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Effects of Riparian Land Use on Physico-Chemical Parameters of Water in Dadin Kowa Dam, Gombe State, Nigeria

Amos, Jummai Tidi[1]* and Newton Moses[2]

[1]Department of Biological Sciences, Federal University Wukari, P.M.B 1020, Taraba State, Nigeria.
[2]Federal College of Horticulture, Dadin Kowa, P.M.B 108, Gombe State, Nigeria

*Corresponding author Email: jummaiat@gmail.com, Tel: +234 813 721 1656

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ABSTRACT: Different riparian land use activities were observed around Dadin-Kowa dam, which include both agricultural and domestic practices. These studies aim to investigate the effects of such riparian land use on physicochemical parameters in water. The investigation period was for 18 months from June 2018 - November 2019 and analysed using standard methods. Results reveal no statistically significant difference between the sites studied for the physicochemical parameters. A significant difference ($p<0.05$) was observed between the months under study for temperature, conductivity, bicarbonate and dissolve oxygen. The study identified farming as the commonest land use activity around Dadin-Kowa dam and the use of organic and inorganic fertilisers as well as various forms of pesticides utilised for pest control purposes. The physicochemical parameters in the studied sites were mostly within the recommended values. Therefore, it is important to regulate the human activities taking place around the dam to improve proper water conditions and boost the aquatic life.

Keywords: Dadin-Kowa dam; Physicochemical parameters; Riparian land use; Riparian zone

Introduction

Riparian zone or riparian area is the interface between land and a river or stream. Plants, habitats and communities along the river margins and banks are called riparian vegetation which is characterized by hydrophilic plants. Land use activities affect various streams, dams, rivers, reservoirs. Characteristics, such as the microclimate, air temperature, stream water temperature, humidity, wind speed, the concentration of nutrients, sediments and pollutants in streams as well as ecological conditions (Umar, 2013).

Dam water is a valuable resource for humans (direct consumption, power, irrigation and industry) and provides essential habitat for many organisms, including highly valued fish species. Aquatic habitat is influenced by processes not only in the near-stream (riparian) zone (e.g., provision of shade) but also over the entire watershed (e.g., hill slope hydrologic processes that control the supply of water or the generation of landslides). Several studies have been carried out on the effects of riparian land use on stream benthic communities elsewhere (Umar, 2013; De Castro *et al*., 2016; Merritt *et al.,* 2017).

The increase in human population which brought about fishing activities, irrigation, and farming activities has been reported to put massive pressure on the quality state of water in the reservoir (Tepe *et al*., 2005; Ajuzie, 2012). Heavy metal contamination and organic pollution such as pesticides are also listed as measure activities affecting the quality of the water supply. The major concern about the occurrence of these water pollutants in a water body is the strong negative effect on the structural biodiversity of the dam (Shiva, 2016).

Multiple factors including season, physical and chemical properties of water can play a significant role in metal accumulation in different fish tissues. Several studies (Karthikeyan *et al*., 2007) have also indicated that fish can

accumulate and retain heavy metals from their environment depending upon exposure, concentration and duration as well as salinity, temperature, hardness and metabolism of the animals.
The water from Dadin-Kowa reservoir has long been known for its usage as a source of water supply to the local community around the region. About eleven local government areas including neighbouring states depend on Dadin Kowa dam for their livelihood. Since its construction, human interference has been reported to be the major factor affecting the quality of water in the dam which threatened the life of aquatic biota such as fish and aquatic macroinvertebrate (Ja'afaru and Abubakar, 2015). Therefore, this study aims to assess the effect of riparian land use on the physical and chemical properties of water in Dadin Kowa Dam, Gombe State, Nigeria.

Materials and methods

Description of study area: Dadin-Kowa dam 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. The area lies within longitude 11° 30' E and 11° 32' E, and latitude 10° 17' N and 10° 18' N of the equator. The dam is part of River Gongola and is considered the second-largest dam in Nigeria. It is a multipurpose dam that impounds a large volume of water from the Gongola River and it has a storage capacity of 1.77 billion cubic meters (Jesse *et al.*, 2019). The maximum flood level is 249 m (a.s.l.), and the maximum supply level of 247 m (a.s.l.) and the minimum supply of 239 m (a.s.l.), (Noel *et al*., 2020). The surface area of the reservoir is 300 km^2. The 1:10,000-year peak in-flow is 3160 m^3/sec, and the peak outflow is 1110 m^3/sec. The total catchment area of the Gongola River is approximately 56,000 km^3, 58.5% of which lies upstream of the dam. It also has a gated overflow crest open chute bucket spillway with a maximum design discharge of 1,110 m/sec at reservoir maximum flood level and three (3) radial gates. Its drainage basin is situated in North-Eastern Nigeria, with a water capacity of 800 million cubes and a surface area of 300 km^2. Dadin-Kowa dam is the major source of water for drinking, irrigation, hydropower generation and fishing activities in Gombe town, Gombe State (Jesse *et al.*, 2019).

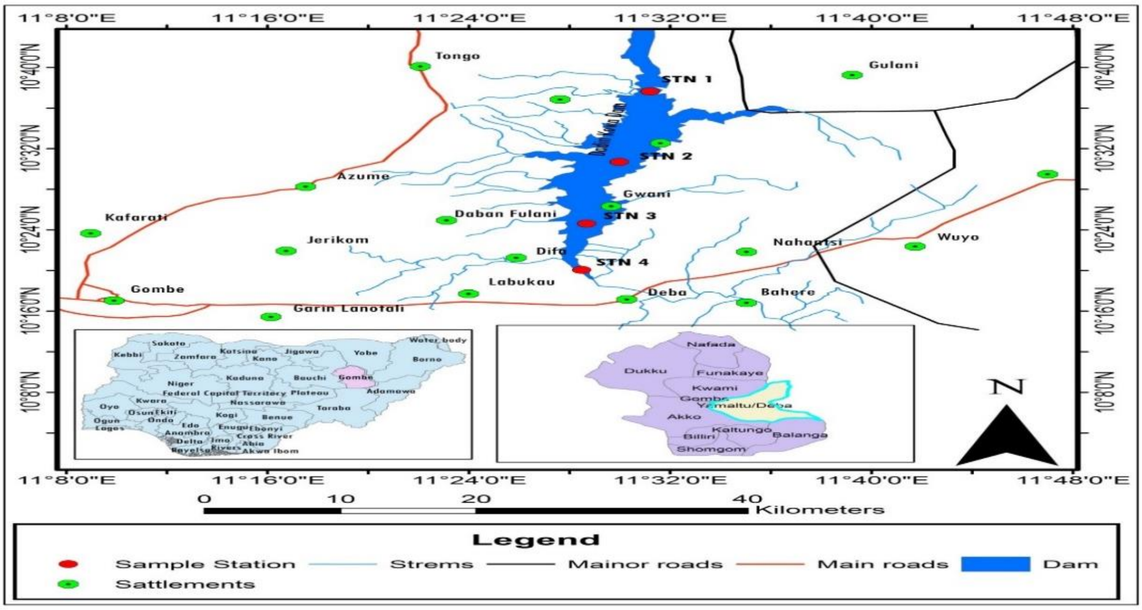

Figure 1: Map of Dadin-Kowa Reservoir showing the study area and the sampling sites.

Sample collection: Dadin-Kowa dam was divided into four (4) sampling stations based on riparian activities. The sample collection lasted for a period of eighteen (18) months (June 2018, - November, 2019) covering two seasons that cut across two years (2018- 2019). The months of May - October considered the wet season while the months of November - April are considered the dry season. Water samples were collected monthly during this study.
Determination of physicochemical characteristics of water: Water samples were collected in 250 ml bottles from four (4) sampling stations. To collect the water samples, the bottles were rinsed before being filled with water for physicochemical analysis in the Biochemistry laboratory.

- *Determination of temperature*: Water temperature was recorded at the sampling site (*in situ*) by using a digital portable dissolved oxygen/temperature meter model (407510A) to measure the temperature values at each site by dipping the electrode into the water and allowing it to stabilize, then the reading was immediately taken (Hughes *et al.*, 2004).
- *Determination of transparency*: The transparency of the water was measured using a Secchi disk. The disk was dipped into the water till the disk disappeared and the depth was recorded (d_1). It was then withdrawn carefully and the depth at which it became visible was also recorded (d_2). Actual measurement was obtained by taking the average of the two readings ($d_1 + d_2/2$) (Hughes *et al.*, 2004).
- *Determination of pH*: The pH was recorded directly at the sampling site (*in-situ*) using a pH meter (Model: ATC pH/T meter) as described by Hughes *et al.*, (2004).
- *Determination of dissolved oxygen*: A digital portable dissolved oxygen/temperature meter model (EXTECHIN STRUMENTS-407510A) was used to measure the dissolved oxygen values at each site. For each site, the probe was inserted into the water, and reading was displayed and recorded, the same procedure was applied for all the sites after rinsing the probe in distilled water.
- *Determination of conductivity*: Conductivity was recorded at the site (*in situ*) using a conductivity meter (Model:850037 with Serial Number; 152847). The electrode of the conductivity meter was dipped into the water and allowed to be stable before the reading was recorded.
- *Determination of nitrate*: Nitrate was measured using a testab water investigation kit as recommended by Cambell and Weinberger (2001).
- *Determination of phosphate*: Phosphate was estimated as described by Hughes *et al.* (2004).

Data analysis: Data were subjected to descriptive statistics, following established statistical procedures. The data was subjected to ANOVA across the stations with the help of SPPS software (Graphpad software).

Results

Physicochemical parameters: The temperature observed during this study ranges from 26.78 ºC - 25.56 ºC in sites A and B. Monthly mean temperature value ranges from 28.25 °C - 24.25 ºC which were recorded in March 2019 and December 2018 then January, and February 2019 which revealed no significant difference in all site ($p<0.05$) and across months (Fig. 2)

The value of conductivity in Dadin-Kowa dam revealed the highest value of 5.38 µs/cm at site A, and the lowest value of 4.83 µs/cm at sites B and C, respectively. Monthly mean value range between 7 µs/cm - 3.25 µs/cm which was observed in February and October 2019, which revealed no significant variation between sites ($P<0.05$) and there is significant variation between months ($P>0.05$) (Fig. 3)

Fig. 4 shows the mean value of pH, the highest pH value 7.60 was recorded at site C and the lowest value 7.27 was recorded at site B. Monthly mean pH values ranged between 8.47 - 6.7 which were observed in September 2019 and August 2018. There was no significant difference between sites and months ($P>0.05$).

The value of water transparency is presented in Table 4. The value of 3.22 cm at site B and 2.05 cm at site A were recorded while the monthly mean value range between 2.0 cm - 5.25 cm showed no significant difference across sites and months ($p>0.05$) (Fig. 5).

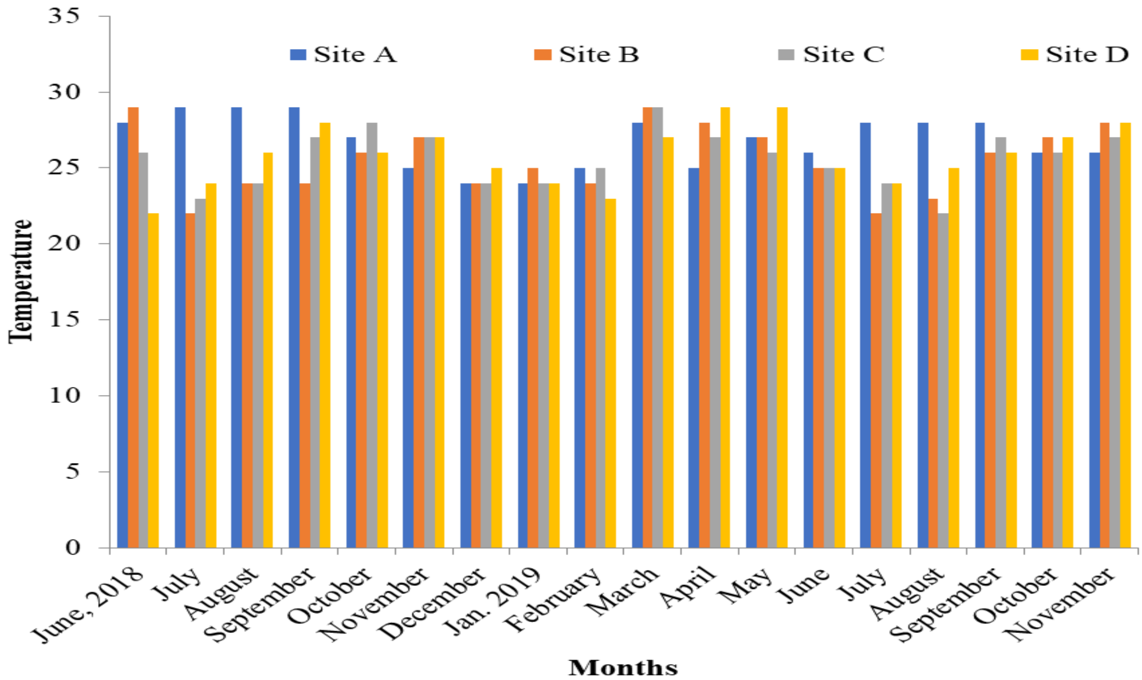

Fig. 2: Concentration of water temperature (°C) at Dadin Kowa dam.

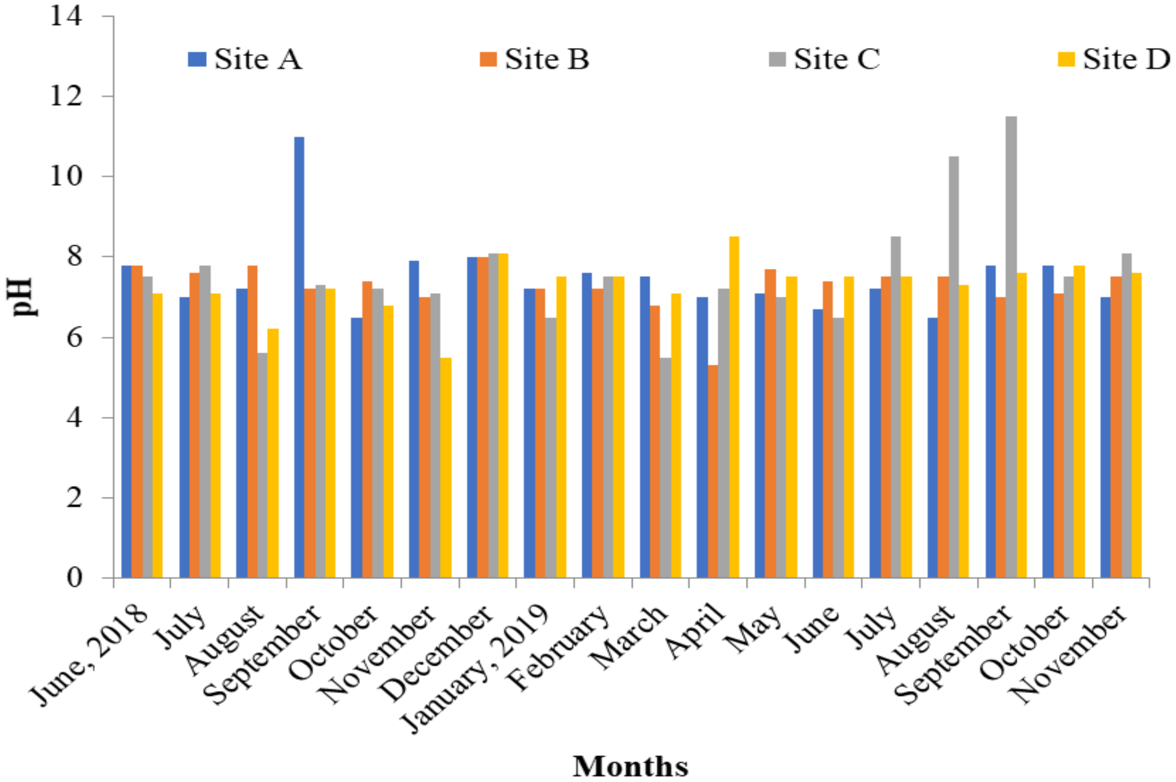

Fig. 3: Concentration of water pH at Dadin Kowa dam.

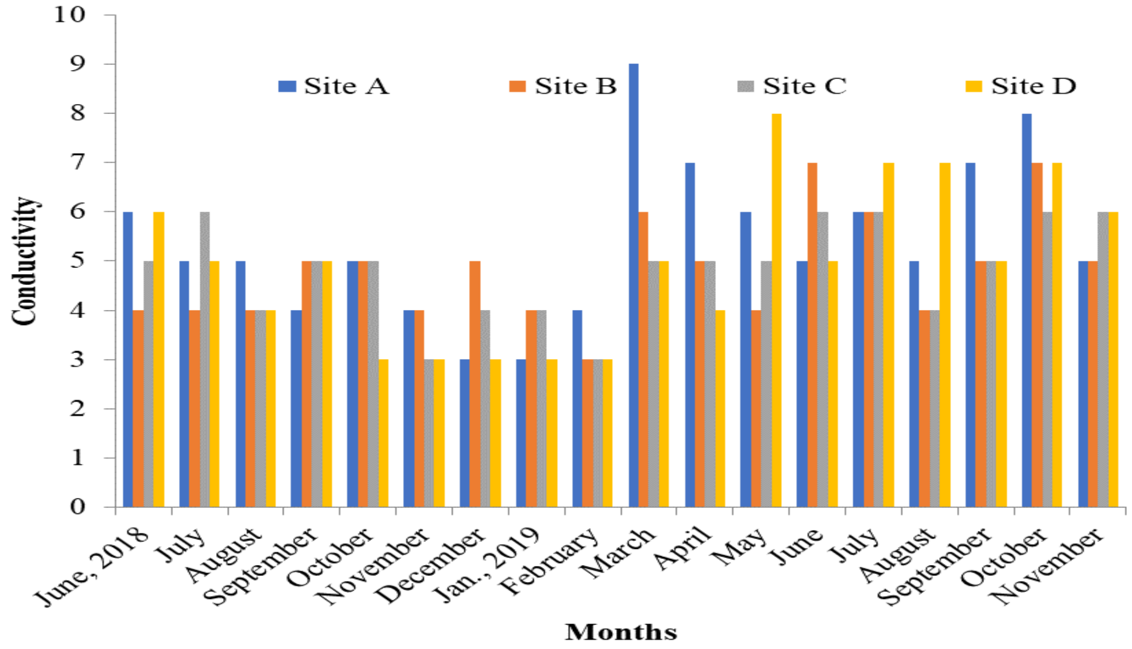

Fig. 4: Concentration of water conductivity (μs/cm) at Dadin Kowa dam.

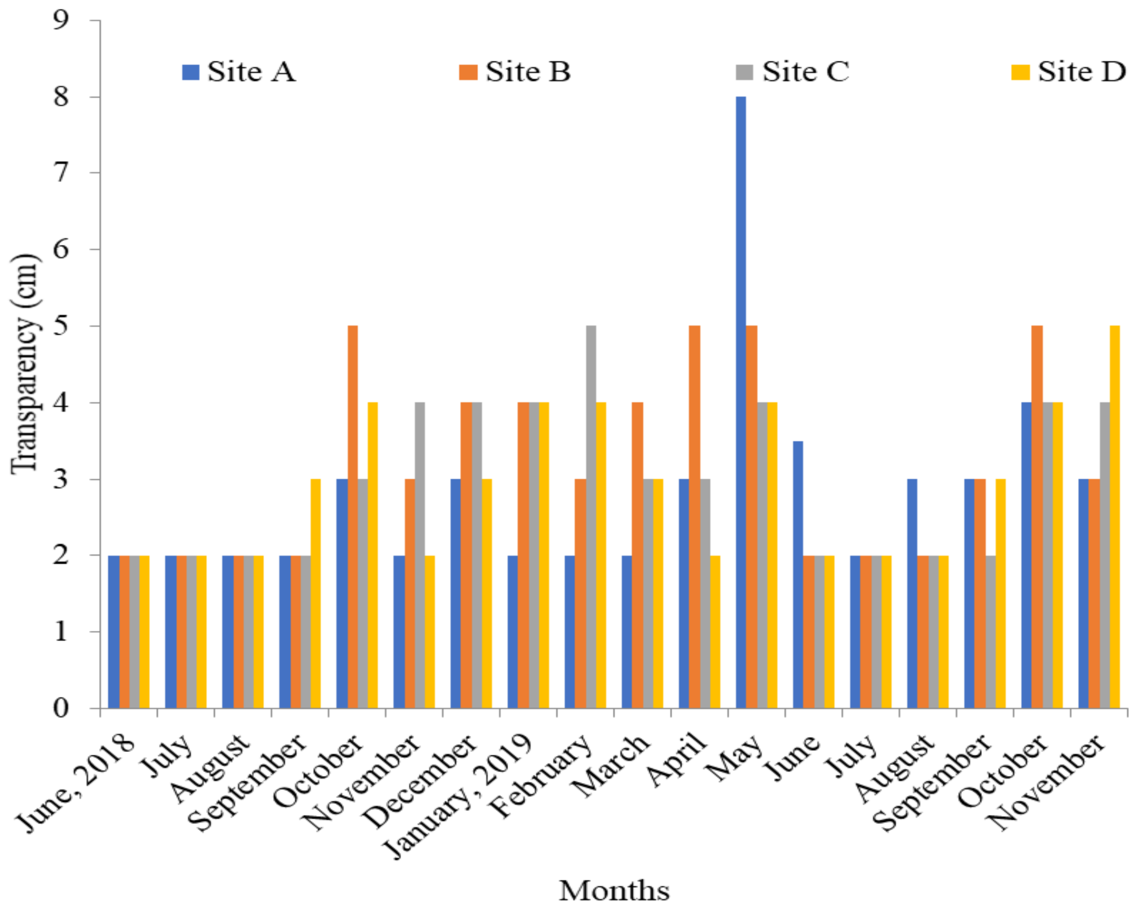

Fig. 5: Concentration of water transparency (cm) at Dadin Kowa dam

The highest value of 30.13 mg/kg CO_3 was recorded at site B and 0.00 mg/l across other sites, the highest monthly mean variation of 116.52 mg/kg and 19.08 mg/kg of CO_3 was recorded in June and July 2018 while 0.00 mg/kg of CO_3 was recorded in the rest of the months (Fig. 6). There was no significant difference in carbonate (CO_3) across sites and months ($p>0.05$) during the period of the study.
The highest value of bicarbonate (HCO_3) 396.22 mg/kg was recorded at site A while the lowest of 50.42 mg/kg was recorded at site C. The monthly mean value ranges between 730.38 mg/kg to 18.59 mg/kg in July 2018 and July 2019. There is no significant difference across sites and months ($P<0.05$) (Fig. 7).
The highest value of chlorine recorded at site C was 7.83 mg/kg while the lowest was 5.97 mg/kg at site A. The monthly mean value of chlorine ranges between 23.78 mg/kg to 1.37 mg/kg in July 2019 and December 2018, respectively (Fig. 8). No significant difference ($P>0.05$) across the sites and months
The value 69.29 mg/kg of NO_3 was recorded at site B and 51.01 mg/kg was recorded at site C. The monthly mean value of NO_3 ranged between 85.20 mg/kg to 33.65 mg/kg in August 2018 and June 2019 (Fig. 9). There was no significant difference in trioxonitride (NO_3) across sites and months ($P>0.05$).
Fig. 9 revealed the average value of phosphate (PO_4) in which 324.75 mg/kg was observed and the lower value of 41.7 mg/Kg was recorded at site D. The monthly mean value range between 1346.82 mg/kg to 10.75 mg/kg in August 2019 and December 2018. There was no significant difference in phosphate across sites and months ($p>0.05$) (Fig.10).
Fig. 10 shows the average value of sulphate, where the highest value of 6.31 mg/kg was recorded at site B and the lowest value of 3.81 mg/kg was recorded at site C. The monthly mean value of sulphate ranged between 10.74 mg/kg to 0.80 mg/kg in December 2018 and April 2019. No significant difference in site and across months ($p>0.05$). While Figure 12 showed the average value of dissolved oxygen (DO), the highest value of 3.98 mg/kg was observed at site C while the lowest DO value of 3.47 mg/kg was observed at site A, the monthly mean variation ranges between 6.03 mg/kg to 1.94 mg/kg in July 2018 and July 2019. There was no significant difference across the sites ($P>0.05$), while there was significant difference across months ($P<0.05$)

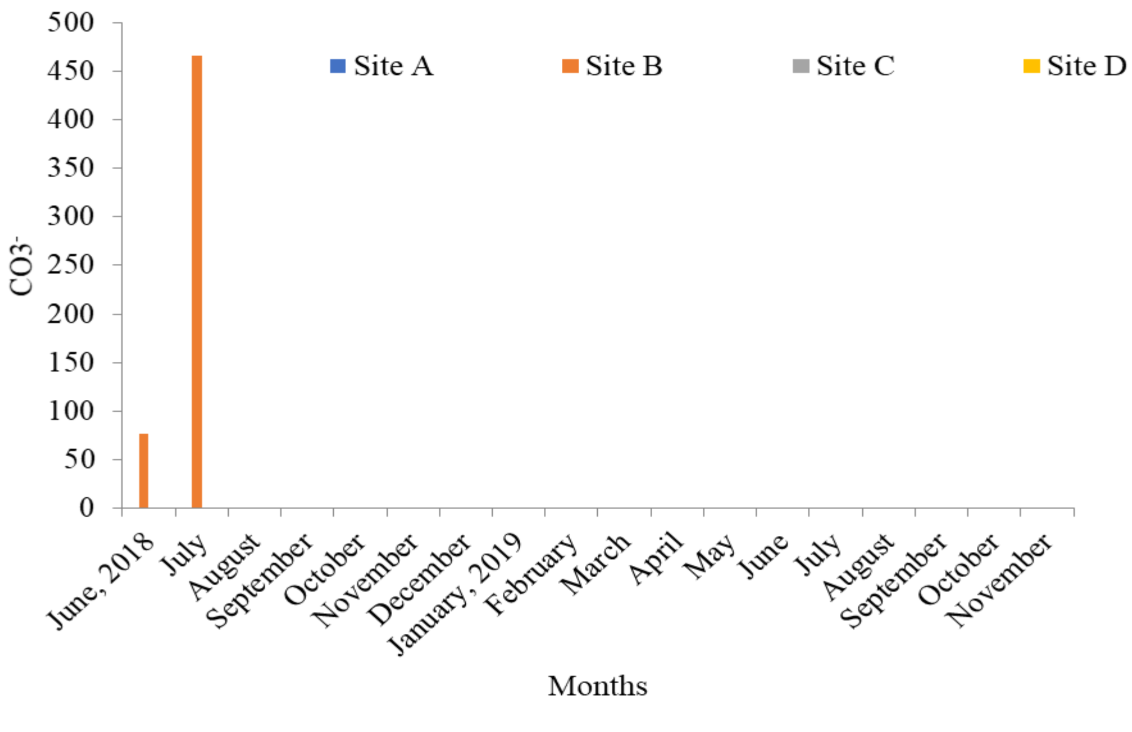

Fig. 6: Concentration of carbonate (CO_3^-) in Dadin Kowa dam

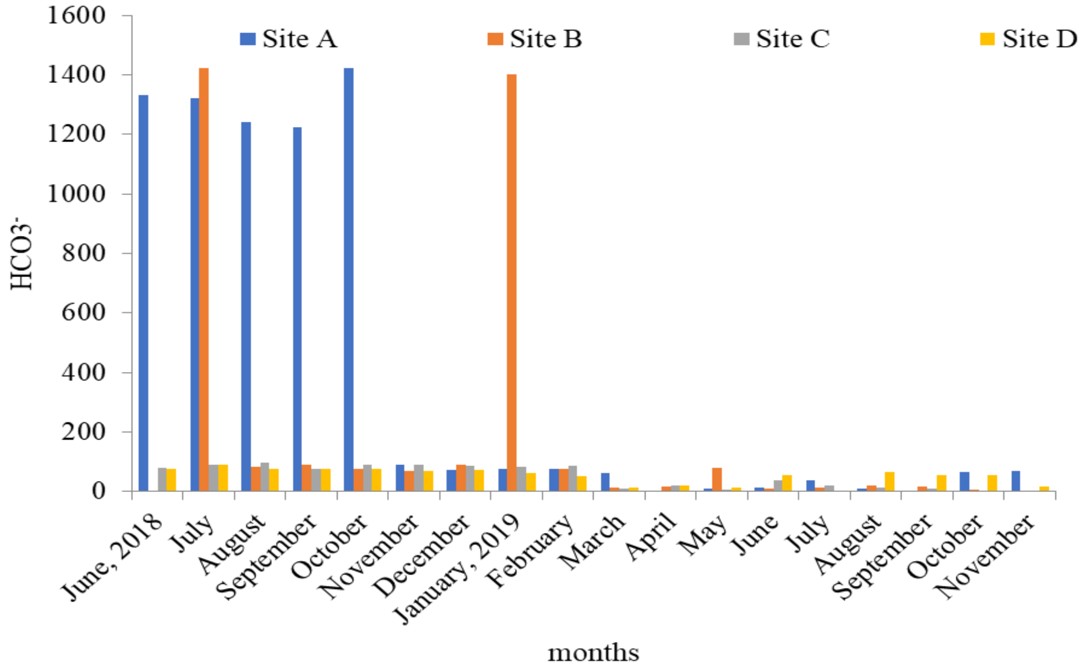

Fig. 7: Concentration of bicarbonate (HCO_3^-) in Dadin Kowa dam

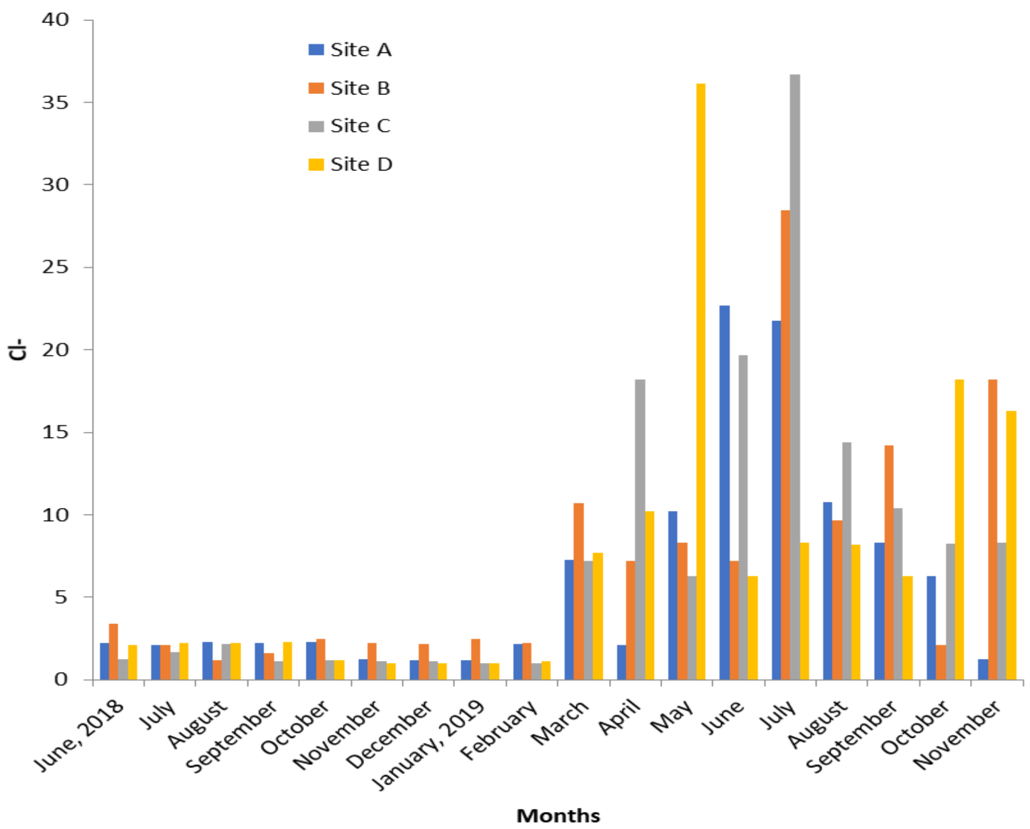

Fig. 8: Concentration of chloride (Cl^-) in Dadin Kowa dam

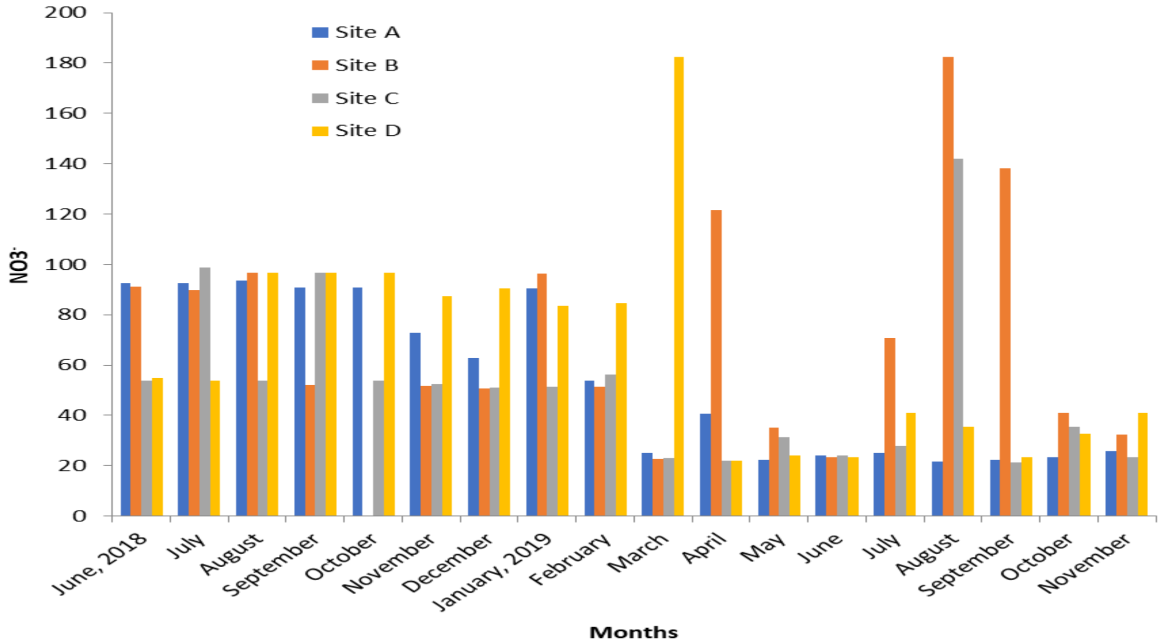

Fig. 9: Concentration of nitrate (NO_3^-) in Dadin Kowa dam

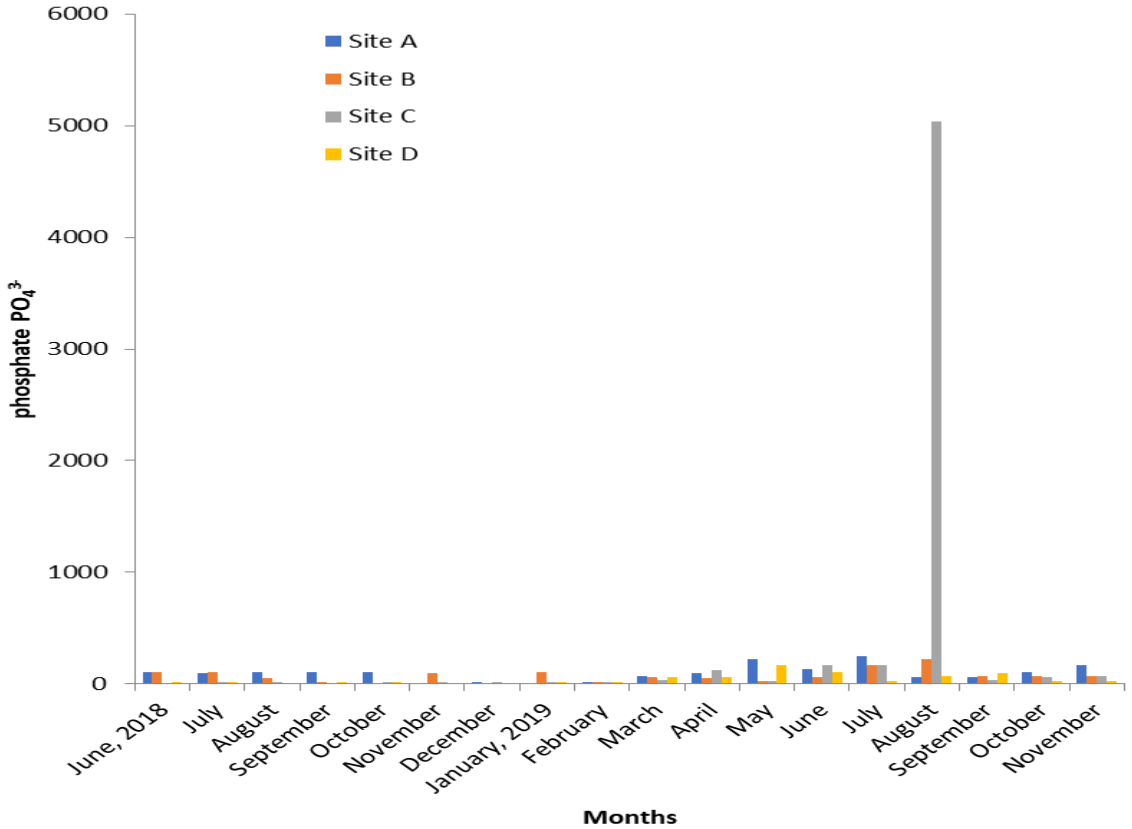

Fig. 10: Concentration of phosphate (PO_4^{3-}) in Dadin Kowa dam

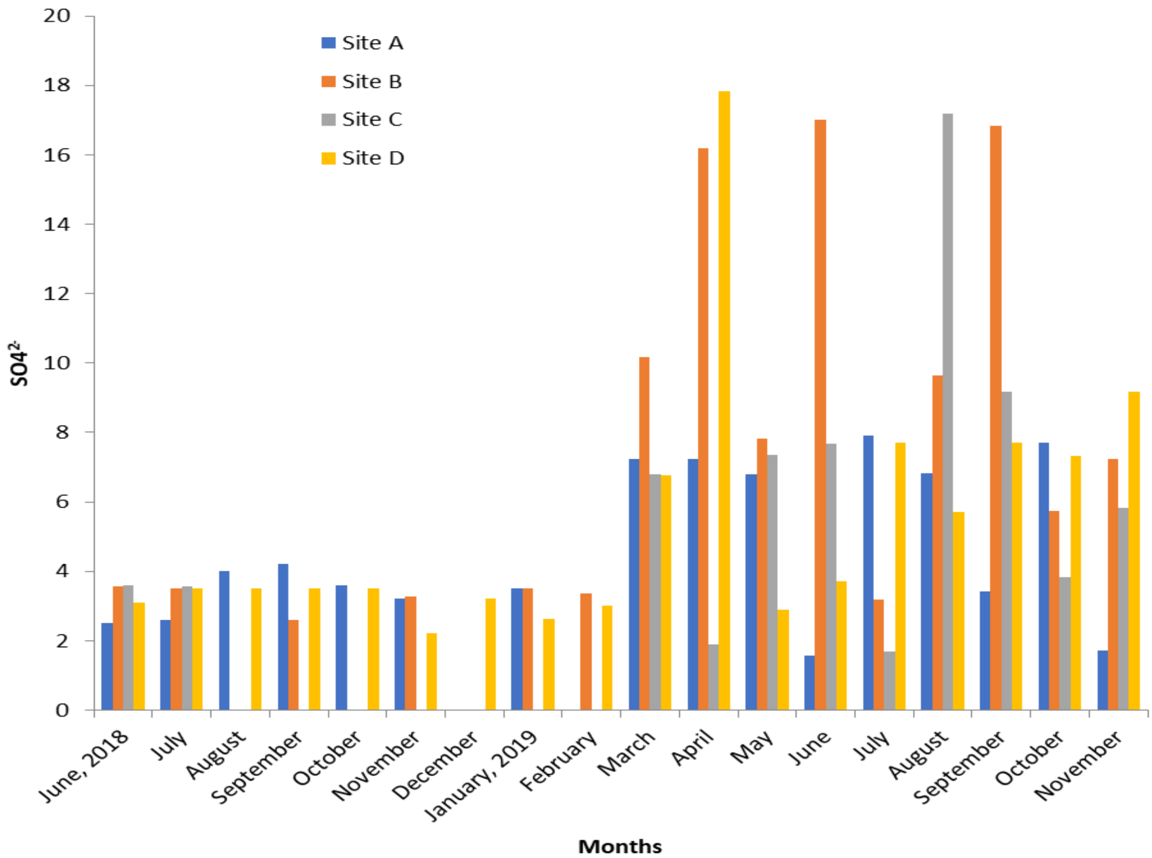

Fig. 11: Concentration of sulphate (SO_4^{2-}) in Dadin Kowa dam

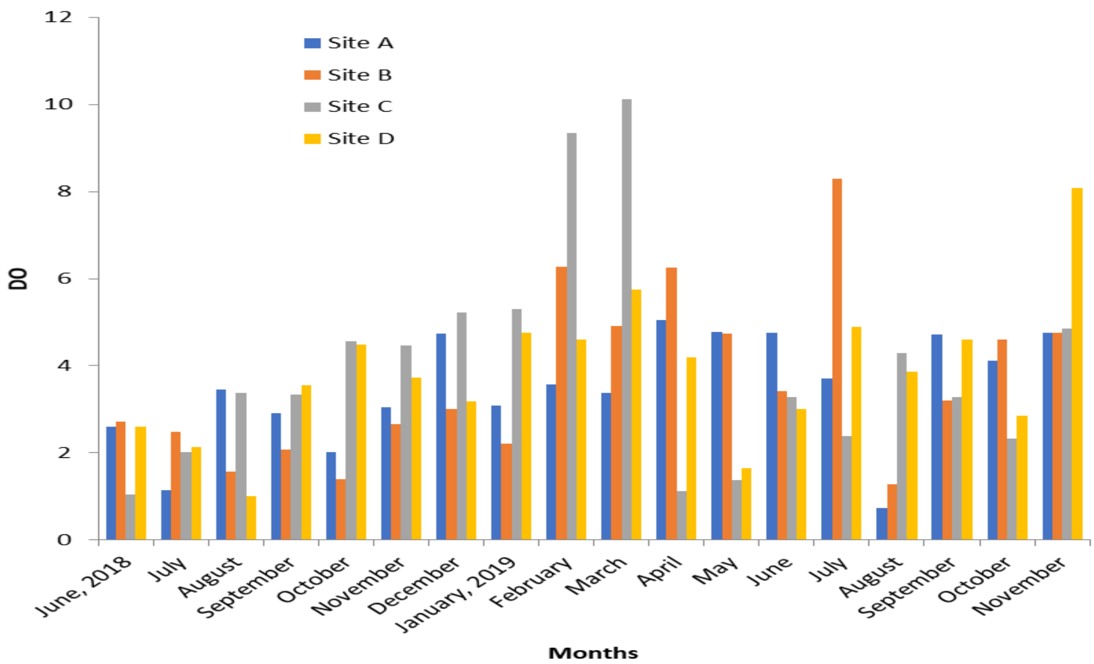

Fig. 12: Concentration of dissolved oxygen (DO) in Dadin Kowa dam.

Discussion

Riparian land use: The riparian activities at the dam might be the reason for the increased pollution of the dam as shown in the present study of some physicochemical parameters of water. A similar observation was made by Norton and Fisher (2000) and Hayakawa *et al.* (2006), who reported that water quality in many water bodies is severely influenced by the non-point source pollution resulting from farmland and residential land, whereas forest and grassland can effectively mitigate water quality degradation. These indices were exhaustively analyzed to assess the impact of riparian land use on Dadin Kowa dam.

Physiochemical parameters of Dadin-Kowa dam: The slight variation in some physiochemical parameters could be a result of the flow variability and changes in watershed conditions. Gwani (Site A) which is the Upper course of the dam, water volume tends to be low at the lower course at Hina (Site D) where the water volume is high due to the addition of water from the tributaries such as Upper Benue River Basin and also catchments activities around the river. These agree with the findings of Ali *et al*. (2002) and Chukwu and Nwankwo (2003) who reported that high variability of water quality may be due to the impact of many factors such as rainfall, surface run-off from farms, tributaries and catchments activities during the wet and dry season periods.

The highest Temperature (26.78 °C) observed in Site A during the dry season might as a result of the dry season as the year advanced towards the dry harmattan period that was severe within December and January. These findings are also in agreement with the findings of Ali *et al*. (2002) who reported low temperatures of 23 °C – 27 °C in all stations within December.

The high electric conductivity of 5 – 7 µs/cm recorded varies with the findings of Zira (2015), who reported electric conductivity of 10.2×10^{-2} to 13.6×10^{-2} during the dry season could be attributed to the neutralization effect of runoff into the reservoir, rainwater, erosion and increase in water volume in the reservoir (Zira, 2015).

The highest pH values observed in this study were not uniform in all the sampling Sites. pH is an important parameter in many ecological studies because there is a strong relationship between pH and the physiology of most aquatic organisms. Low pH creates stress situation in most organisms resulting in a decreased metabolic reaction rate (Ali *et al*., 2002).

Low transparency increases water temperature because suspended particles absorb more heat and this in turn reduces the concentration of Dissolved Oxygen because it reduces the amount of light penetrating the water which reduces photosynthesis as observed in this study. Transparency correlates negatively with temperature Ali *et al.*, (2002).

Carbonate and bicarbonate are the measure of the buffering capacity of Carbonate and bicarbonate values. The higher values of carbonate and bicarbonate observed in the study could be a result of evaporation and high concentration of ions in the water Ali *et al*., (2002).

The mean nitrate value recorded in all the Sites during this study was above the recommended level for aquatic life as suggested by WHO (2015) for drinking water. Nitrate level greater than 1.0 mg/l is not healthy for aquatic life. The highest nitrate could be due to decomposition of organic effluent and waste released into the dam by Ali *et al*. (2002).

The high Phosphate observed in Site C could be attributed to rain-fed and dry-season farming taking place and also due to inorganic fertilizers being washed from nearby farms. Phosphate values obtained during this study were higher than the recommended tolerable range of 1.0 mg/l recommended in a natural aquatic environment by WHO (2015).

Sulphate can enter the freshwater environment through the burning of fossil fuel, smelting of ores, and erupting of volcanoes releasing sulphur oxide which can be transformed into sulphuric acid in the atmosphere. The sulphuric acid precipitates from the atmosphere and then dissociates in the surface water to form a sulphate ion. This can have a deleterious effect on aquatic habitat causing a drop in pH which affects the gills permeability of organisms and influences the speciation and solubility of dissolved metals (WHO, 2015).

The DO in the current study was within the recommended acceptable limit of not less than 5 mg/l (Campbell and Wilberger, 2001).

Conclusion

Most of the physicochemical parameters observed in the Dadin Kowa dam were within recommended values while the water is suitable to support aquatic organisms, particularly fish, allometric growth pattern was observed amongst most fishes in all the studied areas. It is important therefore to regulate the human activities taking place around the dam to improve proper water condition as well as of the aquatic life.

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