# The Pollution Status of West African Arid Zone Lake

Idowu Rachel Toyosi[1], Gadzama Usman Ngamarju[1]

1. Department of Biological Science, University of Maiduguri, Borno state, Nigeria, West Africa

ugadzama@yahoo.com, idowu_toyosi@yahoo.com

**Abstract:** Limnological studies were conducted in Lake Alau, the second largest lake in the North east arid zone of Nigeria, West Africa to determine its pollution status. Five sampling stations were selected to determine the physical and chemical parameters. The result showed that water temperature range from 23.05±0.12°C to 25.25±0.25, $P^H$ varied from 6.59±0.01 to 7.29±0.05, dissolved oxygen range from 5.10±0.02mg/l to 6.35±0.03mg/l. the range for the Biochemical oxygen demand (BOD) was 4.30±0.03 to 5.31±0.25. Conductivity was between 115.47 ohms/cm and 131.45±0.75 ohms/cm. Total dissolve solids (TDS) was between 59.17±0.42 and 65.84±0.62mg/l. The dissolved metals are arranged in the following order of abundance: Cu>Fe>Mn. The levels of metals in Lake Alau were markedly lower than those found in some Africa inland water. The results obtained from the study show that most of the physicochemical parameter were within tolerable limit for human consumption, biodiversity productivity and are below pollution level.
[Idowu Racheal Toyosi, Gadzama Usman Ngamarju. The pollution Status of West Africa Arid Zone Lake. Nature and Science 2011;9(7):245-249].(ISSN: 1545-1003). http://www.sciencepub.net/nature

**Key word:** Lake Alau, pollution, arid zone, temperature, conductivity and dissolved metals

## 1. Introduction

Over the last year in many Africa countries a considerable population increase has taken place accompanied by a steep increase in urbanization, industrial and agricultural land use. This has entailed a great increase in discharge of pollutants to receiving water, causing undesirable effects on the aquatic environment and on fisheries. The fresh water of the west Africa region provide livelihood to some communities, support industries, provide storage for irrigation, hydropower electricity production, support largely subsistence fisheries and act as repositories of biological diversity.

Organic pollution of inland waters in West Africa, in contrast to the situation in developed Countries, is often the result of poverty, poor economy and social underdevelopment. According to Talba (1982), it is in these countries that the quality of water, and often the quantity, is lowest, coupling with poor sanitation and nutrition, the problem become worsen leading to high water born disease prevalent in connection to population and industrial growth. In the past natural purification and dilution were usually sufficient to give clean water for most domestic and industrial activities due to less participation of man in urbanization and industrialization. However, today inland waters (river, Lake etc.) often become the recipient of organic matter and industrial waste in large amount exceeding their natural purification capacity due rapid urbanization and industrial activities going on continuously. Sewage and other effluents rich in decomposable organic material have been known to cause primary organic pollution (Lee et al., 979). Lee described secondary organic pollution as surplus of organic matter, which is the sum of undecomposed organic material introduced into the water body with primary pollution and the materials resulting from the organic substances extremely increased bio productivity within the polluted ecosystem itself.

There are very reports on water quality studies for most Africa inland water and the few reviews available on the state of pollution of Africa inland water (Dejoux et al., 1981; Alabaster 1981; Calamari 1985; Burgis and Symoens 1987; Davies and Gasse 1988) mostly do not concentrates on arid zone pollution. Organic pollution of aquatic system is on the increase in Nigeria mainly due industries sited along river, lakes and streams which discharge their effluents into these water bodies (Alabaster and Lioyd, 1980). In addition to discharge from industrial waste, surface run-off and domestic sewage also contribute to water pollution (Steele and MaGhee, 1979). Organic pollutants could include Biochemical oxygen demand (BOD), chemical oxygen demand (COD) hydrocarbons, grease and oils and so on (Swisher, 1989), however, some factors such as Temperature, Dissolved Oxygen (DO), Total Dissolved Solids (TDS) and conductivity have been reported to affect the concentration of these pollutants in aquatic system (Okpokwasili, 1990).

Increase organic pollution result in elevation of phytoplankton activity, the effect is an increase in primary productivity leading to eutrophication (Lee et al .1978). Run- off water transport soil to steams, river and lake by erosion processes, including dissolved and particulate organic matter. Decomposition of this organic matter continues during transportation and sedimentation process, giving rise to new soluble organic and inorganic matter. Man himself is viable to use all the energy stored in foods and his wastes are often discharged into the water without treatment which could result to public health hazard.

Shuval, (1986) observed that untreated sewage creates a public health danger being a potential for epidemics of water–born diseases, such as typhoid fever, cholera etc., and also cause a serious loss of recreational value of the inland waters. This study was thus conducted to determine the pollution status of Lake Alau so that whatever information obtained here would be useful in the management of the Lake upon which the entire populace of Maiduguri depend on as the major source of water for both domestic and industrial use.

## 2. Materials and methods

**2.1 Study area and sampling station:** Lake Alau is the second largest lake in Borno State of Nigeria, West Africa. 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 11ºE and 13ºE 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 (CBDA, 1986).The lake is located in the North-East Arid zone and the climate is sahelian, with three district season. A rainy season starts from June to September, with mean annual rainfall of about 600 mm; the harmattan season precedes dry season, and starts from October to February. It is a period of very low temperature and cold dry harmattan wind. The dry hot season starts from March to May, marking the driest period with intense heat (Bankole et al., 1994, Idowu et al., 2004).

The water volume is lowest during the months of March and April during which great portions of the lakebeds are dried and field of sand and rocks are exposed (Idowu et al., 2004). There was neither pre-impoundment nor immediate post impoundment survey or pollution studies of the lake. The earliest report was the preliminary study of the Fishery resources of the Lake by Odunze et al., (1995). After its impoundment, Bankole (1994) worked on the frame and catch assessment of the lake. Fasesan (2000) observed that zooplankton composition of the lake. The Lake serves as the main practical site for the undergraduate and post graduate student of the University of Maiduguri as well as for the student of Fresh Waters, Fisheries Research Institute, Maiduguri Borno State.

Sampling station 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 station were marked at intervals of 2.5 to 9 km to from the head region.

### 2.2 Water sample collection

Surface water sample were collect at five (5) sites along the cause of the lake. All samples were collected between 8 am and 10 am. Collection was made twice a month from October 2001 to September 2002. Water temperature were recorded in the field using a mercury thermometer of range (0-50 ºC), sample for Dissolved Oxygen (DO) and Biochemical Oxygen Demand) (BOD) were collected with 250 ml DO and BOD bottles.

Hydrogen ion concentration and conductivity determinations were made within 5 minutes of collection with battery operated field meters Model, PYE $P^H$ 56 for pH and Electronic switch gear model MHI-9033 Mark V set for conductivity. Oxygen was fixed on the fields and its determination was according to Mackereth (1963, Mackereth and Heron, 1978). The Total Suspended Solids (TDS), nitrates, total alkalinity and ammonia concentration, were determined by the method recommended in standard methods for examination of water and wastes water (Taras *et. al* 1980). The copper, iron, manganese and nitrates contents were monitored with a spectrophometer (spectronic 21 digital type). Comparism of data between stations and sampling period was made using one-way ANOVA and t-test at 5% level of probability.

## 3. Results analysis and Discussion

The results (averages with their standard errors) for the chemical analysis are shown in Table 1.The results shows that the average temperature of the lake lie between 25.13 to 27.45 $^{o}C$, and falls within the normal temperature recommended as the International Standard for river, Lakes and Streams. The temperature ranges for all the stations was higher than that of Lake Asejire 22.5 ºC. This could be due to the fact that water in higher latitude is subjected to temperature extremes. However, the difference in the upper temperature limit is not much and so the fear of the drought with its concomitant high temperature accelerating the concentration mineral salts through evaporation is very remote. Within the periods under study, the pH of the lake range between 6.59 to 7.29 also falls within pH for normal discharge into surface waters as recommended by European Economic Community (EEC) standard. The EEC pH standard for most uses is 7.0 - 8.5, and the lake standard proposed for Nigeria is 6-8 (Akeredolu, 1972). The pH ranges obtainable in the Lake suggest a medium carbon dioxide supply and medium productivity. The $P^H$ ranges of lake Alau were comparatively narrow and falls within the recommended range (6.5- 9), as suitable for aquatic life and human consumption (Adeniji, 1989). The dissolved oxygen showed a significant variation between all stations during the 12 months being reviewed. The dissolved oxygen saturation was about 5.15 – 6.35mg/l. one would have expected a decrease in dissolved oxygen concentration during the drought phase due to shallower depths and higher temperature since the solubility of oxygen increase with decreasing temperature. This was not the case probably because of the constant agitation of the water mass by very strong North-Eastern winds there by aerating the water and sending more oxygen into solution. The Nigeria standard for most uses is 5 mg/l (Akeredolu, 1972). Boyd (1979) also recommended 5mg/l for tropical waters.

The mean conductivity value was highest in station 1 (131. 45 ± 0.75 ohms/cm) while Station 4 has the lowest mean value of 115.47 ± 0.75ohms/cm. Considering the lake as a whole and the changes in conductivity in relation to the stations; there is an increase in the concentration of ions of the lake. An increase in conductivity value from one station to another shows the effect of increased organic and inorganic load of the lake with increased volume. Messerve and Camp (1974) reported that water with the conductivity value of 75.0 – 225.0 ohms/cm is satisfactorily good for agricultural purposes especially irrigation. Also the minimum and maximum conductivity values for portable water in European Economic Community (EEC) countries are between 400 and 1250 ohms/cm respectively. Thus, the concentration of ions in all the stations studied, are below the acceptable value for domestic and industrial uses.

The concentration of the free carbon dioxide recorded in this study falls between recommended values of below 6.0 mg/l for fishery production, (Boyd, 1979). The lowest mean value of 2.55 ± 0.05 mg/l was recorded in station 1, compared to other stations.

The Biochemical Oxygen Demand (BOD) exhibited the same trend as Dissolved oxygen (DO) measurement. Table 1 showed that BOD was highest in station 5 (5.31 ± 0.25) and lowest in station 2 (4.30 ± 0.28). There was no observable variation in the values as one progress from station 1 to station 5 indicating the absence of the effects of domestic agricultural and industrial sewage discharged and increase run-off as well as soil erosion along the course of the lake. Biochemical Oxygen Demand indirectly depicts the amount of putressible organic matter degradable by microbial metabolism on the assumption that the water medium has no bacteriostatic effects. Moore and Moore (1976) 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. The results in Table 1 show that the Lake water was fairly clean.

The mean phosphate phosphorus ($P – PO_4$) recorded varies between 0.26 + 0.00 mg/l in station 2 and 0.34 + 0.00 mg/l. The phosphate phosphorous value range recorded in this study falls below the observed range of 3.2 – 6.30mg/l observed by Beadle (1981). The reason for the decrease value compared to those aquatic systems may involve heterophic update by microorganisms, sediments absorption and removal by the current. The slightly higher value 0.37 ± 0.10 mg/l recorded in station 3 may be connected with effects of fertilizers and agricultural by-products washed directly into the lake.

The data of the dissolved metals recorded in Table 1 showed that Copper gave the highest levels in all the stations 0.52 + 0.01 - 0.64+ 0.00mg/l with a consideration wide variation compared to iron. The dissolved metals are arranged in the following orders of abundance Cu >Fe>Mn. The levels of metals in Lake Alau were markedly lower that those found in most Africa inland waters. This reflects the direct influence of pollution on the Lake and Rivers. Lake Alau showed low to moderate metal concentrations compared to Niger delta in Nigeria, which recorded 2.02mg/l for copper, 4.5mg/l for iron and 2.18 mg/l for Manganese (GESAMP, 1982). The above not with standing, the occurrence of heavy metal in Africa aquatic systems is not excessive when compared to some other areas of the world.

The results obtained from the study shows that most of the physico-chemical parameters were within the observed range recorded by the other researchers, and were found to be within tolerable limits for biodiversity, specie, richness, high yield of fish production and human consumption. Most station in Lake Alau shows low to moderate metal concentration, which indicates low level of pollution. In conclusion, the chemical parameter in Lake Alau is comparable with what is obtained in other West African Sahel reservoir. The little variation in the concentration of heavy metals in the station may be attributed mostly to the discharge of waste water from domestic and agricultural activities as well as direct deposition of dry and wet particles by harmattan winds and rainy seasons flood.

**4. Conclusion**:

In view of the expected increase in industrialization and urbanization in most West Africa countries, it is still important to formulate pollution control policies that take into account the needs to regulate discharge of contaminant into the aquatic system. It is also important to add that as part of the objective of pollution control emphasis should be placed on the need to minimize waste generation. Industries should be encouraged to adopt low and Non-waste Technologies (LNWT) at all stage of a product's life, i.e., raw materials extraction, production, use and disposal.

Environmental auditing which involves self-regulations should be encouraged within the community as part of an overall environment management policy. Since self-regulation is believed to be frequently more effective than reliance on official rules which may not cover every contingency. The monitoring of pollutants in the aquatic environment has become an important issue in recent years, as the persistence and biological activity of many of these compounds have been recognized. Rapid methods for the evaluation and understanding of toxic effect of chemical both direct and indirect, of west Africa aquatic organism and ecosystem are urgently needed so that real-time' management decision can be made and further environmental degradation averted.

**Table 1.** The physico - chemical parameters of Lake Alau with standard errors (SE) in five stations labeled 1 to 5.

| Parameter | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Temperature (°C) | $25.25\pm0.18^b$ | $23.05\pm0.14^b$ | $25.05\pm0.19^b$ | $2.14\pm0.12^b$ | $25.13\pm0.00^b$ |
| Depth (m) | $2.85\pm0.18^b$ | $3.64\pm0.03^b$ | $3.92\pm0.25^b$ | $23\pm0.13^a$ | $3.18\pm0.06^b$ |
| pH | $6.79\pm0.05^b$ | $6.97\pm0.03^b$ | $6.83\pm0.02^b$ | $7.29\pm0.05^b$ | $6.59\pm0.01^b$ |
| Dissolved Oxygen (DO) (mg/l) | $6.15\pm0.05^a$ | $6.35\pm0.03^a$ | $5.18\pm0.02^b$ | $6.32\pm0.01^a$ | $5.15\pm0.03^b$ |
| Conductivity (ohms.cm) | $131.45\pm0.75^b$ | $128.25\pm0.52^b$ | $119.42\pm0.83^b$ | $115.47\pm0.75^a$ | $118.14\pm0.16^a$ |
| Free $CO_2$ (mg/l) | $2.55\pm0.05^b$ | $2.90\pm0.01^{ab}$ | $2.85\pm0.02^{ab}$ | $3.06\pm0.04^a$ | 2.84±0.04+ab |
| Alkalinity (mg/l) | $30.30\pm0.32^b$ | $36.85\pm0.05^{+b}$ | $40.67\pm0.18^b$ | $47.00\pm0.02^a$ | $37.25\pm0.24^b$ |
| Biochemical Oxygen demand (mg/l) | $4.30\pm0.32^a$ | $4.30\pm0.32^a$ | $4.45\pm0.50^a$ | $5.03\pm0.33^a$ | $5.31\pm0.25^a$ |
| Nitrate-nitrogen ($NO_{3)}$) (mg/l) | $4.27\pm0.18^a$ | $5.43\pm0.19^a$ | $5.40\pm0.25^a$ | $5.73\pm0.37^a$ | $6.30\pm0.50^a$ |
| Phosphate-phosphorous (P-$PO_4$) (mg/l) | $0.34\pm0.00^b$ | $0.28\pm0.00^b$ | $0.37\pm0.10^b$ | $0.31\pm0.01^b$ | $0.32\pm0.01^b$ |
| Total dissolved solids (mg/l) | $63.31\pm0.30^b$ | $67.88\pm0.28^a$ | $59.17\pm0.42^b$ | $65.84\pm0.62^b$ | $60.73\pm0.33^b$ |
| Copper (CU) (mg/l) | $0.52\pm0.01^a$ | $0.52\pm0.02^b$ | $0.52\pm0.01^b$ | $0.60\pm0.00^a$ | $0.64\pm0.00^a$ |
| Iron (Fe) (mg/l) | $0.09\pm0.00^b$ | $0.7\pm0.00^b$ | $0.08\pm0.00^b$ | $0.09\pm0.00^b$ | $0.12\pm0.01^b$ |
| Manganese (Mn) (mg/l) | $0.05\pm0.01^b$ | $0.04\pm0.01^b$ | $0.09\pm0.01^b$ | $0.09\pm0.02^b$ | $0.09\pm0.01^b$ |

The value with the same superscript on the same row arte not significantly different at $P \geq 0.05$

**References**.


[1]. Adeniji HA.. Limnological Characteristics of Man Made Lakes in Nigeria In: The proceeding of the National Conference of Two Decades of Research on Lake kanji, Nigeria Institute of Fresh Water Fishery Research 1989; 224-32.

[2]. Akeredolu FA. Setting Water Quality Standards of Nigeria. Paper Presented at the Third National Conference of Water Pollution 17-18th October. Port Harcourt Nigeria. 1972; 6

[3]. Alabaster JS, Lioyd R. Water Quality Criteria for Freshwater Fish, 2nd Edition. London. Butter worth 1980; 361-2.

[4]. Alabaster JS. Review of the state of Aquatic pollution of East African inland waters. CIFA occasional paper 1981;(9):36-7.

[5]. Beadle LC. The inland waters of Tropical Africa, Longman – London 1981; 321-2.

[6]. Baijiot E, Bauda S, Quedraogo L. Physical, Chemical and Biological Characteristics of Reservoirs in Burkina Fasso.. In: Hydro Biological aspects of fisheries in small reservoirs in the Sahel Region.Technical Center for Agriculturaland Rural Cooperation, wagcningen, Netherlands 1997; 25-9.

[7]. Bankole NO, Sule OD, Okwundu EC, Amadi M. Preliminary investigation on the frame and catch assessment survey of Alau Reservoir. Annual report of NIFFRI, 1994;28-9.

[8]. Boyd EC. Water Quality in Warm water fishpond Craft print. Inc. Auburn, Alabama. 1979; 353- 4

[9]. Burigis MJ, Symoens J. Africa Wetland and Shallow water bodies/ zones humides et lacs peu profounds d'Afrique Director/repertorire. TRAV. Doc. Inst. Fr. Rech. Dev. Coop, 1987;( 211):650

[10]. Calamari R, Chiauderi G. Problems and methods in defining water quality Criteria of micro

pollutants in aquatic ecosystems. In: proceedings of the third conference of prevention

by substances derived from wasted, Rome. 1985;302-20.

[11]. CBDA. A resettlement plan for the Alau reservoir Dam, and JERE Bow Scheme. Report submitted to Chad Basin Development Authority Askonig Nigerian ltd., 1986;59-60.

[12]. Davies B, Gasse F. African wetlands Shallow water Bodies/Zones. Humide set lacspeu profoundd'Afrique. Biobliography /bibliography. Doc. Inst. Fr. Rech. Sic. Dev. Coop 1988;( 21):502-3.

[13]. Dejoux C., Lauzane L. and Leveque C. Nature des fords. Repartitioned Organisms benthiques don la region de bal (lac Chad) cahiers ORSTOM series Hydrobiogic 1981; (5):213-3.

[14]. Fasesan RT. Zooplankton Composition and Abundance in lake Alau. North Eastern Nigeria Journal of Experimental and Applied Biology. 2000; 1(2): 11- 16.

[15]. GESAMP. (Joint Group of Experts on the Scientific Aspect of Marine Pollution Review of Potentially Harmful substances, REP STUD. 1982; 16(1):48-57.

[16]. Idowu RT, Inyang N.M, Ezenwaji HM. Heavy Metal Concentration in a West Africa Sahel Reservoir. Animal Research International 2004; 1(1):12 – 5.

[17]. Idowu RT, Inyang NM Ezenwaji,HMG. The physio-chemical parameters of African Arid Zone Man Lake. Animal Research International 2004;1(2):113-19.

[18]. Lee FG, Rest W, Jones RA. Eutrophication of Water Bodies: insights for an Age-old problem. Environ Sci. Technol. 1978; 12:901-8.

[19]. Mackereth FJ. Some methods of Water Analysis for Limnologist, Fresh Water Biological Association, Scientific Publication, 1963; 21:72.

[20]. Mackereth FJ, Heron J, Talling JF. Water Analysis: some Revised Methods for Limnologists. Freshwater Biological Association Scientific Publication. 1978; 36:112.

[21]. Messerve RL, Camp TR. Water and its impurities. Dowde*n*, Hutchinson and Ross inc. Strand Burg, Pennsylvania.1974; 346.

[22]. Moore WJ, Moore EA. Environmental Chemistry Academic Press, London 1976;360-8.

[23]. Odunze FC, Awojobi R, Ntakigm T. Preliminary Fisheries Survey of Lake Alau Maiduguri. Paper presented at the workshop on Substance Management and Conservation of Fisheries and other Aquatic Resource of Lake Chad and Arid Zone of Nigeria. Held on the 16$^{th}$ -17$^{th}$ at Lake Chad Research Institute, Maiduguri, 1995; 10-11.

[24]. Okpokwasili GC. Effect of Salinity on the Biodegradation of oil spill dispersants. Waste Management 1990; 10(2):141- 6.

[25]. Shuval HI. Thalassogenic diseases. UNEP Reg. Seas. Rep. Stud., 1986; 79:44.

[26]. Steel EW, Maghee JJ. Water Supply and Sewage, McGraw-Hill. Book Company, New York, 1979.

[27]. Swisher RD. Surfactant biodegradation, 2nd Edition, Marcel Decker, New York. 1987.

[28]. Taras JM, Greenberg EA, Noak DR. Standard Methods for the Examination of Water and Waste Water. 15$^{th}$ Edition, APHA- AWWA IWPCF. Pub., New York. 1980.

[29]. Talba MK. Development without Destruction. Evolving Environmental Perceptions. Dublin, Tycooly. Natural Resources Environ. Ser. 1982; (12):197.

6/17/2011