



Research Paper

Effects of Seasons on Chemical Water Quality Parameters in Bakolori Reservoir

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Abstract

The study was conducted in Bakolori reservoir. In this study, some chemical water quality parameters of Bakolori reservoir in Zamfara State in north western Nigeria were assessed through standard methods. Water samples were collected once every month and concentrations were determined in the agriculture chemical laboratory of Usmanu Danfodiyo University, Sokoto Nigeria. Data generated were analyzed seasonally and sub-seasonally using analysis of variance (ANOVA). The effects of the season on some chemical parameters recognized in this study were determined. Dissolved oxygen was highest (11.03 ± 1.65 mg/l) in late dry sub-season with overall mean of 9.50 ± 2.10 mg/l. Biological oxygen demand obtained highest value of 18.68 ± 2.87 mg/l in flood sub-season and annual mean of 11.83 ± 5.30 mg/l. The annual mean pH value was 7.67 ± 2.94 . Conductivity was highest (196.35 ± 73.50 μ S/cm) in flood sub-season with annual mean of 128.34 ± 66.49 μ S/cm. The results obtained indicated that seasons affected biological oxygen demand. Conclusively, there was slight pollution by biological oxygen demand, therefore close monitoring of this parameter/element to avoid increase in its concentration was highly recommended.

1. Introduction

Nigeria is the most populous country in Africa with a population of over 200 million (Ekiye & Luo, 2010). It is endowed with water bodies (USAID, 2010). The source of these waters is the natural hydrological cycle which encompasses earth surface and the atmosphere (Ojekunle *et al.*, 2014; Ibrahim *et al.*, 2019). Fresh water bodies such as rivers and reservoirs are for water supply, irrigation and fresh water fish production (Adekole, *et al.*, 2003). The resources in these water bodies are of various kinds. They include fish and some planktons as well as macrophytes. Water bodies show variations in their composition especially between seasons. It increases from lower levels in rainy season to high levels in dry season (Luoto, 2009; Anita & Poojo, 2013).

One of the most important qualities of water that affect it is the temperature. It determines the solubility and concentration of dissolved gases in the water as reported by Mason (2002).

Agricultural, industrial, and urban activities are considered as being major sources of chemicals and nutrients to aquatic ecosystems, while atmospheric deposition could be an important source to certain constituents such as mercury and nitrogen. The concentrations of toxic chemicals and biologically available nutrients in excess can lead to diverse problems such as toxic algal blooms, loss of oxygen, fish kills, loss of biodiversity, and loss of aquatic plant beds and coral-reefs (Vousta *et al.*, 2001). Nutrient enrichment seriously degrades aquatic ecosystems and impairs the use of water for drinking, industry, agriculture, and recreation and for other purposes.

Pollution of the lower Bakolori Reservoir with contaminants such as nutrients, hydrocarbons, pesticides, and heavy metals comes from both point and non-point sources, which are the results of storm water runoff, discharge from ditches and creeks, groundwater seepage, aquatic weed control, naturally occurring organic inputs, and atmospheric deposition.

The degradation of water quality due to these contaminants has resulted in altered species composition and decreased overall health of aquatic communities within the river basin (Campbell et al., 1993; Durell et al., 2001). With increased understanding of the importance of drinking water quality to public health and raw water quality to aquatic life, numerous efforts have been devoted to restoring the health of the people and preventing its further pollution during the last several decades.

To the aquatic organisms, it regulates their behaviors, (activities, feeding, growth) and reproduction. Maushal & Sharma (2001) observed that pH, dissolved oxygen, sewages, anthropogenic, agricultural and industrial activities in addition to dissolved mineral substances in the water bodies adversely affect the biodiversity in the water. Water quality is the physical, chemical and biological factors that influence the beneficial uses of water (Moses, 2018). The quality of water for human and livestock consumption as well as for fish performance depends on three major factors namely physical, chemical and biological factors which interrelate to make the water to have good or bad qualities (Nakashima et al., 2007). They regulate the suitability of water for living organisms (Ita, 1994). The aim of this study is to assess the effects of seasons on some chemical water quality parameters in bakolori reservoir.

2. Materials and Methods

2.1 Study Area

The study was conducted in Bakalori reservoir which is on the elevation of 333m above sea level (Google earth, 2019) on coordinates $12^{\circ} 26' 50''$ N to $12^{\circ} 43' 0''$ N and $06^{\circ} 10' 0''$ E to $6^{\circ} 17' 0''$ in Zamfara State in North-Western Nigeria (Ibrahim & Ogueji, 2017). It was built on Sokoto River, a tributary of Rima River. The construction began in 1974 and ended in 1978 and became impounded with water in 1981. It has a capacity of 450 million cubic metres (Ibrahim & Ogueji, 2017) and 8,000 hectares (Mohammed, 2002; Ibrahim & Ogueji, 2017; Aminu et al 2018). This reservoir was initially designed to supply 30,000 hactres with water. However, due to some technical problems, the scope was reduced to 23,000 hactres. Bakolori reservoir is found within Sokoto River basin area known to have a temperature, rainfall and humidity ranging from 25°C to 32°C , 550mm to 1000mm per annum and 20% to 40% respectively (Gusau et al., 2015; Aminu et al, 2018). Extreme heat is experienced before the rainfall (Gusau et al., 2015; Aminu et al, 2018;). It is fed by River Sokoto and many other tributaries such as Rivers Nkaba and Tarka from Niger republic (Oiganga et al., 2015). It's catchment areas are scarcely populated with the grasses, shrubs and trees. Irrigation, illegal mining and fishing are the major occupations of the people living around the reservoir (Oiganga et al., 2015).

2.2 Sampling Points and Water Sampling

Four sampling points denoted as A, B, C and D were used. Sampling points A and D were located up and down streams of the reservoir respectively. B and C were at the centre. For chemical parameters, three samples from each sampling point were collected and transported to Agriculture Chemical laboratory of Usmanu Danfodiyo University, Sokoto on the same day.

2.3 Concentrations Determination

The concentrations of dissolved oxygen (D.O), biological oxygen demand (BOD), pH and conductivity were determined in the Agriculture Chemical laboratory of Usmanu Danfodiyo University, Sokoto Nigeria following the procedure below:

2.3.1 Dissolved Oxygen

Twelve light 250ml bottles were washed with the water from Bakalori reservoir and filled with water from the same reservoir, then fixed (Stirling, 1985). The samples were taken to the laboratory for D.O. determination on the same day of collection following standard winkler's titration method (Best & Ross, 1977; Boyd, 1984; Udo & Ogunwale, 1986; Sutherland, 2022). In the laboratory, the samples were acidified with concentrated tetraoxosulphate (VI) acid. The prepared samples were poured into conical flask and titrated with sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$) solution. The volume of sodium thiosulphate used (tire value) was noted and taken as the concentration of D. O

2.3.2 Biological Oxygen Demand

Twelve 250ml dark bottles were washed with the water from Bakolori reservoir and filled with water from the same reservoir, then fixed and incubated for 5 days at room temperature. Cleared liquid were decanted and acidified with concentrated tetraoxosulphate (VI) acid (H_2SO_4) and some distilled water to dissolve the precipitate. Titration with 0.025M sodium thiosulphate was conducted as in D.O. determination. The volume of sodium thiosulphate used was noted. BOD_5 is the difference between initial D.O_1 and final D.O_5

B.O.D₅ (mg/l) = $\text{D.O}_1 - \text{D.O}_5$, Where **B.O.D₅ = B.O.D. at 5th day**, DO_1 = Dissolved oxygen at day 1 and D.O_5 = Dissolved oxygen at day 5 (Bennet & Humphries, 1974; Boyd, 1984; Udo & Ogunwale, 1986; Sutherland, 2022).

2.3.3 pH

It was determined in the laboratory using Jenway 3015 pH metre (Delince, 1992; Panday et al., 2005).

2.3.4 Electrical Conductivity

This was measured using a Windaus 3392 conductivity meter (UNEP, 2005).

2.5 Data Analysis

Data was analysed monthly (January to December), seasonally (rainy and dry seasons) and sub-seasonally (early rainy sub season-June and July, flood sub-season-August and September, Early dry sub-season-October, November and December, mid dry sub-season-January and February and late dry sub-season-March, April and May) (NIMA, 2015: Onaji *et al.*, 2005) following analysis of variance (ANOVA) (Steel & Torrie, 1980). The analysis was carried out using Statistical Package for Social Science (SPSS) software. Mean separation was done following Duncan Multiple Range Test (Gomez & Gomez, 1984).

3. Results

The dissolved oxygen (D.O.) concentration was highest in December and lowest in February. Dry season and late dry sub-season obtained the highest value of 10.68 ± 1.35 mg/l (Table 1) and 11.03 ± 1.65 mg/l (Table 1) respectively. However, minimum of 6.41 ± 0.69 mg/l in early rainy sub- season was recorded. The annual mean value was 9.50 ± 2.10 mg/l. (Table 3) The highest values in dry season (10.68 ± 1.35 mg/l) and late dry sub-season (11.03 ± 1.65 mg/l) in Table 2.

Biological oxygen demand (B.O.D.) ranged from 5.38 ± 0.94 mg/l in July to 21.44 ± 0.62 mg/l in March. B.O.D. recorded 18.31 ± 2.08 mg/l in rainy season and 8.60 ± 2.81 mg/l in dry season. The annual mean was 11.83 ± 5.30 mg/l (Table 1). Sub-seasonal mean values ranged from lowest (7.42 ± 3.27 mg/l) in early dry sub- season to highest concentration of 18.68 ± 2.87 mg/l in flood sub- season (Table 2). The lowest value (7.42 ± 3.27 mg/l) (Table 4) in early dry sub-season may be attributed to increase in biological reactions in the reservoir as a result of increase in the water temperature during the dry season while highest value may be due to influx of organic inputs and high rate of decomposition of these materials in the water body. B.O.D. concentration increased gradually and significantly from the lowest value (7.42 ± 3.27 mg/l) in early dry sub-season to peak (18.68 ± 2.87 mg/l) in flood sub-season.

The pH ranged from lowest value (acidic) in January to highest one (alkaline/basic) in July. 8.35 ± 9.39 was the mean for rainy season. 7.35 ± 0.23 was the mean for dry season with the annual mean of 7.67 ± 2.94 (Table 1). This indicated that seasonally Bokolori reservoir was slightly alkaline that is more in rainy season. Early rainy sub-season recorded 6.68 ± 0.30 as the lowest sub-seasonal value while early dry sub- season obtained 7.54 ± 0.16 as the highest value (Table 2). This revealed that sub-seasonally, Bokolori reservoir was slightly acidic in early rainy sub-season and basic/alkaline in the other sub-seasons.

The acid condition (6.68 ± 0.30) during early rainy sub-season may be due to influx of run off,

resuspension of sediment that accompanied early rainy

sub- season and decay of both allochthonous and autochthonous organic materials in the reservoir. On the other hand, alkaline/basic condition in the dry sub-seasons could be attributed to significant concentrations of some basic ions in those seasons.

Conductivity ranged from 70.35 ± 6.99 μ S/cm in August to 172.25 ± 47.93 μ S/cm in May. Electrical conductivity was 151.12 ± 69.01 μ S/cm as mean for rainy season and 116.91 ± 64.15 μ S/cm for dry season, 128.34 ± 66.49 μ S/cm was the annual mean (Table 1). The sub-seasonal values for conductivity ranged from 75.64 ± 7.13 μ S/cm in mid dry sub-season to 196.35 ± 73.50 μ S/cm in flood sub-season (Table 2).

The conductivity was seasonally high in rainy season and sub-seasonally in flood sub-seasons. This may be due to influx of solute rich waters containing high concentration of dissolved minerals substances. This showed that Bakolori reservoir contains more electrolytes during high water level and thus more conductive than at low water level.

The conductivity of Bakolori reservoir was lower than the conductivity recorded in Lake Chad (450 μ S/cm) (Adeniyi & Mbagwu, 2021). However, it was high than the conductivity in Osun River (70 μ S/cm) in Nigeria. These mean values obtained in this study were within the water quality standard (100-1500 μ S/cm) favourable for aquatic life (NIS, 2007).

4. Discussion

High temperature in these seasons that may increase the rate of photosynthesis by phytoplankton in the water and the plants in the catchment areas of the reservoir, this agree with the findings of Okayi (2003), Mustapha (2009) and Bala & Bolorunduro (2011). The minimum of 6.41 ± 0.69 mg/l (Table 2) in early rainy sub-season could be attributed to increase in biological oxygen demand owing to high organic load in water during this early rainy sub-season. The concentrations of D.O. in the sub-seasonal values were significantly different in early rainy and late dry sub-seasons. Magami (2011) in Shagari dam and Abubakar *et al.* (2013) in fishing site for AIFCF also recorded maximum D.O. in dry season. The mean value (9.50 ± 2.10 mg/l) was higher than the mean (6.95 mg/l) in Lake Chad. However, it was lower than 13.68 mg/l obtained in Sokoto rima River at fishing site for Argungu International Fishing and Culltural Festival (AIFCF) (Abubakar *et al.*, 2013) in Kebbi State north western Nigeria. These recorded concentrations were in line with the water quality standard favourable for aquatic life.

The annual mean (11.83 ± 5.30 mg/l) obtained in this study was higher than the mean (4.25 mg/l) recorded in Kigera in the middle belt zone of Nigeria (Abohweyere, 2014). It was however similar to 13.68 mg/l obtained in Sokoto rima River at the fishing site for AIFCF in Kebbi State north western Nigeria (Abubakar *et al.*, 2013).

Table 1: Seasonal means of some chemical water quality parameters in Bakolori reservoir

Parameter	Rainy season	Dry season	Annual mean
D.O. (mg/l)	7.16±1.27 ^c	10.68±1.35 ^a	9.50±2.10
B.O.D. (mg/l)	18.31±2.08 ^a	8.60±2.81 ^c	11.83±5.30
Ph	8.33±9.39 ^a	7.35±0.23 ^a	7.67±2.94
Conductivity(uS/cm)	151.12±69.01 ^a	116.91±64.15 ^a	128.34±66.49

Table 2: Sub-seasonal means of some chemical water quality parameters in Bakolori reservoir

Parameter	Sub-season				
	Early rainy	Flood	Early dry	Mid dry	Late dry
D.O. (mg/l)	6.41±0.69 ^a	7.90±1.28 ^b	10.80±1.30 ^d	9.96±0.24 ^c	11.03±1.65 ^d
B.O.D. (mg/l)	17.93±0.60 ^c	18.68±2.87 ^c	7.42±3.27 ^a	9.14±2.79 ^b	9.42±1.83 ^b
pH	6.68±0.30 ^a	7.28±0.11 ^c	7.54±0.16 ^d	7.15±0.09 ^b	7.28±0.22 ^c
Cond (uS/cm)	105.90±7.89 ^b	196.35±73.50 ^c	102.96±88.00 ^a	75.64±7.13 ^a	103.39±17.39 ^a

According to Wetzel (2001) which stated that water body with BOD equal to or greater than 10 mg/l is polluted., looking at the July mean (21.44 ± 0.62 mg/l), rainy season mean (18.31±2.08), flood sub-season mean (18.68 ±2.87 mg/l) and year mean (11.83 ± 5.30 mg/l) this indicated that Bakolori reservoir was polluted during the study period. The level of BOD in Bakolori reservoir was above the optimum B.O.D. requirement of 10 mg/l for fish production in natural water bodies in the tropics. Therefore, there was pollution due to BOD during this period. The pH of Bakolori reservoir varied significantly among sub-seasons. The means pH value obtained in this reservoir were within the optimum requirement (6.5- 8.0) for fish production in the tropical fresh water bodies (Delince, 1992).

5. Conclusion

Base on the findings it was concluded that B.O.D. was affected by rainy season, early rainy and flood sub-seasons. However, other chemical parameters considered in this study were not affected by the seasons. They were in line with water quality standard favorable for aquatic life.

6. Statements and Declarations

Ethical Approval: Not Applicable

Conflict of Interest: The authors declare that there are no conflicts of interest regarding the publication of this study.

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