the reservoir was deepest (20 m) in October and shallowest (11 m) in May at all the Stations. The lack of variation in water depth in the Reservoir during this study may be as a result of the geomorphological features of the reservoir.

The variation in electrical conductivity in Dadin-Kowa reservoir is presented in Fig. 6. The electrical conductivity and total dissolved solids showed similar pattern of variation among the months. The lowest value of 20.0 µs/cm was observed in Station A in November and the highest (68 µS/cm) was in May in Station B. There was significant increase in EC between the months of January and February. The electrical conductivity values obtained in the study varied according to season. The range of 20 to 68 µs/cm in this study was lower than the range (177 - 214 µs/cm) reported by Tukura *et al.* (2012), and higher than the 0.02 – 0.13 µs/cm observed by Liu and Yu, (1992). The EC values of the water in Dadin-Kowa are within the range of 10 - 1000 µs/cm for surface freshwater reported in Calabar Nigeria (Asuquo, 1999). The TDS varied significantly across the months but consistently similar in the three Stations with a pattern similar to that of the EC (Fig. 8). The highest value of 35 mg/l was recorded in May with the lowest (10 mg/l) in November in all the stations. Conductivity can be used as indicator of primary production (chemical richness) and thus fish production. Fish are known to differ in their ability to maintain osmotic pressure; therefore, the optimum conductivity for fish production differs from one species to another (Bhatnagar and Devi, 2013**)**. Enrique (1992) also observed that ground water and surface runoff from ground and surrounding farmlands lead to increased ionic substances and reduced water volume (Chia, *et al.*, 2011), could result in high EC values. Kadiri (1988) reported lower transparency in reservoirs during the rainy season than the dry season. The highest TDS value in the Dadin-Kowa reservoir at the peak of the dry season agrees with the findings of Chia *et al.* (2011) in water bodies in Zaria and Tukura *et al*. (2012) in Mada River in Nasarawa, Nigeria. The levels of TDS in abroad sense reflect the burden of aquatic systems. Pandey *et al.* (2012) reported that high dissolved solids in water could have organo-trophic implication and can cause suffocations to aquatic fauna and impair gill function.

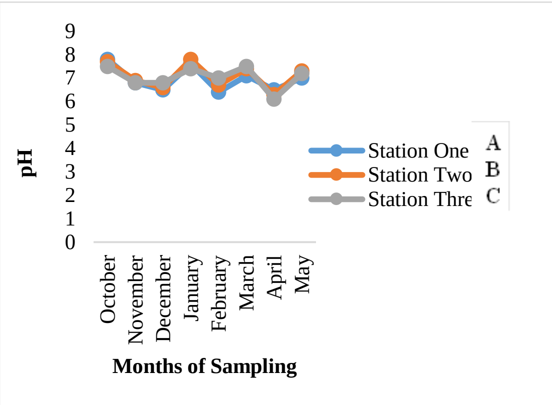

Fig. 5: Mean monthly variation in water pH of the stations in Dadin-Kowa Reservoir

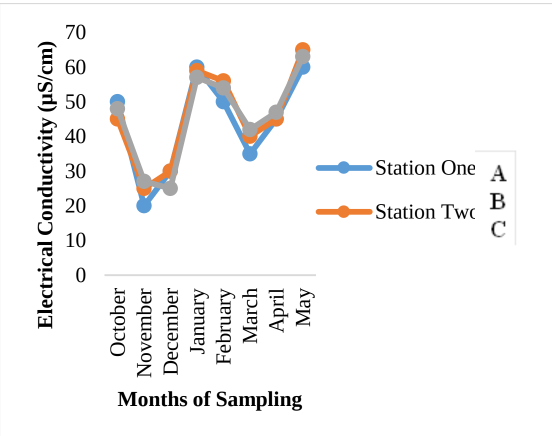

Fig. 6: Mean monthly variation in electrical conductivity of the stations in Dadin-Kowa Reservoir

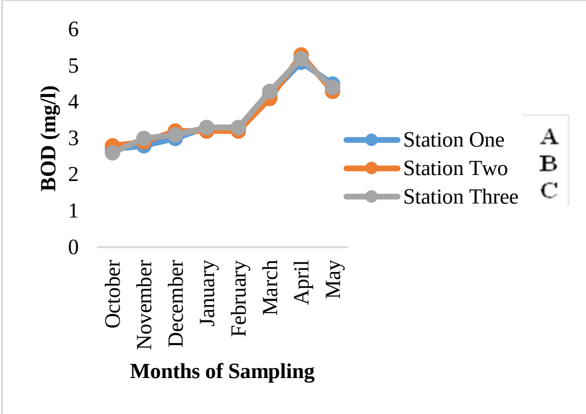

Fig. 7: Mean monthly variation in biochemical oxygen demand of the stations in Dadin-Kowa Reservoir

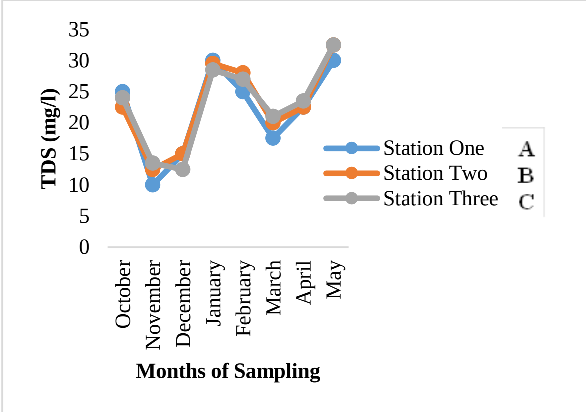

Fig. 8: The mean monthly variation in total dissolved solids of the stations in Dadin-Kowa Reservoir

The dissolved oxygen showed similarities in months while the biochemical oxygen demand distinctly varied throughout the months. The variation in BOD in all the stations showed gradual increase from the lowest value of 2.6 mg/l in October to the highest value of 5.4 mg/l in April before s slight drop in May. The Stations showed similarity in the pattern of variation in BOD in the reservoir (Fig. 7). Figure 9 represents the fluctuation in the concentration of dissolved oxygen (DO). The highest concentration of 9.5 mg/l was observed in May in the three Stations. The lowest concentration (3.3 mg/l) was in Station A in November. The concentration of DO increased in stations A and B from October to December and dropped in January. There was gradual increase in DO in all the Stations from February to May. The biochemical oxygen demand (BOD) is the measurement of total dissolved oxygen consumed by microorganisms for biodegradation of organic matter such as food particles or sewage (Bhatnagar and Devi, 2013). This study showed consistency in the BOD (2.6 – 5.4 mg/l) of the water body over the months of the study. This BOD range makes the reservoir to be slightly polluted. Clair *et al.* (2003) reported that water bodies with BOD_5 in the range of 2 – 8 mg/l are moderately polluted. Important factor influencing BOD include organic matter content, pH, reduction in organic matter, nitrification and types of microorganisms (Kumar and Bahader, 2009). Higher level of BOD could be as a result of increase in phosphate from anthropogenic activities such as washing and high organic load from cattle using the reservoir as water drinking points. The dissolved oxygen (DO) range of 3.3 – 9.5 mg/l of the reservoir could be considered adequate for aquatic life compared to the range reported of 4.3 – 8.8 mg/l for lake Alau (Ahmed and Lawal, 2014), 3.9 – 8.0 mg/l of Wateri Lake

(Haruna, 2005), 0.3 – 3.2 in Jakara Lake in Kano, Nigeria (Haruna, 1992), and the value of 3.0 mg/l recorded for water quality, abundance of fish and plankton species of Ikwori Lake, Nigeria (Offem *et al.*, 2011).
Tropical fishes have more tolerance to low DO than temperate fishes (Bhatnagar and Devi, 2013**)**. According to Bhatnagar and Singh (2010) and Bhatnagar *et al.* (2004) DO level >5 ppm is essential to support good fish production. The minimum DO (3.3 mg/l) from station A in the month of November is lower than minimum of 6.37 mg/l reported (Ahmed and Lawal, 2014) and can be considered low and could slow down growth and development of fishes after prolonged exposure (Andem *et al.,* 2012). Phytoplankton diversities, rates of mixing in upper and lower layers and organic matter decay could influence oxygen saturation percentage of a water body (Clarke and Warwick, 1994).

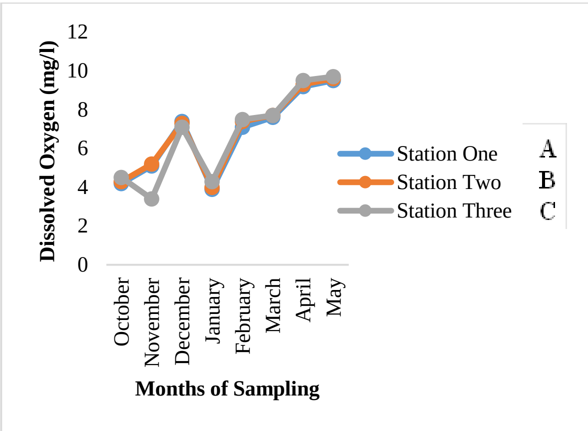

Fig. 9: The mean monthly variation in dissolved oxygen of the stations in Dadin-Kowa Reservoir

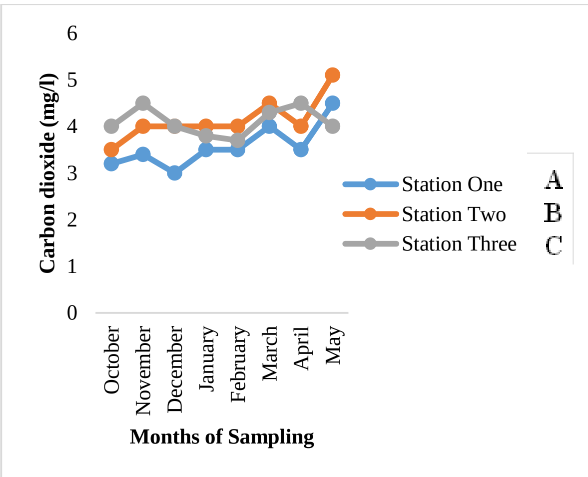

Fig. 10: The mean monthly variation in carbon dioxide of the stations in Dadin-Kowa Reservoir

The carbon dioxide concentration of the three Stations of Dadin-Kowa reservoir is represented in Fig. 10. The pattern of variation is similar in all the Stations. The highest (5.1 mg/l) CO2 concentration was observed in Station B and the lowest (3.0 mg/l) in Station A in the month of December. There was gradual increase in water hardness (Fig. 11) from the month of October with 29 mg/l (lowest) in Station C to May with 82 mg/l (highest) in Station B. A very significant increase in hardness was observed between November and December as well as April and May. The pattern of variation was similar in all the three stations. The carbon dioxide (CO_2) content of the reservoir is consistent throughout the study period. Dissolved CO_2 is constituted mainly by respiration from aquatic fauna, decomposition of organic matter and from atmospheric gases. Carbon dioxide concentrations are known to increase when dissolved oxygen concentration are reduced. Free carbon dioxide, a highly soluble gas in water, main source of carbon pathway in the nature, is contributed by the respiratory activity of animals and can exist in water as bicarbonate or carbonates. When CO_2 dissolves in water it forms carbonic acid which decreases the pH of any system and can be harmful to aquatic organisms (Bhatnagar and Devi, 2013).
The mean water hardness value of 14.75±7.48 mg/l in station C was significantly lower ($P \leq 0.05$) than those of stations A and B. Water hardness is important to fish culture and is a commonly reported aspect of water quality. The water hardness values in this study fall within the range of 30 – 60 for moderately soft water. Bhatnagar *et al*. (2004) reported hardness values less than 20 ppm to cause stress, 75-150 ppm is optimum for fish culture and >300 ppm is lethal to fish life as it increases pH, resulting in non-availability of nutrients. However, Swann (1997) recommended ideal value of hardness for fish culture to be higher than 20 mg/l and range within 30-180 mg/l (Santhosh and Singh, 2007).

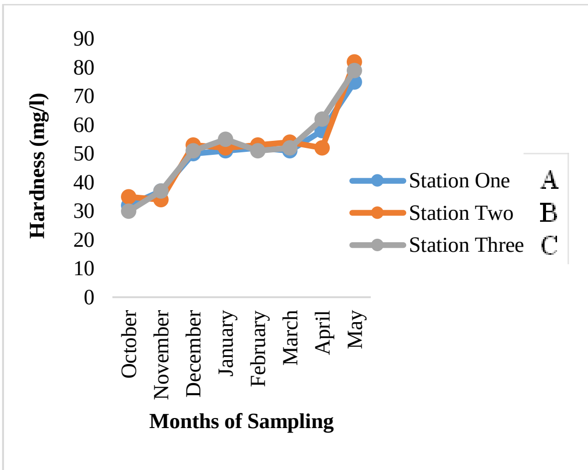

Fig. 11: The mean monthly variation in water hardness of the stations in Dadin-Kowa Reservoir

The relationships among the physicochemical parameters are represented in Table 3. There was high positive association between BOD and DO and between carbon dioxide with EC and TDS. Temperatures showed moderate significant positive relationship with carbon dioxide, BOD and DO. A perfect positive and significant association was observed between TDS and EC. Water depth was found to significant negative association with temperature, EC, BOD, TDS, DO and carbon dioxide. A significant moderate negative correlation was observed between pH and dissolved oxygen (Table 3).

Table 1: Mean monthly variation of the physicochemical parameters of water in Dadin-Kowa Reservoir

Months	Temp. (°C)	Depth (m)	Transparency (cm)	pH	Electrical Conductivity (µS/cm)	BOD (mg/l)	TDS (mg/l)	Dissolved Oxygen (mg/l)	Carbon dioxide (mg/l)	Hardness (mg/l)
Oct.	30.65 ± 0.24^{b}	13.40 ± 6.70^{a}	49.00 ± 4.04^{d}	7.67 ± 0.09^{a}	47.67 ± 1.45^{c}	2.70 ± 0.06^{g}	23.83 ± 0.73^{c}	4.33 ± 0.09^{c}	3.57 ± 0.23^{ab}	32.33 ± 1.45^{a}
Nov.	28.53 ± 0.15^{c}	18.10 ± 0.38^{a}	46.00 ± 1.73^{d}	6.83 ± 0.03^{c}	24.00 ± 2.08^{e}	2.90 ± 0.06^{f}	12.00 ± 1.04^{e}	4.57 ± 0.58^{c}	2.47 ± 1.25^{ab}	36.00 ± 1.00^{a}
Dec.	25.63 ± 0.39^{d}	18.50 ± 0.40^{a}	73.33 ± 1.45^{a}	6.63 ± 0.09^{c}	28.33 ± 1.67^{e}	3.10 ± 0.06^{e}	14.17 ± 0.83^{e}	7.2 ± 0.09^{b}	2.33 ± 1.20^{b}	51.33 ± 0.88^{a}
Jan.	24.17 ± 1.09^{e}	17.67 ± 0.44^{a}	74.33 ± 1.45^{a}	7.60 ± 0.12^{a}	58.67 ± 0.88^{a}	3.27 ± 0.03^{d}	29.33 ± 0.44^{a}	4.07 ± 0.12^{c}	3.77 ± 0.15^{ab}	34.33 ± 17.17^{a}
Feb.	30.23 ± 0.15^{b}	15.93 ± 0.47^{a}	76.00 ± 2.00^{a}	6.70 ± 0.17^{c}	53.33 ± 1.76^{b}	3.27 ± 0.03^{d}	26.67 ± 0.88^{b}	7.33 ± 0.12^{b}	3.73 ± 0.15^{ab}	35.00 ± 17.50^{a}
March	33.50 ± 0.36^{a}	14.90 ± 0.21^{a}	65.67 ± 1.20^{b}	7.33 ± 0.12^{ab}	39.00 ± 2.08^{d}	4.20 ± 0.06^{c}	19.50 ± 1.04^{d}	7.67 ± 0.03^{b}	4.27 ± 0.15^{ab}	35.00 ± 17.52^{a}
April	34.40 ± 0.17^{a}	11.80 ± 0.42^{a}	57.67 ± 2.19^{c}	6.30 ± 0.12^{d}	45.67 ± 0.67^{c}	5.20 ± 0.06^{a}	22.83 ± 0.33^{c}	9.33 ± 0.09^{a}	4.00 ± 0.29^{ab}	36.67 ± 18.41^{a}
May	33.23 ± 0.15^{a}	11.20 ± 0.17^{a}	56.67 ± 1.76^{c}	7.17 ± 0.09^{b}	62.67 ± 1.45^{a}	4.40 ± 0.06^{b}	31.67 ± 0.83^{a}	9.60 ± 0.06^{a}	4.53 ± 0.32^{a}	52.33 ± 26.24^{a}
Mean	**30.04 ± 0.74**	**15.19± 0.90**	**62.33 ± 2.37**	**7.03 ± 0.10**	**44.92 ± 2.73**	**3.63 ± 0.17**	**22.50 ± 1.38**	**6.77 ± 0.44**	**3.58 ± 0.24**	**39.13 ± 4.85**
Acceptable Range	**26–32 (FAO, 2006)**		**10 –100 (Boyd, 1990)**	**6.5–9.0 (Davies, 1993)**	**20 – 1,500 (Boyd, 1990)**	**3 – 20 (Boyd, 2003)**	**0.13 – 13.6 (Davies, 1993)**	**3 – 5 (Boyd, 1990)**	**0.0 -10 (Boyd, 1990)**	**20-150 (WHO, 2003)**
P value	**0.000***	**0.266ns**	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.228ns**	**0.961ns**

A,b,c,d,e_ means with the same superscripts along the columns were not significantly different (P > 0.05).
* - significant at P ≤ 0.05; ns – not significant (P > 0.05)

Table 2: Mean monthly variation of the physicochemical parameters among stations at Dadin-Kowa Reservoir

Stations	Temp. (°C)	Depth (m)	Transparency (cm)	pH	Electrical Conductivity (µS/cm)	BOD (mg/l)	TDS (mg/l)	Dissolved Oxygen (mg/l)	Carbon dioxide (mg/l)	Hardness (mg/l)
A	29.83±1.47^{a}	13.53±2.15^{a}	60.75±4.28^{a}	6.96±0.18^{a}	43.75±5.07^{a}	3.61±0.31^{a}	21.88±2.53^{a}	6.75±0.76^{a}	3.58±0.17^{a}	50.75±4.60^{a}
B	30.07±1.21^{a}	16.55±1.15^{a}	66.13±3.88^{a}	7.09±0.19^{a}	45.63±4.94^{a}	3.63±0.31^{a}	22.81±2.47^{a}	6.85±0.76^{a}	4.14±0.17^{a}	51.88±5.21^{a}
C	30.24±1.34^{a}	15.49±1.16^{a}	60.13±4.36^{a}	7.04±0.17^{a}	45.38±4.81^{a}	3.65±0.31^{a}	22.81±2.47^{a}	6.71±0.85^{a}	3.04±0.67^{a}	14.75±7.48^{b}
Mean	**30.04±0.74**	**15.19±0.90**	**62.33±2.37**	**7.03±0.10**	**44.92±2.73**	**3.63±0.17**	**22.50±1.38**	**6.77±0.44**	**3.58±0.24**	**39.13±4.85**
P value	**0.976ns**	**0.395ns**	**0.546ns**	**0.888ns**	**0.958ns**	**0.996ns**	**0.954ns**	**0.992ns**	**0.189ns**	**0.000***

a,b,c,d,e_ means with the same superscripts along the columns were not significantly different (P > 0.05).
* - significant at P ≤ 0.05; ns - not significant (P >0.05)

Table 3: Correlation of physicochemical parameters in Dadin-Kowa Reservoir

	Temp.	**Depth**	**Transp**	**pH**	**EC**	**BOD**	**TDS**	**DO**	**CO$_2$**	**Hardn**
Temp.	1.00									
Depth	-0.85*	1.00								
Transp	-0.41	0.39	1.00							
pH	-0.21	-0.01	-0.09	1.00						
EC	0.18	-0.55*	0.25	0.38	1.00					
BOD	0.71*	-0.69*	-0.01	-0.40	0.30	1.00				
TDS	0.19	-0.56*	0.24	0.37	1.00*	0.30	1.00			
DO	0.67*	-0.61*	0.13	-0.56*	0.21	0.82*	0.22	1.00		
CO$_2$	0.64*	-0.77*	0.06	0.30	0.80*	0.65*	0.80*	0.47	1.00	
Hardn	-0.04	-0.09	0.13	-0.28	0.00	0.19	0.01	0.55*	-0.10	1.00

* = strong positive or negative correlation; Temp = Temperature; Transp = Transparency; Hardn = Hardness

This study showed marked significant (P ≤ 0.05) mean monthly variation in the water temperature, transparency, pH), electrical conductivity, biological oxygen demand, total dissolved solids and dissolved oxygen in Dadin-Kowa reservoir. These parameters could have positive and negative influence on the aquatic community structure and fish species in the reservoir. It is recommended that regular monitoring of the physicochemical parameters of water in the reservoir be carried out in order to monitor its suitability for aquatic life.

Acknowledgement
The authors wish to acknowledge the support of Gombe State University.

Conflict of Interest
There is no conflict of interest.

References

Adebowale KO, Agunbiade FO & Olu-Olawolabi BI 2008. Impacts of natural and anthropogenic multiple sources of pollution on the environmental conditions of Ondo State Coastal Water, Nigeria. *Electronic J. Envtal., Agric. & Food Chem.*, 7(4): 2797-2811.

Adeniji HA 1981. Limnological characteristics of man- made lakes in Nigeria. In: Ayeni and Olatunde (eds). *Proceedings of the National Conference of two Decades of Research on Lake Kainji*, pp. 41-52.

Adeniji HO & Ita EO 1977. Preliminary investigations into the technology and fisheries of Tiga Lake Kano State Nigeria. *Report Presented to Kainji Lake Research Institute*, No. 19.

Ahmed A & Lawal I 2014. Physico-chemical parameters in relation to fish abundance in DaberamReservoir, Katsina State, Nigeria. *Entomol. & Appl. Sci.*, 1(3): 43-48.

Ahmed FF & Philip UJ 2012. The impact of the second national Fadama development Program on the standard of living of Dadin-Kowa community of Yamaltu-Deba Local Government of Gombe State (2004-2010). *Acad. Res. Int.*, 2(2): 549-554.

Andem AB, Udofia U, Okorafor KA, Okete JA & Ugwumba AAA 2012. A study on some physical and chemical characteristics of Ona River, Apata, Ibadan South-west, Oyo State, Nigeria. *Eur. J. Zoolo. Res.*, 1(2): 37 – 46.

APHA (American Public Health Association) 1999. Standard Method for Examination of Water and Waste Water.American Public Health Association, New York, USA.

Asuquo FE1999. Physico-chemical characteristics and anthropogenic pothition of the surface waters of Calabar River, Nigeria. *Global J. Pure & Appl. Sci.*, 5(4): 595-600.

Atobatele OE & Ugwumba OA 2010. Distribution, abundance and diversity of macrozoobenthos in Aiba Reservoir Iwo, Nigeria. *African J. Aquatic Sci.*, 35(3): 291-297.

Balarabe ML 1989. Limnology and Zooplankton distribution of Makwaye (Ahmadu Bello University Farm) lakeSamaru Zaria Nigeria Unpublished Msc. Thesis Ahmadu Bello University, Zaria.Nigeria, pp. 20-41.

Bhatnagar A & Devi P 2013. Water quality guidelines for the management of pond fish culture. *Int. J. Envtal. Sci.*, (3): 6,

Bhatnagar A & Singh G 2010. Culture fisheries in village ponds: a multi-location study in Haryana, India. *Agric. & Bio. J. North Am.*, 1(5): 961-968.

Bhatnagar A, Jana SN, Garg SK, Patra BC, Singh G & Barman UK 2004. Water quality management in aquaculture, In: Course Manual of summer school on development of sustainable aquaculture technology in fresh and saline waters, CCS Haryana Agricultural, Hisar (India), pp. 203- 210.

Blackmore DJ 2000. Dams the dilemma. Australia Centre for International Agricultural Research (ACIAR).

Bolorunduro PI & Abdullah AY 1996. Water management in fish culture. National Agricultural Extension and Liaison Services, Ahmadu Bello University Zaria, Nigeria. Extension Bulletin No. 98. Fisheries Series No. 3, 53pp.

Boyd CE 1990. Water quality management for pond fish culture. Department of Fisheries and

Allied Aquaculture. Agricultural Experiment Station, Auburn, Alabama, Birmingham

Publishing Company, New York, 482pp.

Chia AM, BakoSP, Alonge SO & Adamu AK 2011. Green algal interactions with physicochemical parameters of some manmade ponds in Zaria, Northern Nigeria. *Revista Brasil. Bot.*, 34(3): 285-295.

Clair AI, Charkroff M, Darvin J & Machelet A 2003. Fresh water pond assessment, peace cone and volunteers in technical assistance. Virginia, USA, pp. 79-92.

Clarke KR & Warwick RM 1994. *Change in marine communities:* An approach to statistical analysis and interpretation. *Natural Envtal. Res. Council, Bournemouth*, 231-235.

El-Nemaki FA, Ali NA, Zeinhom MM & Radwan OA 2008. Impacts of different water resources on the ecological parameters and the quality of Tilapia production at El-Abbassa Fish Farms in Egypt. *Int. Symposium on Tilapian Aquacul.*, 491 – 512.

Ekubo AA & Abowei JFN 2011. Review of some water quality management principles in culture fisheries. *Res. J. Appl. Sci., Engr. & Tech.*, 3(2): 1342-1357.

Enrique V 1992. Temperature and dissolved oxygen in Lake of the Lower River Floodplain (Venezuela). *Hydrobiologia*, 25: 23-33.

EPA 2001. Parameters of Water Quality: Interpretation and Standards .Environmental Protection Agency. Published by EPA Ireland, pp. 1 – 132.

Esenowo IK&Ugwumba OA2010.Growth response of Catfish exposed to water soluble fraction of detergent and diesel oil. *Envtal. Res. J.*, 4(4): 298-301.

FAO 2006. State of World Aquaculture. Food and Agriculture Organization of the United Nations (FAO) Fisheries Technical paper 500. Rome: FAO Fisheries Department.

Haruna BA 1992. M.Sc. Thesis, Bayero University, Kano, Nigeria. In: Lawal, I. and Ahmed, A. (2014). Physico-chemical parameters in relation to fish abundance in Daberam Reservoir, Katsina State, Nigeria. *Entomo. & Appl. Sci.*, 1(3): 43-48.

Ibrahim BU, Auta J & Balogun JK 2009. An assessment of the physicochemical parameters of Kontagora reservoir, Niger State, Nigeria. *Bayero J. Pure& Appl. Sci.*, 2(1): 64 - 69.

Imevbore AMA 1990. Some Preliminary observation on the ratios and fecundity of the fish in the River Niger. In: *S.A visser (ed)Kainji lake studies. Vol. 1, Ecology, S.A vises* (ed). 87-88 pp.

Kadye WT, Moyo NAG, Magadza CHD & Kativu S 2008. Stream fish assemblages in relation to environmental factors on a Montane Plateau (Nyika Plateau, Malawi). *Environmental Biology of Fishes*, 83: 417-428.

Kadiri MO 1988. Seasonal changes in the phytoplankton biomass of shallow tropical reservoir. *Nigeria J. Botany*, 6: 167-173.

Kolo RJ & Oladimeji AA 2004. Water quality and some nutrients levels in Shiroro lake Niger State. Nigeria. *J. Aquatic Sci.*, 19(2): 99-103.

Kumar A & Bahadur Y 2009. Physico-chemical studies on the pollution potential of River Kosi at Rampur India. *World J. Agric. Sci.*, 5(1): 1-4.

Liu J & Yu ZT 1992. Regulated River Resources and Management, 7(4): 359 – 368.

Needham JG & Needham PR 1975. *A guide to the study of fresh water biology*. Holden day region. *Orissa Environ. Pollut*. 8: 43-44.

Offem BO, Ayotunde EO, Ikpi GU, Ochang SN & Adaet FB 2011. Influence of seasons on water quality, abundance of fish and plankton species of Ikwori Lake, South-Eastern Nigeria. *Fisheries & Aquac. J.*, 13: 1-18.

Oniye SJ, Ega RAI, Ajanusi OJ & Agbede RIS 2002. Some aspects of the physico-chemical parameters of Zaria reservoir. *Nig. J. Agric. & Envt.*, 11(2): 367-379.

Pandey SC, Singh SM, Pani S & Malhosia A 2012. Limnology: A case study of highly polluted Laharpur Reservoir, Bhopal, (M.P.) India. *International Journal of*

Chemical, Biological and Physical Sciences, 2(3): 1560 – 1566.

Rodríguez-Ruiz A 1998. Fish species composition before and after construction of a reservoir on the Guadalete River (SW Spain). *Archivfuer Hydrobiologie*, 142: 353-369.

Santhosh B & Singh NP 2007. Guidelines for water quality management for fish culture in Tripura, ICAR Research Complex for NEH Region, Tripura Center, Publication No. 29.

Sawyer CN, McCarty PL & Parkin GF 1994. *Chemistry for Environmental Engineering.* McGraw Hill Publication, New York.

Swann LD 1997. A Fish Farmer's Guide to Understanding Water Quality, Aquaculture Extension Illinois, Purdue University, Indiana Sea Grant Program Fact Sheet AS-503.

Tukura BW, Gimba CE, Ndukwe IG & Kim BC 2012. Physicochemical Characteristics of Water and Sediment in Mada River, Nasarawa State, Nigeria. *Int. J. Envt. & Bioenergy*, 1(3): 170-178.

Ugwumba OA & Ugwumba AAA 1993. A study of the physico-chemical hydrology and plankton of Awba Lake, Ibadan, Nigeria. *Fish Acadbiz Comm.*, 1(1&2): 20-39.

Unanam AE & Akpan AW 2006. Analysis of physico-chemical characteristics of some fresh water bodies in EssienUdim local government area of Akwa-Ibom State, Nigeria. In: *Proceeding of the 21st annual Conference of the Fisheries Society of Nigeria* (FISON), Calabar 13th - 17th November, 2006.

Upper Benue River Basin Development Authority (UBRDA) 1980. Dadin-Kowa Resettlement Project, Draft final report, Vol. 2.

Usman A, Solomon SG & Kayi RG 2013. Aspects of the biology of some selected fish species from Lake Alau, arid zone Nigeria. *Nig. J. Fisheries & Aquac.*, 2(1): 24 – 36.

Venkatesharaju K, Ravikumar P, Somashekar RK & Prakash KL 2010. Physico-chemical and Bacteriological Investigation on the river Cauvery of Kollegal Stretch in Karnataka, *J. Sci. Engr. & Tech.*, 6(1):50-59.

WHO 1990. Environmental Health Criteria 101, Methylmercury. International Programme on Chemical Safety, Geneva, 88p.

William MA 2001. Green development: environment and sustainability in the Third World. Routledge, pp. 238: (ISBN 0-415-14766-2.5).