SITUATION ANALYSIS OF BOTTLED DRINKING WATER QUALITY IN SUDAN

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ABSTRACT

The quality parameters of 21 Sudanese bottled drinking water brands, as labeled by bottlers, were studied and compared. These parameters include TDS (total dissolved salts), pH, the major cations (Ca^{++}, Mg^{++}, Na^{+} and K^{+}), anions (Cl^{-}, SO_4^{-}, NO_3^{-}, F^{-} and HCO_3^{-}) and total hardness beside the disinfection procedure and water category or source.

Cross comparison among the brands revealed an inconsistency in the choice of quality parameters as well as their magnitudes. No indication or parameter, of any kind, for the microbiological quality was shown on the labels; however, the disinfection method is clearly indicated.

Statistical analysis of the data revealed significant variations in the magnitudes of the quality parameters as indicated by the wide range and high standard deviation of the data. Moreover, the indication of the source of water on labels is confusing and warrants further attention. Salient conclusions and remarks pertaining to bottled water were reported.

Keywords: Bottled water, Nile water, Tap water, Quality parameters International water, Comparison.

INTRODUCTION

Water quality is the chemical, physical and bacteriological characterization of water. The primary basis for such characterization are parameters which relate to potability, safety for human consumption, human contact and for the health of ecosystems. Another general perception of water quality is that of a simple property that tells whether water is polluted or not. Water quality is a very complex subject, in part because water is a complex medium intrinsically tied to the ecology of the planet. Contaminants that may be found in untreated water include microorganisms such as bacteria, viruses, inorganic contaminants such as salts and metals, pesticides and herbicides, organic contaminants from industrial processes, petroleum use and radioactive contaminants.

Bottled water is drinking water packaged in bottles for individual consumption and retail sales. This water can be natural mineral water, purified water, well water or artesian/artesian well water (IBWA, 2000; 2009).

Changes in ways of life and the increasingly high standard of living in Sudan boosted bottled water utilization and sales. Increasing urbanization, causing tap water shortages and deterioration in quality explains this situation. Consequently, the increased bottled water consumption has boosted the bottled water industry and market trends and showed very promising perspectives for the future, especially in urban areas. Currently, bottled water is one of the fastest growing and booming beverage categories in Sudan with vigorously competitive markets involving numerous companies.

In Khartoum State alone more than 25 bottled water brands were produced. However, there is a very little or limited public awareness pertaining to the source (category), and the physicochemical and bacteriological quality of bottled water.

The objective of this investigation is to provide an overview of the current situation pertaining to the quality of the locally produced bottled drinking water by processing and statistically analyzing the available labeled data and comparing them with the Sudanese Standards and Metrology Organization (SSMO, 2002) bottled drinking water guidelines, our previous research findings on the Nile Rivers water as well as the regional and the international drinking water standards.

MATERIALS AND METHODS

Twenty-one locally produced drinking bottled water brands were used in this study. The quality parameters as written by manufacturers on the label of each brand and other pertinent information were recorded and tabulated (Table 1).

Statistical analysis of the data was performed using Statistical Analysis System (SAS) package to compute means, range and standard deviation (SAS, 1996). The data recorded for the various quality parameters, as presented by the manufacturer for consumers, were compared among the various brands and evaluated according to the SSMO (2002) Standards and guidelines. A precision analysis for the data is shown in Table 3.

Table1: Name of water brand, source and disinfection procedure

	Name of Bottled water brand	Source or Category of water	Disinfection procedure
1	Soba	Natural mineral water	Ozone
2	Safwa	-	
3	Reem	Natural pure water	U.V+ Ozone
4	Safia	-	Ozone
5	Anhar	-	Ozone
6	Farah	-	Ozone
7	Crystal 1	Purified Natural Water	Ozone
8	Crystal 2	Purified Natural Water	Ozone
9	Tana	Pure drinking water	Ozone
10	Aqua Nadia	Pure natural water	Ozone
11	Vitana	Bottled drinking healthy water	Ozone
12	Family	-	Ozone
13	Rayan	-	Ozone
14	Oriental	Pure natural water	NI*
15	Sehab	Pure Bottled Drinking water	Ozone
16	Aziza	Pure Bottled water	Ozone
17	Ghadeer	An Ideally Balanced Water	Ozone
18	Marwa	Pure and Healthy water	Ozone
19	Hayat	Premium Natural Drinking Water	Ozone
20	Sawagi El-Neel	Pure drinking water	Ozone
21	Rio	Natural Drinking Water	Ozone

NI = Not indicated

RESULTS AND DISCUSSION

The data recorded from the bottle labels of the various brands surveyed are presented in Tables 2 and 3. The following salient information were discussed:

Only two of the quality parameters, namely TDS and pH were unanimously and consistently shown on labels for all brands. Other quality parameters were invariably shown; they are mentioned for some of the brands and not mentioned for the others.

As shown in Table 2 the maximum permissible limit for the various quality parameters viz. TDS, pH, Cl , SO_4, NO_3, F, and total hardness were documented in the SSMO (2002) standard for bottled drinking water. However, it can be observed that the standard did not show, either explicitly or implicitly, quality limits for Ca, Mg, Na and K+ in spite of their importance for the health of consumers. Some of the brands neglected the indication of the level of Ca, Mg, Na and K that are important for the health of consumers. It is well-known that pure water (e.g. distilled or deionized water) is devoid of salts and is, therefore, not suitable for human consumption . However, consuming such water is dangerous to the health as it is capable of leaching salts such as K and Na which may affect the efficiency of heart and brain. Therefore, when the source of water is devoid of Ca, Mg, Na and K they must be compensated by adding, for example, calcium hydroxide solution in suitable amounts not less than 100 mg/L (Al-Minhrawi and Hafiz, 1997) .

Table 3 shows the precision of the quality parameters indicated on the labels. Significant variations in the magnitude of the quality parameters are indicated by the wide range and high standard deviation of the data analyzed.

The magnitudes of the drinking bottled water quality parameters presented in this work (Table 2) are, in general, lower than those recommended by the local SSMO (2002) standard as well as the regional (SASO, 1984 and G.C.C.S., 1993 standards) and the international (the WHO, 1993, the USEPA, 1976 and the EEC, 1992 standards), for example, the U.S.A standard requires for natural mineral water to have a minimum level of 250 ppm TDS (IBWA, 2000). For comparison Mustafa (1973) and Abdel Magid *et al.* (1984) obtained acceptable results for the physical and the chemical quality of the Niles water (Tables 4 and 5, respectively).

Table 6 shows the average chemical composition (mg/L) of some international (European) bottled water brands (Abdel Magid, 1997). It may be observed that, on the average, the magnitudes of the various parameters recorded for these brands are, generally, higher than those reported for our locally produced bottled water, Niles water and tap water (Tables 2, 4 and 5).

2

Table 3: Statistical precision of the data:

Parameter measured	N	Mean	Range	SD*
TDS	21	121.3	100 – 220	27.6
pH	21	7.5	7 – 8	0.30
Ca	18	17.4	0.12 – 75	17.72
Mg	20	7.7	0.044 – 25	5.48
Na	13	24.5	0.12 – 128	32.9
K	16	1.5	0.014 – 6	1.46
CL^-	14	11.7	0.23 – 25	7.80
SO_4	15	16.6	0.32 – 36	11.50
NO_3^-	11	0.5	0 – 2	0.69
F^-	12	0.2	0 - 0.50	0.16
HCO_3^-	10	60.7	0.42 -130	49.13
Total hardness	14	64.0	20 – 100	23

***SD = Standard deviation N: Nomber of Bottles**

Table 4: Mean of water analysis data for the Blue Nile (B.N) and the White Nile (W.N) during the year 1971 (12 months: Jan.-Dec.)*

Source of water	mg/L		Meq/L		
	TDS	Total Hardness	$Ca^{++} + Mg^{++}$	Na^+	$CO_3^{--} + HCO^-_3$
B.N	202	117	2.3	0.54	2.14
W.N	209	85	1.7	1.23	2.60

***= Mustafa (1973).**

Table 5: Chemical and physical characteristics (mg/L) of Niles and tap water*

Water source	pH	TDS	Ca^{++}	Mg^{++}	Na^+	K^+	Cl^-	HCO^-_3	NO^-_3
Blue Nile	7.0	109	25.4	7.1	5.1	2.0	11.9	128.1	0.0
White Nile	8.1	96	16.0	6.1	12.4	7.0	10.5	114.7	0.0
River Nile	7.1	102	19.0	7.1	9.9	5.1	14.0	124.4	0.0
Tap water	6.7	109	24.0	6.3	5.1	2.3	14.0	109.8	0.0
Mean	7.2	102	21.1	6.7	8.1	4.0	12.6	119.3	0.0
CV (%)	8.9	5.9	20.6	8.0	44.8	58.9	13.6	7.1	0.0

*** = Abdel Magid *et a.l* (1984) .**

Table 6: Average Chemical Composition (mg/L) of some International bottled water brands*

pH	TDS	Ca^{++}	Mg^{++}	Na^+	K^+	Fe^{++}	Cl^-	SO_4^{--}	NO_3^-	F^-	Total hardness
6.1	-	95	7.8	17	0.63	-	25.1	22.7	-	-	277.8

*** = Tasmanian (Australia) , Perier (France) , Evian (France), Ramlosa (Sweden), Valvert (Belgium).**

Some salient conclusions and remarks pertaining to bottled water:

1. It is a fact that categories of bottled water change from one country to another depending on economic, social and ethical considerations.
2. Bottled water is often an alternative to tap water, but it is not a sustainable alternative and is not an exempt of periodical contamination. However, bottled water is not necessarily safer than tap water and, in some cases;

bottled water is actually bottled tap water. Consumers often object to the taste and chemicals, particularly chlorine, used to disinfect tap water.

3. In some cases, bottlers do not facilitate consumer's identification of the product they buy.
4. According to Danone (2000), the world bottled water market is blooming and it amounted to about an annual volume of 89 billion liters (i.e. an average of 15 Liters drunken bottled water yearly per person). More than half (59%) of the drunken bottled water in the world is purified water, the remaining 41% are spring & mineral water (Belot, 2000).
5. In Sudan, like anywhere in the world, the lack of confidence on tap water quality, fear of health and sanitary hazards in addition to general or seasonal shortages of tap water led some people in urban areas to turn to bottled water.
6. Stringent legislatures regarding the water quality, in general, are deemed necessary in Sudan especially with respect to bacteriological surveillance, correct labeling, indication of bottled water source or category, the disinfection process, and storage conditions. The European Union of bottled water standards set limits for total bacteria count and ban all parasites and pathogenic microbes, e.g. coliform bacteria (Council directive 80/777, 1980) .
7. Like any industrial activity, bottled water is not completely innocuous to the environment: it is not an exempt of environmental impact positive or negative. Natural mineral water and other bottled waters as well as regular water, must meet strict quality requirements.

In this respect we must remember the plastic environmental problem. It is the major material used to make bottles used for water packaging. Several authors (Howard, 2009; IBWA, 2009 and Karlstrom and Dell' Amore, 2010) explained the impact of plastic on environment and health due to the chemicals it contains. beside being resistant to natural biodegradation – thus recycling by landfilling is not effective (Abdel Magid 1996) .

8. Moreover, the information to consumers, on the bottle's labels, is a key issue but may be insufficient or not accessible enough as it is written in too small characters.
9. The bottled water industry may be advised to pay more attention to the standardization of the quality parameters and their magnitudes.
10. Public awareness about all aspects of drinking bottled water quality is deemed necessary.

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تحليل جودة مياه الشرب المعبأة في قوارير بلاستيكية في السودان

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في هذا البحث تم دراسة الجودة النوعية لعدد 21 نوعاً من أنواع المياه المعبأة في قوارير بلاستيكية والمتداولة حالياً بالسودان وخاصة في المناطق الحضرية وذلك فيما يختص بمعالم الجودة النوعية والموضحة على الملصقات الموجودة على القوارير . هذه المعالم تشمل الآتي: الأملاح الكلية الذائبة، رقم الأس الهيدروجيني، الكاتيونات الذائبة مثل الكالسيوم المغنسيوم، الصوديوم، البوتاسيوم والأيونات الذائبة مثل الكلوريد ، الكبرتيات ، الفلوريد، النترات والبيكربونات بالإضافة إلي العسر الكلي ومصادر تلك المياه قبل المعاملة والتطهير والتعبئة.

بعد المقارنة والتحليل الإحصائي اتضح الآتي :

1. أن هناك تضارب واختلاف بين شركات تعبئة المياه موضوع الدراسة في اختيار المعالم الهامة لتحديد الجودة النوعية للمياه المعبأة وكذلك عدم الالتزام بنمط موحد لاختيار المصدر ومعالم الجودة وطريقة التطهير.
2. أن التحليل الإحصائي لمعالم الجودة أشار إلي وجود فروق معنوية بين المعالم كمقياس للجودة النوعية ويظهر ذلك جلياً في عظم كل من المدى والانحراف المعياري.
3. أنه رغم تدوين معالم الجودة الكيميائية على الملصقات الموجودة على القوارير إلا أنه لم تتم الإشارة إلي مستوي الجودة النوعية الميكروبية بل اكتفت معظم الشركات بتوضيح طريقة التطهير فقط.
4. أن الدراسة تمخضت عن عدد من التوصيات والملاحظات الهامة في شأن المياه المعبأة في قوارير بلاستيكية وذلك للارتفاع بالجودة النوعية في هذا القطاع الهام.

قام بتحكيم البحث

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Table 2: Physicochemical composition (mg/l or as indicated) and disinfection procedure of locally produced bottled water as shown on manufacturer labels :

Bottled water brand or Standard	TDS	pH	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Fe^{-}	Cl^{-}	SO_4^{--}	NO_3^{-}	F^{-}	HCO_3^{-}	Total hardness	Disinfection procedure
SSMO Standard (2002)	80-500	6.5-8.5	-*	-	-	-	0.3	250	250	20.0	0.6	-	<200	Not listed
Soba	140	8.0	35.27	7.7	12.8	2.4	-	15.4	13.0	0.0	0.36	128.0	-	ozone
Safwa	140	7.8	0.12	0.044	0.12	0.014	-	0.23	0.32	-	0.008	0.42	48	Ozone
Reem	147	7.6	25.0	8.0	15.0	1.7	-	3.0	13.0	0.0	0.15	130	93	Ozone+ U.V.
Safia	100	7.5	-	4.0	8.0	0.6	-	-	8.0	1.0	0.25	50	61	Ozone
Anhar	108	7.2	18.0	12.0	-	0.9	0.001	10.0	-	-	0.30	-	40	Ozone
Farah	120	7.2	5.0	3.5	15.0	1.5	-	15.4	13	1.0	0.025	25.0	-	Ozone
Crystal 1**	110	7.2	75	25	-	-	-	-	-	-	-	-	100	NI***
Crystal 2**	130	7.1	-	-	-	-	-	-	-	-	-	-	65	NI***
Tana	140	7.5	2.6	8.0	20.4	0.9	-	-	30.8	0.0	0.0	-	-	Ozone
Aqua (Nadia)	100-120	7-7.57.5	5-10	3-7	-	-	-	5.5	-	-	-	-	20-40	Ozone
Vitana	110	7.2	14.0	7.0	-	3.0	-	-	-	-	0.2	-	60	Ozone
Family	220	7.2	35.27	7.7	128	2.4	-	15.4	13.0	0.0	0.38	128	-	Ozone
Rayan	125	8.0	9.0	10	36.5	1.3	-	22	36.5	-	-	25.5	-	Ozone
Oriental	100	7.5	14.0	2.0	-	6.0	0.1	12	-	2.0	-	-	65	NI***
Sehab	110-150	7.2-7.6	6-8	1.5-3.5	22-35	1-2.5	0.01-0.03	25-32	15-22	0.0-3.5	0.5-0.7	45-50	50-100	Ozone
Aziza	125	8.0	9.0	10.0	36.5	1.3	-	22.0	36.5	-	-	25.5	-	Ozone & U.V
Ghadeer	101	7.5	18.43	11.08	-	-	0.025	4.25	14.7	-	-	-	91.6	Ozone
Marwa	101	7.5	18.43	11.08	-	-	0.025	4.25	14.7	-	-	-	91.6	Ozone
Hayat	100	7.5	3.4	6.0	7.0	0.2	-	-	2.0	0.0	0.3	-	50	Ozone
Sawagi El-Neel	120	7.4	20.0	12.0	9.0	0.3	-	10.0	30.0	0.0	-	-	-	ozone
Rio	100	7.5	-	4.0	8.0	0.6	-	-	8.0	1.0	0.25	50	61	Ozone

* - = Not listed ** = Crystal 1 (Chriwa – Germany), Crystal 2 (Arak Group) *** = NI

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953

960