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**Review Article**

# Physico – Chemical Water Quality Analyses of Lake Alau, North – Eastern Nigeria

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**Abstract:** This study was conducted on the physico – chemical water quality analyses of Lake Alau, North – eastern Nigeria. Water was sampled biweekly for the period of seven months from five sampling stations. The physico – chemical qualities were determined using the methods described by APHA, (1985) and Boyd (1990). The mean values of the physico – chemical parameters of water qualities analysed are 23.04°C, 56.21 cm, 7.8, 6.41 mg / l, 0.68, 0.034 mg / l, 0.07 mg / l, 39.46 mg / l and 56.28 mg / l for temperature, turbidity, pH, DO, BOD, Nitrite, $NH_3$, alkalinity and total hardness of Lake Alau. The results indicated that, there are no variations between the five stations, except ammonia and nitrate which exhibited significant variations. The water quality parameters were within the range recommended for aquatic life; fish production and domestic use. The physico – chemical parameters were within the observed ranges in unpolluted water bodies and also were found to be within tolerable limit for high yield for aquatic life; fish production and domestic use. It provided vital information on about some of the quality status of Lake Alau, and its suitability for fish production and uses. Any variation, weather seasonal or spatial in physical and chemical characteristic of the Lake has being influence by climatic regime and catchment characteristic, i.e. extent of human activities and water volume fluctuations. Farmers bordering the Lake, dispose both their organic and inorganic wastes in to the Lake directly or indirectly. It is recommended that the relevant stakeholder charged with management of the Lake should carry out a sensitization campaign to educate the people on the danger associated with loading of the Lake with waste (toxic), from washing disinfectant or herbicides spraying machine in the Lake Alau.

**Keywords:** Environment, Freshwater, Fish Production, Lake Alau, Physico – Chemical Parameter, Water Quality

## 1. Introduction

Water is essential to life, a universal solvent; water is also used for domestic and industrial purposes which include drinking, irrigation, fishing, etc [22]. As a resource is not only tied to its quantity and availability, but also to its quality [22, 39]. Water is a vital resource for fish production, it is the medium in which fish and aquatic organisms' lives, and therefore, the growth of any organism is directly related to the quality of the water [5, 6, 13, 25]. Water system may be either static (lentic) e.g. lake, reservoirs, etc. or flowing (lotic) e.g. rivers or streams, rain water etc. Water sources have different physical, chemical and biological characteristics [34, 41].

In northern part of Nigeria, numerous small and medium sized of Lakes and reservoirs do exist, and various works have been done on these Lakes and reservoirs in this country, e.g.

Lake Alau [39]. Tabor (1992) reported that West African in shore water is rich in fish resources in quantities that can support commercial exploitation on a sustainable basis. However, later, deterioration of water quality among other factors is one of the most important compounds to the ecosystem.

Lake Alau was created in 1987 on River Ngadda for the purpose of supplying portable water to Maiduguri metropolitan as well as for irrigating over 8,000 ha of farm lands in the catchment area of the reservoir [16, 30]. After its impoundment, Bankole *et al.,* (2003) reported on the diversity, abundance and distribution of fish species in the lake and identified ten fish species belonging to eight families with annual fish catch from 471.1 metric tons at low water tide to 584.9 metric tons at high water tide. The Lake serves much purpose, such as majority irrigation, fishing as well as a source of drinking water for humans and animals, especially livestock. Also many depend on the resources of the water as their main sources of food and family in come as a result the water is subjected to intensive use. Some factors such as temperature, pH, dissolved oxygen, turbidity, total alkalinity and total hardness have been reported to affect water quality and fish production of water body [5, 13, 25, 39].

Water quality (an essential factor to be considered) affects the general welfare of all aquatic animals as it determines the health and growth conditions of aquatic organisms [13, 41]. Although the environment of aquaculture, fish is a complex system, consisting of several water quality variables, only few of them play decisive role [25]. The critical parameters are temperature, suspended solids and concentrations of dissolved oxygen, ammonia, nitrite, carbon dioxide and alkalinity [5, 7]. The quality of water plays a vital role in the production of any water body. The fertility of water is related to its chemical properties which will determine the primary production such as planktons and micro – benthic invertebrates [19].

Greenness appearance of water bodies is one of indicators of primary productivity and good water quality parameters [25]. Water quality is the totality of physical, biological and chemical parameters that affect the growth and welfare of aquatic organisms, as it determines the health and growth conditions of aquatic organisms [5]. The critical parameters are temperature, suspended solids and concentrations of dissolved oxygen, ammonia, nitrite, carbon dioxide and alkalinity, any slight changes do affects the organisms [5, 7, 19]. Understanding lakes physical and chemical properties is essential to determining the lakes condition and gathering information for lake management decisions [5]. However, some parameters interact with other and influence the overall water quality [4, 30].

In Lake Alau (Nigeria), little or no extensive work has been carried out on the quality for supporting lives, and is one of such reservoirs [39]. There are very few reports on the water quality in Lake Alau; water quality monitoring is an important component of lake stewardship activities. It provides a scientific basis for understanding lake characteristics and how activities around the lake may impact water quality and fish production. The aim of this study is to find out the physico – chemical water quality of lake Alau, Nigeria. The physical parameters to be determined in this study include; temperature, turbidity / transparency. Chemical parameters such as include dissolved oxygen, pH, ammonia, nitrite, total alkalinity, total hardness and Biochemical Oxygen Demand (BOD) of Lake Alau would be determined.

# 2. Methodology

### *2.1. Study Site and Location*

Lake Alau is a fresh water lake in North – Eastern Nigeria. It is 19 km south – east of Maiduguri, the capital city of Borno state of Nigeria, which is located between latitude 10°43$^{1}$N and Latitude 10°15 E and 13°17E° [39]. Lake Alau is the second largest lake in Borno state. The reservoir was created in 1985 by damming river Ngadda which takes its sources from Mandara Plateau. It is located between Latitude 12°N and 13°N and longitudes 11°E and 13°E with a total surface area of 56 km$^2$. The reservoir was formed primarily for the provision of portable water for Maiduguri Metropolis as well as to irrigate over 8,000 hectares of farmland within and around the basin, Chad basin development authority [16]. It has a total surface area of 56 km with three distinct seasons; a rainy season with mean annual rainfall of 600 mm for July to October and a hot dry season from March to July, the dry season is preceded by a period of harmattan (a dusty, dried, cool and windy breeze blown from the Sahara desert from North Africa) between Novembers to February [39].

The climate is Sahelian. The water volume is lowest during the months of March and April, where the great portions of the lake beds are dried, field of sand and rocks are exposed [27]. There was neither pre-impoundment nor immediate post impoundment survey. It has a relative humidity of 49% with temperature range of 28°C, to 46°C, for both seasons. It has a maximum storage capacity of 54,600 ha [39]. The Lake serves for many purposes such as fishing, farming, and the main practical site for the undergraduate and postgraduate student of the University of Maiduguri as well as for the student of Freshwater, Fisheries Research Institute, Maiduguri.

### *2.2. Materials*

The standard and analytical grade materials were required and used in the cause of this scientific research study and Standard Operation Procedures (SOP) are absolutely been observed.

### *2.3. Methods*

The methods applied in study work are of the methods described by APHA, (1985); AOAC, (1990); Boyd (1990).

#### *2.3.1. Sampling Stations*

Sampling stations were chosen after preliminary surveys of the Lake based on such factor as volume of water, accessibility and the various activities taken place in and around the Lake. Five sampling stations were marked at

intervals of 1.5 to 3 km to form the head region. Five landing sites were selected based on certain factors such as accessibility to the area, security and fishing activities. These stations are Abari fishing community, Daban Ali Zaki, automatic spillway, Gada and Musari landing sites respectively.

(1) Station A:

This station is about 500 m from the bank of the lake shore where students of the department of fisheries usually conduct their practical. It is one of the landing sites that are very close to main dam.

(2) Station B:

This station is located closed to the community of Alau town. Low farming activities take place here the water is deep and flows faster.

(3) Station C:

This station is located 500 meters away to north ward of Daban Ali Zaki; farming activities such as irrigation are carried out here at small scale level.

(4) Station D:

This station is located closed to one of the Large fishing camp of fishermen; a lot of human activities are taking place in this station.

(5) Station E:

This station is the largest landing side for canoe fishermen in Lake Alau.

#### *2.3.2. Samples and Sampling*

At 6:30 AM, water was sampled from Lake Alau biweekly for the period of seven months from August 2012 to February 2013.

#### *2.3.3. Laboratory Measurement of Parameters*

*I. Temperature*

An in-glass mercury thermometer was used to take the water temperature of different station. The temperature was taken twice every month, once at day break for period of seven month according to method described by Boyd (1990).

*II. Turbidity*

Water from different station was taken with the aid of fabricated Secchi disc. This was achieved by lowering the disc in to the water body gradually and a depth reading was taken at the point the instrument just disappear from your sight. The instrument was then gently raised and another reading was taken at the point the disc re-appears. The average of the two reading is the correct Secchi reading for the water.

*III. Hydrogen Ion Concentration (pH)*

The Bicasa pH meter (model B. E. 104) was used to determine the pH reading of the water from all station. The pH of water was taken for period of six month, twice every month from August 2012 to February 2013. The pH cell was lowered in to the water, the fine and course adjusted on the pH meter without lifting; the pH reading was taken.

*IV. Dissolved Oxygen*

The dissolve oxygen from different stations was taken with aid of the digital dissolved oxygen meter (model FT 607) was used. The dissolved oxygen cell was dipped in to the water without lifting out the cell point. The result was displayed on the screen. The dissolved oxygen was taken twice every month, once at day break for period of six month.

*V. Biochemical Oxygen Demand (BOD)*

Water sample was collected in one litre airtight sampling bottle. Dissolved oxygen was recorded after five days the biochemical oxygen demand was calculated using the following formula.

BOD = Do1 - Do2 in mg / l.

Where, Do1 initial dissolved oxygen and Do2 Dissolved oxygen after 5days.

*VI. Ammonia*

Total ammonia concentration was measured by Hatch comparison apparatus following the method reported by APHA, (1985), and then the deionised ammonia ($NH_3$) was calculated from total ammonia according to Boyd (1990) method.

*VII. Nitrite and Total Hardness*

Water sample from different stations were collected in one litre airtight bottle to Maiduguri water treatment plan for analysis according to the method described by Boyd (1979).

### *2.4. Statistical Analysis*

The data obtained were analysed by using Analysis of variance (ANOVA), which was used to determine differences between treatments at significance rate of $P<0.05$. The standard errors of treatment means were estimated. All statistics were carried out using Statistical Analysis System (SAS, 2000).

## 3. Results

The study was designed to determine and assess the impact of physico – chemical parameters of Lake Alau, in Borno state, Nigeria. Water quality monitoring is an important component of Lake Stewardship activities. The results obtained provide a scientific basis for understanding Lake Alau characteristics and how activities around the lake may impact water quality environment. The results were presented in the tables and figures below as follows:

Table 1 shows the results obtained from the seven months (August, 2012 to February, 2013) mean values of some physico – chemical parameters; 23.04°C, 56.21 cm, 7.8, 6.41 mg / l, 0.68 mg / l, 0.034 mg / l, 0.07 mg / l, 39.46 mg / l and 56.28 mg / l for temperature (18.68 - 27.80°C), turbidity (39.90 - 72.46 cm), pH (7.1 - 8.6), DO (6.08 – 6.70 mg / l), BOD (0.57 – 92 mg / l), Nitrite (0.019 – 0.088 mg / l), $NH_3$ (0.04 – 0.14 mg / l), alkalinity (36.16 – 45.38 mg / l) and total hardness (53.10 – 58.20 mg / l) of Lake Alau respectively.

Table 2 shows the results obtained revealed the mean values of physico – chemical parameters; 23.04°C, 56.21 cm, 7.8, 6.41 mg / l, 0.68 mg / l, 0.03 mg / l, 0.07 mg / l, 39.46 mg / l and 56.28 mg / l for temperature (22.03 – 22.90°C), turbidity (55.12 – 57.94 cm), pH (7.6 – 7.9), DO (6.24 – 6.64 mg / l), BOD (0.44 – 0.77 mg / l), Nitrite (0.02 – 0.08 mg / l), $NH_3$ (0.03 – 0.14 mg / l), Alkalinity (37.91 – 41.16 mg / l) and total hardness (54.21 - 58.29 mg / l) of Lake Alau by stations.

Figure 1 shows the results of monthly mean water

temperature. The water temperature ranged from 18.7°C to 27.8°C. The maximum (27.8 ± 0.247) was recorded in the month of August, 2012 (raining season) and the minimum 18.7°C was recorded in the month December, 2013 (dry season).

Figure 2 shows the variation in turbidity of water in Lake Alau. The turbidity fluctuates from 39.9 cm to 72.86 cm. The maximum value 72.5 ± 2.30 was recorded in the month of November, 2012 (dry season) and minimum value 39.9 ± 2.00 was obtained in the month of August, 2012 (raining season).

Figure 3 shows monthly mean values of pH. The pH value was alkaline throughout the study period. The value ranges from 7.1 to 8.9. The maximum mean pH value 8.5 ± 0.34 was recorded in the month of December, 2013 and the minimum value pH 7.08 ± 0.80 in February, 2013 all are in (dry season).

Figure 4 shows the value of dissolved oxygen (DO). The DO values ranges from 6.1 to 6.8 mg / l. The maximum value of 6.8 mg / l was recorded in the month of December, 2012 (dry season) and the minimum value 6.1 mg / l in the month of August, 2012, (raining season).

Figure 5 shows the results of monthly mean Biochemical oxygen demand (BOD). The Values range between 0.06 mg / l to 0.92 mg / l. The maximum (0.92) was recorded in the month of November, 2012 (dry season) while minimum was recorded in the month September, 2012 (rainy season).

Figure 6 shows the results of unionized ammonia in Lake Alau. The values range from 0.02 to 0.03. The maximum value was obtained in the month of August, 2012 (raining season) while the minimum value of 0.02 mg / L was obtained in months of February, 2012 (dry season).

Figure 7 shows the monthly mean value of nitrite $NO_2$. The value ranged from 0.005 to 0.025 mg / l. The highest value 0.025 mg / l was obtained in November, 2012 (dry season) and minimum value 0.005 mg / l was obtained in August, 2012 (raining season).

Figure 8 shows the variations in monthly mean of Total Alkalinity in Lake Alau. The values range from 36.16 mg / l to 45.39 mg / l. The maximum mean value 45.38 ± 1.84 mg / l was obtained in the month of August, 2012 (raining season) and minimum mean value 36.16 ± 0.26 was recorded in the month of November, 2012 (dry season).

Figure 9 shows the monthly mean of total hardness of Lake Alau. Total hardness of water during the study period fluctuates from 53.10 to 60.10 mg / l. The highest mean value of 60.10 ± 1.70 was recorded in the month of October, 2013 and lowest mean value 53.10 ± 0.40 was obtained in the month of February, 2013 (dry season).

***Table 1.*** *Monthly Mean Values of Some Physico – Chemical Parameters of Lake Alau.*

| Month | Physico – Chemical Parameters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Temperature °C | Turbiditycm | pH | DO mg/l | BODmg/l | Nitritemg/l | $NH_3$ mg/l | Alkalinitymg/l | Total Hardnessmg/l. |
| August | $27.80^{a}$ | 39.90 | $7.2^{c}$ | $6.12^{b}$ | $0.58^{b}$ | 0.02 | 80.04 | $45.38^{a}$ | $58.20^{ab}$ |
| September | $27.56^{a}$ | $49.33^{d}$ | $7.4^{bc}$ | $6.44^{ab}$ | $0.57^{b}$ | 0.02 | 80.14 | $43.88^{a}$ | $65.90^{bc}$ |
| October | $25.82^{b}$ | $48.91^{d}$ | $7.7^{b}$ | $6.34^{ab}$ | 0.64 | 0.03 | 0.07 | $39.36^{b}$ | $60.10^{a}$ |
| November | $20.04^{d}$ | $72.46^{a}$ | $8.3^{a}$ | $6.54^{a}$ | $0.92^{a}$ | 0.01 | 90.04 | $38.16^{b}$ | $57.56^{ab}$ |
| December | 18.68 | $67.35^{ab}$ | $8.6^{a}$ | $6.70^{a}$ | $0.74^{ab}$ | 0.02 | 30.12 | $36.88^{b}$ | $54.90^{cd}$ |
| January | $19.90^{d}$ | $60.45^{bc}$ | $8.3^{a}$ | $6.66^{a}$ | $0.68^{b}$ | 0.08 | 80.08 | $36.16^{b}$ | $53.20^{d}$ |
| February | $21.50^{c}$ | $55.05^{d}$ | $7.1^{c}$ | $6.08^{a}$ | $0.60^{b}$ | 0.02 | 60.02 | $36.40^{b}$ | $53.10^{d}$ |
| Mean | 23.04 | 56.21 | 7.8 | 6.41 | 0.68 | 0.03 | 40.07 | 39.46 | 56.28 |
| SE ± | 0.42 | 2.45 | 0.15 | 0.43 | 0.07 | 0.02 | 0.05 | 1.13 | 0.90 |
| LSD 0.05% | 1.22 | 7.1596 | 0.45 | 0.40 | 0.21 | NS | NS | 3.30 | 2.62 |

KEYS: NS = Not Significance, Temp = temperature, mg / l = milligram / litre, BOD = Biochemical Oxygen Demand, DO = Dissolved Oxygen, a = highly significance, b = moderately significance, c = more significance, d = less significance.

***Table 2.*** *Monthly Mean Values of Physico – chemical Parameters of Lake Alau by Stations.*

| Station | Mean Values of Physico – Chemical Parameters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Temperature °C | Turbiditycm | pH | DOmg/l | BODmg/l | Nitritemg / l | $NH_3$ mg/l | Alkalinitymg/l | Total Hardnessmg/l |
| A | 23.24 | 55.19 | 7.9 | 6.36 | 0.68 | 0.08 | 0.04 | 39.64 | 57.90 |
| B | 23.03 | 56.88 | 7.8 | 6.26 | 0.74 | 0.03 | 0.03 | 38.74 | 58.29 |
| C | 22.63 | 57.94 | 7.8 | 6.24 | 0.44 | 0.02 | 0.09 | 37.91 | 55.86 |
| D | 22.90 | 55.90 | 7.8 | 6.56 | 0.77 | 0.02 | 0.14 | 41.16 | 55.86 |
| E | 23.41 | 55.12 | 7.6 | 6.64 | 0.75 | 0.03 | 0.05 | 39.84 | 54.21 |
| Mean | 23.04 | 56.21 | 7.8 | 6.41 | 0.68 | 0.03 | 0.07 | 39.46 | 56.28 |
| SS SE ± | 0.35 | 2.07 | 0.13 | 0.12 | 0.06 | 0.02 | 0.04 | 0.96 | 0.76 |
| L SD 0.05% | NS | NS | NS | NS | 0.18 | NS | NS | NS | 2.21 |

KEYS: mg / l = milligram / litre, BOD = Biochemical Oxygen Demand, DO = Disserved Oxygen.

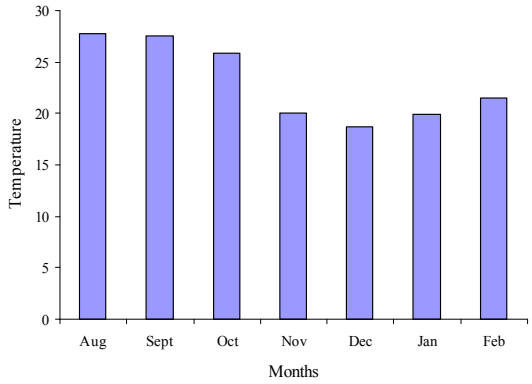


***Figure 1.*** *Monthly mean water temperature in Lake Alau.*

The water temperature ranged from 18.7°C to 27.8°C. The maximum (27.8 ± 0.247) was recorded in the month of August, 2012 (raining season) and the minimum 18.7°C was recorded in the month December, 2013 (dry season). The variation in water temperature between the months was highly significance ($p<0.05$). However there was no significance difference between the stations ($p<0.05$).

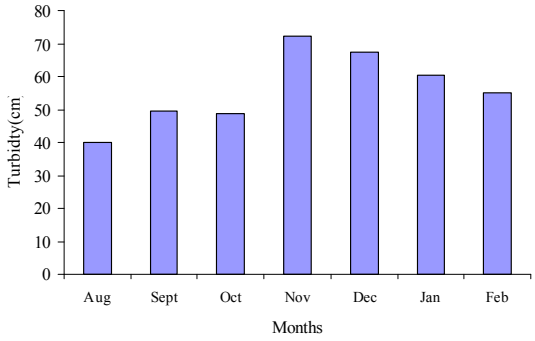


***Figure 2.*** *Monthly mean variations in water turbidity in Lake.*

The turbidity fluctuates from 39.9 cm to 72.86 cm. The maximum value 72.5 ± 2.30 was recorded in the month of November, 2012 (dry season) and minimum value 39.9 ± 2.00 was obtained in the month of August, 2012 (raining season). The turbidity variation in month by season means were statistically difference ($p<0.05$). However, there were no significance differences between the stations.

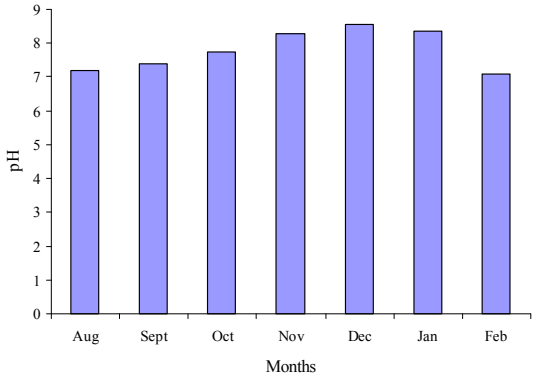


***Figure 3.*** *Monthly mean hydrogen ion concentration (pH) in Lake Alau.*

The pH value was alkaline throughout the study period. The value ranges from 7.1 to 8.9. The maximum mean pH value 8.5 ± 0.34 was recorded in the month of December, 2013 and the minimum value pH 7.08 ± 0.80 in February, 2013 all are in (dry season). There was significance difference between the months and the season throughout the study period. No significance difference between the stations.

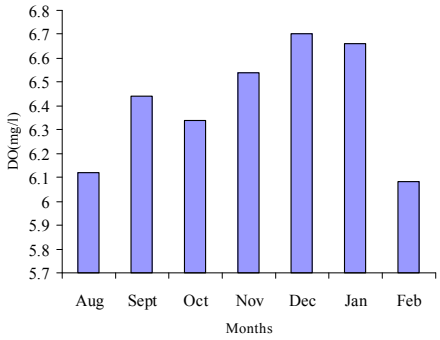


***Figure 4.*** *Mean Monthly Dissolved oxygen (DO) in Lake Alau.*

The DO values ranges from 6.1 to 6.8 mg / l. The maximum value 6.8 mg / l was recorded in the month of December, 2012 (dry season) and the minimum value 6.1 mg / l in the month of August, 2012, (raining season). Statistically, there were significance differences between the months and the season. However the result shows no significance variations between the stations.

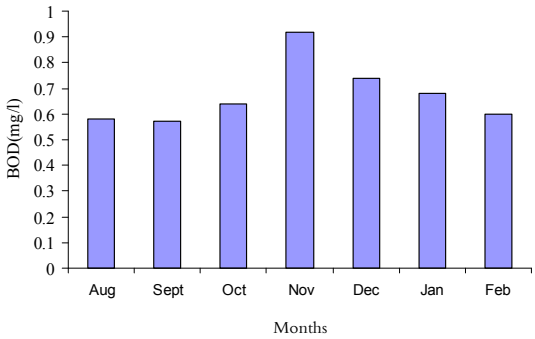


***Figure 5.*** *Mean Monthly Biological Oxygen Demand (BOD) in Lake Alau.*

The Values range between 0.06 mg / l to 0.92 mg / l. The maximum (0.92) was recorded in the month of November, 2012 (dry season) while minimum was recorded in the month September, 2012 (rainy season). The result showed significance difference between the months.

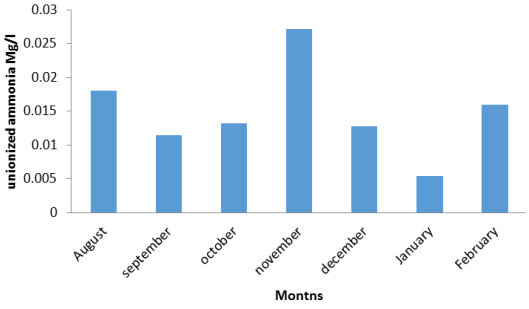


***Figure 6.*** *Monthly Mean Unionized Ammonia in Lake Alau.*

The values range from 0.02 to 0.03. The maximum value was obtained in the month of August, 2012 (raining season) while the minimum value of 0.02 mg / L was obtained in months of February, 2012 (dry season). There are no significance differences between the months.

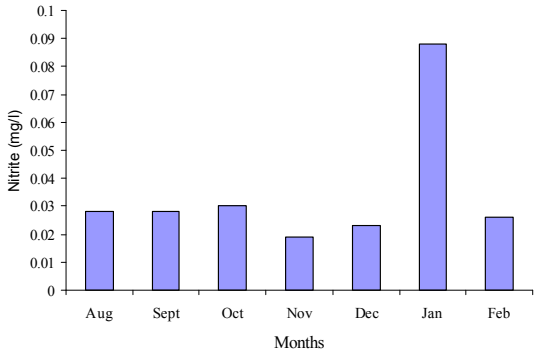


***Figure 7.*** *Monthly Mean Nitrite in Lake Alau.*

The value ranged from 0.005 to 0.025 mg / l. The highest value 0.025 mg / l was obtained in November, 2012 (dry season) and minimum value 0.005 mg / l was obtained in August, 2012 (raining season). The results show significance between the months and the stations respectively.

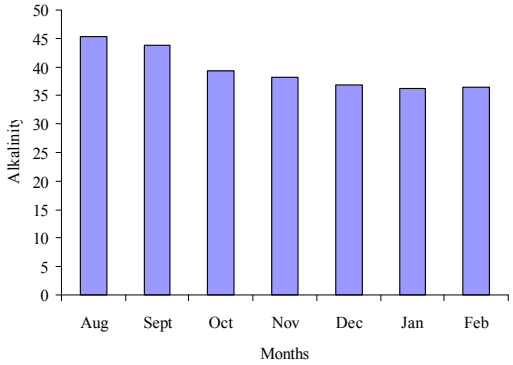


***Figure 8.*** *Mean Monthly Alkalinity in Lake Alau.*

The values range from 36.16 mg / l to 45.39 mg / l. The maximum mean value (45.38 ± 1.84 mg / l) was obtained in the month of August, 2012 (raining season) and minimum mean value 36.16 ± 0.26 was recorded in the month of November, 2012 (dry season). The result shows significance difference between the months and no significance difference between the stations.

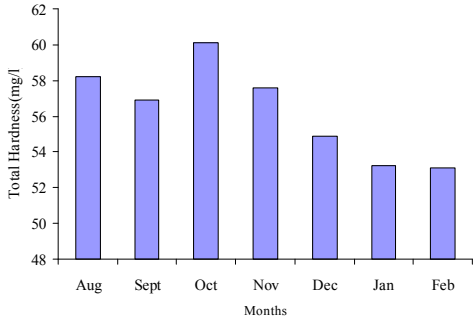


***Figure 9.*** *Mean monthly total hardness of Lake Alau.*

Total hardness of water during the study period fluctuates from 53.10 to 60.10 mg / l. The highest mean value of 60.10 ± 1. 70 was recorded in the month of October, 2013 and lowest mean value 53.10 ± 0.40 was obtained in the month of February, 2013 (dry season). The result showed significance difference between the months and the station.

# 4. Discussion

The extreme ecological condition of the studied area especially the climatic variation could have resultant effect in modifying Lake Alau ecosystem. The water regime in this Lake was mainly influence by rainfall pattern and discharge from its tributaries. So it is expected that any variation weather seasonal or spatial in physical and chemical characteristic of Lake Alau may be influence by climatic regime and catchment characteristic. i.e. extent of human activities and water volume fluctuations. Higher water temperatures were recorded in August (rainy season) and relatively lower in the dry season. These correspond with the months of cool weather at the studied area. Studies by Idowu *et al.*, (2011) showed that temperature variation in Lakes might be caused by influence of environmental factors and human activities around the Lake. However, the low water temperature recorded in the present study from October to February may be attributed to the characteristic cool dry north – east trade wind popularly called harmattan and Lake Alau share the climatic of the north – east zone. This observation was in line with Idowu *et al.,* (2011), who reported that, the dry harmattan season precedes rainy seasons and start from October to February; it is a period of low water temperature between (16°C – 19°C).

The mean temperature values recorded in Lake Alau during this study is similar to work of Idowu *et al*., (2004); Mohammed and Yaji, (2013). The temperatures variation of the Lakes falls within the range of 20 – 50°C meant for domestic purposes and for fish production in tropical fresh water. This is in conformity the report of World Health Organisation (WHO), 1984; Huet, (1997). Similar range was reported by Environmental Protection Agency, (1986) and some African in land water bodies. Khan and Ejike, (1984); Ovie and Adeniji, (1993), also observed low water temperature during this same period in their studies of some related aspects of some Northern Nigeria water bodies. Low temperature was also recorded during this period by other workers in various water bodies, among these researchers are Babale, (1989) and Davies, (2008).

Turbidity of any water is the reduction of transparency due to the present of particulate matter such as clay or silt. More precisely, its measures the extent to which light penetrates and observed to a less extent planktons and other microscopic organism. In the present study, decreased level of turbidity was obtained in the month of August to September (rainy season). This remarkable decreases of the transparent in the study area indicated that floods draining in to the reservoir were responsible for the low water transparency within that period of the study. This is in line with the report of Clesceri *et at*., (1994). Decrease in the level of might be attributed to

flooding due to heavy rain fall and consequent rise in water level, run off from nutrient rich Agricultural lands, some particles and debris were carried a long while other where responded under the action of wind. The decrease in the turbidity in the present study probably has no relationship within creased in population of phytoplankton or zooplanktons. Natural and anthropogenic inputs of sediments and dissolved organic matter in to the column can result in increased turbidity level. Low value obtained during dry season may be due to absence of surface run off water and settling effect of the suspended solid due secession of rainfall. Using the criteria proposed by Environmental Protection Agency, (1986), the mean value obtained in Lake Alau was within the range accepted as safe limit for aquatic life. Ayodele and Ajani (1999), reported that turbidity value of 30 and 60 cm are within acceptable value for fish production, the value obtained are also compared with those of water of most tropical Lakes.

Potential hydrogen ion ($p^H$) is an important parameter in evaluating the acid – base balance of water. The $p^H$ of Lake Alau was alkaline throughout the studied period; $p^H$ value was slightly high in the dry season than in the rainy season. Under the present study, the $p^H$ of the Lake Alau falls within $p^H$ for normal discharge in to surface waters as recommended by European Economic Community (EEC) standard. The $p^H$ value obtained is similar to the work of Idowu *et al.*, (2011). $p^H$ value of 7.0 to 8.5 is ideal for biological productivity. Fishes can become stressed in water with a $p^H$ ranging from 4.0 to 6.5 and 9.0 to 11.0, and death is almost certain at a $p^H$ of less than 4.0 or greater than 11.0 as reported by Ekubo and Abowei, (2011). Fresh waters with a $p^H$ range of 6.0 to 9.0 have been noted to be productive and thus recommended for fish production as being reported by Adeniji, (1986) also. Outside this range water may have sour taste and could be corrosive to metals, which probably increases some heavy metal ions. High mean value recorded during rainy season could be due to combined effects of run-off from agricultural lands (with high concentration of lime) and photosynthetic activity of macrophytes. Low $p^H$ value in dry season was attributed to anthropogenic acidification of allochthonous organic matter.

Dissolved Oxygen (DO) provides a broad indicator for ecological status, productivity and health of a Lake. It also determines the behaviour, growth and distribution of aquatic life as reported by Adakole, (2000), and its concentration in unpolluted water are normally about 8 mg / l. Dissolved oxygen level recorded in this study is within the range for optimum fish growth. However, the result is slightly higher compared to 4.94 mg / l recorded for Ogun River and 3.4 mg / l for Calabar River. Similar result (5.15 - 6.35 mg / l) was obtained by Idowu *et al.,* (2004) in Lake Alau. A higher value obtained may be due to agitation and frequent wind current in the water. Low DO values obtained in dry seasons are probably due to low water depth and less agitation by wind current. Pillay and Kutty, (2005) and Bhatnagar *et al.,* (2004), reported that, DO level > 5 ppm is essential to support good fish production, and less than 1 – 3 ppm has sub - lethal effect on growth and feed utilization; 0.3 - 0.8 ppm is lethal to fishes and > 14 ppm is lethal to fish fry, and gas bubbled is ease may occur. DO less than 1 ppm will cause death to fish, less than 5 ppm cause fish to survive, but grow slowly and will be sluggish. 5 ppm and above is desirable. Santhosh and Singh, (2007) observed that Catfishes and other air breathing fishes can survive in low oxygen concentration of 4 mg L-1.

In the present study BOD level was high in the rainy season. This might be attributed to several microbes present in the water bodies accelerated their metabolic activities with concentrated amount of organic matter and agricultural waste discharge in to water bodies and hence required much amount of oxygen so the demand of oxygen increased. This studies revealed that Lake Alau remain clean and unpolluted water. This is in line with Ekubo and Abowei, (2011) who reported that, aquatic system with BOD levels between 1.0 and 2.0 mg L-1 is considered clean; 3.0 mg L-1 fairly clean; 5.0 mg L-1 doubtful and 10.0 mg L-1 definitely bad and polluted. Similarly, Clerk, (1986) reported that BOD range of 2 to 4 mg L-1 does not show pollution while levels beyond 5 mg L-1 are indicative of serious pollution.

The results indicate that alkalinity of Lake Alau increases with decreased in water level, usually experienced during the dry season. The mean total alkalinity was high in the month of August, during the rainy season and the result is compared favourably well with the ranges given for Lake by USEPA, (1979) and is an indicative to the good quality of Lake water. The present results obtained are in conformity with the earlier works elsewhere. Ekubo and Abowei, (2011) who reported that total alkalinity above 40 mg / l is an indicative of high productivity. Similar observations were made by Holden, (1996) on River Sokoto, Nigeria. Swann, (1997) recommended total alkalinity values of at least 20 ppm for cat fish production and for good pond productivity. Bhatnagar *et al*., (2004) suggested that < 20 ppm indicates poor status of water body; 20 -50 ppm shows low to medium, 80 – 200 ppm is desirable for fish / prawn.

During this present study, high level of total water hardness was recorded in Lake Alau in rainy season, this may be due to present of high content of calcium and magnesium and inflow from agricultural land, roadsides and trees. This report is in line with the finding of Pandey *et al*., (1993) who noted that, total hardness is mainly due to Ca, Mg and eutrophication. Swingle, (1967) reported that the water having a hardness of 15 mg / l or above are satisfactory for the growth off is hand do not require addition of lime for higher production of fish. Desirable concentrations of total hardness for fish production is generally fall with the range of 20 – 300 mg / l as reported by Boyd, (1990). The results of this study obtained are in conformity with study elsewhere.

The levels of nitrite in Lake Alau were marked lower and although the value obtained are within the recommended ranged for fish production compared to those found in Niger delta in Nigeria, which recorded 2.02 mg / l. Low level of nitrite recorded in the study period might be attributed to low human activities such agricultural land use in the catchments; this includes intensive farming around much of the margins of

Lake, low inputs from urban land use and, indirectly, discharges of waste water. Clesceri *et al*, (1994) reported a similar observation that certain human activities increase the amount of nitrite concentration in aquatic - system. Warm water fishes like Carps, Catfishes, and Tilapia are fairly sensitive to nitrite, while trout and other cool water fish are sensitive to extremely small amounts of nitrite. Fish that are exposed to even low levels of nitrite for long periods of time suffer damage to their immune – system and are prone to secondary diseases, such as ich, fin rot and bacterial infections. As methemoglobin levels increase damage occurs to the liver, gills and blood cells.

Ammonia is a toxic compound that can adversely affect fish health, even in very low concentrations. The nature and degree of its toxicity depends on many factors, such as chemical form of ammonia, the $p^H$ and temperature of the water. High level of ammonia was obtained in September (rainy season). The value of ammonia obtained in rainy season is slightly greater than dry season; this might be attributed to high $p^H$ and high temperature in rainy season. Boyd, (1990) reported that ammonia formation in aquatic environment depends on water $p^H$, where at higher $p^H$; free toxic ammonia is released to critical levels.

# 5. Conclusion

This study has provided information on about some the quality status of Lake Alau in north – east part of Nigeria and its suitability for fish production and uses. Any variation weather seasonal or spatial in physical, chemical characteristic of Lake has being influence by climatic regime and catchment characteristic i.e. extent of human activities and water volume fluctuations. The study revealed that most of the physico – chemical parameters were within the observed ranges in unpolluted water bodies and also were found to be within tolerable limit for high yield for fish production.

The physico – chemical parameters such as temperature, turbidity, pH, dissolved oxygen, biochemical oxygen demand, nitrite, ammonia, total hardness and alkalinity were studied in five stations in Lake Alau in Borno state of Nigeria. The studies indicate that there are no variations between the five stations except ammonia and nitrate which exhibited significant variations. However, all the water parameters were within the range recommended for fish production. The study indicates that most of the water quality parameters were within the range for aquatic life and domestic use.

# Recommendations

Since majority of households and farmers bordering the Lake, dispose both their organic and inorganic wastes in to the Lake directly or indirectly. It is recommended that the relevant stakeholder charged with management of the Lake should carry out a sensitization campaign to educate the people on the danger associated with loading of the Lake with waste (toxic), from washing disinfectant or herbicides spraying machine in the lake, while, household should be restricted from washing in the Lake and a community based monitoring program should be developed to capture valuable data and increase awareness within the local population on water quality and shoreline issues.

# References


[1] Abowei, J. F. N. Advance. Journal of Food Science & Technology, (1), 2010; Pp: 16-21.

[2] Adakole, J. A. The effects of domestic, Agricultural and Industrial effluents on the water quality and biota of Bind is stream, Zaria – Nigeria. PhD. Thesis, Department of Biological Sciences, Ahmadu Bello University, Zaria, Nigeria, 2000; Pp: 256.

[3] Adeniji, H. A. Some Immunological Precaution for Fish Farmer's fisheries enterprise and Information Brochure in Commemoration of 5th Annual Conference of the Fisheries Society of Nigeria (FISON), 1986; Pp: 126.

[4] Adigun. Water Quality Management in Aquaculture and Fresh Water Zooplankton Production for use in Fish Hatchie's, 2005; Pp: 86.

[5] Ali, A. N. Ecological Study on Some Water Characteristics used in Fish Farms and their Relation to Fish Productivity. Ph.D. Thesis. Chemistry Dept., Faculty of Science, Al-Azhar University, Egypt, 2007; Pp: 306.

[6] American Public Health Association, A. P. H. A. Standard Methods for Examination of Water and Waste Water. Washington, D. C. USA, 1985; Pp: 281-284.

[7] Anderson, C. W. Turbidity (Version 2.1): U.S. Geological Survey Techniques of Water – Resources Investigations, 2005; Pp: 234.

[8] AOAC. Official Methods of Analysis. Association of Official Analytical Chemists, 15th Edition, AOAC Press; Gaithersburg, USA, 1990.

[9] Ayodele, I. A and Ajani, E. K. Essentials of Fish Farming (Aquaculture), Published by Odufuwa Printing Works, Ibadan, Nigeria, 1999; Pp: 47.

[10] Babale, M. L. Limnology and Zooplankton Distribution of Makwaye Lake, Zaria. M.Sc. Thesis, Ahmadu Bello University, Zaria, 1989; Pp: 51.

[11] Bankole, N. O. and Adikwu, I. A. Diversity and Abundance of Fish Species in Lake Alau, Maiduguri, and Borno State Nigeria. Journal of Sustainable Tropical Agricultural Research, 8, 2003; Pp: 31–37.

[12] Bhatnagar, A., Jana, S. N., Garg, S. K.; Patra, B. C., Singh, G. and Barman, U.K., Water Quality Management in Aquaculture, In: CCS Haryana Agricultural, Hisar (India), 2004; Pp: 203-210.

[13] Boyd, C. E. Water Quality in Pond for Aquaculture. Agriculture Experiment Station, Auburn University, Alabama, U.S.A, 1990; Pp: 482.

[14] Boyd, C. E. Water Quality in Warm Water Fish Pond. Auburn University, Auburn, Alabama. Resources and department. Series, 22, 1979; Pp: 30.

[15] Boyd, C. E. and Litchk koppler, W. Water Quality in Warm Water pond Auburn University, Alabama. Res. And Dev. Series, 22, 1975; Pp: 30.

[16] CBDA. A Resettlement for the Lake Alau Dam and Jere Bowl Scheme. Agricultural Survey and Background Studies. Report submitted to Chad Basin Development Authority by Askonin Nigeria Limited, 1984; Pp: 59.

[17] Clerk, R. B. Marine Pollution. Clarandon Press, Oxford, 1986; Pp: 256.

[18] Clesceri, L. S., A. E. Greenberg, and A. D. Eaton. Standard Methods for the Examination of Water and Waste water, 20 ed. American Public Health Association, Washington, DC, 1994.

[19] Davies, O. A. Physico – Chemical Parameters, Plankton, Epiphyton and Finfish Assemblages of Okpoka Creek, Niger Delta, Nigeria. Ph. D Thesis, University of Ibadan, Ibadan, 2008; Pp: 310.

[20] Ekubo, A. A. and Abowei, J. F. N. Review of Some Water Quality Management Principles in Culture Fisheries, Research Journal of Applied Sciences, Engineering and Technology, 3 (2), 2011; Pp: 1342-1357.

[21] Environmental Protection Agency. Quality Criteria for Water, 1986; EPA. 440 / 5 – 86 - 001.

[22] Gwana, A. M., Bako, M. M., Auwal, M. S., Bagudu, B. Y., Kadai, K. I., Sadiq, A. B., Halima, M. B. Physico – Microbiological and Chemical Examination of Domestic Water Used by the College of Agriculture Community, Maiduguri, North – Eastern Nigeria. International Journal of Science, Technology and Society. Vol. 2, No. 4, 2014, Pp. 63 - 68. doi: 10.11648/j.ijsts.20140204.11.

[23] Holden J. M and Green, J. The Hydrology and Plankton of the River Sokoto Journal of Animal Ecology, 29, 1996; Pp: 65-84.

[24] Huet, M. Text book of Fish Culture, Breeding and Cultivation of Fish. 2nd edition, Fishing News Books, Published University Press, Cambridge, 1997; Pp: 438.

[25] Hujare, M. S. Seasonal Variation of Physico – Chemical Parameters in the Perennial Tank of Talsande, Maharashtra. Ecotoxicol. Environ. Monit. 18 (3): 233, Acad. Environ. Biol. 2 (2), 2008; Pp: 161-167.

[26] Idowu Racheal Toyosi, Gadzama Usman Ngamarju. The Pollution Status of West Africa Arid Zone Lake, Nature and Science, 9 (7), 2011; Pp: 245-249.

[27] Idowu R. T, Inyang, N. M. Ezenwaji, H. M. G. The Physio – Chemical Parameters of African Arid Zone Man Lake. Animal Research International, 1 (2), 2004; Pp: 113–19.

[28] Khan, M. A and Ejike, C. C. Limnology and Plankton Periodicity of Jos Plateau Water Reservoir, Nigeria. West Africa Hydro - biologia, 114, 1984; Pp: 189 – 199.

[29] Mohammad Mustapha Abubakar and Yaji Abubakar J. Some Aspects of the Limnology of Nguru Lake, northern - eastern Nigeria, International Journal of Basic and Applied Science, 2 (2), 2013; Pp: 140–144.

[30] Odunze, F. C., Awojobi R. and Ntakigm. Preliminary fisheries survey of Lake Alau, Maiduguri. Paper presented at the workshop on sustenance and conservation of fisheries and other aquatic resources of Lake Chad and the arid zone of Nigeria. Held on the 16th - 17th January, 1995 at Lake Chad Research Institute, Maiduguri, 1995; Pp: 10.

[31] Ovie, S. I and Adeniji H. A. A simple guide to water quality management in Fish Pond. National Institute for Fresh water Fisheries Research. Technical Report. Series, 23, 1990; Pp: 29.

[32] Pandey, A. K., Siddiqi S. Z. and Rama Rao. Physico – chemical and biological characteristics of Husain Sagar, An industrially polluted Lake, Hyderabad. Proc. Acad. Environ. Biol. 2 (2), 1993; Pp. 161-167.

[33] Pillay, T. V. R. and Kutty, M. N. Aquaculture, Principles and Practices, 2nd Edition. Blackwell Publishing Ltd, Oxford, UK, 2005; Pp: 630.

[34] Saeed, M. S. A study on factors affecting fish production from certain fish farms in the delta. M.Sc. Thesis. Ins. Environmental Studies and Research. Ain Shams Univ. Egypt, 2000; Pp: 416.

[35] Santhosh, B. and Singh, N. P. Guidelines for water quality management for fish culture in Tripura, ICAR Research Complex for NEH Region, Tripura Center, Publication No. 29. 2007; Pp. 35.

[36] Swann, L. D. A Fish Farmer's Guide to Understanding Water Quality, Aquaculture Extension Illinois, Purdue University, Indiana Sea Grant Program Fact Sheet AS, 1997; Pp. 503.

[37] Swingle, H. S. Methods of analysis for water organic matter and pond bottom soil used in fisheries research. Auburn university Alabama. Proceedings of the 9th Science Congress, 1986; Pp: 497.

[38] Tabor J. G. Fin and shellfish conservation populations. Academic Press, London, 1992; Pp. 29.

[39] Umaru Buba Wakil, A. B. Haruna, Gwana Adamu Mohammed, Wanas Lalai Ndirmbita, Bukar – Kolo M. Yachilla, Mohammed Umar Kumai. Examinations of the Stomach Contents of Two Fish Species (Clarias Gariepinus and Oreochromis Niloticus) in Lake Alau, North – Eastern Nigeria. Agriculture, Forestry and Fisheries. Vol. 3, No. 5, 2014, Pp. 405 - 409. doi: 10.11648/j.aff.20140305.23.

[40] United States Environmental Protection Agency. U. S. E. P. A., Quality Criteria for Water. EPA, 1986; Pp. 440 / 5 – 86 - 001.

[41] Williams, J. E. The Co – efficient of Condition of Fish, Chapter 13 In: Schneider, James, C. (ed.) 2000 Manual of Fisheries Survey Methods II: With Periodic Updates. Michigan Department of Natural Resources, Fisheries Special Report 25, 2000; Ann Arbor.

[42] World Health Organization. Guidelines for drinking water quality. World Health Organization, Geneva, 1984; pp: 211.