Qualitative and Bacteriological Assessment of Commercially Available Bottled Water in the City of Mymensingh, Bangladesh

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A B S T R A C T

Bottled water has become one of the most popular drinks in Bangladesh. Now a days it is easily available in the market. The objectives of this study were to assess the overall quality (qualitative and bacteriological) of bottled water samples in the city of Mymensingh, Bangladesh. For achieving the objectives, standard questionnaire, methods of heterotrophic plate count (HPC) and total coliform count (TCC) were applied. Qualitative assessment of bottled water indicated that a good number of people preferred bottled water to tap water. The criterion in order to qualify for a 'good bottled water' was the taste (43.3%). The bottled water quality was satisfactory in 40% of the responders in this study on the basis of peoples' satisfactions, perceptions and expenditures on bottled water quality. On the other hand, the percentage of dumping of bottled water after consumption refuse was 33.3%. Monthly expenditure on bottled water was less than 300 taka in 80% of the responders. The geometric mean of HPC of different brands of bottled water ranged from 2.9×10^3 cfu/100 ml to 6.2×10^3 cfu/100 ml. In addition, the geometric mean of TCC of different brands of bottled water ranged from 9 cfu /100 ml to 43 cfu /100 ml. The results indicate that most of the bottled water studied were out of their safety guidelines. Recommendations for better treatment systems for bottled drinking water to address the issue appears to be essential.

Keywords: Quality, Bacteriological Assessment, Bottle Water

Introduction

The World Health Organization has estimated that up to 80% of all sicknesses and diseases in the world are caused by inadequate sanitation, polluted water or unavailability of water. It was estimated that nearly 1.5 billion people lack safe drinking water and that at least 5 million deaths per year can be attributed to water- borne diseases. Health effects associated with water supplies in developing countries are based on four bacterial indicators of tropical drinking-water quality (faecal coliforms, *Escherichia coli*, *Enterococci* and faecal *Streptococci*) and their relationship to the prevalence of diarrhoeal disease in Cebu, Philippines (Moe *et al.* 1991). The contaminated water or inadequate supply of safe drinking water causes various gastrointestinal diseases like diarrhoea, dysentery and other water-borne diseases like cholera and typhoid. It is now evident that most of the enteric diseases of human and animals are transmitted through contaminated food and water (Johnson *et al.* 2003). The transmission of waterborne diseases is still a matter of major concern, despite worldwide efforts and modern technologies are being utilized for the production of safe drinking water (Venter, 2000). This problem is not only confined to the developing world where water treatment may not exist or is inadequate, but also in some developed countries. There may also be contamination during storage, lack of regulations, limited understanding and awareness among the population (American Academy of Microbiology, 1996).

Effective marketing and a general skepticism on the quality of tap water resulted increased consumptions of bottled/dispenser waters (Liguori *et al.*, 2010). As neither treatment nor bottling or materials shall otherwise change the natural composition of the water, large bacterial populations usually develop from small initial populations shortly after production (Loy et al., 2005). Although the concept of safe water is much discussed and is under consideration to address in Bangladesh, there is no or little science-based information available. Therefore, the present study was conducted to determine the qualitative and bacteriological assessments of bottled water available in the open market in Mymensingh city, Bangladesh.

Materials and Methods

Collection of bottled water samples

A total of 30 bottled water samples from 5 different domestic brands (5 from each brand) were collected randomly from retail stores in Mymensingh, Bangladesh during October to November, 2012. After collecting water samples in a conical flask, the mouth and neck of flask was covered with aluminum foil and taken to the bacteriology laboratory of the Department of Microbiology and Hygiene, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh for detail investigation.

Questionnaire for qualitative assessment

To acquire a public perception regarding bottled water in the Mymensingh city of Bangladesh, a questionnaire survey was designed (questionnaire not shown).

Heterotrophic Plate Count (HPC)

For the determination of heterotrophic plate count, 100 micro liter of a tenfold serial dilution of bottled water and 100 micro liters of a tenfold serial dilution of tap water from original samples were transferred and spread onto a nutrient agar media using micro pipette for each dilution. The diluted samples were spread as quickly as possible on the surface of plate with a sterile glass spreader. One sterile glass spreader was used for each plate .The plates were then incubated at 37ºC for 24-48 hours. Following incubation, plates exhibiting 30-300 colonies were counted. The heterotrophic plate count was calculated according to ISO (1995). The result of total bacterial count was expressed as the number of organism or colony forming units per milliliter (CFU/ml) of water samples.

Total Coliform Count (TCC)

For the determination of total Coliform count, 100 micro liter of serial tenfold dilution of bottled water and 100 micro liters of serial ten fold dilution of tap water from original samples were transferred and spread on MacConkey agar media using micro pipette for each dilution. The diluted samples were spread as quickly as possible on the surface of plate with a sterile glass spreader. One sterile glass spreader was used for each plate .The plates were then taken in an incubator at 37ºc for 24-48 hours. Following incubation, plates exhibiting 30-300 colonies were counted. The average number of colonies in a particular dilution was multiplied by the dilution factor to obtain the total Coliform count. The total Coliform count was calculated according to ISO (1995). The result of total bacterial count was expressed as the number of organism or colony forming units per milliliter (CFU/ml) of water samples.

Data analysis

For data processing, Microsoft Excel spreadsheet (2007) and SPSS16 were used.

Results

Qualitative assessment

The qualitative assessment of bottled water is evaluated by responder's perception using the questionnaire provided in the section of Materials and Methods. The distribution of the study subject as per demographic and bottled water consumption is summarized in Table 1. Among the respondents, the maximum (60%) belong to the age group of 12-24 years, where the lowest (13.3%) presenting the age groups of 37+ years. In terms of educational qualification, the highest numbers (66.7%) were undergraduate respondents, followed by Higher Secondary School Certificate (H.S.C.) examination candidates (10%). During the study period it was observed that, for the most part (60%) of the respondents were living in Mymensingh city for 0 to 10 years, followed by 11-20 years (30%) and 21+ years (10%). It was observed that, out of 30 respondents, the highest (90%) number of respondent was overwhelming bottled water in diverse situations for different purpose. A total of 70% respondents said that they had been consuming bottled water for longer period of time because of health consciousness. Scarcity of treated drinking water is another important reason of consumption of bottled water (estimated around 13.3%). The other reasons include the easy access to the bottled water from various sources and the ease of portability, as opined by the responded 10% and 6.7%, respectively. Around 50% of the total respondents were consuming bottled water for 6-10 years and 43.3% of the respondents were found to consume bottled water for a period of 11+ years. About 6.7% respondents were also found to consume bottled water for a period of 0-5 years. In the present study, it was observed that the respondents were distinguishing good or bad bottled water on the basis of some criteria. The highest number of respondents (43.3%) prioritized taste while choosing good quality bottled water. About 20% and 16.7% of the respondent also viewed that, clarity and mineral composition of the water respectively, should also be considered as deterministic criteria to be good quality bottled water.

Bangladesh Standards and Testing Institution (BSTI) approval ranked third (10%), as the criteria for selecting good quality bottled water. Only a few, 6.7% and 3%, rely on outlook and popularity as a deterministic criterion to be good quality bottled water, respectively.

The responders' satisfactions, perceptions and expenditures on bottled water quality are summarized in Table 2. A total of 40% of the respondents considered that the quality of bottled water has been satisfactory, on the contrary to the 30% of the respondents, who judged that, the quality of bottled water was not that satisfactory. However, the 20% of the respondents didn't know whether the quality of the bottled water was good or bad.

During the study period, respondents were asked whether they consumed bottled water instead of municipal water, if the quality were highly maintained. Highest (50%) number of respondents positively reacted, while 20% of the respondents replied that, they would not do so. A good number (30%) of respondents were in doubt. During the study period, 46.7% respondents expressed that the price of bottled water was satisfactory in comparison with the quality they were getting. However, 40% thought that the price of bottled water was not so satisfactory. It was observed that, 80% respondents' monthly expenditures on bottled water was less than 300 taka. A total of 13.3% respondents were found whose monthly expenditure for buying bottled water was more than 500 taka. During the study period, respondents were asked about the consequence of the empty bottled water after consumption. A total of 26.7% respondents alleged that they throw the bottles anywhere after consuming the water from the bottles. A total of 40% respondents replied that they dumped the bottles in dustbins, and 33.3% said they reused those bottles. Again when the respondents were asked whether the dumping of empty water bottles to open spaces or roadsides could be hazardous for environment, 80% respondents considered that the empty bottles could be environmentally hazardous due to their non biodegradable plastic content as well as for clogging of drainage system. 3.3% respondents thought that it was not so environmentally hazardous compared to 6.7% respondents who never thought about such problem. Respondents were also asked whether the contaminated bottled waters were adverse for health or not. A total of 70% of the total respondents had the realization that the contaminated bottled water would adversely affect human health, whereas about 10% considered it would not affect the human health, and the 20% had no idea on this issue. A total of 76.7% respondents told that they consumed bottled water only when they were outside the home, whereas about 10% respondents were found to consume bottled water every day, while a good number (13.3%) of respondents only consumed bottled water in fast food stores and restaurants.

Bacteriological assessment

Heterotrophic plate count (geometric mean) of bottled water was presented in Table 3. The geometric mean of HPC of brand A, brand B, brand C, brand D, brand E and brand F bottled water were 3.7×10^3, 4.1×10^3, 6.2×10^3, 4.0×10^3, 2.9×10^3 and 5.2×10^3 cfu / 100 ml, respectively. However, the total geometric mean of HPC of different brands of bottled water was 4.3×10^3 cfu/100 ml.

The summary of total coliform count in bottled water is presented in Table 4. The geometric mean of TCC of brand A, brand B, brand C, brand D, brand E and brand F bottled water were 18, 12, 26, 12, 9, 43 cfu /100 ml respectively.

Discussion

The objective of this research work was to assess the overall quality of bottled water (both qualitative and bacteriological) available in Mymensingh city of Bangladesh. Qualitative assessment of bottled water indicated that a good number of

Table1. Demographic attributes towards bottled water consumption

Varibles		No. of samples	Frequency (%)
Age groups	12-24 25-36 37+	30	18 (60) 8 (26.7) 4 (13.3)
Educational Qualification	H.S.C Undergraduate Postgraduate	30	3 (10) 20 (66.7) 7 (23.3)
Year of living of Mymensingh city	0-10 11-20 21+	30	18 (60) 9 (30) 3 (10)
Consumption of bottled water	Yes No	30	27 (90) 3 (10)
Cause of preference for bottled water	Health consciousness Easy access to bottled water Scarcity of treated drinking water Ease of portability	30	21 (70) 3 (10) 4 (13.3) 2 (6.7)
Bottled water consumption Duration in years	0-5 6-10 11+	30	2 (6.7) 15 (50) 13 (43.3)
Criteria to be a good bottled water	Clarity Taste Popularity BSTI approval Mineral composition Outlook	30	6 (20) 13 (43.3) 1 (3) 3(10) 5 (16.7) 2(6.7)

Table 2. Consumers perceptions towards bottled water quality

Variables		No. of samples	Frequency (%)
Perception	Satisfactory Not satisfactory Not known Never thought about	30	12 (40) 9 (30) 6 (20) 3 (10)
Substitute of municipal water	It Yes No Not known	30	15 (50) 6 (20) 9 (30)
Price	Satisfactory Not satisfactory Not known Never thought it	30	14 (46.7) 12 (40) 1 (3.3) 3 (10)
Post consumption dumping place	Throw Anywhere Throw to Dustbin Refuse it	30	8 (26.7) 12 (40) 10 (33.3)
Monthly expenditure	Less than 300 taka 300 taka-500 taka More than 500 taka	30	24 (80) 2 (6.7) 4 (13.3)
Effect of contamination	Adverse Not so adverse Not known	30	21 (70) 3 (10) 6 (20)
Effect of indiscriminate dumping	Hazardous Not so hazardous Not known Never thought of it	30	24 (80) 1 (3.3) 3 (10) 2 (6.7)
Frequency of consumption of bottled water	Everyday Only outside Fast food shop	30	3 (10) 23 (76.7) 4(13.3)

Table 3. Determination of heterotrophic plate count in bottled water

Brand of bottled water	Sample code	HPC (cfu/100 ml)	Geometric mean of HPC (cfu/100 ml)	Total Geometric mean of HPC (cfu/100 ml)
A	MW_a1	3.5×10^3	3.7×10^3	4.3×10^3
	MW_a2	4.0×10^3		
	MW_a3	3.6×10^3		
B	MW_b1	4.5×10^3	4.1×10^3	
	MW_b2	4.3×10^3		
	MW_b3	3.6×10^3		
C	MW_c1	6.3×10^3	6.2×10^3	
	MW_c2	5.8×10^3		
	MW_c3	6.7×10^3		
D	MW_d1	3.2×10^3	4.0×10^3	
	MW_d2	3.5×10^3		
	MW_d3	5.3×10^3		
E	MW_e1	2.7×10^3	2.9×10^3	
	MW_e2	3.7×10^3		
	MW_e3	2.4×10^3		
F	MW_f1	5.4×10^3	5.2×10^3	
	MW_f2	5.8×10^3		
	MW_f3	4.6×10^3		

HPC = Heterotrophic Plate Count.

Table 4. Determination of total coliform count in bottled water

Brand of bottled water	Sample code	TCC (cfu/100 ml)	Geometric mean of TCC (cfu/100 ml)
A	MW_a1	12	18
	MW_a2	19	
	MW_a3	22	
B	MW_b1	7	12
	MW_b2	13	
	MW_b3	17	
C	MW_c1	23	26
	MW_c2	27	
	MW_c3	29	
D	MW_d1	15	12
	MW_d2	9	
	MW_d3	11	
E	MW_e1	6	9
	MW_e2	9	
	MW_e3	13	
F	MW_f1	39	43
	MW_f2	43	
	MW_f3	48	

TCC = Total Coliform Count.

people preferred bottled water rather than tap water in this study. The age group belonging to 12-24 years preferred bottled water mostly (60%). However, 66.7% undergraduate student preferred bottled water for their daily consumption. In this study, the cause of preference of bottled water was health consciousness, which is 70% of the total peoples. The criteria to be a good bottled water was taste (43.3%). The bottled water quality was satisfactory in 40% of the peoples in this study on the basis of people's satisfaction, perception and expenditure on bottled water quality. On the other hand, the percentage of dumping of bottled water after consumption refuse was 33.3%. Moreover, monthly expenditure on bottled water was less than 300 taka in 80% of the total people. The findings of the present study are more or less similar to the findings of Majumder *et al.* (2011).

Heterotrophic plate count and total coliform count are commonly used to assess the general microbiological quality of bottled water. The HPC of bottled water of different brands such as A, B, C, D, E, and F were 3.7×10^3, 4.1×10^3, 6.2×10^3, 4.0×10^3, 2.9×10^3 and 5.2×10^3 cfu/100 ml respectively in this study. HPC was found lowest in brand E bottled water but highest in brand C bottled water in this study. However, the total geometric mean of HPC of different brands of bottled water was 4.3×10^3 cfu/100 ml in this study. According to the world health report (2002), drinking water quality specifications world-wide recommend HPC limits 50 cfu/ml in bottled water. In case of HPC, the findings of the present study differ with the findings of Islam *et al.* (2010) who found the geometric mean of mineral water was 1.0×10^2 cfu/100 ml. On the other hand, Zam *et al.* (2010) found the values of HPC between less than 10 and 72,000 cfu/ml for ten different brands of bottled water. Furthermore, the geometric mean of TCC of different brands such as A, B, C, D, E, and F were 18, 12, 26, 12, 9, 43 cfu /100 ml respectively. TCC was found lowest in brand E bottled water but highest in brand F bottled water in this study. In this study, brand E bottled water was found to be best in terms of microbiological quality when compared with other brands of bottled water available in Mymensingh city of Bangladesh. However, not a single brand was found totally free from coliform. The presence of total and fecal coliform in bottled water samples has been reported to be due to poor hygienic practices of the producers, failure to wash hands, illiteracy and unhygienic practices of vendors (Coroler *et al.,* 1996).

Conclusion

The bottled water market has steadily increased over the last decade and is now the largest category of commercial beverage sold by volume in Bangladesh. Many prefer bottled water over tap water for a number of reasons. People may not like the taste, smell or color of bottled water, but they continue to drink bottled water despite quality concerns. On the other hand, some people are worried about their health and perceive bottled water as more natural, pure and a healthier alternative to supplied water by local authorities. Therefore, ever-increasing demand for bottled water is continuing in Bangladesh. Quality differences among different brands of bottled water were observed. Analysis of 30 bottled water samples showed a wide assortment of microbial qualities. Generally, bottled water is good for drinking in Bangladesh. However, bottled water quality in Bangladesh needs to be monitored regularly. Indeed, it is a requirement that a tri-monthly monitoring should be carried out on water quality of bottled water of different brands, generally by BSTI and by the Ministry of Health in Bangladesh.

Acknowledgement

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