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## Assessment of Bacteriological Quality of Vended Water in Jerry Cans for Domestic Use in Zaria, Kaduna State, Nigeria

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### Abstract

The practice of vending water in plastic jerry cans for domestic use has become a major source of household drinking water in Zaria due to inadequate pipe-borne water. The unhygienic practice of the water vendors and poor sanitary condition of the jerry cans and the water sources are of public health concern. Accordingly, this research was conducted to examine the bacteriological quality of vended water from jerry cans in Zaria city, Kaduna state, Nigeria. Water samples from five different vendors from twenty different locations were collected and used for isolation and enumeration of bacterial loads. The isolation and biochemical characterizations of the isolates revealed the presence of seven genera represented by eight bacterial species namely: *Escherichia coli*, *Proteus mirabilis*, *Salmonella typhi*, *Klebsiella pneumoniae*, *Corynebacterium sp*, *Proteus vulgaris*, *Citrobacter freundii* and *Bacillus subtilis*. *Escherichia coli* is the most predominant bacterial species among the vended water samples (44.44%) followed by *S. typhi* (18.52%) while *Proteus mirabilis*, *Corynebacterium sp* and *Citrobacter freundii* are the least prevalent with 3.70%. Most of the identified bacterial species in the samples were pathogenic. More so, the bacterial loads associated with the jerry cans water ranged between  $1.0 \times 10^6$ - $8.0 \times 10^6$  CFU/mL from the plates count which is above WHO standard limit of  $<1.0 \times 10^1$  CFU/mL. It was therefore inferred that the bacterial counts associated with the jerry cans can pose public health risk. Proper sanitation and orientation on personal hygiene to the vendors are urgently needed.

**Key Words:** Bacteria, Drinking Water, Jerry cans, Permissible limit, Zaria.

### INTRODUCTION

Water is essential to life in adequate, safe and accessible supply (WHO, 2008). There is an increasing concern upon the safety of drinking water worldwide. The World Health Organization (WHO, 2011) estimated that 1.1 billion of the world's population does not have access to safe water which accounts for 80% of all diseases and one-third of deaths in developing countries (WHO, 2011). Water related diseases continue to be one of the major health issues globally. The high prevalence of diarrhoea among children and infants can be traced to the use of unsafe water and unhygienic practices (Omaluet *et al.*, 2010). Many diseases are directly or indirectly related to water quality. Cholera, diarrhea, dysentery and hepatitis-A are linked to unhygienic and contaminated potable water. It is estimated that each year more than 842,000 people die from diarrhea globally (WHO 2017). Waterborne disease cause about 3.4 million deaths every year making it the leading

cause of morbidity and mortality all-over the world (Sunday *et al.*, 2014). Source of these microbes could be mostly due to unhygienic practices (Olagoke *et al.*, 2018). This means that supply of safe drinking water is crucial to human life (WHO 2011).

Water vending is the practice of selling water to household users by water haulers or water facility owners with the exception of bottled and packaged water (WHO, 2015). Water vending is a common problem in both under-developed and developing countries of the world due to scarcity in the supply of potable water as well as inadequate pipe distribution network from the source to users (Kjellen, 2006). The major sources of street vended jerry can water are boreholes and hand-dug wells (Ibrahim *et al.*, 2019). Water vending using plastic jerry cans has become a norm in the ancient city of Zaria, Kaduna state, Nigeria and a job opportunity for thousands of people in the area. The poor personal hygiene of water vendors who retailed the water by jerry cans to

individuals after purchasing directly from water facilities (Whittington *et al.*, 2009) poses an issue of public health concern as this can be one of the main causes of contamination of the vended water. Furthermore, it has been reported that water container materials is an important factor that affects the quality of water used at homes (Ogbozige *et al.*, 2018). The neglect by the authorities concerned in Nigeria and the non-involvement of the National Agency for Food and Drug Administration and Control in the issues concerning jerry cans vended water in Nigeria adds to the gravity of the problem. This research therefore aimed at assessing the bacteriological quality of the jerry cans used for vending water in Zaria.

## MATERIALS AND METHODS

### Sample Collection

Jerry cans water was collected from five different vendors in twenty different locations within Zaria metropolis, Kaduna State. The samples were labeled accordingly and stored in ice and transported to the Bacteriology Laboratory, Department of Microbiology, ABU Zaria for analyses.

### Analysis of the Water Samples

About one milliliter (1 ml) of each jerry can water sample was pipette samples were mixed with 9 ml of buffered peptone water in a tube. From the solution, serial dilutions were made. About 0.5 ml of the mixture from the tube containing  $10^{-4}$  was transferred onto the surface of a sterile Nutrient agar (Oxoid Ltd, England) then spread and incubated at  $37^{\circ}\text{C}$  for 24 hours for bacterial enumeration. Bacterial counts were expressed as colony-forming-units per ml (cfu/ml). About 0.5ml of the jerry can water from each sample was inoculated onto the

surface of freshly prepared Nutrient agar and incubated at  $37^{\circ}\text{C}$  for 24 hours after which were sub-cultured for microbial isolation and identification (Cheesbrough, 2006).

### Bacterial Identification

Distinctive morphological properties of the pure culture such as colony form, elevation of colony and colony margin were observed. Further microbial identification such as Gram staining, morphological characterization and biochemical characterization was based on the methods of Fawole and Oso (2001).

### Data Analysis

Data obtained was analyzed using chart and simple statistical means such as frequency and percentage.

## RESULTS

The result for the characterization of bacterial isolates associated with vended jerry cans water in Zaria is shown in Table 1. The result indicated the presence of eight (8) different bacterial species associated with the samples. The bacterial species identified were: *Escherichia coli*, *Proteus mirabilis*, *Salmonella typhi*, *Klebsiella pneumoniae*, *Corynebacterium sp*, *Proteus vulgaris*, *Citrobacter freundii* and *Bacillus subtilis*.

The prevalence of the bacterial species in the water samples is presented in Figure 1. The result showed that *E. coli* had the highest occurrence of 44.44%. It is followed by *Salmonella typhi* with 18.52%. The least prevalent bacterial species in the water samples were *P. mirabilis*, *Corynebacterium sp* and *Citrobacter freundii* with 3.70% each.

The result for bacterial loads present in the jerry cans vended water samples is shown in Table 2. The result showed a range of bacterial counts from  $1.0 \times 10^6$ - $8.0 \times 10^6$  CFU/mL.

**Table 1: Biochemical characterization of bacterial isolates from vended jerry cans in Zaria**

Location	Cell morphology	Color	Gram's reaction	Ind	Cat	Oxi	MR	VP	Cit	Mot	Isolated organisms
A	Circular	Creamy	-	+	+	-	+	-	+	-	<i>Proteus mirabilis</i>
	Short rod	Whitish green	-	+	+	-	+	-	-	-	<i>Escherichia coli</i>
	Short rod	Whitish green	-	+	+	-	+	-	-	-	<i>Escherichia coli</i>
B	Short rod	Whitish green	-	+	+	-	+	-	-	-	<i>Escherichia coli</i>
	Circular	Yellowish	-	+	+	-	+	-	+	+	<i>Salmonella typhi</i>
	Irregular	Creamy	-	-	+	-	-	+	+	-	<i>Klebsiella pneumonia</i>
C	Short rod	Whitish green	-	+	+	-	+	-	-	-	<i>Escherichia coli</i>
	Irregular	Creamy	-	-	+	-	-	+	+	-	<i>Klebsiella pneumonia</i>
	Short rod	Whitish green	-	+	+	-	+	-	-	-	<i>Escherichia coli</i>
D	Short rod	Whitish green	-	+	+	-	+	-	-	-	<i>Escherichia coli</i>
	Irregular rod	Purple	+	-	+	-	+	-	-	-	<i>Corynebacterium sp,</i>
	Contoured	Pink	-	+	+	-	+	+	-	+	<i>Proteus vulgaris</i>
	Circular	Dirty White	-	-	+	-	+	-	+	+	<i>Citrobacter freundii</i>
E	Short rod	Whitish green	-	+	+	-	+	-	-	-	<i>Escherichia coli</i>
	Irregular	Creamy	-	-	+	-	-	+	+	-	<i>Klebsiella pneumonia</i>
	Irregular	Creamy	-	-	+	+	-	+	+	+	<i>Bacillus subtilis</i>

Key: Ind= Indole      Cat= Catalase      Oxi= Oxidase      MR= Methyl red  
 Vp= Voges Proskauer      Cit= Citrate      Mot= Motility      + = Positive reaction - = Negative reaction

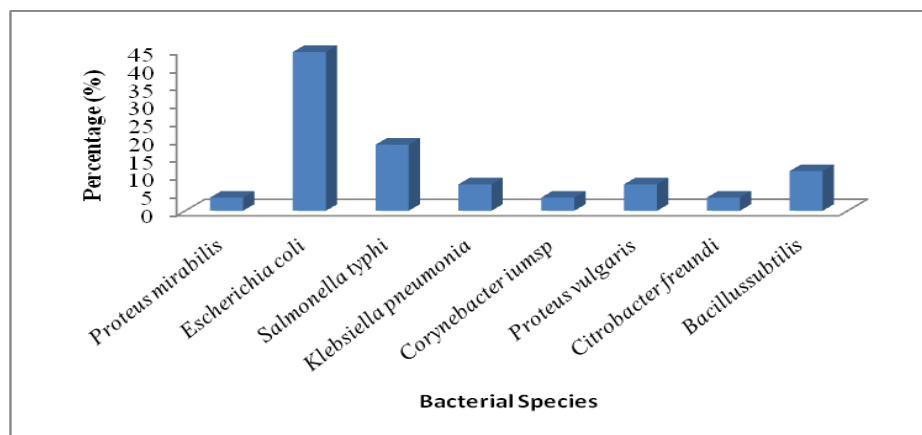


Figure 1: Prevalence of Bacterial species among jerry cans vended water in Zaria

**Table 2: Enumeration of Bacterial Loads from Jerry cans Vended Water in Zaria**

Sample code	Bacterial Load (CFU/mL)	WHO Permissible Limit
A	5.0 X 10 <sup>6</sup>	<1.0x10 <sup>1</sup> CFU/mL
B	8.0 X 10 <sup>6</sup>	
C	1.2 X 10 <sup>6</sup>	
D	2.3 X 10 <sup>6</sup>	
E	1.0 X 10 <sup>6</sup>	

## DISCUSSION

The presence of seven genera represented by eight species of bacteria associated with jerry cans vended water in Zaria proved the low level of bacteriological quality of the vended water. The presence of bacterial populations in drinking water is of concern to consumers and poses risk to public health as stressed by Izah and Ineyougha (2015). These microorganisms are pathogenic (Ashbolt *et al.*, 2001; Hussain *et al.*, 2013). The high prevalence of *E. coli* among the samples reported by this study is in agreement with the work of Otorkpa (2019) who reported *E. coli* as the most predominant microbial contaminant of drinking water in Nigeria. The presence of *Escherichia coli* in almost all the samples reported by this study has shown the degree of contamination of the water and the plastic jerry cans. The presence of *Escherichiacoli* in water is reported by Oyedeji *et al.* (2010) to be associated with faecal pollution and it is the preferred indicator organism for this purpose. Although most strains of *E. coli* are harmless or cause relatively brief diarrhea, virulent strains, such as *E. coli* O157:H7 can cause severe symptoms including bloody diarrhea and vomiting (Gillard, 2011). This organism is the most common bacterial contaminant in drinking water (Otorkpa, 2019). According to WHO standard for drinking water quality, there should be less than 1 MPN/100 ml of total coliforms and no *E. coli* in 1 ml of water. Tambe *et al.* (2008) also recorded that water samples were frequently contaminated with human faecal organisms. Also, a similar study by Salim *et al.* (2013) who reported 17.3% of *E. coli* recovered from drinking water.

*Proteus mirabilis* are widely distributed as free-living organisms in soil and water in the natural environment. In humans, *Proteus* is found as part of the normal flora of the gut. Its main pathological role is in infections of the urinary tract, but it can also cause wound infections and septicaemia (Anonymous, 2014). *Proteus* organisms are implicated in the causation of serious infections in humans, along with *Escherichia*, *Klebsiella*, *Enterobacter*, and *Serratia* species as reported by Gonzalez and Bronze (2016). Kaljee *et al.* (2017) reported that, *Salmonella typhi* is the causative agent of typhoid fever which is a serious disease condition with an annual global burden of approximately 16 million cases, leading to 600,000 fatalities. Humans become infected with *S. typhi* by the consumption of contaminated water or food (Kaljee *et al.*, 2017). Deji-Agboola *et al.* (2017) also reported the presence of *S. typhi* in water from some

hand-dug shallow water wells in Awka metropolis in South Eastern Nigeria.

*Klebsiella* species frequently cause human nosocomial infections and account for a significant proportion of hospital-acquired pneumonia, septicemias, soft tissue infections and urinary tract infections (Podschun and Ullmann, 1998). Similarly, Ajayi *et al.* (2008) and Owamah (2018) individually confirmed the presence of *Klebsiella sp.*, and *Pseudomonas aeruginosa* from some drinking water samples consumed in Ibadan and Asaba in South West and South South Nigeria respectively.

*Bacillus spp* have also been isolated previously from drinking water systems (Lee *et al.*, 2009). *Pseudomonas aeruginosa*, *Klebsiella spp* and certain “slow growing” bacteria may be naturally present in the environment (WHO, 2011). Funmilayo *et al.* (2021) also reported the presence of *Bacillus subtilis*, *Pseudomonas spp*, *Citrobacter spp* and *Klebsiella oxytoca* from drinking water. Similarly, Daniel and Daodu (2016) reported the presence of *Pseudomonas sp*, *Bacillus spp*, *Proteus vulgaris* and *Escherichia coli* among the bacterial species isolated from sachet water vended in Ugbor, Benin city, Nigeria. Hussain *et al.* (2013) also reported *Pseudomonas sp* and *Bacillus spp* among drinking water source from Kohat Pakistan. More so, Ugochukwu *et al.* (2015) reported *Klebsiella spp.*, *Proteus spp.*, *Pseudomonas spp* and *Salmonella sp* among some sampled sachet water vended in Samaru Zaria. Similar conglomeration of these bacterial species was reported by Oyedeji *et al.* (2010) from packaged drinking water. Most of the bacterial species isolated were pathogenic. The bacterial load in the vended jerry cans water reported by the present study is higher than the recommended value for portable water (1.0x10<sup>1</sup>cfu/ml) by National Agency for Food, Drug Administration /NAFDAC (2004).

Daniel and Daodu (2016) reported the presence of *Pseudomonas sp*, *Corynebacterium sp.*, *Bacillus sp.*, *Bacillus badius*, *Proteus vulgaris* and *Escherichia coli* from packaged drinking water in Edo state, South South Nigeria. Similarly, Omezuruike *et al.* (2008) reported *Salmonella sp.*, and *Escherichia coli* among several other microorganism from drinking water samples collected in Abeokuta, Ogun State and Ojota in Lagos State all in South west Nigeria. In another study by Agwaranze *et al.* (2017) reported *Escherichia coli*, *Pseudomonas species*, *Proteus species* *Salmonella species* and *Klebsiella species* among drinking water from wells in Wukari, Taraba State, North east Nigeria. Umar *et al.* (2019) reported *Escherichia coli*, *Salmonella sp*, *Citrobacter freundii* and

*Proteus vulgaris* isolated from sachet-packaged drinking water in Zaria, North western Nigeria. Similarly, Pauline *et al.* (2018) reported *Escherichia coli*, *Salmonella* sp, *Citrobacter freundii* and *Proteus vulgaris* from drinking water.

Microbial contamination of drinking water is due to several factors that contribute to failure of treatment process. They include poor hygienic conditions of the handlers, presence of biofilms on processing surfaces due to poor cleaning and sanitation and packaging of treated water under unhygienic conditions (Ollos *et al.*, 2003). The bacteria characterized and identified from the sachet water samples were found mostly to be opportunistic pathogens which are usually isolated from unhygienic environments or materials (Bitton, 2005). The predominant ones include *Staphylococcus aureus*, *Proteus vulgaris*, *Pseudomonas spp.*, *Bacillus spp.* and *Aeromonas sp.* Onifade and Ilori (2008) also encountered *Bacillus subtilis*, *Escherichia coli* and *Staphylococcus aureus* in sachet water samples vended in Ondo State. These microorganisms are versatile in their nutrient requirements and can survive with limited nutrient availability. Most of these bacteria are indigenous to

aquatic environments (Berger and Oshiro, 2002). The microbial populations reported by the present study can be attributed to the unhygienic practices of the handlers and the water source. This agrees with the findings of Mgbakor *et al.* (2011) who reported that the increase in the demand, sale and indiscriminate consumption of drinking water in Nigeria and the unhygienic practices of the handlers and processing methods pose significant public health risks to the citizens especially individuals with compromised immune systems. Egwari and Aboaba (2002) attributed faults in pipeline and pipes aging as the major cause of high level contamination of drinking water.

## CONCLUSION

Water samples from Jerry cans collected from vendors in Zaria contains pathogenic bacteria and carries microbial load above the WHO permissible limit for potable water. Thus consumption of water from these jerry cans may pose a public health risk in Zaria and its environs. Water collected from water vendors should be treated before consumption and that the vendors using jerry cans should be oriented on personal hygiene.

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