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Chemical Characterization and Quality Compliance of Bottled Mineral Water in Bangladesh

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Abstract

Environmental auditing on bottled water chemistry has done to support sustainable practices and to have a positive impact on the bottled water consumption to community level and environment. Bottled water consumption is increasing day by day in Bangladesh with the safe and pure water supply perception (customer) and advertisements (company). The article is intended to provide an environmental audit to find out the integrity between perception and the existing facts of the bottled waters chemistry in Bangladesh. Nine brands available in the local market (MUM, FRESH, JIBON, ACME, FUWANG, PRAN, ALMA, MUKTA, and LIBRA) were analyzed to verify the labeled value and its compliance with local standards (BSTI) and International standards (WHO). In the study the Bangladesh Standard Specification for Drinking Water BDS-1240:2001 and the Bangladesh Standard Specification for Natural Mineral Water BDS-1414:2000 are taken as the standard parameter for environmental auditing of bottled waters to make compliance audits of labeling. The findings of the study revealed that consumer rights are not protected and the practices the manufacturers follow to control the quality of drinking water are largely flawed.

Key words: Chemistry, Compliance, Auditing, Mineral water

I. Introduction

Bottled water consumption reflects a certain way of life. Bottled water consumption has been steadily growing in the world for the past 30 years. It is the most dynamic sector of all the food and beverage industry. Its consumption in the world increases by an average 7% each year, in spite of its excessively high price compared to tap water (Feru, 2004)[1]. Consumers perceive it as being safer and of better quality. They also look for security: food scandals in industrialised countries and water-borne diseases in developing countries have a great impact on their attitude. Bottled water is perceived as pure and safe, although it is not necessarily the case (Ferrier, 2002)[2].

The chemistry of bottled water is important for all consumers especially for those with health concerns and safety. Bottled water which sold for human consumption varies in composition and flavor depending on the source of the water and processing method used (CBWA, 2006; FDA, 1992, 1996)[3, 4, 5]. Labels may or may not disclose the source of the water and descriptive terms that appear on bottled water labels may or may not have legal definitions. However, if the manufacturer lists the source, it must be able to defend the source (IBWA, 2000)[6].

In Bangladesh bottled water, labeled as 'mineral water' entered the market after the 1988's flood when *Hepatitis-B* broke out widely and people began to regard tap water as unsafe. Now a day there is some additional cause to increase bottled waters demand as arsenic contamination of well water and the poor quality of tap water (CAB, 2004)[7].

The concept used in environmental auditing of bottled water quality is closely related to verification and testing of water quality with review of label documentation and standards. In Bangladesh bottled water is subject to the requirements on BSTI specification of BDS-1414:2000 and BDS-1240:2001 Standard. So the review for compliance to bottled waters quality requirements with specifications, and standards of national (BSTI) regulatory body made the rational to facilitate the consumers' access to the packaged water quality and conformity.

This paper will then identify the major reasons why consumers choose to buy expensive bottled water rather than drink tap water. It will finally analyze the impact this industry has on the environment.

II. Materials and Methods

According to BSTI the bottled water's are specified as– Natural Drinking Water and Natural Mineral Water. Generally and popularly "Mineral water" bottle is the synonym of the bottled waters purchased and sells in our country market. The same brand of bottled water marketed all over the country containing same label and water quality have no significant variation whether collect from Dhaka, Khulna, Chittagong or other remote area of Bangladesh. So the selection of the available nine (9) brand of bottled water from four market places of Khulna was done by the deliberate/convenience sampling procedure. The selected Sample brands were MUM, FRESH, JIBON, ACME, FU-WANG, PRAN, LIBRA, and MUKTA. These nine brands of samples were purchased and divided into two groups according to BSTI Certification Mark.

Group-A: BDS-1240:2001[8] (Drinking Water).

Sample-1: MUM; Sample-5: FU-WANG; Sample-7: ALMA; Sample-8: MUKTA

Group-B: BDS-1414:2000[9] (Natural Mineral Water).

Sample-2: FRESH; Sample-3: JIBON; Sample-4: ACME; Sample-6: PRAN; Sample-9: LIBRA

Chemical parameters for the present study had been selected on the basis of comparative review of labeled parameters and the parameters had the laboratory facilities to test. To measure the drinking water quality of the collected sample, 17(seventeen) chemical examination such as pH, EC, TDS, Sodium(Na^+), Potassium (K^+), Calcium(Ca),

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Magnesium(Mg^{++}), Cadmium(Cd^{++}), Arsenic (As^{3+}/As^{5+}), Bicarbonate (HCO_3^-), Dissolve silica ($H_4SiO_4^{--}$), Ortho-phosphate (PO_4^{---}), Sulphate (SO_4^{--}), Fluride (F^-), Chloride (Cl^-), Iodied (I^-), Nitrate (NO_3^{2--}) were performed (Ramesh and Anbu, 1996)[10] and interpretation were carried out after Hounslow, 1995[11].

And finally auditing status (Saha, 2004)[12] and BSTI regulations were matched to confirm its quality and conformity.

III. Result and Discussion

Status of Bottled Water Chemistry

Water chemistry refers to the composition of water and the mechanism which govern its chemistry. The water chemistry plays an important role for detecting the quality of water. The chemical compositions of water chemistry which found from parameters test, brand labels and, standards of BDS-1240 and BDS-1414 are depicted on the table 1.

Table. 1. The chemical compositions of water chemistry (*Bold denotes tested result, latin denotes labeled value, and normal denotes standard (BDS-1240 and BDS1414) value of the parameters. BDL=Below Detection Limit*).

BDS No	NO	pH	TDS (ppm)		Na^+	K^+	Ca^{2+}	Mg^{2+}	Cd^{2+}	Cl^-	F^-	HCO_3^{2-}	$H_4SiO_4^{2-}$	PO_4^{3-}	SO_4^{2-}	NO_3^{2-}
1240	1	**7.18**	**201**	**288**	**10**	**1.25**	**19**	**0.60**	**0.004**	**34**	**0.035**	**1**	**26**	**0.11**	**20.5**	**1.1**
		7.4	----	----	*4*	*2*	*29*	*0.1*	---	*10*	*<1*	*134*	----	---	*1*	----
		6.4-7.4	500	----	200	----	75	----	0.003	250	1	----	----	----	---	4.5
1414	2	**6.30**	**47.1**	**67.9**	**7**	**0.60**	**3**	**1.8**	**0.01**	**9.4**	**0.085**	**4.5**	**2.6**	**0.035**	**1**	**0.01**
		7.4	----	----	*4*	*2*	*29*	*0.1*	---	*10*	*<1*	*134*	----	----	---	---
		6.4-7.4	1000	----	----	----	---	----	0.003	250	1	----	---	-----	---	4.5
1414	3	**7.01**	**79.3**	**113**	**12**	**0.80**	**6**	**1.8**	**0.014**	**10**	**0.090**	**30**	**17.5**	**0.18**	**1**	**0.05**
		7.4	*1000*	-----	----	*2*	*20*	-----	----	----	*0.20*	*130*	----	----	*4*	----
		6.4-7.4	-----	-----	----	-----	-----	-----	0.003	----	1	----	----	----	---	4.5
1414	4	**7.15**	**56.8**	**80.7**	**20**	**0.25**	**3**	**2.4**	**0.0023**	**9.6**	**0.035**	**33.5**	**1.09**	**0.05**	**1.05**	**BDL**
		---	*150*	------	------	------	------	------	------	-----	-----	-----	-----	-----	-----	----
		6.4-7.4	1000	------	------	------	------	------	0.003	------	1	-----	-----	-----	-----	4.5
1240	5	**6.72**	**8.8**	**12.1**	**2**	**0.06**	**5**	**1.2**	**0.008**	**7.1**	**0.025**	**0.3**	**2.8**	**0.02**	**1.05**	**10.1**
		7.4	*<30*	------	------	-------	-------	-------	*0.001*	----	----	----	----	----	----	*<3.2*
		6.4-7.4	500	------	------	200	75	-------	0.003	----	1	----	----	----	----	4.5
1414	6	**6.83**	**41.2**	**58.6**	**15**	**0.06**	**4**	**1.2**	**BDL**	**0.1**	**0.04**	**9**	**2.39**	**0.02**	**1.5**	**0.05**
		7.4	*1000*	-------	-------	-------	*12.8*	*2.51*	------	----	*0.25*	*122*	----	----	----	----
		6.4-7.4	-------	------	-------	-------	------	-----	0.003	----	1	----	----	----	----	4.5
1240	7	**9.08**	**44.3**	**64.0**	**10**	**0.06**	**4**	**1.2**	**BDL**	**8.8**	**0.048**	**0.5**	**10.5**	**0.175**	**2.6**	**BDL**
		6.4-7.4	*<20*	-------	-------	-------	*60*	-------	*0.002*	----	----	----	----	-----	-----	*3.5*
		6.4-7.4	500	-------	-------	200	75	-------	0.003	----	1	----	-----	-----	-----	4.5
1240	8	**6.96**	**6.1**	**8.7**	**2.5**	**0.25**	**3**	**1.8**	**0.006**	**9.4**	**0.065**	**0.35**	**2.6**	**0.035**	**1.15**	**BDL**
		6.70	*<17*	------	-------	-------	*0.2*	-------	-------	----	----	----	----	-----	-----	----
		6.4-7.4	500	------	-------	200	75	-------	0.003	----	1	---	-----	-----	-----	4.5

Source of Controlling Bottled Water Chemistry

Water chemistry is largely controlled by natural and anthropogenic sources. An approach has been offered by Gibbs (1970)[13] to describe the overall controlling process of on solute compositions of fresh waters. The following figure shows the Gibbs (1970) diagram of controlling water chemistry mechanism.

From the Gibbs diagram it is evident that the controlling sources of Group-A bottled waters samples are rock dominance and precipitation dominance. The intermediate position between rock dominance and precipitation dominance of Sample-7 (ALMA) bottled water source represented as ground water. The source of Sample-1 (MUM) is governed by rock weathering and indicates groundwater. In Group-B sample-4 (ACME) and sample-9 (LIBRA) bottled water source indicate ground water and it is evident from the Gibbs diagram showing rock dominance. However sample-2 (FRESH) and sample-6

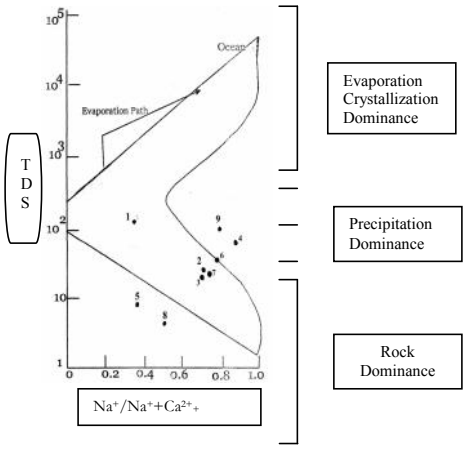

Fig. 1. Shows the Gibbs (1970) diagram of controlling different brands bottled water chemistry.

(PRAN) sources of water positioned between rock dominance and precipitation dominance (Fig.3.2) and it has been mentioned as ground water. Precipitation dominance water source are represented as surface water. The sources of Sample-5 (FUWANG) and Sample-8 (MUKTA) bottled waters are precipitation dominance represented as surface water. The source of Sample-3 (JIBON) has been mentioned as surface water as precipitation dominance.

Characterization of Water

The diamond part of a Piper diagram is used to characterize different water types. So the sampled different brands of bottled water types are derived from the Fig 02.

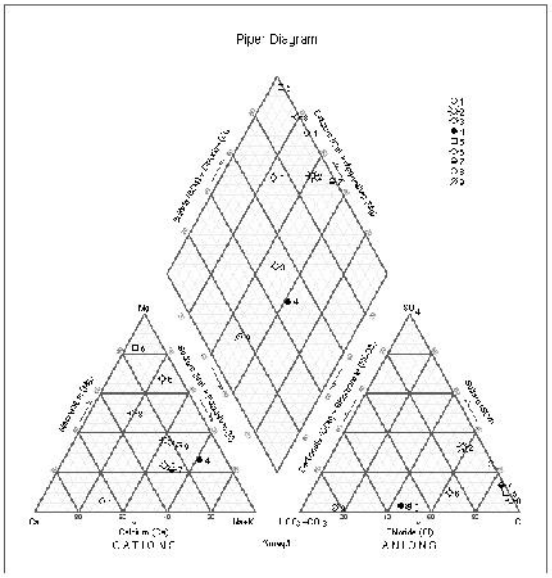

Fig. 2. Different brands of bottled water types in the diamond of Piper diagram.

From the Piper plot (Fig 02) most of the bottled water type (MUM, ALMA, MUKTA, FRESH, PRAN) is calcium-magnesium-chloride and sulfide rich showing the trend of permanent hardness and the rest of the brand JIBON is calcium- magnesium-bicarbonate rich showing temporary hardness. ACME (sample-4) brand water is rich in (Na^+ +K^+ and HCO_3^- + CO_3^{2}) and considered alkalic. LIBRA (sample-9) had the indication of both alkalic and saline (Na^+ +K^+ and Cl^- + SO_4^{2-}) type.

Verification of Bottled Water Quality

The verification of different brands of bottled water has achieved many significant gaps, nonconformities and noncompliance in the present study (table 02). The testing of bottled waters chemistry has done for the verification of labeled data and the Standard value of BSTI and WHO acted as parameters to signify the safety and portability of bottled water as drinking water and mineral water purpose.

The study has established some major gaps, nonconformities and noncompliance's which are depicted below:

- Most of the brands water contains permanent hardness that has exposed from the bottled water chemistry verification made nonconformities to long term consumption of bottled waters.
- The bottled water drawn from the sources are some time misleading to consumers with nonconformities of source on label or wrong information. The sources are as ground water labeling but the verification conform it surface water source i.e. FUWANG.
- Most of the bottled waters have contained underscore concentration value than the labeled value where some brands (FUWANG) contain high concentration value of toxic substance like cadmium and nitrate.
- Most of the labeled mineral constituents are not specified in BSTI Standard Specification for drinking water quality requirements. Brand labeling with unspecified mineral constituents have been certified by BSTI certification authority. Ignorance of that noncompliance of different brands labeling is established the weakness of the BSTI certification authority.
- The study results that most of the labeling misleads to the customers with ambiguous declarations and limited to high quality of drinking water and natural mineral water as food with underscored and exceeded Standard value.
- The prior documentation as waters free from arsenic was evident by the study.
- A finding of the study is that the bottled waters do not practiced what they labeled in fact and it's a kind of deception to consumers.

Table. 2. Verification of bottled water quality in respect to sources (analyzed and labeled value) of bottled waters.

Group no	Serial no	Sample No. and name of brand	Analyzed Source from Gibb's Diagram.	Source depth (feet): From secondary data and label.	Analyzed water type from Piper diagram	Labeled water type in respect of chemical composition	Review comments/ results of verification.
A	1	Sample-1 MUM	Groundwater	400	Permanent hardness	Permanent hardness	Unsuitable for long term consumption
	2	Sample-5 FUWANG	Surface water	400	Permanent hardness	Temporary hardness	
	3	Sample-7 ALMA	Groundwater	>400	Permanent hardness	Permanent hardness	
	4	Sample-8 MUKTA	Surface water	400	Permanent hardness	Acidic	
B	1	Sample-2 FRESH	Groundwater	600	Permanent hardness	Temporary hardness	
	2	Sample-3 JIBON	Surface water	600	Temporary hardness	Temporary hardness	Suitable for Short term consumption
	3	Sample-4 ACME	Groundwater	600	Alkali carbonate	Temporary hardness	
	4	Sample-6 PRAN	Groundwater	450	Permanent hardness	Alkaline	Unsuitable for long term consumption
	5	Sample-9 LIBRA	Groundwater	600	Alkali carbonate With	Alkaline	

Secondary data means data from company's profile
Gaps, Nonconformities and Noncompliance audited from the Bottled Water Chemistry

Conclusion

Drinking bottled water has become an inconsequential practice in many people's everyday lives. Bad tap waters taste or quality, fitness objectives or safety purpose, availability on travels, easy access to safe water, numerous reasons lead consumers to buy bottled waters. So it becomes a need to verify the safety, accessibility and affordability of bottled waters in respect of their products quality and labeling. Like any other industrial activity, bottled water is not completely innocuous to the environment. It is essential that consumers have access to major information, directly on the bottles' labels, i.e., the "type" of water (natural mineral water, purified water, etc.), its mineral composition, the location of the spring or the treatments this water may have undergone.

The present study is conducted to verify the bottled waters quality requirements. The evaluation of the audit evidence as bottled waters quality analysis and regulatory compliance against the audit criteria as national and international drinking water quality standards and specifications lead to find out the conformity or nonconformity with the criteria, i.e. the labeling of the bottled water does or does not conform to the applicable requirements. Because it is not possible to provide tap water in every remote corner of Bangladesh or the surface water storage to avoid arsenic contamination or availability of drinking water supply at natural disasters as flood, the common occurrence in Bangladesh. For the safe, easy, convenient and affordable supply of drinking water bottled water would be an alternative in Bangladesh. So Environmental audit compliance of bottled water quality standards regulations and specification is to review for bottled waters to ensure its sustainable safety and purity of drinking water quality and prevention of customers misleads by different brands labeling.

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