

Bacteriological quality and physicochemical assessment of water vended by pushcarts within Ilorin metropolis, Kwara State, Nigeria

Sule^{1*}, I.O., Abdul Rahman², T. A., and Opaluwa¹, C.

¹Department of Microbiology, University of Ilorin, PMB 1515 Ilorin, Nigeria

²SLT Department, Microbiology Unit, Kwara State Polytechnic, Ilorin, Nigeria

***Corresponding author's E-mail address: suleism@gmail.com**

Phone number: +2348056663764

ABSTRACT

*Vended water is one of the primary sources of water for many households in Ilorin. Water samples were collected from the plastic Jerrycans of 20 different water vendors delivering their water to consumers using pushcarts. Physicochemical and bacteriological analyses were conducted on the water samples. The pH, chloride content, suspended solids, and total hardness of the water samples ranged from 6.80 – 8.40, 0.60 - 15.62 mg/l, 0.001 - 0.025g/100ml, and 0 to 80 mg/l respectively. The bacterial count ranged between 0 - 1.5 x 10⁴ cfu/ml while the total coliform ranged between 0 – 2400 MPN per 100ml of the water samples. The counts of *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Salmonella spp.* and *Shigella spp.* of the water samples ranged from 0 to 2.6 x 10³ cfu/ml, 0 to 1 x 10³ cfu/ml, 0 to 1 x 10² cfu/ml, and 0 to 3 x 10³ cfu/ml respectively. Faecal coliform (*E. coli*) was not isolated. The bacteria isolated were: *Bacillus sphaericus*, *Bacillus megaterium*, *Micrococcus roseus*, *Micrococcus varians*, *Micrococcus lylae*, *Micrococcus sp.*, *Staphylococcus saprophyticus*, *Staphylococcus capitis*, *Staphylococcus epidermidis*, *Staphylococcus intermedius*, *Staphylococcus simiae*, *Staphylococcus lentus*, *Corynebacterium matruchotii*, and *Enterobacter aerogenes*. Sanitary evaluation revealed lack of good hygiene by the water vendors. The study revealed that most of the vended water was potable. It is recommended that the consumers should not use this water for drinking purpose without additional treatment at the point of use.*

Keywords: *Evaluation, Quality, Pushcarts, Vended water, Sanitary appraisal*

Introduction

Water is one of the most important elements for all forms of life. It is indispensable in the maintenance of life on earth. It is also essential for the composition and renewal of cells (Solomon *et al.*, 2011). Less than one per cent of the world's surface or below-ground freshwater is accessible for human use. This has resulted to an inadequate supply of water for human use in many parts of the world (Hutin *et al.*, 2003). Nowadays, a large percentage of the rural population in developing countries continue to live without adequate access to safe and convenient water supply and sanitation (Dada, 2009).

Nigeria is blessed with abundant water resources but largely untapped. The total volume of water available in surface and groundwater resources is sufficient to meet current drinking water demands. However, lack of efficient distribution capacity coupled with highly variable rainfall patterns have led to water scarcity in some areas particularly in the North (Joseph, 2012).

The inadequacy of water is as a result of factors such as geometric increase in population, water wastage from running taps, decrease in well capacity, increased water requirements, rainfall fluctuations, inability of the government to provide potable water for the citizens and pollution of water (Eniola *et al.*, 2015). In Nigeria, more than 90% of rural areas and 60% of urban areas face water related problems. The average daily per capita consumption of water in Nigeria is 46 litres which is far below the internationally recommended minimum requirement of 115 litres per person per day. This shortfall in water requirement is due to differences in availability and supply (Utsev and Aho, 2012).

Bacteria cause the majority of the water related illnesses. The most prevalent pathogenic bacteria that causes water related diseases are *E. coli* O157:H7, *Salmonella* sp., *Shigella* sp., *Campylobacter* sp., *Vibrio cholerae* and *Pseudomonas* sp. These organisms cause diseases such as diarrhoea and gastroenteritis, salmonellosis, typhoid fever, shigellosis, and cholera (Eniola *et al.*, 2015). *E. coli* is the predominant faecal coliform bacteria found in the gut of warm-blooded animals. The presence of *E. coli* in water indicates direct contamination with faecal matter (Saha *et al.*, 2011).

There are various sources of water supply to households in Nigeria. It could be by the individuals sourcing the water themselves such as from streams, rivers or by collecting rain water. It could be water provided by the government distributing the water to various homes through a piped system or by the private sector of the population, by packaging the water in sachet or bottles. Water vending is a means of water supply to households for use. Due to the inadequacy of the government to provide adequate and potable water for the population, majority resorted to getting water from water vendors which is now on the increase in many parts of the country.

Water vending is taken as a sign of failure in these piped systems, which still provide water to only a minority of urban dwellers in many parts of the world. When collecting international statistics on access to water those who buy their water from vendors along with people who get their water from unimproved wells or surface-water sources are classified as not having reasonable access to an improved water supply (Kjellén, 2010).

Water vendors are individuals that sell the water to the final consumers usually for households use or for small scale production processes. In this context, water vending does not include bottled or packaged water or water sold through vending machines. Water vending may be undertaken by formal bodies such as water utilities, registered associations, and by informal and independent suppliers. Where formal vending is practiced, the water typically comes from treated utility supplies and it is supplied through tanker trucks or from standpipes (Onyenechere *et al.*, 2012). Informal suppliers tend to use a range of sources, including untreated surface water, dug wells and boreholes to deliver small volumes of water for domestic use, often in plastic containers or Jerrycans. Water vendors use a range of modes of transport to deliver drinking water for sale directly to the consumer including wheelbarrows, trolleys, pushcarts (WHO, 2011).

In Ilorin, Kwara State, Nigeria, water vending is usually practiced by the Hausa ethnic group of the population and they are fondly called '*Mai Ruwa*' meaning 'Water sellers'. They are uneducated and water vending serve as their means of livelihood. The final consumers use the water for domestic activities such as drinking, washing, cooking, and bathing.

Both the quality and adequacy of vended supplies can vary significantly, and vended water has been associated with outbreaks of diarrheal disease (Hutin *et al.*, 2003; WHO, 2011).

This research was conducted due to the fact there is need to know the quality of vended water supplied to households by the pushcarts especially in the dry season of the year.

The objectives of this research were to determine the counts of bacteria, total and faecal coliform; counts of pathogenic bacteria: *Staphylococcus aureus*, *Salmonella* sp., *Shigella* sp., and *Pseudomonas aeruginosa* in the vended water; isolate, characterized and identified the bacterial isolates; determine the physicochemical characteristic; and conduction of the sanitary appraisal of the Jerrycans of the water vendors.

MATERIALS AND METHODS

Collection of vended water samples

Water samples were collected from 20 different water vendors at different locations such as Zango, Fate-Tanke, G.R.A and Basin areas of Ilorin metropolis, Kwara State, Nigeria. The water samples were collected by pouring off some water from the Jerrycans of the water vendors into a sterile 500ml conical flask. Then, the sample was taken immediately for bacteriological and physicochemical analysis.

Determination of pH

The electrode of a standardized pH meter was inserted into the water sample and allowed to stand for about one to five minutes in order to obtain a non- fluctuating pH value. The pH value was taken when the reading was stable (Goldman and Green, 2009).

Determination of suspended solids

Whatman filter paper was dried at 105°C in an oven for one hour to obtain an initial weight. It was used to filter 100ml of the water sample, dried at the above temperature, and weighed to obtain final weight. The difference in weight represents the suspended solids (Bilotta and Braziera, 2008; Sule *et al.*, 2016).

Determination of chloride content

Argentometric titration was used to determine the chloride content. One hundred millilitre of the water sample was measured using a measuring cylinder and poured into a conical flask. Then, 2ml of 5% potassium chromate was added as an indicator. The solution was titrated with 0.1N silver nitrate solution (AgNO_3) until the colour changed from yellow to faint pink. The titre value multiplied by a factor of 3.55 gives the chloride content in mg/l (Sawyer *et al.*, 2000).

Determination of total hardness

One hundred millilitre of the water sample was measured and 5 drops of 25% ammonia and 3 drops of erichrome black-T was added as an indicator to give a purple colour. The resulting solution was titrated with 0.1N EDTA until a light blue colouration was obtained. Titre value multiplied by 100 gives the total hardness in mg/l (De Zuane, 1997; Sule *et al.*, 2016).

Isolation and enumeration of bacterial count

The pour plate technique was used. The water sample was serially diluted using ten fold serial dilution, and 0.1ml aliquot from 10^{-1} and 10^{-2} dilutions were taken into separate sterile Petri dishes followed by the addition of nutrient agar which has been cooled to about 45°C. The plates were incubated and the counted colonies expressed in cfu/ml (Fawole and Oso, 2007).

Enumeration of total and faecal coliform

Multiple tube fermentation method was used to determine the total coliform count in MPN per 100ml of the water sample while eosin methylene blue agar was used to determine the counts of *E. coli* (Goldman and Green, 2009).

Isolation and enumeration of pathogenic bacteria

Aliquot (0.1ml) from 10^{-1} and 10^{-2} dilutions of the water sample was transferred on solidified mannitol salt agar, salmonella-shigella agar, and cetrimide agar media using spread plate technique. After incubation, the number of characteristics colony of *Staphylococcus aureus*, *Salmonella/Shigella*, and *Pseudomonas aeruginosa* was counted. They were further confirmed through Gram staining and biochemical tests (Fawole and Oso, 2007; Willey *et al.*, 2008).

Purification and preservation of isolates

Subculturing of the mixed culture was done repeatedly on nutrient agar until pure culture was obtained and the slants were stocked in the refrigerator until they are needed (Brown, 2007).

Characterization and identification of bacterial isolates

The bacterial isolates were characterized on the basis of their colonial morphology, cellular and biochemical characteristics (Cowan and Steel, 1985; Fawole and Oso, 2007).

Sanitary appraisal of water vendors' containers

The sanitary appraisal of water vendors' containers was done at the sampling point by physically examination of their containers as well as questioning the pushcart operators. The following parameters were observed: source of water, colour of the container, presence of cap, presence of algal growth in the container, as well as asking them about how frequent they wash their containers.

RESULTS

Physicochemical characteristics of the water samples

The physicochemical characteristics of the water samples varied. The pH of the water samples, chloride content, suspended solids, and total hardness ranged from 6.80 to 8.40, 0.60 to 15.62 mg/l, 0.001 to 0.025 g/100ml, and 0 to 80 mg/l respectively (Table 1).

Bacteriological counts of the water samples

The bacterial count ranged from 0 to 1.5×10^4 cfu/ml. Counts of *S. aureus*, *Pseudomonas aeruginosa*, *Salmonella* sp. and *Shigella* sp. ranged from 0 to 2.6×10^3 cfu/ml, 0 to 1×10^3 cfu/ml, 0 to 1×10^2 cfu/ml, and 0 to 3×10^3 cfu/ml respectively. *E. coli* (faecal coliform) was absent in all the water samples. The total coliform of the vended water ranged between 0 to 2400MPN/100ml (Table 2).

Characterization and identification of bacterial isolates

The bacterial species isolated were: *Bacillus sphaericus*, *Bacillus megaterium*, *Micrococcus roseus*, *Micrococcus varians*, *Micrococcus lylae*, *Micrococcus* sp., *Staphylococcus saprophyticus*, *Staphylococcus capitis*, *Staphylococcus epidermidis*, *Staphylococcus intermedius*, *Staphylococcus simiae*, *Staphylococcus lentus*, *Corynebacterium matruchotii*, and *Enterobacter aerogenes* (Table 3). The occurrence of the bacterial isolates is presented in Table 4.

Sanitary appraisal of the water vendors containers

All the water samples from the water vendors were sourced from borehole. The sanitary appraisal of the water vendors' containers is presented in Table 5.

Table 1: Physicochemical characteristics of water samples from water vendors

Sampling sites	pH	Chloride content(mg/l)	Suspended solids (g/100ml)	Total hardness (mg/l)
Fate Tanke vendor 1	6.80	0.60	0.025	13
Fate Tanke vendor 2	7.10	1.07	0.016	12
Zango vendor 1	6.90	7.81	0.012	0
Zango vendor 2	7.60	5.68	0.011	32
Zango vendor 3	7.70	11.36	0.006	0
Zango vendor 4	7.30	9.94	0.005	20
Zango vendor 5	7.60	9.94	0.010	28
Zango vendor 6	6.80	9.94	0.001	24
Zango vendor 7	7.70	12.78	0.001	0

Zango vendor 8	7.70	9.23	0.001	24
Zango vendor 9	7.60	10.65	0.007	35
Zango vendor 10	7.60	15.62	0.011	0
Zango vendor 11	7.50	2.56	0.013	80
GRA vendor 1	8.10	1.07	0.011	15
GRA vendor 2	7.80	0.71	0.010	15
GRA vendor 3	7.70	0.71	0.013	20
GRA vendor 4	7.80	1.07	0.012	20
Basin vendor 1	8.10	0.89	0.023	50
Basin vendor 2	8.40	0.83	0.014	25
Basin vendor 3	8.40	1.07	0.016	30

Table 2: Bacteriological counts of water samples from water vendors

Sampling Sites	Bacterial counts (cfu/ml)	<i>S. aureus</i>	<i>Pseudomonas aeruginosa</i> (cfu/ml)	<i>Salmonella</i> spp. (cfu/ml)	<i>Shigella</i> spp. (cfu/ml)	<i>E.coli</i> (cfu/ml)	Total Coliform (MPN/100ml)
Fate Tanke vendor 1	0	0	0	0	0	0	4
Fate Tanke vendor 2	1 x 10 ²	0	0	0	0	0	240
Zango vendor 1	5 x 10 ³	1 x 10 ³	1 x 10 ²	0	0	0	43
Zango vendor 2	2.6 x 10 ³	0	0	0	1 x 10 ²	0	2400
Zango vendor 3	1.5 x 10 ⁴	0	0	0	0	0	9
Zango vendor 4	7 x 10 ³	2.6 x 10 ³	0	0	0	0	23
Zango vendor 5	7 x 10 ³	0	0	0	0	0	2400
Zango vendor 6	1.1 x 10 ³	0	0	0	0	0	9
Zango vendor 7	7 x 10 ³	0	0	0	2 x 10 ²	0	23
Zango vendor 8	1.4 x 10 ³	0	0	0	0	0	9
Zango vendor 9	4.6 x 10 ³	0	0	0	0	0	43
Zango vendor 10	4.6 x 10 ³	0	0	1 x 10 ²	3 x 10 ³	0	43
Zango vendor 11	0	0	0	0	0	0	0
GRA vendor 1	0	0	0	0	0	0	4
GRA vendor 2	0	0	0	0	0	0	0
GRA vendor 3	1 x 10 ³	0	0	0	0	0	2400
GRA vendor 4	1 x 10 ³	0	0	0	0	0	1100

Basin vendor 1	1.5 x 10 ⁴	0	1 x 10 ³	0	0	0	43
Basin vendor 2	1 x 10 ³	0	0	0	0	0	23
Basin vendor 3	1 x 10 ³	0	0	0	0	0	23

Table 3: Characterization and identification of bacterial isolates

Bacterial isolates	Gram reaction	Cell shape	Cells' arrangement	Motility	Oxidase	Catalase	Coagulase	Haemolysis	Starch	Citrate	Indole	Urease	Glucose	Lactose	Sucrose	Maltose	Mannitol	Raffinose	VP	Nitrate	Cellobiose	Trehalose	Fructose	OF	Arabinose	Identified organisms
1	+	R	s	+	-	+	-	α	-	-	-	+	A	A	A	A	A	-	-	-	-	A	A	F	-	<i>Bacillus sphaericus</i>
2	+	C	cl	-	+	+	-	α	-	-	-	+	A	-	-	A	A	+	-	-	-	-	A	O	-	<i>Micrococcus roseus</i>
3	+	c	cl	-	+	+	-	α	-	-	-	+	A	A	A	A	A	-	-	+	-	A	A	O	-	<i>Micrococcus varians</i>
4	+	c	s	+	-	+	-	α	-	-	-	-	-	-	A	A	A	-	+	+	-	A	A	F	-	<i>Staphylococcus saprophyticus</i>
5	+	c	sl	-	-	+	-	γ	-	-	-	-	A	-	A	A	A	-	+	+	-	-	A	F	-	<i>Staphylococcus capitis</i>
6	+	c	cl	-	+	+	-	β	+	-	-	+	A	A	A	-	A	-	+	+	-	A	A	F	-	<i>Staphylococcus epidermidis</i>
7	+	r	cl	-	+	+	-	α	+	+	-	+	A	A	A	A	A	-	-	+	-	-	A	F	-	<i>Bacillus megaterium</i>
8	+	c	cl	-	-	+	-	β	-	+	-	+	A	A	A	-	A	-	-	+	-	A	A	F	-	<i>Staphylococcus lentus</i>
9	+	r	cl	-	+	+	-	γ	-	+	-	+	A	-	A	A	-	-	-	+	+	-	A	F	-	<i>Corynebacterium matruchotii</i>
10	+	c	cl	+	-	+	+	α	-	-	-	+	A	A	A	-	A	-	-	+	-	A	A	F	-	<i>Staphylococcus simiae</i>
11	+	c	cl	+	-	+	+	β	-	-	-	+	A	A	A	A	A	-	+	+	-	A	A	F	-	<i>Staphylococcus intermedius</i>
12	+	c	s	-	+	+	-	α	-	+	-	+	A	A	A	A	A	-	-	-	-	A	A	O	A	<i>Micrococcus lylae</i>
13	+	c	cl	-	+	+	-	α	-	-	-	+	A	A	A	A	A	-	-	-	-	-	A	-	-	<i>Micrococcus sp.</i>
14	-	r	cl	+	-	+	-	β	+	-	+	+	A	A	A	A	A	-	+	+	-	-	A	F	-	<i>Enterobacter aerogenes</i>

Key: - = Negative reaction; + = Positive reaction; c = Cocci; r = Rod; s = Single; cl = Cluster; Ch = chain; F = Fermentative; O= Oxidative; OF = Oxidation-Fermentation; AG = Acid and gas; A = Acid only; VP = Voges proskauer

Table 4: Occurrence of bacterial isolates.

Journal of Science, Technology, Mathematics and Education (JOSTMED), 12(3), December, 2016

Sampling sites	<i>Bacillus anthracinis</i>	<i>Micrococcus roseus</i>	<i>Micrococcus varians</i>	<i>Staphylococcus</i>	<i>Staphylococcus</i> <i>us. Capitis</i>	<i>Staphylococcus</i> <i>us epidermidis</i>	<i>B. megaterium</i>	<i>Staphylococcus</i> <i>us lentis</i>	<i>Corynebacterium</i>	<i>Staphylococcus</i> <i>us simiae</i>	<i>Staphylococcus</i> <i>us intermedium</i>	<i>Micrococcus</i>	<i>Micrococcus</i>	<i>Enterobacter</i> <i>parvulus</i>
Fate Tanke vendor 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fate Tanke vendor 2	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Zango vendor 1	+	+	+	-	-	-	-	-	-	-	-	-	-	-
Zango vendor 2	-	+	+	+	+	-	-	+	-	-	-	-	-	-
Zango vendor 3	+	+	+	-	-	-	-	-	-	-	+	-	-	-
Zango vendor 4	+	+	+	-	-	+	-	+	-	-	-	-	-	-
Zango vendor 5	+	-	+	+	+	+	+	-	-	-	-	-	-	-
Zango vendor 6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zango vendor 7	+	-	-	+	+	+	+	+	-	-	-	-	-	-
Zango vendor 8	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Zango vendor 9	+	+	+	-	-	-	-	-	-	-	-	-	-	-
Zango vendor 10	+	-	+	-	-	-	-	-	-	-	-	-	-	-
Zango vendor 11	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GRA vendor 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GRA vendor 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GRA vendor 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GRA vendor 4	-	-	-	-	-	-	-	-	+	+	-	-	+	-
Basin vendor 1	+	-	-	-	-	+	-	-	-	+	-	+	-	+
Basin vendor 2	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Basin vendor 3	-	-	-	-	-	-	-	-	-	-	-	+	-	-

Table 5: Sanitary appraisal of the water vendor's containers

Sampling sites	Colour of container	Presence of cap	Algal growth	Washing of container
Fate Tanke vendor 1	Yellow	Yes	No	Daily
Fate Tanke vendor 2	Yellow	Yes	No	Daily
Zango vendor 1	Yellow	Yes	No	Daily
Zango vendor 2	White	Yes	No	Daily
Zango vendor 3	Yellow	Yes	Yes	Weekly
Zango vendor 4	Blue	Yes	Yes	Weekly
Zango vendor 5	Blue	Yes	Yes	Weekly
Zango vendor 6	Blue	Yes	No	Daily
Zango vendor 7	White	Yes	No	Weekly
Zango vendor 8	Yellow	Yes	No	Weekly
Zango vendor 9	Yellow	Yes	Yes	Weekly
Zango vendor 10	Yellow	Yes	Yes	Daily
Zango vendor 11	Yellow	Yes	No	Daily
GRA vendor 1	Yellow	Yes	No	Daily
GRA vendor 2	Blue	Yes	No	Daily

GRA vendor 3	White	Yes	No	Daily
GRA vendor 4	Yellow	Yes	Yes	Daily
Basin vendor 1	Yellow	Yes	Yes	Weekly
Basin vendor 2	Yellow	Yes	No	Weekly
Basin vendor 3	Yellow	Yes	No	Weekly

DISCUSSION

pH is an important factor that affects the growth and survival of microorganisms in water. Most microorganisms especially bacteria grow best at neutral to slightly alkaline pH. The pH range set by WHO (2011) is between 6.5 – 8.5 and the pH of the water samples were within the acceptable standard. In a similar study, Agbabiaka and Sule (2010) obtained the pH range of 6.4 – 7.4 from selected borehole water samples within Ilorin metropolis.

Suspended solid in water is dependent on the amount of inorganic and organic matter which is held in the water column (Bilotta and Braziera, 2008). Suspended solids lowered the effectiveness of the disinfecting property of chemicals used in water treatment. The result obtained for suspended solids is below the limit of 500 mg/l allowed (Standards Organization of Nigeria, 2007). Chloride increases the electrical conductivity of water and thus increases its corrosiveness. In metal pipes, chloride reacts with metal ions to form soluble salts, thus increasing levels of metals in drinking water. In this study the chloride is within the limit of 250mg/l (SON, 2007).

Water containing calcium carbonate at concentrations below 60 mg/l is generally considered as soft; 60–120 mg/l, moderately hard; 120–180 mg/l, hard; and more than 180 mg/l, very hard. Exposure to hard water has been suggested to be a risk factor that could exacerbate eczema (Yusuf *et al.*, 2015). The maximum permitted level of total hardness is 60mg/l as set by SON (2007), the water samples were within the range of permitted level.

Only five of the water samples met the standard of not more than 100 cfu/ml of bacterial cells (WHO, 2011). In a study on treated piped water in parts of Ilorin metropolis, Eniola *et al.* (2015) obtained bacterial count in the range of 1.0×10^4 to 2.25×10^5 cfu/ml.

Staphylococcus aureus, *Salmonella* sp., *Shigella* sp., and *Pseudomonas aeruginosa* were isolated in 2, 1, 3 and 2 out of the twenty vended water samples respectively. Makut *et al.* (2015) reported the contamination of wells and boreholes with pathogenic microorganisms. *E. coli* was not isolated in all the water samples. In a similar study on selected borehole water samples in Ilorin metropolis, Agbabiaka and Sule (2010) had zero count of faecal coliform.

Seven out of the twenty water samples met the maximum permitted level of 10 coliform/100ml of water allowed by SON (2007). In a similar study Agbabiaka and Sule, (2010) obtained total coliform which ranged from zero to 16 MPN of coliform/100ml.

A total of 14 bacterial species belonging to genera *Bacillus*, *Micrococcus*, *Staphylococcus*, *Corynebacterium* and *Enterobacter* were obtained in this study. In a study on treated piped water in parts of Ilorin metropolis, Eniola *et al.* (2015) observed the dominance of *Bacillus subtilis*, *Enterobacter* and *Staphylococcus aureus*.
 Key:
 + Present - Absent

The sanitary appraisal revealed that some of the water vendors used white Jerrycans for collection of water and this encourage algal growth. All the water vendors used plastic caps to cover their Jerrycans and not all of them wash their Jerrycans on daily basis.

Conclusion

It can be concluded from this study that some of the vended water are not potable in regard to their bacteriological and physicochemical quality.

Recommendation

The water vendors should wash their jerry cans daily with detergent and clean water and should observe strict sanitary measures while fetching the water and during delivery to the final consumers. The water needs additional treatment before drinking. There is need to keep the environment where the water is being fetched clean. The carts or trolleys used by the water vendors to convey the water to the final consumers should be regularly washed and kept clean. The water vendors should ensure sourcing their water from treated potable sources.

References

- Agbabiaka, T. O. & Sule, I. O. (2010). Bacteriological Assessment of Selected Borehole Water Samples in Ilorin Metropolis. *International Journal of Applied Biological Research* 2(2), 31-37.
- Bilotta, G. S. & Braziera, R. E. (2008). Understanding the Influence of Suspended Solids on Water Quality and Aquatic Biota. *Water research* 4(2), 2849-2861.
- Brown A.E. (2007). *Benson's microbiological applications, 10th edition*, Mc Graw Hill Higher Education, Newyork. pp. 25-295.
- Cowan S. T., & Steel K. J. (1985). *Manual for the identification of medical bacteria*. 4th edition, Cambridge University Press, London. pp. 217.
- Dada, A.C. (2009). Sachet water phenomenon in Nigeria: Assessment of the potential health impacts. *African Design Report* 2(15), 15-17.
- De Zuane J. (1997). Maintaining potability. *Handbook of drinking water quality*. 2nd edition. John Wiley and sons Inc., NewYork. pp. 478-480.
- Eniola, K. I. T., Odaibo, A. D, Olayemi, A. B., & Ajiboye, T. O. (2015). Bacteriological Assessment of Treated Piped Water in Parts of Ilorin Metropolis. *Nigerian Journal of Microbiology* 28: 2797 - 2803.
- Fawole, M. O. & Oso, B. A. (2007). *Laboratory manual of microbiology*. Spectrum book limited, Ibadan, Nigeria. pp. 16-35.
- Goldman E. & Green L.H. (2009). *Practical Handbook of Microbiology, 2nd edition*, CRC Press, Taylor and Francis Group, Boca Raton, USA. pp. 11-67.
- Hutin, Y., Luby, S. & Paquet, C. (2003). A large cholera outbreak in Kano City, Nigeria: The importance of hand washing with soap and the danger of street-vended water. *Journal of Water and Health* 1(1), 45-52.
- Joseph, M. (2012). Health implications of water scarcity in Nigeria. *European Scientific Journal* 8(18), 111-117.

- Kjellen, M. (2010). *Water Vending in Dar es Salaam, Tanzania : Hydropolitics in East Africa*. IFRA, Nairobi and Mkuki na Nyota Publishers Ltd. Tanzania. pp. 173-184.
- Makut M.D., Kelechi A., & Alabi S. (2015). Bacteriological quality of potable water from different sources in Keffi, Nasarawa State, Nigeria. *Nigerian Journal of Microbiology* 28, 2791-2796.
- Onyenechere, E. C., Eleazu, E. I. & Umeh, A.O. (2012). Domestic Water Vendors' Supply Sources and Quality Implications in Enugu North of Enugu State, Nigeria. *Journal of Research and Development* 3(1), 9-21.
- Saha, U., Sonon, L., Kissel, D. & Hitchcock., R. (2011). Total Coliform and *Escherichia coli* bacteria in Georgia Private Wells: Relationships of Age and Depth of the Wells. In: *Proceeding of the 2011 Land Grant and Sea Grant National Water Conference*. Washington, D.C.
- Sawyer, C. N., McCarty, P. L., & Parkin, G. F. (2000). *Chemistry for Environmental Engineering* (4th ed.). McGraw-Hill, Inc. New York. pp. 1-2.
- Solomon, A., Ahmed, Z., Biruktawit, K., Amare, D., Solomon, A. & Endalew, Z. (2011). Bacteriological Analysis of Drinking Water Sources. *African Journal of Microbiology Research* 5(18), 2638-2641.
- Standards organization of Nigeria SON (2007). *Nigerian standards for drinking water quality (NSDWQ)*, *Industrial Standards* 5(4): pp. 1-14.
- Sule, I.O., Odebisi-Omokanye M. B., Gambari-Ambali R. O., & Okewale T.A. (2016). Effects of 'disinfectant A' on the physicochemical and bacteriological quality of some well water. *Journal of Science, Technology, Mathematics, and Education* 12(1), 1-8
- Utsev, J. T. & Aho, M. I. (2012). Water shortage and health problems in Benue state, Nigeria: Impacts and prospects for solutions. *International Journal of Scientific and Technology Research* 1(8): 79-85.
- Yusuf, Y.O., Jimoh, A. I. & Onaolapo, E. O. (2015). An assessment of sachet water quality in Zaria Area of Kaduna State, Nigeria. *Journal of Geography and Regional Planning*. 8(7), 174-180.
- Willey, J .M., Sherwood, L. M. and Woolverton, C. J. (2008). *Prescott, Harley and Klein's Microbiology 7th edition*, Mc Graw-Hill, Washington D.C. pp. 1222.
- World Health Organization* (WHO) (2011). Guidelines for Drinking Water Quality, Recommendation. WHO publication, Geneva. pp. 120-130.