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Microbiological Quality of Lower Usuma Dam Water from Inlet to Distribution in Three Area Councils of Federal Capital Territory, Nigeria

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ABSTRACT: An assessment of the microbiological quality of water samples from the Lower Usuma Dam Water Treatment Plant and three urban districts (Bwari, Abuja Municipal and Gwagwalada) of the Federal Capital Territory, Nigeria was carried out. A total of 26 samples were analyzed in this study. The membrane filtration method for the detection of coliforms was used to determine aerobic, total coliform and faecal bacteria counts. The study found that total coliforms and faecal counts were not detected in the treated water of the lower Usuma Dam, but only along the distribution. The average number of coliforms ranged from 5.71 cfu/100ml to 4.91×10^{1} cfu/100ml, with Gwagwalada having the highest. The results also showed that the difference in total coliforms and faecal counts for the water samples from AMAC and Bwari were not statistically significant ($p<0.05$), they were significantly different ($p<0.05$) in the total coliforms and faecal counts of the water samples from Gwagwalada distribution axis. Results obtained for bacteriological parameters were below set limits of WHO guidelines for drinking water quality at the treatment plant. The coliforms isolated in this study include the genera; *Escherichia coli*, *Pseudomonas spp*., *Klebsiella spp*., *Shigella spp*., *Enterobacter spp.*, *Proteus spp.*, and *Salmonella spp*. Their detection is an indication of the presence of pathogenic organisms. Efforts should be intensified by relevant authorities to improve monitoring, enlighten the populace on importance of proper hygiene and sanitation.

Keywords: Microbiological quality, coliforms, water treatment plant, treated water, distribution

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INTRODUCTION

Water is essential to sustain life. In 2013, the United Nations reported that billions of people are without access to safe drinking water (UN-Water, 2013), most of whom are in developing countries. The deterioration of water quality primarily involves microbiological hazards, since the majority of evident water-related health problems are the result of microbial contamination (Farkas *et al*., 2012). The microbiological assessment of drinking water quality is based on the relationship between indicator microorganisms and pathogens (Borrego *et al*., 2002). Waterborne pathogens cause diseases in approximately 250 million people each year, resulting in 10 to 20 million deaths around the globe (Dzwairo *et al*., 2006). These pathogens continue to occur as outbreaks (Reynolds *et al,* 2008) and contribute to 80% of health problems in developing countries (Jayana *et al*., 2009). Waterborne outbreaks have been associated with inadequate treatment of water supplies and unsatisfactory management of drinking water distribution (WHO, 2018).

Abuja is the capital city of Nigeria. It has an area of 7,315km^2. It is geographically located in the centre of the country, lying between latitude 8.25 and 9.20 North of the equator and longitude 6.45 and 7.39 east of Greenwich Meridian. Abuja has moderate climatic conditions. In a bid to meet the potable water needs of the growing populace of the Federal Capital Territory, Abuja, Lower Usuma Dam water treatment facilities were constructed. Lower Usuma Dam Water Treatment plant (LUDWTP) is located in Ushafa along Dutse-Bwari road, Abuja, Nigeria's capital city. It is owned by the Federal Capital Territory Water Board, Abuja, which has been saddled with the responsibility of producing safe drinking water for the residents of the Federal Capital Territory, Abuja. A wide spectrum of pathogenic agents can be found in water and monitoring their presence routinely becomes very difficult and impractical. According to APHA (2012), total coliform bacteria are used in water quality studies as a systems indicator, which provides information on the efficiency of water treatment. WHO (2018) reported that contaminated drinking water and poor sanitation are linked to transmission of diseases such as diarrhea, cholera, dysentery and polio. The objective of this study is to assess the microbiological water quality of Lower Usuma Dam treatment plant from the inlet point to the distribution points for presence of coliforms and to characterize isolated coliforms using biochemical methods.

METHODOLOGY

Study area

This research was carried out in Lower Usuma Dam water treatment plant located in Federal Capital Territory, Abuja and owned by the Federal Capital Territory Water Board Abuja, Nigeria. It is located in Bwari area council (Figure 1). The area council has the highest elevation than any of the settlement areas in Abuja the Federal Capital Territory of Nigeria. It is located within latitude 9^{o}N and longitude 7^{o}E. Lower Usuma Dam water treatment plant is the major source of drinking water to the residents of the Federal Capital Territory. Its source is the Lower Usuma dam. The final treated water is usually distributed via gravity.

Bwari area council

Bwari is one of the six area councils of the Federal Capital Territory Abuja. It is located within 9^{0}N and longitude 7^{0}E. It is located at an elevation of 584 meters above sea level.

Abuja municipal area council (AMAC)

AMAC is the largest and most developed of the six area councils of FCT Abuja. It is located between Latitude 7^{0}N longitude 7^{0}E. It has a landmass of about 2500sq km.

Gwagwalada area council

Gwagwalada has an area of 1,043 km^2. It had a population of 157,770 as at 2006 census. It is projected to have a 6.26% growth between 2020 and 2025, the largest increase on the African continent. It is located between latitude 8^{0}N and longitude 7^{0}E (Figure 1).

Preparation and sterilization of media

The media used include Eosin methylene blue (Hi-media M001-500G), MacConkey agar (Hi-media), Triple sugar iron agar (Hi-media), Citrate agar (Hi-media), and Nutrient agar (Himedia). All the media were prepared following manufacturer's instructions and standard preparatory methods (APHA, 2012).

Sample collection

A total of 26 water samples were collected from the inlet of Lower Usuma Dam Water treatment plant (before undergoing any treatment) and after treatment (when it leaves the plant) and distribution points in various location in three area councils namely; Bwari, Abuja Municipal(AMAC) and Gwagwalada Area Councils of the Federal Capital Territory. Pre-sterilized sampling bottles (300ml size), containing 0.1ml 3% sodium thiosulphate to neutralize any free or combined residual chlorine present in the samples were used. These were labelled appropriately noting place of collection, date and time of collection.

Bacteriological analysis of water samples

Total aerobic count (TAC), total coliform (TCC) and faecal coliform counts (FCC) were determined using membrane filtration method following standard methods (APHA, 2012). Enumeration of colonies took place on nutrient agar (for TAC), MacConkey agar (for TCC) and Eosin methylene blue agar (for detection of E. coli. FCC) (Table 1).

Membrane filtration method

The membrane filtration technique was done as follows; by sterilizing the tips of the blunt-ended forceps in a flame and allowed to cool. It was used to remove a sterile membrane filter from its package. This was carefully done by holding only its edge. The membrane filter was then placed in the filter apparatus and clamped in place. 100ml water samples were poured into the filter funnel and vacuumed by suction through the membrane filter with a pore size of 0.45micron. After filtration, the filtration apparatus was dismantled. Then the filter paper was aseptically removed with a sterile forceps and placed with the grid side up in the centre of a petri dish containing appropriate medium agar. Starting at one edge, the membrane was lowered in order to avoid trapping air bubbles between membrane and agar. These were appropriately labelled. For total coliforms, the Petri dishes were incubated at 35^{o}C for 24hrs and faecal coliforms were incubated at 44.5^{o}C for 22-26hrs. Inoculation was done in duplicates. Bacterial cells trapped on the membrane grew into colonies that could be counted.

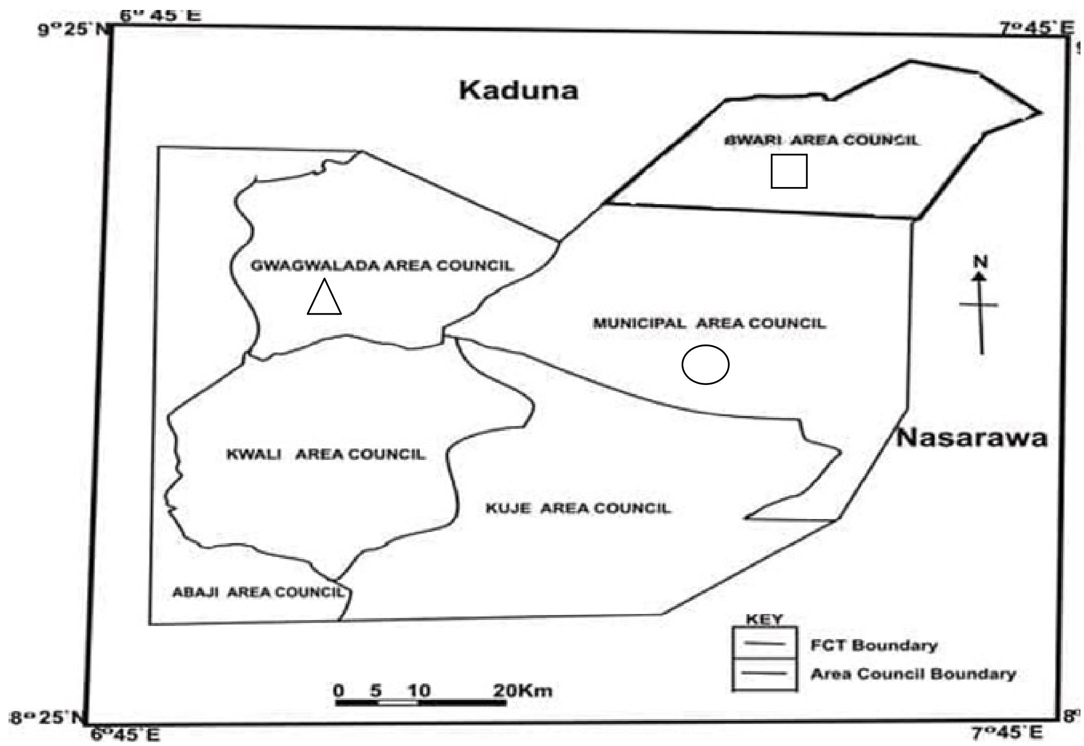

Figure 1: Map of FCT showing Study Area: □ Bwari Abuja ◯ Municipal Area Council (AMAC) and △ Gwagwalada (AGIS, 2004)

Table 1: Aerobic Bacterial, Total Coliform and Faecal counts (cfu/100ml) of Treated Water Samples from Lower Usuma Dam to Distribution.

Parameters	Treated (Lower Usuma Dam)	Distribution			WHO permissible limit
		Bwari	AMAC	Gwagwalada	
TAC	$1.0\times10^{1}\pm0.00^{ab}$	$3.72\times10^{1}\pm14.19^{ab}$	$2.64\times10^{1}\pm4.61^{ab}$	$6.38\times10^{1}\pm18.01^{c}$	500.00
TCC	0.00^{ab}	$0.64\times10^{1}\pm3.04^{ab}$	$0.57\times10^{1}\pm2.75^{ab}$	$4.91\times10^{1}\pm16.51^{c}$	0.00
Faecal count	0.00^{ab}	$0.16\times10^{1}\pm1.154^{ab}$	$0.13\times10^{1}\pm0.84^{ab}$	$2.41\times10^{1}\pm10.86^{c}$	0.00

Keys: TAC= Total Aerobic Count, TCC= Total Coliform Count
Values are a Means ± Standard Error. Superscript with same alphabets within a row are not significantly different ($p>0.05$).

The results are expressed as colony forming units (cfu) per unit sample volume (100 mL). Drinking water standard for total coliform is 0cfu/100ml and faecal coliform is 0cfu/100ml of water sample (WHO, 2011; NSDWQ, 2015).

Identification of Isolated Bacteria

The coliforms isolated were identified according to biochemical tests outlined in the Bergey's Manual of Determinative Bacteriology (Holt *et al*., 1994).

RESULTS AND DISCUSSION

Bacteriological assessment of water quality was also carried out on samples from the water treatment plant and the distribution locations in the three area councils studied. Results of Lower Usuma Dam water is shown in (Figure 1). It was observed that coliform and faecal counts were not detected in the Lower Usuma Dam treated water samples indicating adequate treatment (Figure 2). This complied with WHO guideline for drinking water quality (WHO, 2017). In this study, mean total coliforms counts (TCC) ranged between 5.71 cfu/100mland 4.91×10^{1}cfu/100ml. Gwagwalada recorded the highest mean TCC of 4.91×10^{1}cfu/100ml, while AMAC recorded the lowest mean total coliform count. The highest faecal coliform counts was recorded from Gwagwalada (2.41×10^{1}cfu/100ml) while AMAC had the least faecal count(0.13×10^{1}cfu/100ml).

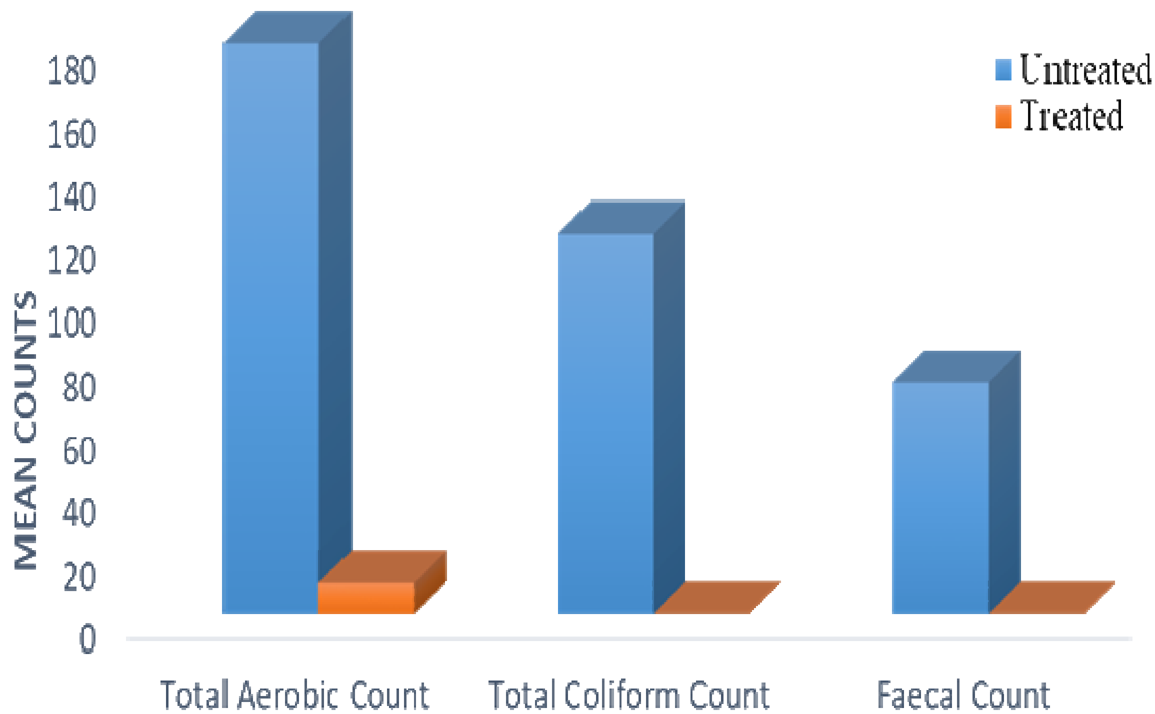

Figure 2: Bacteriological results of the Lower Usuma Dam (untreated and treated) water samples.

The results of this study show that the following coliforms were isolated from Lower Usuma Dam raw water (Table 2); *Escherichia coli*, *Salmonella enterica* and *Shigella flexneri*.*Escherichia coli* and *Salmonella* are fecal coliforms. Their presence in water indicates that there has been fecal contamination. Similar results on dam water have also been reported by Agbabiaka and Otuyelu (2019). Lower Usuma Dam treated water, on the other hand, tested negative for coliforms. Both total coliforms and faecal coliforms counts were within the permissible limits of WHO drinking water guideline values (0cfu/100ml), (WHO, 2011;). Reduction in the number of coliform bacteria in the treated water is likely due to the treatment process, when comparing treated water to raw water. However, this study shows the occurrence of coliforms in some of the water samples analyzed which indicates water contamination as some of these species are indicators of faecal contamination (Koschelow and Briedis, 2013).*Pseudomonas aeruginosa* and *Enterobacter cloacae* were isolated from samples from Bwari (Table 2). *Pseudomonas aeruginosa* is an opportunistic pathogen particularly good at forming biofils. It is reported that its growth in drinking water can cause problems with colour, taste, odour and turbidity if found in high numbers. While *Proteus mirabilis* was isolated from AMAC water samples (Table 2). AMAC is the most developed of the areas sampled. Most people there are more enlightened compared to the other parts with higher populations and probably with high living standards, including maintenance of high level of sanitation.

It was also observed from the study that Gwagwalada had the highest total and faecal coliform contamination. *Klebsiella pneumonia, Salmonella typhymurium, Escherichia coli, Pseudomonas flourescens* were isolated from Gwagwalada samples (Table 2) accounting for 57.1 % of the isolates. Gwagwalada is one of the suburbs of Abuja. Rapid population growth and high economic activities has put a lot of pressure on facilities such as those for sanitation. This is in agreement with the findings of Malhotra *et al.,* (2015). These have a huge impact on the environment as rubbish dumps are seen becoming a source of water pollution. The highest total coliforms and faecal matter concentration in Gwagwalada could be due to poor sanitation and hygiene conditions in the sampled areas and storage tanks. Another source of contamination could be infiltration due to leakages and burst pipes. These findings are consistent with those of

Table 2: Cultural, Morphological and Biochemical Characteristics of Coliforms Isolated from Lower Usuma Dam, Bwari, AMAC and Gwagwalada Area councils.

Morphological characteristics			Biochemical Reaction							Sugar Fermentation					
Isolate code	Gram's	shape	indole	Methyl red	VP test	citrate	catalase	Oxidase test	Urease test	lactose	sucrose	glucose	gas	H^2S	Probable Organisms
Lower Usuma Dam raw water samples															
R1	-	Rod	d	+	-	-	+	-	-	-	-	-	=	-	*Shigella flexnori*
R2	-	Rod	-	+	-	-	+	-	-	+	d	+	+	-	*Escherichia coli*
R3	-	Rod	-	+	-	-	+	-	-	-	-	+	-	+	*Salmonella enterica*
Bwari Area council water samples															
B1	-	Rod	-	-	-	+	+	+	-	-	-	-	+	+	*Pseudomonas Aeruginosa*
B1	-	Rod	-	-	+	+	+	-	-	-	+	+		-	*Enterobacter Cloacae*
Abuja Municipal Area Council water samples															
M1	-	Rod	-	+	-	+	+	-	+	-	-	+	+	+	*Proteus Mirabillis*
Gwagwalada Are council water samples															
G1	-	Rod	-	-	+	+	+	-	+	+	+	+	+	-	*Klebsiella spp*
G2	-	Rod	-	+	-	+	-		-	-	-	+	-	+	*Salmonella typhymurium*
G3	-	Rod	+	+	-	-	+	-	-	+	-	+	+	-	*Escheridia coli*
G4	-	Rod	-	-	-	+	+	+	-	-	-	-	+	-	*Pseudomonas flourescens*

Muktar and Oyeyi (2005). The continued presence of some of these bacterial isolates have health implication, which is that they accountable for different forms of waterborne infections (Muktar and Oyeyi, 2005). Coliform bacteria which includes members of the family Enterobacteriaceae, for example, *Escherichia coli, Salmonella, Shigella and Klebsiella* in water cause diseases like cholera, typhoid, dysentries etc in humans and livestock (Ashbolt, 2004; Odonkor and Addo, 2018). Others include various forms of diseases that are caused by *E. coli* for example enterohemorrhagic disease by E. coli 0157:H7. This study also supports the findings that coliforms have been recognized as a suitable microbial indicator for drinking water quality due to the ease of detection and enumeration in water (Odonkor and Ampollo, 2013; Malhotra *et al*., 2015). Findings from this study clearly highlight the non-compliance of some water samples investigated across the distribution with WHO guideline for drinking water quality (WHO, 2017). This study may therefore, provide information about the microbiological quality of drinking water in the Federal Capital Territory, Nigeria using membrane filtration method.

Conclusion

In conclusion, this study reveals that treated water from Lower Usuma Dam water treatment plant complied with World Health Organization guidelines and national standards for drinking water quality and thus safe for human consumption. Treatment was effective at the point of production and before distribution. No coliforms were isolated from the treated water. However, across the distribution, some of the samples were contaminated with coliforms. Outbreaks of waterborne diseases caused by these genera can have serious implications health-wise. The socioeconomic and political consequences of such an occurrence on the Federal Capital Territory and the nation by extension can also be far reaching. Based on the results obtained from this study in which coliforms were detected in water samples from some of the distribution locations, it is evident that there is recontamination along some axis and proper sanitation and hygiene are also lacking. It is therefore recommended that there should be regular monitoring and maintenance of facilities along distribution network and monitoring to ensure that treated water quality is maintained and to forestall any outbreak of waterborne diseases. Public awareness and enlightenment programs be carried out on importance of proper sanitation and hygiene.

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Disclosure of conflict of interest

There was no conflict of interest/competing interest

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