Physicochemical and Bacteriological analyses of Tagwai Lake Minna , Nigeria

Chukwuemeka .V.I.[1], Olajide. K.O.[1], Auta.Y.I. [1], Samuel .P.O.[1], Auta .H.S.[2], and Erhabor O.F.[3]

[1]Department of Animal Biology, Federal University of Technology, Minna
[2]Department of Microbiology, Federal University of Technology, Minna
[3]Department of Microbiology, College of Education, Warri, Delta State

Abstract

Water is an indispensable natural resource on earth which is a major determinant of existence of all living things; Its decrease in terms of quality due to anthropogenic activities is a threat to life. For this study, water samples were collected between April to September 2019 and analysed for bacteriological quality and physicochemical properties The mean temperature value ranged from 21.56± 0.45°C -31.30±0.50°C, pH (6.48±0.19 – 7.46±0.10), Total dissolved solid (1.05±.0.01-1.28±0.05mg/l), Nitrate (0.21±0.03 – 0.51± 0.04mg/l), Phosphate (0.13±0.01 – 0.32±0.06mg/l), Dissolved Oxygen(4.96±0.40 – 6.80±0.58mg/l), Biological Oxygen Demand (3.12±0.34 – 4.60±0.51mg/l), Conductivity (26.60±1.94 – 95.60±2.93µS/cm),Total hardness (26.40±2.04 – 43.20±1.02mg/l), Total Alkalinity (8.40±1.17 – 34.00±0.03mg/l) .The mean bacteria counts ranged from 22×10^3cfu/ml to 29×10^3cfu/ml, the total coliform count ranged from 8×10^3cfu/ml to 15×10^3cfu/ml, the total fecal coliform count ranged from 1×10^3cfu/ml to 7×10^3cfu/ml. The bacteria isolated include *Bacillus subtilis, Salmonella typhi, Pseudomonas aeruginosa, Escherichia coli, Streptococcus pyogenes, Staphylococcus epidermidis, Streptococcus faecalis, Klebsiella*. The result of the physicochemical parameters showed that its within the permissible level, set by World Health Organization (WHO) and Nigeria Standard for Drinking Water Quality (NSDWQ). The Bacteriology result were not in accordance with WHO and NSDWQ, hence, the water is not suitable for consumption.

*Correspondence email: chucks.vic@futminna.edu.ng

Introduction

Rivers and Lakes are very important part of Nigeria heritage which are widely utilized by mankind over the century. Knowledge of the physicochemical regime of a water body is of great value in the determination of its productivity, usefulness and other characteristics (Adebisi, 1980). Lake and reservoirs are valuable natural resources that also possess tremendous economic value. They provide enjoyment as well as many beneficial uses such as flood control, recreation, aquatic life support, domestic water supply, irrigation and industrial water sources. In Niger State, there is Zungeru dam at Wushishi Local Government Area of the State, Chanchaga River, Bosso dam at Bosso Local Government Area of the State and Tagwai dam located in Chanchaga area of Niger state.

Water plays a significant role in maintaining the human health and welfare. Clean drinking water is now recognized as a fundamental right of human beings. Around 780 million people do not have access to clean and safe water and around 2.5 billion people do not have proper sanitation. As a result, around 6–8 million people die each year due to water related diseases and disasters (UN-WATER 2013). Therefore, water quality control is a top-priority policy agenda in many parts of the world. In the today world, the water use in household supplies is commonly deemed as domestic water. This water is processed to be safely consumed as drinking water and other

purposes. Water quality and suitability for use are determined by its taste, odour, colour, and concentration of organic and inorganic matters (Dissmeyer, 2000). Contaminants in the water can affect the water quality and consequently the human health. The potential sources of water contamination are geological conditions, industrial and agricultural activities, and water treatment plants. These contaminants are further categorized as microorganisms, inorganics, organics, radionuclides, and disinfectants (Nollet, 2000).

Water must be analysed to determine its acceptability for the intended purpose. Non availability of portable water to settlements necessitates heavy reliance on coastal waters for domestic, agricultural or recreational purposes. The ever-increasing pollution of the environment has been one of the greatest concerns of science and the general public. Idowu *et al.* (2011) positioned that the pollution of the aquatic environment by inorganic and organic chemicals is a major factor posing serious threat to the survival of aquatic organisms. Man-made toxic compounds are also resistant to physical, chemical, or biological degradation and thus represent an environmental burden of considerable magnitude (FEPA, 1992).

Opukri and Ibaba (2008) opined that the effect of anthropogenic activities on the quantity and quality of water resources are felt over a wide range of space and time scales. In advanced countries, environmental monitoring agencies are more effective and environmental laws are strictly followed. General environmental quality monitoring is compulsory and the monitoring of the quality of water resources is done on a regular basis. Water pollution in Nigeria occurs in both rural and urban areas. In rural areas, water from natural sources such as rivers and streams is usually polluted by organic substances from upstream users who use water for agricultural activities (Richard *et al.*, 1997).

The surface water resource such as rivers, ponds and dams located around cities are heavily polluted as a result of the discharge of effluents from municipal and industrial waste. Water is regarded as been polluted when it is unfit for it intended use (Turk, 1980). Any alteration in the physical, chemical and biological properties of any water due to discharge of any liquid, gaseous or solid substances that is likely to create detrimental or injurious effect to aquatic life and consequently public health, could be termed water pollution (Pandey and Shukla, 2005) or can be referred to as any impairment to the quality of water that prevent it beneficial use. Thus, affecting the biota of an aquatic ecosystem.

The most serious problem being experienced globally in the present age is the pollution of the environment mainly by inorganic, organic, and organometallic materials (Mashhood, 2011) According to the World Health Organization (WHO), 42% of sub-Sahara Africa lacks safe drinking water. It is also predicted that more than 47% of the global population will experience severe water shortage by 2030. Human activities of domestic, non-domestic, agricultural and industrial origin are known to be sources of point and non-point pollution to rivers, streams, lakes, etc. The activities of car, motorcycle, clothes washings, bathing, agro-products processing, pesticides and herbicides dissolved in rainwater, run-off from adjacent farms etc. are the major sources of effluents to water bodies.

The entry of contaminants into the environment due to human and natural activities is one of the most important issues facing today's communities. Due to the industrial and economic growth and the production of a variety of compounds and chemicals followed by increased consumption of man makes some unwanted pollutants, many of which cause serious problems and risks for the environment and for man himself.

The importance of water cannot be overemphasized. It is used for electrical generation. It also serves agricultural, industrial and recreational purposes. It is crucial for sustainable development including the preservation of our natural environment and alleviation of poverty and hunger. Water is the most important and most abundant substance on earth. In nature, all water contains some impurities as water flow in streams, accumulates in lakes and filter through the layers of soil and rock on the ground; it dissolves or absorbs the substances that come in contact with it. Some of these substances are harmful and as such termed as heavy metals and however, at a certain level, minerals may be considered contaminants that can make water unpalatable or even unsafe. These substances however, can be the result of human activities or can be found in nature. For instance, chemicals through the activities of man can be transferred from disposal sites to some other places even to drinking water sources thereby serving as contaminants to such sources (Akaninwor *et al.*, 2007).

Most reservoir and dam ecosystems in Nigeria are threatened by anthropogenic activities (Ibrahim *et al.*, 2009). Due to development, urbanization, industrialization and rapid population growth, the insidious activities of humans on our natural water bodies have led to alterations in the quality of water bodies as they are the target points for effluents discharge.

The study area, Tagwai lake is dominated with farmlands and villages; While Phosphorus is an essential nutrient for plant growth which can be found in fertilizers; runoffs from agricultural farms containing manures and fertilizers can accelerate eutrophication resulting in severe impairment of water bodies that support aquatic, recreational and drinking water uses because they are not easily bio-degradable. Other anthropogenic activities such as waste disposal, discharge from cars, motorcycles and domestic activities like washing, bathing and swimming by the shore of the dam are the major problem that Tagwai dam is experiencing. These inputs have led to the death of several aquatic organism, reduction of water quality thereby making water unfit for human consumption.

The broad aim of the study is to determine the effects of Human activities on water quality in Tagwai lake, Minna by investigating some selected Physicochemical parameters of surface water of Tagwai Lake and the bacteriological parameters of same Lake.

Materials and Methods

Study Area

The study was carried out in Minna, Niger State, located within longitude 6°33'E and latitude 9°37'N, covering a land area of 88km^2 (Fig 1) with an estimated human population of 1.2 million. The area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30°C, 61.00% and 1334.00mm, respectively. The climate presents two distinct seasons, a rainy season and a dry season. The vegetation in the area is typically grass-dominated savannah with scattered tree species. Tagwai Lake is about 10km away from Minna town. Mean maximum temperature remain high throughout the year having about 30°C, particularly in March and June. The vegetative cover is characterised by woodland and tall grasses inter spread with tall dense species. In some areas, traces of rain forest species can be seen of Sudan Savannah alongside the plain of the river. (NSPC, 2011). The secondary benefits from this dam include fishing, recreation and wild life conservation. The occupation of the people of the area is fish farming. The study sites are characterised by different fishing gears. Tagwai settlement is dominated by

Nupe and Gwari people (Alkali, 1994; Chukwuemeka 2019).

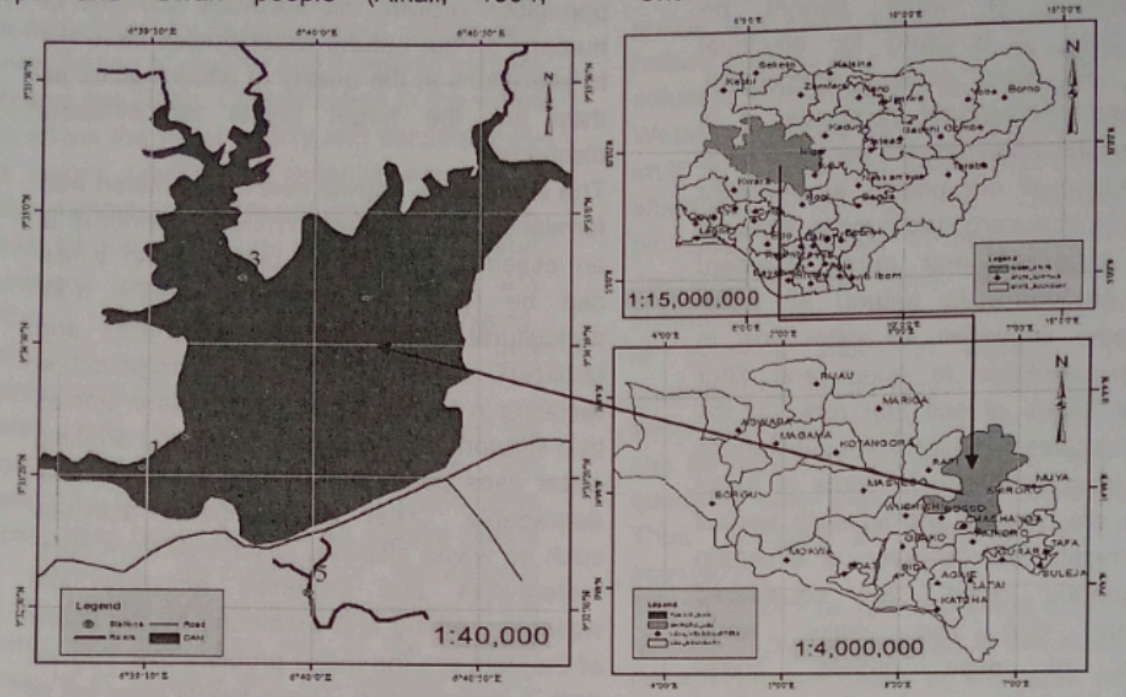

Figure 1. Map of the study site (Tagwai Lake) in Niger State, Nigeria
Source:The Department of Geography, FUT, Minna. Centre for Remote Sensing (2018).

Collection of Water Samples for Physicochemical parameter

Water samples were collected on monthly basis from five sampling stations namely 1,2,3,4 and 5 (Figure 1). The study was carried out between April and September 2019. Water samples were collected in the early hours of the day between 7.00 a.m. and 9.00 am. Parameters were measured *In-Situ* and *Ex-Situ* on samples collected from the stream. The *In-Situ* physical and chemical parameters measured according to the method of All Physicochemical parameters analysed (APHA, 2005). The parameters measured include electrical conductivity, Total dissolve solid, Water temperature and pH using Hanna meter. The meter was used by submerging the probe into the water, switching on and the values of each parameter were measured. Parameters such as Dissolved Oxygen, Biological Oxygen Demand, Alkalinity, Total Hardness, Phosphate and Nitrate, were analysed *Ex-Situ* in the laboratory, the Department of Water, Aquaculture and Fisheries Technology, Federal University of Technology, Minna. The bacteriological analysis was done in the Laboratory of the Department of Microbiology, Federal University of Technology, Minna.

Nitrate

The nitrate concentration in the sampled water was determined using phenol disulphonic acid method. These methods were carried out in the following way using spectrophotometer, laboratory glassware, hot water bath and reagents as given below:

Phenol disulphonic acid: 25g of white phenol was dissolved in 150 ml of concentrated sulphonic acid and 85ml of sulphonic acid was further added. The solution was heated for about 2 hours on a dark bottle.

Potassium hydroxide solution was prepared by dissolving 336.5g of potassium hydroxide

in distilled water to make 500ml volume. Standard nitrate solutions were also prepared by dissolving 0.722g of anhydrous potassium nitrate in distilled water to get 1litre of the stock solution.

Procedure: 25ml of water to be sampled was placed in a porcelain basin and was evaporated to dryness on a hot water bath. 0.5ml of phenol disulphonic acid (reagent A) was then added to the residue and dissolved with the help of a spatula. 5ml of distilled water was added and then 1.5ml of potassium hydroxide solution (reagent B) was also added. The mixture was stirred for thorough mixing which it turned yellow indicating the presence of nitrate. The absorbance was read using spectrophotometer at 410nm (APHA,2005). Nitrate was recorded in mg/l.

Water sample was analysed for phosphate by pouring it into the standard flask to 25 ml mark and 10ml of vanado-molybdate reagent added. 15 ml of distilled water was added to make-up 50 ml mark on the standard flask. Samples were placed in a spectrophotometer for 10minutes at a wavelength of 470 nm to determine the level of phosphate and values calculated using the formula below:

$$\text{Phosphate (mg/PO43-P)} = \frac{\text{Reading from curve} \times 1000 \times D}{\text{Ml sample}}$$

Where D = dilution factor

Collection of Water Samples for Bacteriological analysis

The water samples collected from the five stations were serially diluted and 1 ml of the diluted water samples (that is 10^{-3},10^{-4} and 10^{-5} dilutions) were inoculated in the respective media. Enumeration of total viable bacteria was done on sterile nutrient agar plate using pour plate method. The Petri plates were incubated at 37°C for 24 hours. The colonies, which developed after the incubation were counted and recorded as colony forming units per millilitre (cfu/ml) of the water sample (Chessbrough, 2006). The bacteria isolated were subjected to colonial, microscopic and biochemical characterization using the conventional bacteriological methods. The bacterial isolates were identified by comparing their characteristics with those of known taxa.

Membrane filter technique was used for the determination of total coliform as described by Ajumobi *et al.* (2014). The bacteria isolated were subjected to colonial, microscopic and biochemical characterization using the conventional bacteriological methods described by Cheesbrough (2006). The bacterial isolates were identified by comparing their characteristics with those of known taxa.

Data analysis was done using ANOVA Duncan Multiple Range test and T test.

Results

Table 1, reveals the physicochemical parameters of Tagwai lake Minna, between April to September, 2019. All parameters analysed were within the limit set by WHO and NSDQW. The mean pH value ranged from 6.48±0.19 to 7.16± 0.10. Temperature which is a very important parameter in any water body ranged between 21.23±0.45 and 31.30 ±0.50. The highest temperature was recorded in the month of April which coincide with the dry season period. Nitrate and phosphate also fell within the limit set by WHO and NSDWQ.

Table 1: Physico-chemical parameters of Tagwai Lake, Minna between April to September, 2019.

Physico-chemical Parameters	April	May	June	July	August	September	WHO STANDARD	NSDWQ
pH	6.48±0.19^{a}	6.56±0.13^{a}	7.41±0.07	7.46±0.10^{b}	6.87±0.03^{ab}	7.17±0.02^{b}	6.5 – 9.5	6.5 – 8.5
Conductivity (mg/l)	26.60±1.94^{a}	76.00±11.74^{b}	95.60±2.93^{d}	83.60±1.60^{c}	81.00±0.77^{c}	82.20±0.86^{c}	350	1000
Temperature (°C)	31.30±0.50^{a}	26.84±0.07^{c}	29.74±0.44^{d}	21.56±0.45^{a}	21.23±0.42^{a}	24.40±1.79^{b}	Variable	Ambient
DO(mg/l)	6.40±0.40^{b}	6.80±0.58^{b}	6.20±0.66^{b}	6.60±0.40^{b}	5.00±0.43^{ab}	4.96±0.40^{a}	4.0	5.0
BOD(mg/l)	3.80±0.20^{ab}	4.60±0.51^{b}	3.12±0.34a	4.00±0.32^{b}	3.30±0.20^{a}	3.40±0.21^{a}	6	-
Total Alkalinity (mg/l)	8.40±1.17^{a}	32.00±0.63^{a}	34.00±0.03^{d}	32.80±1.02^{c}	32.80±2.06^{c}	29.60±1.72^{b}	250	-
Total Hardness (mg/l)	26.40±2.04^{a}	42.60±0.68^{c}	43.20±1.02^{c}	40.80±0.49^{c}	41.60±1.94^{c}	35.60±0.75^{b}	100-500	150
NO^{3}(mg/l)	0.21±0.03^{a}	0.34±0.01^{b}	0.51±0.04^{d}	0.44±0.02^{c}	0.32±0.02^{b}	0.29±0.01^{a}	50	50
PO^{4}(mg/l)	0.13±0.01^{a}	0.17±0.01^{a}	0.17±0.02^{a}	0.32±0.06^{c}	0.25±0.01^{b}	0.16±0.01^{a}	1.00	-
TDS(mg/l)	1.22±0.01^{a}	1.20±0.03^{a}	1.28±0.05^{a}	1.08±0.01^{a}	1.05±0.01^{a}	1.05±0.01^{a}	-	500

Table 2: Bacteriology Analysis of Tagwai Lake, Minna between April to September, 2019.

Bacteriology Analysis	April	May	June	July	August	September	WHO	NSDWQ
TBC	22.40±1.80^{b}	25.00±2.43^{c}	29.60±2.52^{d}	27.40±0.06^{c}	26.00±2.81^{c}	21.00±3.00^{a}	100	100
TCC	8.60±2.48^{a}	13.00±2.10^{ab}	15.00±1.41^{c}	13.20±3.02^{ab}	11.60±2.73^{a}	12.20±1.50^{ab}	0	10
TFCC	2.60±0.98^{b}	5.40±1.12^{c}	2.60±0.40^{b}	1.40±0.60^{a}	4.40±1.63^{c}	7.20±0.86	0	0

TBC – Total Bacteria Count TCC- Total Coliform Count TFCC- Total Fecal Coliform Count

For the bacteriological analysis of Tagwai lake, Total Bacteria Count (TBC) had the highest count all through the study period (21.00±3.00 to 29.60±2.52). TFCC had the least count range from 1.40 ± 0.60 to 7.20 ± 0.86. The value for Total coliform count (TCC) were higher than WHO and NSDWQ standard. It was only low in the month of April.

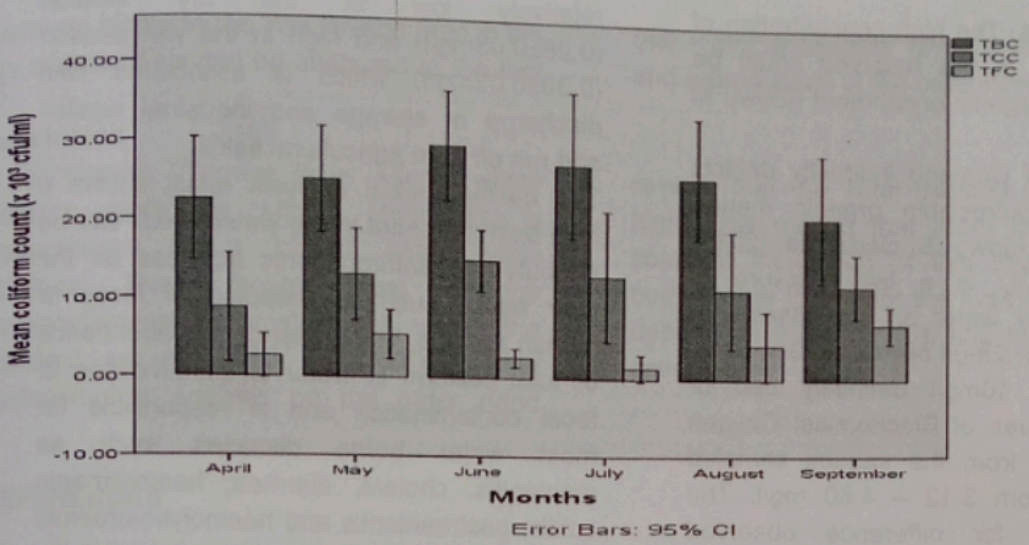

Figure 2: Monthly mean Total Coliform Count from Tagwai Lake between April –September 2019

The result from the physicochemical analysis shows that the Physicochemical characteristics of the lake is in agreement with the WHO and NSDWQ standard for drinking water. Though there are variations, this variation may be related to the use of the water, rainfall or even as a result of anthropogenic activities.

Temperature is one of the most important parameters for aquatic environment because all the physical, chemical and biochemical properties are governed by it; The results show that the seasonal mean temperature ranged between 26.34°C and 29 °C. The result agreed with previous reports that the temperatures in tropics vary between 210C and 320C (Kamra *et al.*, 2003; Ayoade *et al.*, 2006).

The pH of water is important because many biological activities can only occur within a range of selected pH. Variations in mean pH was observed with higher values of 7.23±0.06 in wet season and lower value of 6.52±0.11 in dry season; The seasonal variation in pH values is in line with results reported by Usman *et al.* (2014), with highest pH in the wet season and lower values in late dry season. The seasonality in the pH of water may be due to the influx and decay of debris in the area as well as imbalance level of H^+ ions input from surface run-offs during the rains. Thus, the pH range obtained in this study is within the acceptable level of 6.5 to 9.5 for the recommended levels of drinking water (WHO, 2011). Its also within the range of Nigerian Standard for Drinking water Quality (NSDWQ, 2007) recommended pH of 6.5 to 8.5 for drinking water.

The Total dissolved solids which is usually a constitution of organic and inorganic substances dissolved and washed into the lake by run-off. Seasonally, the TDS level ranged from 1.11±0.02 to 1.21±0.01 mg/l which is generally recommended to be good by WHO and NSDWQ. Total Dissolve solids determination are important in water quality studies, though no serious health effects have been associated with dissolved solids ingestion in water.

The result of the Dissolved oxygen (4.96 – 6.80mg/l) showed that the lake is well oxygenated within allowable limits during the dry season and wet season. If the concentration of dissolved oxygen falls below 5 mg/L, it may have adverse effects on the functioning and survival of biological communities and below 2 mg/L, it may lead to death of the biological organisms inhabiting

the lake like fishes. The high concentration of dissolved oxygen in the reservoir could be attributed to low organic enrichment (Idowu *et al.*, 2005)

Biological Oxygen Demand indirectly depicts the amount of putrescible organic matter. Abolude (2007); Idowu & Gadzama (2011) reported that BOD is a fair measure of cleanliness of any water on the bases that values of less than 2mg/l are clean, 3 – 5mg/l fairly clean and 10mg/l definitely bad or polluted. The values of Biochemical Oxygen Demand (BOD5) from the various sampled stations range from 3.12 – 4.60 mg/l. The possible reason for difference observed between the ranges obtained in this study is in anthropogenic activities in the lake.

Generally, the Conductivity of the natural water is directly proportional to the concentrations of ions; Different ions vary in their ability to conduct electricity. The monthly variation of conductivity values in all stations fluctuated between 26.60±1.94 - 95.60±2.93mg/l. The general trend in this study is that conductivity tended to decrease in the dry season and increased in the wet season. This result is in conformity with the report of Makwe *et al.* (2013).

Phosphate is an essential nutrient for living organisms and exists in water bodies. It is the nutrient that boost algal growth and therefore controls the primary productivity of the lake. The mean phosphate level of the lake in different stations ranged from 0.13 ±0.01mg/l to 0.32±0.06 mg/l. The highest mean phosphate was observed in July while the lowest was in April. Seasonally, the mean phosphate level increased from0.15±0.01 during the dry season to 0.22±0.02 in the wet season. The increase of phosphate level can be associated to run-off of agricultural inputs on farmlands surrounding the lake or from detergents used in washing by the shores of the lake.

Nitrate is associated with algae growth and eutrophication. The mean Nitrate values were relatively low in the dry season (0.28±0.03mg/l) and high in the wet season (0.39±0.02mg/l) which is associated with discharge of sewage and industrial wastes and run off from agricultural fields.

The bacteriological analysis result shows a high bacteria count in the water which can be attributed to anthropogenic activities on the river banks such as dropping of feces or human sewage. The presence and abundance of total coliform in water is an indication of fecal contamination and is responsible for most water borne diseases such as meningitis, cholera, diarrhea, haemorrhagic colitis, gastroenteritis and haemolytic-uraemic syndrome as well as morbidity and mortality among children (World Health Organization, 1997).The Total Coliform count 8.60±2.48 - 15.00±1.41 cfu/ml which is in accordance to Isa *et al.*(2013) while its significantly different from the result obtained from the analysis of bacteriological quality of water sources in Kenya by Sila *et al.*(2019) .The result of this study revealed that the total bacteria count of the lake exceeded the recommended standards of potable water by WHO and NSDWQ standard. The bacteria isolated according to morpho- logical and biochemical characteristics include *Bacillus subtilis, Salmonella typhi, Pseudomonas aeruginosa, Escherichia coli, Streptococcus pyogenes, Staphylococcus epidermidis, Streptococcus faecalis, Klebsiella.* The isolated bacterial species in this study have been identified to be the same with those commonly encountered in water and aquatic environments as was also reported in a study on streams surface water in Ogun State, Nigeria as reviewed by Egberongbe *et al.* (2012). Water contaminated with these bacterial species is generally considered as a greater risk to human health. Variation in contamination level of the lake with higher bacteria counts encountered during the rainy seasons agrees with the findings of Oyeleke *et al.*,(2017). The concentration of the coliform

count are higher in the Wet season than in the Dry season; This can be attributed to the fact that water availability favours the movement and reproduction of the organisms.

Conclusion

In conclusion, Tagwai lake, Minna which supplies water to Minna Metropolis is characterized by a lot of Antropogenic activities. Even though most of the physicochemical parameters fell within the standard set by WHO and NSDWQ, the bacteriological analysis on the other hand reveals that the Total bacteria count is very high. This means that there is a need for constant monitoring of this important water body, so as to protect the lives of those who depend on it for drinking and other domestic activities.

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