



STUDY ON PHYSICOCHEMICAL PARAMETERS AND PLANKTON COMPOSITION OF LAKE RIBADU IN FUFORE LOCAL GOVERNMENT AREA OF ADAMAWA STATE, NIGERIA

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ABSTRACT

This study assessed the physicochemical parameters and plankton composition of Lake Ribadu in Fufore Local Government Area of Adamawa State, Nigeria, to determine the influence of water quality on plankton distribution and its abundance. Water samples were collected monthly from three sampling stations (A, B, and C) between July and December 2025. Physicochemical parameters including temperature, turbidity, conductivity, dissolved oxygen (DO), biochemical oxygen demand (BOD), pH, total dissolved solids (TDS), and ammonia were analyzed using standard laboratory procedures. Plankton samples were collected using a 55 µm mesh net, preserved with Lugol's iodine solution, and identified microscopically using standard identification keys. The Data was analyzed using one-way analysis of variance (ANOVA) to determine spatial variations among stations. The Results showed that temperature ranged from 22.00 to 29.04°C, turbidity from 38.00 to 66.00 cm, conductivity from 100 to 159 µS/cm, and dissolved oxygen from 3.7 to 6.6 mg/L. The pH ranged from 6.53 to 7.80, BOD from 5.0 to 7.6 mg/L, TDS from 100.60 to 106.86 mg/L, and ammonia from 0.03 to 0.08 mg/L. A total of 21 phytoplankton species belonging to four taxa (Bacillariophyceae, Chlorophyceae, Myxophyceae, and Chrysophyceae) with a total abundance of 433,677 cells/L were recorded. Bacillariophyceae was the dominant group (37.8%), followed by Chlorophyceae (35.12%), Myxophyceae (25.82%), and Chrysophyceae (1.53%). Zooplankton comprised 21 species (125,416 individuals/L), with Copepoda being most abundant (38.18%). The findings indicate that water quality conditions were within acceptable limits and supported diverse plankton communities, with seasonal variations influencing their distribution and abundance patterns.

Keywords: Physicochemical parameters, Plankton composition, Phytoplankton, Zooplankton, Water quality

INTRODUCTION

Quality of water can be described according to its physico-chemical parameters and plankton diversity and distribution. The physico-chemical characteristics of water are important determinants of the aquatic system. Their characteristics are greatly influenced by climatic vegetation and general composition of water (Ja'afaru *et al.*, 2015). Lakes and rivers are a very important part of our natural heritage, and they have widely been utilized by mankind over the centuries to the extent that very few, if not many, are now in a natural condition (UNEP, 2025; Gonzalez Rodriguez *et al.*, 2023). The maintenance of healthy aquatic ecosystem is dependent on the physicochemical properties and biological diversity (Venkatesharaju *et al.*, 2010). The interactions of both the physical and chemical properties of water play a significant role in composition, distribution, abundance, movements and diversity of aquatic organisms (Mustapha and Omotosho, 2005; Sangpal *et al.*, 2011; Murlngan and Prabaharn, 2012; Deepak and Singh, 2014). To minimize energy expended for survival, species typically favor habitat conditions that optimize their physiology process (Burraco *et al.*, 2025; Buckley *et al.*, 2023).

The Plankton community is a mixed group of tiny plants and animals that float, drift, or feebly swim within the water mass. Plankton constitutes a diverse group of organisms living in the water column that are unable to swim against currents, and their distribution is largely determined by water movement. The term *plankton* is derived from the Greek word *planktos*, meaning "wanderer" or "drifter," which reflects their drifting lifestyle in aquatic environments. Although some planktonic forms can move vertically, sometimes hundreds of meters in a single day—their horizontal position remains controlled by surrounding water currents. Modern definitions consistently emphasize that plankton are organisms unable to overcome water currents, most of which are microscopic and visible

only under a microscope. They are abundant and form a foundational component of aquatic ecosystems. There are two major types of plankton, namely phytoplankton and zooplankton (Britannica, 2026; Biology Insights, 2025; Science Insights, 2025).

Zooplankton

These are the animal parts of plankton which consists of protozoans, rotifers and crustaceans that formed the major groups of freshwater zooplankton. Zooplankton constitute important source of natural food resources for aquatic organisms, therefore occupied a strategic trophic level (coming after the primary producers-phytoplankton in any aquatic ecosystem). Ecologically, their selective grazing habit has resulted in different seasonal succession and abundance of phytoplankton species (Branco, 2023; Spilling *et al.*, 2023). The complex plankton community comprises of primary producers, herbivores, carnivores, detritivores and decomposer organisms. Thus, prokaryotes, plants and animals are the plankton. Primary producers are the basis for the Planktonic food web and food energy in other aquatic communities (van Velzen *et al.*, 2025; Cui *et al.*, 2025). Zooplankton is a considerable nutrition resource for waterfowl and fish (Altındağ *et al.*, 2009). The species distribution and abundance of zooplankton in any water body depend upon the physicochemical parameters of water (Yang *et al.*, 2023; Caroni *et al.*, 2025). Zooplanktons occupy an intermediate position in the food web. Also, they play an important role as indicators of trophic condition in both cold temperate and tropical waters (Ahmad *et al.*, 2011).

The Phytoplankton

In a reservoir, it is an important biological indicator of the water quality. While phytoplankton are important primary producers and are at the base of the food chain in open water,

some species on the other hand can be harmful to humans and other animals by releasing toxic substances (hepatotoxins or neurotoxins etc.) into the water (Melaram *et al.*, 2024; Villalobos *et al.*, 2025).

Zooplanktons are heterotrophic planktonic animals floating in water which constitute an important food source for many species of aquatic organisms. In addition, they serve as indicator organisms of water type, fish yield and/or total biological production. These probably explain why much of the fascination in the study of lakes lies in the structure and dynamics of zooplankton populations (Caroni *et al.*, 2025).

The number of zooplankton in water depends generally on the number of phytoplankton and detritus available to feed on, detritus can be food for primary consumers, (Hassan *et al.*, 2010). Phytoplankton is recognized worldwide as bioindicator organisms in the aquatic environment, Phytoplankton in a reservoir is an important biological indicator of water quality (Yakubu *et al.*, 2000). The relationship between the physico-chemical parameters and plankton production of water bodies are of great importance in management strategies of aquatic ecosystems. Reservoirs, ponds, rivers and ground waters are used for domestic and agricultural purposes. The quality of water may be described according to their physico-chemical and plankton characteristics. Lakes have the tendency to become thermally stratified during hot and cold, dry or wet, summer or winter to undergo definite seasonal periodicity in depth distribution of heat and oxygen. Light to penetrate only to a certain depth depending upon turbidity. These gradations of oxygen, light and temperature profoundly influence life in the lake, its distribution and adaptation (Wander *et al.*, 2024; Buckley In recent years, there has been increasing concern about the rate at which inland waters are polluted through run-offs into streams and lakes, as it is in Lake Ribadu. Secondly there is no published work that exists which provides baseline information on the physicochemical and plankton composition of the Lake. Lake Ribadu serves many purposes including irrigation farming, cattle watering, public water source and fishing. Many depend on the resources of this water as their main source of food and family income as a result, the water has been subjected to intensive use. The aim of this study is to assess the physicochemical parameters and plankton composition of Lake Ribadu in Fufure L.G.A. and to determine the physico-chemical characteristics of the water as it influence plankton distribution. The specific objectives include the following to evaluate the physicochemical parameters of Lake Ribadu in fufure LGA, to determine the plankton compositions in Lake Ribadu, to determine the plankton abundance in Lake Ribadu.

Both man and animal rely most on water, as about 70% of animal body is water, there is therefore a need to monitor the biological and physico-chemical characteristics of water bodies such as the lake. The main source of freshwater

pollution can be attributed to the increasing level of using chemicals, herbicides, pesticides, insecticides and fertilizer, improper disposal of sewage as well as global warming. In Nigeria it has created a growing awareness on the rational management of aquatic resources and control of waste discharge from the environment. Information on the study of planktonic population and physico-chemical characteristics in Lake Ribadu is scarce. Therefore, the result of this research is intended to provide baseline information for further management and monitoring of the water body, planktonic community of the lake and by extension, fisheries of that lake.

MATERIALS AND METHODS

Study Area

The study site is Lake Ribadu. Lake Ribadu is in Ribadu village of Fufore Local Government Area, Adamawa State, Nigeria. As shown in figure (1) Lake Ribadu is a perennial lake situated in latitude 9.12 – 16.51 N and longitude 12.28 – 12.43 E (Linus, 2025). Lake Ribadu is a wet flood plain adjacent to River Benue. River Faran is a tributary of the lake which takes its course at the far part of Korchiel and empties into River Benue at the south-west foot of Ribadu hills (Linus, 2025). Aquatic vegetation in the lake consists of mass floating weeds such as water lily, water lettuce, water hyacinth, typha grass and wild guinea corn which move on the lake according to the prevailing winds (Linus, 2025).

Sampling Stations

The lake was divided into three sampling stations A, B, and C, for the purpose of this study. Station A was located at the shore of the lake where human activities, like bathing, washing and other domestic activities, are taking place. Station B was located at the middle of the lake where there are fewer human activities, only fishing is supposed to take place. Station C was located downstream of the lake where irrigation is the major activity there.

Sample Collection

Three samples were collected once every month from each of the three-sampling station in Lake Ribadu during morning hours (7:00am – 8:00am), for a period of six months (July – December 2025). All the water samples were analyzed in the laboratory. Cool box was used in transporting the samples from the sampling site to the laboratory for analysis. It was ensured that all the sampling materials were sterilized to avoid contamination. Samples for plankton were collected from each station using plankton net of mesh size 55 μ m by hauling horizontally for five meters according to the method (Anene, 2003). The resultant concentrated plankton samples were then transferred to plastic containers, Samples collected for plankton were preserved in situ by adding 4ml Lugols iodine solution according to the methods (Boney, 1983; Anene, 2003). Then it was taken to the laboratory for analysis.

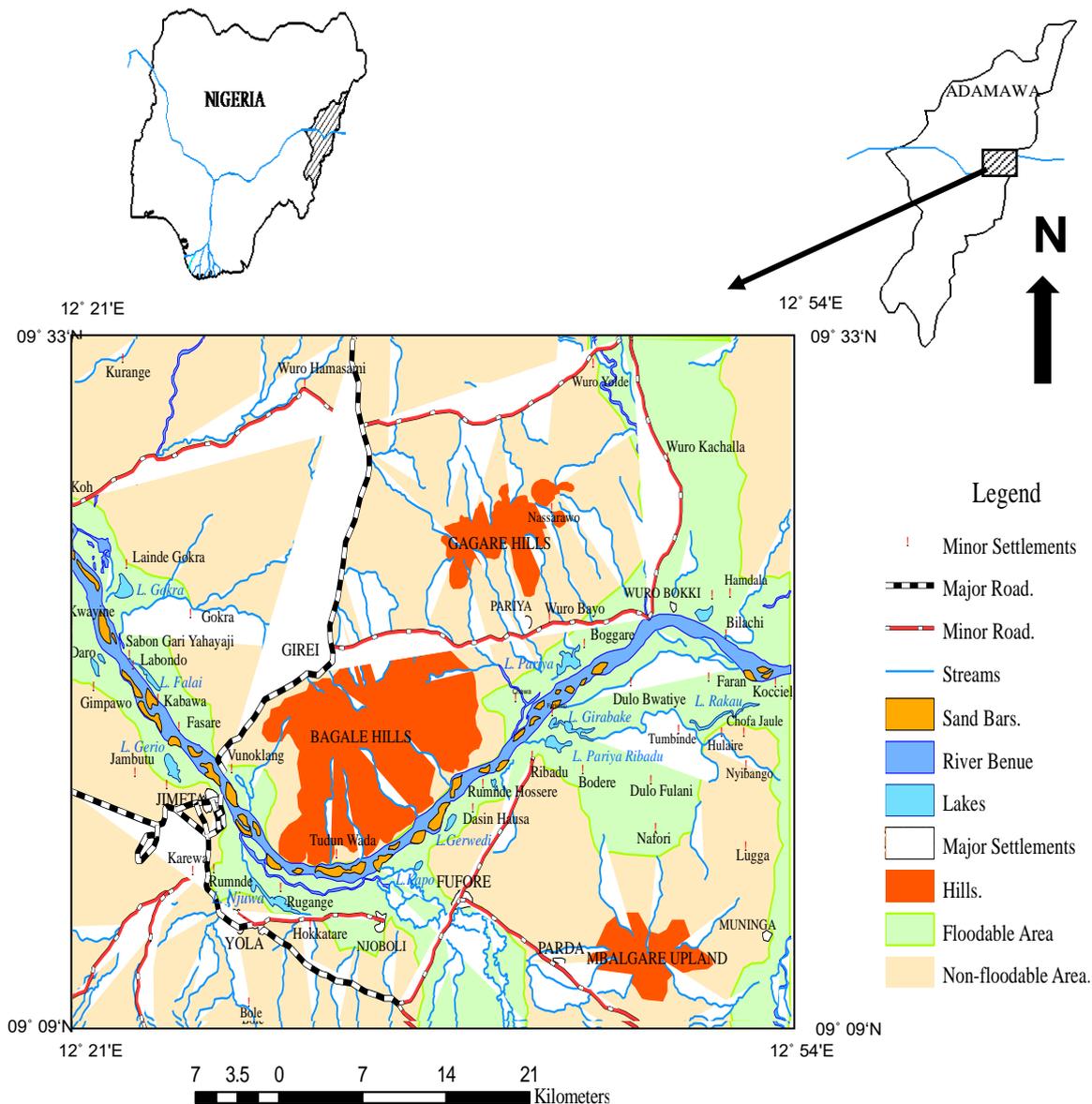


Figure 1: Map of Fufore LGA showing the Study Area (Lake Ribadu)
(Source: Department of Geography Adamawa State University Mubi, 2025)

Laboratory Procedures

The readings were taken for the physico-chemical parameters such as water temperature, turbidity, pH, dissolved oxygen, total dissolved solid, biochemical oxygen demand (BOD), Ammonia and conductivity, once every month.

Determination of Water Temperature

Temperature ($^{\circ}\text{C}$) of the water was measured by dipping a mercury in glass thermometer into the water at each station insitu for about 1-2 minutes then the readings were recorded, American Public Health Association (APHA, 1999).

Turbidity

Turbidity of Water from different stations was determined using a sechi disc. This was achieved by lowering the disc into the water gradually and a depth reading was taken at the point where the instrument just disappeared from your sight. The instrument was then gently raised, and another reading was taken at the point where the disc re-appears. The average of

the two readings was the correct reading for the water sample (Stirling, 1985).

Determination of Conductivity

This parameter was measured using portable Hand Large display conductivity pen (Model: 850037). Water samples were placed into clean beakers; conductance cell of the meter was immersed into samples. The electrode was placed into the sample for about 5 minutes before taking the readings (Golterman, et al., 1978).

Determination of Dissolve Oxygen

Dissolved oxygen was determined. In the field glass stopped at 100ml volume stopped the field with a sample avoiding any bubbling. Air should be trapped in the bottle after the stopper is placed. The bottle was opened and 1ml of each Manganous sulphate and alkaline reagents (potassium iodide plus potassium hydroxide) using separate pipette was poured in it. A precipitate appears. The stopper was placed and the bottle was shaken thoroughly. 2ml of H_2SO_4 (reagent) was added

and shaken thoroughly to dissolve precipitate. 50ml of content was transferred gently (avoiding bubbling) in a conical flask. Four (4) drops of starch indicator were added. Titration was done against sodium thiosulphate solution, and the end point was noted when initial blue color turns to colorless (Saxena, 1990)

Calculation:

50ml of contents were used for titration

$$DO(mg/l) = V_1 \times N \times 8 \times 1000$$

$$\frac{V_4(V_2 - V_3)}{V_2}$$

Where, DO= dissolved oxygen; V_1 = volume of titrant (ml); N = normality of titrant (0.025); V_2 = volume of sampling bottles after placing stoppers (ml); V_3 = volume of $MnSO_4 + (KI+KOH)$ added (ml); V_4 = volume of the contents used for titration (50ml); To obtain the value of DO in m/l divide the DO in mg/l by 1.43.

Biochemical Oxygen Demand (BOD)

100ml part of the sample was incubated for five days in dark cupboard at room temperature and dissolved oxygen was determined after five days 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 (APHA, 1999; Mahar, 2003).

Determination of Hydrogen Ion Concentration (pH)

pH was measured with Hanna 420 pH meter. 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 (APHA, 1999).

Total Dissolved Solids

The evaporating dish was weighed in milligrams (mg). Making sure that it is completely dry and completely cleaned of any extraneous particulate matter. The water sample was stirred in the beaker with a stirring stick vigorously enough to agitate the solution. This ensures that any particulate matter is more or less evenly distributed throughout the sample. 50 ml of the water was collected in a pipette still stirring the water while collecting the sample. the filtrate was Extracted 50 ml water sample from the pipette was put through the filter paper three times to ensure all particulate matter has been collected in the filter. The evaporating dish with the filtrate were Weighed and the filtrate was transferred to the evaporating dish that was weighed earlier. The filtrate was allowed to dry completely, and then the dry dish and filtrate are weighed in milligrams (mg).

The following formula was used to calculate the TDS of the solution:

$$TDS = (A-B) \times 1000 / \text{ml sample} \quad (3)$$

Where;

A = weight of the evaporating dish + filtrate

B = weight of the evaporating dish on its own.

Determination of Total Ammonia

The total ammonia was determined, Philips (1985). Samples collected were immediately filtered through pre-rinsed whatman GF/C filter paper. The phenol hypochloride method is adopted for freshwater samples. 1.0ml of phenol-nitroprusside reagent was added to 25ml of sample. It was mixed and 1.5ml of alkaline hypochloride reagent was added, the flask was covered and the mixture was left to stand in the dark for 1 hour at room temperature. The absorbance of standard ammonia stock was serially diluted with the same procedure

used for the samples and reagents and calibration curves were prepared using standard ammonia concentration.

Determination of Plankton Abundance, Composition and Distribution

Samples collected were homogenized by inverting the bottle few times, with a wide mouth pipette. 1ml of the plankton sub-sample was withdrawn from the field samples and was placed on a sedge-wick rafter-counting chamber with cover slip and was observed by direct microscopy. Keys provided by standard works of Umar, 2013, Botes, 2001, Emi and Catlin, 2007, APHA 1999 and various authors were used for species identifications.

Counts were made in triplicates, and their averages were taken and expressed as either cells/ml or organisms/ml of water. The number of organisms per litre of water was calculated from the following relationship.

$$\text{Number of organisms per liter of water} = \frac{\text{Number of organisms per liter of water} \times \text{volume of conc}}{\text{Volume of lake water filtered}} \quad (1)$$

The volume of the lake water filtered was calculated using the equation:

$$V = \pi r^2 L \quad (2)$$

Where

$$\pi = 3.1415$$

r = diameter of the net sampler ÷ 2

L = length haul by net in meters (Robert, 2003)

Statistical Analysis

All data were entered into excel and explored. Analysis of the data was conducted using one way ANOVA to determine the level of variation of physicochemical parameters across the three sites. Percentage was used to determine the abundance of the plankton species in the lake and in each month of the study period.

RESULTS AND DISCUSSION

Monthly Variations of Physicochemical Parameters of Lake Ribadu

Table 1-8 presented the monthly variations of physicochemical parameters sampled in Lake Ribadu from July to December 2025. The monthly variation of temperature ranged from 22.00 to 29.04 °C. The highest temperature of 29.04 °C in October was recorded from station C while the lowest temperature recorded was in station A and C with the value of 22.00 °C in December (Table 1). The monthly variation of turbidity ranged from 38.00 to 66.00 cm. The highest transparency value (66.00 cm) in station C was recorded in the months of September while the lowest turbidity recorded 38.00cm in station A in the month of July (Table 2).

The Conductivity Level within Lake Ribadu ranges between 100µs/cm and 159µs/cm. The highest conductivity value of 159µs/cm was recorded in the month of December in all stations and in November at station A and B. The lowest was 100µs/cm in station B in the month of July (Table 3). The Dissolved Oxygen of Lake Ribadu varied from 3.7 mg/L to 6.60 mg/l. The highest Dissolved Oxygen observed was 6.6 mg/l in station C in the months of December. While the lowest value observed was 3.7 mg/l in station C in the month of August (Table 4).

The monthly variation of Biochemical oxygen demand (BOD) ranged from 5.0 mg/l to 7.6 mg/l. The highest monthly value, 7.6 of BOD was observed in station C in the month of October while the lowest 5.0 mg/l was observed in station B in the month of July (Table 5). The monthly variations of

Hydrogen Ion Concentration (pH) ranged from 6.53 to 7.80. The highest pH of 7.8 was recorded from station A in the month of December. While the lowest pH record was in station B with the value of 6.53 in November (Table 6). The monthly variations of total dissolved solid in Lake Ribadu varied between 100.60 μ S/cm and 106.60 μ S/cm. The highest monthly value 106.86 μ S/cm of total dissolved solid was observed in station C in the month of November while

the lowest value 100.60 μ S/cm was observed in station B in the month of September was 100 μ S/cm in station B in the month of July (Table 7). The ammonia level in Lake Ribadu ranged from 0.03 in July and August to 0.08 mg/l in October. The highest ammonia of 0.08 mg/l was recorded in all stations in the month of October while the lowest ammonia 0.03 mg/l recorded was in all stations in the month of July and August (Table 8).

Table 1: Monthly Variations of Temperature Sampled in Lake Ribadu from July to December 2025

Temperature	July	August	September	October	November	December
Station A	28.00 ^a	24.50 ^a	29.00 ^a	28.00 ^{ab}	26.00 ^a	22.00 ^a
Station B	28.00 ^a	25.00 ^a	28.20 ^a	28.20 ^a	26.00 ^a	23.00 ^b
Station C	28.70 ^a	25.00 ^a	28.30 ^a	29.04 ^{ac}	27.00 ^b	22.00 ^a
Mean	28.20	24.83	28.5	28.14	26.33	22.33
SEM	0.23	0.17	0.25	0.32	0.33	0.33

NB: Means with same superscripts are not statistically different to each other and vice versa ($p < 0.05$)

Key:

Station A = Shore of the lake where anthropogenic activities are taking place

Station B = Middle of the lake where there are less human activities.

Station C = the downstream of the lake

SEM = Standard error of the mean

Table 2: Monthly Variations of Turbidity Sampled in Lake Ribadu from July to December 2025

Turbidity	July	August	September	October	November	December
Station A	43.00 ^a	38.00 ^a	40.00 ^a	39.00 ^a	41.00 ^a	40.50 ^a
Station B	48.00 ^{ac}	40.00 ^a	48.00 ^a	47.00 ^{ac}	47.00 ^{ac}	42.30 ^a
Station C	63.00 ^{bc}	39.00 ^a	66.00 ^b	64.00 ^{bc}	64.00 ^{bc}	41.50 ^a
Mean	51.33	39	51.33	50	50.67	41.43
SEM	6.01	0.58	7.69	7.37	6.89	0.52

NB: Means with the same superscript are not different to each other and vice versa at $p > 0.05$

Key:

Station A = Shore of the lake where anthropogenic activities are taking place

Station B = Middle of the lake where there are fewer human activities.

Station C = the downstream of the lake

SEM = Standard error of the mean

Table 3: Monthly Variations of Conductivity Sampled in Lake Ribadu from July to December 2025

Conductivity	July	August	September	October	November	December
Station A	101.00 ^a	102.00 ^a	110.00 ^a	155.00 ^a	159.00 ^a	159.00 ^a
Station B	100.00 ^a	106.00 ^b	110.00 ^a	154.00 ^a	159.00 ^a	159.00 ^a
Station C	106.00 ^b	107.00 ^b	111.00 ^a	155.00 ^a	158.00 ^a	159.00 ^a
Mean	102	105	110.33	154.67	158.67	159
SEM	1.9	1.53	0.33	0.33	0.33	0

NB: Means with the same superscript are not statistically different to each other and vice versa at $p < 0.05$

Key:

Station A = Shore of the lake where anthropogenic activities are taking place

Station B = Middle of the lake where there are fewer human activities.

Station C = the downstream of the lake

SEM = Standard error of the mean

Table 4: Monthly Variations of Dissolved Oxygen Sampled in Lake Ribadu from July to December 2025

Dissolved Oxygen	July	August	September	October	November	December
Station A	4.00 ^a	3.73 ^a	5.40 ^a	6.00 ^a	5.40 ^a	5.40 ^a
Station B	4.50 ^a	3.73 ^a	5.30 ^a	6.00 ^a	5.90 ^a	6.40 ^b
Station C	4.30 ^a	3.70 ^a	5.40 ^a	6.00 ^a	5.60 ^a	6.60 ^b
Mean	4.27	3.72	5.37	6	5.63	6.13
SEM	0.15	0.01	0.03	0	0.15	0.37

NB: Means with the same superscript are not statistically different to each other and vice versa at $p < 0.05$

Key:

Station A = Shore of the lake where anthropogenic activities are taking place

Station B = Middle of the lake where there are less human activities.

Station C = the downstream of the lake

SEM = Standard error of the mean

Table 5: Monthly Variation of Biochemical Oxygen Demand Sampled in Lake Ribadu from July to December 2025

BOD	July	August	September	October	November	December
Station A	5.16 ^a	5.10 ^a	5.20 ^a	6.20 ^a	5.80 ^a	6.70 ^a
Station B	5.00 ^a	5.16 ^a	5.30 ^a	7.40 ^b	5.90 ^a	5.90 ^a
Station C	5.30 ^a	5.16 ^a	5.40 ^a	7.60 ^b	5.78 ^a	5.80 ^a
Mean	5.15	5.14	5.3	7.07	5.83	6.13
SEM	0.09	0.02	0.06	0.44	0.04	0.29

NB: Means with the same superscript are not statistically different to each other and vice versa at $p < 0.05$

Key:

Station A = Shore of the lake where anthropogenic activities are taking place

Station B = Middle of the lake where there are less human activities.

Station C = the downstream of the lake

SEM = Standard error of the mean

Table 6: Monthly Variation of Hydrogen Ion Concentration (pH) Sampled in Lake Ribadu from July to December 2025

PH	July	August	September	October	November	December
Station A	6.81 ^a	6.80 ^a	7.00 ^a	7.20 ^a	6.85 ^a	7.80 ^a
Station B	6.93 ^a	6.94 ^a	7.10 ^a	7.00 ^a	6.53 ^{bc}	7.50 ^{bc}
Station C	6.79 ^a	6.80 ^a	7.00 ^a	7.10 ^a	6.70 ^{ac}	7.70 ^{ac}
Mean	6.84	6.85	7.03	7.1	6.69	7.67
SEM	0.04	0.05	0.03	0.06	0.09	0.09

NB: Means with the same superscript are not statistically different to each other and vice versa at $p < 0.05$

Key:

Station A = Shore of the lake where anthropogenic activities are taking place

Station B = Middle of the lake where there are less human activities.

Station C = the downstream of the lake

SEM = Standard error of the mean

Table 7: Monthly Variations of Total Dissolved Solids Sampled in Lake Ribadu from July to December 2025

TDS	July	August	September	October	November	December
Station A	101.53 ^a	112.00 ^a	101.53 ^a	106.00 ^a	106.53 ^a	106.54 ^a
Station B	104.80 ^{bc}	110.00 ^{bc}	100.60 ^{ab}	105.00 ^a	106.53 ^a	105.54 ^a
Station C	103.00 ^{ac}	111.00 ^{ac}	103.00 ^{ac}	105.80 ^a	106.86 ^a	105.00 ^a
Mean	103.11	111	101.71	105.6	106.64	105.69
SEM	0.95	0.58	0.7	0.31	0.11	0.45

NB: Means with the same superscript are not statistically different to each other and vice versa at $p < 0.05$

Key:

Station A = Shore of the lake where anthropogenic activities are taking place

Station B = Middle of the lake where there are less human activities.

Station C = the downstream of the lake

SEM = Standard error of the mean

Table 8: Monthly Variations of Ammonia Sampled in Lake Ribadu from July to December 2025

Ammonia	July	August	September	October	November	December
Station A	0.03	0.03	0.04	0.08	0.05	0.04
Station B	0.03	0.03	0.04	0.08	0.05	0.05
Station C	0.03	0.03	0.04	0.08	0.05	0.04
Mean	0.03	0.03	0.04	0.08	0.05	0.04
SEM	0.00	0.00	0.00	0.00	0.00	0.00

NB: Means with the same superscript are not statistically different to each other and vice versa at $p < 0.05$

Key:

Station A = Shore of the lake where anthropogenic activities are taking place

Station B = Middle of the lake where there are less human activities.

Station C = the downstream of the lake

SEM = Standard error of the mean

Plankton's Composition Assessment Result

Phytoplankton Composition

At the end of the six-month long survey, four families (*Bacillariophyceae*, *Chlorophyceae*, *Chrysophyceae*, and *Myxophyceae*) comprising of different species were identified (Table 8). A total of 433677 cells (individuals of each species)

were found distributed across 21 phytoplankton species (Table 9).

Most individuals of various species were more abundant in site A than in stations (B and C). Generally, there were more species cumulatively in station A than in site B and C, with 159542, 145973 and 128162 cells per litre in station A, B and C respectively, as can be seen (Table 10).

Most species were not found in some stations while some species (*Flagillaria*, *Ankistrodesmus*, *Anabaena*, *Aphanocopsa*) were found in all three stations with varying degrees of abundance (Table 10).

Bacillariophyceae recorded the highest with the percentage abundance of 37.8% followed by *Chlorophyceae*, *Cytophyceae* and *Chrysophyceae* having 35.12%, 25.82% and 1.53% respectively (Table 11).

As shown in Table 12, *bacillariophyceae* has the highest percentage abundance in the month of September (45.4%) and

the least was in the month of July (29.94%), *Chlorophyceae* has 39.94% as the highest in the month of August while the lowest was in the month of September (30.46%), *Myxophyceae* recorded 33.47% in July and 21.19% in November as the highest and lowest respectively, *Chrysophyceae* had highest 2.9% in October and 0.38% lowest in the month of July. There were no *chrysophyceae* species recorded in December.

Table 9: Phytoplankton Species Observed and their Taxa

<i>Bacillariophyceae</i>	<i>Chlorophyceae</i>	<i>Myxophyceae</i>	<i>Chrysophyceae</i>
<i>Flagillaria</i>	<i>Ankistrodesmus</i>	<i>Aphanocopsa</i>	<i>Mallomonas</i>
<i>Tabellaria</i>	<i>Chlorella</i>	<i>Anabaena</i>	<i>Synuva</i>
<i>Naviculales</i>	<i>Ulothrix</i>	<i>Oscillatoria</i>	
<i>Nitzschia</i>	<i>Enteromorphy</i>	<i>Aphanizomenon</i>	
<i>Cyclotella</i>	<i>Closterium</i>		
	<i>Oocystics</i>		
	<i>Eudorina</i>		
	<i>Zugnema</i>		
	<i>Microspora</i>		

Table 10: Total Phytoplankton in Lake Ribadu

Taxa and species	July	August	September	October	November	December	Total Abundance	%Abundance
<i>Flagillaria</i>	19253	28802	22105	21579	20000	13157	124896	28.79931377
<i>Tabellaria spp</i>	1025	-	10000	1052	3158	-	15235	3.512983165
<i>Naviculales</i>	-	1569	-	2105	526	-	4200	0.968462704
<i>Nituschia</i>	-	1930	526	-	-	-	2456	0.566320095
<i>Cyclotella</i>	-	-	8948	-	1579	5369	15896	3.665400748
<i>Ankistrodesmus</i>	11948	24956	20000	19833	12106	8948	97791	22.54927054
<i>Chlorella</i>	7342	11399	-	-	-	-	18741	4.321418936
<i>Ulothrix</i>	4200	-	2632	-	526	-	7358	1.696654423
<i>Enteromorphy</i>	1035	-	-	-	-	-	1035	0.238656881
<i>Closterium</i>	-	562	526	2105	1053	1579	5825	1.343165536
<i>Eudorina</i>	-	-	1053	-	-	-	1053	0.242807435
<i>Oocystic</i>	-	-	2632	-	6843	3684	13159	3.034285886
<i>Zugrema</i>	-	-	1053	-	526	-	1579	0.364095859
<i>Microspora</i>	-	-	-	2632	1053	2106	5791	1.335325599
<i>Aphanocopsa</i>	18042	18705	13158	18948	11053	6895	86801	20.01512647
<i>Anabaena</i>	3554	1035	1053	2106	1579	5632	14959	3.44934133
<i>Oscillatoria</i>	1068	-	-	-	526	-	1594	0.367554655
<i>Aphanizomenon</i>	-	1795	6842	-	-	-	8637	1.991574374
<i>Mallomonas</i>	-	1678	1053	2105	1579	-	6415	1.479211487
<i>Synuva</i>	256	-	-	-	-	-	256	0.059030108
Grand TOTAL	67723	92431	91581	72465	62107	47370	433677	100

Table 11: Phytoplankton Percentage Abundance in the Study Area Across the 3 Stations A, B, C

Taxa and Species	Station A	Percentage A	Station B	Percentage B	Station C	Percentage C	Total Abundance
<i>Flagillaria</i>	40945	25.66408845	45067	30.87351771	38884	30.33972628	124896
<i>Tabellaria spp</i>	11025	6.910406037	1578	1.081021833	2632	2.053650848	15235
<i>Naviculales</i>	1568	0.982813303	526	0.360340611	2106	1.643232784	4200
<i>Nituschia</i>	1831	1.147660177	625	0.428161372	-	-	2456
<i>Cyclotella</i>	4843	3.035564303	7368	5.047508786	3685	2.87526724	15896
<i>Ankistrodesmus</i>	37516	23.51481115	35268	24.16063245	25007	19.51202384	97791
<i>Chlorella</i>	7637	4.786827293	3826	2.621032657	7278	5.678750332	18741
<i>Ulothrix</i>	6305	3.951937421	-	-	1053	0.821616392	7358
<i>Enteromorphy</i>	-	-	-	-	1035	0.807571667	1035
<i>Closterium</i>	3685	2.309736621	1088	0.745343317	1052	0.820836129	5825
<i>Eudorina</i>	1053	0.660014291	-	-	-	-	1053
<i>Oocystic</i>	4737	2.969124118	4211	2.884780062	4211	3.285685305	13159

Taxa and Species	Station A	Percentage A	Station B	Percentage B	Station C	Percentage C	Total Abundance
<i>Zugrema</i>	-		-		1579	1.232034456	1579
<i>Microspora</i>	2106	1.320028582	2106	1.44273256	1579	1.232034456	5791
<i>Aphanocopsa</i>	27509	17.2424816	35263	24.15720715	24029	18.74892714	86801
<i>Anabaena</i>	4063	2.546664828	6317	4.327512622	4579	3.572821897	14959
<i>Oscillatoria</i>	562	0.352258339	-		1032	0.80523088	1594
<i>Aphanizomenon</i>	1795	1.125095586	-		6842	5.33855589	8637
<i>Mallomonas</i>	2106	1.320028582	2730	1.870208874	1579	1.232034456	6415
<i>Synuva</i>	256	0.160459315	-		-		256
Total	159542	100	145973	100	128162	100	433677

Table 12: Total Percentage Distribution of Phytoplankton in Lake Ribadu

Taxa	Number of cells per litre	% abundance
<i>Bacillariophyceae</i>		37.8
<i>Chlorophyceae</i>	152332	35.12
<i>Myxophyceae</i>	111991	25.82
<i>Chrysophyceae</i>	6671	1.53
Total	433677	100

Table 13: Monthly % Abundance of Phytoplankton

Taxa	July	August	September	October	November	December
<i>Bacillariophyceae</i>	29.94	34.95	45.4	34.14	40.68	39.11
<i>Chlorophyceae</i>	36.21	39.94	30.46	33.91	35.59	34.45
<i>Myxophyceae</i>	33.47	23.29	22.99	29.05	21.19	26.44
<i>Chrysophyceae</i>	0.38	1.82	1.15	2.9	2.54	-

Zooplankton Composition

At the end of the research Zooplankton species observed were 21 drawn from 6 taxa (*cladocera* 2, *copepod* 3, *rotifer* 2, *protozoa* 7, *macroinvertebrates* 6 and *Fishlarvae* 1) table 13 shows species for each family represented. 125416 individual's cells per litre of zooplankton were observed. Most individuals of various species were more abundant in the month of August (29469 individual cells per litre) and the least was in the month of December (12789 individual cells per litre) while some species were not found in some of the months (Table 14). Generally, there were more species cumulatively in station A than in station B and C, with 50685, 43683 and 31048 individual cells per litre respectively. Some species like *dytyscidae* were unique to only one station while most species were found in all three sites with varying degree of abundance (Table 15).

Table 16 shows that *copepoda* was recorded as the highest in the lake with 38.18% abundance followed by macroinvertebrates (21.82%), *cladocera* (16.37%), protozoa (10.49%), fish larvae (7.2%) and the least was *rotifera* (5.87%) abundance. Table 17 shows that *Cladocrea* was higher in the month of December and November having 25.8 and 24.69 % abundance respectively. The lowest abundance

was recorded in the month of July, having 8.89 % abundance. *Copepoda* was also recorded in all the month with a maximum number in the month of November having 53.49 % abundance and a minimum of 31.82 % abundance in the month of September. *Rotifera* was observed in all months except October. The highest and lowest percentage abundance was recorded in the months of December and August having 12.89 % and 3.57 % abundance respectively. Protozoa were also observed in all the months. A higher number was observed in the month of July (17.8% abundance). The lowest abundance was recorded in the month of November with a percentage abundance of 8.22%.

Macroinvertebrates were recorded in the month of July, August, September and October. The maximum abundance was recorded in the month of July having 33.33% abundance. The minimum was recorded in the months of August and December having 26.79% and 26.31% abundance respectively. Fish larvae were observed in all the months except the month of July. A higher number was recorded in the month of August having 10.71% abundance Lower abundance was recorded in the month of September recording 6.85% abundance.

Table 14: Zooplankton Species Observed and their Taxa

<i>Cladocera</i>	<i>Copepoda</i>	<i>Rotifera</i>	<i>Protozoa</i>	Macroinvertebrates	Fish larvae
<i>Bosmina</i>	<i>Nauplius</i>	<i>Notholca</i>	<i>Paramecium</i>	<i>Chironomidae</i>	Fish larvae
<i>Daphnia</i>	<i>Diaptomus</i>	<i>Brachionus</i>	<i>Chlymadomonas</i>	<i>Mosquitoes larvae</i>	
	<i>Senecella</i>		<i>Hylosphenia</i>	<i>Dystticideae</i>	
			<i>Coleps</i>	Stone fly	
			<i>Arcella</i>	Shrimp	
			<i>Cryptomanus</i>	May fly	
			<i>Gymnodiniym</i>		
			<i>Vannela</i>		

Table 15: Total Abundance of Zooplankton in Lake Ribadu

Species	July	August	September	October	November	December	Total Abundance	% Abundance
<i>Bosmina</i>	2105	-	-	-	1052	1579	4736	3.776232698
<i>Daphnia</i>	-	4738	3685	2632	2106	2632	15793	12.59249219
<i>Nauplius</i>	4738	7363	3159	3158	3159	3158	24735	19.72236397
<i>Diaptomus</i>	3158	2631	3684	3158	2105	2632	17368	13.84831281
<i>Senecella</i>	-	-	526	2632	1578	1053	5789	4.61583849
<i>Notholca</i>	1579	1052	-	-	526	1052	4209	3.356031128
<i>Brachionus</i>	-	-	2105	-	-	1052	3157	2.517222683
<i>Paramecium</i>	-	526	1052	526	526	526	3156	2.516425336
<i>Chlamydomonas</i>	2106	1052	-	-	-	-	3158	2.518020029
<i>Hylosphenia</i>	-	1052	526	-	-	-	1578	1.258212668
<i>Cloleps</i>	1052	-	-	526	-	-	1578	1.258212668
<i>Arcella</i>	1053	-	-	-	-	-	1053	0.839605792
<i>Gymnodinium</i>	-	-	526	-	-	526	1052	0.838808445
<i>Vannella</i>	-	-	-	526	526	526	1578	1.258212668
<i>Chironomidae</i>	-	-	-	526	-	-	526	0.419404223
<i>Mosquito Larvae</i>	4211	4210	3685	3158	-	-	15264	12.17069592
<i>Dytiscidae</i>	-	-	-	526	-	-	526	0.419404223
Stone fly	1579	-	526	-	-	-	2105	1.678414237
Shrimp	2105	3687	2105	-	-	-	7897	6.296644766
May fly	-	-	-	1052	-	-	1052	0.838808445
Fish larvae	-	3158	1579	1579	1211	1579	9106	7.260636601
GRAND TOTAL	23686	29469	23158	19999	12789	16315	125416	100

Table 16: Zooplankton Percentage Abundance in the Study Area Across the 3 Stations A, B, C

Taxa and Species	Station A	Percentage (A)	Station B	Percentage(B)	Station(C)	Percentage (C)	Total Abundance
<i>Bosmina</i>	2105	4.153102496	1053	2.410548726	1578	5.082452976	4736
<i>Daphnia</i>	6843	13.50103581	4738	10.84632466	4212	13.56609121	15793
<i>Nauplius</i>	11049	21.79934892	7369	16.86926264	6317	20.345916	24735
<i>Diaptomus</i>	7896	15.57857354	5789	13.25229494	3683	11.86227776	17368
<i>Senecella</i>	2105	4.153102496	1579	3.614678479	2105	6.779824787	5789
<i>Notholca</i>	2105	4.153102496	1052	2.408259506	1052	3.388301984	4209
<i>Brachionus</i>	1052	2.075564763	1579	3.614678479	526	1.694150992	3157
<i>Paramecium</i>	526	1.037782381	1578	3.612389259	1052	3.388301984	3156
<i>Chlamydomonas</i>	1579	3.115320114	1579	3.614678479	-	-	3158
<i>Hylosphenia</i>	1052	2.075564763	526	1.204129753	-	-	1578
<i>Cloleps</i>	1052	2.075564763	-	-	526	1.694150992	1578
<i>Arcella</i>	-	-	1053	2.410548726	-	-	1053
<i>Gymnodinium</i>	526	1.037782381	-	-	526	1.694150992	1052
<i>Vannella</i>	526	1.037782381	526	1.204129753	526	1.694150992	1578
<i>Chironomidae</i>	-	-	-	-	526	1.694150992	526
<i>Mosquito Larvae</i>	4738	9.347933314	5789	13.25229494	4737	15.25702139	15264
<i>Dytiscidae</i>	-	-	526	1.204129753	-	-	526
Stone fly	1053	2.077537733	526	1.204129753	526	1.694150992	2105
Shrimp	2108	4.159021407	4211	9.639905684	1578	5.082452976	7897
May fly	526	1.037782381	-	-	526	1.694150992	1052
Fish larvae	3844	7.584097859	4210	9.637616464	1052	3.388301984	9106
TOTAL	50685	100	43683	100	31048	100	125416

Table 17: Total Percentage Distribution of Zooplankton in the Lake

Taxa	Number of cells per liter	% abundance
<i>Cladocera</i>	20529	16.37
<i>Copepoda</i>	47892	38.18
<i>Rotifera</i>	7366	5.87
<i>Protozoa</i>	13153	10.49

Taxa	Number of cells per liter	% abundance
Macroinvertebrates	27370	21.82
Fishlarvae	9106	7.2
Total	125416	100

Table 18: Monthly % Abundance of Zooplanktons

Class	July	August	September	October	November	December
<i>Cladocera</i>	8.89	16.08	15.91	13.16	24.69	25.81
<i>Copepoda</i>	33.33	33.91	31.82	44.74	53.49	41.94
<i>Rotifera</i>	6.67	3.57	9.09	-	4.11	12.89
<i>Protozoa</i>	17.78	8.92	9.01	7.89	8.23	9.67
Macroinvertebrates	33.33	26.79	27.27	26.31	-	-
Fishlarvae	-	10.72	6.82	7.89	9.47	9.68

Discussion

Physicochemical Parameters

Recent studies show that elevated or abnormally low water temperatures significantly impair aquatic organisms by increasing physiological stress, reducing resistance to pollutants, and heightening vulnerability to diseases and parasites (Itua *et al.*, 2024)

The higher temperature recorded in the month of October was 29.04 °C which is characterized by low rainfall and high sun rays. The high temperature observed in this study was due to the intensity of sunlight and possibly the shallowness of the lake, which exposed the water body and sediment to the heat of the sun. This work agreed with Abubakar (2014) who states that Climatic factors are determining factors for increase or decrease in temperature in the arid zone.

Recent findings by Jonah (2025) similarly demonstrate clear seasonal fluctuations in water temperature and other physicochemical properties in Nigerian freshwater systems, reinforcing the established pattern of temperature minima during cooler seasonal periods.

The result of the findings also agreed with previous reports that the temperatures in tropics vary between 21 °C and 32 °C (Kramer and Botterweg, 1991; Ayoade *et al.*, 2006; Atobatele and Ugwumba, 2008). This implies that the temperature range in Lake Ribadu is suitable for aquatic growth. Ayoade *et al.* (2006), recommended temperature range of 20 – 30 °C for optimum fish growth (Lewis, 2000) Also, Wetzel (1983) observed increase in temperature increase the rate of molting and brooding. Since the temperature of water in Lake Ribadu ranged from 22°C to 29.04°C. These studies show that there is a gradual increase in temperature during the sampling periods and this might be a driving factor responsible for plankton abundance in the water. Therefore, water temperature increases the rate of reproduction in water bodies.

Dissolved oxygen is a crucial factor that helps in the survival of aquatic organisms. The lowest means Dissolved Oxygen of 3.72 mg/L in the month of August observed and the highest means Dissolved Oxygen of 6.13mg/Lin the month of December observed were within the acceptable range. This agrees with McNeely *et al.*(1979) who reported that natural surface water has dissolved oxygen less than 10mg/L. Low dissolved oxygen affects the growth of many aquatic life, oxygen helps in metabolic activities (Charles, 2003). Therefore, adequate dissolved oxygen is necessary element to all processes of life. It was observed in the study that dissolved oxygen of the lake was within the acceptable range thus, the plankton abundance. The dissolved oxygen observed in Lake Ribadu was significantly higher during the dry season than the rainy season. The high oxygen value for the dry season coincides with periods of lowest turbidity and

temperature. The high DO observed in dry season might be as result of cool harmattan wind which increases wave action and decreases surface water. Temperature might have contributed to the increased oxygen concentration during the dry season while the overflow of water from rivers created increased turbidity and increased oxygen concentration during the rainy season. ; The relationship between temperature and oxygen is that, as the temperature increases, the oxygen level decreases, that is to say, cold water holds more oxygen than warm water. Dissolved oxygen concentrations in natural waters are not constant but fluctuate due to factors such as temperature, atmospheric exchange, depth, and biological activity. Recent studies show that oxygen availability in aquatic habitats can vary widely, often shifting between high saturation and low-oxygen conditions as environmental and biological processes interact (Fusi *et al.*, 2023). Similarly, modern water-quality assessments confirm that DO levels are strongly shaped by temperature, pressure, salinity, and microbial degradation, and natural waters typically exhibit DO well below full saturation (Singh *et al.*, 2025)

The mean conductivity of Lake Ribadu generally varied significantly ($P < 0.05$). The lowest mean value was 102 $\mu\text{S}/\text{cm}$ in the month of July, and the highest mean value was 159 $\mu\text{S}/\text{cm}$ in the month of December. This agrees with the findings (Ja'afaru *et al.*, 2013), in Lake Alau were the mean conductivity of Lake Alau generally varied significantly ($P < 0.05$) and ranged between $95.8 \pm 3.04 \mu\text{S}/\text{cm}$ and $121.2 \pm 8.24 \mu\text{S}/\text{cm}$ throughout the period of study. Higher value recorded in December was in line with finding of previous study on the Alau Lake by Idowu *et al.* (2004). Higher conductivity in the month of December may be possibly due to the concentration of the ions because of decreased flow from other Rivers Benue and possibly decreased depth following dry season.

This present research agrees with the findings of Kiourt *et al.* (2023), who classified conductivity levels into low, medium, and high categories. The conductivity observed in Lake Ribadu ranged from 100 to 159 $\mu\text{S}/\text{cm}$, placing it within the medium conductivity range, which supports favorable plankton abundance.

The turbidity of Lake ribadu shows that there is no significant difference ($P > 0.05$) throughout the study period. The values of turbidity recorded in Lake Ribadu were low compared with the findings of Ja'afaru *et al.* (2013) in Lake Alau. The mean turbidity values showed signs of good quality environments during the study period. This may be linked to less or reduced disturbance of the water body by canoe paddlers, reduced irrigation activities by farmers. This may also be linked with the increased restriction of human activities by the security in the area (Curtis and Sloan 2004; Idowu *et al.*, 2004) observed

that Primary production is reduced in turbid waters because of decreased photosynthesis due to low light penetration. This range of 39.0 cm to 51.33 cm indicated that the water was not very turbid, therefore, all the stations received relatively equal amount of light from the sun, and this might be responsible for the presence of phytoplankton in all the stations. And the slight decrease in zooplankton at the early onset of the rain may be due to decrease in phytoplankton which serves as nutrients to them because of high turbidity. The turbidity ranged from 38cm to 66cm this is in line with the findings (Idowu *et al.*, 2004) who reported that the relationship between conductivity and transparency is that an increase in transparency, increases suspended materials in water and subsequently decreases conductivity which results in a decrease in light penetration and phytoplankton growth.

The pH range recorded in this study is moderate and falls within the recommended limits for aquatic life. Recent research establishes 6.5–9.0 as the ideal pH range for freshwater fish, beyond which physiological stress occurs (Swain *et al.*, 2020). Studies from Nigerian aquaculture systems also report typical pH values between 6.70 and 7.87, confirming suitability for fish production (Onajobi *et al.*, 2023). In addition, field assessments of Nigerian coastal waters document pH values around 7.4–7.7, further supporting these recommendations (Ayo-Olalusi *et al.*, 2022). For tropical fish, a practical optimum range of 6.5–7.8 is widely accepted (All About Tropical Fish, 2024)

Generally, the obtained pH values of Lake Ribadu fall within the World Health Organization-aligned acceptable pH range of 6.5 to 8.5, which is the widely recommended standard for drinking water and recreational water quality. Recent guidance shows that the U.S. EPA and WHO-aligned recommendations both place safe drinking water within the 6.5–8.5 pH range, confirming that the lake's pH values are suitable for human use and aquatic ecosystem health

Therefore, this indicated that various anthropogenic activities inputs did not alter the pH of the lake. PH this is the measure of hydrogen ions concentration. High water pH can affect reproduction, cause death too many aquatic organisms, inability to dispose metabolic wastes and low pH can cause shock and sudden increase in number of some plankton species.

The BOD value was significantly higher in October (7.60 mg/L) compared to the other months sampled. This increase is likely due to elevated organic matter entering the lake during the rainy season, as surface runoff and overflow transport decomposable materials into the waterbody. Recent studies similarly report that BOD levels rise during the wet season because of increased organic loading from runoff and anthropogenic inputs. For example, Etuk *et al.* (2023) found higher BOD concentrations in major Niger Delta rivers during the wet season, linked to rainfall-driven increases in organic matter. Likewise, Jonah *et al.* (2025) observed that seasonal runoff significantly elevates BOD in the Qua Iboe River, confirming the strong influence of wet-season hydrology on oxygen-demanding pollutants who reported that BOD is a fair measure of cleanliness of any water on the bases that values of less than 2 mg/l are clean, 3 -5 mg/l, fairly clean and 10 mg/l definitely bad and polluted.

Total dissolved solids were significantly higher in the dry seasons than those observed in the wet season. Abolude *et al.* (2012) reported that total dissolved solids or particulate matter in fresh or marine waters are of importance to aquaculture because they may damage fish gills and interfere with respiration. Secondly, they may cause siltation and smothering of benthos and interference with feeding of bivalve filter feeders. High turbidity due to suspended solids

also reduce photosynthesis and hence production of phytoplankton and submerged periphytoplankton. Suspended organic solids in high content may exert a biological oxygen demand and lead to oxygen depletion.

According to the guidelines provide by FEPA (1991) the total dissolved solids observed in Lake Ribadu are much less than the upper limit set that could cause pollution.

The monthly mean total ammonia concentration (0.030–0.08 mg/L) observed in this study is slightly higher than values reported in earlier Nigerian freshwater studies but still within environmentally relevant ranges. Elevated ammonia levels are commonly associated with increased decomposition of organic matter, a process that releases ammonia as a final breakdown product of proteins and nitrogenous wastes. Recent studies in Nigeria confirm that ammonia concentrations tend to rise during periods of high organic input, often due to surface runoff, wastewater intrusion, and decaying vegetation. For example, Jonah *et al.* (2025) reported ammonia values ranging from 1.85–17.95 mg/L in the Qua Iboe River, identifying surface runoff and anthropogenic activities as major contributors to elevated ammonia levels. Similarly, Ubani *et al.* (2024) found that ammonia levels in urban rivers of Enugu were consistently above WHO limits across both seasons, linking the increases to untreated sewage, effluents, and organic matter influx. These recent findings support the interpretation that the higher ammonia values in this study likely resulted from organic matter decomposition and excretory products of aquatic organisms, consistent with known nitrogen-cycle dynamics.

Plankton Composition

Phytoplankton

Seasonal variation in phytoplankton community structure is strongly influenced by hydrological and water-circulation dynamics, which differ markedly between the wet and dry periods of tropical aquatic systems. Recent studies show that shifts in water flow, nutrient loading, and turbidity during seasonal transitions are the primary drivers of changes in phytoplankton abundance and composition. For example, Okere *et al.* (2020) reported that phytoplankton communities in Lagos lagoon waters varied significantly with rainfall-driven changes in nutrient input and suspended solids, with Bacillariophyceae identified as the dominant group across seasons. Similarly, Xu *et al.* (2025) found that diatoms (Bacillariophyceae) remained the most abundant phytoplankton class during flood-season conditions in a tropical estuarine ecosystem, reflecting their ability to thrive in nutrient-rich, dynamic environments. During the six-month study period (July–December), the higher abundance of Bacillariophyceae followed by Chlorophyceae aligns well with these recent findings, supporting the view that seasonal hydrological changes enhance diatom proliferation through increased nutrient availability and mixing.

A total number of twenty-one (21) species of planktons were identified during the study period. Out of these 9 were *Chlorophyceae*, 5 *Bacillariophyceae*, 4 *Myxophyceae* and 2 *Chrysophyceae*. Generally, plankton species composition was similar in all three sites. This is similar with the findings (Mohammed *et al.*, 2009; Anago *et al.*, 2011) reported phytoplankton and zooplankton abundance in a study of phytoplankton diversity from Koil Coastal waters India and Awba Reservoir Ibadan Nigeria respectively. The findings of present study show *Bacillariophyceae* (37.5%), *Chlorophyceae* (35.12%), *Myxophyceae* (25.82%), and *Chrysophyceae* (1.53%). The *Bacillariophyceae* had the highest % abundance. Dike and Adedolapo (2012), reported *Bacillariophyceae* (53.25%), *Cyanophyceae* (21.25%),

Chlorophyceae (10.33%), *Chrysophyceae* (4.84%), *Pyrrophyceae* (4.57%), *Xanthophyceae* (3.39%), and *Euglenophyceae* (2.42%) in studies of seasonal dynamics in plankton abundance and diversity of freshwater body in Nigeria. The more conclusive evidence for compositions in phytoplankton diversities was the pattern at which the plankton keeps changing monthly. The result showed that from the month of July to August there was moderate abundance in all the phytoplankton species then a decline, through the months of September, October and declined again in November and December. The slight differences in phytoplankton species distribution amongst the months are probably due to rainfall which can increase nutrients because of overflow from the catchment areas of Lake and ability of the individual species to multiply rapidly.

Zooplankton

In this research 20 zooplankton species were identified belonging to 6 taxa (*cladocera*, *copepod*, *rotifera*, *protozoa*, macroinvertebrates and fish larvae). The cluster of species in Lake Ribadu shows lower value of some zooplankton in early set of the rain. The zooplankton includes *Protozoa* 8, *Cladoceran* 2, *Copepods* 3, *Rotifer* 2, *Macroinvertebrates* 6 and fish larvae 1. Zooplankton percentage abundance recorded were Copepods (38.18%), Macroinvertebrates (21.82%), *Cladoceran* (16.37%), and *Protozoa* (10.49%) *Pisces* (7.26%) *Rotifera* (5.2%). Their distributions might be due to availability of nutrients in water. This agrees with the findings (Kolo et al., 2010), Jerling and Wooldridge (1995) who reported that the zooplankton was dominated by *Copepoda* and phytoplankton was dominated by *Bacillariophyceae* (diatoms) which were more abundant after flood. Macroinvertebrates were the second most abundant zooplankton having 21.82% abundance. USEPA, (2002) reported that Planktons are organisms that are large (macro) enough to be seen with the naked eye and lack a backbone (invertebrate). They inhabit all types of running waters, from fast-flowing mountain streams to slow-moving muddy rivers.

These results contrast the findings of Kolo et al., (2010) who revealed that plankton abundance in the reservoir was in the order: *Crustaceans* > *Cynophyceae* > *Protozoans* > *Rotifiers* > *Bacillariophyceae* > *Desmidaceae* > *Chlorophyceae*. While species diversity of zooplankton was in the following order: *Protozoans* > *Crustaceans* > *Rotifiers*, phytoplankton followed the order of *Chlorophyceae* > *Bacillariophyceae* > *Cynophyceae* > *Desmidaceae*. Plankton abundance of the reservoir was greatly influenced by season although not influenced by station. *Bacillariophyceae* was positively and significantly correlated with *Chlorophyceae*, *Crustaceans* and *Cynophyceae* ($P < 0.05$)

Zooplankton are widely recognized as sensitive bio-indicators of aquatic pollution, as fluctuations in water quality parameters directly influence their composition, abundance, and diversity. Recent studies confirm that changes in physicochemical characteristics—such as dissolved oxygen, turbidity, nutrient levels, and organic pollution—produce corresponding shifts in zooplankton distribution and population density. For example, Antakil & Umaru (2025) reported that zooplankton groups in Kawo Dam (Niger State) showed noticeable fluctuations in abundance that closely followed seasonal changes in water quality and increased pollutant loading during runoff periods. Similarly, Mohammed et al. (2023) found that temporal variations in zooplankton abundance in Lapai-Gwari Stream were strongly linked to environmental factors such as alkalinity, total dissolved solids, and rainfall-driven inputs, with indicator

species (e.g., *Brachionus* spp., *Asplanchna* spp.) signaling perturbed water conditions.

The present study showed that although the zooplankton species composition remained consistent throughout the July–December sampling period, there were clear month-to-month changes in the number of individuals within species. This pattern aligns with recent findings that zooplankton abundance is highly responsive to seasonal environmental variability. Seasonal rainfall, nutrient influx, and hydrological shifts often affect food availability, predation pressure, and water quality, leading to dynamic fluctuations in zooplankton numbers even when species richness remains stable. This observation is therefore consistent with the well-documented influence of environmental factors on zooplankton community structure in tropical aquatic ecosystems.

CONCLUSION

The study assessed the physicochemical characteristics and plankton composition of Lake Ribadu over a six-month period from July to December 2025 using three sampling stations. The results showed that the measured physicochemical parameters—including temperature, turbidity, conductivity, pH, dissolved oxygen, biochemical oxygen demand (BOD), total dissolved solids, and ammonia—were within the recommended limits for drinking water and aquatic life as established by the World Health Organization (WHO, 2006). These findings suggest that the lake water quality during the study period remained generally suitable for fish production and other aquatic organisms.

Seasonal variations significantly influenced several physicochemical parameters, particularly temperature, conductivity, transparency, dissolved oxygen, and biochemical oxygen demand ($p \leq 0.05$). However, there was no significant variation among the sampling stations, indicating relatively uniform environmental conditions across the lake. The study also revealed a diverse plankton community. A total of forty-one Plankton species were identified, including twenty species of phytoplankton and twenty-one taxa of zooplankton belonging to different major g

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