Supported by
tetfund
TERTIARY EDUCATION TRUST FUND

BACTERIOLOGICAL QUALITY OF SOME SACHET WATER SOLD IN DUTSE METROPOLIS, JIGAWA STATE

Usman Lawan Ubani[1], Shiaka Gimba Peter[2], Auwal Aliyu[3], Abduljalil Ismail Idris[4] and Musa Aminu Ahmad[5].

[1, 2, 4 and 5] Department of Microbiology and Biotechnology, Federal university Dutse, Jigawa state
[3]Department of Biological Sciences, Federal university Dutse, Jigawa state
[1]Usmanlawan063@gmail.com, Tel; +2348086613000

Received: December 13, 2021 Accepted: February 20, 2022

ABSTRACT Water is an essential natural resource needed to maintain basic health, sanitation and is believed to be an elixir of life. Among the rural population of developing countries, only 22% have reasonable amount of safe water supply and only 15% had waste disposal facilities. The cases of salmonellosis and typhoid fever have been increasing in recent years. Subsequently, a large proportion of Dutse inhabitants use sachet water as their main source of drinking water hence,-the need to examine the microbiological quality of these sachet water. This study was conducted to determine the bacteriological quality of some sachet water sold in Dutse Metropolis. Ten different brands of sachet water were selected at random from vendors for a period of 5 weeks (March- April 2019). A total of 50 samples were purchased from retailers, labelled and transported to Microbiology laboratory in the department of microbiology and biotechnology, Federal University, Dutse for microbiological examination. The highest Aerobic Mesophilic Bacterial Count (AMBC) was obtained in sample F (2.76×10^1 cfu/ml), while sample D showed the least count (0.08×10^1 cfu/ml). Selected coliforms: Escherichia coli, Salmonella spp. and Shigella spp. were found to be absent in all the samples. These were below the standard of the regulatory agencies WHO, FAO and NAFDAC of 1.2×10^2 cfu/ml for AMBC and less than 1 coliform bacteria per 100ml of drinking water and are therefore considered fit for human consumption. Frequent microbiological assessment complemented with molecular methods should be employed to detect the presence of these pathogenic micro-organisms along-side physiochemical analyses of some parameters as they might influence the growth of few organisms if present.

Keywords: Bacteriological analysis, Coliforms, Dutse metropolis, NAFDAC, Sachet water.

INTRODUCTION

One of the precious resources vital to life is water (Umar *et al.*, 2019). It is necessary for existence and survival of all human beings (Abdullahi *et al.*, 2010). Potable drinking water serves as an important pillar for primary prevention of diseases and it continues to be the foundation for the prevention and control of water borne diseases (Isa *et al.*, 2013). Water serves vital functions to man just as air and food are (Ugochukwu, *et al.*, 2015). It is estimated that each individual needs 30–40L of water for domestic purposes, including drinking, food preparation, cooking and washing. Industrially, water may be used either as part of manufacturing processes or as ingredient such as for boiling, cooling, cooking, washing or transportation of raw materials (Ugochukwu, *et al.*, 2015). Generation of hydroelectric power is also an indispensable role of water.

Good drinking water is of enormous importance to human physiological functions, and man's continued existence depends very much on its availability. The human body constitutes about 70% water (Oluwafemi *et al.*, 2012). However it is not only essential for life, it also remains an important source of disease transmission, and infant mortality in many developing countries (Botkin and Keller, 1998). It is also a key parameter affecting survival and growth of

microorganisms in foods and other microbial environments (Isa *et al.,* 2013).

The demand for safe drinking water in Nigeria cannot be overemphasized, considering the government's inability to provide adequate pipe-borne water to the population (Oginni and Fadipe 2016). Packaged water in bottles or food grade polythene sachets designed for food processing is a ready alternative for the ever-growing population of over 140 million people in Nigeria (National Census, 2006). Statistics on sales of packaged sachet water are more difficult to obtain due to increase in consumption rate (Stoler *et al.,* 2013).

There are several rules and regulations for the production of sachet water in Nigeria; such regulations are monitored by the National Agency for Food Drug Administration and Control (NAFDAC). Surveillance carried out by NAFDAC between 2004 and 2005 revealed that some producers of packaged water indulge in sharp practices such as packaging of untreated water, production of sachet water under unhygienic conditions, illegal production of unregistered water in unauthorized premises, use of non-food grade sachets and release of packaged water for distribution and sale without date-marking. These malpractices compelled the agency to formulate guidelines for the production of wholesome packaged water. Ideally sachet water is expected to be free from any disease-causing microorganism. The World Health Organization (WHO) guidelines for drinking water quality requires that *Escherichia coli* and thermotolerant coliform bacteria should not be detectable in any 100ml sample of water and that total coliform must not be detected in both treated and untreated samples (WHO 1995). Unfortunately, water-borne pathogens are found in a number of water bodies including surface and underground waters. Prominent among these pathogens are: S*almonella typhii* implicated as the causative agent for typhoid fever, *Shigella dysentariae* implicated as the causative agent of bacillary dysentery, *Escherichia coli* which causes gastroenteritis and *Klebsiella pneumonia* which causes pneumonia, to mention a few of them (Ashish *et al.,* 2014). Water-borne viral disease such as acute non-bacterial gastroenteritis is caused by noro virus. It is transmitted predominantly through faecal-oral route and also from person to person contact.

In 2006, water-borne diseases were estimated to cause 1.8 million deaths worldwide, while about 1.1 billion people lacked safe drinking water (Clasen *et al.,* 2007). Consequent to the realization of the potential health hazards that may result from contaminated drinking water, its contamination is therefore of primary concern because of the danger and risk associated (Oluwafemi *et al.,* 2012).

Among the rural populations of developing countries, only 22% has reasonable safe water supply and only 15% had waste disposal facilities (Umar *et al.,* 2019). Although there is dearth of documented data on incidence rates of water borne diseases directly associated with consumption of sachet water, it has been widely observed that cases of salmonellosis and typhoid fever have been increasing in recent years (Bukar *et al.,* 2015).

Large proportion of Dutse inhabitants use sachet water as main source of drinking water, This study was therefore conducted to ascertain the public health safety of sachet water sold in Dutse metropolis.

MATERIALS AND METHODS

Study Area

This study was conducted in Dutse metropolis of Jigawa state. Dutse local government is situated on the Latitude 11.777^{o}N, Longitude 9.334^{o} E and an Altitude of 460meters above the sea level (maplandia.com). According to the 2006 population census, Dutse had 251,135 people (NPC 2006).

Collection of Samples

Ten different brands of sachet water were purchased from retailers at random, labelled, and conveyed in an ice pack to the Microbiology Laboratory of the department of Microbiology and Biotechnology, Federal University Dutse (FUD) for analyses. This was repeated for five weeks (March to April) 2019, making a total of 50 sachets of water considered for the period of study.

Laboratory Procedures

The water samples brought to the laboratory were subjected to series of laboratory tests including Aerobic Mesophilic Bacterial Count (AMBC), coliform counts, isolation and characterization of selected bacteria.

Aerobic Mesophilic Bacterial Count

Pour plate technique was used in which 1mL of the water sample was transferred into sterile petri dish aseptically after which about 15mL of a prepared plate count agar (PCA) was poured into the plate and then allowed to solidify. The inoculated plate was incubated at 37^{0}C for 24 hours after which the colonies formed were counted and expressed in colony forming

unit per mL (CFU/mL). This procedure was repeated for all other water samples.

Coliform Counts

1 mL of the water sample was transferred into sterile petri dish using a sterile syringe. After which a prepared Eosine Methylene Blue (EMB) agar was poured into the plate and then allowed to solidify. The inoculated plate was incubated at 37^0C for 24 hours after which the colonies formed were counted and expressed in colony forming unit per milliliter (CFU/mL). This procedure was repeated for all other water samples.

Isolation of the Selected Bacteria

The water samples were analysed for the presence of *Escherichia coli*, *Salmonella spp.* and *Shigella spp.* as described by Chessbrough (2006). The Eosine Methylene Blue (EMB) was observed for green metallic sheen colony while the water sample was plated on *Salmonella Shigella* Agar (SSA) agar using pour plate method. The inoculated SSA media were incubated at 37^0C for 48 hrs after which the presence of colourless colony on SSA was suspected to be positive for *Shigella* while presence of a colourless colony with black centre on SSA was suspected to be positive for *Salmonella*. This procedure was repeated for all other water samples.

RESULTS

The AMBCs of the different brands of sachet water samples examined during the period of this research showed that during the first week, samples H, D and E recorded the least count of 0.0 ×10 CFU/mL, 0.1 ×10 CFU/mL and 0.2 ×10 CFU/mL respectively. On the other hand, samples A (2.2 ×10 CFU/mL) and F (3.1 ×10 CFU/mL) showed the highest count as presented in Table 1. Similar results were obtained in the second, third, fourth and the fifth week. However, samples D and E had the least bacterial counts with a record of 0.08 ×10 CFU/ml and 0.12 ×10 CFU/ml respectively.

Table 1: Aerobic Mesophilic Bacterial Count of the Sachet water samples (×10 CFU/mL)

	Week/AMBC						
Sample	1st	2nd	3rd	4th	5th	MBC	Inference
A	2.2	1.8	2.0	2.5	2.3	2.16	Accepted
B	1.7	2.0	2.7	2.0	1.8	2.04	Accepted
C	1.2	1.5	1.2	1.4	1.3	1.32	Accepted
D	0.1	0.2	0.0	0.0	0.1	0.08	Accepted
E	0.2	1.0	0.0	0.0	0.3	0.12	Accepted
F	3.1	2.5	2.8	2.6	2.8	2.76	Accepted
G	1.2	0.9	0.8	0.8	1.2	0.98	Accepted
H	0.0	0.6	0.2	0.1	0.1	0.2	Accepted
I	1.4	1.4	1.0	1.2	1.6	1.32	Accepted
J	1.0	1.7	1.5	1.3	1.1	1.32	Accepted

AMBC: Aerobic Mesophilic Bacterial Count; CFU/mL: Colony Forming Unit Per Milliliter MBC: Mean Bacterial Count

Table 2 presented the result of coliform counts conducted on the ten different brands of sachet water samples analyzed during the period of study. All samples analyzed during the period were found to be of zero coliform bacteria.

Table 2: The Level of Coliforms Present in the Sachet Water Samples

Sample	Coliform count (CFU/ml)	Inference
A	0.00	Accepted
B	0.00	Accepted
C	0.00	Accepted
D	0.00	Accepted
E	0.00	Accepted
F	0.00	Accepted
G	0.00	Accepted
H	0.00	Accepted
I	0.00	Accepted
J	0.00	Accepted

Table 3 below showed the results on isolation of coliforms present in the water samples during the period of study. No any coliform of interest was found (*Escherichia coli, Salmonella spp.* and *Shigella spp)* to be present in the sachet waters. They all tested negative.

Table 3: Isolation of Selected Coliforms from the Samples of Sachet Water

Sample	*Escherichia coli*	*Salmonella spp*	*Shigella spp*	Inference
A.	-	-	-	Accepted
B.	-	-	-	Accepted
C.	-	-	-	Accepted
D.	-	-	-	Accepted
E.	-	-	-	Accepted
F.	-	-	-	Accepted
G.	-	-	-	Accepted
H.	-	-	-	Accepted
I.	-	-	-	Accepted
J.	-	-	-	Accepted

CFU/mL: Colony Forming Unit Per Milliliter; - : Absent

DISCUSSION

The relatively high mean AMBC observed in samples A (2.16 ×10 cfu/ml) and F (2.76 ×10 cfu/ml) might be due to improper manufacturing practice including poor processing, packaging or storage of the sachet drinking water. Others might be due to violation of human safety practices such as sneezing, coughing, unwashed hands, use of unclean overall and head gears by the personnel involved in the manufacturing process. The total sum of which can lead to bacterial contamination, and can provide an avenue for bacterial growth. All the ten samples analyzed recorded an average bacterial count that fall within the standard set by WHO (1996) of 1.2×10^2 cfu/ml. This might be due to the improvement of the level of hygiene by the sachet water producers resulting from recent concern over water quality by the consumers in the study area. Other reasons may include the inability of the bacterial population if present to complete its generation time because all samples used were freshly produced and supplied to local retailers. This low counts deviates from the findings of Okonko *et al.,* 2008; Anyanwu and Okoli, 2012, who reported higher heterotrophic plate counts from water samples analyzed from various water sources. However, the findings supported those of Umar *et al.* (2019) and Shiaka *et al*. (2020) conducted in Zaria and Dutse respectively in which about 80% of the sachet water considered had aerobic mesophilic bacterial count below the WHO/FAO standards.

The zero targeted coliform results obtained was in agreement with results of Shiaka *et al*. (2020), Umar *et al.,* (2019) and Bukar *et al.* (2015). Hence, all the sachet drinking water analyzed were considered to have conformed to the standard of safe drinking water by World Health Organization of less than 1 coliform bacteria per 100ml of treated water (Umar *et al.,* 2019).

All the sachet water samples analyzed during the period of this research have met the standard set by the regulatory agencies of less than 1 coliform bacteria per 100ml of treated water samples and are considered microbiologically fit for human consumption. (Umar *et al.,* 2019).

However, zero targeted coliforms obtained in this research deviated completely from those of Ashish *et al*. (2014) conducted in Delhi, India and Bukar *et al*. (2015) conducted in Maiduguri metropolis where some of the sachet water samples considered were found to be contaminated with pathogenic bacteria such as *Klebsiella species*, *Escherichia coli*, *Pseudomonas species* and *Enterobacter species*.

CONCLUSION

The results of this research proved that all the samples analyzed contained aerobic mesophilic bacteria count below the standard set by WHO and FAO. Similarly, the coliform counts of the sachet water samples were found to be within the standard set by WHO (<1 coliform per 100ml of treated water samples) and are microbiologically considered fit for human consumption. This study also showed that sachet water sold in Dutse might likely be free from *Escherichia coli*, *Salmonella spp* and *Shigella spp* and may be considered microbiologically acceptable. It is therefore recommended that bacteriological analysis of sachet water should be conducted using advanced technological methods such as 16s ribosomal Ribonucleic Acid (rRNA) sequence determination of coliform bacteria among others. Physicochemical analyses should be conducted alongside bacteriological analyses for more accurate and reliable results.

REFERENCES

Abdullah, S., Mohammed, A.I. and Mohammed, I.F. (2010). Physicochemical Analysis of the Freshwater at Kundalika Dam. *India Global Journal of Environmental Research*, **4**(1): 01-05

Anyawu C.U. and Okoli E.N. (2012). Evaluation of the bacteriological and physicochemical quality of water supplies in Nsukka, Southeast, Nigeria. *African Journal of Biotechnology*; **11**(48): 10868-10873. DOI: 10.5897/AJB12.903

Ashish, S., Hansa, K., Basavaraj, P., Shilpi, S., Khushboo, S. and Swati, J. (2014). Physico-Chemical and Bacterial Evaluation of Packaged Drinking Water Marketed in Delhi - Potential Public Health Implications: *Journal of Clinical and Diagnostic Research*. **8**(3): 246-250. DOI: 10.7860/JCDR/2014/7845.4175

Botkin, B.D. and Keller, E.A (1998). Environmental Science. 2nd Edition. John Willey and Sons Inc. U.S.A., Pp.392-420.

Bukar, A.M., Isa, M.A., Mustapha, A., Kyari, M.Z. and Ibrahim F.K. (2015). Bacteriological Analysis of Sachet Water in Maiduguri Metropolis. *The Journal of Applied Sciences Research*, **2**(1): 20-25

Cabral, J. P. (2010). Water microbiology. Bacterial pathogens and water. *International journal of environmental research and public health* **7**(10): 3657-3703.

Chessbrough, M. (2006). District Laboratory Practice in Tropical Countries, Part II, 2nd ed. Cambridge University Press. Pp. 47-104.

Clasen, T., Thomas, S., Wolf-Peter, R., Tamer, R. and Cairncross, S. (2007). Interventions to improve water quality for preventing diarrhoea: systematic review and meta-analysis." *Biomedical journal* **334**(7597): 782.

Flora, O., and Michael, E.O. (2012): Microbiological Examination of Sachet Water Due to a Cholera Outbreak in Ibadan, Nigeria. *Open Journal of Medical Microbiology*, **2**(3): 15-120 http://dx.doi.org/10.4236/ojmm.2012.23017 Published Online September 2012 (http://www.SciRP.org/journal/ojmm)

Gangil, R., Tripathi R., Patyal, A., Dutta, P. and Mathur K.N. (2013). Bacteriological evaluation of packaged bottled water sold at Jaipur city and its public health significance. *Vet World*; **6**(1): 27-30.

Isa, M. A., Allamin, I. A., Ismail, H. Y. and Shettima, A. (2013). Physicochemical and bacteriological analyses of drinking water from wash boreholes in Maiduguri Metropolis, Borno State, Nigeria. *African Journal of Food Science*, **7**(1): 9-13.

Kalpana, S., Bagudo, A.I. and Aliero, A.A. (2011). Microbiological analysis of sachet water marketed at two sites in Aliero, Kebbi state, Nigeria. *Continental Journal Microbiology*, **5**(1): 29-36.

Majumder, A.K., Islam, K.M.N., Nite, R.N. and Noor R. (2011). Evaluation of Microbiological Quality of Commercially Available Bottled Water in the City of Dhaka, Bangladesh. *Journal of Microbiology*; **1**(1): 24-30.

National Population Commission of Nigeria (web), National Bureau of Statistics (web). (2006). Population of Dutse Local Government https://www.citypopulation.de/php/nigeria-admin.php?adm1id=NGA018. Last accessed, 11 January 2021.

Oginni, F. A. and Fadipe, O.O. (2016). Demostic water supply sources and distribution issues in Ilesha west local council, Osun state, Nigeria. *International Journal of Civil Engineering and Technology*; **7**(3): 407-418

Okonko, I.O., Adejoye, O.D., Ogunnusi, T.A., Fajobi, E.A. and Shittu, O.B. (2008). Microbiological and physicochemical analysis of different water samples used for domestic purposes in Abeokuta and Ojota, Lagos State, Nigeria. *African Journal of Biotechnology*; **7**(5): 617-621.

Oluwafemi, F. and Michael, E. O. (2012): Microbiological Examination of Sachet Water Due to a Cholera Outbreak in Ibadan, Nigeria. *Open Journal of Medical Microbiology*, **2**(3): 115-120 http://dx.doi.org/10.4236/ojmm.2012.23017 Published Online September 2012 (http://www.SciRP.org/journal/ojmm)

Oluwatoyim A.I. and Adebayo L. (2014). The bacteriological quality of different brands of bottle water available for consumers in Ile-Ife south-western Nigeria. *Journal of Biomedical Central*: (7)pp 859

Sails, A., Bolton, F.J., Fox, A.J., Wareing, D.R.A. and Greenway, D.L.A. (2002). Detection of Campylobacter jejuni and Campylobacter coli in environmental waters by PCR enzyme-linked immunosorbent assay. *Journal of Applied Environmental Microbiology* **68**(3): 1319-1324.

Shiaka, G.P., Sani, N.M., Gumel, A.M., Sadiq, S.I. and Amoo, K.F. (2020). Bacteriological evaluation of commercially packaged Sachet Water Commonly Sold in Dutse Metropolis. *Journal of New Discovery in Microbiology*, 1(1): 1-6.

Stoler, J., Weeks, J.R. and Otoo, R.A. (2013). Drinking water in transition: a multi-level cross-sectional analysis of sachet water consumption in Accra. *Journal of Water, Sanitation, and Hygiene for Development*, **8**(6): 272

Ugochukwu, S., Giwa, F. and Giwa, A. (2015). Bacteriological evaluation of sampled sachet water sold in Samaru-Zaria, Kaduna-State, Nigeria. *Nigerian Journal of Basic and Clinical Sciences*, **12**(1): 6.

Umar, M., Kambai, J., Mohammed, I. B., Oko, J. O., Obafemi, A. A., Ibrahim M., Ajiya, K. G., Yaya, A. A., Abdulkarim, I. M., Akafyi, D. E., Idris, S., Tashi U. T. and Ahmed S. (2019). Bacteriological Quality Assessment and Antibiogram Profile of Bacteria Associated with Sachet Drinking Water Sold at Zaria, Northern Nigeria. *International Journal of Pathogen Research* **2**(2): 1-13

Wang, X., Han, J., Xu, L. and Zhang, Q. (2010): Spatial and seasonal variations of the contamination within water body of the Grand Canal, China. *Environmental Pollution*. **158**: 1513–1520.

WHO, G. (2011). Guidelines for drinking-water quality. World Health Organization, **216**, Pp.303-304.

WHO. Guidelines for drinking water quality. World Health Organization. Health Criteria and other supporting information. W.H.O. Geneva. 1995;2.

WHO. International standards for drinking water third edition. Health and other support information, World Health Organization Chronicle. 2000;11:19-20,46. 6

World Health Organisation. Guidelines for drinking water quality - Health criteria and other supporting information. 2nd ed., Vol. 2. Geneva: WHO; 1996. Available from: http://www.who.int/water_ sanitation_health/dwq/2edvol2p1.pdf

World Health Organization (WHO) (2008): Guidelines for Drinking water Quality and Recommendations, Incorporating 1st and 2nd

Addenda, Volume **1**: 3rd edition. Geneva, Switzerland.

World Health Organization WHO, (2004). *Guidelines for Drinking Water Quality*. Vol.1, 3rd ed. World Health Organization Geneva, Switzerland.

Zanipinin, M., Canesi, L., Bett, M., Ciacei, C., Tarsi R., Gaoo, G. and Pruzo, C. (2003). Role for Mannote Sensitive Haemagglutinin in Promoting Interaction between *Vibrio cholera*, Ether and mussel Hemolymph. Journal of *Applied General Microbiology* **69**(9): 5711.

Zeenat, A., Hatha, A.A., Viola, L. and Vipra, K. (2009). Bacteriological quality and risk assessment of the imported and domestic bottled mineral water sold in Fiji. *Journal of Water Health*; **7**(4): 642-649.