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Original article

VARIATIONS IN PHYSICOCHEMICAL CHARACTERISTICS ALONG RIVER NIGER IN LOKOJA, KOGI STATE

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ABSTRACT

This study elucidated the physicochemical attributes of water bodies in some communities across River Niger. In-situ measurements of water parameters were carried out for Total Dissolved Solids (TDS), Temperature, Salinity, Dissolved Oxygen (DO), pH, Electrical Conductivity, and Total Dissolved Oxygen following standard procedures. The water samples were collected, twice every month, from four different sites from August to December 2023. Samples were collected from two sites (upstream and downstream) into white plastic bottles which were washed with distilled water and dried, then were used to collect water from the sampling sites according to standard procedure. The results obtained showed that the Physico-chemical parameters of the water bodies in the selected communities varied significantly ($P<0.05$). Parameters such as Temperature, Salinity, Dissolved Oxygen (DO), pH, Total Dissolved Oxygen, Total Hardness, Transparency and Depth were all below permissible limit (WHO) while Electrical Conductivity was far below permissible limit of WHO. This study established that the surface water harvested from this river for domestic and agricultural purposes is in a good stand but should be discouraged once there are build up in the parameters. Findings from this study recommends water quality monitoring of the river in order to protect the integrity of the aquatic ecosystem.

Keyword: Physicochemical parameters, River Niger, Water quality, Lokoja

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INTRODUCTION

Water is a natural resource essential to all living things and basic need of humans, thus water is as considered pretty good national asset. With growing demands in various sectors, water needs appropriate planning, development, and management [5]. The periodical changes of Physico-chemical parameters including temperature,

transparency, dissolved oxygen, chemical oxygen demand, nitrate, and phosphate of any water body may provide valuable information on its biological production in any aquatic body [15]. For instance, phytoplankton is vital and important organisms which act as producer to the primary food supply in any aquatic ecosystem. Water quality deteriorates when its properties and composition are changed due to the release of pollutants such that it becomes less suitable for drinking, domestic uses, fish production and other purposes, than would otherwise be in its unpolluted state [22]. According to [8], life in aquatic environment is largely governed by Physico-chemical characteristics and their stability. Knowledge of the physico-chemical parameters of a river is significant due to its comprehensive insights into water quality, ecological health, anthropogenic impacts, and practical applications for infrastructure development [32]. These physical and chemical characteristics of water determine the species composition, distribution and abundance of organisms of any aquatic ecosystem. The water pH, Temperature, turbidity, dissolved ions, and nitrate, controls the activities of aquatic organisms and determines their composition, distribution and abundance [29]. The health, structural size and biomass of fish population densities as well as the general health of the biotic community are almost related to the results of the physio-chemical conditions of the water. In developing country, like Nigeria, there is paucity of data on the regular monitoring of the physicochemical parameters of water bodies [13]. This is a threat to the integrity of water bodies whose resources are vital to the wellbeing of the nation. In the quest to fill the above vacuum among others, the current study was designed to assess the monthly status of the physicochemical parameters of river Niger.

The River Niger is a source of drinking water, hydro-electric power, irrigation, transportation, fishing among a number of other uses. Human activities have been implicated to impair water quality, sometimes to unacceptable limits [4]. The river harbours 36 families and nearly 250 species of freshwater fish, out of which 20 are found nowhere else on Earth; Eleven (11) of the 18 families of freshwater fish that are endemic to Africa are represented in the Niger River [36].

The importance of monitoring the physicochemical parameters of the Niger River is evident from various studies that have highlighted the environmental, ecological, and public health implications of water quality and pollution in this vital water body [28]. These studies underscore the need for comprehensive and continuous monitoring to ensure the sustainable management and protection of the Niger River and its associated ecosystems [16]. The Niger River is a vital water body, and monitoring its physicochemical parameters is crucial due to various environmental and public health implications. Several studies have emphasized the significance of monitoring the physicochemical characteristics of the Niger River. For instance, the assessment of water quality and identification of pollution risk locations in other river systems have been conducted to determine spatial and seasonal variations in water quality [25]. Additionally, studies have evaluated the occurrence, distribution, and composition profiles of persistent organic pollutants (POPs) in the River Niger, highlighting the importance of monitoring these pollutants [24]. Furthermore, the impact of urban pollution on

macroinvertebrate traits in forested riverine systems in the Niger Delta area has been investigated, emphasizing the need for monitoring urban pollution sources and their influence on aquatic ecosystems [10,9]. This study was therefore designed to examined some physico-chemical parameters of river Niger for any build up due to increasing human activities around the river.

MATERIAL AND METHODS

Description of the study area

Lokoja lies between latitude $7^{0}5'$N and Longitude $6^{0}44'$E. The city is well connected and accessible through state and federal highways. The vegetation along the river comprises mainly of wooded savannah grassland with shrubs and trees. The climate of the area consists of two seasons; the dry season and wet season. The wet season begins toward the end of March and ends towards the end of October or early December, while the dry season begins in November and lasts until late march. The annual rainfall record between 1016 and 1700mm while the mean daily temperature ranges between 25°C and 29°C (Kogi State Ministry of Information (KGMoI, 2009). The Niger River is the principal river of western Africa, extending about 4,180 km. Its drainage basin is 2,117,700 km^2 in area. Its source is in the Guinea highlands in southeastern Guinea, it runs in a crescent through Mali, Niger, on the border with Benin and then through Nigeria meeting with the River Benue. It is the third-longest river in Africa, exceeded only by the Nile and the Congo rivers. The river water serves multiple purposes such as drinking, irrigation, fishing, domestic use, and transportation. Additionally, runoff from the town tends to flow into the river, given that much of the town's landscape slopes towards it. The sampling area is located in River Niger Kogi State. Sampling points were chosen based on the human activities in those areas, these sampling units are; Irenedu village, along Lokoja-Koton-Karfe road (Niger River), Ganaja Village and Kpata market (Figure 1).

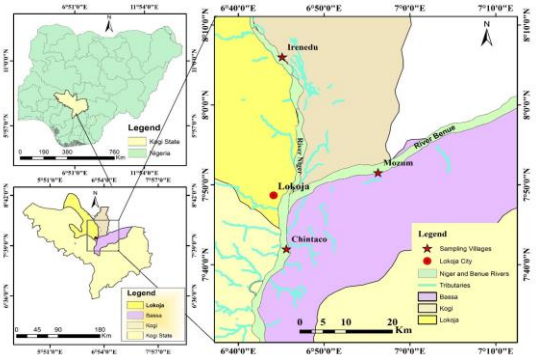

Figure 1: Map of Sampling Villages in the Study Area.
Source: GIS Unit, Geography Department, Kogi State University, Anyingba.

Sample collection and procedure

The study involved monthly sampling of water for Physico-chemical parameters. Sampling of water took place during the morning hours, between 8:00 am and 11:00 am. The readings were taken twice every month (fortnightly). The water samples were collected from four different sites. Samples were collected from two sites (upstream and downstream). The water was collected with white plastic bottles which were washed with distilled water and dried according to standard procedure [26] and was taken to the Laboratory for analysis [2].

Determination of Physico-Chemical Parameters

In-situ measurements of water parameters were carried out for Total Dissolved Solutes (TDS), Temperature, Salinity, Dissolved Oxygen (DO), pH. Electric conductivity, Total dissolve Oxygen, Total Hardness, Transparency and Depth. All analyses were conducted according to the standard methods used by [3].

Data analysis

Data obtained from the study were expressed in mean ± standard error of their replicate. The mean and standard error and tables were done using Microsoft excel 16th version while statistical packages for social sciences (SPSS) 23rd version was used for the Analysis of Variance (ANOVA) to analyzed physicochemical characteristics. The analysis was assumed significant at $P<0.05$.

RESULTS

Mean Monthly Temperature

The mean monthly temperature of Niger River from August to December ranges from 20.11±0.54 to 29.63±0.11°C (Table 1). The mean minimum temperature was observed in December and the maximum temperature occurred in August and September, respectively. The water temperature in the months of September and October was moderately high.

Table 1. Mean Monthly Variation in Temperature (°C) of River Niger

Months	Mean±SD	Range (Minimum – Maximum)
August	27.83 ± 0.85^{b}	20.20 - 30.30
September	29.63 ± 0.11^{d}	28.70 - 30.10
October	29.35 ± 0.22^{d}	27.80 - 31.20
November	28.49 ± 0.12^{c}	27.70 - 29.50
December	20.11 ± 0.54^{a}	17.50 - 23.30
Mean Total	**26.66±0.28**	**16.90 - 31.20**
p Value	<0.005*	

Values are presented in mean ± standard error of three replicates. Values followed with the same superscript are not significantly different at $p<0.05$

Mean Monthly pH

Present study revealed that monthly mean pH values ranged from 6.70 ± 0.04 to 7.63 ± 0.19 (Table 2). The minimum value was observed in October while the maximum value was recorded in December (Table 2). The ANOVA revealed that there was significant difference ($p<0.05$) in the mean monthly pH.

Table 2. Mean Monthly Variation in pH of River Niger

Months	Mean±SD	Range (Minimum – Maximum)
August	6.93±0.08[c]	6.70 - 7.60
September	6.77±0.03[a]	6.50 - 6.90
October	6.70±0.04[a]	6.40 - 6.90
November	6.78±0.06[b]	6.40 - 7.20
December	7.63±0.19[d]	6.50 - 8.80
Mean Total	**6.96±0.04**	**5.20 - 8.80**
p Value	<0.005*	

Values are presented in mean±standard error of three replicates. Values followed with the same superscript are not significantly different at p<0.05

Mean Monthly Conductivity

The mean monthly conductivity ranges between 0.07±0.01 and 0.47±0.11 µS/cm (Table 3). The maximum value was found in December while, the minimum values were recorded in November (Table 3). The result showed that there were no significant difference (P>0.05) between the EC mean values recorded for all the months from August to November (Table 3).

Table 3. Mean Monthly Variation in Electrical Conductivity (µS/cm) of River Niger

Months	Mean±SD	Range (Minimum – Maximum)
August	0.08±0.01[a]	0.05 - 0.14
September	0.10±0.01[a]	0.05 - 0.15
October	0.08±0.01[a]	0.03 - 0.14
November	0.07±0.01[a]	0.05 - 0.14
December	0.47±0.11[b]	0.10 - 1.16
Mean Total	**0.29±0.03**	**0.03 - 2.22**
p Value	<0.005*	

Values are presented in mean±standard error of three replicates. Values followed with the same superscript are not significantly different at p<0.05

Mean Monthly Variation in Dissolved Oxygen

Table 4 shows that mean in dissolve oxygen ranged from 6.04±0.11 to 6.37±0.5 mg/l, the result indicate that there were no significant differences (P<0.05) between the DO mean values recorded for all the months from August to November throughout the study.

Table 4. Mean Monthly Variation in Dissolved Oxygen (mg/l) of River Niger

Months	Mean±SD	Range (Minimum – Maximum)
August	6.33±0.04[c]	6.10 - 6.50
September	6.04±0.11[a]	5.10 - 6.50
October	6.13±0.07[b]	5.40 - 6.50
November	6.37±0.03[c]	6.10 - 6.50
December	6.37±0.51[c]	3.40 - 9.80
Mean Total	**6.45±0.06**	**3.40 - 9.80**
p Value	<0.005*	

Values are presented in mean±standard error of three replicates. Values followed with the same superscript are not significantly different at p<0.05

Mean Monthly Total Dissolve Solid

The mean total dissolve solid ranged from 60.67±6.90 to 240.88±50.33 while the minimum and maximum total dissolve solid were observed between 20.00 to 773.00 mg/l. The result showed that there were no significant differences (P<0.05) between the TDS mean values recorded for all the months from August to November (Table 5).

Table 5. Mean Monthly Variation in Total Dissolved Solids (mg/l) of River Niger

Months	Mean±SD	Range (Minimum – Maximum)
August	63.67±7.44[a]	40.00 - 107.00
September	64.29±5.82[a]	44.00 - 100.00
October	65.17±8.72[a]	20.00 - 131.00
November	60.67±6.90[a]	17.00 - 127.00
December	240.88±50.33[b]	95.00 - 773.00
Mean Total	**130.60±11.17**	**17.00 - 873.00**
p Value	<0.005*	

Values are presented in mean±standard error of three replicates. Values followed with the same superscript are not significantly different at p<0.05

Mean Monthly Total Hardness

Result from Table 6 showed that minimum value was 4.63 in October while the maximum value was 8.83 which was observed in December. The maximum mean Total Hardness in the river occurred at November with observation of 7.74±0.20ab. There were significance differences among mean monthly Total Hardness in August, November and December. However, there were no significant differences between mean values of September and October at 0.05 probability level.

Table 6. Mean Monthly Variation in Total Hardness (mg/l) of River Niger

Months	Mean±SD	Range (Minimum – Maximum)
August	7.21±0.22[b]	5.25 - 8.31
September	6.03±0.18[c]	4.64 - 7.62
October	6.15±0.23[c]	4.63 - 7.46
November	7.74±0.20[a]	6.25 - 8.80
December	7.29±0.24[b]	5.23 - 8.83
Mean Total	**7.26±0.07**	**4.63 - 9.15**
p Value	<0.005*	

Values are presented in mean±standard error of three replicates. Values followed with the same superscript are not significantly different at p<0.05

Mean Monthly Transparency

The mean transparency of study area ranged between 25.26±0.82 and 33.85±0.48cm (Table 7). The minimum value was recorded in the Month of September while the maximum value was recorded in October (Table 7). The result showed that there were significant differences (P<0.05) among the mean values recorded for all the months from August to November (Table 7).

Table 7. Mean Monthly Variation in Transparency (cm) of River Niger

Months	Mean±SD	Range (Minimum – Maximum)
August	25.50±1.12[a]	20.00 - 34.20
September	25.26±0.82[a]	19.20 - 29.98
October	33.85±0.48[c]	30.20 - 37.02
November	30.00±1.05[b]	22.30 - 35.93
December	30.54±0.66[b]	27.10 - 34.98
Mean Total	**27.46±0.33**	**17.50 - 37.02**
p Value	<0.005*	

Values are presented in mean±standard error of three replicates. Values followed with the same superscript are not significantly different at p<0.05

Monthly Variation in Depth (m)

The minimum and maximum observations of depth were recorded in August and October respectively. However, mean maximum value of depth was recorded in September 7.70m. The result showed that there were significant differences (P<0.05) among the mean values recorded for August, November and December (Table 8).

Table 8. Mean Monthly Variation in Depth (m) of River Niger

Months	Mean±SD	Range (Minimum – Maximum)
August	5.05±0.25[b]	4.17 - 6.60
September	6.74±0.15[d]	6.20 - 7.70
October	6.73±0.15[d]	6.10 - 7.70
November	5.77±0.14[c]	5.30 - 6.70
December	4.78±0.14[a]	4.30 - 5.60
Mean Total	**4.52±0.10**	**2.33 - 7.70**
p Value	<0.005*	

Values are presented in mean±standard error of three replicates. Values followed with the same superscript are not significantly different at p<0.05

DISCUSSION

In the current study, the lowest temperature values recorded in December otherwise could likely be influenced by the environmental temperature as well as other climatic conditions prevailing in the study area. Mean temperature from August and November, also September and October showed no significant differences among others at 0.05 probability level. Temperatures in the tropical regions have been observed to exhibit no statistically

significant variations between seasons; similar results have been reported by [30,6]. In every aquatic environment, temperature exerts major influence on biological activity, growth and development. It governs the kinds of organisms that can live in rivers and lakes. Fish, insects, zooplankton, phytoplankton, and other aquatic species all have a preferred temperature range. As temperatures get too far above or below this preferred range, the number of individuals of the species decreases until finally there are none. The ranges of temperature recorded in the current study indicate a moderate range for the survivorship of its fauna.

The pH range of 6.77 – 7.63 reflected a slightly acidic to a slightly alkaline aquatic environment and was within the acceptable range (6.5 – 8.5) for a healthy aquatic life [35]. Also [23], observed pH value of 7.85±0.08 from Kpata Lake, Lokoja Kogi state in 2016 which showed higher alkaline than the observations from the present study but still in range of WHO recommended level. The variation in pH observed in this study may be due to the high rainfall and flow through the river tributaries. Thus, the pH range obtained in this study is within acceptable level of 6.0 to 8.5 for culturing tropical fish species [33,12] and or the recommended level for drinking water [34]. Similar findings were also recorded by [17] reflecting neutral to slightly alkaline conditions.

Conductivity is a measurement of the ability of an aqueous solution to carry an electrical current. The sources of conductivity may be abundance of dissolved salts due to poor irrigation, minerals from rain water run-offs, or other discharges. The mean variation of conductivity for the study area are below the recommended values of 20 - 1000 µS/cm [35]. [23], also reported higher value of conductivity (113.38±24.3 µS/cm) compare to the observations of the present study. The observed low conductivity levels in the River Niger indicate a low presence of dissolved salts in the study area. This phenomenon may be attributed to the temperature at the time of sample collection. Similar findings reported in [1,11] noted a positive correlation between conductivity and temperature values in Dadin Kowa Dam.

The presence and abundance of aquatic organisms are significantly influenced by the levels of dissolved oxygen in water. [20]. For all the aquatic aerobes, oxygen is pre-requisite for life, thus the more the oxygen available, the more the organisms are found [7,21]. According to [34,14], the amount of DO in water depends on the source, temperature, chemical and biological process taking place in a water body. The observed means of DO in the lower Niger River corresponds to the study of [27]. The concentration of dissolved oxygen was discovered to fall within the range of 5 mg/L to 9 mg/L, meeting the limits set for drinking water. [31]. The DO values recorded in this study is similar to 0.58-10.00mg/l recorded by [18]. The high value may be due to collection period that are possibly characterized with steady wind which increases wave action, and decrease in surface run offs and alternatively the cause of decrease in dissolved oxygen may be due to increase in turbidity during torrential rainy season [11]. It can be stated that the monthly DO concentrations in the study area was moderate.

Primarily, alkalinity and hardness contribute to the buffering capacity of water and the ability of the water to resist change in pH when small amount of acid, base or alkaline is added to the water. The mean minimum value of Total hardness occurred in

September (6.03±0.18) while maximum observation identified in December (7.29±0.24 mg/l). The findings indicated notable variations ($P<0.05$) in the recorded observations across all months (Table 6). Water hardness is influenced by the concentrations of magnesium and calcium, with their levels playing a significant role.

Turbidity is the determination of the muddiness or opaqueness of water and it is usually influenced by the total number of materials that are present in the water [18]. Transparency is the measure of light penetration in water. It is an important criterion for assessing the quality of water. When the water is cloudy and contains a lot of particles, light cannot penetrate deeply into the water column which may limits primary productivity or photosynthesis. According to the WHO, the turbidity of drinking water should be less than 5 nophelometric turbidity unit (NTU) or 20-80cm seechi disc reading. The least transparency value obtained for Niger River in September may be as a result of human activities, high amount of rainfall and increase in debris load by water run-off which is characteristic of the wet seasons. This agrees with a previous study by [19], who reported that reduced activity in Lake Geriyo and complete lack of rains accounted for high transparency.

Declarations

Authors Contribution

OAEA conceived the idea about the project and designed the study. OAEA and OVU participated in the data collection and samples from the study areas. OAEA performed the data analysis. OVU and OAEA interpreted the data and prepared the first draft of the manuscript, reviewed by OMM. All authors contributed to the development of the final manuscript and approved its submission.

Disclosure of Conflict of Interest

None

Ethics Approval and Informed Consent

This study did not use human or animal subjects. Therefore, ethical consideration was not applicable.

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