ASSESSMENT OF PHYSICO- CHEMICAL PARAMETERS OF SAFA RESERVOIR KIYAWA, JIGAWA STATE, NIGERIA

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ABSTRACT

This study assessed the physico-chemical parameters of Safa Reservoir, Kiyawa Local Government Area, Jigawa State, Nigeria. Water samples were collected monthly from three sites (A, B, and C) from January to June 2024. Parameters analyzed included temperature, turbidity, electrical conductivity, total dissolved solids (TDS), pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), nitrates, and phosphates. In situ measurements were taken for temperature, pH, DO, turbidity, and conductivity, while BOD, nitrates, and phosphates were analyzed in the laboratory using standard methods. Two-way ANOVA was used to assess variations across sites and months. Results showed significant seasonal and spatial variations in the reservoir's water quality. Temperature varied significantly across months ($p < 0.05$), peaking in April–June, but showed no significant difference among sites ($p > 0.05$). Turbidity, pH, DO, nitrates, and phosphates exhibited significant variations among sites, months, and their interactions ($p < 0.05$). DO was significantly higher in January and March at site A, while nitrate levels peaked in June across all sites. Phosphate was highest in May (sites A and C) and June (site B). However, electrical conductivity, TDS, and BOD showed no significant variations ($p > 0.05$). The correlation analysis revealed significant positive relationships among the physico-chemical parameters of Safa Reservoir. Temperature showed a strong positive correlation with phosphate and BOD. Transparency was positively correlated with TDS and pH, while TDS and nitrate, as well as phosphate and nitrate, also exhibited highly significant positive relationships. Findings highlight seasonal influences on water quality, emphasizing the need for continuous monitoring to ensure ecological sustainability and water usability.

Keywords: Physico-chemical parameters, Reservoir, Safa,

INTRODUCTION

Water is essential for the survival of all living organisms, and it plays an essential role in aquaculture, agriculture, domestic usage, and industrial processes. However, water quality has continued to deteriorate globally due to both natural processes and increasing human activities (UNEP, 2021). The growing global demand for water, driven by rapid population growth, urbanization, and industrialization, has made alternative water sources like shallow wells and reservoirs more commonly utilized (Adimalla *et al.,* 2021). To ensure that water remains safe and sustainable for use, various physico-chemical parameters must fall within specific acceptable limits (Ajibare, 2020).

Water resources are abundant and renewable, but their sustainable use depends on careful management of ecosystems that are becoming increasingly fragile due to anthropogenic pressures. As urbanization and industrialization intensify, managing water quality becomes crucial to prevent degradation (Gupta & Verma, 2022). Physico-chemical parameters like temperature, pH, turbidity, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), nitrates, and phosphates are vital indicators of water quality and are regularly monitored to ensure optimal conditions for aquatic life (Vaddel *et al.,* 2020).

Aquatic ecosystems, particularly fisheries, are heavily influenced by water quality. Pollution from industrial, agricultural, and domestic sources continues to pose significant risks to both marine and freshwater species. These pollutants have led to biodiversity loss, and, consequently, the essential ecosystem services they provide to human societies have been compromised (Li *et al.,* 2021). Protecting freshwater ecosystems is crucial to ensure the sustainable consumption of fish and maintain the livelihoods of communities dependent on these resources (Nash *et al.,* 2022).

In recent years, the importance of science-based fishery management has become increasingly evident as the precise, localized data on freshwater fish populations remain insufficient at both national and global levels (Taylor *et al.,* 2020). Understanding the physico-chemical characteristics of aquatic environments is essential for maintaining fish health, growth, and production. Changes in these parameters can have detrimental effects on aquaculture activities (Niyoyitungiye *et al.,* 2021).

The degradation of water quality can harm aquatic life, and each species of fish has specific water quality requirements for optimal growth and reproduction. Farmed fish, due to their domestication, have shown higher tolerance to fluctuating water conditions than wild fish, but extreme changes in water quality can still make conditions unsuitable for fish farming (Dawood *et al.,* 2020). As aquaculture production increases globally, maintaining appropriate water quality standards is essential to prevent adverse effects on fish health and the productivity of aquaculture systems (Nguyen *et al.,* 2021). Given the increasing pressures on freshwater ecosystems, there is a pressing need for sustainable water management strategies that incorporate scientific data and monitoring of water quality parameters.

MATERIALS AND METHODS

Study area

The study was conducted at Safa reservoir, located on latitude 11°46'51.19"N and longitude 9°35'52.63"E. Safa reservoir serves as a vital resource for the local community, supporting key activities such as fishing and irrigation, contributing significantly to the livelihood and agricultural productivity of the area. Reservoirs, like Safa Reservoir, are increasingly impacted by both natural and anthropogenic activities, which degrade water quality and threaten the sustainability of their natural resources.

Sampling sites

Three (3) sampling sites (A, B and C) with distance of 0.70 km apart were chosen for the study.

Site A: Area near the beginning of the reservoir within the Northwest section, where vegetation and plankton are available.

Site B: The part of the reservoir where most fishing activities mostly take place.

Site C: The area of the reservoir where domestic and other household activities take place.

Sample collection

Samples collection lasted for six (6) months in the morning hours between 7 and 10 am throughout the research period. One-liter containers were used to collect water samples for physico-chemical parameters at each site. The water parameters to be studied were measured in-situ (water temperature, pH, dissolved oxygen, transparency and conductivity) while biochemical oxygen demand, nitrite, and phosphate were analyzed in the laboratory according to American Public Health Association (APHA, 2005).

Measurement of physico-chemical parameters

Temperature: Water temperature was determined using a mercury-in-glass thermometer. Reading was measured, recorded and expressed in °C. By inserting the thermometer in the water to a depth of 5cm for 3 minutes as described by Hira (1966), with an instrument model H198129.

Transparency: Ttransparency was determined in-situ by using secchi- disc. The calibrated secchi- disc was suspended into the reservoir at various stations. The length at which the disc could be seen was noted (L_1) and the length at which the disc could not be seen equally noted (L_2). The average of these two lengths determined and results expressed in meter (APHA, 1999).

pH: The hydrogen ion concentration (pH) of the water was determined using portable pH meter (model pH-012). The pH meter was standardized using prepared buffer solutions of pH 4.00, 7.00 and 9.00. The probe was lowered into the water and readings taken immediately after stabilization of the meter according to ALPHA (2005).

Dissolved oxygen: Portable dissolved oxygen meter (model: ExStik DO600) was used to determine the dissolved oxygen concentration at the different stations. The meter was standardized using prepared buffer solutions. The meter was set at zero point, inserted in the water and readings was taken and recorded.

Electrical Conductivity: Conductivity of the experimental water was routinely monitored and determined at different sites with portable pH/TDS/Conductivity measuring instrument (model: ExStik EC500). The meter was standardized using prepared buffer solutions. The meter was set at zero point, inserted into the water at each site for about 1-2minutes then the readings were recorded immediately the timer stabilizes and it is express in *m2/cm*. (APHA, 1999).

Total dissolved solids (TDS): the total dissolved solids of the water were determined at each site with portable pH/TDS/Conductivity measuring instrument (model: ExStik EC500). The meter was standardized using prepared buffer solutions. The meter was set at zero point, lowered into the reservoir and reading was taken immediately the timer stabilizes (APHA, 1999).

Biological Oxygen Demand (BOD): the BOD was determined with exactly 200ml of water sample which was poured into a 200ml standard BOD sample bottle and covered carefully to exude air bubbles. The sample bottle was wrapped in a black sheet and was kept in an incubator for 5 days. After 5 days in incubator, the bottle was brought out and 2ml of $MnSO_4$ was added followed by 2 ml alkaline iodide azide reagent. The bottle was stoppered carefully to exude air bubbles, and then mixed thoroughly by inverting the bottle several times, the precipitate was allowed to settle leaving clear supernatant after which 2 ml of Conc. H_2SO_4 was added. The bottle was stoppered and mixed with gentle inversion. 100ml of the prepared solution was transferred into a conical flask, and 2ml of freshly prepared starch indicator was added. The solution was titrated with 0.0125N of sodium thiosulphate solution until disappearance of the blue color. BOD was then calculated using the formula: $(BOD)_5$ in mg/l = $DO_1 - DO_2$ (APHA, 1999). Where DO_1 is initial dissolve oxygen, DO_1 is dissolve oxygen after 5 days

Nitrate-Nitrogen (NO_3): NO_3 of the water was determined with Exactly 100 ml of water sample was poured into a clean dry metallic crucible, and kept in an oven at 100^0C till evaporated to dryness, it was then removed and allowed to cool after which 2ml of phenoldisulphonic acid was added and swirled round uniformly in the crucible, it was left to stand for 10minutes and 10ml of distilled water was added followed by 5ml strong ammonia solution and allowed to cool. Color change was read at the wave length

430nm using calorimeter instrument (APHA 1999).

Phosphate (PO_4): phosphate was obtained from exactly 100 ml of water sample which was transferred into a conical flask, 1ml of Ammonium molybdate reagent was added and 1 drop of stannous chloride, then allowed to stand for 12 minutes, colour changes was read at 600nm using calorimeter instrument (APHA 1999).

Statistical analysis

Physico-chemical parameters were analyzed using two-way analysis of variance (ANOVA) to determine the effect and interaction effect of the sampling site and month. Charts were made using GraphPad Prism 9.

RESULTS

Physico chemical parameters of Safa Reservoir

The temperature readings of Safa reservoir is presented in Figure 1. The results shows that there is no significant difference in the temperature of site A, B, and C ($p > 0.05$). However, the temperature significantly varies between the months studied ($p < 0.05$) while the interaction between months and sampling sites was significantly different ($p < 0.05$). Highest significant temperature values were obtained in the months of April, May, and June respectively in all the study sites.

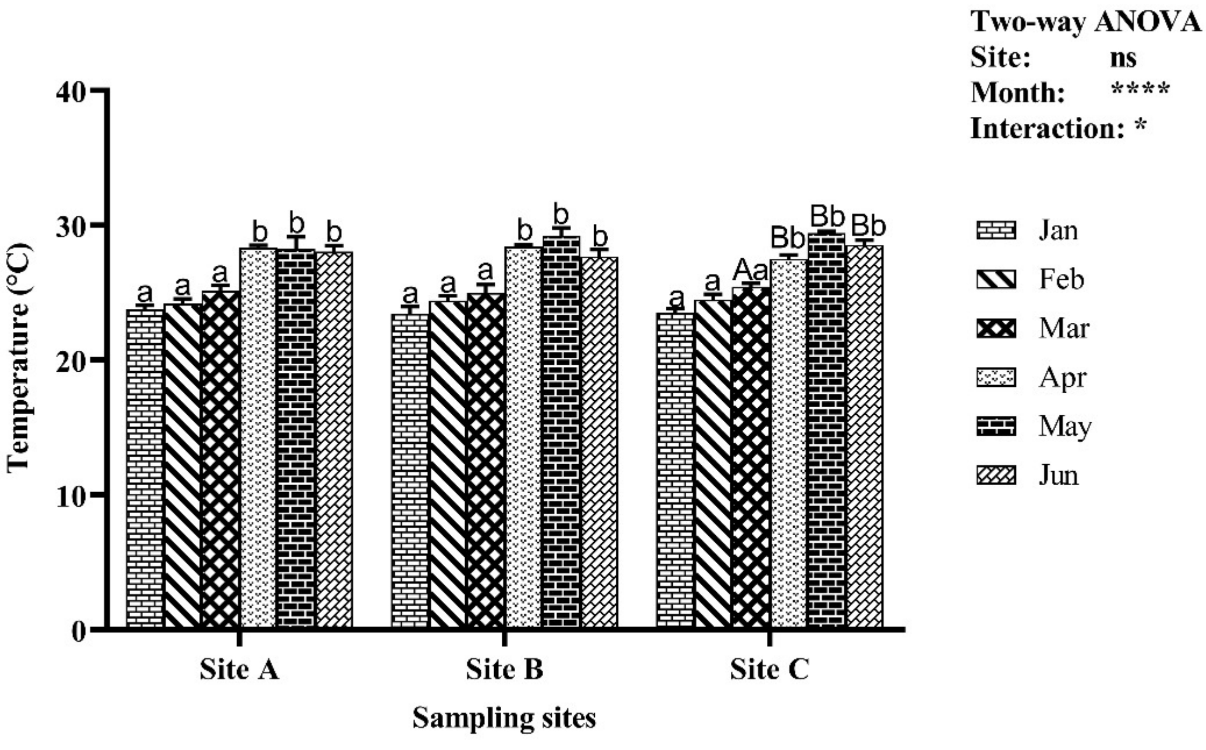

Figure 1: Temperature of Safa reservoir

The turbidity readings of Safa reservoir is presented in Figure 2. The results shows that significant differences existed among the sampling sites, months and their interaction respectively ($p < 0.05$). The lowest turbidity value was recorded in May in site A and B respectively while in site C, the lowest turbidity value was recorded in April.

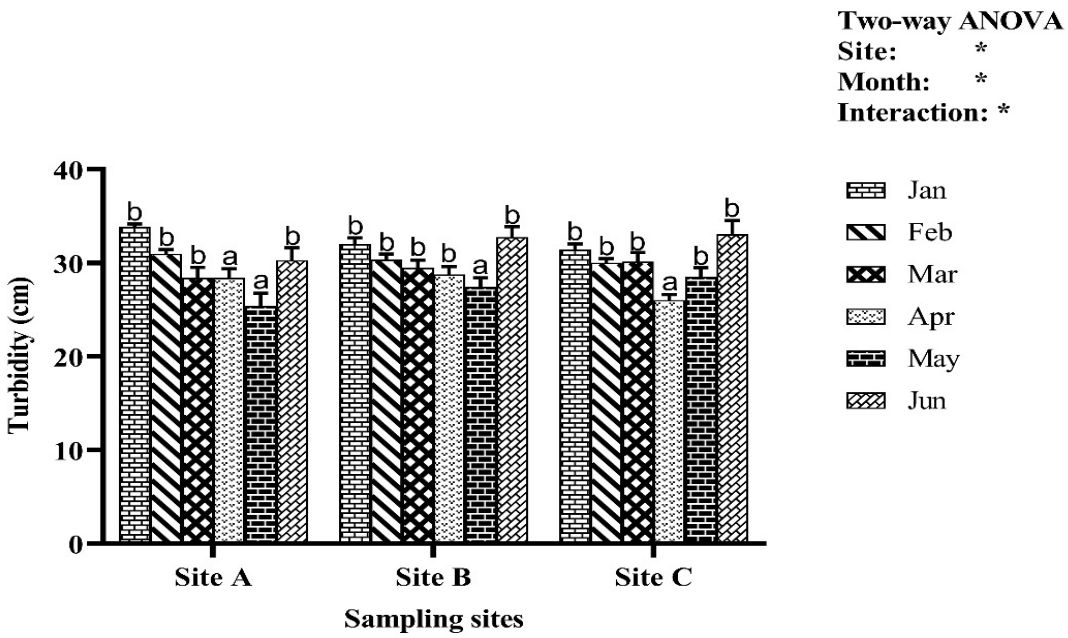

Figure 2: Turbidity of Safa reservoir

The pH of Safa reservoir is presented in Figure 3. The results shows that significant differences existed among the sampling sites, months and their interaction respectively ($p < 0.05$). Significantly highest pH values were recorded in January, February, May and June for site A and B respectively ($p < 0.05$), while in Site C, pH was highest in January and June.

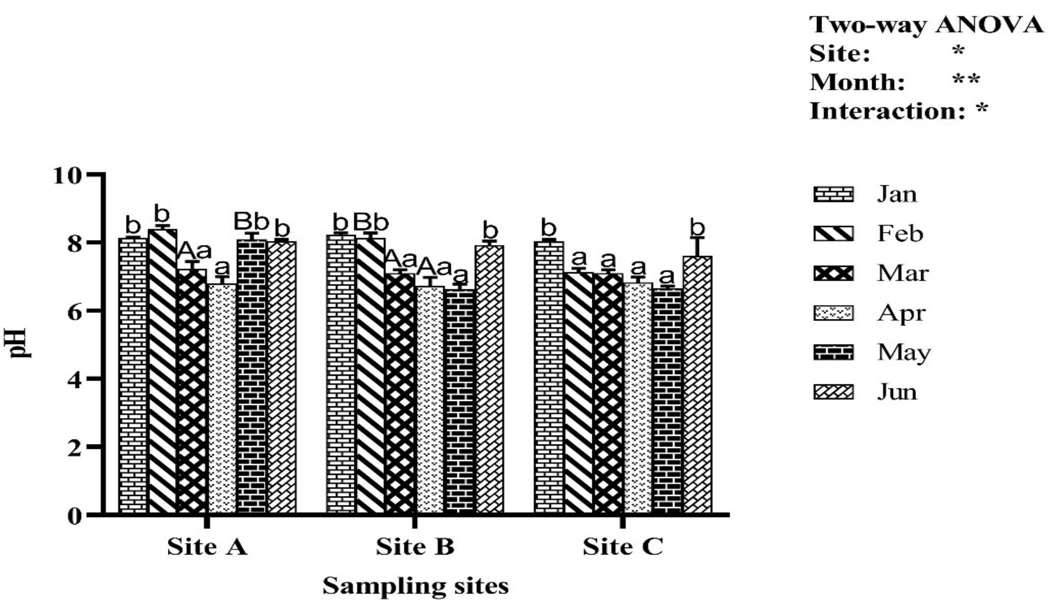

Figure 3: pH of Safa reservoir

The dissolved oxygen concentration of Safa reservoir is presented in Figure 4. The results shows that there were significant differences in the sampling sites, months and their interaction respectively ($p < 0.05$). However, there was no significant difference ($p > 0.05$) in the dissolved oxygen level of site B and C in all the months studied. For site A, dissolved oxygen levels were significantly higher ($p < 0.05$) in January and March respectively compared with other months.

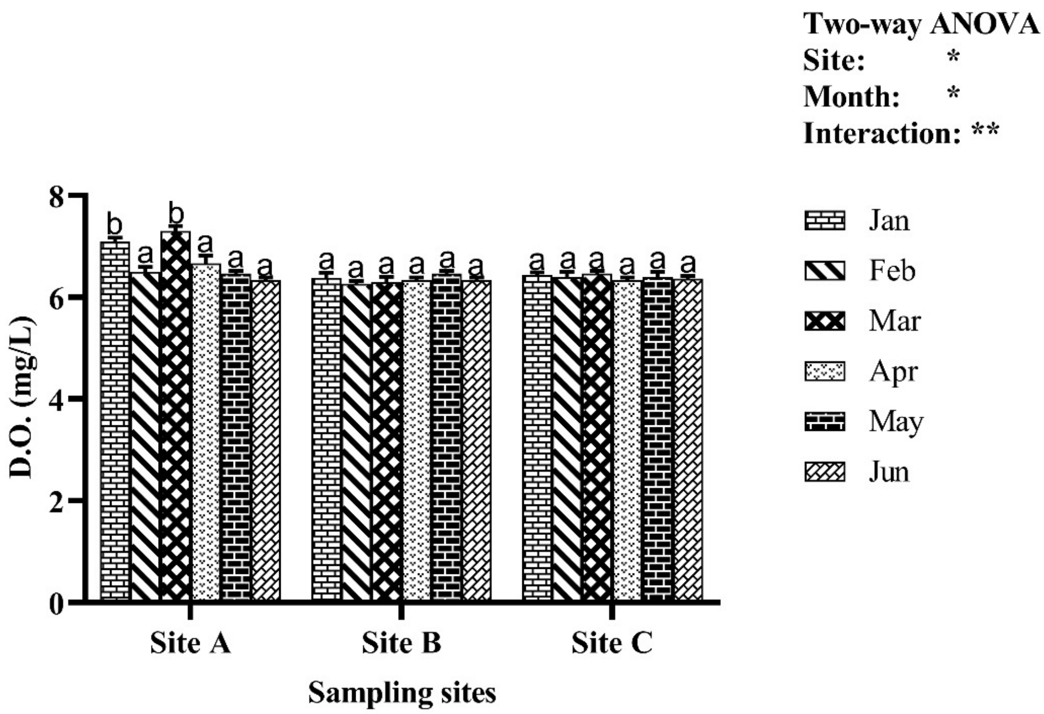

Figure 4: D.O. concentration of Safa reservoir

The electrical conductivity of Safa reservoir is presented in Figure 5. The results shows that there was no significant difference in the sampling sites, months and their interaction respectively ($p > 0.05$).

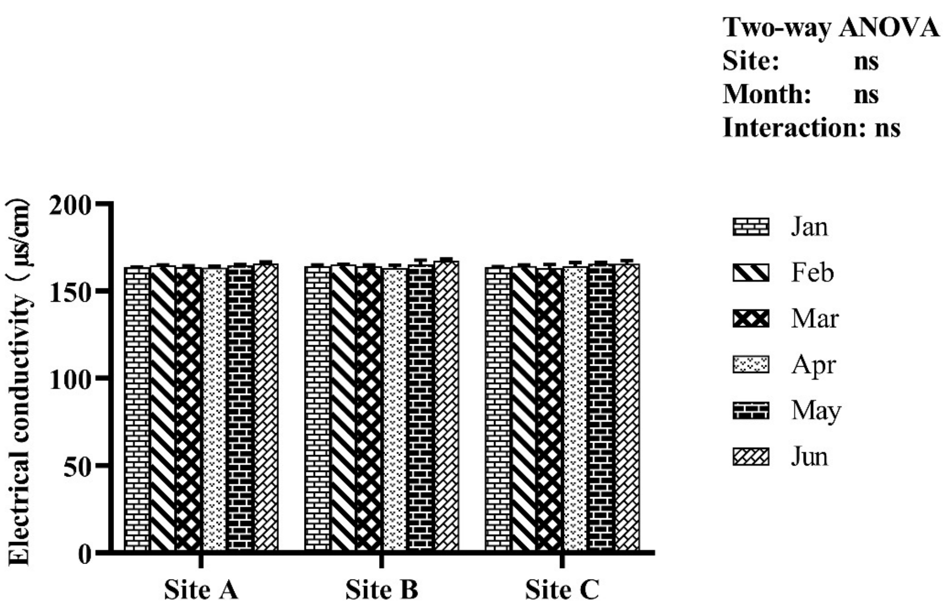

Figure 5: Electrical conductivity of Safa reservoir

The total dissolved solids of Safa reservoir is presented in Figure 6. The results shows that there was no significant difference in the sampling sites, months and their interaction respectively ($p > 0.05$).

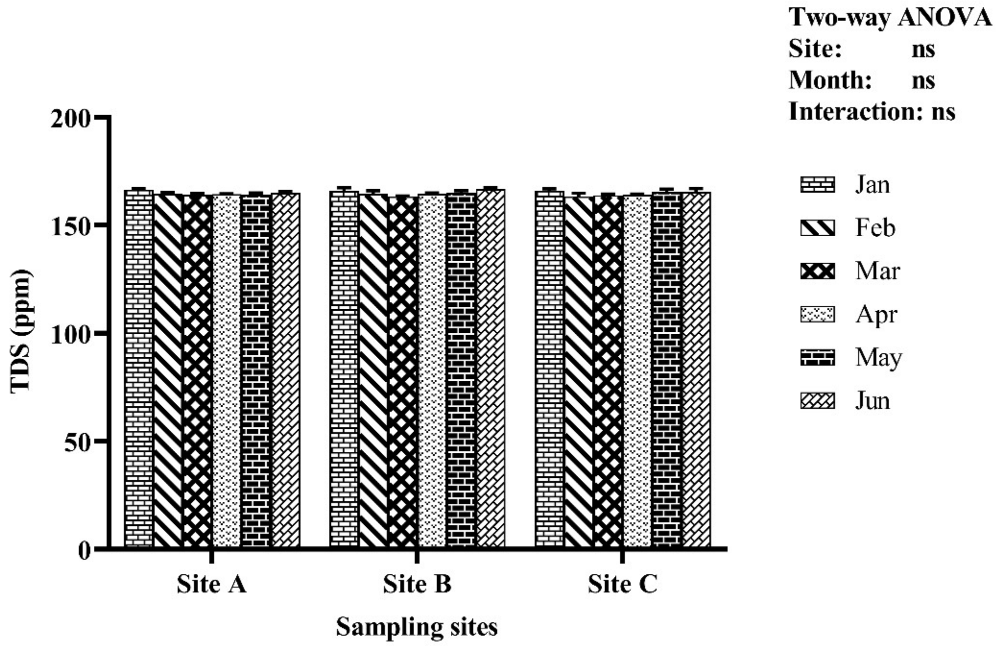

Figure 6: TDS of Safa reservoir

The biochemical oxygen demand of Safa reservoir is presented in Figure 7. The results shows that there was no significant difference in the sampling sites, months and their interaction respectively ($p > 0.05$).

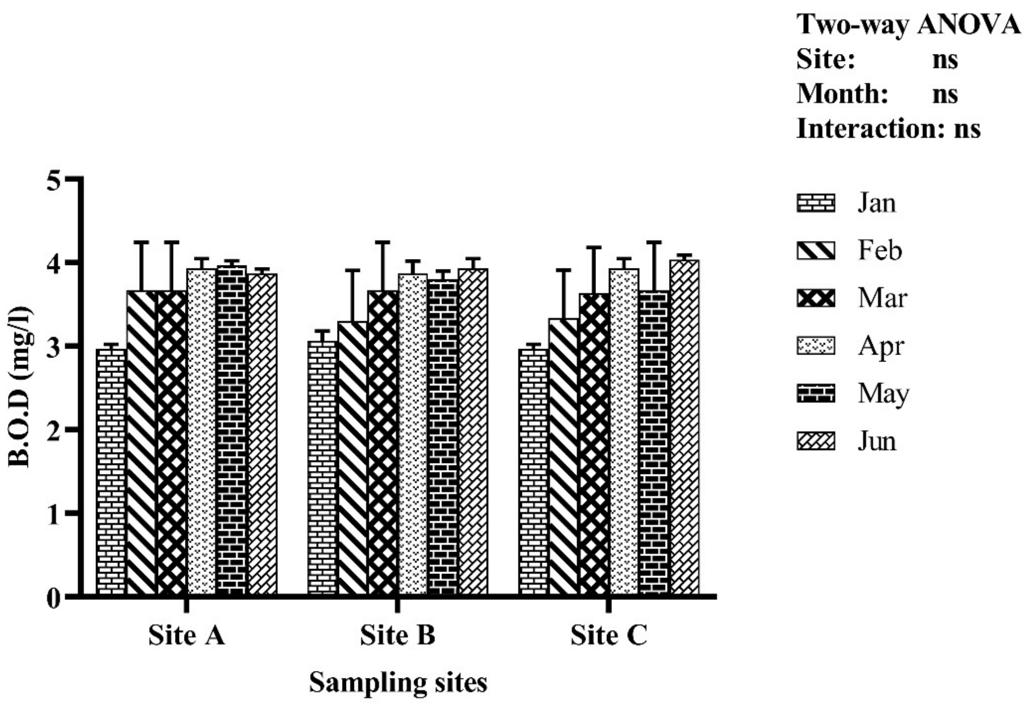

Figure 6: B.O.D. of Safa reservoir

The nitrate concentration of Safa reservoir is presented in Figure 7. The results shows that there were significant differences in the sampling sites, months and their interaction respectively ($p < 0.05$). Significantly highest nitrate concentration was obtained in the month of June for all the sampling sites, followed by May. While the lowest nitrate levels were obtained in January and March for all the sampling sites.

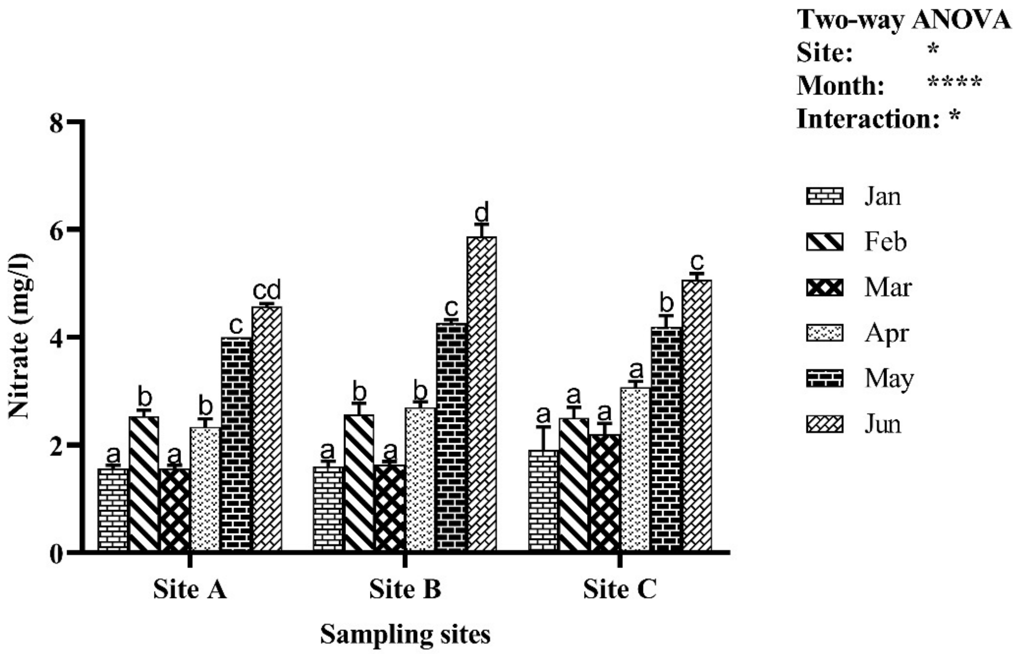

Figure 7: Nitrate concentration of Safa reservoir

The phosphate concentration of Safa reservoir is presented in Figure 7. The results shows that there were significant differences in the sampling sites, months and their interaction respectively ($p < 0.05$). Highest phosphate values were obtained in May for site A and C respectively, while in site B, the highest phosphate value was recorded in June.

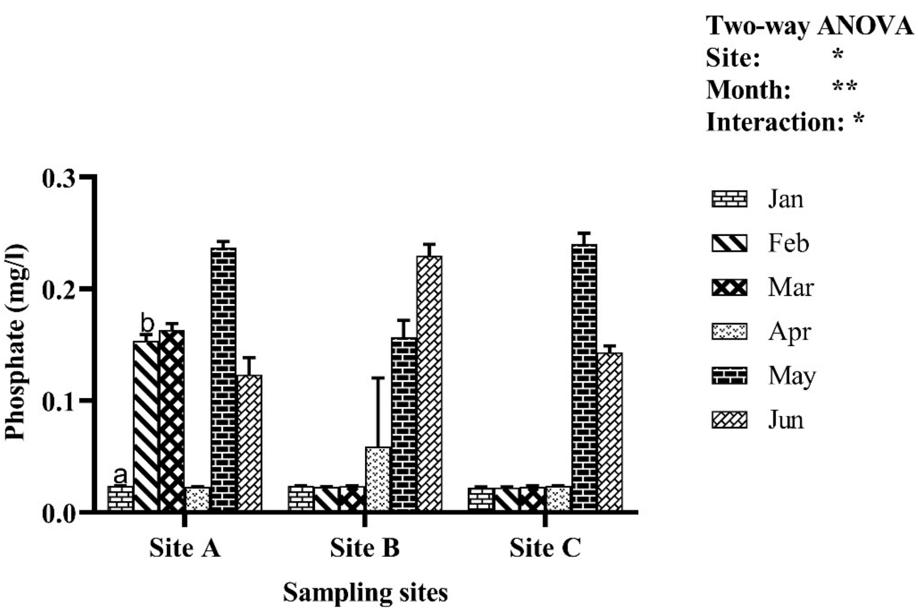

Figure 8: Phosphate concentration of Safa reservoir

Correlation matrix of physico-chemical parameters of Safa reservoir

The relationship between the physico-chemical parameters of Safa reservoir is presented by a correlation matrix in Figure 9. The results showed highly significant positive correlations were observed. Temperature correlated positively with phosphate and B.O.D. Furthermore, transparency exhibited highly significant positive relationship with TDS and pH while TDS and NO3 and phosphate and NO3 also exhibited highly significant positive relationship.

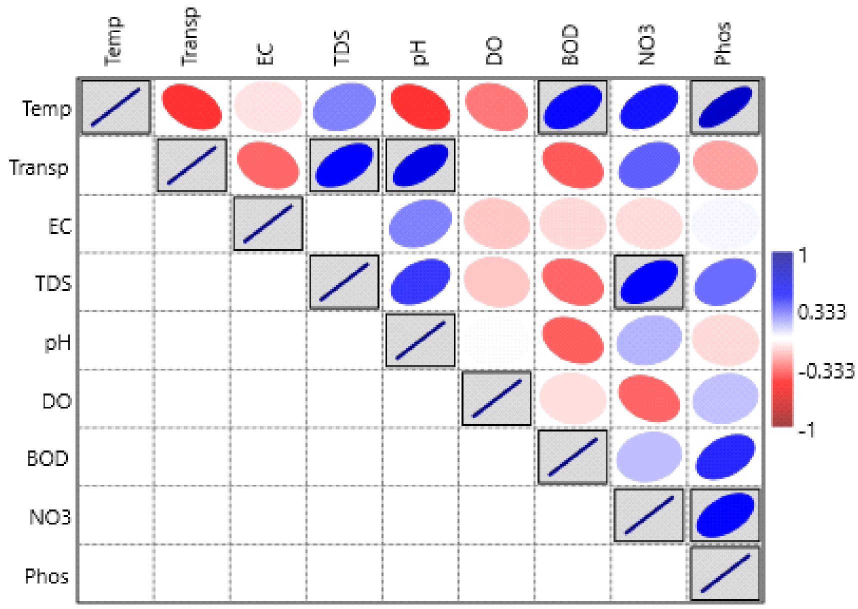

Figure 9: Correlation matrix of physico-chemical parameters of Safa reservoir

DISCUSSION

The use of land has intensified with the increase in human population, method of use and technology advancement. Several technics have been applied in assessing and understanding the relationship between land and water quality in different watersheds. Land use activities have significant impacts on water quality due to the rapid and continues development that the country was experiencing over the last decades. This development activity are sources of water quality degradation in various water bodies through different process (camara *et al.,* 2019).

The findings related to the physico-chemical parameters of Safa Reservoir, emphasizing the implications for water quality, aquatic life, and potential environmental concerns. The results presented indicate significant variations in various parameters across different months, sites, and environmental conditions.

Temperature

The mean monthly temperature of Safa Reservoir ranged from 23.30 ± 1.30°C in February to 26.5 ± 0.34°C in May, indicating a notable seasonal. The observed correlation between temperature and other parameters, such as dissolved oxygen (DO) and pH, aligns with established ecological principles that warmer waters typically hold less dissolved oxygen (Mayer and Kline, 2018). The negative correlation between temperature and DO (r = -0.723) is critical for aquatic life, as reduced oxygen levels can lead to hypoxic conditions, particularly affecting sensitive species (Baird *et al.,* 2017). Moreover, the positive correlation between temperature and nitrate (r = 0.760) and phosphate (r = 0.740) suggests that increased temperatures could enhance nutrient runoff, further exacerbating the nutrient loading in the river, leading to potential eutrophication.

Transparency and Turbidity

The observed transparency levels of the Safa River showed significant seasonal changes, with the lowest readings during April and May. This decline in transparency can be attributed to increased sedimentation and runoff during these months. The strong positive correlation between turbidity and pH (r = 0.622) highlights the role of suspended solids in altering water chemistry. Higher turbidity can limit light penetration, thereby affecting photosynthetic organisms, which are vital for maintaining the river's ecological balance (Kirk, 2011).

Electrical Conductivity

Electrical conductivity (EC) levels varied significantly, with the highest readings recorded in June. The positive correlation between EC and temperature (r = 0.487) suggests that increased temperatures enhance ion solubility, affecting water chemistry. The observed negative correlation with transparency (r = -0.521) indicates that elevated conductivity may be associated with higher levels of suspended particles, potentially affecting aquatic habitats and organisms.

Biochemical Oxygen Demand (BOD)

The BOD levels exhibited a wide range, with the highest values observed in March at site C. The strong negative correlation between BOD and DO (r = -0.680) emphasizes the relationship between organic pollution and oxygen depletion. Elevated BOD levels indicate high organic matter decomposition rates, which can result in adverse conditions for aquatic life due to diminished oxygen availability (APHA, 2017). The correlation of BOD with turbidity (r = 0.485) further supports the idea that increased organic loads lead to higher turbidity, creating a detrimental cycle for water quality.

Total Dissolved Solids (TDS)

TDS levels remained relatively stable across the study period, with a slight increase in warmer months. The moderate positive correlation with turbidity (r = 0.515) suggests that dissolved solids and particulate matter may rise together due to runoff and erosion, affecting water quality. The correlation of TDS with nitrates (r = 0.562) implies that agricultural runoff contributes both nutrients and dissolved solids, potentially impacting the river's health.

pH Levels

The pH values indicated a slightly alkaline trend across the study period. The negative correlation between pH and temperature (r = -0.404) may suggest that warming waters could slightly increase acidity, impacting the overall ecosystem. The strong positive correlation between pH and DO (r = 0.528) indicates that maintaining higher pH levels is beneficial for aquatic organisms, as more alkaline conditions often support healthier ecosystems (Wetzel, 2001).

Dissolved Oxygen (DO)

DO levels show significant fluctuations, with the highest concentrations in March. The observed correlations with temperature, turbidity, and BOD indicate that seasonal changes and pollution levels directly influence oxygen availability. The negative correlation between DO and nitrate (r = -0.466) suggests that higher nitrate concentrations can lead to eutrophication, resulting in decreased oxygen levels and adverse conditions for aquatic life (Smith *et al.,* 1999).

Phosphate and Nitrate Levels

Phosphate levels peaked in March, while nitrate levels demonstrated a concerning rise in June, particularly at site B. The strong positive correlation between nitrate and temperature (r = 0.760) suggests that warmer conditions may promote nutrient runoff, intensifying eutrophication processes (Carpenter *et al.,* 1998). The implications of these nutrient levels are significant, as they can lead to algal blooms, further depleting oxygen levels and harming aquatic ecosystems.

Conclusion

The study revealed significant temporal and spatial variations in the physico-chemical parameters of Safa Reservoir. Temperature, turbidity, pH, dissolved oxygen, nitrate, and phosphate concentrations varied significantly across months and sampling sites, indicating dynamic environmental conditions. The highest temperature was recorded in the dry season months (April–June), while turbidity, pH, and dissolved oxygen exhibited site-specific and seasonal fluctuations. Nitrate and phosphate levels peaked in May and June, suggesting potential nutrient input during these months. In contrast, electrical conductivity, total dissolved solids, and biochemical oxygen demand remained relatively stable. These findings highlight the need for continuous monitoring to assess the reservoir's water quality and its suitability for aquatic life and other uses.

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