Assessment of Drinking Water Quality of Alau Dam Maiduguri, Borno State, Nigeria

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Abstract- This work assessed the quality and use of water from Alau Dam Maiduguri, Borno State on the physical, chemical and microbiological parameters. Raw water sample were collected at River Ngadda, Lake Alau, domestic, industrial and irrigation water use points from Alau as well as treated water from Alau Dam as supplied to households by Borno Water Corporation. Using purposive sampling technique, Six (6) samples were taken and analysed for physical parameters: colour and turbidity. Chemical parameters: phenolphthalein, total Alkalinity, total hardness, calcium hardness, magnesium hardness, chloride, sulphate, fluoride, nitrites, PVC estimate, TDS, Free chlorine, magnesium, calcium, copper, lead ,zinc and Iron. Microbiological parameters: Aerobic Mesophilic count, coliform, E. coli count and P. aeruginosa. The result shows that the value for some of the parameters are within the maximum limits of World Health Organisation (WHO) and National Agency for Food, Drug Administration and Control (NAFDAC) standards while some parameters especially, turbidity for treated water as well as PH, turbidity of some, untreated water and microbiological parameters for, all untreated water were above maximum limits prescribed by WHO and NAFDAC. Therefore, the research has revealed that Alau Dam, Maiduguri suffers from pollution as a result of in-stream uses and on-site activities, thus, outbreak of communicable diseases has been experience in the area, mitigating these problems on human health and environment.

Index Terms- Alau dam, water quality, Maiduguri

I. INTRODUCTION

The sources of water for any specific purpose are not as important as the suitability of the water for the desired purpose. With increasing human population, industrialization, urbanization and the consequent increase in demand for water for both domestic and industrial Introduction

Uses, the attendant increase in the implication of polluted water on man and the environment have been severally studied (Asiwaju-Bello and Akande, 2004; Ige et al; (2008).

Water quality is determined by the physical and chemical limnology of a reservoir (Sidnei et al; 1992) and includes all physical, chemical and biological factors of water that influences the beneficial use of the water. Water quality is important in drinking water supply, irrigation, fish production, recreation and other purposes to which the water must have been impounded (Moshood, 2008). Notwithstanding, many people in developing countries do not have access to safe and clean drinking-water or adequate amount of water for basic hygiene, due to water pollution from agricultural, industrial and other human activities. As pointed out by (Dabi and Dadan-Garba, 2009) that such level of pollution is visible in Nigerian cities and it have serious impacts on human health and well-being since about 80 percent of all diseases and more than one-third of all deaths in developing countries are caused by contaminated water. The MDG drinking-water target will be exceed by 2015, but the sanitation target will be missed by about 1 billion people. It further states that, 2.2 million people in developing countries, most of them children die every year from diseases associated with lack of access to safe drinking-water, inadequate sanitation and poor hygiene. And half (1/2) of the world hospital beds are filled with people suffering from water related illness. In Nigeria despite the generous endowment of surface and groundwater, which are capable of meeting demands, sanitation receives far less attention than water supply. Urban sanitation is in a dismal state and improving the situation requires better-formulated policies and a massive injection of investments. The poor state of the water and sanitation sector in Nigeria is related in the high infant mortality and morbidity rates for the country. Mortality rates for infants and children under five years old were 100 and 201 per 1000 live birth respectively. The three major causes were malaria, diarrhea and acute respiratory infections, all of which are related to unclean water and inadequate sanitation. Together with typhoid, these diseases account for more than 70 percent of all mortality and morbidity in Nigeria. In recent times, Maiduguri has experience an outbreak of cholera that many lives were lost. Thus, the research intent to look at the quality of water of the lake (dam) and supply to various parts and that supposedly treated and supplied to households.

II. STUDY AREA

Maiduguri is the capital of Borno state located between latitude 10^000 and 14^000 north of the equator and longitude 11^030 and 14^045 east of the Greenwich Meridian. The state lies some 355m above sea level and it occupies a total area of 50,778 sq km lying within the sudan-sahalian zone of Nigeria. It is the largest town in the North-Eastern area of Nigeria. The relief of the study area is basically a plain surface founded on the Chad Basin and broken by the valleys of both Ngadda and Yedseram rivers. The relief of Maiduguri lies on the vast open plain which is relatively flat or gently undulating. The landscape is developed on the young sedimentary rocks of the Chad formation. This formation is overlain by sand drifts which may be up to 90 metres thick. The extensive plain contains no prominent hill and

attains an elevation of about 350m above sea level (Ijere and Daura, 2000).

Lake Alau a dam constructed by the Lake Chad Basin Authority depends on run off and annual flow of two rivers: River Ngadda which rises some 20km in Askira-uba after having descended the Precambrian hill, crossed the alluvial plain (Chad formation) and become confused with the course of River Yedseram that runs into the Sambisa Swamps areas of Borno state (Ijere and Daura, 2000).

Alau Dam, a water reservoir constructed across river Ngadda to store water during seasonal floods in undulating low land of the south of Konduga village. Apart from the dam which provide water, there are intake works at Alau Raw Water pumping Station having 3 pumps (2 on duty and 1 standby) with flow per pump 540 l/sec and discharge pressure of 55m; a transmission line for raw water with pipe size of 800mm diameter with total length of 12.5km to the water treatment plant. The plant is designed to treat $67,000m^3$/day and pump 15,000, 000 gal/day with flow of 775 l/sec. The treatment plant has 32 ground reservoir each with capacity of 16, $750M^3$, 2 overhead concrete tanks each with capacity of $4,500M^3$, 4 flat bottom clarified tanks, rapid gravity sand filters, chemical treatment section, power supply system PHCN and 2 generators of 100 KVA and high lift pumps.

III. METHODS AND MATERIALS

The nature of the data was of infinite because it was derived from continues distribution of river flow and dam. The data was, however reduced from continues distribution to discrete by taking water samples at six (6) points within the following locations as listed below:

Table I. Locations of Sampling points of Alau Dam

Locations	Samples	Symbols
Water from River Ngadda	I	WRN
Water from Lake Alau	II	WLA
Domestic water use point from Alau Dam	III	WDU
Irrigation water use point from Alau	IV	WIU
Industrial water use point from Alau Dam	V	WIN
Treated water from Alau dam supplied to household	VI	WTS

Note: symbols were not used in details, only the samples in Roman numerals as representation of the sampling points

The method used for data collection for the purpose of this research followed a purposive sampling approach based on the procedure stated in the NAFDAC Guidelines for Drinking Water Quality in Nigeria. Based on this, water samples were collected for quality analysis by using a fetcher tied to a rope and dipped into the water and poured inside a plastic bottles capped and labelled with respect to their points of collections and uses to which the raw water from the dam is put to as well as the treated water from the treatment plant was collected from the tap ready for supplied to households. Samples collected in bottles were transferred from the collection points to the laboratory in a cooler to maintain steady temperature of the water.

The samples of water were collected and subjected to laboratory analysis, using all the required materials, equipment and procedures as practiced in a standard laboratory. The following parameters of water were analyzed:
   i.   Physical parameters: *colour, odour, taste*
   ii. Chemical parameters: *PH, total hardness, calcium hardness, total dissolved solids, dissolved carbondioxide, chloride, fluoride, nitrite, sulphate, free chloride; trace metals; copper, lead, zinc, iron, calcium and magnesium;*
   iii. Biological parameters: *coliform count, E.coli count and P.auriginosa.*

These parameters are considered as the most common contaminated found in water used households in the study area which causes cholera outbreak almost every year, typhoid fever, skin irritation, bilherziosis etc. determining the levels of these parameters in water used by the households in the study area will help in assessing the portability or quality of the water from the dam for human consumption and other uses.

The results of the laboratory analysis were compared with that of WHO and NAFDAC, maximum limits of water quality parameters for drinking water; these are World and national standard for quality drinking water.

IV. RESULT AND DISCUSSION

Figure 1.reveals that colour of untreated water at sampling points I-V are 337, 267, 310, 227, and 193 Hazen's scale in mg/l respectively, which are all above WHO and NAFDAC specified limits of 15 and 20 Hazen, mg/l standards for colourless water. Taste and odour for all the samples were not detected while turbidity shows the following 14, 18, 16, 36 and 30 NTU mg/l for the sampling points. The turbidity value for sampling points I,II and III falls within the specified limits of 5-25 NTU by WHO and NAFDAC while at points IV and V where both above the maximum limit of the Regulatory Standard. Colour of the treated water (sampling point VI) is 40 Hazen scale mg/l which is above WHO and NAFDAC limits of 15 and 20 Hazen's scale mg/l specified standard. Taste and Odour where not detected from the treated water while the turbidity is 39 NTU mg/l was found to be above specified limit of 5 and 25 NTU by WHO and NAFDAC, respectively.

Figure 1. Physical Parameters sampling points of Alau Dam in compare with NAFDAC and WHO
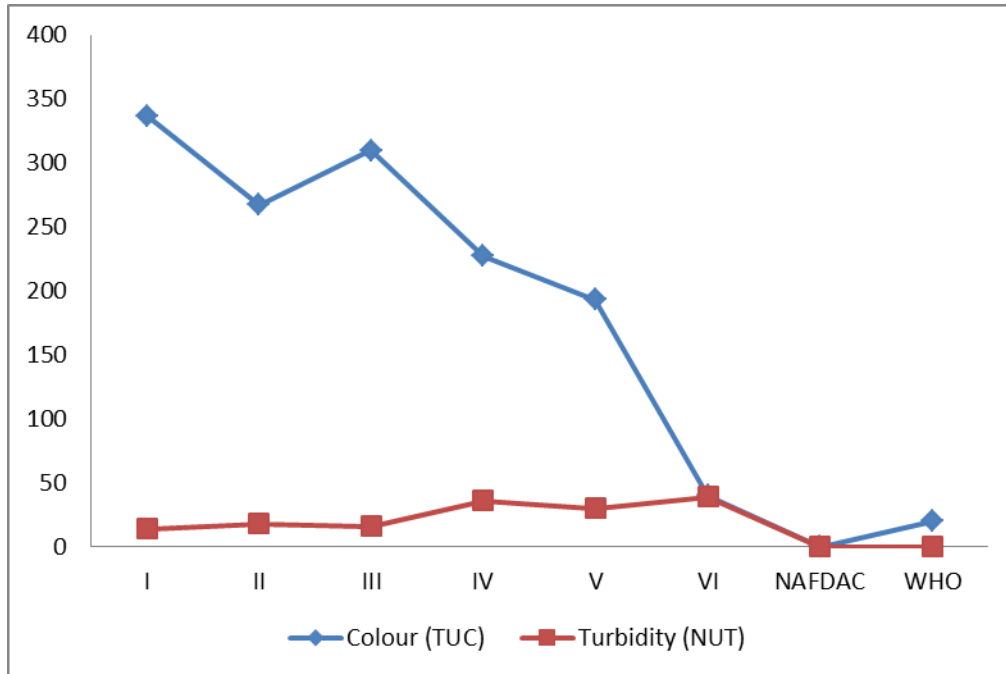
Source: author's research and lab analyses (NAFDAC's Lab) Maiduguri, 2012.

Note: WRN, WLA, WDU, WIU, WIN and WTS symbols were not used to represent sample points

Table II: Chemical Parameters sampling points of Alau dam in compare with NAFDAC and WHO

CHEMICAL PARAMETERS	I	II	III	IV	V	VI	WHO	NAFDAC
PH	8.886	8.399	8.78	8.182	8.436	7.763	6.5 - 8.5	6.5 - 8.5
DCD (mg/l)	1	1	2	1	1	4	-	50
Total Alkalinity (mg/l)	72	64	60	52	48	36	-	100
Chloride (mg/l)	13	7	13	8	9	12	-	250
Total hardness (mg/l)	40	52	32	40	48	52	-	100
Calcium hardness (mg/l)	25	32	20	25	30	30	-	50
Magnesium hardness (mg/l)	19	20	12	15	18	22	-	50
Sulphate (mg/l)	10	10	5	10	10	0	500	250
Fluoride (mg/l)	0.2	0.4	0.2	0.2	0.4	0.2	1.5	1.3
Nitrate (mg/l)	0.03	0.03	0.03	0.03	0.02	0.02	50	3
TDS (mg/l)	220	260	200	260	200	240	500	500
Free Chlorine (mg/l)	0.16	0.17	0.15	0.14	0.19	0.12	0.4	0.3
Copper (ppm)	0.21	0.32	0.19	0.41	0.19	0.12	2	2
Calcium (ppm)	2.17	2.26	3.1	2.14	1.96	1.12	200	75
Zinc (ppm)	0.01	-	-	0.09	0.03	-	3	5
Iron (ppm)	0.16	1.3	0.37	0.41	0.34	-	0.3	0.3

| Magnesium (ppm) | 3.16 | 2.93 | 2.63 | 2.14 | 3.71 | 1.06 | 150 | 50 |

Source: author's research and lab analyses (NAFDAC's Lab) Maiduguri, 2012.
Note: WRN, WLA, WDU, WIU, WIN and WTS symbols were not used to represent sample points.

Table 2. indicate the following about chemical parameters for untreated water: the PH for water samples at points I-V are 8.886, 8.399, 8.780, 8.182 and 9.436 respectively, all the PH are within the WHO and NAFDAC limits of 6.5-8.5 except for sampling points 1 and 3 which are above the standard; the amount of Dissolved Carbon-dioxide (DCD) for the sampling points are 1.0,1.0, 2.0, 1.0 and 1.0 mg/l which are below the maximum value of 50mg/l as stipulated by WHO and NAFDAC; Acidity, phenolphthalein Alkalinity and PVC estimate were not seen in all the sampling points of untreated water; Total Alkalinity in the untreated water for sampling points I-V are: 72, 64, 60, 52 and 48 mg/l respectively are within the maximum limit of 100mg/l as specified by NAFDAC while WHO has no specification; chloride content in the untreated water were found to be 13,7, 13, 8 and 9mg/l for sampling points I-V, but all are far below the maximum limit of 250mg/l by NAFDAC specification while WHO has no specification; Total hardness for sampling points are 44, 52, 32, 40 and 48 mg/l respectively, all are within the maximum limit of 100mg/l NAFDAC specification while WHO set no guidelines; calcium hardness peaked at point II, followed by point V then I, IV and III corresponding to 32.0, 30.0,25.0,25.0 and 20.0 mg/l are below NAFDAC maximum limit of 50mg/l while WHO set no standard; magnesium hardness for sampling points I-V are 19.0,20.0, 12.0, 15.0 and 18.0mg/l respectively and all are below 50mg/l as maximum limit set by NAFDAC while WHO set no standard; sulphate content is generally low in the untreated water for sampling points I-V, all have uniform value of 10mg/l except at point 3 with the value of 5 mg/l. They are far below maximum limit of 250mg/l and 500mg/l standard set by NAFDAC and WHO respectively; Fluoride at sampling points I,III and IV assumed uniform value of 0.2 mg/l while point 2 and 5 has the same value of 0.4mg/l. And they are within the maximum limit of 1.5 and 1.3 mg/l standard of WHO and NAFDAC; Nitrites value of 0.030 mg/l was recorded for points I-IV with the least at point V having 0.020 mg/l and all within maximum limits of 5.00 and 3.00 mg/l standard of WHO and NAFDAC respectively; Total dissolved solids is peaked at points II and IV followed by point I, then III and V with the following values 260, 220mg/l; and all are below maximum limit of 500 mg/l standard for both WHO and NAFDAC.

Free chlorine for sampling points I-V are 0.16, 0.17, 0.15, 0.14 and 0.19 respectively, they are below the maximum standard of 0.40 and 0.30 set by WHO and NAFDAC; Copper is

peaked at point 4 followed by points, II, I then III and V in descending order with following values; 0.41, 0.32, 0.21 and 0.19mg/l which are below maximum limit of 2.0mg/l standard for WHO and NAFDAC; Calcium is quite low compared to WHO and NAFDAC standard of 200 and 75mg/l respectively, sampling points I-V have the following values; 2.17, 2.25, 3.10, 2.14 and 1.96 mg/l; The values are below the maximum limit of 0.01mg/l standard of WHO and NAFDAC; Zinc peaked at point 4 followed by point V then I corresponding to values of 0.09, 0.03 and 0.01 mg/ respectively, the units are all below the maximum limits of 3.00 and 5.00mg/l standard by WHO and NAFDAC while at points II and IV no trace of Zinc was detected; Iron peaked at point 2 followed by points 4, 3, 5 and 1 in descending order with corresponding values of 1.30, 0.41, 0.37, 0.34 and 0.16, mg/l. The iron content in water samples at points II, III and IV are above the maximum limit of 0.30 mg/l but at points I and V the values are below limit of NAFDAC and WHO; Magnesium for sampling point I-V are 3.16, 2.93, 2.63, 3.14 and 3.71mg/l respectively with it peak at point V, but all are below the maximum limits of 150 and 50mg/l standard for WHO and NAFDAC.

The PH of the treated water (sampling point 6) is 7.763 is within the stipulated limits of (6.5-8.5) as standard for both WHO and NAFDAC; Total dissolved solids (TDS) at point VI is 240mg/l, far below the maximum limits of 500mg/l Regulatory Standard; Total Alkalinity; Total hardness, Magnesium hardness and Calcium hardness for sampling point VI were 36mg/l, 52mg/l, 22.0mg/l, and 30.0mg/l are all below the maximum limit of 100mg/l, 100mg/l, 50mg/l and 50mg/l respective standard set by NAFDAC while WHO has no specification. Chloride, fluoride and Nitrites at sampling point VI are 12mg/l, 0.2mg/l and 0.020mg/l respectively, are below maximum limit of 250mg/l, 1.5 and 1.3 mg/l and 50 and 3.0mg/l standard by WHO and NAFDAC. Magnesium and Calcium content in water sample at point VI are 1.06 and 1.12 mg/l respectively, compared with maximum limits of WHO and NAFDAC standard of 150 and 50 mg/l for magnesium, 200 and 75mg/l for calcium both are far from the maximum. Free chlorine is 0.12 mg/l below the maximum limits of 0.4 and 0.30mg/l of WHO and NAFDAC, Copper and Dissolved Carbon-dioxide (DCD) at sampling point VI are 0.12 and 40mg/l respectively, they are below maximum limit of WHO and NAFDAC standard of 2.0mg/l for Copper and 50mg/l for DCD.

Figure2. Biological Parameters sampling points in Alau dam in Compared with NAFDAC and WHO.
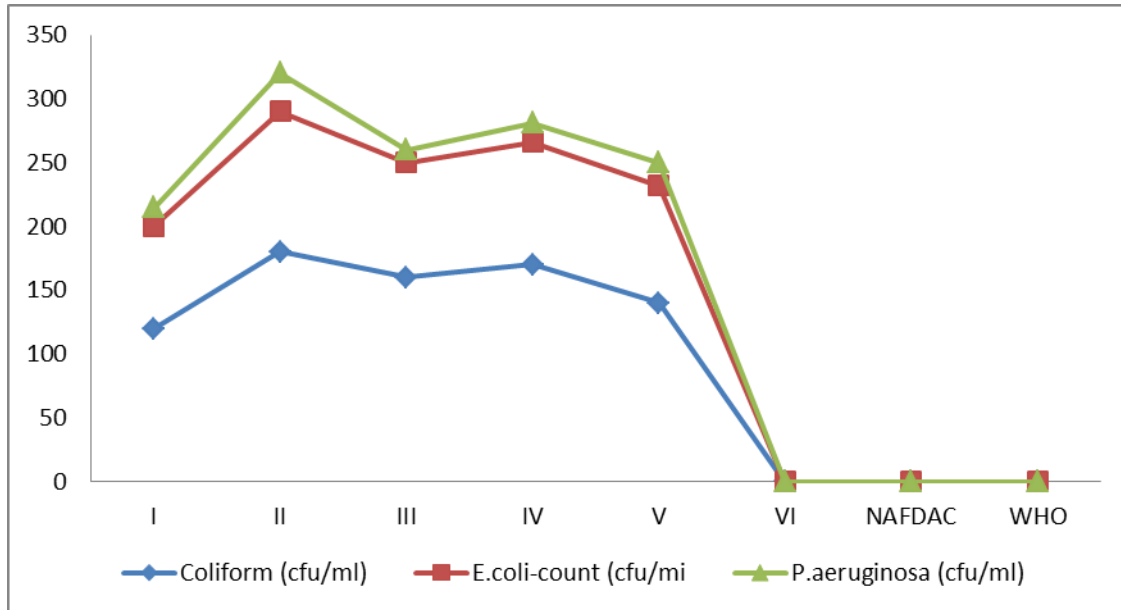
Source: author's research and lab analyses (NAFDAC's Lab) Maiduguri, 2012.

Note: WRN, WLA, WDU, WIU, WIN and WTS symbols were not used to represent sample points

Figure 2.reveals that Aerobic mesophilic count for untreated water samples was peaked at point 2 with 430cfu/ml followed by point IV then V, I and III in descending order having 410, 370, 360 and 300cfu/ml respectively. Coliform was highest at point II with 180cfu/ml by 170, 160, 140 and 120cfu/ml corresponding to points IV, III, V and 1. Also point II recorded the highest *E. coli* count of 110cfu/ml followed by 96, 90 and 80cfu/ml for points IV, V, III and I respectively. *P*. aeruginosa also is peaked at point II followed by point V then I and IV with least at point III corresponding 30, 18, 15, 15 and 10cfu/ml respectively.

There is an indication that the microbiological parameters found in the untreated water from the Alau Dam are related to some of these diseases; cholera, typhoid fever, diarrhoeal, bilharziasis, skin irritation among others, due to the fact that, villages around Dam are using the raw water for their domestic usage.

The treated water (sampling point VI) has 110cfu/ml for Aerobic mesophilic count, which both WHO and NAFDAC have not set standard. Coliform, *E.* Coliform and *P*.aeruginosa all these were zero (0) i.e. not detected from the treated water which correspond to both WHO and NAFDAC standard for household water quality. This indicated that treated water from Alau dam meet the accepted standard of WHO and NAFDAC for biological parameters whereby, could be used for any domestic, industrial and agricultural uses without any health implications.

In conclusion, the colour and turbidity both have value above the standards of WHO and NAFDAC. These could be attributed to the pumping action taking place at the pumping station located close to the dam. During the pumping process, the water is being mixed thoroughly and when it get to the treatment site the water is coloured and turbid. Hence, this call for addition of more Alum, that is, calcium carbonate (CaCO3) during the treatment processes.

The analysis for chemical parameters shows that: PH, DCD, Total Alkalinity, TDS, Total, hardness, calcium hardness, magnesium hardness, magnesium, calcium, free chlorine, chloride, sulphate, Fluoride, Nitrites and copper their values were found to be above and within the standards of WHO and NAFDAC.

Microbiological parameters which includes: Acrobic Mesophilic count, coliform, E.Coli count and P. auriginosa are very high values for microbial parameters with exception of sampling point V. Aerobic mesophilic count which signifies the amount of need oxygen by the Aerobic bacteria is peaked, the water from Lake Alau dam. These could be due to irrigation, fishing and animal grazing activities as well as washing of plates, clothes and bathing taking place in and around the lake.

The river serves as the only sources of large surface water for Maiduguri metropolitan city and its environs. This makes the water in the dam to suffer heavy pollution as a result of irrigation, fishing, grazing and domestic usage. Hence, the problem of cholera outbreak almost every year as well as typhoid fever, diarrhea, dysentery, bilharziasis (painful urination) and skin irritation that is common among the inhabitants of the area may be associated with use of untreated (raw) water from Alau Dam.

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