Sahel Journal of Life Sciences FUDMA (SAJOLS)
March 2025 Vol. 3(1): 173-181
ISSN: 3027-0456 (Print)
ISSN: 1595-5915(Online)
DOI: *https://doi.org/10.33003/sajols-2025-0301-20*

Research Article

Ensuring Clean Water for All: The Vital Importance of Assessing Lake Alau Water Quality Index

***Abasiryu, A.[1,2], Fabian, Z. L.[2] and Abubakar, K. A.[2]**

[1]**Department of Biological Sciences, Federal University Dutsin-Ma, Katsina State, Nigeria**
[2]**Department of Zoology, Modibbo Adama University Yola, Adamawa State, Nigeria**
****Corresponding Author's email***: abasiryu@fudutsinma.edu.ng; ***Phone***: +2348133335300

ABSTRACT

This study evaluates the Water Quality Index (WQI) of Lake Alau in Borno State, Nigeria, to determine its appropriateness for consumption, fish culture, and industrial use. Lake Alau, formed by damming the Ngadda River, is a critical water source for Maiduguri Metropolis and surrounding agricultural areas. The study was conducted over 18 months, from January 2019 to June 2020, across three sampling stations, assessing key physicochemical parameters including temperature, dissolved oxygen (DO), biological oxygen demand (BOD), nitrate (NO^3), and nitrite (NO^2). The findings reveal that Lake Alau's WQI is 30.96, categorizing it as 'good' and suitable for various uses. Despite significant anthropogenic activities such as agriculture and settlements around the lake, water quality parameters remain within acceptable Limits established by the World Health Organization. (WHO). The study highlights the lake's resilience and ability to maintain water quality amidst external pressures. Seasonal variations influenced water temperature, with the lowest temperatures recorded during the harmattan season correlating with higher DO levels. Nitrate and nitrite concentrations were well below hazardous levels, ensuring the safety of aquatic life and human consumption. The study underscores the importance of continuous monitoring, pollution control measures, community education, and sustainable practices to preserve Lake Alau's water quality. By maintaining these efforts, Lake Alau can continue to provide clean water, support biodiversity, and meet the needs of the local population, thereby contributing to the broader goal of ensuring clean water for all.

Keywords: Lake Alau; Water Quality; Water Quality Index (WQI); Physicochemical parameters

Citation: Abasiryu, A., Fabian, Z.L. & Abubakar, K.A. (2025). Ensuring Clean Water for All: The Vital Importance of Assessing Lake Alau Water Quality Index. *Sahel Journal of Life Sciences FUDMA*, 3(1): 173-181. DOI: *https://doi.org/10.33003/sajols-2025-0301-20*

INTRODUCTION

Water is the essence of life, a fundamental resource upon which all living organisms depend, and one of the key resources that man is exploiting more than any other resource for life sustenance (Rana and Guleria, 2018). It quenches our thirst, irrigates our crops, supports aquatic life, and plays a pivotal role in industrial processes (Flannery *et al.,* 2004). However, in an increasingly interconnected world facing mounting environmental challenges, the quality of our water sources is under constant threat due to the surge of various human activities (Rana and Guleria, 2018).

Water quality is a measure of the characteristics of water in terms of its chemical, physical, biological, and radiological properties. Kumar and Aravindh, (2020), opined that, water quality has far-reaching implications for the well-being of both human health and the planet's health (Zahoor and Mushtaq, 2023). It is not merely a concern for scientists or environmentalists; it is a matter of survival and well-being for all. It has been applied for surface and groundwater quality assessment worldwide for the last few decades (Bora and Goswami, 2017).

In this age of rapid urbanization, industrialization, and climate change (Humbal *et al.,* 2023), understanding and assessing water quality is not merely an academic pursuit, as Water has always been involved in the social, economic, political, ethical, and spiritual aspects of human history and development but a pressing necessity. (Porta and Wolf, 2021). It involves monitoring and evaluating the state of our rivers, lakes, streams, and groundwater to ensure they meet the criteria for safe drinking water, healthy aquatic habitats, and sustainable resource use.

Assessing water quality serves several critical purposes. Safe Drinking Water: Perhaps the most immediate and vital application of water quality assessment is ensuring the safety of the water we drink. Contaminants, including bacteria, viruses, heavy metals, and chemical pollutants, can lead to significant health dangers that must be taken seriously if they exceed safe limits. Regular assessments help safeguard public health by identifying and addressing potential threats to our drinking water sources.

Aquatic ecosystems are fragile and interconnected (David *et al.,* 2015). Poor water quality can disrupt ecosystems' normal settings, leading to the decline of aquatic species and the degradation of vital habitats. Water quality assessment helps to identify areas in need of protection and restoration, contributing to biodiversity conservation.

Agriculture relies heavily on water for irrigation, making it crucial to ensure that water used for farming is of suitable quality. Water quality assessments can thus lead to responsible water usage in agriculture, optimizing crop production while minimizing environmental impact (Carlo *et al.,* 2023)

Many industries depend on water as a raw material or for cooling and processing purposes (Earnest *et al.,* 1982). Poor water quality can result in equipment damage, increased operational costs, and economic losses. Regular assessments support efficient industrial processes and economic sustainability (Sujit *et al.,* 2023)

Governments and regulatory bodies use water quality data to establish and enforce environmental laws and regulations (Ahmed *et al.,* 2021). Assessments play a pivotal role in shaping policies that protect both human health and the environment.

As we delve deeper into the 21st century, the challenges of water resources continue to evolve. Emerging contaminants, climate variability, and population growth further underscore the importance of comprehensive water quality assessment (Brzezinski, 1993).

This article explores the parameters and methods used in assessing water quality, delve into the implications of poor water quality, and discuss the role of technology and research in safeguarding this precious resource.

This article aimed to study the paramount important water quality parameter, illustrating its profound impact on human health, ecosystems, industry, and policy.

Water quality assessment relies on several key parameters, including physical factors like temperature and transparency, chemical indicators such as pH, nutrient levels, and heavy metals (lead, mercury, chromium and cadmium) as well as biological parameters like macroinvertebrate communities and microbial testing. These parameters collectively provide insights into water's suitability for various purposes and its impact on ecosystems, making them critical for informed environmental management and policy decisions.

Water Quality Index is a valuable tool used to study the complex water quality data into a single, easy-to-understand value (Uddin *et al.,* 2022). It serves as a powerful instrument for assessing, managing, and improving water quality, supporting informed decision-making, and promoting responsible stewardship of this vital natural resource.

The Water Quality Index is a composite value calculated by combining data from multiple water quality parameters (Akhtar *et al.,* 2021), which can include physical, chemical, and biological measurements. These parameters are chosen because they are critical indicators of water quality for different intended purposes (e.g. domestic, aquatic life and recreation).

The purpose of a WQI is to condense complex water quality information into a single number or rating, typically on a scale from 0 to 100, where lower values indicate better water quality (Table 1). The index is calculated using mathematical formulas that assign weights to each parameter based on its relative importance and impact on overall water quality (Abbasi and Abasi, 2012). These weights reflect the significance of each parameter about the intended use of the water.

Several well-known Water Quality Index (WQI) systems have been developed to assess water quality comprehensively and communicate results effectively such as NSF WQI, CWQI, NYWQI, and the GEMS/WQM Index. These indices vary in their components, calculation methods, and regional applicability. They are designed to provide a simplified representation of water quality based on key parameters, aiding decision-making, environmental monitoring, and the protection of water resources.

MATERIALS AND METHODS

Study Area

Lake Alau, located in Borno State, Nigeria, is the second largest lake in the Northeast region, created in 1985 by damming the Ngadda River, which originates from the Mandara Plateau. The lake was coordinated between Latitudes 11°42’13”N and Longitudes 13° 16’2”E, covering a total area of 56 km². Initially, the lake was intended to supply domestic water to Maiduguri Metropolis and to irrigate over 8,000 hectares of farmland around the reservoir. The creation of the lake was managed by the Chad Basin Development Authority.

The region has a Sahelian climate characterized by three distinct seasons: Rainy Season (June to September), Harmattan Season (October to February), Dry, Hot Season (March to May). Water level in Lake Alau is at its lowest in March and April, revealing lakebeds composed of sand and rocks. The reservoir has a height of 9 meters and a reservoir area of 50 km², with the capacity to store up to 112 million cubic meters of water (CBDA, 1986; Mala *et al.,* 2024).

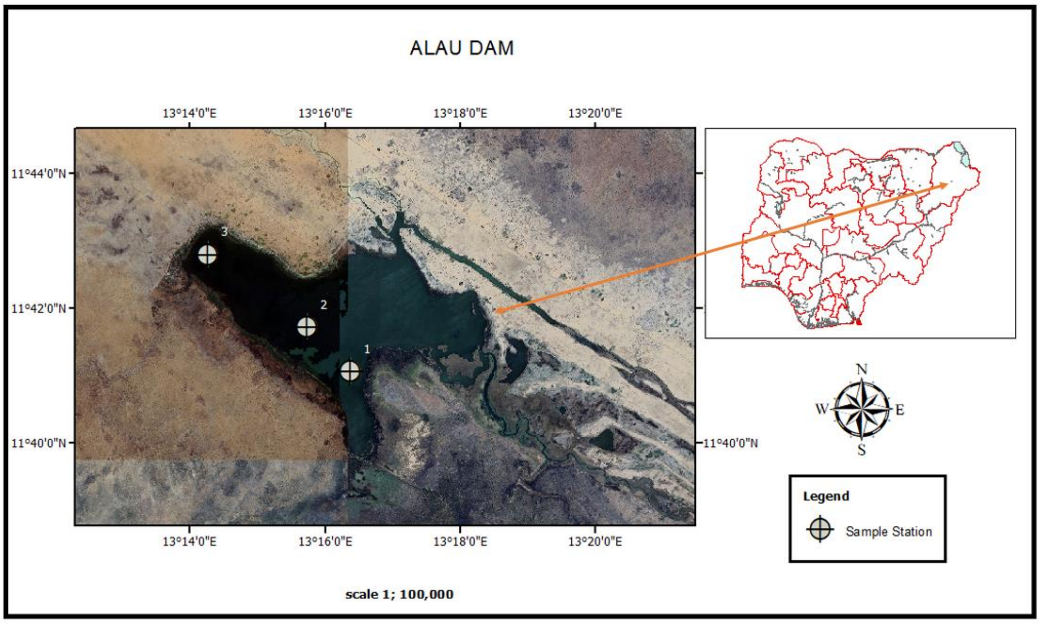

Fig. 1: Map of Lake Alau Showing the Sampling Stations

Sampling Stations: Sampling stations were selected based on several factors, including water volume, accessibility, security, and the various activities taking place in and around the lake. Three sampling stations were established at intervals ranging from 1.5 to 3 kilometers to create the head region.

Station 1 is the general landing site for all lake fishermen and consists of some farmlands for rain-fed agriculture and irrigation.

Station 2 is situated near the community of Alau town. The area is characterized by low farming activities, deep water, and a fast water flow. The water body is approximately 102 meters wide and is supported by a large dyke made of heavy stones. It is utilized for various anthropogenic activities (washing, bathing, and serving as a drinking spot for cattle) etc. Additionally, it is used for irrigating the surrounding farmland. There are also significant fishing activities in the area that employ a variety of simple fishing gears.

Station 3 is located 500 meters northward of Daban Ali Zaki, with Small-scale irrigation farming activities. It is also the prominent center for canoe paddlers and artisanal fishermen, and the littoral areas contain burrow pits used for sand extraction for road construction and building purposes.

Sample Collection and Preservation

Water samples from Lake Alau were collected over eighteen months, from January 2019 to June 2020. The collection process followed these steps:

Sample bottles were thoroughly cleaned by first soaking in a 1.3 M nitric acid solution for two days after being washed with detergent and rinsed. This was followed by soaking in deionized distilled water acidified with nitric acid (pH < 1) for 48 hours to remove trace metals and other pollutants. The bottles were then rinsed thoroughly with deionized distilled water.

Samples were collected at 8 am local time at a depth of 10 cm below the water surface. Water samples were taken in triplicates in 1-liter plastic bottles at three different stations (Stations 1, 2, and 3) using a simple randomized design. The bottles were rinsed with lake water before filling to avoid contamination. The bottles were filled to the brim and covered immediately to prevent air bubbles as described by APHA (2017)

Samples were preserved using ice blocks and transported within 60 minutes to the Department of Food Science and Technology at the University of Maiduguri and the National Agency for Food and Drug Administration and Control (NAFDAC) laboratories in Maiduguri for analysis **Data Analysis** Data for water quality parameters were analyzed and Means and Standard deviations were calculated, and results were presented as Mean ± SD.

Water Quality Index (WQI) Computation

Eleven water quality parameters were chosen for WQI calculation, based on the standards recommended by the WHO, 2017 for drinking water quality. The WQI was calculated using the weighted arithmetic index method (Brown *et al.,* 1970).

Calculation of Sub-Index of Quality Rating (qn):

q_n=100(V_n−$V_{i0}$$S_n$−$V_{i0}$)

q_n=100(S_n−$V_{i0}$$V_n$−$V_{i0}$)

q_n: Quality rating for the nth water quality parameter.

V_n: Estimated value of the nth parameter at a given sampling station.

S_n: Standard permissible value of the nth parameter.

V_{i0}: Ideal value of the nth parameter in pure water (0 for all parameters except pH, where it is 7.0, and dissolved oxygen, where it is 16.6 mg/dm³).

Calculation of Unit Weight (Wn):

W_n=KS_n

Wn=S_nK

W_n: Unit weight for the nth parameter.

S_n: Standard value for the nth parameter.

K: Constant of proportionality.

Calculation of WQI:

WQI=∑$q_n$$W_n$∑$W_n$

WQI=∑W_n∑$_{qn}$$W_n$

The overall water quality index was calculated by aggregating the quality ratings with their respective unit weights.

RESULT AND DISCUSSION

To calculate the Water Quality Index (WQI) for Lake Alau, we compiled a statistical summary of key water quality parameters from various sampling sites. These parameters include temperature, total solids (TS), total dissolved solids (TDS), and total suspended solids (TSS) etc (Table 2:).

Temperature: The average temperature measured at three stations is 23.40±3.64°C. Temperature has a significant impact on various properties of the lake, including oxygen concentration and suspended solids, as well as chemical and biochemical reactions. Temperature fluctuations are influenced by factors such as season, geographical location, and the entry of effluents into the water body. It governs aquatic ecosystems, affecting the distribution, health, and survival of organisms.

Total Solids (TS): Total solids in water include both Total Dissolved Solids (TDS) and Total Suspended Solids (TSS), which measure the concentration of organic and inorganic particles. The mean values observed for Total Solids (TS), Total Dissolved Solids (TDS), and Total Suspended Solids (TSS) were 365.68 mg/L, 192.99 mg/L, and 171.95 mg/L, respectively. All of these values are within the desirable limit of 500 mg/L set by the Bureau of Indian Standards (BIS).

High concentrations of Total Solids can indicate pollution from various land use practices and can lead to deterioration in water quality, which in turn requires higher treatment costs.

Total Dissolved Solids (TDS): TDS measures the presence of inorganic salts and small organic matter in water. TDS concentrations can differ due to geological variances and human activities like agriculture and urban runoff. High TDS levels can reduce water clarity, impede photosynthesis, and raise water temperatures. However, the TDS levels in Lake Alau were found to be below the WHO guideline of 1000 mg/L, making the water suitable for aquatic life and domestic use.

Total Suspended Solids (TSS): TSS measures soil and silt particles that affect water turbidity. High TSS levels result from soil erosion, which is often accelerated by human activities. Increased TSS can reduce biodiversity because suspended solids absorb heat, raise water temperatures, and lower dissolved oxygen levels. They also harm aquatic life by causing physical harm and reducing the light penetration necessary for photosynthesis.

Hydrogen Ion Concentration (pH): The pH level of water has a significant impact on chemical reactions and the structure of aquatic biological communities. The pH scale ranges from 0 to 14, with 7 being neutral. Water with a pH below 7 is acidic, and above 7 is basic or alkaline. pH affects the corrosive nature of water; lower pH means higher corrosivity. In the study of Lake Alau, the average pH values ranged from 7.06 ± 0.15 to 7.10 ± 0.16 across different stations, falling within the acceptable range of 6.5 to 8.5 set by health and pollution control organizations such as WHO. These values are suitable for fish production and other aquatic life. The pH values remained neutral throughout the study period, with minimal variability. pH is crucial as it affects the solubility and availability of nutrients, influencing the ability of aquatic organisms to utilize them. It is an important indicator of water quality and pollution levels, as variations in pH can be caused by photosynthesis and respiration cycles of algae or organic matter decay, leading to the formation of carbonic acid. Overall, the pH levels in Lake Alau were within acceptable limits, indicating good water quality for aquatic life and human use. The obtained value is in agreement with the work of Abasiryu *et al.,* 2022

Dissolved Oxygen (DO): Dissolved oxygen (DO) is crucial for the respiration of fish and other aquatic organisms. In Lake Alau, DO levels ranged from 6.73 to 7.33 mg/L across three sampling stations, exceeding the permissible limits of 4 mg/L and 5 mg/L, indicating good water quality. High DO levels were maintained due to significant water movement and the unpolluted nature of the lake. For context, DO levels below 3 mg/L are stressful to most aquatic organisms, with fish typically dying at 1-2 mg/L. Waters with DO levels from 0.2 to 0.5 mg/L are considered hypoxic, and those below 0.5 mg/L are anoxic. Excessive algal growth can lead to DO oversaturation, while algal respiration at night can deplete DO and potentially cause fish kills. The lowest DO value recorded in September 2019 at station 3 was likely due to organic material influx from runoff. Overall, DO levels in Lake Alau support a healthy aquatic ecosystem, with concentrations suitable for sustaining aquatic life.

Biological Oxygen Demand (BOD): The BOD levels at all sampling stations in Lake Alau were within the EU guidelines of 3.00 to 6.00 mg/L, making the water suitable for fisheries, aquatic life, and domestic water supply. Station 2 had the highest mean BOD value of 4.44±0.05 mg/L, with the highest monthly mean value of 4.63±0.12 mg/L in October. This increase in October was likely due to an influx of organic material from surrounding agricultural lands.

BOD is important for assessing water quality as it measures the oxygen required by microorganisms to decompose organic matter. High BOD levels can indicate pollution and potential harm to aquatic organisms due to oxygen depletion. The study noted that BOD levels were higher during the rainy season (4.81±0.29 mg/L in September 2019) due to increased organic matter and agricultural waste.

In comparison, other studies have reported higher BOD levels in Lake Alau, attributed to factors such as wastewater discharge and natural debris decomposition. Overall, the BOD levels in Lake Alau indicate clean and unpolluted water, aligning with standards that classify waters with BOD levels between 1.0 and 4.0 mg/L as clean and those above 5.0 mg/L as polluted.

Chemical Oxygen Demand (COD): The COD levels observed in Lake Alau were highest at station 2 (4.39±0.03 mg/L) and lowest at station 3 (4.33±0.03 mg/L), with statistically significant differences ($P<0.05$). All stations recorded values below the WHO recommended standard of 200 mg/L, indicating a low influx of organic matter. The values contrast sharply with Lake Chad, where COD levels range from 353 to 689 mg/L due to higher concentrations of suspended organic matter and wastewater discharges. COD in Lake Alau showed a positive correlation with TSS, TS, and TDS, suggesting chemical pollution mainly originates from wind action and runoff.

Phosphorus Levels: The level of phosphorus in Lake Alau is significantly affected by human activities. Phosphates primarily come from domestic activities, agricultural runoff, fertilizers, and organic manure. Research indicates that lakes in agricultural areas have higher phosphorus levels compared to those near urban areas. Phosphates from fertilizers and organic manure promote the growth of plankton and water plants, which benefits fish populations but can also lead to harmful algal blooms if the concentration exceeds 1 mg/L. The average phosphate levels recorded in the study were below the recommended limit of 1 mg/L by the World Health Organization, indicating healthy conditions for aquatic life. However, the highest phosphate level observed in April 2020 at station 3 (0.42±0.04 mg/L) suggests occasional influxes from detergents and surrounding farmlands. The values are similar to those of Ogbozige *et al.,* 2017

Phosphates are necessary in small quantities for algae and plant growth but can cause eutrophication and oxygen depletion at higher levels. The phosphate levels in this study were significantly lower than those found in Lake Chad, where concentrations ranged from 16.54 to 43.22 mg/L due to heavy agricultural and domestic waste influx. Overall, the phosphate levels in Lake Alau suggest minimal pollution, in line with findings that indicate controlled human impact.

Nitrate Levels: Nitrates are important nutrients for algae and aquatic plants, but they can be harmful to aquatic organisms at concentrations above 90 mg/L. Nitrate is a crucial part of the nitrogen cycle, highly soluble in water, and commonly found in soil and water. The study found that the average nitrate levels in Lake Alau are within the recommended levels for aquatic life and human consumption set by the World Health Organization (45 mg/L). The nitrate concentrations in Lake Alau ranged from

0.18±0.02 mg/L to 0.55±0.08 mg/L, which are considered safe.

The low nitrate levels in the lake can be attributed to several factors, including the presence of dissolved oxygen (DO) at the water-sediment interface, which affects nitrate degradation. Additionally, the activity of bacteria in denitrification and the uptake of nitrate by aquatic plants contribute to these lower concentrations. Previous studies by Wakil (2015) and Idowu *et al.* (2004) reported similar or slightly higher nitrate concentrations, indicating the lake's low nutrient status and high nutrient turnover rate.

The levels of nitrates in the lake show a strong correlation with total suspended solids (TSS) and temperature. This correlation suggests that agricultural runoff, poor drainage, and the spread of animal manure and sewage sludge can contribute to nitrate influx and leaching into the lake. Overall, the nitrate levels in Lake Alau indicate minimal pollution, in line with findings that suggest a controlled anthropogenic impact.

Nitrite Ion (NO^{2}−): Nitrogen is an essential component of proteins and nucleic acids and plays a significant role in aquatic systems. Nitrites, which are less stable than nitrates, can negatively impact water quality, giving it a brown color and an offensive odor, making it unsuitable for irrigation, fish culture, and drinking (Kudesia *et al.,* 1986; Ekhande, 2015). In this study, the average nitrite concentration was 0.07±0.03 mg/L. Nitrites can be reduced to various compounds or oxidized to nitrates through chemical and biological processes. The acceptable nitrite concentration for humans and animals, including wildlife, is between 10 mg/L and 100 mg/L (Riordan, 1983). The highest concentration recorded was 0.19±0.08 mg/L at station 3 in October 2019. This spike was likely due to organic pollution from human activities such as agriculture and traditional farming, which increased the concentration of chemical oxygen demand (COD).

The generally low concentration of nitrites aligns with their minimal environmental role and short residence time in water (Malhotra and Zanoni, 1970). Fresh input through water runoff and water agitation, aiding in the oxidation and release of ammonia from sediment, may also contribute to this low level. Lake Alau's ample sunlight throughout the year supports the growth of macrophytes, which utilize nitrites as a nitrogen source, further explaining the low nitrite levels (Yang *et al.,* 2001; Zhang *et al.,* 2015).

Nitrites can cause brown blood disease, or nitrite poisoning, in fish by oxidizing bivalent iron in hemoglobin to trivalent iron, producing methemoglobin, which reduces the blood's oxygen-carrying capacity (Oladele *et al.,* 2021). This condition is more common in freshwater fish than in saltwater fish (Boyd, 2014). Additionally, nitrites react with amines to form carcinogenic nitrosamines (Moshoeshoe and Obuseng, 2018).

The nitrite concentrations in Lake Alau during the study period were not high enough to pose a threat to the lake's ecological health or its fisheries, despite the human activities, especially around station 1.

The water quality index (WQI) for Lake Alau, as indicated in Table 3, was registered at 30.96, categorizing it as "good" (WQI 26 – 50), and suitable for drinking, fish culture, and industrial use. Despite the reported anthropogenic activities in the lake and its surrounding catchment, the lake shows resilience—an absence of danger signals in the ecosystem and an ability to quickly and completely recover. This suggests a lack of risks or threats that could compromise the ecosystem's composition, structure, or function.

Table 1: Water Quality Index (WQI) Range, Status and Possible Usage of the Water Sample

WQI Range	Water Quality Status	Possible Usage
0 – 25	Excellent Water Quality	Drinking, Irrigation and Industrial
26 – 50	Good Water Quality	Drinking, Irrigation and Industrial
51 – 70	Poor Water Quality	Irrigation and Industrial
71 – 90	Very Poor Water Quality	Irrigation
91 – 100	Unsuitable for Drinking and Propagation of Fish Culture	Proper Treatment is required before Usage

Source: Bouslah *et al.,* 2017

Table 2: Physicochemical parameters of Lake Alau

Parameters	Station 1	Station 2	Station 3	Mean
Temperature	23.19±3.55	23.38±3.53	23.63±4.01	23.40±3.64
Total solid	373.45g	370.45g	358.88g	365.68g
TDS	194.85g	191.48g	192.64g	192.99g
TSS	175.68g	172.62g	173.10g	171.95g
pH	7.10±0.16	7.06±0.15	7.10±0.11	7.80±0.06
DO	7.33±0.95	6.72±0.54	7.10±0.70	7.05±0.56
BOD	4.32±0.17	4.44±0.16	4.39±0.17	4.38±0.13
COD	4.50±0.16	4.60±0.16	4.54±0.11	4.55±0.11
Nitrite	0.07±0.05	0.07±0.03	0.06±0.03	0.07±0.03
Nitrate	0.37±0.08	0.37±0.07	0.36±0.08	0.37±0.07
Phosphate	0.08±0.04	0.11±0.06	0.10±0.10	0.10±0.05

Table 3: Water Quality Index Calculation of Lake Alau January 2019 – June 2020

S/No	Parameters	Observed value	Standard Value	Wn	Quality rating Qn	Weighted value Wn • Qn
1.	Temperature	23.40	28	0.036	83.57	3.009
2.	Total solid	365.68	500-1500	0.0007	36.57	0.026
3.	Total Suspended solid	171.95	500	0.002	34.39	0.069
4.	Total Dissolved Solid	192.99	500	0.002	38.60	0.077
5.	pH	7.80	8.5	0.118	53.33	6.293
6.	DO	7.05	5	0.2	82.33	16.476
7.	BOD	4.38	10	0.1	43.80	4.38
8.	Nitrate	0.37	50	0.02	0.74	0.74
9.	Nitrite	0.07	3	0.333	2.33	0.777
10.	Phosphate	0.10	5	0.2	2.0	0.4
11.	COD	4.55	150	0.007	3.03	0.021

ΣW_n=1.0187 ΣQ_n=380.69 ΣW_nQ_n=31.543 WQI = $\Sigma W_nQ_n / \Sigma Q_n$ = 30.96

CONCLUSION

Evaluation of Lake Alau's water quality shows that the aquatic ecosystem is strong and able to withstand human activities in the surrounding area. Important measures like dissolved oxygen, BOD, and COD indicate low pollution levels, creating a healthy environment for aquatic life. While nutrient levels are affected by agricultural runoff, they remain within safe levels, preventing problems like eutrophication. Similarly, the lake's capacity to uphold ecological balance and rebound from minor disturbances highlighted its resilience.

Recommendation

It is recommended to continue monitoring and managing the lake to maintain water quality to mitigate the potential threats from increased human activities

REFERENCE

Abasiryu, A., Abubakar, K.A. and Fibian, Z.N. (2022). Assessment of water quality potential of Luhu mini dam, Michika, Adamawa State, Nigeria. *The International Journal of Science and Technoledge* 10(3) 26-30

Abbasi, T., and Abbasi, S. A. (2014). Water quality indices. Environ Earth Sci (2014) 71:4625–4628.

Ahmed, A., Mohd, Y.I., Khadijah, M. Y. and Aminu, S. Z. (2021). The role of government institutions in managing the environment in Nigeria: policy and governance review. *The journal of science and technology* 42(2) 1-11

Akhtar, N., Ishak, M. I. S., Ahmad, M. I., Umar, K., Md Yusuff, M. S., Anees, M. T., ... & Ali Almanasir, Y. K. (2021). Modification of the water quality index (WQI) process for simple calculation using the multi-criteria decision-making (MCDM) method: a review. Water, 13(7), 905.

APHA (2017) Standard Methods for the Examination of Water and Wastewater (18th Edition), American Public Health Association.

APHA (2017). Standard Methods for the Examination of Water and Wastewater, 23rd ed.; American Public Health Association: Washington, DC, USA

Bora, M., and Goswami, C. D. (2017). Water Quality Assessment in terms of Water Quality Index (WQI): Case Study of the Kolong River, Assam, India. Appl Water Science 7:3125–3135

Boyd, C. E. (2014). Nitrite Toxicity Affected By Species Susceptibility, Environmental Conditions. Global aquaculture advocate. 34-37.

Brown, R. M., McClelland, N. I., Deininger, R. A. and Tozer, R. G. (1970) A water quality index—Do we dare? Water Sew Works 117(10):339–343

Brzezinski, Z. (1993). Out of Control: Global Turmoil on the Eve of the 21st Century, New York, Macmillan, pp. 4-5.

Carlo, I., Rossana, S., Giovanni, L. and Donald, H. (2023). Water scarcity in agriculture: An overview of causes, impacts and approaches for reducing the risks. H*eliyon* 9(8) 1-16

CBDA (1984). A resettlement plan for the Alau dam Jare Bowl scheme. Agricultural survey and background studies. *Report summitted to Chad Basin Development authority, Askoning Nigeerian Limited.* PP 56

David, A.C., Winsor, H.L., Frederick, W.A., Tibor, E., Debra, S.F., Bronwyn, M.G., Wade L.H., Chris, H., Virgilio, Simon, J., Raouf, W.K., Ivan, N., Michael, M.H., Timothy, J.P., Cynthia, R., Brian, F. and Jane M.H. (2015). Human effects on ecological connectivity in aquatic ecosystems: Integrating scientific approaches to support management and mitigation. *Science of The Total Environment*. 534, 52-64

Earnest, F. Gloyna, P.E., Davis L. and Ford P.E. (1982). Water and other natural energy. Energy, Resources and Environment https://doi.org/10.1016/C2013-0-03669-9

Ekhande, A. (2015). Hydrobiological studies of Yashwant Lake, toranmal (m.s.) with special reference to selected biodiversity. Laxmi book Publication 258/34 Raviwar Peth Solapur Maharashtra, India.

Flannery, D. M., Gardner, B. D., and Vining, J. R. (2004). The Water Resources Protection Act and Its Impact on West Virginia Water Law. W. Va. L. Rev., 107, 749.

Humbal, A., Chaudhary, N., and Pathak, B. (2023). Urbanization Trends, Climate Change, and Environmental Sustainability. In: Pathak, B., Dubey, R.S. (eds) Climate Change and Urban Environment Sustainability. Disaster Resilience and Green Growth. Springer, Singapore. https://doi.org/10.1007/978-981-19-7618-6_9

Idowu, R. T.., Inyang, N. M. and Eyo, J. E. (2004). Physico-chemical parameters of an African Arid Zoneman-made Lake. Animal Research International,1(2): 113-119

Kudesia, K. P. Verma, S. P. Sangh, K. P. and Sanjiv (1986). Pollution studies of drinking water quality of environmentally degraded village Kamalpur (District Meerut) and their remedial measures. Indian Journal of Environment and Agriculture. 1(1): 38-44.

Kumar, M. A., and Aravindh, G. (2020). An Efficient Aquaculture Monitoring Automatic System for Real-Time Applications. In 2020 3rd International Conference on Intelligent Sustainable Systems (ICISS) (pp. 150-153). IEEE.

Mala, B. G., Jibril, A. Y., Umar, B. and Sadiq, A. W. (2024). Navigating the Depths: An Assessment of the Management and Operations of Alau Dam Reservoir. *International Journal of Civil and Structural Engineering Research* 12(2) 1-14

Malhotra, S. K. and Zanoni, A. E. (1970). Chloride interference in nitrate nitrogen determination, Journal of American Water Works Association. 62: 568-571.

Moshoeshoe, M. N. and Obuseng, V. (2018). Simultaneous determination of nitrite and phosphate in environmental samples by high-performance liquid chromatography with UV detection. *South African Journal of Chemistry*, 71, 70-85.

Ogbozige, F.J., Adie, D.B., Igboro, S.B. and Giwa, A. (2017). Evaluation of water quality of River Kaduna, Nigeria using Water Quality Index. *J. Appl. Sci. Eviron. Manage* 216 1119-1126

Oladele, O. O. Ameji, N. O. Gurumyen, G. Y. Adanu, W. A Kolade, T. T. Agbato, O. A. and Lombin, L. H. (2021). Mortality of Clarias gariepinus caused by Aeromonas caviae and nitrite toxicity in a fish farm. *Sokoto Journal of Veterinary Sciences*, 19(2): 138 - 144.

Porta, E. L., and Wolf, A. T. (2021). Intrinsic and Spiritual Dimensions of Water at the Local Scale, and the Disconnect with International Institutions. *Sustainability*; 13(16):8948.

Rana, M., and Guleria, V. (2018). Water Scarcity in India: A Threat to Sustainable Management of Water. *ESSENCE International Journal of Environmental Rehabilitation and Conservation* IX (1): 35- 44.

Riordan, J. O. (1983). Ambient water quality objectives for Yakoun and its tributaries, water quality branch, water management division, Ministry of Environment, Land and Parks, Overview Reports, Government of British Columbia, Canada.

Sujit, D., Heidi, F., Ritu, P. and Prakash, R. (2023) A review of water valuation metrics: Supporting sustainable water use in manufacturing. *Water Resources and Industry* (29) 1-13

Uddin, M. G., Nash, S., Rahman, A. and Olbert, A. I. (2022). A comprehensive method for improvement of water quality index (WQI) models for coastal water quality assessment. Water Research, 219

Wakil, M. (2015). Some Aspects of Limnology and Fisheries of Lake Alau, Maiduguri, Borno State. M.Tech. Thesis, Modibbo Adama University of Technology, Yola. 79 page.

WHO (2017). Guidelines for drinking-water quality - 4th ed.

Yang O. Alain N. R. Baixing Y. Lixia W. Yu Z. (2021). Grass barriers for mitigating diffuse pollution within a source water area - A case study of Northeast China, Agricultural Water Management, Volume 243, 106461

Zahoor, I., and Mushtaq, A. (2023). Water Pollution from Agricultural Activities: A Critical Global Review. International Journal of Chem. Biochem. Sci, 23, 164-176.

Zhang, H., Wang, H., Yang, K. Sun, Y. Tian, J. and Bin Lv. (2015). Nitrate removal by a novel autotrophic denitrifier (Microbacterium sp.) using Fe(II) as an electron donor. Annals of Microbiology. 65, 1069–1078.