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Research Article

Physicochemical Parameters of Sabke Reservoir, Katsina State, Nigeria

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ABSTRACT

Reservoirs, as critical water resources, serve diverse purposes such as irrigation, fisheries, and domestic water supply. This study evaluates the physicochemical parameters of Sabke Reservoir in Katsina State, Nigeria, with focusing on understanding their ecological impact and pollution status. The research, conducted between June and November 2024, analysed parameters such as temperature, pH, turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD), total dissolved solids (TDS), and conductivity across three sampling stations (upstream, middle, and downstream). Measurements were taken following APHA standards and subjected to statistical analysis using ANOVA and the Duncan Multiple Range Test at a 95% confidence interval. Results revealed significant seasonal and spatial variations in the reservoir's physicochemical parameters. Temperature ranged from 27.96°C to 30.00°C, with higher values observed during October. Turbidity peaked at 55.83 NTU in November, exceeding WHO permissible limits and reflecting sedimentation and runoff impacts. pH values remained neutral to slightly acidic (6.32–6.89), suitable for aquatic organisms. DO concentrations (5.09–5.63 mg/L) were stable but slightly below WHO recommendations for aquatic life. TDS values (319.3–397.3 mg/L) exceeded permissible limits, correlating strongly with conductivity ($r=0.617$, $p<0.01$), indicating increased ionic concentrations. The study underscores the influence of seasonal changes and anthropogenic activities on water quality. High turbidity and TDS levels pose potential risks to aquatic biodiversity and ecosystem functionality. These findings are consistent with studies across Nigeria and other tropical regions, emphasizing the need for integrated management strategies to mitigate pollution and sustain the ecological health of reservoirs.

Keywords: Physicochemical parameters; Sabke Reservoir; Water quality; Aquatic ecosystems; Seasonal variations; Pollution management

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INTRODUCTION

Reservoirs (Artificial and natural lakes) store water from tributaries such as rivers, streams, brooks and waterways, and this stored water is capable of going through numerous chemical and physical alterations that can change the quality of the fish environment within the water body (Khatri and Tyagi, 2015). Reservoirs constitute important ecosystem and food resources for a diverse array of aquatic life. Reservoir ecosystems are fragile and can undergo rapid environmental changes, often leading to significant declines in their aesthetic, recreational and aquatic ecosystem functions (Lawal *et al.*, 2020). The freshwater environs, including rivers, lakes, ponds, dams, reservoirs as well as streams, face pressures from numerous physicochemical parameters/factors. These factors, comprising pressure, dissolved oxygen, and temperature, in addition to pH, can significantly influence the fauna and flora, fluctuating their richness, diversity, and distribution (Auta *et al.*, 2023; Ibrahim *et al.*, 2023). Freshwater is amongst the most significant endowments of nature to mankind as well as it plays

extremely vital roles in existence and meeting daily needs of man (Sadauki *et al.*, 2022a). Water, a vital environmental resource, plays an important role in supporting natural life in addition to satisfying day-to-day human beings wants, ranging from domestic water supply to industrialized usages (Sadauki *et al.*, 2022a; Ibrahim *et al.*, 2023). Corresponding to Jenyo-Oni *et al.* (2010) and Sadauki *et al.* (2022a), it is a massive environmental resource of communal and economic aid. It has been over the years used for home water supply, industrialized water needs, hydroelectric power supply, fishing activities, and dry farming of farmlands among others (Keshere *et al.*, 2017; Sadauki *et al.*, 2022a). Nigeria is blessed with plentiful water resources ranging from watercourses, streams, rivers, reservoirs and dams. Intensive attempts/efforts have also been made in the country to block rivers and streams to have reservoirs (manmade reservoirs) to meet human being demands for water and its resources. Katsina State is among the states with the highest number of artificial reservoirs in the nation with about 40 reservoirs (Dauda e*t al.*, 2015; Sadauki *et al.*, 2022a). Sabke Reservoir in Maiadua Local Government Area of Katsina State is one of the most important in the State. Water organisms need balanced environments with adequate nutrients for development and survival. According to Neha *et al.* (2013; Sadauki *et al.*, 2022a), the productivity of water is affected by the physicochemical qualities of the water bodies, therefore a requirement for steady inspection of water quality parameters. Jenyo-Oni *et al.* (2010) and Sadauki *et al.* (2022a), noticed that water quality parameters comprise all the chemical, physical and biological factors that impact the advantageous usage of water to man as well as other living organisms. The significant physicochemical parameters are pH, dissolved oxygen, temperature, hardness, alkalinity, nitrite, nitrate and ammonia-nitrogen (Ahmad *et al*., 2016; Sadauki *et al.*, 2022a), in addition to these are more frequently considered in surveys on water quality assessment. Numerous studies have stated water quality parameters of water bodies in Nigeria, a small number of among them are Olanrewaju *et al.* (2017) on Eleyele Reservoir, Southwest Nigeria, Lawal and Ahmed (2014) on Daberam Reservoir, Katsina State, Nigeria, Hassan *et al*. (2014) on lower River Ogun wetlands and Apollos *et al.* (2016) on Zobe Reservoir, Katsina State. On the other hand, as human activities near water bodies are continuously ongoing, appraisal of the quality level of water bodies should be a continuous effort. Sabke Reservoir is used for their water resource, irrigation of farmlands and fisheries activities among others. The basins are currently under the pressure of dumping of untreated waste, sewage, and runoff from the agricultural fields. The study consequently evaluates the physicochemical parameters of Sabke Reservoir in Katsina State, Nigeria with an opinion to understand the pollution status of the freshwater body.

MATERIALS AND METHODS

Study Area

The survey area is Sabke reservoir which is situated at latitude 12°57' 30" – 13°5' North and longitude 8°11' 00" – 8° 14' 00" East at 451 meters above sea level and 35km northwest of Daura, Katsina State (Bala and Abdullahi, 2011; Suleiman, and Rabi'u, 2024). The reservoir was stored with the blocking of two main seasonal rivers namely Bulbula at the eastern bank and Babbar Ruga at the western bank in Mai'adua and Mashi Local Government Areas respectively (Bala &Abdullahi, 2011; Suleiman & Rabi'u, 2024). The rivers are supported by minor streams in both LGAs, including spillovers from the nearby Daberam dam in the Daura and Dutsi LGAs. The reservoir has an active storage capability of 31.60 million cubic meters of water and a flood storage capacity of 56 million cubic meters (Suleiman & Rabi'u, 2024). The reservoir land use under dry season farming was proposed at 1,000 hectares with surface lift as the type of irrigation system (Zango & Rafindadi, 2015; Suleiman & Rabi'u, 2024). The crops grown are mostly vegetables with fishing occupations (activities) and home purposes being other uses of the reservoir (Suleiman & Rabi'u, 2024).

Water sampling location/procedures

Three sample locations were selected for this study within Sabke Reservoir. Station A was located at the upstream of the reservoirs, station B was located at the middle area of the reservoirs and station C was located at the downstream of the reservoir. Water samples were collected from three sampling stations between the hours of 8:00 am to 12:00 pm, for a period of 6 months (June to November 2024).

Determination of Physicochemical Parameters.

The water physicochemical parameters of water samples were analysed, including; temperature, turbidity, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), total dissolved solids (TDS) and conductivity using the methods described by Sadauki *et al.* (2022a) and Sadauki *et al.* (2022b). All the procedures followed the standard methods (APHA, 2012).

Data Analysis

Data obtained are presented in tables. Results were summarised using descriptive analysis and data were subjected to One-Way Analysis of variance (ANOVA) to test for differences in means and Duncan Multiple Range Test (DMRT) was done for separation of means of physicochemical parameters with months and stations of sample at p=0.05, 95% confidence interval.

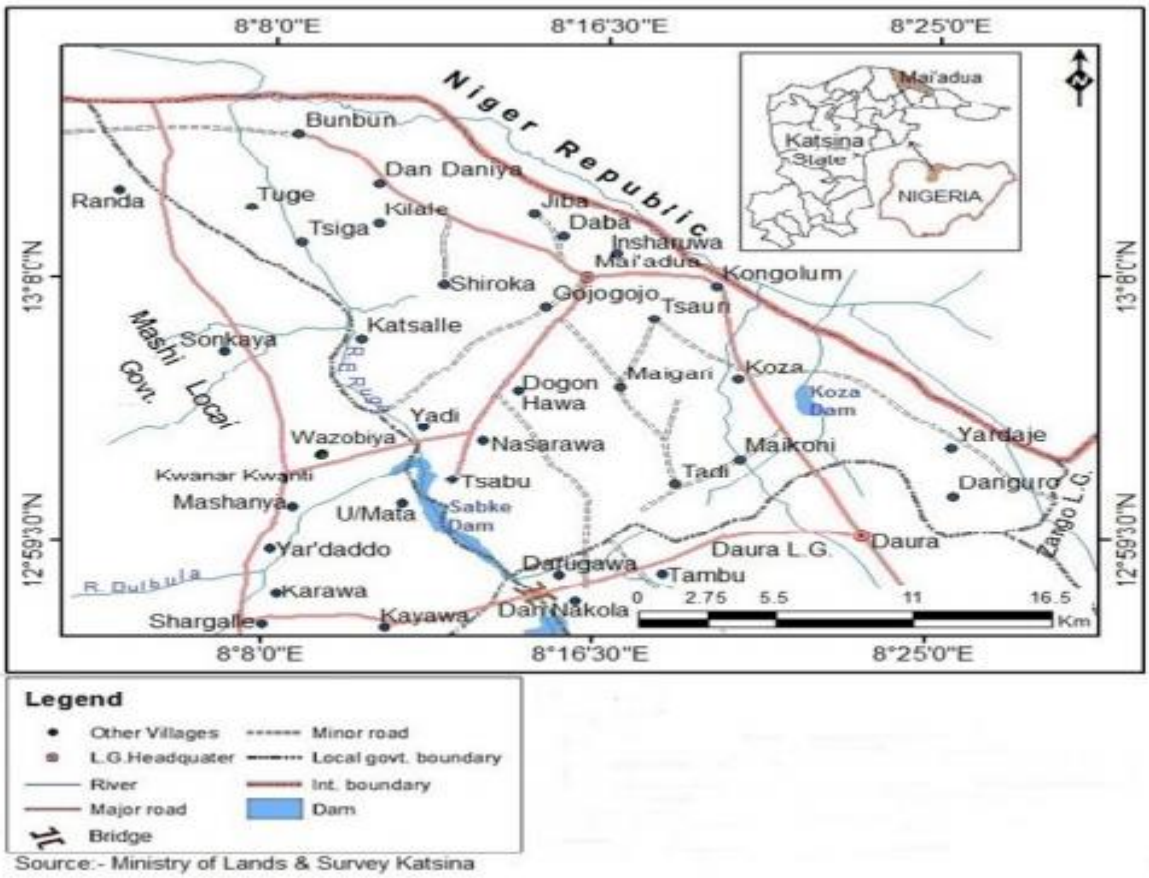

Figure 1. Showing the map of Sabke Reservoir

RESULTS

The study of physicochemical parameters in the Sabke Reservoir provides critical insights into the environmental quality and its influence on aquatic ecosystems. The parameters assessed include temperature, turbidity, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), total dissolved solids (TDS), and conductivity. These variables reveal both temporal and spatial variations, alongside their correlations, reflecting the reservoir's ecological dynamics. Table 1 provides a summary of the physicochemical parameters of the Sabke Reservoir, Katsina State, which includes the mean values, standard deviations (S.D.), and the range values (minimum and maximum) for each parameter.

Temporal Variations in Physicochemical Parameters

From Table 2, the temperature ranged between 27.96°C and 30.00°C across the months, with significant variations (p=0.00). The highest temperature was observed in October, likely due to seasonal effects such as reduced cloud cover or increased solar radiation. Elevated water temperatures can influence metabolic rates and DO levels, underscoring their importance in aquatic ecology. Turbidity levels exhibited significant monthly variations (p=0.00), peaking in November (54.08 NTU). This could be attributed to sediment runoff or reduced vegetation cover during the dry season. High turbidity reduces light penetration, impacting primary productivity and potentially stressing aquatic organisms.

The pH ranged from 6.32 to 6.89, with no significant variations (p=0.12). These values align with the neutral range suitable for most aquatic organisms. However, fluctuations could influence chemical reactions and nutrient availability within the ecosystem. DO concentrations remained relatively stable across months (5.09–5.63 mg/L) with no significant differences (p=0.79). This consistency suggests a balance between oxygen production (via photosynthesis) and consumption (via respiration and organic matter decomposition).

Spatial Variations in Physicochemical Parameters

The spatial analysis (Table 3) revealed that Station C had the highest turbidity (55.83 NTU, p=0.00) and temperature (29.26°C, p=0.01). This station may experience greater anthropogenic disturbance or receive more sediment runoff compared to other

stations. Conversely, Station A showed lower turbidity (29.78 NTU), indicating relatively clearer water conditions. The pH values (6.55–6.79) and DO concentrations (5.14–5.65 mg/L) were consistent across stations, reflecting minimal localized chemical variability. These findings suggest that the reservoir maintains relatively stable water chemistry despite spatial differences in temperature and turbidity.

Correlation among the Physicochemical Parameters

Correlation analysis (Table 4) highlighted several relationships between parameters. Turbidity showed a moderate positive correlation with TDS (r=0.509, $p<0.01$), indicating that sediment and dissolved solids are linked, likely due to runoff events. Conductivity exhibited a strong positive correlation with TDS (r=0.617, $p<0.01$), consistent with their shared relationship to ionic concentration. DO showed a strong positive correlation with BOD (r=0.698, $p<0.01$), emphasizing the role of biological activity in oxygen dynamics. However, temperature negatively correlated with DO (r= -0.033), highlighting the temperature-dependent solubility of oxygen in water. Such relationships are critical for understanding the reservoir's ecological balance.

Table 1. Physicochemical Parameters of Sabke Reservoir, showing mean, standard deviation (S.D.) and range values

Parameters	Mean±S.D	Range Values	
		Minimum	Maximum
Temperature (°C)	28.90±1.13	26.00	33.40
Turbidity (NTU)	40.47±25.64	6.50	111.00
pH	6.65±0.78	4.00	7.50
Dissolved Oxygen (mg/L)	5.41±1.24	2.20	8.20
BOD (mg/L)	3.00±1.08	1.0	6.00
TDS (mg/L)	37.41±4.29	26.90	44.20
Conductivity (µs/cm)	73.04±11.73	39.20	89.50

Table 2. Mean Monthly Physicochemical Parameters of Sabke Reservoir, Katsina State

Parameter	June	July	August	September	October	November	P-value
Temperature (°C)	29.34±0.63^{a}	28.65±1.23^{b}	27.96±1.07^{c}	29.04±0.76^{ab}	30.00±0.97^{c}	28.44±0.88^{bc}	0.00
Turbidity (NTU)	51.31±37.59^{a}	50.39±33.90^{a}	16.49±6.86^{b}	24.62±2.99^{b}	45.94±12.43^{b}	54.08±0.04^{a}	0.00
pH	6.38±1.14^{ab}	6.69±1.05^{ab}	6.32±0.93^{a}	6.81±0.25^{ab}	6.89±0.27^{b}	6.81±0.30^{ab}	0.12
DO (mg/L)	5.39±1.29	5.61±1.34	5.48±1.27	5.09±1.1.02	5.63±1.32	5.31±1.23	0.79
BOD (mg/L)	2.92±1.14	2.77±1.29	2.96±1.02	2.82±0.98	3.22±1.01	3.29±1.05	0.64
TDS (mg/L)	42.23±1.26^{a}	39.46±0.27^{b}	32.03±1.79^{c}	32.69±1.19^{c}	36.78±3.05	41.23±1.04^{a}	0.00
Conductivity (µs/cm)	85.22±2.88^{a}	65.76±19.07^{b}	64.47±2.50^{b}	66.11±2.17^{b}	73.76±5.62^{c}	82.95±2.25^{a}	0.00

Table 3. Mean Physicochemical Parameters at Sampling Stations of Sabke Reservoir, Katsina State

Parameter	Station A	Station B	Station C	P-value
Temperature (°C)	28.43±0.87^{a}	29.02±1.17^{b}	29.26±1.19^{b}	0.01
Turbidity (NTU)	29.78±19.00^{a}	35.81±15.77^{a}	55.83±31.92^{b}	0.00
pH	6.79±0.42	6.60±0.85	655±0.95	0.39
DO (mg/L)	5.14±1.22	5.65±1.16	5.45±1.30	0.22
BOD (mg/L)	2.95±1.04	3.04±1.20	3.01±1.02	0.94
TDS (mg/L)	37.11±4.20	37.58±4.72	37.53±4.03	0.88
Conductivity (µs/cm)	74.83±8.60	72.00±13.36	72.30±12.78	0.54

Table 4. Correlation Coefficient of Physicochemical Parameters at Sabke Reservoir, Katsina State

	Temperature	Turbidity	pH	DO	BOD	TDS
Turbidity	0.277**					
pH	0.083	- 0.009				
DO	- 0.033	0.149	- 0.074			
BOD	- 0.010	0.103	0.043	0.698**		
TDS	0.108	0.509**	- 0.012	- 0.033	0.024	
Conductivity	0.189*	0.187	0.142	- 0.144	- 0.054	0.617**

*Correlation is significant at the 0.05 level (2-tail)

**Correlation is significant at the 0.01 level (2-tail)

DISCUSSION

The findings from the Sabke Reservoir study provide valuable insights into the physicochemical parameters and their implications for the aquatic environment and ecosystem health. Key parameters assessed include temperature, turbidity, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), total dissolved solids (TDS), and conductivity. These results are discussed below in the context of their ecological implications and compared with findings from other freshwater studies in the tropics.

The temperature ranged from 27.96°C to 30.00°C, with significant monthly variations (p=0.00). Seasonal changes, particularly during the transition from the rainy to dry season, likely influenced these variations. Higher temperatures observed in October align with reduced cloud cover and increased solar radiation during the dry season. Elevated temperatures impact aquatic life by influencing metabolic rates, dissolved oxygen solubility, and biological processes. Similar temperature ranges have been reported in Nigeria's Lower Niger River by Ogbe *et al.* (2020), where seasonal fluctuations mirrored those in this study. In Sokoto River, Raji *et al.* (2015) found comparable ranges of 26.0°C to 31.5°C, attributing variations to climatic and anthropogenic influences. These findings underscore the typical tropical freshwater temperature patterns seen across Nigeria and Africa.

Turbidity values ranged from 29.78 NTU (Station A) to 55.83 NTU (Station C), exceeding the WHO permissible limit of 5 NTU for drinking water. High turbidity values indicate sediment influx and suspended particulate matter, possibly from runoff during the rainy season or anthropogenic activities near the reservoir. Increased turbidity reduces light penetration, negatively affecting primary productivity and fish-feeding efficiency. This aligns with studies by El-Naggar *et al.* (2016), who reported similarly elevated turbidity levels in tropical freshwater systems due to sedimentation. In the Warwade Reservoir in Dutse, Dogara *et al.* (2020) also observed turbidity exceeding WHO limits, which they linked to agricultural runoff and erosion. In Katsina State, Danjuma *et al.* (2023) similarly found high turbidity levels in local reservoirs, highlighting the widespread issue of sediment load in the region.

The pH values ranged from 6.32 to 6.89, indicating slightly acidic to neutral conditions, with no significant variation across stations or months. This range is suitable for most aquatic organisms and is within WHO permissible limits (6.5–8.5). However, slightly acidic pH could result from organic matter decomposition or acidic runoff, especially during the rainy season. Comparable pH values were reported by Sikoki and Anyanwu (2013) in the Niger Delta and Ogolo *et al.* (2017) in the River Niger, reflecting neutral to slightly acidic conditions typical of tropical freshwater ecosystems. These findings suggest that the Sabke Reservoir's pH is within a tolerable range for aquatic life.

DO concentrations ranged between 5.09 mg/L and 5.63 mg/L, with no significant variation (p=0.79). These values, although slightly below the WHO minimum limit of 6 mg/L, indicate sufficient oxygen availability for aquatic life. The observed DO levels likely result from a balance between photosynthetic oxygen production and microbial oxygen consumption during organic matter decomposition. In Sokoto River, Raji *et al.* (2015) reported DO values ranging from 4.8 to 6.2 mg/L, which aligns with the findings of this study. Similarly, Ogbe *et al.* (2020) observed DO levels in the Lower Niger River that were slightly higher but consistent with natural seasonal variations. This highlights the influence of regional and seasonal factors on oxygen dynamics.

Total dissolved solids (TDS) ranged from 319.3 mg/L to 397.3 mg/L, exceeding the WHO permissible limit of 300 mg/L. Higher TDS levels can indicate the presence of dissolved salts and ions, potentially affecting water quality. Conductivity, which ranged from 152.4 µS/cm to 158.3 µS/cm, correlates positively with TDS, as observed in this study ($r=0.617$, $p<0.01$). Elevated TDS and conductivity values may result from agricultural runoff, sedimentation, or leaching of minerals.

Comparable findings were reported in the Kiri Dam, Adamawa State, by Sanu *et al.* (2020), where TDS exceeded permissible limits, highlighting the impact of runoff and evaporation. In Warwade Reservoir, Dogara *et al.* (2020) also found high TDS levels associated with agricultural activities, consistent with this study's findings in Sabke Reservoir.

High turbidity levels significantly correlated with BOD ($r=0.698$, $p<0.01$), indicating that suspended particles likely contain organic matter contributing to oxygen demand. The BOD values reflect the microbial decomposition of organic matter, potentially reducing oxygen availability for aquatic organisms. This pattern is consistent with findings in the River Ogun by Dimowo (2013), where elevated BOD and turbidity were linked to organic pollution. In the Vadeikya Local Government Area of Benue State, Atsuwe *et al.* (2019) similarly reported high BOD in freshwater systems, emphasizing the impact of organic matter on aquatic ecosystems.

The study highlights the ecological challenges faced by the Sabke Reservoir, including high turbidity and TDS levels that could impair water quality and aquatic biodiversity. Elevated turbidity reduces light penetration, affecting photosynthesis, while high TDS and conductivity can stress aquatic life. Seasonal and spatial variations underscore the need for integrated water management strategies to mitigate runoff and

sedimentation impacts. The findings are consistent with similar studies across Nigeria, Africa, and other tropical regions, demonstrating the widespread nature of these issues. Future research should focus on biological indicators and long-term monitoring to better understand ecosystem health and inform management practices.

CONCLUSION

The results underscore the dynamic nature of Sabke Reservoir's water quality, influenced by both seasonal and spatial factors. The significant correlations between parameters highlight the interconnectedness of physical, chemical, and biological processes. These findings provide a baseline for assessing the reservoir's health and guiding sustainable management practices. Further research should explore the biological implications of these physicochemical variations, including their effects on biodiversity and ecosystem productivity.

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