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Original Article

COMPARATIVE ANALYSIS OF BOTTLED AND SACHET WATER SOLD IN URBAN AND RURAL AREAS OF EDO STATE, NIGERIA.

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ABSTRACT

This study was aimed at comparatively studying the microbiological quality of several bottled and sachet water sold in Edo State. Microbial counts included total heterotrophic bacterial count (THBC), Total coliform count (TCC) and Total Fungal count (TFC). Counts for urban bottled water ranged from 0.0 to 6.5×10 for THBC and no count for TCC and TFC. Urban sachet water had 0.0 to 7.5×10 for THBC, 0.0 to 1.8×10 for TCC and none for TFC. Counts for rural bottled water ranged from 0.0 to 2.0×10 for TFC. Rural sachet water had 0.0 to 3.1×10 for THBC and no count for TCC and TFC. The bacteria isolated from the samples were *Micrococcus luteus, Bacillus subtilis* , *Staphylococcus aureus* and *Klebsiella* sp. And the fungus isolated from the samples was *Saccharomyces* sp. It was shown that most of the brands of the sachet water had bacterial growth, hence, the word 'pure water used instead of sachet water' is practically incorrect. This may be as a result of poor handling. Educating the water handlers i.e sellers, distributors and producers could be of help in reducing or eradicating incidences of water transmitted infections.

Keywords: Coliform, Sachet water, Bacteriological analysis, Drinking water, Potable water.

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INTRODUCTION

Water is indispensable for life. However, it is estimated that about 1.2 billion individuals worldwide do not have access to portable water (WHO, 2005, Okonko et al., 2009b). In many developing countries, availability of water has become a critical and urgent problem and it is a matter of great concern to families and communities that depend on non-public water supply system (0konko et al., 2008). Lack of adequate supply of portable water is a critical challenge in Nigeria. Increase in the human population has exerted an enormous pressure on the provision of safe drinking water in developing countries (Umeh et al., 2005). Portable water also called drinking water in reference to its intended use, is defined as water which is fit for consumption by humans and other animals (Tchobanoglous et al., 2003). The usual source of drinking water is the streams, rivers, wells and boreholes which are mostly untreated and associated with various health risks (Agbarie and Obi , 2009). To curb this health problem, bottled water was introduced, but only individuals who have good financial status can afford these products. Low-income earners are left with no option but to consume sachet packaged water that is cheaper. It is readily available and affordable; sachet water is sold in most roadside vending food stalls in Nigeria.

Water of good drinking quality is of basic importance to human physiology and man's continued existence depends very much on its availability (Lamikanra, 1999; Okonko et al., 2008a, b). Water-related diseases continue to be one of the major health problems globally (Oladipo et al., 2009). Unsafe water is a global public health threat, placing persons at risk for a host of diarrheal and other diseases as well as chemical intoxications (Hughes and Koplan, 2005). Biological contaminants such as bacteria, viruses, fungi, protozoa and helminths constitute the major cause of food-borne and water-borne diseases with varying degrees of severity, ranging from a mild indisposition to chronic or life-threatening illness, or both (Okonko et al.,2009b). Small nylon sachets which are electrically heated and sealed at both ends are used to packaged 50-60ml of water and these were introduced into the market in Nigeria (Umeh et al., 2005; Alli et al., 2011). There are many different brands of sachet drinking water that are beautifully packaged, properly labelled and advertised (Ekwunife et al., 2010).

Although these products are popularly termed "pure water", they are usually not free of microbial contaminants (Caroli et al., 2005; Taura et al., 2005; Ezeugwunne et al, 2009; Oladipo et al, 2009). Occasionally, contamination of sachet water may occur either during the processing, transportation or improper handling by hawkers. Moreover, a greater proportion of the water that is used for the production of sachet water is obtained from boreholes that are exposed to microbial contamination through rainfall runoffs and the fact that they are usually constructed very close to pit toilets (Adegoke et al., 2012).

Many people in rural and urban communities rely on sachet water and or borehole water as the source(s) of their drinking water supply. The integrity of these sachet water is doubtful, in fact, unconfirmed report abounds that most of the vendors do not treat their sachet waters before selling to the public (Oladipo et al., 2009).

Several studies on the microbial quality of bottled and sachet water have reported violations of international quality standards. Over the recent years, however, concerns have been raised over the microbial quality of drinking water (Fewtrell et al., 1997; Rosenberg, 2003; Khaniki et al., 2010). The bacteriological analysis of water samples provides essential information of the quality and indicates whether or not the water is in a bacteriological acceptable condition (Akinnibosun and Ekundayo, 2007; Atlas, 1988). It may also indicate why and from where the deterioration of quality has occurred. The examination also indicates the degree of pollution present. Due to the difficulty and time consumed in doing routine tests for pathogenic organisms, some bacteria are used as indicators of water quality (Bank, 1994). These are

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normal excreta organisms. This kind of practice can be justified because the greatest danger associated with drinking water is that it may be contaminated with human and animal wastes. The wastes may contain both pathogenic and normal excreta organisms (Akinnibosun and Ekundayo, 2007).

The normal excretal organisms can be detected more easily in water, microbiologists, therefore routinely use organisms as indicators of faecal contamination or pollution. The most widely used indicator for microbial water contaminant is the coliforms group of micro-organisms. Coliforms are used as an indicator of water contamination because many of them inhabit the intestinal tract of humans and other animals in large number , thus , their presence in water indicates faecal contamination. The aim of this work was to comparatively analyze bottled and sachet water sold in urban and rural areas in Edo state.

MATERIALS AND METHODS

Collection of samples

Bottled and sachet water samples were purchased from urban (G.R.A, Ekenuwan and Ugbowo) and Rural (Udo and Oluku) areas of Edo state.

Enumeration of microorganisms

Nutrient agar was used to determine the total heterotrophic bacterial count (THBC) while potato dextrose agar was used to determine the fungal count. Ten-fold serial dilution was made and 1ml of from the 10-1 dilution was plated out by pour plate method on nutrient agar and potato dextrose agar. The nutrient agar plates were incubated at 37^{O}C for 24hrs, while the potato dextrose agar plates were incubated at 28^{O}C for 72hrs. After incubation, discrete colonies of culture on nutrient agar and potato dextrose agar plates were counted and expressed in colony forming unit per ml (CFU/ml).

Determination and Estimation of Total Coliform count:

The Most Probable Number (MPN) technique was used for the water analysis (APHA, 1998).

Characterization and Identification of Isolate:

Bacteria isolates were identified on the basis of cultural, morphological and biochemical tests according to Jolt et al., 1994 and Cheesbrough, 1984. The fungal colonies were identified as described by Harrigan, 1998.

Physico-chemical analysis:

Some physicochemical parameters (pH, turbidity, taste, odour and appearance) were analysed according to the methods in APHA, 1998.

RESULTS AND DISCUSSION

This study was aimed at comparatively analyzing bottled and sachet water sold in urban and rural areas in Edo state. pH is the measure of hydrogen ion concentration or hydroxide ions concentrations in a solution. From the results, the pH of the water samples ranged between 6.45-7.1. The results were within the normally acceptable range (6.0-9.0). The pH of the water samples was within the Nigerian Standard for Drinking Water (NSDW) range acceptable for normal consumption . The result compares well with studies of Adefemi et al., (2007) in water samples from Ureje, Egbe, Ero and Itapaji dams, South West of Nigeria. Asaolu, (1997) also obtained similar results from water samples from the coastal regions of Ondo state, Southwest of Nigeria.

Turbidity is the cloudiness or haziness of water sample. It is usually caused by suspended solid particles which can be as a result of the presence of phytoplankton in open waters or in drinking water. The more turbid the water, the greater the chances of water-borne diseases. This is because contaminants like bacteria and viruses attached to these suspended solids and are protected by these solids from disinfection by chlorination or UV sterilization (USEPA, 1986). The Nigerian Standard for Drinking Water (NSDW)

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acceptable standard is 5 NTU. From the results, the turbidity of the potable water ranged between 0.19-0.38 NTU. This showed that the water samples are safe for drinking. The taste and odour of water samples were unobjectionable and the appearance was clear. The result of this study showed the presence of bacteria in the water samples studied. The Counts for urban bottled water ranged from 0.0 to 6.5×10 for THBC and no count for TCC and TFC. Urban sachet water had 0.0 to 7.5×10 for THBC, 0.0 to 1.8×10 for TCC and none for TFC. Counts for rural bottled water ranged from 0.0 to 2.0×10 for TFC. Rural sachet water had 0.0 to 3.1×10 for THBC and no count for TCC and TFC.

The bacteria detected in the water samples were Micrococcus luteus, Bacillus subtilis, Staphylococcus aureus and Klebsiella sp, while the fungal organism detected was Saccharomyces sp. This is similar to the studies by Adekunle et al., (2004). In Ibadan, Ezeugwunne et al., (2009) in Nnewi Oladipo et al., (2009) in Ogbomoso, all in Nigeria which showed the presence of some bacteria in sachet and water. Staphylococcus aureus and Klebsiella sp were mostly detected in the table water samples while Micrococcus luteus, Bacillus subtilis, and Staphylococcus aureus were mostly detected in the sachet water samples. The presence of Staphylococcus and Micrococcus sp could be as a result of ubiquitous nature of the organism or poor staff handling during water processing (Edema et al., 2001). The presence Klebsiella sp. and Bacillus subtilis may be as a result of the contaminated vending machine (Oladipo et al., 2009). Similar species of bacteria were isolated from wastewater and surface of the sachets with the wastewater containing a significant higher numbers of bacteria while Adegoke et al., (2011) reported the presence of high microbial load of Proteus sp, Klebsiella sp, Enterobacter sp, Pseudomonas sp, Staphylococcus sp and Escherichia coli in borehole water at Oyigbo, Rivers state suggesting that those borehole water did not meet WHO standard. The international standards for drinking water state that potable water should not contain 100 cells of heterotrophic bacteria per 100ml of water (WHO, 1984). The study of the bottled and sachet water samples collected from both rural and urban areas in Edo state met up with this standard and this could be as a result of proper location of the water source and effective treatment which the water has received, therefore the public who drink these water could be free from water-borne diseases.

There was coliform detected in water sample G collected. No fungal count was also detected in the water samples except M table water (Iguobazuwa). The presence of coliform bacteria, an indicator bacteria is used to evaluate the quality of drinking water. World Health Organization (WHO) standards for treated water says that no sample of 100ml should contain more than three coliform organisms and Escherichia coli should not be detected in any sample of 100ml (WHO,1984). Egwari, et al., (2005) in their study on the bacteriology of sachet water sold in Lagos reported that organisms contained in the wastewater were inevitably the source of contaminants on the sachet surface. Egwari, et al., (2005) in their study on the bacteriology of sachet and bottled water sold in Lagos reported that enteric pathogens and Escherichia coli were not isolated from any samples and the water vendors and their patrons contributed to the overall contamination of hawked sachet water in Lagos. Again, the water samples studied in this work except G met up with this standard which could be attributed to the effective water treatment and proper location of water source away from sewage tanks. In order to protect public health and ensure that water is safe for public use, any water intended for drinking treated or untreated, piped or unpiped must meet a certain microbiological standard. A violation of set standards warrants treatment of the present source or the need for an alternative water supply.

A study conducted in Lagos, Nigeria revealed that bacteriological characteristic of sachet water deteriorates considerably as products moved farther down the distribution chain. Less than 7% of sachet water contamination took place after production while between 40 and 45% of the products were observed between the distribution sheds and the street hawkers (Omalu et al., 2010). Egwari, et al., (2005) in their study on bacteriology of sachet water sold in Lagos reported that enteric pathogens and Escherichia coli were not isolated

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from any samples and brands of sachet water but formed significant part of the isolates on the sachet surfaces of samples collected from the cooling receptacles (pail, wheelbarrow and refrigerator).

Table 1: Physico-chemical Parameters of the Water Samples

Water samples	Ph	Turbidity	Taste	Odour	Appearance
A	6.71	0.21	U	U	C
B	6.82	0.37	U	U	C
C	6.8	0.31	U	U	C
D	6.84	0. 25	U	U	C
E	6.72	0.19	U	U	C
F	6.84	0.22	U	U	C
G	6.77	0.29	U	U	C
H	6.81	0.28	U	U	C
I	7.1	0.41	U	U	C
J	6.83	0.33	U	U	C
K	6.66	0.38	U	U	C
L	6.75	0.25	U	U	C
M	6.85	0.29	U	U	C
N	7.4	0.3	U	U	C
O	7.1	0.19	U	U	C
P	6.45	0.25	U	U	C
Q	6.82	0.2	U	U	C
R,	7.1	0.28	U	U	C
S,	7.4	0.31	U	U	C
T	7.1	0.34	U	U	C
U	7	0.27	U	U	C
V	6.83	0.19	U	U	C
W	6.9	0.22	U	U	C
X	6.81	0.28	U	U	C

Key:

C = clear/colourless
U = unobjectionable
A = Aqua Baula Table water (Ekenhuan)
B = Big Joe Table water (Ekenhuan)
C = Notre Dame Table water (GRA)
D = Eva Table Water (GRA)
E = Olivia Table Water (ugbowo)
F = Uniben Table Water (ubgowo)
G = Notre Dame Sachet Water (Ugbowo)
H = Uniben Sachet Water (ugbowo)
I = Europa Sachet Water (Ekenhuan)
J =Notre Dame Sachet water (Ekenhuan)
K = Dewlife Sachet Water (GRA)
L = Nelan Sachet Water (GRA)
M = CJ table Water (Iguobazuwa)
N = Ven Table Water (Iguobazuwa)
O = Dewlife Table Water (Oluku)
P = Claire Table Water (Oluku)
Q = Olivia Table Water (Udo)
R = Samis Table Water (Udo)
S = Uwa Sachet Water (Iguobazuwa)
T = De-city Sachet Water (Iguobazuwa)
U = Noren Sachet Water (Oluku)
V = Adima Sachet Water (Oluku)
W = IK Table Water (Udo)
X = Kelda Table Water (Udo)

Table 2: Microbial Counts of Urban Bottled water

Samples	THBC (cfu/ml)	TCC (cfu/ml)	TFC (cfu/ml)
A	0	0	0
B	6.5 x 10	0	0
C	5.6 x 10	0	0
D	0	0	0
E	0	0	0
F	0	0	0

Key:

THBC = Total Heterotrophic Bacterial count
TCC = Total Coliform Count
TFC = Total Fungal Count

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Table 3: Microbial Counts of Urban Sachet water

Samples	THBC (cfu/ml)	TCC (cfu/ml)	TFC (cfu/ml)
G	7.5 x 10	1.8 x 10	0
H	2.0 x 10	0	0
I	1.0 x 10	0	0
J	0	0	0
K	1.9 x 10	0	0
L	7.0 x 10	0	0

Key:

THBC = Total Heterotrophic Bacterial count
TCC = Total Coliform Count
TFC = Total Fungal Count

Table 4: Microbial Counts of Rural Bottled water

Samples	THBC (cfu/ml)	TCC (cfu/ml)	TFC (cfu/ml)
M	2.1 x10	0	2.0 x 10
N	2.0 x 10	0	0
O	7.5 x 10	0	0
P	7.5 x 10	0	0
Q	0	0	0
R	2.1 x 10	0	0

Key:

THBC = Total Heterotrophic Bacterial count
TCC = Total Coliform Count
TFC = Total Fungal Count

Table 5: Microbial Counts of Rural Sachet water

Samples	THBC (cfu/ml)	TCC (cfu/ml)	TFC (cfu/ml)
S	0	0	0
T	3.1 x10	0	0
U	1.3 x 10	0	0
V	0	0	0
W	0	0	0
X	1.0 x 10	0	0

Key:

THBC = Total Heterotrophic Bacterial count
TCC = Total Coliform Count
TFC = Total Fungal Count

Table 6: Bacteria Isolated from the Samples

Isolated Bacteria
Micrococcus luteus
Bacillus sp.
Staphylococcus aureus
Klebsiella sp.

Table 7: Fungus Isolated from Samples

Isolated Fungus
Saccharomyces sp.

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CONCLUSION

It was shown that most of the brands of the Sachet Water had bacterial growth, hence, the word "Pure Water "used instead of Sachet Water is practically incorrect. This may be a result of poor handling. Educating the water handlers' i.e. sellers, distributors and producers could be of help in reducing or eradicating incidences of water transmitted infections.

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