QUALITY ASSESSMENT OF SELECTED SACHET WATER PRODUCED IN MUBI METROPOLIS

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Ismaila Yada Sudi[1]*, Sirante Martin Richard[1], Clifford L. Barnabas[2] and Samuel T. Magili[3]

[1]Department of Biochemistry, Adamawa State University, PMB 25, Mubi, Nigeria
[2]Deparment of Biochemistry, Ahmadu Bello University Zaria, Kaduna State, Nigeria
[3]Department of Pure & Applied Chemistry, Adamawa State University, PMB 25, Mubi, Nigeria
*Corresponding author: yada280@gmail.com

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Abstract: Water is one of the most essential and indispensable resources for continuous existence of living organism including humans on earth. Sachet water mostly referred to as pure water is a major source of drinking water in Mubi metropolis. In spite of its importance as a major drinking water source there is little or no focus on its wholesomeness for human consumption. This study is conducted with the aim of assessing the quality of 10 brands of sachet water produced in Mubi metropolis. Physicochemical and bacteriological parameters were analyzed using standard methods. Physicochemical parameters studied (electrical conductivity, pH, temperature, total dissolved solids and turbidity) were within world health organization and standard organization of Nigeria recommended values. Similarly, among the heavy metals studied (Zinc, Cadmium and Lead), only Cadmium (from 0.05 to 0.07 mg/L) was found to be above the upper limit recommended by World health organization and standard organization of Nigeria in two brands of the selected sachet water AFA and MAY analyzed. Bacteriological analyses reveals that three of the water samples analyzed (ADS, DNM and UKT) contained *Escherichia coli*) above the upper limit recommended by world health organization. The contaminations observed reflect poor sanitary conditions of the water samples during or after production and lack of adherence to standard manufacturing practices by producing companies. This study suggests that all the sachet water analyzed in this study are not wholesome and therefore not fit for drinking at the time. Sachet water producers and retailer should be educated on the importance of maintaining good hygienic practices during production, handling, packaging, storage and sales. There should be a periodic analysis of sachet water quality by regulatory Agencies so as to maintain quality assurance in line with the international drinking water standard and further studies should be conducted to focus on water sources of the producing companies as this will go a long way in identifying how contaminants get into sachet water.

Keywords: Assessment, bacteriological, *Eschericia coli*, physicochemical, quality, sachet, selected

Introduction

Water is one of the most essential and indispensable resources for continuous existence of living organism including human (Yusuf *et al*., 2015). It is one of the most essential commodity needed for the survival of the ecosystem (Mustapha *et al*., 2015).Water is an extremely important part of human nutrition, both directly as a drinking water or as a constituent of food (Akpen *et al*., 2018). The provision of safe drinking water to the population cannot be overemphasized and is the fundamental right of every individual in the community (Tula *et al*., 2018). About 70% of the earth crust is made up of water, despite its abundance good quality drinking water is not readily available to man (Juneja *et al*., 2013).

About 1.2 million people lack access to portable drinking water worldwide (Mustapha *et al*., 2018). Issues of drinking water quality have rising concern in developing countries (Mohammad *et al*., 2013). 2.3 million People suffer from diseases caused by contaminated water each year, 1.8 million people die from diarrhea diseases and 9% of these deaths are children under the age of 5 years (WHO, 2004). Many years of government neglect of and inadequate investment in the public infrastructure has left the public drinking water supply in undesirable state in this country. The society therefore has taken adaptive measures to alleviate this stress. One of these measures is dependence on sachet water popularly known as pure water (Dada, 2009). The inability of the government to address the ever increasing water demand of many communities in the rural and sub urban areas resort to alternative sources of water supply such as well and boreholes for drinking and other domestic activities (Tula *et al*., 2018).

Any commercial treated, packaged water distributed for sale in seal grade container that is intended for human consumption is called sachet water (Lydia *et al*., 2018). Pure water or sachet water contain 500 ml of water in plastic bags that is clear, electrically heated and sealed at the opposite ends. Water used for sachet water or pure water usually obtained from spring, ground water or portable pipe borne water (Lydia *et al*., 2018). In an attempt to make it safe or purer, sachet water passes through a number of processes before packaging (Addo *et al*., 2009).

Material and Methods

Description of the study area

Mubi metropolis is located between latitude 1005^{0} and 10'30N of equator and longitude 13'12 and 13'19'E of Greenwich Meridian. It is a geopolitical area comprising of two local government areas, Mubi North and Mubi South (Figs. 1 & 2). The two local governments occupying a land area of 192,307 Km² and supports a total population of 260,009 people (National Population Census, 2009). The area shares boundary with Maiha Local Government Area in the south, Hong LGA in the west, Michika LGA and Cameron Republic in the east. The major ethnic groups includes; Fali, Gude, Kilba, Higgi, Marghi and Nzanyi (Adebayo, 2014).

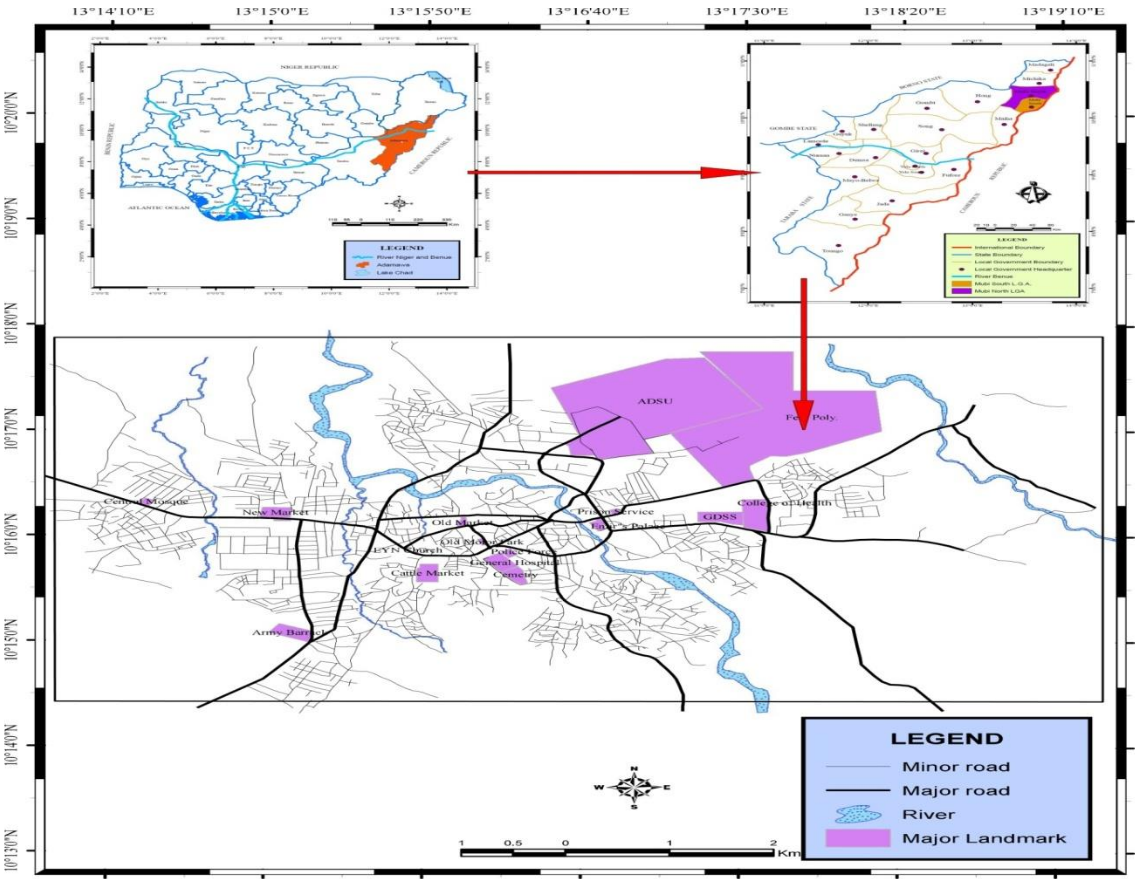

Fig. 1: Map of Mubi Metropolis
Source: Modified from ArcMap 10.2.2, 2019

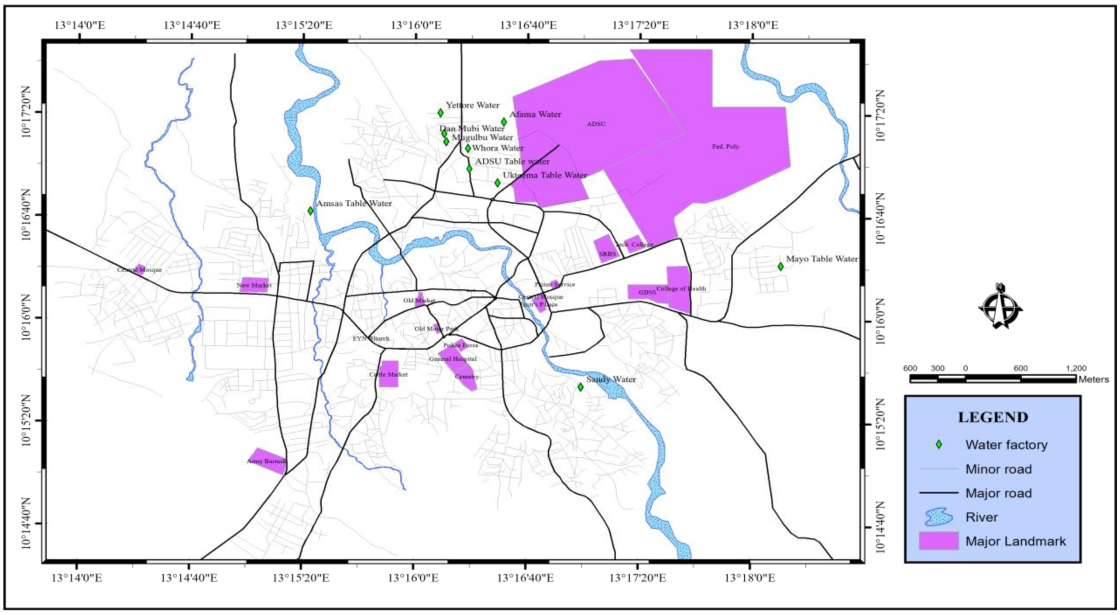

Fig. 2: Map of Mubi metropolis showing the location of water factories
Source: Field Survey

Sample collection

The sample belonging to 10 brand of sachet water, 3 samples from each making a total of 30 samples was collected and analyzed for this study. The sachet water sample were coded as follows; ADS, AFA, AMS, DNS, MAY, MUG, SND, UKT, WHR and YTT. Samples were labelled and transported in ice packs to the laboratory and were analyzed within 1 – 2 h after collection.

Water quality analysis

Heterotrophic plate count

A total of heterotrophic plate count was determined using the Pour Plate Method. Ten-fold serial dilution of water samples was prepared in sterile peptone broth (Himedia) and 0.5 mL aliquots of each dilution was inoculated into 10 ml each of molten nutrient agar in Universal bottles. These were then thoroughly mixed poured into petri-dishes and incubated at

37C for 24 h. Petri-dishes from dilutions containing between 30 and 300 discrete colonies were counted and result expressed in colony per milliliter according to the methods described by (APHA, 2005).

Determination of total Coliform and E. coli

Multiple tube fermentation technique was used for enumeration of total coliform (APHA, 2005). Mackonkey Broth containing inverted Durham tubes was incubated at 37ºC for 24 hours for estimation of total coliform. Eosin methylene blue (EMB) agar was used for confirmatory test for the presence of *E.coli.* Organism with green metallic sheen and dark centers was taken as positive for *E.coli.* Standard biochemical test was used to identify other organisms according to the methods described by (Washington *et. al.,* 2006).

Determination of turbidity

Turbidity was determined using a portable turbidity meter (Model: TN-100/T-100 produced by EUTECH Company), based on standard methods as described in the instrument manual. The instrument was calibrated by standardizing with distilled water and then the sample was placed inside the cell holder. The read /enter key was pressed and then the value of the turbidity was directly taken in NTU. The value was recorded. The test was performed twice on each sample and the average value recorded (Akpen *et al*., 2018).

Determination of total dissolved solids (TDS)

Total dissolved solid was determined with a total dissolved solid meter (Model: 50150 from HACH Company). The probe was rinsed with distilled water followed by the water to be tested. The rinse probe was allowed to standardize in the sample for a minute. The total suspended solid was directly taken in mg/L the test was performed twice in all samples and the average value recorded (Akpen *et al*., 2018).

Determination of temperature

Thermometer was used to determine the temperature. This was done at the time of the analysis in the laboratory. An aliquot of 50 mL of sample was measured into a 100 mL beaker and a 0-60ºC thermometer was immersed in the solution. The reading on the thermometer was recorded

Determination of pH

The temperature was determined using Digital pH meter by EUTECH. The pH meter was calibrated using different buffer solution of pH 12.1, 10.1, 7.0 and 4. The electrode was immersed in water sample and the value of the pH was taken. The test was repeated twice and the average result recorded (Akpen *et al*., 2018).

Heavy metal analysis

Atomic absorption spectrophotometer (AAS) (Buck scientific VPG 210) was used to analyze the concentration of metal Ions. The absorption curve was constructed using standard solution of metal Ion by following the procedure in the instrument manual. 30.00 ml of samples was transferred into a kjeldahl flask and 25 mL of digestion acid (Aqua regia HCl: $HNO_3$3:1) was added. It was swirl and heat gently at first until fronting stops, then more strongly until a clear pale yellow solution results, it was allow cool and the digest was transfer into a 100 ml volumetric flask, it was make up to the mark with distilled water and filter using Whatman No. 1 filter paper. The filtrate was taken to the AAS (Back Scientific, VPG 210) a hallow cathode lamp of the desired metal was installed into the instrument and the wavelength characteristics of the metal was set for the determination of all heavy metals. Standards was run with corresponding lamps using air acetylene flame integrated mode and the concentration of each metal was obtained by extrapolation from the calibration curve of standards. (AOAC, 2010)

Data analysis

Data was analyzed using IBM SPSS statistical version 21 (Armonk, NY: IBM Corp). Descriptive statistics was used to summarize the physicochemical parameters, heterotrophic plate count (HPC) and most probable number (MPN) index of all the water samples. Continuous data was analyzed using Mann Whitney Statistical Test an alpha level of less than or equal to 0.05 was used to determine significance for all the data obtained.

Results and Discussion

The results in Table 1 showed the values of the physicochemical parameters of all the water samples. The EC of MAY water is significantly higher than that of other brands while that of AFA water is significantly lower than that of other brands. The pH of MAY water is significantly higher than that of the other brands while that of WHR water is significantly lower than that of the other brands. The TDS of ADS water is significantly higher than that of the other brands. YTT water is found to be significantly lower than the rest of the brand. The Temperature of WHR Water is significantly higher than that of the other brands. ADS Water Temperature is significantly lower than that of the other brands. Turbidity of all the water samples were found to be 0.00.

Table 1: Physicochemical parameters of selected sachet water samples in Mubi

S/N	Brand	EC (µs/cm)	pH	TDS (mg/L)	Temp (ºC)	Turbidity (NTU)
1	ADS	105.33 ± 0.58^b	6.67 ± 0.01^f	57.50 ± 0.56^b	22.50 ± 0.17^e	0.00
2	AFA	10.33 ± 0.58^h	6.71 ± 0.01^e	10.53 ± 0.50^h	25.20 ± 0.26^b	0.00
3	AMS	26.17 ± 0.15^e	6.59 ± 0.03^g	12.97 ± 0.15^f	24.73 ± 0.12^c	0.00
4	DNM	15.03 ± 0.06^g	6.88 ± 0.02^b	26.97 ± 0.06^d	23.67 ± 0.31^d	0.00
5	MAY	141.33 ± 0.58^a	6.91 ± 0.03^a	67.03 ± 0.06^a	23.63 ± 0.15^d	0.00
6	MUG	90.33 ± 0.58^c	6.87 ± 0.02^b	43.03 ± 0.12^c	23.43 ± 0.15^d	0.00
7	SND	45.83 ± 0.29^d	6.82 ± 0.01^c	24.83 ± 0.29^e	25.33 ± 0.12^b	0.000
8	UKT	20.33 ± 0.58^f	6.67 ± 0.03^f	10.03 ± 0.06^i	24.63 ± 0.06^c	0.00
9	WHR	20.60 ± 0.36^f	6.55 ± 0.03^h	11.03 ± 0.15^g	33.03 ± 0.06^a	0.00
10	YTT	20.17 ± 0.29^f	6.72 ± 0.03^e	10.00 ± 0.00^i	25.20 ± 0.35^b	0.00
USEPA	-	1000	6.5-8.5	500	-	5.00
SON	-	-	6.5-8.5	500	-	-
WHO	-	1000	6.5-8.5	500	-	5.00

Values are express as mean± Standard deviation (SD); N=3 values along the same column with the same subscript are not significantly different. P>0.05 was considered significant; ADS= ADSU water, AFA= Afama water, AMS= Amsas water, DNM= Dan Mubi water, MAY= Mayo water, MUG= Mugulbu water, SND= Sandy water, UKT= Ukteema water,WHR= Whora water, YTT= Yottore water, USEPA=United State Environmental Protection Agency, SON= Standard Organization of Nigeria, WHO = World Health Organization, EC = Electrical conductivity, TDS = Total dissolved solids.

The result in Table 2 showed the values of heavy metals of all the water samples. The Zinc content of MAY water and UKT water are significantly higher than that of the other brands, but are not significantly different from each other while YTT water is significantly lower than the other brands.
The level of cadmium in AFA water is significantly higher than that of the other brands but are not significantly different from MAY water. AMS water, DNM water, WHR water and YTT water are significantly lower than the other brands except MUG water in which cadmium was not detected. Lead (Pb) was not dictated in any of the water samples studied.

Table 2: Heavy metal parameters of selected sachet water samples in Mubi

S/N	Brand Code	Zinc (mg/L)	Cadmium (mg/L)	Lead (mg/L)
1	ABS	0.02 ± 0.00^{c}	0.03 ± 0.00^{c}	ND
2	AFA	0.02 ± 0.00^{c}	0.07 ± 0.00^{a}	ND
3	AMS	0.02 ± 0.00^{c}	0.02 ± 0.00^{d}	ND
4	DNM	0.02 ± 0.00^{c}	0.02 ± 0.00^{d}	ND
5	MAY	0.03 ± 0.00^{a}	0.05 ± 0.00^{b}	ND
6	MUG	0.02 ± 0.00^{c}	ND	ND
7	SND	0.02 ± 0.00^{c}	0.03 ± 0.00^{c}	ND
8	UKT	0.03 ± 0.00^{a}	0.03 ± 0.00^{c}	ND
9	WHR	0.03 ± 0.00^{b}	0.02 ± 0.00^{d}	ND
10	YTT	0.01 ± 0.00^{d}	0.02 ± 0.00^{d}	ND
USEPA	-	5	0.03	0.01
SON	-	3	0.03	0.01
WHO	-	5	0.03	0.01

Values are express as mean± Standard deviation (SD), N=3 values along the same column with the same subscript are not significantly different. P>0.05 was considered significant; ND= not detected, ADS= ADSU water, AFA= Afama water, AMS= Amsas water, DNM= Dan Mubi water, MAY= Mayo water, MUG= Mugulbu water, SND= Sandy water, UKT= Ukteema water, WHR= Whora water, YTT= Yottore water, USEPA=United State Environmental Protection Agency, SON = Standard Organization of Nigeria, WHO = World Health Organization

Table 3: Heterotrophic plate count in cfu/mL and most probable number/100 mL of selected sachet water samples in Mubi

S/N	Brand Code	HPC (cfu/mL)	MPN/100 mL
1	ADS	$7.50 \times 10^{3} \pm 0.50^{d}$	14.33 ± 2.52^{a}
2	AFA	$3.50 \times 10^{5} \pm 0.50^{b}$	5.33 ± 1.15^{b}
3	AMS	$5.60 \times 10^{4} \pm 1.00^{d}$	13.33 ± 4.04^{a}
4	DNM	$6.60 \times 10^{3} \pm 1.00^{d}$	13.66 ± 2.89^{a}
5	MAY	$5.50 \times 10^{5} \pm 1.00^{b}$	10.00 ± 173^{b}
6	MUG	$7.00 \times 10^{3} \pm 0.29^{d}$	7.33 ± 1.53^{b}
7	SND	$3.50 \times 10^{4} \pm 1.00^{c}$	7.33 ± 1.53^{b}
8	UKT	$6.00 \times 10^{5} \pm 1.00^{a}$	9.66 ± 4.04^{b}
9	WHR	$2.00 \times 10^{5} \pm 0.50^{c}$	$10.\ 00 \pm 1.73^{b}$
10	YTT	$6.50 \times 10^{3} \pm 1.00^{d}$	12.66 ± 1.15^{a}
USEPA	-	1.00×10^{2}	0.00
SON	-	-	10
WHO	-	1.00×10^{2}	0.00

Values are express as mean± Standard deviation (SD); N=3 values along the same column with the same subscript are not significantly different. P>0.05 was considered significant; ADS= ADSU water, AFA= Afama water, AMS= Amsas water, DNM= Dan Mubi water, MAY= Mayo water, MUG= Mugulbu water, SND= Sandy water, UKT= Ukteema water,WHR= Whora water, YTT= Yottore water, USEPA= United state environmental protection agency, SON= Standard Organization of Nigeria, WHO= world health Organization,HPC = Heterotrophic plate count, MPN = Most probable number

The result in Table 3 showed the values of HPC and MPN/100 ml of all the water samples. The HPC of UKT water is significantly higher than that of the other brands. The HPC of YTT water is found to be significantly lower than that of the other brand.
The MPN of ADS water is higher but not significantly different from those of DNM water, AMS water, YTT water, WHR water, MAY water, and UKT water but significantly higher than those of SND water, MUG water, and AFA water. The MPN of AFA is significantly lower than the other brand but not significantly lower than SND and MUG. The result in Table 4 shows bacterial specie *E. coli* isolated from water samples*; E. coli* was detected in ADS water, DNM water, and UKT water brands of water samples. *E. coli* was not dictated in the other brands of sachet water samples.

Table 4: Determination of *E. coli* in the selected sachet water samples in Mubi

Brand code	ADS	AFA	AMS	DNM	MAY	MUG	SND	UKT	WHR	YTT	WHO	SON
E. coli	+	–	–	+	–	–	–	+	–	–	–	–

+ = present, – = absent ADS= ADSU water, AFA= Afama water, AMS= Amsas water, DNM= Dan Mubi water, MAY= Mayo water, MUG= Mugulbu water, SND= Sandy water, UKT= Ukteema water,WHR= Whora water, YTT= Yottore water, SON= Standard Organization of Nigeria, WHO= world health Organization

Conductivity is an index of total ionic content of water and indication of freshness of otherwise of water (Ogbeibu, 1991). The EC values of all the brands of water samples were lower than the recommended standard by WHO (2017). Mustapha *et al.* (2015), low EC indicates the presence of minimal amount of dissolved salt (mineral elements such as calcium, magnesium and fluoride) in water. The long term drinking of packaged water with EC value less than 40 µs/cm constitute a number of health risks such as high probability of fracture in children, pregnancy disorder (preeclampsia), diuresis, premature or low body weight at birth, and increases tooth decay (Alpalsan, 2009).
The pH of all the water samples were within the standard recommended by WHO (2011). Asamoa & Amorin (2011) where of the opinion that it is very important that packaged water pH should be within WHO recommended guidelines value so as to reduce the probability of posing health issues like acidosis. The TDS of all the water samples were observed to be within the WHO (2011) standard and SON (2007) of 500 mg/L. TDS above the upper limit affects the taste of

drinking water negatively and is not consider fit for drinking purposes. The study showed that the salinity of portable water is within the limits recommended for consumption.

Temperature value reported is within the ambient temperature. Although there is no standard set by WHO (2017) and SON (2007). Turbidity of drinking water is dependent on amount of particulate matter present in it. The turbidity of all water samples within was found to have zero turbidity. This is within the WHO, 2011 recommended standard. Turbidity in water result from the presence of suspected solids therefore observed zero turbidity is also a reflection of zero total dissolve solid (Mustapha *et al.,* 2015).

Zinc was detected in all the water samples. However, the values were below the recommended standard by WHO (2011) of 5 mg/L. Zinc is required in trace amount in the body as it helps balance copper in the body and is essential for male reproductive activity (Nolan, 2003), zinc also serves as a co-factor for dehydrogenating enzymes and in carbonic anhydrase (Halum, 1983). Zinc deficiency causes anemia and retraction of growth and development (Mc Cluggage, 1991).

Cadmium was present in all the water samples except MUG. However, all the other samples have Cadmium within the recommended standard value by WHO (2004) and SON (2007) except AFA (0.07 mg/L) water and MAY (0.05 mg/L) water which have values higher than the standard values (0.03 mg/L). Cadmium Accumulate in human body negatively affecting several organs such as liver, kidney, lungs, bones, placenta, brain and the CNS (Castro-Gonzalas & Mendez Armenta, 2008). Other damages that have been observed include; reproduction, developmental toxicity, hematological and immunological effect (Apostoli & Catalani, 2011). Lead (Pb) was not detected in any of the samples. Therefore, all the water samples were within the recommended standard of 0.01mg/L by WHO (2004). Lead has no any essential function in man (Simeon *et al.,* 2012).

The heterotrophic plate count (HPC) of all the water samples were above the recommended standard of SON (2007); WHO (2008) and USEPA (2018). HPC are groups of grams negative bacteria and opportunistic pathogens although nothing is known about their effect on humans (Toranzos and McFeters, 1997). HPC is useful to water treatment plant operators with regard to assessing the efficiency of various treatment processes including disinfection in a water treatment plant, monitoring the bacteriological quality of the finished water during storage and distribution, determining bacterial growth on surfaces of materials used in treatment and distribution systems and determining the potential for regrowth or after growth in treated water in distribution systems (Rajendran *et al.,* 2006).

The MPN of all the water samples were above the WHO (2008) and USEPA (2018). Three brands of the water samples (MUG, AFA and SND) met SON, 2007 recommended standard. The high number of coliform bacteria is indicative of poor sanitary condition and fecal contamination during processing and handling of sachet water by the producers. Consequently undermine suitability for consumption. This may be due to ineffectiveness or malfunctioning of the treatment process employed (Tula *et al.,* 2018). No treatment process or process used in mass production of drinking water yield a sterile product; it only produce a safe product devoid of pathogenic organism. Dictation of organism indicative of fecal contamination in these water samples emphasized the need for continues implementation of several rules promulgated by national agency for drug administration and control (NAFDAC) in Nigeria, and continues monitoring to reduce the sales of contaminated brand of sachet water. *E. coli* was dictated in 3 of the sachet water brand, however, these brands does not conforms to the guidelines of USEPA (2011) and WHO (2008) for drinking water which state that water meant for drinking should not contain *E. coli* and ideally there should be no total coliform (WHO, 2008). The absence of *E. coli* in seven brands conforms to USEPA (2011) and WHO (2008) guidelines. This does not guarantee that these brands of sachet water were completely safe because the total coliforms were high and the samples analyzed were only snap shots of water being distributed within Mubi metropolis. More so *E. coli* are generally more sensitive to disinfection than chlorine resistance pathogens such as viruses and *Cryptosporidium oocyte* including protozoa and helminthes which are now increasingly transmitted through drinking water (Health Canada, 2012; Ogochukwu *et al*., 2015).

Conclusion

This study showed that all the water samples analyzed have high concentration of *Escherichia coli* above the recommended standard by WHO (2008); USEPA (2018) and SON (2007). This could be due to unhygienic practices during production handling and storage of sachet water or failure to adhere to standard manufacturing processes by sachet water companies. Therefore the sachet water analyzed is not wholesome for consumption at the time. Frequent monitoring and assessing quality of sachet water in Mubi is necessary.

Conflict of Interest

The authors declare that there is no conflict of interest in this work.

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