Health Concerns on Microbiological Quality of Bottled Drinking Water Sold in Dar es Salaam, Tanzania

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Abstract: *Background*: Dar es Salaam City has over 10 million habitants, who are constantly circumvented by water-borne diseases. The city experiences humid and hot weather throughout a year, which lead to high consumption of bottled drinking water because of being perceived as safer than tap or well water. Waterborne disease outbreaks still create havoc among the city habitants. This study determines heterotrophic plate count (HPC) values in bottled water and performs antimicrobial resistance tests on isolated microorganisms.

Methods: A cross-sectional study was conducted. Fifty-four samples of bottled water were randomly purchased from shops, supermarkets and street vendors. HPC values were determined and microbial contaminants identified. The disk diffusion method was employed for testing antimicrobial resistance of microbial contaminants against four widely used antibiotics.

Results: HPC values were variable (4.7×10^2 to 7.0×10^5 cfu/ml). Majority (86.7%) of analyzed samples revealed high HPC values. Four bacterial species were isolated and identified from 47 samples. Predominant bacterial contaminants were *Brevundimonas vesicularis* (54.5%), while *Pseudomonas thomasii* was only isolated from one brand A sample. Brand E samples had the highest HPC values (2.2×10^4 to 2.16×10^5 cfu/ml) while F samples were free from microbial contaminants. A total of 21 (46.7%) bacterial isolates were resistant to commonly used antibiotics namely ciprofloxacin, ampicillin, cotrimoxazole and chloramphenicol.

Conclusion: Of 54 analyzed bottled water samples, 47 had high HPC values. High rates of antibacterial resistance was exerted against ciprofloxacin (68.2%) and ampicillin (56%). This calls for responsible authorities to impose more stringent measures on in-process quality control among bottled water producers and indefatigably conduct post-production surveillance to avert the endemic water-borne outbreaks resulting from consumption of such products.

Keywords: Heterotrophic plate count values, microbial contaminants, antibiotic resistance profiles.

INTRODUCTION

Dar-es-Salaam City has over 10 million habitants who consume a lot of bottled drinking water, because of very hot weather condition: daily maximum temperature ranging from 29-32°C, with annual average relative humidity over 70% [1]. Unfortunately, tap water supply system in the city is inefficient and unsafe due to outdated pipe system and/or lack of water decontamination process [2]. This significantly has attributed to constant waterborne disease outbreaks in Dar es Salaam [3], which certainly have led to proliferation of bottled water business. In most urban areas in Tanzania, large proportion of the people depend on bottled/packaged water owing to its perceived safety as compared to water from public pipe systems [4]. Currently, there are about 47 different brands of bottled drinking water registered by the Tanzania Food and Drug Authority (TFDA) [5] and accredited by the Tanzania Bureau of Standards (TBS) [6], of which 16 brands are plentifully in the market. Because of bottled drinking water being fast moving and non-perishable products, several persons have been attracted into this business. Nevertheless, due to financial constrains or urge for maximization of profits, some businessmen have dared to introduce into the market ‘’unsafe’’ bottled drinking water [7-9].

Despite bottled water being perceived as pure, clean, of good quality and ‘protected’, waterborne diseases associated with consumption of commercial bottled water have been reported [4, 10-14]. The reasons behind are inadequate access to safe water, poor *Sanitation* services and *hygiene* practices, which are ascribable to high morbidity and mortality among citizens of developing countries, Tanzanians inclusive. Consequently, this probably leads to further impoverishment, partially as consequence of diminished productive potential. Heterotrophic plate count (HPC) bacteria are potential indicator of overall sanitation in bottling and source water; though they may be harmless by themselves. Occasionally, heterotrophic microorganims/bacteria may indicate presence of pathogenic bacteria and can be associated with various infectious diseases. The heterotrophic bacteria can also interfere with detection of coliform bacteria and/or other infectious microorganisms [15].

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It is important to note that bottled water consumers are frequently unaware of the potential health risks associated with exposure to waterborne contaminants and often consult medical practitioners who are unfamiliar with water contamination from biological, chemical or radiologic hazards and their subsequent impact on human health [16]. Moreover, because of high prevalence of water-borne disease outbreaks despite the plentiful bottled drinking water in Dar es Salaam; we embarked on microbiological assessment of the products and carry out antimicrobial resistance profiling on the isolated microorganisms. The study also aims, first to ascertain whether such microorganims can be controlled by readily available antimicrobials or no, and secondly, to alert responsible authorities to adopt necessary measures to resolve the everlasting problem of water-borne disease outbreaks.

MATERIALS AND METHODS

Study Area

Dar es Salaam is situated on the equator and therefore experiences a tropical climate with hot humid weather from December through March, the hottest month being January. Dar-es-Salaam was specifically selected as study area because of being the largest cosmopolitan commercial city with the highest population in Tanzania. Thus the city not only has the largest number of bottled water consumers but also the largest number of bottled water producers in the country [5].

Samples Collection and Preparation

Bottled water samples were purchased from shops, supermarkets/malls and street vendors. Random sampling technique was employed for selection of 6 (designated A-F) out of 16 brands readily available in the market. For each brand, 9 samples were randomly purchased and analysed. Containers label information such as water source, treatment method, packaging materials and container's volume were recorded. Then each sample's container was externally inspected for intactness and then swabbed with 70% ethanol prior to being subjected to microbiogical assessment.

Quantitative and Qualitative Assessment of Microbial Contaminants

Direct spread plate and enrichment techniques were employed to determine HPC values and detect presence of microbial contaminants in the water samples respectively. Aseptic techniques were observed to avoid potential contamination of the samples by using clean gloved hands and inoculation of each sample into sterile broths and onto agar plates. Nutrient agar and broth were used for detection of bacterial contaminants while Sabouraud's dextrose broth and agar were used for assessment of fungal contaminants.

Direct Spread Plate Count

One milliliter aliquot of each sample was aseptically transferred onto Nutrient agar (NA) and Sabouraud's dextrose agar (SDA)–(Carl Roth, GmbH) plates and uniformly spread by using sterile cotton wool. The plates were incubated at 30°C for 24 to 48 hours before observation of bacterial and fungal growth/contaminants, which were then expressed as cfu/ml of water sample.

Enrichment Method

Two 1ml -aliquots of each water sample were transferred into two bottles, one containing Nutrient broth and another had Sabouraud's broth (Carl Roth, GmbH). The bottles were incubated at 30°C and turbidity was observed after 24-48 hours. Visual/macroscopic observation was done to detect microbial growth in the broth based on change of turbidity with respect to controls (water and broth alone). Results were recorded as either positive or negative, standing for presence and absence of microbial growth respectively.

Identification of Microbes and Antibacterial Resistance Testing

The substantively isolated microorganisms/bacteria from drinking water samples were identified by sub-culturing in various selective and differential media based on colony morphologies, biochemical and physiological tests [17-18]. The identified bacteria were subjected to resistance profiling against commonly used antibiotics (using the Kirby-Bauer method disc diffusion method). Reference strain of *Escherichia coli* (ATCC 25922) was used as control bacterium. Each microbial contaminant was sensitized by sub-culturing in freshly prepared Muller-Hinton broth followed by an overnight incubation at 37°C. Then turbidity of each bacterial suspension was compared to that of McFarland 0.5 standard turbidity (equivalent to $1.5x10^{8}$cfu/ml) prior to performing the antibiotic resistance tests against commonly used antibiotics viz. ciprofloxacin (1µg), ampicillin (30µg) (Medochemies, Cyprus), chloramphenicol (30µg) and cotrimoxazole (25µg) (Pharmathen-SA, Greece). Diameters of inhibition zones (mm) were determined and interpreted as per Clinical Laboratory Standards Institute (CLSI) [19].

Statistical Data Analysis

All above procedures were conducted in triplicates and performed twice for statistical purpose and consistence of results. Therefore, resultant numerical data are expressed as mean. Statistical data analysis (for means and variance) for zones of inhibition (IZ) and correlation between HPC values and container's volume of each sample were carried out using a computer package SPSS version 16 (Chicago, IL). Differences of means of ZI among the samples were analyzed by the T-test, and the differences were considered statistically significant when $p<0.05$.

RESULTS

Physical Assessment of Bottled Water Sample Containers

According to TBS specifications [20], bottled drinking water should be packaged in sterile and hermetically sealed containers of up to 2 liters, which was complied by all manufacturers (Table **1**). Packaging materials were intact and made up of mainly plastics namely polyester-terephthalate (PET) and high-density polyethylene (HDPE) for bottles, while plastic bags were made up of low-density polyethylene (LDPE). The maximum volume of the analyzed samples was 1500mL (1.5L). Most of the street vendors kept the water samples in poor sanitary conditions. Generally, it was observed that storage conditions were poor since bottled water samples were directly exposed to sunlight and dusts in contrary to the Tanzania Drinking Water Specifications [20] and WHO guidelines [21]. Noticeably leaking or defective water containers and/or those with loose caps were excluded from the study. Water sources and treatment methods for some brands of the assessed water samples were not disclosed on their label information.

Assessment of Microbial Contamination

Majority (86.7%) of analyzed water samples indicated presence of microbial contaminants that exceeded the acceptable limits (100cfu/ml of HPC values or total viable counts per mL and only 20 microbes per mL for containerized drinking water) as per the East African Standards-152 (EAS 152) [22]. Five out of 6 brands of bottled water were contaminated (Table **2**). Samples of brands A, B, C, D and E harboured heterotrophic bacteria. No microbial contamination was observed in all brand F samples. Of all bacterial contaminants isolated from the water samples, 54.5% (n=24) were *Brevundimonas* (*Pseudomonas) vesicularis*. While *P. thomasii* isolates/contaminants were only detected from brand A

Table 1: Description and Bacteriological Quality of the Analyzed Bottled Water Samples

Brand	Water source	Water treatment method	Package volume (mL)	Microbial contaminants (number of isolates)	
				Bacterial	Fungal
A	Underground stream	Reverse osmosis	350 500 1000	*Pseudomonas thomasii* (1) *Myroides odoratimimus* (3) *Brevundimonass vesicularis* (4)	Nil
B	Not mentioned	Not mentioned	600	*Sphingomonas paucimobilis* (4) *Myroides odoratimimus* (2) *Brevundimonass vesicularis* (3)	Nil
C	Not mentioned	Not mentioned	1000	*Sphingomonas paucimobilis* (2) *Brevundimonass vesicularis* (5) *Myroides odoratimimus* (2)	Nil
D	Not mentioned	Not mentioned	500 1000 1500	*Myroides odoratimimus* (3) *Brevundimonass vesicularis* (2) *Brevundimonass vesicularis* (4)	Nil
E	Snow / rain on top of Kilimanjaro mountain	Water filtration	500 1000	*Brevundimonass vesicularis* (6) *Sphingomonas paucimobilis* (3)	Nil
F	Not mentioned	Reverse osmosis	500 1000	None	Nil

Table 2: Results on the Quantitative and Qualitative Assessments of Bottled Water Samples

Brand	No. of samples	HPC values (cfu /ml)	Turbidity		Isolated contaminants
			Nutrient broth	Sauboraud's dextrose broth	
A	2	4.70×10^2 - 6.3×10^4	++	ND	PT, BV
	2	8.33×10^2 - 3.2×10^4	++	ND	MO
	5	1.2×10^4 - 4.0×10^4	+++	ND	BV
B	9	1.19×10^3 - 9.56×10^4	++	ND	SP, MO, BV
C	9	1.27×10^5 - 1.73×10^5	++++	ND	SP, BV, MO
D	3	1.2×10^4 - 7.05×10^5	++++	ND	MO
	2	4.2×10^4 -7.63×10^4	+++	ND	BV
	4	1.0×10^5 - 1.78×10^5	++++	ND	BV, MO
E	6	1.9×10^4 - 1.943×10^5	+++	ND	BV
	3	2.2×10^4 - 2.16×10^5	+++	ND	SP
F	9	ND	ND	ND	ND

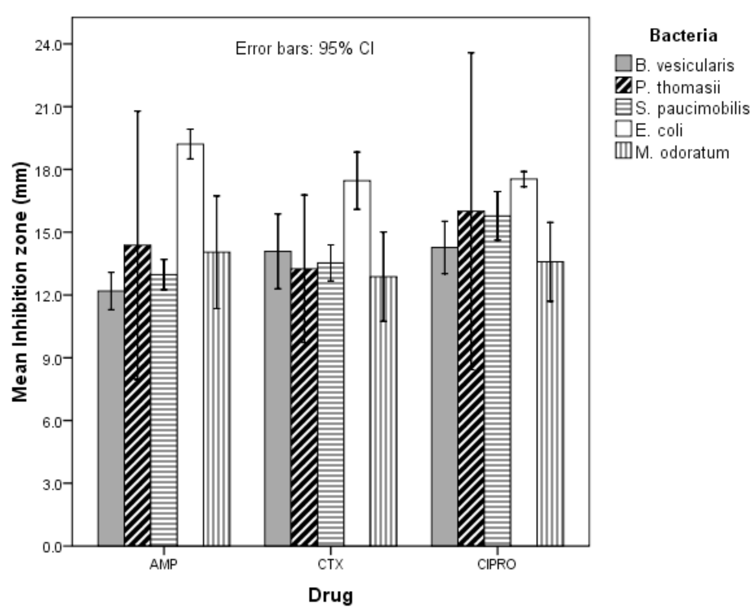
Key note: ND= not detected; (+)-magnitude/presence of microbial contaminants; PB-B. *vesicularis*; PT-*P. thomasii*; SP-*S. paucimobilis*; MO-M. *odoratum*; R=resitant; I-intermediate and S-susceptible. The same apply for subsequent table.

samples (Tables **1-2**). Results show no apparent association between container's volume of bottled water sample and number of isolated microbial contaminants as shown in Table **1**. However, a positive correlation between HPC values and volumes of water sample containers was observed (Pearson R= 0.645; p=0.01).

Antibacterial Resistance Profiles

The isolated bacteria were subjected to antibacterial resistance assays on four commonly used antibiotics namely ciprofloxacin (1µg), ampicillin (30µg), cotrimoxazole (25µg) and chloramphenicol (30 µg). The latter had dead discs, thus results for this antibiotic could not be displayed. Bacteria of the same species isolated from different brands of bottled water yielded distinct antibacterial resistance profiles (Figure **1**).

Comparative analysis (independent samples T-test) for antibacterial (ampicillin) resistance profiles between reference strain *E. coli* and bacterial contaminants as well as among the isolated contaminants (between groups) revealed no statistically significant differences



Key: AMP=ampicillin, CTX=cotrimoxazole, CIPRO=ciprofloxacin

Figure 1: Susceptibility tests of bacterial contaminants to commonly used antibiotics.

Table 3: Antibiotic Resistance Profiles of Isolated Bacteria from Bottled Water Samples

Drug	IZ (mm)	Isolated bacterial isolates				Total (%)	Remarks
		BV	PT	SP	MO		
AMP	<13	12	1	7	5	25 (56)	R
	14-16	9	-	2	2	13 (30)	I
	>17	3	-	-	3	6 (14)	S
CXT	<10	9		4	2	15 (31.1)	R
	11 to 15	7		2	5	14 (34.1)	I
	>16	8	1	3	3	15 (34.1)	S
CIP	<15	16	1	5	8	30 (68.2)	R
	16-20	7	-	2	2	11 (25.0)	I
	>21	1	-	2	-	3 (6.8)	S

(p>0.05); with exception to *P. thomasi* isolates (df=54; F=0.272; p=0.0001). Similar comparison of antibacterial resistance profiles against ciprofloxacin among bacterial isolates and in respect to control bacterium (*E. coli)* showed no significant differences (df=54; F=9.984; p=0.374) with exception to *E. coli* and *P. thomasi* (p<0.001). Likewise analysis of variance for inhibition zones (antibacterial resistance profiles) produced by the isolated bacteria from different brands of bottled water samples when tested on the same antibiotics didn't show significant differences among them (X^2=12.150; p=0.428).

Prevalence rates of antibacterial resistance among the tested bacterial contaminants from different water samples ranged from 31-68%, with an average of 28 (52%) antibiotic resistant bacterial contaminants. The antibiotic resistance patterns for the tested bacterial isolates are shown in Tables **3-4**. Of 44 bacterial isolates, 25(56%) were resistant to the ampicillin, 15(31%) to co-trimoxazole and 30(68%) resistant to ciprofloxacin. Of all 9 tested *Sphingomonas* (*Pseudomonas) paucimobilis* isolates, 77.8% (n=7) and 57% (n=5) were resistant to ciprofloxacin and ampicillin respectively.

DISCUSSION

Microbiologically contaminated drinking water is a cause of both hospital and community-acquired infections. Some of well-known waterborne causes of hospital acquired infections include *Flavobacterium* species, group A streptococci, *Pseudomonas aeruginosa*, *Alicagenes fecalis, Pseudomonas*

Table 4: Comparison of Antibacterial Resistance Profiles of Contaminants Isolated from Different Brands of Bottled Water

Brand	Tested isolated bacteria/antibiotics		
	AMP	CTX	CIP
A	*B. vesicularis (R)* *P. thomasii(I)* *M. odoratum(R)*	*B. vesicularis (I)* *P. thomasii(I)* *M. odoratum(I)*	*B. vesicularis (R)* *P. thomasii(I)* *M. odoratum(S)*
B	*B. vesicularis (I)* *S. paucimobilis(S)* *M. odoratum(I)*	*B. vesicularis (S)* *S. paucimobilis(S)* *M. odoratum(I)*	*B. vesicularis (I)* *S. paucimobilis(R)* *M. odoratum(I)*
C	*B. vesicularis (R)* *S. paucimobilis(I)* *M. odoratum(s)*	*B. vesicularis (I)* *S. paucimobilis(S)* *M. odoratum(I)*	*B. vesicularis (R)* *S. paucimobilis(R)* *M. odoratum(R)*
D	*B. vesicularis (R)* *M. odoratum(R)*	*B. vesicularis (I)* *M. odoratum(I)*	*B. vesicularis (R)* *M. odoratum(I)*
E	*B. vesicularis (I)* *S. paucimobilis(S)*	*B. vesicularis (S)* *S. paucimobilis (I)*	*B. vesicularis (I)* *S. paucimobilis (R)*

thomasii, and other enteric bacteria [24]. Therefore, it has become a costume for most people, especially those who are vulnerable to infection (such as the infirm elderly, young infants, people living with HIV/AIDS, persons on immunosuppressive chemotherapy, transplant patients and the like) to use bottled water as an alternative to tap water out of concern for their safety [24]. Some leading public-health experts, therefore, argue that bottled water should be of higher microbiological quality than most foods [25, 26]. Waterborne diseases are serious health problems since can interfere with diagnosis of other infectious bacterial diseases [27]. Notwithstanding, there are direct evidences that HPC values are directly related to health risks either from epidemiological studies or from correlation with occurrence of waterborne pathogens [28]. Specific strains of microbial species that form part of HPC microbiota may cause infection in certain vulnerable people especially the immuno-compromised [12]. Likewise, misdiagnosis and under diagnosis of waterborne diseases by the medical practitioners are common and may result in morbidity for the general population and, possibly, mortality in vulnerable populations at increased risk of water-related diseases [16].

Our results revealed storage of bottled water products under direct sunlight and unhygienic conditions [21]. In view of this, the possibility of growth of microorganisms is greatly increased considering that temperatures in Dar es Salaam may be as high as 30°C. A study conducted by Nsaze & Babarinde [12] in the United Arab Emirates demonstrated that the microorganisms multiply more easily between 25 and 37°C. High temperature storage of bottled water or exposure to sunlight enhances organic and inorganic compounds leaching over a period of time [29]. Evidences indicate that this could be due to increase of total dissolved solids, chemical oxygen demand and ions like nitrates, sulphate and ammonium as well as decrease of pH as result of acceleration of organic and inorganic compounds leaching from bottled to the water [30]. Previous studies have reported even higher bacterial counts in bottle water samples as compared to tap water, which was ascribed to mineral contents of the water itself and addition of some micronutrients or trace elements such as salts potassium phosphate and magnesium sulfate that have microbial growth promoting effects [31]. Despite of high HPC values that were observed in this study, but that can hardly be attributed to water treatment methods or/and water sources; because of some water brands that had undergone similar treatment methods depicted very different HPC values (ranging from nil to being heavily contaminated). Moreover, lack of label disclosure information hindered better comparison of the water samples/brands.

Rapid microbial proliferation during water storage may be due to oxygenation of the water during processing [32], the increase in surface area provided by the bottle, the increase in temperature, and the amount of nutrients arising from the bottle [33-34]. Microbial growth may also occur *via* carriers such as introduced flakes of human skin, particularly in non-ozonated and non-carbonated water [35]. In other circumstances, bottled water manufacturers use practices that don't protect the water against contamination; these practices can remain unnoticed for extended periods of time, due to the lack of accountability in the bottled water industry [36].

In Tanzania, just like other developing countries, distribution systems of bottled water products before they reach consumers are excessively longer compared with those in most developed countries where bottled water is mostly obtained directly from authorized sellers, which are usually regulated [26]. Hence, the possibility of post-packaging contamination is greatly increased especially where street vendors, who normally operate in unsanitary conditions, are involved. Lack of water treatment for prevention of bacterial growth and poor post production handling may also partly explain the observed high rate of contamination, which is inline with some previous studies conducted elsewhere [11, 35].

Sphingomonas paucimobilis (formerly Pseudomonas paucimobilis) is an opportunistic pathogen that takes advantage of underlying conditions and diseases. Cases of pseudobacteraemia have been recorded in association with *S. paucimobilis*, as have many cases of unusual infections both invasive and severe such as septic arthritis and osteomyelitis. No cases of death have been recorded in the literature related to *S. paucimobilis* though the bacterium is more important than previously thought [37]. However, resistance to penicillins and the first-generation cephalosporins is commonly encountered. A patient with acute myeloid leukaemia who developed *S. paucimobilis* bacteremia complicated by septic shock was previously reported in Saudi Arabia [38].

The presence of *Pseudomonas s*pecies supposedly bacteria-free commercially available bottled water is of concern. Whether the species of bacteria present in the samples are pathogenic or not, the hazard of contamination and health risk to consumers should not be underestimated. *Pseudomonades* usually are associated with urinary tract infections (UTI), it can also cause bacteremia. *Brevundimonas vesicularis*, *Pseudomonas aeruginos and Pseudomonas thomasii* are common water contaminant in hospital settings. One previous study observed that even distilled water supply in a pharmacy was found to be contaminated with these *Pseudomonas* species. Disinfection of the piping system proved impracticable, and use of the water from this supply was discontinued [39]. This is because ailing people and persons with advanced HIV infection are more prone to opportunistic infections and other related microbial malignancies [12, 24].

Flavobacteria are generally commensal bacteria that live in soil and water and are opportunistic pathogens. They can be found in water and soil in many areas around the world [40]. *Myroides odoratimimus* (*Flavobacterium odoratum*) causes opportunistic infections, UTI, bacteremia, cellulitis and endocarditis. The bacterium can also cause serious diseases and affects vital organs of human especially in immune-compromised patients [41-43]. In Tunisia, *Myroides odoratimimus* had been implicated in hospital acquired infections of skin and other soft tissues, which was attributed to serious and prolonged nosocomial outbreaks of UTIs [43]. Moreover, there are two microorganisms (*Alcaligenes odorans* and *Flavobacterium breve*) that are occasionally isolated from clinical materials may be confused with *F. odoratum* [41, 44]. Hence it is recommended that *Myroides* species should be included in the differential diagnosis of skin and soft tissue infections in both immunocompromised and immunocompetent hosts, especially when the patients are not responding to routine antimicrobial treatment [45-46]. Clinicians should be aware that *M. odoratimimus* may not only induce nosocomial infections but also interfere with diagnosis of the common waterborne-diseases causing bacteria.

Water/food-borne illnesses result in a major public health impact around the world [47]. Development of antimicrobial-resistant waterborne bacterial pathogens can potentially compromise human drug treatments. The increasing incidence of antimicrobial-resistant bacterial pathogens will have serious repercussions for the future treatment and prevention of infectious diseases in both animals and humans [48]. Antibiotic resistance is considered in both hospital and community settings, as ecosystems that are separate yet blending. Microbial resistance to the antimicrobials is becoming more prevalent [41, 46, 48]. Some of the identified *M. odoratimimu* isolates were resistant to ampicillin and ciprofloxacin that are generally useful in the treatment of infections caused by gram-negative, non-fermentative microorganisms, and this suggests that infections due to this microorganism might prove difficult to treat [42].

Cotrimoxazole, useful in treatment of diarrheal related infections in HIV and AIDS patients was intermediately susceptible to the isolated contaminants. Obviously, this may have negative impact on management of opportunistic and microbial infections for which the drug is indicated. Cotrimoxazole prophylaxis has been recommended as part of the essential care and support package for symptomatic HIV-infected individuals in sub-Saharan Africa since 2000 [49]. The drug has proved to be useful in treatment and prophylaxis of *Pneumocystis jirovecii pneumonia,* and other diarrheal related *Isospora belli* and *Cyclospora cayetanensis* infections. The effect of cotrimoxazole on mortality reduction among persons with HIV in Africa is now well documented [50-52]. Therefore, isolation of bacterial contaminants in bottled drinking water that are presumed to be safe raises major health concerns. Cotrimoxazole and ciprofloxacin have been jointly used for treatment and prophylaxis of Isospora belli and *Cyclospora cayetanensis* infections in HIV-infected patients [53]. In the present study, *Brevundimonas vesicularis and Sphingomonas paucimobilis* were found to be resistant to ciprofloxacin, which means ingestion of such contaminated water by already sick patients might worsen their health status.

Researches on the microbial content of bottled drinking water in developed countries revealed relatively lower prevalence rates of microbial contaminants in bottled water (6-12%) [12, 14, 54] compared to 86% observed rate of in this study. The present study depicts slight decline in prevalence rate of microbial contamination in bottled water (86.3%) as compared to (96%) previously observed in 2007; though antibacterial resistance tests were not conducted [4]. Moreover, our results show that there are no microbial indicators of faecal contamination in contrary to previous study's findings. Public health education on prevention and control of water borne and communicable diseases could have positively impacted on the general public and bottled water producers and thus led to significant decreased rate of HPC values in the analyzed water samples.

In conclusion, high HPC values were observed in the bottled water available in the market. Only one brand of bottled water was free from microbial contaminants. Four bacterial species namely *B. vesicularis, P. thomasii, M. odoratam* and *S. paucimobilis* were isolated and identified. About 52% (n = 28) of the isolated bacteria were resistant to one or more of the antibiotics. The highest rate of antibiotic resistance was exerted on ciprofloxacin (68.2%). Poor storage conditions of the products, high temperature and defective packaging to great extent attributed to high HPC values in the assessed bottled water samples. Thus a call is made for TFDA and TBS to enhance inspection of bottled water production units and ensure good manufacturing practice guidelines are strictly adhered to. Moreover, the public need to be well informed on the potential health hazards of using such microbiologically contaminated bottled water to avert possibility of water borne-diseases and resultant complications.

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