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Bacteriological and Physicochemical Analysis of Sachet Water Sold in Ilorin Metropolis, Nigeria.

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Abstract

Twenty brands of sachet water sold within Ilorin metropolis were assessed for their Physicochemical and bacteriological quality using standard methods. The pH, chloride content, and total hardness of the sachet water samples ranged from 6.5 – 8.0, 0.78 – 5.04 mg/l, and 15 – 75mg/l respectively. The counts of heterotrophic bacteria, total coliform, and faecal coliform ranged from 0 to 2.8×10^3 cfu/ml, 0 to 52 MPN/100ml, and 0 to 24 cfu/ml respectively. Pathogenic bacteria such as *Staphylococcus aureus*, *E. coli*, and *Salmonella* sp. were isolated while *Shigella* sp. and *Pseudomonas aeruginosa* were not isolated in any of the samples. Furthermore, *Staphylococcus equorum*, *Staphylococcus hominis*, *Bacillus stearothermophilus*, *Bacillus psychrosaccharolyticus*, *Corynebacterium pseudotuberculosis*, *Micrococcus kristinae*, *Micrococcus luteus*, *Micrococcus candidus*, *Micrococcus flavus*, *Bacillus smithii*, and *Staphylococcus capitis* were also characterized and identified. It can be concluded from this study that most of the sachet water purchased from the open markets were not wholesome. Only six brands of the sachet water samples met the bacteriological quality with regard to heterotrophic bacteria, total coliform, and faecal coliform counts. It is recommended that producers of sachet water should adhere to good manufacturing practices and there is need for proper handling of these products during sales and distribution.

Keywords: Sachet water, quality, safety, assessment

INTRODUCTION

Water is indispensable. In the home water is used for cooking, washing, bathing, drinking, and other domestic uses. Industrially, water is the starting point of most processes. It is important for the growth of organisms. Available water include surface water such as streams, rivers and lakes as well as ground water which is subsurface water that fill small pores of loose sediments (Ibemesim, 2014).

Quite a number of human pathogens find their way into a susceptible host through contaminated water. These pathogens often called waterborne pathogens have the ability to survive at least for a short period in water. An estimated 748 million people all over the world lack access to potable water and close to 2.5 billion persons are not provided with adequate sanitation (WHO, 2014).

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Access to safe drinking water is important to health and development but because of its inadequacy and government's inability to provide enough, a number of small scale water producing industries are packaging and marketing filled sachet drinking water (Adegoke *et al.*, 2012; Thliza *et al.*, 2015). The sales and consumption of packaged water continue to grow astronomically and rapidly in most countries of the world (Olayemi, 1999; Oyedeki *et al.*, 2010; Mgbakor *et al.*, 2011; and Gangil *et al.*, 2013).

The quest for cheap and readily available source of potable water has led to the emergence of sachet water which provide access to safe water in rural and semi urban settings of developing nations (USEPA, 2012; Anyamene and Ojiagu, 2014; Balogun *et al.*, 2014). Sachet water is thought to be cheaper and more affordable than bottled water and also safer than hand filled, hand tied, packaged polythene bag water initially sold before the advent of sachet water (Oyedeki *et al.*, 2010). Consequently sachet water has gradually become the most consumed liquid for both the rich and poor (Akinde *et al.*, 2011). Current trends however suggest that sachet water could be a route of transmission of enteric pathogens which is of public health concern (Oladipo *et al.*, 2009; Mgbakor *et al.*, 2011).

This research was undertaken in order to determine the level of safety of sachet water consumed by the people. The consumers viewed the sachet water popularly called "pure water" to be of the right quality.

This research aimed at determining the bacteriological quality of sachet water in terms of counts of heterotrophic bacteria, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Salmonella/Shigella* sp., total coliform, and faecal coliform; characterize and identify the bacterial isolates; determine the occurrence of the bacterial isolates; determine some physicochemical properties of the sachet water; and proffer recommendation on measures that would ensure potability of sachet water.

MATERIALS AND METHODS

Collection of sachet water samples

The sachet water samples were bought from retail outlets within Ilorin metropolis, Nigeria. In order to protect the identity of the producers, the twenty brands of sachet water were coded A to T. Three sachet water samples from the same pack were purchased for each brand and used for the analysis.

Determination of pH

The hydrogen ion concentration (pH) of water sample was measured using Denver instrument which was standardized with buffer of pH 4, 7 and 9 (Dubey and Maheshwari, 2005).

Determination of chloride content

One hundred milliliter of each water sample was introduced into 250ml conical flask and 2ml of 5% potassium chromate (indicator) was added. Silver nitrate solution (AgNO_3) of 0.1N strength was then used to titrate the water sample with continuous shaking until the initial yellow colouration turned faint pink. The titre value multiplied by 3.55 gave the chloride content in mg/l (Sule *et al.*, 2016).

Determination of total hardness

One hundred milliliter of the water sample was introduced into conical flask and 10 drops of 25% ammonia was added after which 2 drops of Eriochrome black – T (indicator) was also added. Then, 0.1N EDTA was used to titrate the sample until the initial purple colouration changed to light blue. The titre value multiplied by 100 gave the total hardness in mg/l (Sule *et al.*, 2011).

Determination of heterotrophic plate count

Pour plate method was used to determine the heterotrophic plate count of the water sample using sterile nutrient agar (APHA, 1998; Bukar *et al.*, 2015).

Isolation and enumeration of pathogenic bacteria

Pathogenic bacteria: *Staphylococcus aureus*, *Salmonella*, *Shigella* and *Pseudomonas aeruginosa* were isolated and enumerated tentatively using mannitol salt agar (MSA), salmonella-shigella agar (SSA), and cetrimide agar (CA) respectively. Spread plate techniques were used for the analysis (Collins and Lyne, 1970; Aneja, 2014). The positive plates were used for biochemical tests.

Enumeration of total and faecal coliform

The most probable number (MPN) of total coliform was determined using multiple tube fermentation method with MacConkey broth as the medium for cultivation. The faecal coliform was determined using spread plate technique and Eosin methylene blue agar medium (EMB) for cultivation (Fawole and Oso, 2007).

Purification and preservation of isolates

The bacteria isolated from the heterotrophic plate count and the selective media (MSA, SSA, and CA) were subcultured on nutrient agar until pure culture was obtained and then stocked as agar slant in a refrigerator (Fawole and Oso, 2007).

Characterization and identification of isolates

The bacteria isolated from the heterotrophic plate count and selective media such as MSA, SSA, EMB were characterized based on their cultural, cellular, and biochemical characteristics (Aneja, 2014).

Statistical analyses

Statistical analysis package SPSS 15.0 was used to determine the mean, range, standard deviation and then one way analysis of

variance was used to determine the differences within the means (SPSS, 2010).

RESULTS

Physicochemical characteristics of the sachet water samples

The pH, chloride content, and total hardness of the sachet water samples ranged from 6.5 – 8.0, 0.78 – 5.04mg/l, and 15 – 75mg/l and respectively (Table 1).

Bacteriological counts of the sachet water samples

The counts of heterotrophic bacteria, total coliform, and faecal coliform of the sachet water samples ranged from 0 to 2.8×10^3 cfu/ml, 0 to 52 MPN/100ml, and 0 to 24 cfu/ml respectively. Similarly, the counts of *Staphylococcus aureus*, and *Salmonella* sp. ranged from 0 – 98 cfu/ml and 0 – 18 cfu/ml respectively. *Pseudomonas aeruginosa* and *Shigella* sp. had count of zero in the sachet water samples (Table 2).

Identification and occurrence of bacterial isolates in the sachet water samples

The following bacteria were isolated and identified from the heterotrophic plate counts of the sachet water samples: *Staphylococcus equorum*, *Staphylococcus hominis*, *Bacillus stearothermophilus*, *Bacillus psychrosaccharolyticus*, *Corynebacterium pseudotuberculosis*, *Micrococcus kristinae*, *Micrococcus luteus*, *Micrococcus candidus*, *Micrococcus flavus*, *Bacillus smithii*, and *Staphylococcus capitis* (Table 3). Furthermore, *Staphylococcus aureus*, *Salmonella* sp., and *E. coli* were isolated from the tentative plates of MSA, SSA, and EMB. The occurrence of the bacterial isolates is presented in Table 4.

Table 1: Physicochemical characteristics of sachet water samples

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Sample code	pH	Chloride content (mg/l)	Total hardness (mg/l)
A	7.3 ^{defg} ± 0.3	1.62 ^e ± 0.02	36 ^{fg} ± 3.0
B	7.3 ^{defg} ± 0.2	2.20 ⁱ ± 0.2	58 ^h ± 4.0
C	8.0 ^h ± 0.4	3.37 ^m ± 0.07	15 ^a ± 1.0
D	6.6 ^{ab} ± 0.2	5.04 ⁿ ± 0.07	75 ⁱ ± 5.0
E	6.9 ^{abcd} ± 0.3	2.06 ^h ± 0.06	33 ^{ef} ± 3.0
F	7.4 ^{efg} ± 0.4	1.67 ^{ef} ± 0.07	32 ^{ef} ± 2.0
G	7.0 ^{bcd} ± 0.3	2.34 ^j ± 0.04	31 ^{ef} ± 2.0
H	6.8 ^{abc} ± 0.15	1.24 ^{cd} ± 0.04	19 ^{ab} ± 1.5
I	7.8 ^{gh} ± 0.3	3.05 ^l ± 0.05	23 ^{bc} ± 3.0
J	7.6 ^{fgh} ± 0.2	1.88 ^g ± 0.1	29 ^{de} ± 2.0
K	7.4 ^{efg} ± 0.4	2.59 ^k ± 0.09	39 ^g ± 4.0
L	7.6 ^{fgh} ± 0.2	0.78 ^a ± 0.03	23 ^{bc} ± 2.0
M	7.2 ^{cdef} ± 0.2	1.24 ^{cd} ± 0.04	29 ^{de} ± 4.0
N	7.6 ^{fgh} ± 0.15	0.96 ^b ± 0.06	40 ^g ± 1.5
O	7.4 ^{efg} ± 0.2	1.74 ^{efg} ± 0.04	39 ^g ± 2.0
P	7.3 ^{defg} ± 0.3	1.81 ^{fg} ± 0.03	19 ^{ab} ± 2.0
Q	7.9 ^h ± 0.1	1.59 ^e ± 0.09	41 ^g ± 5.0
R	7.2 ^{cdef} ± 0.2	1.10 ^c ± 0.2	25 ^{cd} ± 2.0
S	7.6 ^{fgh} ± 0.1	1.31 ^d ± 0.03	40 ^g ± 3.0
T	6.5 ^a ± 0.3	3.01 ^l ± 0.03	29 ^{de} ± 2.0

Mean followed by the same superscript within the same column are not significantly different at $\alpha = 0.05$ based on Duncan's multiple range test.

Table 2: Bacteriological counts of sachet water samples

Sample code	Heterotrophic bacteria (cfu/ml) x 10 ²	<i>S. aureus</i> (cfu/ml)	<i>P. aeruginosa</i> (cfu/ml)	<i>Salmonella</i> sp. (cfu/ml)	<i>Shigella</i> sp. (cfu/ml)	Total coliform (MPN/100ml)	Faecal coliform (cfu/ml)
A	23 ⁱ ± 1.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0
B	6.0 ^{de} ± 1.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0
C	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0
D	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0
E	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0
F	0.0 ^a ± 0.0	12 ^b ± 1.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0
G	6.6 ^e ± 0.2	2 ^a ± 1.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	6 ^b ± 1.0	0.0 ^a ± 0.0
H	5.3 ^{de} ± 0.05	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0
I	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0
J	10 ^f ± 1.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0
K	15 ^g ± 2.0	48 ^c ± 3.0	0.0 ^a ± 0.0	18 ^b ± 2.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0	0.0 ^a ± 0.0

L	2.6 ^{bc} ± 0.2	72 ^d ± 5.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	52 ^f ± 4.0	0.0 ^a ±0.0
M	19 ^h ± 2.0	92 ^e ± 8.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0
N	2.2 ^{abc} ± 0.1	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0
O	4.1 ^{cd} ± 0.05	70 ^d ± 5.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0
P	1.1 ^{ab} ± 0.1	98 ^e ± 8.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	4 ^b ± 1.0	0.0 ^a ±0.0
Q	28 ^j ± 3.0	76 ^d ± 6.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	16 ^c ± 2.0	0.0 ^a ±0.0
R	14 ^g ± 2.0	23 ^b ± 3.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	24 ^d ± 3.0	23 ^b ± 2.0
S	15 ^g ± 2.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	48 ^e ± 5.0	0.0 ^a ±0.0
T	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0	0.0 ^a ±0.0

Mean followed by the same superscript within the same column are not significantly different at $\alpha = 0.05$ based on Duncan's multiple range test.

Table 3: Characterization and identification of bacterial isolates

Bacterial isolates	Gram reaction	Cell shape	Spore staining	Motility	Oxidase	Catalase	Coagulase	Arabinose	Starch hydrolysis	Citrate	Indole	Urease	Glucose	Lactose	Sucrose	Maltose	Mannitol	Raffinose	VP	Nitrate	Cellobiose	Trehalose	Fructose	OF	Probable identity
1	+	C	-	-	-	+	-	-	-	+	-	+	-	-	A	-	A	-	-	-	-	-	A	F	<i>Staphylococcus capitis</i>
2	+	R	+	+	-	+	-	-	+	-	-	+	A	-	A	A	A	-	-	+	-	-	-	F	<i>Bacillus stearothermophilus</i>
3	+	C	-	-	+	+	-	-	+	+	-	+	A	-	A	-	A	-	-	-	-	-	-	O	<i>Micrococcus flavus</i>
4	+	C	-	-	+	+	-	-	-	-	-	+	A	-	A	-	A	-	-	+	-	-	-	O	<i>Micrococcus luteus</i>
5	+	R	+	+	+	+	-	-	+	+	-	+	A	-	A	A	A	-	-	-	-	-	-	F	<i>Bacillus psychrosaccharolyticus</i>
6	+	C	-	-	+	+	+	-	+	+	-	+	A	A	A	A	A	+	+	-	-	-	+	F	<i>Staphylococcus aureus</i>
7	+	R	+	+	+	+	-	-	+	-	-	+	A	-	A	A	A	-	-	-	-	-	-	F	<i>Bacillus smithii</i>
8	+	R	-	-	-	+	-	-	-	+	-	+	A	-	A	A	A	-	-	-	+	A	-	F	<i>Corynebacterium pseudotuberculosis</i>
9	-	R	-	+	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	F	<i>Salmonellasp.</i>
10	+	C	-	-	+	+	-	-	-	+	-	+	A	-	-	A	A	-	-	-	+	-	-	O	<i>Micrococcus kristinae</i>
11	+	C	-	-	+	+	-	-	-	+	-	+	A	-	A	A	A	-	-	-	+	-	-	O	<i>Micrococcus candidus</i>
12	-	R	-	+	-	+	-	+	-	+	+	+	A	A	A	A	A	-	-	+	-	+	+	F	<i>E. coli</i>
13	+	C	-	-	-	+	-	-	+	+	-	+	-	-	A	-	A	-	-	+	-	-	-	F	<i>Staphylococcus equorum</i>
14	+	C	-	-	-	+	-	-	-	+	-	+	A	-	A	A	A	-	-	-	-	+	-	F	<i>Staphylococcus hominis</i>

Key: - = Negative reaction; + = Positive reaction; C= Cocci; R= Rod; F = Fermentative; O = Oxidative; OF = Oxidation-Fermentation; VP = Vogesproskauer; A= Acid production

Table 4: Occurrence of bacterial isolates in the sachet water samples

Sample code	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14
A	-	+	-	-	-	-	-	-	-	-	-	-	-	-
B	-	+	-	-	-	-	-	-	-	-	-	-	-	-
C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	-	-	-	-	-	+	-	-	-	-	-	-	-	-
G	-	-	+	-	-	+	-	-	-	-	-	-	-	-
H	-	-	-	-	-	-	+	-	-	-	-	-	-	-
I	-	-	-	-	-	-	-	-	-	-	-	-	-	-
J	-	-	-	-	+	-	-	-	-	-	-	-	-	-
K	-	-	-	-	-	+	-	-	+	-	+	-	-	-
L	-	-	-	-	-	+	-	+	-	-	-	-	-	-
M	-	-	-	-	-	+	-	-	-	-	-	-	-	-
N	-	-	-	-	-	-	-	-	-	-	-	-	-	-
O	-	-	-	-	-	+	-	-	-	-	-	-	+	-
P	+	-	-	-	-	+	-	-	-	-	-	-	-	-
Q	-	-	-	-	-	+	-	-	-	-	-	-	-	-
R	-	-	-	+	-	+	-	-	-	-	-	+	-	+
S	-	-	-	-	-	-	-	-	-	+	-	-	-	-
T	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Key: B1 = *S. captis*; B2 = *B. stearothermophilus*; B3 = *M. flavus*; B4 = *M. luteus*; B5 = *B. psychrosaccharolyticus*; B6=*S. aureus*; B7=*B. smithii*; B8=*C. pseudotuberculosis*; B9=*Salmonella* sp.; B10=*M. kristinae*; B11 =*M. candidus*; B12=*E. coli*; B13 =*S. equorum*; B14 = *S.hominis*; + = isolated, - = not isolated

DISCUSSION

The pH of water is extremely important; fluctuation in optimum pH values have effect on the toxicity of poisons in water (Okonko *et al.*, 2008). All the sachet water samples conformed to the limit of 6.5 – 8.5 allowed by WHO (2011). In a similar study, Taiwo *et al.* (2012) obtained pH values of 6.0 – 7.54 in sachet water sold in Abeokuta metropolis.

All the twenty brands of sachet water were below the maximum permitted limit of 150 mg/l of total hardness allowed in potable water (SON, 2007). In related study, Nwosu and Ogueke, (2004) obtained total hardness which ranged from 38.40 to 72.50mg/l in sachet water samples analyzed in Owerri metropolis. The chloride content ranged from 0.78 – 5.04mg/l for all the samples under investigation. The values were extremely low

when compared to the maximum permitted limit of 250mg/l allowed by WHO (2011) in potable water. In a similar study in Kumasi, Ghana, Awuah *et al.* (2014) found that the chloride content was below the maximum limit allowed in sachet water.

The results from this study showed the presence of high heterotrophic plate counts (HPC) above the limit of 100 cfu/ml allowed in potable water (IPAN, 2007; Eniola *et al.*, 2015) as only 6 brands conformed to this standard. The high HPC could be attributed to poor water treatment, defective sealing of the polythene bags, poor condition of storage, poor handling of the product by the distributors and retailers, use of contaminated polythene bags for filling of treated water, contamination from production vat, pipelines, and filling machine. Bukar *et al.* (2015)

obtained heterotrophic bacterial count which ranged from 1.0×10^2 to 1.7×10^4 cfu/ml in sachet water sold in Maiduguri metropolis. Furthermore, Adepegba *et al.* (2015) in Ilaro, Ezeugwunne *et al.* (2009) in Nnewi, Ibemesim, (2014) in Abuja, all in Nigeria reported the presence of high heterotrophic plate counts in sachet water.

The multiple tube fermentation study showed the presence of total coliform bacteria which is an indicator of the quality of drinking water. Sixteen out of the twenty brands conformed to the maximum permitted limit of 10 coliform per 100ml of water allowed in potable (SON, 2007). Nineteen brands of the sachet water satisfied the zero limit of faecal coliform count (WHO, 2011). Omalu *et al.* (2012) and Adewoye *et al.* (2013) obtained total coliform count which ranged from 7 – 398 MPN and 0 – 20 MPN per 100ml of sachet water respectively.

The presence of *Staphylococcus*, *Micrococcus*, *Corynebacterium*, *E. coli*, *Salmonella*, and *Bacillus* species in the sachet water samples in this study could be due to post-production contamination. *Micrococcus* occurs in a wide range of environments, including water, dust and soil. *Micrococcus* has been isolated from human skin, animal and dairy products. *Micrococcus* is generally thought to be saprophytic or commensal organism, though it can be an opportunistic pathogen. *Corynebacterium* is widely distributed in nature and are mostly innocuous (Collins *et al.*, 2004). Members of the *Bacillus* species are generally found in soil and represent a wide range of physiological types, allowing the organism to grow in every environment and compete favourably with other organisms within the environment due to its capability to form extremely resistant spores. Apart from these commensals, pathogenic bacteria, *Staphylococcus aureus*, and *Salmonella* sp. were isolated from nine and one brand of the sachet water samples respectively. *E. coli* which is an indicator of faecal contamination

was isolated in one of the brand of sachet water. Falegan *et al.* (2014) reported that sachet water samples collected from 5 different manufacturers yielded *Pseudomonas aeruginosa* 37.5%, *Staphylococcus aureus* 20.8%, *Klebsiella* spp. 25.02%, *Proteus* sp. 16.68% in Ado Ekiti, Ekiti State, Nigeria while Omalu *et al.* (2015) isolated *E. coli*, *Streptococcus faecalis*, *Bacillus subtilis*, *Staphylococcus aureus*, *Salmonella typhi*, *Klebsiella* spp., and *Pseudomonas aeruginosa* in sachet water sample in Minna, Nigeria.

RECOMMENDATION

Appropriate treatment processes of water should be utilized for the production of high quality and safe packaged drinking water. Assessment of water quality at different stages of production and post-production is essential in order to ensure their quality and safety. There is need for regulatory bodies like National Agency for Food and Drug Administration and Control (NAFDAC), Standard Organization of Nigeria (SON) and other health agencies both at the states and local government to enforce compliance to the required standards. They should also ensure that all sachet water contains both manufacturing and expiry date as well as batch number for easy recall. There should be proper handling and storage of the sachet water to prevent contamination. The sachet water should be properly sealed and checked for leakage.

CONCLUSION

It can be concluded from this study that only 6 brands of the sachet water met the bacteriological parameters in terms of heterotrophic plate count, total coliform, and faecal coliform requirements.

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