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Monthly variation in the physicochemical parameters of lake Laiko, NigerState

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ABSTRACT

This study investigated the monthly variation in the physicochemical attributes of Lake Laiko in Niger State, with the aim of using these parameters as indicators of the water integrity. Water samples were collected from September 2019 to August 2020, between 6:00 to 9: 00 in the morning and 4: 00 to 6: 00 in the evening. Water samples were randomly collected from four stations 200m apart every month along the lake. Various physicochemical parameters including temperature, turbidity, conductivity, total suspended solids, total dissolved solids, pH, dissolved oxygen, biochemical oxygen demand, and nutrient concentrations were analyzed using Analysis of Variance followed by Duncan multiple Range Test which was employed to separate means of parameter with significant differences. Pearson correlation coefficient was used to establish the relationship among the physicochemical parameters. Analysis was assumed significant at $P<0.05$. Analysis was carried out using Microsoft excel, 2010, and Statistical Packages for Social Sciences, 20th version. The results revealed significant variations in these parameters across different months, with implications for the ecological dynamics and water quality of the lake. Temperature showed very weak positive correlation with turbidity (0.114), conductivity (0.137), P (0.124), Biochemical Oxygen Demand (BOD) (0.34), N (0.042) and negative weak correlation with DT (-0.060), TSS (-0.165) and TDS (-0.070) respectively. Similarly, there was weak positive correlation between Turbidity, and conductivity (0.035). Total dissolve solid also show weak negative correlation with Ph (-0.023), Dept (DT) (-0.07), P-0.179) and N (-0.359) respectively. There was very weak correlation between BOD and Temperature, BOD and conductivity was significant. The study provides valuable insights into the seasonal variations of physicochemical parameters in Lake Laiko, emphasizing the importance of monitoring and understanding these variations for effective lake management and conservation. The moderate level of the measured parameters is an indication of the good integrity of the lake for the survival of its bio community.

Keywords: Physicochemical parameters, Laiko Lake, Lake Status, Niger State.

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INTRODUCTION

The physicochemical parameters of a lake play a crucial role in understanding its ecological health and functioning. These parameters encompass a wide range of factors such as salinity, nutrient levels, oxygen concentration, and pH, which collectively influence the biotic and abiotic components of the lake ecosystem. Researchers have shown that these parameters can vary significantly across different lakes, and their fluctuations can have profound effects on the microbial communities, water quality, and overall biodiversity of the lake [32; 23; 11; 25; 10; 26].
Studies have demonstrated that factors such as altitude, salinity, and seasonal variations can impact the bacterio-plankton community composition in high-mountain lakes, highlighting the influence of physicochemical parameters on microbial diversity [31]. Additionally, the vertical profile of water and sediment in lakes has been found to exhibit significant variations in physicochemical parameters, particularly in different zones such as oxic, sub-oxic, and anoxic zones, indicating the complex nature of these parameters within lakes [9]. Furthermore, the impact of atmospheric nitrogen deposition on lakes has been linked to nitrogen enrichment and eutrophication, emphasizing the role of physicochemical parameters in driving ecological changes [6].

The occurrence of toxic cyanobacterial blooms in lakes has been associated with specific physicochemical parameters, highlighting the importance of monitoring these parameters for understanding and managing potential ecological risks [3]. Additionally, the assessment of spatial and vertical variability of water quality in lakes has emphasized the role of physicochemical parameters in shaping the overall water quality, further underlining their significance in lake ecosystems [11].

Physicochemical parameters of lake waters have been shown to influence the core microbial communities of lacustrine microbialites, indicating their role in shaping microbial assemblages within lakes [14]. Seasonal variation of physicochemical parameters in lakes has been extensively studied, with researchers emphasizing the need to characterize these parameters for understanding ecosystem health and management [22]; "Assessment of Seasonal Variations of Physico-chemical parameters of Talikatte lake water of Chitradurga District, Karnataka, India"; [28]. Summarily, the physicochemical parameters of lakes are critical determinants of their ecological dynamics, influencing microbial communities, water quality, and overall ecosystem health. Understanding the variations and influences of these parameters is essential for effective lake management and conservation.

MATERIALS AND METHODS

Description of the Study Area

This study was carried out at Laiko Lake, Niger State (Figure 1). The Lake has a total surface area of 31 hectares and storage capacity of 19.1 million M^3 of water. The lake has a depth of 17m and a length of 13km. The lake is located at longitude 71^0 39' to 71^0 44' East and latitude 38^0 to 98^0 41' North to South-West of Lemu town, Niger State. The Lake has a total surface area of 31 hectares and storage capacity of 19.1 million M^3 of water. Laiko area is characterized by two distinct seasons namely, rainy (from May through October) and dry (December – March); with the two seasons often separated by somewhat transitional periods in April and November.

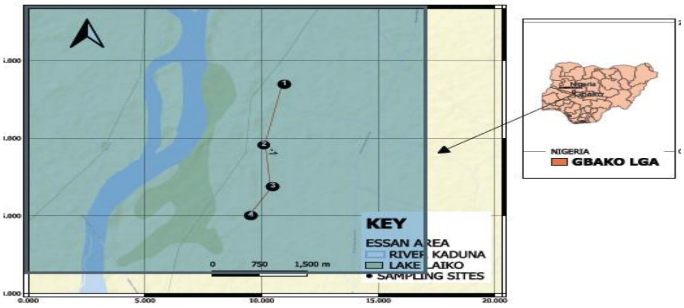

Figure 1: Map of the Laiko Lake, Niger State.

Collection of Water Sample

Water sampling was carried out between September 2019 and August 2020. Sampling was done monthly and on each day measurements was taken between 6:00 – 9:00 in the morning, and 4:00 – 6.00 in the evening. Water samples were randomly collected from four Stations of 200m apart. Four study Stations were selected along the Lake (upper reaches of less human impacts through mid-reaches with relative high human impacts to lower reaches of less human impacts), designated as Stations 1, 2, 3, and 4.

Physico-Chemical Analysis of the Water Sample

Water temperature was measured *in-situ* at each sampling time using mercury-in-glass thermometer. Flow velocity was measured in mid-channel on three occasions by timing of float (average of three trials) as it more over a distance of l0m water depth and width was measured in the sampling area using a calibrated stick [12]. Dissolved oxygen (DO), Biochemical oxygen demand (BOD), pH and Alkalinity was determined according to [2]. Phosphate, sulphate and nitrate were measured spectrophotometrically. This if further detail below

Determination of pH

The water pH was measured with Hanna 420 pH meter; Plate II (a). It was calibrated according to instructional manual provided by the manufacturer. The electrode of the pH meter was dipped into the water sample for 2-3 minutes and readings were recorded [2].

Determination of Water temperature

Temperature (°C) of the water was measured by dipping a mercury in glass thermometer into the water at each Station for about 1-2 minutes then the readings was recorded [2].

Determination of Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD)

Hanna Dissolved Oxygen microprocessor HI 98186 was used to determine the dissolved oxygen, Plate II (b). It was calibrated according to the instruction manual provided by the manufacturer. Sample of the water was collected in 100ml beaker; the electrode of dissolved oxygen microprocessor was dipped into the beaker that contains the sample water for about 2-3 minutes. The readings were recorded in mgl-1. For biochemical oxygen demand; 100ml part of the sample was incubated for five days in dark cupboard at room temperature and dissolved oxygen was determined after five of incubation, the difference between the initial value of dissolved oxygen and the value after five days of incubation was used as value of biochemical oxygen demand in the water sample [2; 18].

Determination of electrical conductivity, dissolved solids (ds) and suspended solid (ss)

Water samples were placed into clean beakers; conductance cell of the meter was immersed into sample solution. The resistance was measured in µS/cm, the readings of conductivity and dissolved solids were noted with the conductivity meter by changing mode of measurement to DS. The cell was rinsed in a beaker with distilled water after each reading. The calibration measurement was performed in 0.00702 NaCl solutions. This solution has a specific conductance of 0.1µS/cm at

25°C then suspended solid are determined using gravimetric method.

Determination of phosphate-phosphorus

This was determined using the Deniges method APHA, (1999). Some 1ml of Deniges reagent and 5 drops of Stannous chloride was added to 100ml water sample. Absorbance at 690nm was measured with spectrometer, model S101 using distilled water as the blank. The phosphate-phosphorus concentration of water sample was read from the calibration curve in mgl-1 [2].

Determination of nitrate-nitrogen

One hundred (100) ml of water sample was poured into a crucible, evaporated to dryness, and cooled. 2ml of phenoldisulphonic acid was added and smeared around the crucible, after 10minutes, 10ml of distilled water was added followed by 5ml of strong ammonia solution. Setting the spectrophotometer at the wavelength of 430nm, absorbance of the sample treated was obtained, using distilled water as blank. The concentration of nitrate-nitrogen was obtained from the Calibration curve in mgL-1 [2].

Data Analysis

The physicochemical attributes of the sampling Stations were compared using Analysis of Variance. Significant ANOVA was followed by Duncan multiple Range Test was employed to separate means of parameter with significant differences. Pearson correlation coefficient was used to establish the relationship among the physicochemical parameters. Analysis was assumed significant at $P<0.05$. Analysis was carried out using Microsoft excel, 2010, and Statistical Packages for Social Sciences, 20th version.

RESULTS

Physicochemical parameters of water samples from Laiko Lake

The results of the physicochemical parameters of water samples from lake laiko in Gbako L.G.A., Niger State is presented in Table 1a, 1b. The temperature ranges from 30.33 ± 0.23 ^{0}C in November to 20.40 ± 0.00 ^{0}C in August. There is no significant differences ($P>0.05$) in the temperature level recorded from January to July. The temperature recorded in September was significantly highest ($P<0.05$) than temperature recorded in other months of the study. Also, the lowest temperature was recorded in August (20.40 ± 0.00) this is not significantly different ($P>0.05$) from the temperature recorded in October (23.70 ± 0.59) and December (22.25 ± 0.48) respectively.

The turbidity ranges from 17.50 ± 1.44 in March to 5.00 ± 2.89 in June. There is no significant differences ($P>0.05$) in the turbidity recorded in the months of January (12.5 ± 1.44), may (12.5 ± 1.44), July (11.25 ± 1.24), August (12.5 ± 1.44), November (13.75 ± 1.25) and December (12.5 ± 1.44). The turbidity recorded in March is significantly highest ($P<0.05$) than the turbidity found in other months of the study. The lowest turbidity was found in February (7.50 ± 1.44), this is not significant different ($P>0.05$) with the month of June (5.00 ± 2.81). Also, there is no significant different ($P>0.05$) in the months of April (15.00 ± 0.00), September (15 ± 0.00) and October (15 ± 2.89) respectively.

The conductivity ranges from 28.98 ± 4.47 to 9.51 ± 4.48 in May. There is no significant different ($P>0.05$) in the month of January (19.88 ± 3.72), February (18.38 ± 4.57), March (20.23 ± 3.83), April (17.25 ± 0.55), July (11.25 ± 1.25), October (22.25 ± 0.55) and November (20.28 ± 0.73). The conductivity recorded in September (28.98 ± 4.47) is significant highest ($P<0.05$) than the conductivity was found in other months of the study. The lowest conductivity is recorded in May (9.51 ± 4.48) and is significantly different ($P<0.05$) with conductivity recorded in other months of the study. There is no significant different ($P>0.05$) in the month of June (24.70 ± 1.34), September (28.98 ± 4.47) and December (26.28 ± 1.66) respectively.

The TSS ranges from 2.00 ± 0.07 in October to 0.49 ± 0.08 in March. There is no significant different (P>0.05) in the TSS recorded in the months of January (0.66±0.06), February (0.72±0.4), April (0.79±0.01) and May (0.81±0.004). The TSS recorded in October (2.00±0.07) is significantly highest (P<0.05) than the TSS recorded in the other months of the study. Also, the lowest was recorded in March (0.49±0.08) and is not significant (P>0.05) from the TSS recorded in the remaining months of the study. There is no significant (P>0.05) in the month of June (1.02±0.14) July (1.34±0.20), August (1.56±0.21), September (1.46±0.17), November (1.80±0.01) and December (1.23±0.05).

The TDS ranges from 1.79±0.23 in September to 0.5 ± 0.11 in March. The highest TDO was recorded in September (1.79±0.23) and is not significantly different (P>0.05) from TDS recorded in the month of October to December. And the lowest is recorded in the month of March (0.5±0.11) and is not significant with January (0.66±0.06), February (0.67±0.06), April (0.67±0.05) and May (0.73±0.06). There is also no significant different (P>0.05) in the months of July (1.15±0.11) and August (1.28±0.12) respectively. There is significant different (P<0.05) in June (0.92±0.16) with remaining months of the study.

The pH ranges from (6.73±0.19) in December to (6.13±0.24) in January and February. There is no significant different (P>0.05) from January to December (Figure 1).

The DT ranges from (18.63±12.46) in June and (6.33±0.78) in March. The DT recorded in June (18.63±12.46) is significantly highest (P<0.05) the DT recorded in other months of the study. The lowest DT recorded in March (6.33±0.78) this is not significant different (P>0.05) with DT recorded from January to May, and from July to December respectively.

The P is ranges between (65±2.89) in March to (10.00±5.77) in May. The highest P was recorded in March (65±2.89) and is significantly different (P<0.05) with P recorded in other months of the study. The lowest P was recorded in May (10.00±5.77) and is significantly different (P<0.05) with other months of the study. There is no significant different (P>0.005) in the month of January (60.0±0.00), February (50.0±5.77), July (50.0±10.0) and September (50.0±5.77). There is no significant different (P>0.05) in the months of April (20.0±0.00) and November (20.0±0.05) respectively. There is also no significant different (P>0.05) in the month of June (30.0±5.77), August (35.0±15.0), October (30.0±5.77) and in December (30.00±5.77).

The N is ranges from (17.72±10.31) in February and (0.08±0.01) in March. (figure 4). The N recorded in February (17.72±10.31) is highest and is not significant different (P>0.05) with the January (17.66±10.34). The lowest N is found to be in March (0.08±0.01) and is significant (P<0.05) with remaining months of the study. There is also no significant different (P>0.05) in the month of June and from August to December. There were also significant different (P<0.05) in the month July (0.62±0.22), April (10.0±0.0) and May (5.05± 2.86).

The BOD is ranges from 0.07± 0.05 in the month of February and March to 0.01±0.00 in December. The BOD recorded in February and March is the highest (0.07±0.05) this is not significant different (P>0.05) with March (0.07±0.05). The lowest BOD is recorded in the month of December and is significant different (P<0.05) with month of study. There is no significant different (P>0.05) with months of January (0.02±0.00), April (0.02±0.00), July (0.02±0.00), August (0.02±0.00) and November (0.02±0.0). There is no significant different (P>0.05) in the month of October (0.03±0.00) and June (0.03±0.00) respectively

Table 1a physicochemical parameters of water samples from Laiko Lake

Sample	Temperature (°C)	Colour	Conductivity (Sm^{-1})	TSS (g)	TDS (ppm)
January	27.28±0.38b	12.50±1.44b	19.88±3.72c	0.66±0.06b	0.66±0.06a
February	27.30±0.37b	7.50±1.44a	18.38±4.57c	0.72±0.04b	0.67±0.06a
March	28.10±0.32b	17.50±1.44d	20.23±3.83c	0.49±0.08a	0.50±0.11a
April	28.05±0.14b	15.00±0.00c	17.25±0.55c	0.79±0.01b	0.67±0.05a
May	27.28±0.48b	12.50±1.44b	9.51±4.48a	0.81±0.04b	0.73±0.06a
June	26.55±0.19b	5.00±2.89a	24.70±1.34d	1.01±0.14c	0.92±0.16b
July	27.63±0.13b	11.25±1.25b	19.75±0.91c	1.34±0.20c	1.15±0.11c
August	20.40±0.00a	12.50±1.44b	14.35±0.68b	1.56±0.21c	1.28±0.12c
September	33.50±0.65d	15.00±0.00c	28.98±4.47d	1.46±0.17c	1.79±0.23d
October	23.70±0.59a	15.00±2.89c	22.25±0.55c	2.00±0.07d	1.77±0.21d
November	30.33±0.23c	13.75±1.25b	20.28±0.73c	1.80±0.01c	1.66±0.03d
December	22.25±0.48a	12.50±1.44b	26.28±1.66d	1.23±0.05c	1.59±0.03d

Values followed by the same superscript alphabet on the same column are not significantly different at P>0.05
Values are presented in mean standard error of two determinations

Table 1b: Physicochemical parameters of water samples from Laiko lake

Sample	pH	DT	P	N	BOD (mg/l)
January	6.13±0.24a	7.45±0.21a	60.00±0.00d	17.66±10.34f	0.02±0.00b
February	6.13±0.24a	7.50±0.20a	50.00±5.77d	17.72±10.31f	0.07±0.05d
March	6.50±0.20a	6.33±0.78a	65.00±2.89e	0.08±0.01a	0.07±0.05d
April	6.50±0.00a	6.60±0.17a	20.00±0.00b	10.00±0.00e	0.02±0.00b
May	6.50±0.00a	6.90±0.22a	10.00±5.77a	5.05±2.86d	0.02±0.00b
June	6.38±0.13a	18.63±12.46b	30.00±5.77c	0.15±0.03b	0.03±0.00c
July	6.38±0.13a	7.70±0.35a	50.00±10.00d	0.62±0.22c	0.02±0.00b
August	6.38±0.13a	7.85±0.25a	35.00±15.00c	0.15±0.09b	0.02±0.00b
September	6.50±0.00a	6.48±0.13aa	50.00±5.77d	0.15±0.02b	0.14±0.07e
October	6.30±0.12a	7.00±0.12a	30.00±5.77c	0.10±0.00b	0.03±0.00c
November	6.63±0.13a	7.08±0.02a	20.00±0.00b	0.10±0.00b	0.02±0.00b
December	6.73±0.19a	6.98±0.12a	30.00±5.77c	0.10±0.00b	0.01±0.00a

Values followed by the same superscript alphabet on the same column are not significantly different at P>0.05
Values are presented in mean standard error of two determinations

Correlation coefficient showing relationship between the physicochemical parameters

The result of the correlation coefficient of the physicochemical parameters of water samples from Lake Laiko is as presented in Table 2. Temperature showed very weak positive correlation with turbidity (0.114), conductivity (0.137), P (0.124), BOD (0.34), N(0.042) and negative weak correlation with DT (-0.060), TSS (-0.165) and TDS (-0.070) respectively. Similarly, there was weak positive correlation between Turbidity, and conductivity (0.035). Total dissolve solid also show weak negative correlation with Ph (-0.023), DT (-0.07), P-0.179) and N (-0.359) respectively. There was very weak correlation between BOD and Temperature, BOD and conductivity was significant.

Table 2: Correlation coefficient showing relationship between the Physicochemical parameters

Parameters	Temp.	Colour	Conductivity	TSS	TDS	pH	DT	P	N	BOD
Temperature	1									
Colour	0.114	1								
Conductivity	0.137	0.035	1							
TSS	-0.165	0.074	0.243	1						
TDS	-0.070	0.127	0.365*	.860**	1					
pH	.335*	0.210	-0.119	0.042	-0.023	1				
DT	-0.060	-0.101	-0.103	-0.054	-0.071	-0.160	1			
P	0.124	0.167	.396**	-0.271	-0.179	0.075	-0.109	1		
N	0.042	-0.103	0.203	-0.359*	-0.396**	-0.279	-0.039	0.223	1	
BOD	0.326*	0.083	0.338*	0.046	0.134	0.270	-0.056	0.268	-0.143	1

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

DISCUSSION

Water is the basic requirement that supports existence of life. The significance of water as basic need for life sustainability goes beyond water alone but the resources within it among which are aquatic organisms that serve as food for man and its livestock [19]. According to [9] damming of water for the development of reservoir is one of the ways of making more water available for the needs of man. Nonetheless, water is only able to be of maximum advantage if it is of optimum quality. Fish and other aquatic resources deserve a proper balance of physical, chemical and biological properties of water for their optimum productivity [5].

Physicochemical Parameters of water sample

Physico-chemical parameters of water and sediments undergo variations from both human intervention and without human intervention by natural processes. These variations influence growth, sexual maturity, hatching from eggs, biological productivity and metabolic activities of aquatic life [13].

These characteristics profusely influence many lives related processes of aquatic ecosystems. The pH in the study is within the recommended range of 6.5 and 9.0 as earlier reported by [23]. That implies the water body is suitable for the survival and development of the aquatic flora and fauna community. Earlier studies have had documented the fact that productivity of fish species is higher in freshwater bodies with pH of the above range [29].

The variation observed in the water Temperature is in the line with earlier report of [21]. Favourable temperature range has been reported to be between 16 ^{0}C and 30 ^{0}C. Thus, fish growth and development will be favored in the lake. The temperature always plays a crucial factor for aquatic organisms because high temperature can change the population dynamics of aquatic animals; as a result, the newborn organisms do not get the nourishment that further hinder their growth. In contrast, low temperature affects dissolve oxygen concentration. The variations in the P and N across the months and stations could be attributed to the variations in anthropogenic activities across the lake. A high level of phosphate for instance stimulates the growth of photosynthesis organisms which may contribute to eutrophication of the lake [16]. The DO reported in this study were similar to 3.50 to 8.2 MG/L reported by [13], in downstream Kaduna River, Niger state. The DO is within recommended limit of WHO [30] and NESREA [20]. The recorded BOD in this current study indicated that the Lake is moderately clear as earlier stated by Stevens Institute of Technology (SIT) [25] as 1.2 m/L: very good with less organic matter, 3.5 mg/L as moderately clean and 6-9 mg/L as somewhat polluted. The strong correlation of Temperature, DO and Conductivity with fish abundance implies that the growth and development of the fish species can be promoted and/or decrease with the variability in the level of the physicochemical parameters [7]. The obtained results from Panjkora River showed that physicochemical parameters including color, odor, temperature, elasticity, pH, conductivity and TDS of water and soil are suitable for aquatic life as well as human life [13].

Conclusion

The study focuses on Lake Laiko in Niger State and examines its physicochemical attributes as an indicator of water integrity. The recorded levels of the physicochemical parameters highlight the importance of monitoring these attributes to understand the ecological health and functioning of the lake ecosystem. That means that the water has good integrity for the productivity and survival of its fauna and flora. The results showed significant variations in these parameters across the study period. Overall, the study emphasizes the importance of understanding these parameters for effective lake management and conservation. There is need to establish the current zoo and phytoconstituens of the lake in order to continue to annex its economic importance. Overall, this study emphasizes the need for effective lake management and conservation. It underscores the importance of monitoring and understanding the variations and influences of the physicochemical parameters, which are critical determinants of the ecological dynamics of the lake. Consequently, this study contributes to the body of knowledge on lake management and conservation and provides valuable insights into the importance of monitoring and managing the physicochemical attributes of lakes for sustainable development.

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