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Assessment of Physico-Chemical Parameters of River Sabon Dagah, Minna, Niger State

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ABSTRACT
The study on the assessment of the physico-chemical parameters of Sabon Dagah River Minna, Niger State, was carried out from May to September, 2019 with the aim of determining the physical and chemical parameters of Sabon Dagah River and also to identify the fish that may be present in the river. Four sampling stations were selected, namely: Upstream (Station 1), before the bridge (Station 2), after the bridge (Station 3) and downstream (Station 4). The physico-chemical parameters were determined using standard methods, procedures and techniques. The results obtained showed the results of the measured parameters water temperature (26.35±0.20°C to 28.33±0.08°C), pH (6.52±0.05 to 9.08±0.10), conductivity (118.0±1.32 μs/cm to 195.75±0.76 μs/cm), total alkalinity (3.65±0.25 mg/L to 25.5±0.42 mg/L), total hardness (64.5±1.18 mg/L to 34.9±2.31 mg/L), chloride (8.32±0.28 mg/L to 11.21±0.32 mg/L), calcium (6.30±0.75 mg/L to 22.15±0.65 mg/L), CO2 (0.75±0.04 mg/L to 3.41±0.31 mg/L), total dissolved solids (51.84±1.18 mg/L to 125.28±0.46). The assessment of River Sabon Dagah's water quality revealed variations among sampling stations and months. While some parameters met WHO standards, others, like dissolved oxygen and biological oxygen demand, indicated potential pollution sources such as agricultural runoff and industrial discharges. Conservation efforts and pollution control measures are vital to safeguard the river's health and freshwater resources in the region.

Keywords*:* Anthropogenic activities; Physico-chemical parameters; River Sabon Dagah; Water quality

INTRODUCTION

Nigeria boasts an extensive network of wetlands, dams, lakes, and rivers spanning over 14 million hectares, capable of yielding approximately 980,000 metric tons of fish annually (FDF, 2003). Water, an indispensable resource for human activities ranging from industrial to residential and rural use, holds a paramount position in sustaining life and various operations (Carrard *et al.*, 2019). However, the burgeoning industrialization and population growth in recent times have led to a surge in freshwater demand (Ramakrishnaiah *et al.*, 2009; Fang and Jawitz, 2019), necessitating thorough assessment of surface and groundwater quality across physical, chemical, and biological parameters (Loukas, 2010; Masood *et al.*, 2023).

In natural ecosystems, water is the primary habitat for fish and numerous other aquatic organisms. The health of these ecosystems relies heavily on the physicochemical characteristics of their environment, as emphasized by Nubi *et al.*, (2019). Assessing water quality is the process of evaluating the physical, chemical, and biological aspects of water concerning its natural state, human influence, and future usage, as defined by Adelagun *et al.*, (2021). Rivers, serving as primary water resources for irrigation, domestic supply, and industrial usage within watersheds, confront challenges related to sanitation and ecological concerns.

The assimilation of sewage effluents from residential, industrial, and agricultural areas poses substantial hygienic and environmental issues (Sigua and Tweedale, 2003; Lin *et al.,* 2022). Effective pollution control and environmental management necessitate the identification and monitoring of waterway pollution, coupled with a reliable assessment of water quality, particularly concerning anthropogenic contaminants derived from land use activities (Massoud *et al.,* 2006; Aktar *et al.,* 2021).

Human activities, including agriculture, significantly contribute to river pollution, introducing pollutants such as ammonia, nitrogen compounds, and pathogenic bacteria into water bodies (Gasim *et al.,* 2009; Massarelli *et al.,* 2021). Consequently, investigating river pollution becomes imperative due to the diverse sources of contamination, including industrial sewage, animal wastewater, agricultural practices, and urban runoff (Al-Badaii, 2011).

Lin *et al.,* (2022) posited that the presence of pollutants significantly impacts the quality and usability of water, serving as a crucial factor affecting the health conditions of both cultured and wild fish populations. In areas where potable water is not readily available, communities heavily rely on coastal waters for domestic, agricultural, or recreational purposes. The potential for trans-boundary movement of coastal pollutants underscores the importance of determining and monitoring coastal water quality (Tanjung *et al.,* 2019).

Water contamination in Nigeria is pervasive across rural and urban areas. In rural settings, water from natural sources like rivers and lakes is often contaminated with organic substances due to agricultural activities conducted by upstream users (Richard and Ivanildo, 1997; Ferronato and Torretta, 2019). This highlights the urgent need for comprehensive measures to mitigate water pollution and safeguard both human health and aquatic ecosystems.

Moreover, the aquatic habitat's physicochemical characteristics play a crucial role in regulating fish populations and their biological functions (Blaber, 2000; Iqbal *et al.,* 2004; Kolo and Oladimeji, 2004; Mushahida-Al-Noor and Kamruzzaman, 2013; Ojutiku and Kolo, 2011; Bănăduc *et al.,* 2021). Parameters such as temperature, dissolved oxygen, pH, and turbidity directly influence aquatic life (Boyd, 1998; Blabber, 2000; Thirumala *et al.,* 2011; Mushahida-Al-Noor and Kamruzzaman, 2013), emphasizing the significance of understanding the physical and chemical properties of water in supporting aquatic biodiversity (Mustapha and Omotosho, 2005; Sangpal *et al.,* 2011; Murungan and Prabaharn, 2012; Depak and Singh, 2014).

Water quality management is recognized as a top priority on the policy agenda in numerous regions worldwide (WHO, 2011). To address this concern, a range of scientific methods and tools have been developed for assessing water contaminants (Dissmeyer, 2000; Zulkifli *et al.,* 2018). These systems encompass the examination of various parameters, including pH, turbidity, conductivity, total dissolved solids, total organic carbon, total suspended solids, and heavy metals. By comprehensively evaluating these parameters, water quality managers can effectively monitor and address potential threats to water resources, ensuring the protection of public health and environmental integrity. The river in Sabon Dagah village plays a vital role in supporting domestic activities and artisanal fishing, serving as an integral part of life for those residing along its banks. Despite its significance, limited research has been conducted to assess the quality of this water body. Therefore, this research was undertaken to evaluate the river's quality in Sabon Dagah village.

By examining various physicochemical parameters and potential pollutants, this study aims to provide valuable insights into the health of the river ecosystem and the associated risks or concerns for the local community dependent on its resources. The objectives of this study are to determine the physico-chemical parameters of the river and compare if they are within standard levels for aquatic life sustenance.

MATERIALS AND METHODS

Study area

River Sabon Dagah is located in Bosso L.G.A in Minna, Niger state. The river lies between latitude 9^{O}38' N and longitude 6°34' E. The river flows from River Chanchaga down to Sabon Dagah Village which earns it, the name River Sabon Dagah**.** Crop and artisanal fish farming are the predominant occupation of the locals. Bathing, washing of clothes, fishing activities and disposal of domestic wastes are being carried out on the water-body.

Sampling stations in which samples were taken from and their corresponding coordinates are thus: starting from Station 1, The Upstream (09º22'813"N 06º21'428"E), proceeding to Station 2, Before the Bridge (09º23'049"N 06º21'140"E), then to Station 3, After the Bridge (09º23'280"N 06º20'977"E), and finally to Station 4, The Downstream (09º23'573"N 06º20'698"E).

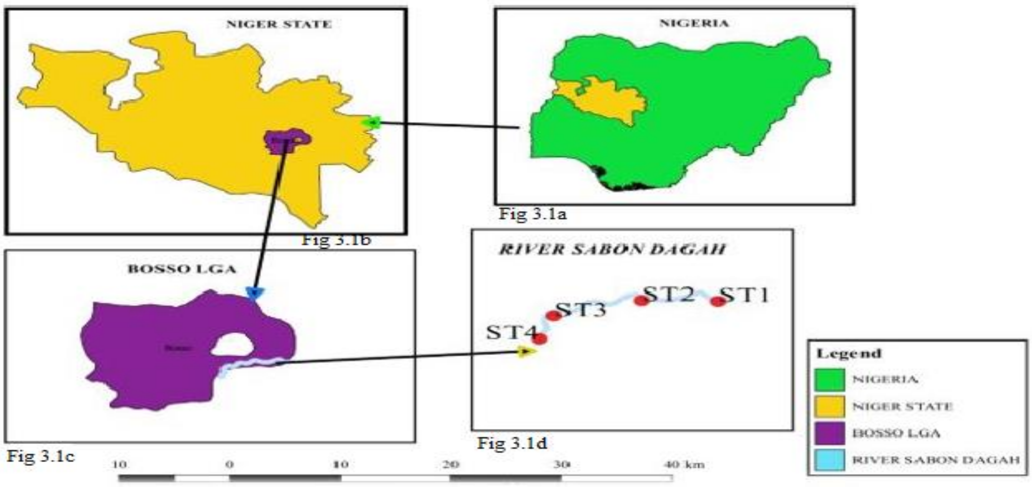

Figure 1: Maps of Nigeria and Niger state showing the four sampling stations at Sabon Dagah, Minna, Niger state.

Sampling Procedure

Water samples were collected were collected from four (4) different stations along the river course, in a clean plastic bottles once in a month between the month of May to September in plastic bottles by submerging the bottles into the rivers until they were filled and properly corked. Then, 1 ml each of Manganese Phosphate and Potassium Iodide were introduced into bottles used for collecting samples for dissolved oxygen, (this is to fix the oxygen for analysis). Laboratory analyses were carried out at the Department of Water Resources, Aquaculture, and Fisheries Technology, Federal University of Technology Minna, Nigeria.

Determination of water quality parameters

The following physicochemical parameters were measured in each water sample:

Water temperature: The Temperature of the water samples were taken insitu by dipping a bulb thermometer of 100°C range till the mercury became stable and readings were taken.

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Dissolved oxygen (DO)
The dissolved oxygen of the sample water was determined by using the modified Winkler azide method (Lind, 1979; APHA, 1992).

Potential hydrogen ion (pH)
A buffer electronic PH meter was used to obtain the pH water samples. The probe was first inserted in a buffer solution, then into the water sample and readings were taken.

Biological oxygen demand (BOD)
The biological oxygen demand of the samples was determined by using the modified Winkler azide method (Lind, 1979; APHA, 1992). The titre values were inputted in (TV × M × 8*1000) / (Volume of sample) then the calculated values were used to determine BOD using BOD = DO1 – DO5

Electrical Conductivity
Water conductivity was measured using a digital conductivity meter, specifically the Kadida Model CT-3030.

Dissolved Oxygen (DO)
The dissolved oxygen content of the water samples was determined using the modified Winkler azide method, a well-established technique documented by Lind (1979) and APHA (2000).

Total Alkalinity (TA)
Total alkalinity was assessed following the method delineated by Lind (1979) and in accordance with APHA (2000).

Total hardness and Calcium (Ca2+)
Total hardness and Calcium were quantified using the titrimetric method in accordance with APHA (2000) guidelines.

Chloride (Cl^-)
The determination of chloride content was conducted using Mohr's method, also known as Argentimetric titration.

Magnesium (Mg^{2+})
The values for magnesium were derived using calculated total hardness and calcium hardness values, according to the formula:
Magnesium in mg/L = $\frac{Total\ hardness\ in\ MgCaCO3}{l}$ - $\frac{Calcium\ Hardness\ in\ MgCa}{L} \times 0.244$

Where the formula for calcium hardness (mg/l) = $\frac{TV \times 1{,}05 \times 1000}{50}$

Total Dissolved Solids (TDS)
The determination of Total Dissolved Solids involved employing the evaporation method, as outlined in the procedure described by Enemaku (2017).

Statistical Analysis
The data collected was subjected to a statistical analysis. A one-way analysis of variance was performed to test for differences, while the mean values were compared using Duncan's Multiple Range Test (DMRT) (Steele and Torrie, 1980).

RESULTS
The results depict an analysis of physico-chemical parameters conducted in Sabon Dagah River. Across all four sampling stations, most of the parameters showed no significant difference ($p<0.05$). However, there were notable exceptions. Dissolved oxygen concentration at Station 4 (5.20±0.27 mg/L) differed significantly from the other stations. Similarly, Biological Oxygen Demand (BOD) exhibited significant differences ($p<0.05$) at stations 3 and 4 (2.80±0.23 mg/L and 2.07±0.39 mg/L, respectively). The temperature fluctuated between 26.80°C and 27.10°C, while the pH value was between 7.34 and 7.71. The lowest temperature was measured at station 3. The mean conductivity fluctuated between 136.93 and 138 µS/cm. Significant monthly fluctuations were observed in the physico-chemical parameters. The pH value fluctuated between 6.52 and 9.08, with the lowest value measured in June and the highest in September. Conductivity fluctuated between 81 and 195.75 µS/cm in May. The calcium values were found to be 6.30 and 22.15 mg/L, while CO2 levels ranged from 0.75 mg/L in July to 3.41 mg/L in May. Total dissolved solids showed variations from 5.0 mg/L to 8.75 mg/L.

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Table 1: Monthly Variation of Physico-chemical Parameters of Composite Site of River Sabon Dagah

Parameters	May	June	July	August	September
Temperature (°C)	26.35±0.20[c]	26.35±0.244[c]	27.25±0.11[b]	28.33±0.08[a]	27.0±0.33[b]
pH	7.16±0.01[d]	6.52±0.05[e]	7.33±0.05[c]	8.17±0.02[b]	9.08±0.10[a]
Conductivity (µs/cm)	195.75±0.76[a]	147.0±0.86[b]	118.0±1.32[d]	81±1.86[e]	138.67±0.68[c]
Total Alkalinity (mg/L)	25.5±0.42[a]	21.5±0.93[b]	20.75±0.51[b]	12.4±0.53[c]	3.65±0.25[d]
Total Hardness (mg/L)	64.5±1.18[a]	64.45±1.12[a]	52.4±1.54[b]	34.9±2.31[d]	44.75±1.10[c]
Chloride (mg/L)	8.32±0.28[c]	10.01±0.22[b]	9.41±0.15[b]	8.63±0.23[c]	11.21±0.32[a]
Calcium (mg/L)	13.98±0.24[c]	17.75±0.24[b]	22.15±0.65[a]	7.56±0.20[d]	6.30±0.75[d]
CO_2 (mg/L)	3.41±0.31[a]	1.87±0.10[c]	0.75±0.04[e]	2.57±0.04[b]	1.25±0.07[d]
Total Dissolved Solid (mg/L)	125.28±0.46[a]	94.08±0.53[b]	75.52±0.83[d]	51.84±1.18[e]	88.64±0.44[c]
Dissolved Oxygen (mg/L)	5.0±0.33[c]	8.75±0.82[a]	6.5±0.42[b]	6.35±0.24[b]	6.5±0.26[b]
BOD (mg/L)	2.35±0.25[b]	3.33±0.50[ab]	2.75±0.53[ab]	3.6±0.20[a]	2.6±0.18[ab]
Magnesium (mg/L)	6.62±0.14[a]	5.62±0.69[a]	1.36±0.55[c]	3.50±0.44[b]	6.49±0.55[a]

Degree of freedom = 11, Values are mean ± Standard Error of the Mean, Mean in the same row followed by the same superscript are not significantly different (p≥0.05)

Table 2: Composite Site Variations of Physico-chemical Parameters of River Sabon Dagah

Parameters	Station 1	Station 2	Station 3	Station 4	WHO 2011
Temperature (°C)	26.90±1.13[a]	27.08±0.68[a]	26.80±1.23[a]	27.10±0.98[a]	Ambient
pH	7.69±0.29[a]	7.71±0.25[a]	7.34±0.17[a]	7.56±0.2[a]	6.5 – 8.5
Conductivity (µS/cm)	138±8.99[a]	136.93±9.72[a]	133±13.49[a]	134.6±10.76[a]	2500
Total Alkalinity (mg/L)	15.5±2.04[a]	17.48±2.18[a]	19.25±1.14[a]	18.04±2.32[a]	50 - 200
Total Hardness (mg/L)	54.32±3.72[a]	49.88±3.50[a]	54.50±2.04[a]	52.00±3.79[a]	100
Chloride (mg/L)	9.26±0.21[a]	9.34±0.43[a]	9.38±0.30[a]	9.74±0.40[a]	200
Calcium (mg/L)	13.82±1.95[a]	12.97±1.36[a]	15.39±1.57[a]	14.42±1.44[a]	1
CO_2 (mg/L)	1.71±0.16[a]	1.77±0.26[a]	2.42±0.36[a]	2.20±0.36[a]	5 - 12
TDS (mg/L)	88.83±5.75[a]	87.55±6.22[a]	85.12±8.63[a]	86.14±6.89[a]	1000
Dissolved Oxygen (mg/L)	7.24±0.51[a]	7.36±0.66[a]	6.65±0.42[a]	5.20±0.27[b]	≥9.00
BOD (mg/L)	3.56±0.20[a]	3.32±0.39[a]	2.80±0.23[ab]	2.07±0.39[b]	≤5.00
Magnesium (mg/L)	5.70±0.91[a]	3.90±0.47[a]	4.50±0.56[a]	4.04±0.49[a]	150

Degree of freedom = 11, Values are mean ± Standard Error of the Mean, Mean in the same row followed by the same superscript are not significantly different (P≥0.05).

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DISCUSSION

Monthly temperature varied between 26.35°C – 28.33°C. The fluctuation in water temperature could be due to change in the weather especially during rainy season when cloud cover reduces the intensity of the solar radiation which limited light rays to the water surface (Abolude *et al.,* 2013). Temperature influences the oxygen content of the water, the quantity and quality of the fish and the food produced (Deekae *et al.,* 2010; Ekere *et al.,* 2018). The values of temperature observed are within the normal range of 8-30°C recommended standard for surface waters by FEPA (1991).

The flow of the river could have resulted in the fluctuation of mean values reported for dissolved oxygen. The dissolved oxygen was high in the month of June than other months, this may be as an occurrence of the heavy downpour of rain, this is similar to what Mustapha (2008) reported that higher dissolved oxygen recorded could be as a result of rain and increased water mixing**.** The significant differences in Dissolved Oxygen (DO) concentration at Station 4 and Biological Oxygen Demand (BOD) at stations 3 and 4 can be attributed to varying environmental factors and human activities specific to each location (Arnab *et al.,* 2019). Station 4 may experience lower DO levels due to factors such as higher organic pollution, reduced water flow, or increased microbial activity, leading to oxygen depletion (Dębska *et al.,* 2021).

Rum-Rukeh *et al.,* (2006) reported similar observation that biological oxygen demand is a fair estimate of the purity of any water body at bases below 1.2mg / L is safe, about 3-5mg / L is fairly clean, and 10mg / L BOD is definitely awful and harmful. This study shows that the water in the river was quite clean. During sampling in the current research, the BOD was strong in the month of August (3.6±0.20), and this could be attributed to precipitation in the rainy season from surrounding lands. Similarly, stations 3 and 4 may have higher BOD levels due to inputs of organic matter from sources like agricultural runoff, industrial discharges, or domestic sewage, which can increase microbial decomposition and oxygen consumption.

Conductivity indicates presence of dissolved ions in water. The electrical conductivity values in the river were typical of freshwater body of 1 – 1000 µS/cm as described by FME (2001). Vajrapp and Singh (2005) reported that water with conductivity below 750 µS/cm is satisfactory for aquatic biota, as the highest recorded was 195.75±0.76 µS/cm in May. The higher mean conductivity values could be due to influx of allochotonous and inorganic materials from the stream surroundings. Electrical Conductivity was maximum in the month of November (dry) while lowest was recorded in the month of August (wet). The highest conductivity was recorded in May (195.75±0.76) there was no rain and the lowest was in August 81±1.86. The increase in conductivity in the month of May could be due to water level fall. Atobatele and Ugwumba (2008) indicated that decreasing conductivity values during rainy season could be due to rainy season dilution.

During the dry season, the river has higher TDS quality this could be attributed to vegetation loss, higher evaporation level due to temperature increase. Similar findings have been recorded Atobatele and Ugwumba (2008), the rise in the amounts of total dissolved solids during the dry season, which may be attributed to vegetation loss, resulting in an increase in the amount of dissolved oxygen. During the rainy season, the total dissolved solids were small and this could be due to water dilution.

In the month of May, water hardness was high, this could be due to low water levels and high nutrient water concentrations.

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Total hardness is due to the geology of the environment associated with the surface. Hardness has no knowledge of adverse health effects; however, there has been some research to highlight its influence on heart disease (Wright, 2010). Higher calcium value was reported in the month of June and this might be as a result of the inflow of water that bring in calcareous materials to the aquatic environment. As observed by Imoobe and Oboh, 2003; Tian *et al.*, 2017, calcium peaks in the rainy season might be explained in terms of influx of floodwaters that bring in calcareous materials.

CO_2 has a good impact on photosynthesis that again affect fish growth. During the analysis there was no substantial difference in the concentration of free CO_2. The measured values in which the water is ideal for fish abundance below 20 mg/L of free CO_2.

High chloride in freshwater environment can be toxic and affect fish growth and survival, especially in aquaculture, the values recorded from the river shows that water is good for aquaculture and freshwater can survive in it. The magnesium recorded was lower than that of Calcium, this might be as a result of in flow of water. The chemical denudation due to heavy precipitation, flow and weathering of rocks found inside the river and run-offs from the environment might contribute to the high availability of magnesium ion in the river. High total alkalinity was recorded in the month of May, compared to other months, this might be due to bicarbonates deposited in the river in the dry season. The low alkalinity in the other months maybe as a result of low carbonates and bicarbonates ions in the water.

CONCLUSION

The assessment of physicochemical parameters of River Sabon Dagah revealed significant variations in water quality among sampling stations and months. The water quality parameters measured at different stations were compared against WHO standards to assess their compliance. Temperature remained consistent with ambient conditions at all stations. pH values fell within the acceptable range, indicating favourable conditions. Conductivity and Total Dissolved Solids were significantly lower than WHO guidelines, suggesting minimal mineral content. Chloride levels were well below the recommended limit, indicating low salinity. Total hardness and calcium levels met standards, signifying soft water with acceptable mineral content. However, Dissolved Oxygen levels at station 4 fell below the WHO threshold, indicating potential oxygen depletion. Additionally, Biological Oxygen Demand levels at stations 3 and 4 exceeded the recommended limit, suggesting higher organic pollution.

These findings highlight areas of concern, emphasizing the need for further investigation and remediation to maintain water quality standards. The presence of elevated nutrient levels, organic matter, and dissolved solids indicates potential inputs from agricultural runoff, industrial discharges, and urban activities. There is need for conservation efforts to protect aquatic habitats. Effective pollution control measures and watershed management practices are essential to safeguard the health of River Sabon Dagah and ensure the sustainability of freshwater resources in the region.

RECOMMENDATIONS

1. The people in the vicinity of the river should be informed about the safe use of the water.
2. Industrial waste should be properly treated before disposal near the river.
3. Additional research on the water body should be conducted to verify the checklist of physico-chemical parameters of the river.

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