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Assessing the drinking water Quality of locally available bottled water in Batticaloa District, Sri Lanka

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Abstract

This study was aimed to determine the physiochemical and microbial quality of bottled water, available in Batticaloa district, Sri Lanka. Twenty bottled water samples, sold in the local markets in this district, were collected. All the samples showed the aerobic bacterial counts and the concentration of the total Coliforms within the limits of World Health Organization (WHO) standards. Whereas, the pH, fifteen brands of bottled water were below the limit, recommended by the WHO (6.5 - 8.5), and varied from 4.97 - 6.40. The total hardness was from 0.4 - 5.2 mg/l for three brands, out of 20 different brands of bottled water, tested. The permissible level of total hardness by WHO is 250 mg/l. The chloride values vary from 1.06 - 1.9 mg/l for five brands, whereas the acceptable level of chloride by WHO is 250 mg/l, which shows the concentrations of minerals were lower than the recommended level by WHO. However, colour, electric conductivity, turbidity, nitrate, fluoride, phosphate, total hardness, iron, coliform, aerobic bacterial counts, total dissolved solids, chemical oxygen demand, dissolved oxygen and sodium and the potassium level were within the limits of Sri Lankan Standard (SLS) and WHO. The results show that the microbial quality of the bottled water brands, available in the study area, comply with the WHO and Sri Lankan standard.

Key words: Bottled drinking water, Physiochemical parameters, Microbial quality.

1. Introduction

Water is the most important resource for humans. It forms 50 to 60% of body weight and play an active role in all the vital processes of our body (Kawther *et al*., 2007) The chemical quality of drinking water during recent years has been deteriorated considerably due to the presence of toxic elements, which even in trace amounts could cause serious health problems (Ikem, *et al*,.2002).

Expansion of industries, agriculture, population growth, and increasing use of harmful chemicals, the geographical factors, lead to the contamination of drinking water, occurs through a range of chemical, microbial, and physical hazards which cause health risks when present at high levels (Madarasinghe, 2015).

Bottled water industry has grown dramatically in the last few decades, and today millions of people around the world in developed and developing countries consume bottled water regularly (Soupioni *et al*., 2006).

The demand for safe and high-quality drinking water by world's growing population has dramatically increased. The main consequence of this perception is the increased in the consumption of processed and bottled water and the number of new brands introduced to the market have increased significantly (Herath *et al*., 2012).

The integrity of the bottled in the stores could also the compromised by poor storage condition, for instance those in high relative humidity in non-air conditioned and inadequately ventilated storage rooms (Duranceau, *et al*., 2012).These conditions may result in water condensation, which can lead to the development of biofilms penetrating the internal surface of the bottle, especially in bottles with inconsistent sealing systems after bottling. Also, the possibility of re-growth of sub-lethally injured bacterial cells or low-level bacterial species in the bottles could occur even after being sealed (Jayasekara, *et al*., 1999).

Hence, there is a need to assure the physiochemical and microbial quality of the bottled drinking water, available at local markets of this district. And therefore, this study was carried out to assess the drinking water qualityof bottled water, available in the local markets of Batticaloa district, Sri Lanka.

2. Material and Methods

Collection of water samples

A total of twenty brands of bottled water were collected from retail outlets in the study area. Parameters such as colour, pH, Electric conductivity, Turbidity, Nitrate, Fluoride, chloride, Phosphate, Total hardness, Iron, coliform and *E. coli*, Aerobic bacterial counts COD, DO, Na and K determination were analysed.

Analytical measurement

Table 1: Methodology, used to measure the physiochemical parameters

S.No	Parameters	Equipment /Methods
1	Colour	HACH DR 2800 Spectrophotometer
2	pH	HACH 5475020pH meter
3	Electric conductivity	HACH 5475020 Electric conductivity meter
4	Turbidity	HACH 2100P Portable Turbidity meter
5	Nitrate	HACH DR 2800 Spectrophotometer
6	Fluoride	HACH DR 2800 Spectrophotometer
7	Chloride	HACH Digital Titrator

8	Phosphate	HACH DR 2800 Spectrophotometer
9	Total hardness	HACH Digital Titrator
10	Iron	HACH DR 2800 Spectrophotometer
11	Sodium	Flame photometer (FP 902-5) PG Instrument
12	Potassium	Flame photometer (FP 902-5) PG Instrument
13	TDS	HANNA Potable meter (HI 98130)
14	COD	Back titration method
15	DO	HACH Sension TM +DO6 Meter
16	Coliform	Membrane filter method

3. Results and discussion

Colour, pH, Electrical conductivity and Turbidity

This investigation indicated that colour value was ranged from 0 - 15. All the colour values of these bottled water were within the acceptable level.

The pH values in all the samples tested during the study period range from 4.97 - 7.46

In the present study, EC value was ranged from 7.79 - 236 µS/cm. EC contents of bottled water samples were lower than recommended level (750 µS/cm). Overall mean of EC of 20 brands is lesser than SLS recommendation. When considering the turbidity values, it ranged from 0.15 - 0.40 NTU. Turbidity contents of bottled water samples were lower than recommended level (2 Nephelometric Turbidity Units).

Turbidity of all 20 brands was lesser than SLS recommendation and was 2 NTU.

Nitrates

The results wasranged from 0.53 - 2.06mg/L, and all values of the tested samples'nitrate level was below the permissible limits.

Fluoride

Fluoride is an essential element of normal growth and development of humans. Excessive amounts of F—(4 mg/L) in water supply may result in teeth molting and skeletal. Fluorosis, whereas low levels (1.0 mg/L) result in diminishing caries reduction (WHO. Guidelines for Drinking-water Quality, 2004)

In this study, the values of fluoride ranged from 0 - 0.42 mg/L, where the recommended value for fluoride is 1.0 mg/l. All the values are within SLS and WHO guidelines.

Chloride

According to SLS standard, permissible limit of chloride is 250 mg/L. Drinking water is often chlorinated for disinfection. The values of chloride range from 1.1 - 29.63 mg/L. All the values are within SLS and WHO guidelines.Chloride concentrations in excess of about 250 mg/liter can give rise to detectable taste in water, but the threshold depends upon the associated cations (WHO. Guidelines for Drinking-water Quality, 2003)

Phosphate

The values of phosphate range from 0.01-0.36 mg/l which is remarkably lower than Sri Lankan Standard. The highest value of phosphate is seen for brand N (0.36 mg/l). Most of the brands were showed very lower phosphate level except Brand I (0.15 mg/l) and Brand N (0.36 mg/l).

Hardness

Present study showed that, hardness of 20 bottled water soldin Batticaloa district was ranged from 0.4(±0.2) mg/l to 72.3(±0.3) mg/l. The minimum value of total hardness was 0.4mg/Lfor brand F and 0.8 mg/L for brand O. while the maximum values was 72.3mg/L for brand I.Thus, all the values are within acceptable limits.

Overall mean of hardness of 20 brands is lesser than SLS recommendation and WHO standards.

Inadequate intakes of calcium have been associated with increased risks of osteoporosis, colorectal cancer, hypertension and stroke, coronary artery disease, insulin resistance and obesity.

Table: 2 Physical and chemical parameters of collected bottled drinking water samples

Parameter	Unit	Minimum	Maximum	Mean±SD	Sri Lankan permissible limit	WHO permissible limit
Colour	-	0	15	4.1 ±3.33	15	15
pH	-	4.97	7.46	6.048 ± 0.68	6.5 - 8.5	6.5 - 8.5

Electric Conductivity	µS/cm	7.79	236	91.83 ± 70.06	750	400
Turbidity	NTU	0.15	0.40	0.21 ± 0.07	2	2
Nitrate	mg/l	0.53	2.06	1.08 ± 0.41	50	50
Phosphate	mg/l	0.01	0.36	0.06 ± 0.07	2	2
Fluoride	mg/l	0	0.42	0.17 ± 0.13	1	1.5
Chloride	mg/l	1.1	29.63	6.62 ± 7.04	250	250
Iron	mg/l	0	0.04	0.01 ± 0.008	0.3	0.3
TDS	mg/l	0	220	55.5 ± 67.63	500	1000
Potassium	mg/l	0.08	9.5	2.52 ± 2.34	12	12
Sodium	mg/l	1.11	21.93	7.59 ± 6.29	200	200
COD	mg/l	3.21	9.60	7.62 ± 1.98	10	10
DO	mg/l	0.20	2.85	1.14 ± 0.68	5	5

Each value represents the mean ± SD of three determinations

Total Iron

Iron has got a little concern as health hazard, but it still is considered as a nuisance in excessive quantities. In the present study, the values of iron range from 0 - 0.04 mg/L and lies below the acceptable limits.

If iron supplements taken in excess, it can cause nausea, vomiting, diarrhoea and even death (WHO. Guidelines for Drinking Water-Quality, 2003).

Total Dissolved Solids (TDS)

The concentration of TDS in the present study was observed in the range from 0 - 220 mg/l. Higher TDS level was observed in the Brand T (200 mg/l) and Brand I (220 mg/l). The WHO has set the permissible limit of TDS to 1000 mg/L (WHO. Guidelines for

Drinking Water Quality, 1996) and the SLS permissible limit 500 mg/l.

Potassium

The concentration of potassium in available bottled waters ranged from 0.08 to 9.5 mg/1. The maximum Potassium content is 9.5mg/l in brand N and the minimum level of Potassium content in Brand F (0.08 mg/1). All the values are within SLS and WHO guidelines.

Sodium

Present study shows the Sodium concentration range from 1.11(±0.06) mg/L to 21.93(±2.65) mg/L. Maximum level of sodium concentration available in the tested bottled water sample was 21.93 mg/L in Brand M. SLS recommended value of sodium is 200 mg/L .Sodium levels in the latter are typically less than 20 mg/liter but can markedly exceed this in some countries. Sodium may affect the taste of drinking-water at levels above about 200 mg/liter(WHO. Guidelines for Drinking Water-Quality, 2003).

Chemical Oxygen Demand (COD)

Chemical oxygen demand (COD) is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water.The presence study indicated that COD value was ranged from 3.21 - 9.60 mg/l. COD contents of bottled water samples were lower than recommended level. Overall COD value of 20 brands is lesser than SLS recommendation.

Dissolved Oxygen (DO)

It is a very important water quality parameter and is also an index of physical and biological processes going on in water.In Batticaloa district all the 20 bottled water DO values were below the permissible limits.

Analysis of Bacterial contamination

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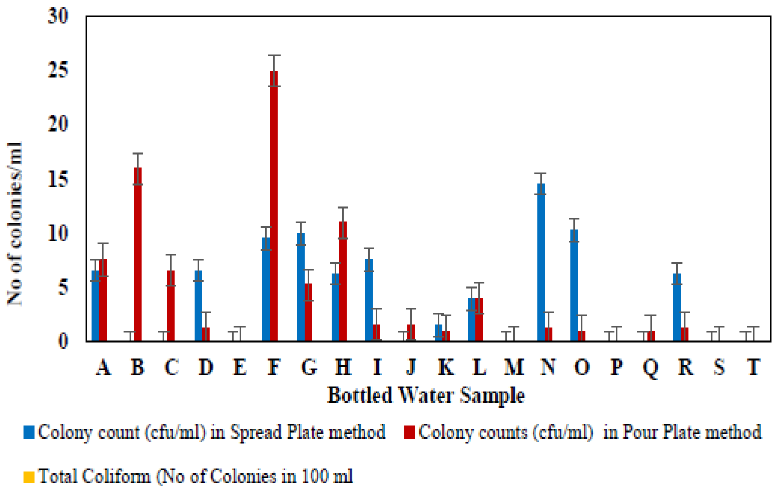
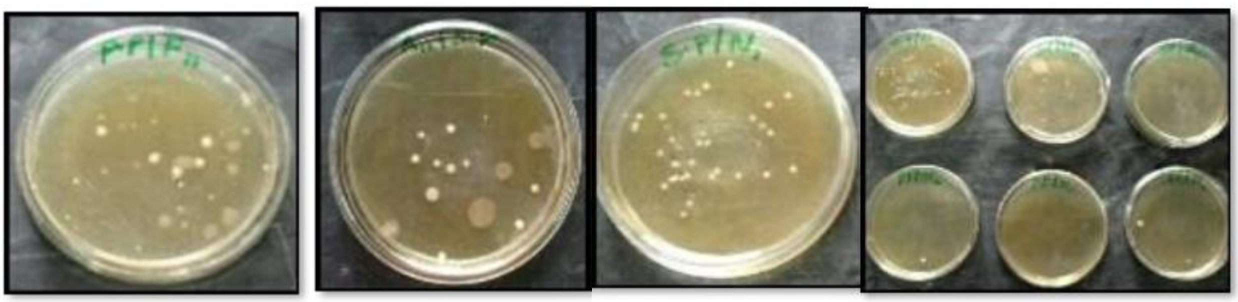


Fig. 1: Microbial contamination of different brands of bottled drinking water

Figure 1 shows the aerobic bacterial count present in different brands of bottled water samples. Total bacterial count by spread plate methods varied from 0 to 14.6 cfu/ml. Among the bottled water brands B, C, E, J, M, P, Q, S & T did not have aerobic bacterial contamination and the remaining samples showed aerobic bacterial contamination less than the minimum level recommended by SLS (1×102 cfu/ml). In pour plate methods Bacterial colonies varied from 0 to 25 cfu/ml.

Among the bottled water brands E, M, P, S & T did not have bacterial colonies. But rest of the brands showed less number of colonies, less than the minimum level recommended by SLS (1×102 cfu/ml).



i ii iii iv

Figure 2: Culture of Aerobic Bacterial Colonies from bottled water samples

i. Colonies from brand F in pour plate culture
ii. Colonies from brand A in spread plate culture
iii. Colonies from brand N in spread plate culture and
iv. Colonies from brand N in both spread plate and pour plate culture

According to the Sri Lankan Standard, acceptable aerobic bacterial count is 1×102 cfu /mL. The present study reveals that the microbiological quality of drinking bottled water samples from the study area were within the acceptable standards and all the samples were of satisfactory microbiological quality. The improper storage of the products also can providesfavorable conditions for the bacteria to grow up to harmful levels (Khatoon *et al*., 2010). Total counts of microorganisms can be used as an indicator of the sanitary quality of bottled water (Arifa,2011).Further; the results revealed that the tested samples are not polluted by any harmful bacteria too, since they do not have the contamination of coliform bacteria too. Microbiological quality Analysis of commercially prepared bottled drinking water in Kandy, Sri Lanka reveal that, all the 10 sample brands of bottled drinking water only 3 samples gave positive results to total coliform test (Dissanayake, 2017).

Correlation between various constituents

Table 6 shows the Pearson's correlation between physicochemical characteristics of water samples. According to Taylor,1990the correlation coefficient, $r \leq 0.35$ represent weak correlations, r value of 0.36-0.67 indicate moderate links, and r value of0.68-1.00 signify strong relationships.

Bottled water samples show strong positive correlation (r= 0.68-1.00) for pH and EC, Total Hardness, between EC and TDS, TH , Cl^-, Sodium, between TDS and TH, between $Cl^-$and TH, between Iron and TH, while moderate correlation (r=0.36-0.67) exit between pH and TDS, Cl^- , Po_4^{3-} , F^- , Iron, Na, K Between EC and No_3^- , Po_4^{3-} , F^- , Iron , K , Between TDS and No_3^- , Cl^- , Po_4^{3-}, F^- , Iron, Na, K , Between No_3^- and Cl^- , F^- ,TH, Na, K, Between Po_4^{3-} and Iron, TH, Between F^- and TH, Cl^- ,Between Cl^- and Na, K, Between TH and Na, K, Between Na and K. weak correlation ($r \leq 0.35$) exits between pH and No_3^- ,between DO and NO_3^- , K, between NO_3^- and Po_4^{3-} , Iron, between Po_4^{3-} and Cl^- , F^- , Na, Between F^- and Na, K,between CL^- and Iron, between Iron and Na , K.

Bottled water samples showed strong positive correlation (r= 0.68-1.00) for pH and DO, between EC and TDS, TH , Cl−, between TDS and TH, Cl−, between DO and Fe^{2+}, between TH and Cl−, while moderate correlation (r=0.36-0.67) exit between NO3- and Fe2+, and weak correlation (r≤ 0.35) exits between pH and Fe2+,between EC and NO3-, between TDS and NO3-, Fe2+, between DO and SO42−, Ca2+, between TH and NO3- and also between SO42− and Fe2+ (Mihayo, 2017).

Table 6: Correlation matrix for water physical and chemical parameters in the bottled drinking water brands

	pH	EC	DO	TDS	No_3^-	Po_4^{3-}	F^-	CL^-	Iron	TH	Na^+	K^+
pH	1.00											
EC	**0.77**	1.00										
DO	-0.34	-0.20	1.00									
TDS	**0.59**	**0.87**	-0.10	1.00								
Nitrate	0.13	**0.51**	0.04	0.48	1.00							
Phosphate	0.45	**0.55**	-0.20	0.39	0.29	1.00						
Fluoride	**0.57**	**0.54**	-0.21	0.47	0.37	0.23	1.00					
Chloride	**0.52**	**0.71**	-0.09	**0.54**	0.42	0.27	0.46	1.00				
Iron	0.49	**0.61**	-0.20	**0.64**	0.24	**0.59**	0.34	0.15	1.00			
TH	**0.69**	**0.91**	-0.15	**0.91**	0.35	**0.56**	0.41	**0.68**	**0.68**	1.00		
Sodium	**0.58**	**0.70**	-0.03	**0.58**	0.38	0.18	0.17	0.39	0.31	**0.51**	1.00	
Potassium	**0.52**	**0.58**	0.17	**0.39**	0.45	**0.67**	0.33	0.42	0.27	0.48	0.44	1.00

Correlation coefficients that is higher than 0.50 are indicated in bold.

Conclusion

The bottled drinking water, although thought to be pure, cannot be relied upon for its safety. Various physio-chemical parameters like colour, DO, hardness, total iron, phosphate, nitrate, pH, etc. were analyzed using standard methods of APHA. All the Physio-chemical parameters such as DO, hardness was within SLS and WHO acceptable limits. Nitrates were found in small quantities but within the limits set by WHO. Hence, it can be concluded that, out of 20 tested bottled water only 5 showed the acceptable level of physical chemical and microbial qualities as per the WHO standard. Hence, necessary steps have to be taken to assure the quality of bottled water samples as it's not maintained always. Also, the bottled water that are without any slandered labels in local markets, have to be checked before use by the public. In addition, all the bottled water companies should fulfil the basic water quality standards given by the Government of Sri Lanka.

5.Acknowledgment

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6. References

[1] Arifa T, Microbial Examination of Bottled water available in local market of Lahore. Journal of Applied Pharmacy, 04(03): 431- 437, (2011).

[2] Dissanayake D M L N K, Microbiological Quality Analysis of Commercially Prepared Bottled Drinking Water in Kandy, Sri Lanka. International Journal of Advanced Scientific Research and Management, 2:36-38, (2017).

[3] Duranceau S, Emerson H P and Wilder R J, Impact of bottled water storage duration and location on bacteriological quality. International Journal of environmental health research, 22(6):543-559, (2012).

[4] Herath A T, Abayasekara C L, Chandrajith R and Adikaram N K B, Temporal variation of microbiological and chemical quality of noncarbonated bottled drinking water sold in Sri Lanka. Journal of food science, 77 (3):160-164, (2012).

[5] Ikem A, Odueyungbo S, Egiebro N O and Nyavor K, Chemical quality of bottled waters from three cities in eastern Alabama. Science and Total Environment, (285): 165-75, (2002).

[6] Jayasekara N Y, Heard G M, Cox J M, and Fleet G H, Association of microorganisms with the inner surfaces of bottles of non –carbonated mineral waters. Food Microbiology, 16(2):115-128, (1999).

[7] Kawther F and Alwakeel S, Mineral and microbial contents of bottled and tap water in Riyadh, Saudi Arabia. Middle-East Journal of Scientific Research, (3): 151-6, (2007).

[8] Khatoon A and Pirzada A Z, Bacteriological quality of bottled water brands in Karachi, Pakistan. Biologia (Pakistan), 56 (1&2), 137-143, (2010).

[9] Madarasinghe P, Natural Mineral Water and Bottled Drinking Water. Vidurava, 29(03):34-39, (2015).

[10] Mihayo I Z and Mkoma S L, Chemical Water Quality of Bottled Drinking Water Brands Marketed in Mwanza City, Tanzania. Research Journal of Chemical Sciences, 2(7): 21-26, (2012).

[11] Soupioni M J, Symeopoulos B D andPapaefthymiou H V, Determination of trace elements in bottled water in Greece by instrumental and radiochemical neutron activation analyses. Journal of Radioanal NuclearChemistry, 268(3):441–444, (2006).

[12] WHO. Chloride in Drinking-water Background document for development of WHO Guidelines for Drinking-water Quality. 2nd ed. Vol. 2. Health criteria and other supporting information. World Health Organization, Geneva. (2011).

[13] WHO. Fluoride in Drinking-water Background document for development of WHO Guidelines for Drinking-water Quality. 2nd ed. Vol. 2. Health criteria and other supporting information. World Health Organization, Geneva. (2004).

[14] WHO. Guidelines for Drinking Water Quality, 2nd edition. Volume II, Health criteria and other supporting information. World Health Organizations, Geneva. (1996).

[15] WHO. Iron in Drinking-water Background document for development of WHO Guidelines for Drinking Water-Quality. 2nd ed. Vol. 2. Health criteria and other supporting information. World Health Organization, Geneva. (2003).

[16] WHO. Sodium in Drinking-water. Background document for development of WHO Guidelines for Drinking Water-Quality. 2nd ed. Vol. 2. Health criteria and other supporting information. World Health Organization, Geneva. (2003).