**ASSESSMENT OF WATER QUALITY PARAMETERS OF OWALA DAM**

**Abstract**

Water quality monitoring is crucial for managing freshwater resources as it provides valuable data for local action planning and decision-making. This study assessed the water quality of Owala Dam, Osun State, Nigeria. Water samples were collected monthly from three stations along the Oba-Ile River (Owala Dam) in Olorunda between 2021 and 2024, and analyzed in the laboratory following standard protocols. In-situ measurements included water temperature (mercury-in-glass thermometer, 0–110°C, 0.1°C intervals), pH (Mueel meter), and electrical conductivity (Lovibond meter). Dissolved oxygen (DO) was measured using Winkler’s method, while biochemical oxygen demand (BOD) was calculated via the five-day BOD test. Total dissolved solids (TDS) were determined through filtration and evaporation, sulphate by the turbidimetric method, and chloride using the APHA titration method with potassium dichromate and AgNO₃. Phosphate levels were determined colorimetrically using a spectrophotometer after treatment with ammonium molybdate and stannous chloride.Results showed a slight, statistically insignificant rise in temperature (25.85°C in 2021/2022 to 26.39°C in 2023/2024). pH remained within the acceptable range (6.5–8.5) set by the Nigerian Standard for Drinking Water Quality (NSDWQ) and WHO. TDS remained constant at ~0.57 mg/L. BOD decreased significantly (p = 0.016), while DO levels were high (~66 mg/L), exceeding WHO's minimum of 6 mg/L. Transparency declined significantly (p < 0.05). Electrical conductivity was stable (~0.34 ds/m), below the 1000 ds/m limit. Nitrate (~0.07 mg/L) and phosphate levels were consistently low, and chloride levels (~40 mg/L) were within safe limits. Except for DO, all parameters complied with WHO standards. Continuous monitoring is therefore recommendedin this dam to ensure sustainable water resource management.

**INTRODUCTION**

Water is a crucial resource for human sustenance, agriculture, and industry, ensuring social and economic progress (Taiwo et al., 2012). Despite global access to water, many areas lack safe drinking water and sufficient quantities to meet basic health needs (Shaheed et al., 2014). The World Health Organization (WHO) reports that 1.1 billion people worldwide consume unsafe water, leading to 88% of diarrheal diseases, and the water supply sector faces significant challenges due to climate change and urbanization with the consequences being felt more in the developing countries (WHO, 2011). The United Nations General Assembly has set 2030 as a goal to ensure access to safe, quality water and sanitation for all as a fundamental human right (UNGA, 2018).

Water quality is determined by its physical, chemical, biological, and aesthetic properties, which are influenced by dissolved or suspended constituents and can be influenced by natural processes and human activities (Hubert and Wolkersdorfer, 2015). Consequently, various federal governments and relevant authorities establish national drinking water standards(Patil et al., 2012). They give priority to some qualities while considering others secondary, and these are used to assess the state's water quality. For example, faecal indicator bacteria (FIB), particularly Escherichia coli (*E. coli*) or thermotolerant coliform (TTC), should not be detected in any 100 mL of drinking water sample, according to drinking water quality criteria (WHO, 2011).

Water-related diseases continue to be the leading cause of death among children under the age of five around the world. These issues are most prevalent in poor countries' rural areas. In recent years, efforts by governments and non-governmental organisations to assure water security and safety have failed in many locations due to a lack of sustainability in water supply infrastructures (Tigabu et al., 2013). However, there has been recent progress in tackling this debacle in Nigeria. As part of its efforts to improve water quality monitoring and surveillance, the federal government has established 12 water quality reference laboratories across Nigeria.

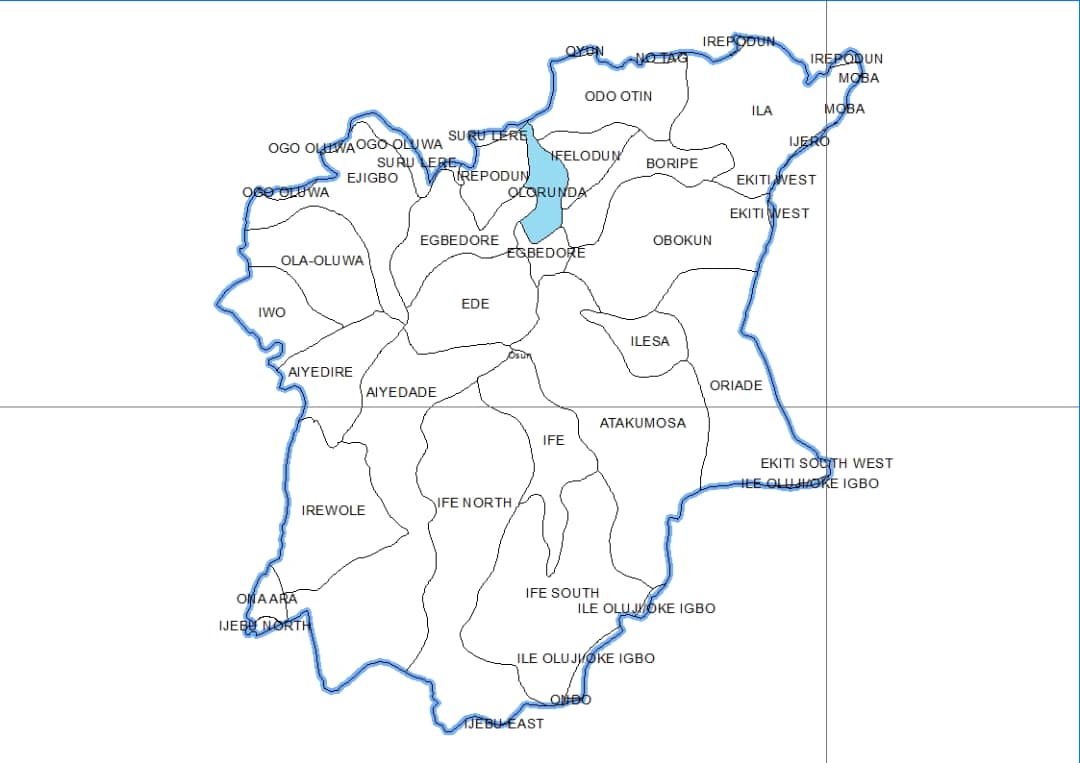
This study was conducted in Erinle River Dam (renamed Owala Dam), in which the dam serves several uses, including water supply, flood control, and fishing. However, a study conducted by Oladejo and Olaleye (2006) in the early 2000s discovered a considerable increase in the prevalence of schistosomiasis, both urinary and intestinal, downstream of the dam. Hence, the need to assess the quality of its water bodies.

**METHODOLOGY**

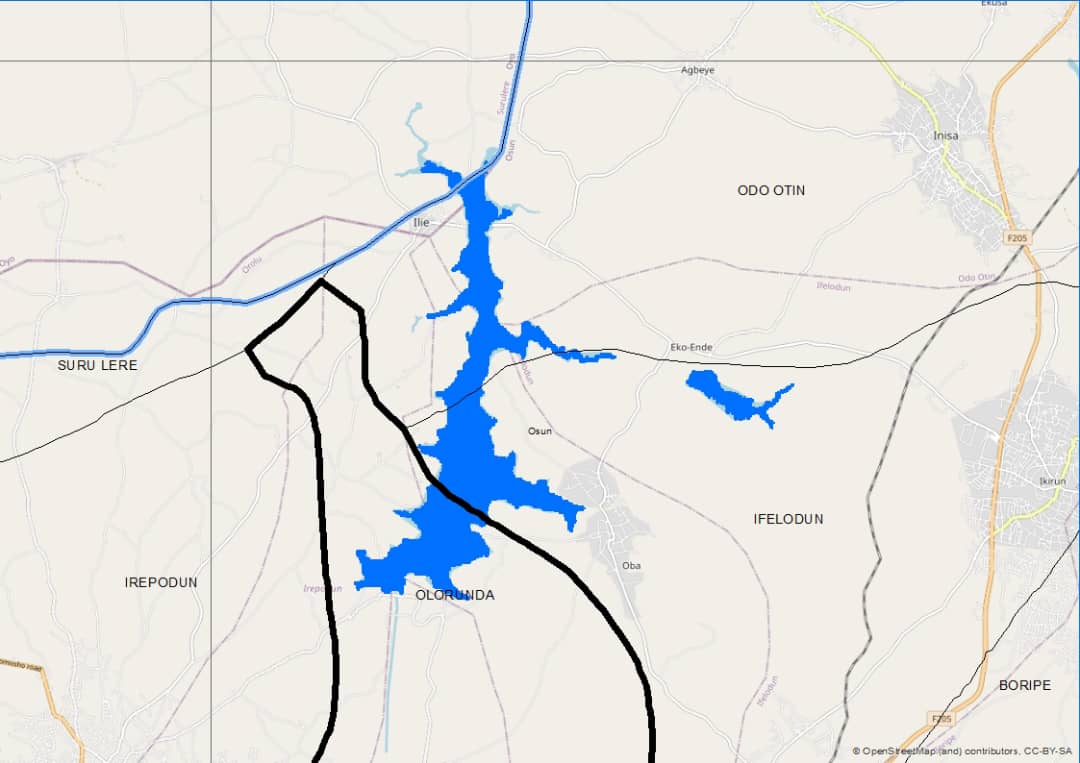
***Study Area***

The study was conducted in Olorunda Local Government Area (LGA), Osun State, Nigeria (Figure 1). The Erinle River Dam (renamed Owala Dam) with latitude 7.75455430N and longitude 4.4500870E (250-450m above mean sea level) is approximately 12 kilometres upstream of Okinni town and is part of the Osogbo-Ede water supply extension system (Figure 2). The enlarged reservoir was constructed to augment the existing water supply system for cities, towns, and rural villages in Osun Central, Osun West, and Ife. The dam's reservoirs span 12 kilometres north along the Erinle River and its Otin River branch, reaching a maximum width of 3.5 kilometres. The reservoir covers around 14 km2 at normal water levels and 15 km2 at high water levels (**Odewumi *et al*., 2019**).

Ekonde Dam is located in Ekonde Town, a rural settlement in Osun State's Ifelodun Local Government Area. The dam is an earth structure that was completed in 1979 and has a capacity of 910,000 cubic meters. The reservoir supplies drinking water to the entire local government. The dam can sustain both commercial fishing and tourism (Odewumi *et al*., 2019). The region is classified as tropical, with an average annual rainfall of around 1400 mm and an eight-month rainy season (April to November).

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**Figure 1. Map showing Osun State**



**Figure 2. Map showing study areas with sampling sites**

***Sample collection***

Water samples were collected from the Oba-Ile River (Owala dam) once a month for three years (October 2021 to October 2024) at 9 a.m. at the researched sites (Owala dam) in Olorunda Local Government Area, Osun State, Nigeria. The water was taken from three separate sampling stations inside the water body: upstream, midstream, and downstream. Two and a half litres of water were collected from the subsurface water with white plastic kegs and immediately transported to the laboratory for physicochemical investigation.

***Physicochemical Analysis***

***Temperature***

The water temperature was measured in the field using a simple mercury-in-glass thermometer (0-1100C) graduated at 0.10C intervals. The thermometer was lowered directly into the water body and when the mercury stabilised at a point, the temperature value was read. Three readings were taken and the average was calculated and recorded as the subsurface water temperature for that site (Bilewu *et al*., 2022).

***Hydrogen Ion Concentration (pH)***

This was determined in situ with a conventional pH meter (Mueel). Readings were acquired by lowering the pH meter's probe into the water sample and recording the value on the meter. This was repeated three times, and the average of the measurements was calculated and recorded as the pH of each site (Patil *et al*., 2012).

**The Dissolved Oxygen (DO)**

The dissolved oxygen was determined in the laboratory by utilising the iodmetric (Winkler’s) method (Clesceri *et al*., 1998). The water samples was collected by utilising the dark coloured 250mL BOD bottles which was fixed in the field by adding 1.0 mL of Wrinkler’s solution (manganese (ii) tetraoxosulphate (vi) and 1.0 mL of Wrinkler’s solution II (Sodium Hydroxide and sodium iodide) using a 2.0 mL pipette. In the laboratory, 20.0 mL of water sample was pipetted into 250mL flat bottom conical flasks, and 0.0125 M standardised disodium trioxosulphate (iv) solution was titrated with 2.0 mL of 1.0% starch solution as an indicator (Bilewu *et al*., 2022). The point at which the blue colour first fades represents the conclusion of each titration.The titration was done three times to obtain the average titre value. The average titre value was used to compute the dissolved oxygen concentration in mg/L using the formula.

Where t = the titre or volume of thiosulphate to be used101.6 = constant

***Biochemical Oxygen Demand(BOD)***

This was calculated by using the five-day BOD test adapted from Bilewu *et al.* (2022). This analysis uses the sample principle and procedure for the dissolved oxygen determination. The difference was that the water sample collected for BOD under the same condition as DO analysis was tightly stopped and incubated in the dark for five days before analysis. The calculated BOD was recorded as the difference between the initial dissolved oxygen determined after five days of incubation. The result was recorded as BOD mg/L of water sample.

***Electrical Conductivity***

This was determined using insitu a model cm-21lovibond conductivity meter. Some of the water samples were poured into different 200 mL beakers. The readings was taken from each of the beakers containing the water samples by lowering the probe of meter into the beakers and allowing it for two minutes for the meter to standardize and the readings taken in s/cm and was recorded (APHA, 1992; Bilewu *et al*., 2022).

***Determination of Total dissolved solid***

The total dissolved solid (TDS) of the surface was determined by filtration and evaporation methods. A filtered sample was evaporated to dryness on a dried dish and on a water bath followed by drying in an oven at 1800C, this dish was cooled in desiccators containing silica gel, weighed again and the increase in weight was recorded this represent the TDS present in the sample (APHA, 1992; Bilewu *et al.*, 2022)

***Determination of Sulphate Content by Turbidimetric Method***

A surface water sample (10 ml) was pipetted into 25 ml volumetric flask and distilled water was added to it to bring the volume to approximately 20 ml. Gelatinous –BaCl2reagent (1 ml) was add and made up to mark with distilled water to form Barium sulphate turbidity. The content was thoroughly mixed and allowed to stand for 30 minutes. The optical density (OD) corresponding to the absorbance of barium sulphate turbidity was measured spectrophotometrically using a HACH DR/2010 portable data logging spectrophotometer at a wavelength of 420 nm. Reading was taken at interval of 30 seconds over a period of 4 minutes and the maximum unit was recorded. A calibration curve was prepared using analytical grade anhydrous potassium sulphate. From the calibration plot, level of sulphate was equivalent to the observed optical densities (absorbance of the test and black solution) which was read off and the level of sulphate in the sample was obtained (Agbozu, 2001; Bilewu *et al.*, 2022).

***Determination of Salinity as Chloride***

The sample (100 ml) was pipetted into 250 ml volumetric flak and 2 drop of potassium dichromate indicator was added and was shaking to mix. The mixture was shaken, after that it was titrated with 0.014N AgNO3 solution to a reddish brown which is indicator end point (APHA, 1992; Bilewu *et al.*, 2022).

***Determination of Phosphate Content***

25 ml of the sample was added to 0.5 ml ammonium molybdate (NH4)6MO7O244H20-40.1g/500ml distilled water and two drop of stannous chloride solution (SnCL22H20-2.5g/100 ml glycerol) was mixed by swirling. A blue colourwas developed within an hour under acidic condition. The intensity of colour was measured using spectrophotometer. The concentration of phosphate was determined as:

Phosphate, =A-B × C

Where A = absorbance of blank sample

B = absorbance of blank sample

C = Volume of slandered phosphate

**Data Analysis**

The data collected were analyzed and expressed as mean and standard error. The mean-difference among sampling sites, years and seasons were then subjected to one-way ANOVA and Duncan Multiple Range Test for comparisons using SPSS 25.

**RESULTS**

***Physicochemical Analysis***

Table 1 presents a comprehensive analysis of various physicochemical parameters of water quality at Owala Dam over three consecutive years (2021-2024). Each parameter is measured with its mean and standard error of the mean (SEM), along with p-values to indicate statistical significance, and compared against regulatory limits set by the Nigerian Standard for Drinking Water Quality (NSDWQ) and the World Health Organization (WHO).

The mean temperature showed a slight increase from 25.85°C in 2021/2022 to 26.39°C in 2023/2024, but this variation was not statistically significant (p>0.05). The temperature remains within the ambient range. The pH values fluctuated slightly, with a notable decrease in 2023/2024 to 6.62, which is still within the acceptable range of 6.5-8.5 for both NSDWQ and WHO. The p-value of 0.051 suggests that this change is approaching statistical significance. Total Dissolved Solids (TDS) remained consistent across the three years at approximately 0.57 mg/L, well below the regulatory limit of 500 mg/L, indicating good water quality regarding dissolved solids. Biological Oxygen Demand (BOD) showed a significant decrease from 150.39 mg/L in 2021/2022 to 143.42 mg/L in 2022/2023, with a p-value of 0.016 indicating statistical significance.

Dissolved Oxygen (DO) levels were relatively high across all years, averaging around 66 mg/L, which is above the minimum requirement of 6 mg/L set by WHO. Transparency decreased significantly from 1.41 m to 1.31 m over the study period with a great significant concern (p< 0.05). Electrical conductivity values remained stable around 0.34 ds/m, well below the regulatory limit of 1000 ds/m. Nitrate levels were consistent at approximately 0.07 mg/L across all years, significantly below the regulatory limit of 50 mg/L. Phosphate levels showed minor fluctuations but remained low and without significant concern. Chloride levels were stable around 40 mg/L, which is acceptable as it is below the WHO limit of 250 mg/L.

Table 2 presents the spatial and temporal variations in water quality parameters at Owala Dam across three different sites (Site A, Site B, Site C) over three consecutive years (2021-2024). The average temperature across the three sites showed minor fluctuations over the years, with values ranging from 25.53°C to 26.78°C. The p-values indicate no significant differences in temperature either spatially or temporally.

pH levels ranged from 6.55 to 7.11 across sites and years, remaining within acceptable limits for aquatic life. The p-values (0.919, 0.635, 0.807) suggest that there are no significant differences in pH levels among sites or over time. TDS values were consistent, ranging from 0.54 to 0.59 mg/L across all sites and years, well below the regulatory limit of 500 mg/L. The p-values indicate no significant spatial or temporal variations. BOD showed a significant decrease at Site B from 147.50 mg/L in 2022/2023 to 143.58 mg/L in the same year (p<0.05), although overall comparisons across sites did not show significant differences. DO levels varied slightly among sites, with averages between 62.39 mg/L and 68.88 mg/L, consistently above the WHO minimum requirement of 6 mg/L for aquatic life support. The p-values reflect no significant differences over time or between sites.

Transparency measurements showed significant spatial and temporal variation, particularly between years with p-values of 0.005 and 0.000 for the last two years indicating increasing clarity at Site C over time compared to Sites A and B. Conductivity values remained stable across all sites and years (ranging from 0.32 to 0.37 ds/m), with p-values indicating no significant differences (p>0.05). Nitrate levels were low and consistent across all sites and years (ranging from 0.05 to 0.09 mg/L), with no significant differences indicated by p-values (p>0.05). Phosphate levels varied slightly but showed significant changes over time at Site B with a p-value of 0.035 between years indicating a decline in phosphate levels. Chloride levels were stable across all sites and years but showed a near-significant trend at Site B in the second year with a p-value of 0.051.

Table 3 summarizes the seasonal variations in various water quality parameters at Owala Dam across two distinct seasons (dry and rainy) over three consecutive years (2021-2024).

The temperature was significantly higher during the dry season compared to the rainy season across all years, with p-values of 0.000 indicating a strong statistical significance. For example, in 2021/2022, the temperature was 27.24°C in the dry season versus 24.47°C in the rainy season. pH levels were significantly lower during the dry season compared to the rainy season in the first two years (p = 0.000 for 2021/2022 and p = 0.008 for 2022/2023). However, in 2023/2024, the p-value of 0.155 indicates no significant difference between seasons. Total Dissolved Solids was significantly higher during the rainy season in 2021/2022 (p = 0.000) and showed a notable increase in 2023/2024 with a p-value of 0.014.

Biological Oxygen Demand levels were significantly higher during the rainy season across all years (p = 0.000), with values reaching up to 157.89 mg/L in the rainy season of 2021/2022. Dissolved Oxygen levels were significantly lower in the dry season compared to the rainy season for all years analyzed (p = 0.000). Transparency did not show significant differences between seasons in most years, except for a significant difference in 2023/2024 (p = 0.010). Electrical conductivity was significantly higher during the rainy season across all years (p = 0.005 for 2021/2022, p = 0.000 for both subsequent years).

Nitrate levels showed no significant differences between dry and rainy seasons in earlier years (p>0.05) but had a significant difference in 2023/2024 (p = 0.047). Phosphate levels were significantly higher during the rainy season across all years analyzed (p = 0.013 for 2021/2022, p = 0.001 for 2022/2023, and p = 0.013 for 2023/2024). Chloride concentrations were generally higher during the rainy season, particularly significant in the second year (p = 0.001) and third year (p = 0.000).

The monthly variations of physicochemical parameters for Owala Dam over three consecutive years (2021/2022, 2022/2023, and 2023/2024) are presented in figures 3 to 12.

November consistently starts with stable temperatures (26.90°C in 2021 and 2023).March records peak dry-season temperatures (28.73°C in 2021/2022), followed by slight drops in April. Lowest values occur during the peak rainy season (July–August), particularly in 2021/2022. The year 2023/2024 has slightly elevated temperatures in August and September compared to previous years. pH values fluctuate between slightly acidic to neutral during the dry season and increase slightly (more alkaline) during the wet season. March 2022/2023 recorded the highest pH (7.60). A notable drop in 2023/2024 occurs in July (6.33) and August (6.37). Values stabilize in September and October near neutral pH 7.0.

Highest dissolved solids values are consistently recorded in April (0.79 mg/L in 2021/2022).A gradual increase is observed in September–October 2023/2024 compared to earlier years. Biochemical oxygen demand peaks in the wet season (July–September). August records the highest BOD each year, with 171.33 mg/L in 2021/2022 and slightly lower values in 2022/2023 and 2023/2024.February–March shows stable but high BOD across years. Rising BOD values was recorded in September 2023/2024. Dissolved Oxygen peaks in the wet season (July–September). Highest DO observed in July–August 2021/2022 (78.17 mg/L and 78.07 mg/L).DO declines in April–May, particularly in 2023/2024 (e.g., 56.60 mg/L in April).September–October values recover slightly across all years.

Highest transparency is recorded in August 2021/2022 (1.60 m) but declines in subsequent years. November and December consistently show clearer water (1.37–1.43 m). September and October 2023/2024 show higher electrical conductivity values (0.64–0.71 mS/cm). March records minor fluctuations, with 0.63 mS/cm in 2022/2023.Highest nitrate (NO₃) values are recorded in August–October across years, with peaks at 0.06 mg/L. June and July show minimal concentrations (0.03–0.04 mg/L).August and September show stable phosphate (PO₄)values (0.37–0.45 mg/L) across years. March 2021/2022 records the highest phosphate (0.44 mg/L). A steady increase in Chloride levels was noted in September–October 2023/2024 (49.28 mg/L).Lowest values occur in December 2021/2022 (30.08 mg/L).

**Table 1: Physico-chemical Analysis of Water Quality Parameters of Owala Dam across Three Consecutive Years (2021–2024) with Regulatory Limits**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| PARAMETERS | 2021/2022 | 2022/2023 | 2023/2024 | P-VALUE | Regulatory Limits | |
| Mean±SEM | Mean±SEM | Mean±SEM | **NSDWQ (2017)** | **WHO (2011)** |
| Temperature | 25.85±0.30 | 26.02±0.21 | 26.39±0.22 | 0.301 | Ambient | - |
| Ph | 6.93±0.14 | 6.98±0.10 | 6.62±0.10 | 0.051\* | 6.5-8.5 | 6.5-8.5 |
| Total Dissolved Solids (mg/L) | 0.57±0.03 | 0.57±0.01 | 0.56±0.02 | 0.930 | 500 | 500 |
| Biological Oxygen Demand (mg/L) | 150.39±2.20 | 143.42±1.32 | 146.03±1.44 | 0.016\* | 250 | 10 |
| Dissolved Oxygen (mg/L) | 66.33±1.38 | 64.15±1.15 | 64.23±1.18 | 0.373 | - | 6 |
| Transparency (m) | 1.41±0.02 | 1.31±0.02 | 1.38±0.02 | 0.007\* | - | - |
| Electrical Conductivity (ds/m) | 0.35±0.01 | 0.33±0.01 | 0.34±0.01 | 0.519 | 1000 | 25 |
| Nitrate (mg/L) | 0.07±0.02 | 0.07±0.02 | 0.07±0.02 | 1.000 | 50 | 50 |
| Phosphate | 0.35±0.01 | 0.33±0.01 | 0.34±0.01 | 0.172 | - | 0.05 |
| Chloride (mg/L) | 39.11±1.10 | 40.79±0.74 | 40.80±1.11 | 0.391 | - | 250 |

**Table 2: Spatial and Temporal Variations in Water Quality Parameters of Owala Dam across Three Sites Over Three Consecutive Years (2021–2024)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PARAMETERS | 2021/2022 | | |  | 2022/2023 | | |  | 2023/2024 | | |  |
| **Site A** | **Site B** | **Site C** | **P-VALUE** | **Site A** | **Site B** | **Site C** | **P-VALUE** | **Site A** | **Site B** | **Site C** | **P-VALUE** |
| Temperature | 25.99±0.53 | 26.04±0.47 | 25.53±0.58 | 0.751 | 26.15±0.40 | 26.47±0.33 | 25.44±0.31 | 0.122 | 26.78±0.41 | 26.63±0.33 | 25.76±0.38 | 0.134 |
| Ph | 6.90±0.23 | 6.88±0.22 | 7.01±0.28 | 0.919 | 6.96±0.16 | 6.88±0.14 | 7.11±0.20 | 0.635 | 6.60±0.18 | 6.55±0.17 | 6.71±0.17 | 0.807 |
| Total Dissolved Solids (mg/L) | 0.56±0.05 | 0.56±0.04 | 0.59±0.05 | 0.923 | 0.56±0.01 | 0.54±0.02 | 0.59±0.02 | 0.139 | 0.57±0.03 | 0.54±0.03 | 0.58±0.02 | 0.639 |
| Biological Oxygen Demand (mg/L) | 154.75±3.82 | 150.75±3.93 | 145.67±3.50 | 0.245 | 147.50±2.12 | 143.58±2.10 | 139.17±2.13 | 0.031 | 149.17±2.62 | 146.25±2.36 | 142.67±2.34 | 0.186 |
| Dissolved Oxygen (mg/L) | 64.60±2.37 | 65.52±2.16 | 68.88±2.62 | 0.421 | 62.39±1.97 | 64.12±1.56 | 65.94±2.39 | 0.465 | 62.94±2.09 | 64.16±1.80 | 65.58±2.34 | 0.673 |
| Transparency (m) | 1.41±0.04 | 1.36±0.03 | 1.45±0.05 | 0.284 | 1.24±0.03 | 1.29±0.03 | 1.41±0.05 | 0.005 | 1.30±0.03 | 1.38±0.02 | 1.47±0.03 | 0.000 |
| Electrical Conductivity (ds/m) | 0.37±0.01 | 0.34±0.02 | 0.33±0.02 | 0.296 | 0.36±0.02 | 0.33±0.01 | 0.32±0.02 | 0.297 | 0.36±0.02 | 0.34±0.02 | 0.32±0.02 | 0.386 |
| Nitrate (mg/L) | 0.05±0.00 | 0.09±0.04 | 0.08±0.03 | 0.616 | 0.05±0.00 | 0.09±0.04 | 0.08±0.03 | 0.687 | 0.05±0.00 | 0.08±0.04 | 0.08±0.03 | 0.669 |
| Phosphate | 0.38±0.02 | 0.35±0.02 | 0.34±0.02 | 0.25 | 0.36±0.01 | 0.33±0.02 | 0.29±0.02 | 0.035 | 0.38±0.02 | 0.33±0.01 | 0.31±0.01 | 0.006 |
| Chloride (mg/L) | 40.28±1.92 | 40.32±1.52 | 36.74±2.16 | 0.318 | 42.77±1.33 | 41.13±1.30 | 38.47±0.93 | 0.051 | 43.13±2.18 | 40.26±2.09 | 39.03±1.38 | 0.313 |

**Table 3: Seasonal Variations in Water Quality Parameters of Owala Dam across Three Consecutive Years (2021–2024)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameters | 2021/2022 | |  | 2022/2023 | |  | 2023/2024 | |  |
| **Dry Season** | **Rainy Season** | **P-Value** | **Dry Season** | **Rainy Season** | **P-Value** | **Dry Season** | **Rainy Season** | **P-Value** |
| Temperature | 27.24±0.35 | 24.47±0.14 | 0.000 | 26.72±0.26 | 25.32±0.24 | 0.000 | 27.41±0.18 | 25.37±0.22 | 0.000 |
| pH | 6.31±0.15 | 7.55±0.09 | 0.000 | 6.73±0.14 | 7.23±0.10 | 0.008 | 6.48±0.17 | 6.76±0.09 | 0.155 |
| Total Dissolved Solids (mg/L) | 0.47±0.04 | 0.67±0.01 | 0.000 | 0.56±0.02 | 0.57±0.01 | 0.953 | 0.52±0.02 | 0.60±0.02 | 0.014 |
| Biological Oxygen Demand (mg/L) | 142.89±1.83 | 157.89±3.15 | 0.000 | 138.50±1.12 | 148.33±1.75 | 0.000 | 140.00±1.12 | 152.06±1.74 | 0.000 |
| Dissolved Oxygen (mg/L) | 60.46±1.44 | 72.21±1.29 | 0.000 | 58.98±1.04 | 69.32±1.10 | 0.000 | 57.98±0.67 | 70.47±0.86 | 0.000 |
| Transparency (m) | 1.44±0.02 | 1.38±0.04 | 0.164 | 1.32±0.03 | 1.30±0.03 | 0.7 | 1.43±0.02 | 1.34±0.02 | 0.010 |
| Electrical Conductivity (ds/m) | 0.32±0.01 | 0.38±0.01 | 0.005 | 0.30±0.01 | 0.37±0.01 | 0.000 | 0.30±0.01 | 0.37±0.01 | 0.000 |
| Nitrate (mg/L) | 0.04±0.00 | 0.10±0.03 | 0.107 | 0.04±0.00 | 0.10±0.03 | 0.061 | 0.04±0.00 | 0.10±0.03 | 0.047 |
| Phosphate | 0.33±0.02 | 0.38±0.01 | 0.013 | 0.29±0.02 | 0.36±0.01 | 0.001 | 0.32±0.01 | 0.36±0.01 | 0.013 |
| Chloride (mg/L) | 37.64±1.80 | 40.59±1.20 | 0.182 | 38.49±0.94 | 43.09±0.86 | 0.001 | 36.80±1.59 | 44.81±0.82 | 0.000 |

**Figure 3: Monthly Variations in Temperature of Owala Dam across Three Consecutive Years (2021–2024)**

**Figure 4: Monthly Variations in pH Values of Owala Dam across Three Consecutive Years (2021–2024)**

**Figure 5: Monthly Variations in Total Dissolved Solids of Owala Dam across Three Consecutive Years (2021–2024)**

**Figure 6: Monthly Variations in Biological Oxygen Demand Levels of Owala Dam across Three Consecutive Years (2021–2024)**

**Figure 7: Monthly Variations in Dissolved Oxygen Levels of Owala Dam across Three Consecutive Years (2021–2024)**

**Figure 8: Monthly Variations in Transparency Values of Owala Dam across Three Consecutive Years (2021–2024)**

**Figure 9: Monthly Variations in Electrical Conductivity Values of Owala Dam across Three Consecutive Years (2021–2024)**

**Figure 10: Monthly Variations in Nitrate Levels of Owala Dam across Three Consecutive Years (2021–2024)**

**Figure 11: Monthly Variations in Phosphate Levels of Owala Dam across Three Consecutive Years (2021–2024)**

**Figure 12: Monthly Variations in Chloride Levels of Owala Dam across Three Consecutive Years (2021–2024)**

**DISCUSSIONS**

***Yearly Variations***

The yearly mean temperature's slight increase suggests seasonal or environmental variations rather than anthropogenic effects. The temperature change however was not statistically significant, indicating that the temperature remains stable within the ambient range acceptable for aquatic life and human consumption. Comparable studies by Ayoade *et al*. (2022) on Oyan Dam, Nigeria, reported similar non-significant temperature variations over time, affirming the stability of water temperature in tropical climates.

Although, the pH values exhibited slight fluctuations with a notable decrease in 2023/2024, this value is still within the acceptable range of 6.5-8.5 set by both NSDWQ and WHO. The decrease in pH to 6.62 in 2023/2024 indicates a trend toward increased acidity. Ogundele *et al*. (2023) reported similar findings in their study of Ero Dam, where declining pH values were attributed to natural organic load increases. Comparatively, other studies have shown pH levels in similar water bodies fluctuating due to anthropogenic influences, often exceeding recommended limits (Ogunfowokan *et al*., 2021).

The consistent total dissolved solids (TDS) values (~0.57 mg/L) well below the regulatory limit (500 mg/L) suggest minimal anthropogenic contamination and high water quality concerning dissolved solids. This is consistent with Adetola *et al*. (2021), who reported similar TDS stability in Kainji Lake over several years, highlighting effective watershed management practices.

The significant reduction in biological oxygen demand (BOD) across the years suggests improved organic matter decomposition rates or lower pollution levels over time, which is crucial for maintaining aquatic health (Olaniyan *et al*., 2023). In contrast, a related study by Adekunle and Fagbohun (2022) on the Osun River found elevated BOD levels linked to nearby agricultural runoff and untreated sewage discharges, underscoring the impact of land use activities. The observed values, however, exceed the WHO recommended threshold (≤5 mg/L), indicating a critical need for intervention.

The average dissolved oxygen (DO) levels were high across all years, which is well above the WHO minimum requirement of 6 mg/L. High DO levels are indicative of good water quality and support diverse aquatic life (Mogaji *et al*., 2020). This is consistent with a study on the Eleyele Dam (Lawal *et al*., 2023), which reported high DO levels due to frequent aeration from natural and artificial inflows. Other studies have similarly found high DO levels in less polluted freshwater systems, emphasizing their ecological health.

The significant decrease in transparency across the years raises concerns about increased turbidity, potentially from sedimentation or organic load. This decline may suggest increased particulate matter or algal blooms affecting water clarity (Adebayo *et al*., 2019). Such a decline can adversely affect aquatic habitats and photosynthetic activity. Okeke *et al*. (2021) reported a comparable reduction in the Oguta Lake study, where deforestation and soil erosion contributed to increased sediment loads.

The stable electrical conductivity far below the regulatory limit (1000 ds/m) suggests low ionic contamination, corroborating findings by Onyekachi *et al*. (2022) in their study of Ikom River, where low conductivity reflected minimal industrial or agricultural inputs. The consistent nitrate and phosphate levels, both significantly below their respective limits in this study, indicate limited agricultural or industrial runoff into the dam (Akinbile and Yusoff, 2019). These findings agree with Nwankwo *et al*. (2023), who observed low nutrient loads in the Cross River basin, attributed to sustainable agricultural practices in the area.

The stable chloride levels (~40 mg/L) in this study well below the WHO limit (250 mg/L) reflect minimal salinity concerns. Oladimeji and Adebayo (2021) noted similar results in their study of Tiga Dam, where controlled salinity was linked to the absence of industrial effluents. Chloride levels are often used as indicators of salinity and potential contamination; thus, their stability is a positive indicator for water quality at Owala Dam.

***Spatial and Temporal Variations***

The spatial and temporal variations in water quality parameters at Owala Dam reveal important insights into the dam's ecological dynamics.

The minor fluctuations in temperature across sites and years, with no significant differences, suggest stable thermal conditions, which are typical for tropical aquatic systems. Nwachukwu *et al*. (2021) observed similar stability in the Imo River, attributing it to consistent climatic influences and limited thermal pollution. In contrast, some studies have noted greater temperature variability in more polluted water bodies, which can lead to ecological stress (Atobatele and Ugwumba, 2016). For instance, Adeyemi and Bello (2022) noted significant temperature variations in Ogbese River due to industrial discharges, highlighting the role of anthropogenic factors in destabilizing thermal regimes.

The pH levels remained within acceptable limits for aquatic life and regulatory standards, with no significant spatial or temporal differences. These results align with Ekwueme *et al*. (2022), who reported stable pH in Anambra River, primarily due to the natural buffering capacity of the water and minimal agricultural runoff. However, Olawale and Idowu (2021) found significant pH fluctuations in Ogunpa River due to wastewater discharge, underscoring the impact of untreated effluents.

The consistently low TDS values in this study well below the regulatory limit of 500 mg/L indicate good water quality in terms of dissolved solids. The lack of significant spatial or temporal variations in the TDS values reinforces the fact that water quality regarding dissolved solids is stable at Owala Dam. This finding aligns with studies from Osun State that reported similarly low TDS values in borehole water samples (Sule *et al*., 2015). In contrast, higher TDS levels have been observed in areas with significant sand mining activities, highlighting how human activities can influence dissolved solids (Okafor and Uche, 2021).

The significant decrease in BOD at Site B suggests improved organic matter degradation, potentially due to localized hydrodynamic changes or reduced organic pollution. However, overall BOD levels remain high compared to regulatory standards. This trend is consistent with findings by Ibrahim and Yakubu (2022) in Hadejia River, where high BOD levels were attributed to agricultural and urban runoff.

DO levels varied slightly among sites and consistently above the WHO minimum requirement of 6 mg/L. This indicates a well-aerated system supportive of aquatic life. Ajayi and Akinola (2022) in Jabi Lake, where natural aeration processes and minimal pollutant loads contributed to high DO levels, observed similar trends. Conversely, lower DO levels have been associated with eutrophication in heavily polluted waters (Atobatele and Ugwumba, 2016).

The significant spatial and temporal variations in transparency, particularly the increase at Site Covertime compared to Sites A and B, suggest localized reductions in sedimentation or organic input. Enhanced transparency can indicate reduced particulate matter or algal blooms affecting light penetration and photosynthesis in aquatic systems (Abdus-Salam *et al*., 2021). Umar and Yakubu (2023) reported comparable trends in KafinZaki Dam, where transparency improvements were attributed to sediment settling during the dry season. In contrast, other studies have reported decreased transparency in reservoirs experiencing high nutrient loads leading to algal growth (Ehiagbonare and Ogunride, 2010).

Conductivity values remained stable across all sites and years with no significant differences. This stability suggests low ionic concentration in the water and aligns with findings of Musa and Adamu (2021), who reported similar conductivity stability in the Gongola River due to low industrial activity. Higher conductivity values have been linked to increased salinity, pollution from runoff or oil exploration activities (Amadi and Nwogu, 2022).

The low and consistent nitrate levels across all sites and years are indicative of limited nutrient pollution from agricultural runoff or sewage discharges, aligning with findings by Fasakin and Ogunlade (2023) in Osse River. The significant decline in phosphate levels at Site B could reflect reduced agricultural runoff, a trend also observed by Ifeanyi and Okon (2021) in Ase River following improved land management practices. However, Okoro and Nnamani (2022) documented rising phosphate levels in Otamiri River due to extensive fertilizer application.

The stable chloride levels, with a near-significant trend at Site B (*p*=0.051) in the second year, indicate limited salinity concerns. Balogun *et al*. (2022) found comparable results in Yewa River, where chloride stability was attributed to minimal saline intrusion. Chloride is often used as an indicator of salinity and potential contamination; thus, monitoring these levels is essential for assessing water quality trends over time.

**Seasonal Variations**

The temperature was significantly higher during the dry season compared to the rainy season across all years. For instance, in 2021/2022, the temperature recorded was 27.24°C in the dry season versus 24.47°C in the rainy season. This trend is consistent with findings from studies conducted in similar tropical environments, such as the Hathaikheda Reservoir in Bhopal, India, where seasonal temperature variations were also significant, reflecting typical climatic patterns (Dey *et al*., 2023). Higher temperatures during dry seasons can lead to increased evaporation rates and potential impacts on aquatic life due to thermal stress (Olalekan *et al*., 2023).

pH levels were significantly lower during the dry season compared to the rainy season in the first two years. However, in 2023/2024, there is no significant difference between seasons. These findings align with research conducted on water bodies in Osun State, Nigeria, where seasonal pH fluctuations were observed due to varying biological activity and runoff effects during different seasons (Awogbami *et al*., 2024). The lower pH during dry seasons may be attributed to increased organic matter decomposition and reduced dilution from rainfall.

TDS values were significantly higher during the rainy season in 2021/2022 and showed a notable increase in 2023/2024. This observation is consistent with studies from other regions where TDS levels tend to rise during rainy seasons due to increased runoff carrying dissolved substances into water bodies. Elevated TDS can indicate potential pollution sources and may affect aquatic life by altering osmoregulation processes.

Biological Oxygen Demand levels were significantly higher during the rainy season across all years analyzed. This trend is similar to findings from studies on freshwater lakes where increased rainfall led to higher organic matter inputs from runoff, resulting in elevated BOD levels (Anyanwu and Ezema, 2021). High BOD can be detrimental as it indicates lower oxygen availability for aquatic organisms.

Dissolved Oxygen levels were significantly lower in the dry season compared to the rainy season for all years analyzed. This pattern aligns with research indicating that lower water levels and higher temperatures during dry periods can reduce oxygen solubility and availability (**Oyedeji** *et al*., 2023). Conversely, higher DO levels during rainy seasons are often linked to increased turbulence and mixing of water.

Transparency did not show significant differences between seasons in most years except for a significant difference in 2023/2024. This finding contrasts with studies conducted at Hathaikheda Reservoir, where high turbidity was noted during rainy seasons due to increased sediment runoff (Dey *et al*., 2023). The lack of significant variation at Owala Dam suggests stable sediment conditions or effective sedimentation processes.

Electrical conductivity was significantly higher during the rainy season across all years analyzed. This trend is consistent with findings from other studies that report increased conductivity during wet periods due to higher concentrations of dissolved ions from surface runoff (Awogbami *et al*., 2024). Elevated conductivity can indicate potential salinity issues affecting aquatic ecosystems.

Nitrate levels showed no significant differences between dry and rainy seasons in earlier years but had a significant difference in 2023/2024. Phosphate levels were significantly higher during the rainy season across all years analyzed. These findings are consistent with studies indicating that nutrient levels often spike during rainy seasons due to agricultural runoff and urban drainage systems contributing excess nutrients into water bodies (Dey *et al*., 2023).

Chloride concentrations were generally higher during the rainy season, particularly significant in the second year and third year. This trend aligns with research indicating that chloride levels can increase due to storm water runoff containing road salts and other contaminants commonly washed into aquatic systems during rainfall events (Awogbami *et al*., 2024).

***Monthly Variations***

The consistently stable temperatures (26.90°C) in Novemberboth 2021 and 2023 and peak values in March (28.73°C in 2021/2022) align with expected dry-season heat intensification. The lowest values recorded in July–August correspond to the cooling effects of rainfall and reduced solar radiation during the rainy season. These trends are similar to findings at Owena Reservoir, where dry-season temperatures peaked in March and rainy-season cooling was observed (Ajibola and Akinwale, 2022). The slight elevation in temperatures in August–September 2023/2024 may reflect climate variability or anthropogenic influences, as reported by Anyanwu *et al*. (2023) in Nigerian inland waters.

The monthly pH fluctuations from slightly acidic to neutral during the dry season and more alkaline conditions during the rainy season reflect buffering from rainfall and dilution of acidic inputs. Similar patterns were observed in Tiga Dam, where rainy seasons improved water alkalinity (Ibrahim and Adamu, 2022). The pH drop in July–August 2023/2024 is concerning and could be linked to organic matter decomposition, as noted in studies of River Benue (Ogundele and Obasola, 2023).

The consistent peak TDS in April 2021/2022 is likely due to evaporation and the concentration of dissolved minerals during the dry season. The observed increase in TDS during September–October 2023/2024 may reflect agricultural runoff following the onset of rains. A similar seasonal TDS pattern was reported in Ogun River, where runoff during rainy months elevated dissolved solids (Balogun and Adewale, 2022).

The peak BOD levels during the wet season, particularly in August (171.33 mg/L in 2021/2022), indicate increased organic matter input from runoff, consistent with findings in Anambra River (Ekwueme and Udeh, 2022). Rising BOD values in September 2023/2024 highlight potential pollution from agricultural or urban activities, similar to observations in River Niger (Okoro *et al*., 2023).

Dissolved Oxygen levels peaking in July–August 2021/2022 underscore the influence of aeration from rainfall and reduced temperature, which enhances oxygen solubility. Declining DO in April–May, particularly in 2023/2024, aligns with increased microbial activity and oxygen consumption. This trend mirrors findings in the Hadejia-Nguru wetlands (Musa and Adamu, 2022).

Transparency peaks in August 2021/2022 (1.60 m) suggest sediment settling during the wet season, while declines in subsequent years indicate sustained sediment influx. The clearer waters in November and December are consistent with dry-season sedimentation dynamics observed in Lake Chad (Yakubu *et al*., 2022).The elevated EC in September–October 2023/2024 (0.64–0.71 mS/cm) likely reflects increased ion concentrations from agricultural runoff. This pattern aligns with studies in Gongola River, where rainy-season runoff increased ionic conductivity (Anyanwu *et al*., 2023).

Highest nitrate values in August–October (0.06 mg/L) correspond to agricultural runoff, consistent with findings in Otamiri River (Okoro and Nnamani, 2022). The minimal nitrate concentrations in June–July reflect lower fertilizer application rates during planting. Stable phosphate values in August–September across years indicate consistent agricultural inputs. The highest phosphate in March 2021/2022 (0.44 mg/L) could result from residual fertilizer runoff after planting, a pattern also observed in Orashi River (Chukwuma *et al*., 2022).

The rising chloride levels in September–October 2023/2024 (49.28 mg/L) suggest saline intrusion or runoff containing salts, similar to trends in Yewa River (Balogun *et al*., 2022). The lowest values in December 2021/2022 reflect reduced anthropogenic inputs during the dry season.

**CONCLUSION**

The water quality at Owala Dam is generally satisfactory, with consistent dissolved solids, pH, and temperature. Rising BOD and decreasing transparency, however, draw attention to new dangers posed by organic pollution and sedimentation. Seasonal increases in conductivity and nutrients highlight the effects of runoff and land usage. Therefore, it is advised that sources of organic contamination, such as runoff from cities and farms, be monitored.

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