Microbiological Physical and Chemical analysis of Bottled Water Sold during the Hajj in Makkah Saudi Arabia

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Abstract: A study on microbial, physical and chemical analysis of bottled water sold in Makkah, Saudi Arabia was carried out. Twenty brands of bottled waters consisting of both purified and ground water spring types collected randomly from various retail outlets in Makkah and Holy places, KSA during the Hajj, were assessed for their suitability for drinking purpose. Investigated parameters included TDS, Cl, T.H, Ca, Mg, NO3, Fe, SO4, NO2, Cu, F, Na, K, conductivity, pH, turbidity, colour, odour, taste, E.coli, coliform, fungi, Ag, Li, Mn, Ni, Pb, Rb, Sb, Se, Sr, Ta, U, Zn, HCO3, Br, Ba, Cr and Hg. The results were compared with Saudi and WHO standards for drinking water. The physical and chemical contents of the tested water brands were found within the acceptable limits set for drinking water. Comparison of analyzed results with the reported label values showed considerable variations for different parameters.

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1. Introduction

The utilization of filtered water has been expanding reliably in the course of the most recent decade, even in nations where tap water quality is viewed as excellent. There has been a growing interest to provide drinking water that has the trust of consumers (e.g. Bonn charter for safe drinking water) and to understand the factors that contribute to the use of tap water alternatives. This pattern has been watched around the world, but the rates of grow change due to increase in demand across the nations. Such a large number of purchasers worldwide have turned to filtered water as their first choice of drinking water consumption (Ahmed et al, 2013).

Bottled water has become very popular for quenching thirst and as a dietary (mineral) supplement. The ever-increasing popularity of bottled waters means that it is of utmost importance to determine not only their minerals contents, but above all, the content of possible contaminants especially the organic ones. In this respect bottled water are special case, because apart from organic contaminants are from the environment, the water may become secondarily contaminated as a result of its being improperly transported and stored. Pesticides volatile organic compounds and carbonyl compounds have been detected in samples of bottled water (Malwina et al., 2011).

Bottled water is also frequently chosen as alternative to municipal water for reasons of taste and smell, because in most countries of the world, water cannot be disinfected by chemical means. The demand for bottled water is completely independent of the supply of municipal water, which is frequently of identical, if not even of higher quality. Suffice to say that sales of bottled water are greatest in high in developed countries, where tap water is of very high quality. A serious environmental problem connected with the constantly rising consumption of bottled water is the bottles in which it is sold. Because of their immense numbers, they are littering the world all over and have become the most troublesome item of rubbish at the present time (Malwina et al., 2011). From strictly objective, perspective, bottled water is not necessarily (better) or (worse) than tap water, it depends on the specificity of the particular cases.

Several studies, which compared bottled water and tap water, concluded that while some bottled water have better quality than tap water, this not always the case (Hunter, 1993; Olson, 1999; Lalumandier and Ayers, 2000; Saleh et al., 2008).

2. Material and Methods

Twenty brands of bottled waters consisting of both purified and ground water collected randomly from various retailed outlets in Makkah and Holly places KSA during the Hajj 2014, were assessed for their suitability for human consumption.

Samples collection:

Samples collection was done according to Saudi Arabia Standard (407/1989) and Gulf Standard (111/1989).

Basic chemical parameters: assessed include the cations like Sodium (Na+), Potassium (K+) Magnesium (M+2), Calcium (Ca+2), Ferrous (Fe+2) and other cations were measured by using DR 4000 Hach USA and Atomic Absorption Spectrophotometer (AAS) Varian Spectr AA110 USA. Also, anions such as the Chloride (cl-) Sulphate (SO4)-2, Nitrates (NO3)-2 and other anions were measured by using Ion. chromatography Metrohum USA.

Bacteriological Analysis: Membrane filtration method was used to determine Coliform group, E. Coli and the colony count.

3. Results

Table (1) shows microbial analysis of the selected bottled water. All samples were acceptable and free of E. coli and fungi contaminations. The physical characteristics of the study samples are shown in Table (2). Total dissolved solid (TDS) varied from 42.00 to 856.00 with mean of 1.4405. Also, the pH varied from 6.5 to 7.84 with mean of 6.779, while Turbidity varied from 0.105to 0,645 with mean of 0.16829. Conductivity varied from 89 to 1739 with mean of 299.95. No Sediments detected in all selected samples, and acceptable results were detected regarding Taste, Odor and color. Different chemical parameters levels in bottled water were measured, the standard deviation, mean, maximum and minimum values were obtained. The findings show acceptable levels and within the Saudi standard for drinking water. Results showed that bottled water samples from different brands are very different in character and display a wide range of parameter values.

Table 1. Summary of the Microbial analysis of Bottled Water Sold in Makkah – Saudi Arabia.

Sample NO	**MICROBIAL**		**Sample NO**	**MICROBIAL**	
	E. coli	**Fungi**		**E. coli**	**Fungi**
1	0	0	11	0	0
2	0	0	12	0	0
3	0	0	13	0	0
4	0	0	14	0	0
5	0	0	15	0	0
6	0	0	16	0	0
7	0	0	17	0	0
8	0	0	18	0	0
9	0	0	19	0	0
10	0	0	20	0	0

Table 2: Summary of the Physical and microbial parameters levels in Bottled Water Sold in Makkah – Saudi Arabia.

parameter	**minimum**	**maximum**	**Mean**	**SD**
TDS (ppm)	42.00	856.00	1.4405	172.97139
pH (Units)	6.5	7.84	6.779	0.4188
Turbidity (NTU)	0.105	.645	0.16829	0.73948
Conductivity	89	1739	299.95	350.16
Sediments	0	0	0	0
Taste	NO	NO	-	-
Odour	NO	NO	-	-
Color	NO	NO	-	-
Coliform	acceptable limits	acceptable limits	acceptable limits	acceptable limits

Table 3:

S. NO	PHYSICAL CHARACTERSTICS								
	TDS (ppm)	pH (units)	Turbidity (NTU)	Conductivity (UmHo)	Sediments	Taste	Odour	Color	Coliform
1	104	6.5	0.105	218	NO	Acceptable	Acceptable	Transparent	0
2	96	6.57	0.136	202	NO	Acceptable	Acceptable	Transparent	0
3	263	7.01	0.163	547	NO	Acceptable	Acceptable	Transparent	0
4	102	7.09	0.267	215	NO	Acceptable	Acceptable	Transparent	0
5	99	6.98	0.149	210	NO	Acceptable	Acceptable	Transparent	0
6	101	7.05	0.146	213	NO	Acceptable	Acceptable	Transparent	0
7	42	7.21	0.157	89	NO	Acceptable	Acceptable	Transparent	0
8	92	6.6	0.454	193	NO	Acceptable	Acceptable	Transparent	0
9	143	6.5	0.645	298	NO	Acceptable	Acceptable	Transparent	0
10	87	6.64	0.432	182	NO	Acceptable	Acceptable	Transparent	0
11	67	6.6	0.284	142	NO	Acceptable	Acceptable	Transparent	0
12	87	6.5	0.441	184	NO	Acceptable	Acceptable	Transparent	0
13	97	6.5	0.281	205	NO	Acceptable	Acceptable	Transparent	0
14	95	6.88	0.233	201	NO	Acceptable	Acceptable	Transparent	0
15	103	6.69	0.241	216	NO	Acceptable	Acceptable	Transparent	0
16	89	6.52	0.331	189	NO	Acceptable	Acceptable	Transparent	0
17	130	7.32	0.339	277	NO	Acceptable	Acceptable	Transparent	0
18	856	6.11	0.374	1739	NO	Acceptable	Acceptable	Transparent	0
19	136	7.05	0.505	286	NO	Acceptable	Acceptable	Transparent	0
20	92	7.84	0.229	193	NO	Acceptable	Acceptable	Transparent	0

Table 4: Chemical parameters levels in Bottled Water Sold in Makkah – Saudi Arabia

Parameter	Unit	Minimum	Maximum	Mean	Standards (Saudi)	WHO Std.2011	Std. Deviation
CL	Ppm	11.00	278.00	46.4250	150		56.21443
Total Hardness	Ppm	30.00	460.00	1.1093	200		115.43248
Ca	Ppm	3.50	105.60	23.9600			25.56637
Mg	Ppm	.56	56.00	13.8600			16.70254
No3	Ppm	5.00	21.10	10.3450	50	50	4.77917
Fe	Ppm	.01	.05	.0210	0.3	0.1	.01165
So4	Ppm	2.00	74.00	23.0000	150		20.28741
No2	Ppm	.00	.03	.0066	3	3	.00549
Cu	Ppm	.01	.08	.0315	2	2	.01899
F	Ppm	.01	1.93	.8695	0.8 – 1.5	1.5	.40688
Na	Ppm	7.20	76.50	21.5400	100	50	13.99565
K	Ppm	.10	15.80	2.1550			3.89176
PH	Unit	6.11	7.84	6.8080	6.5 – 8.5	8.2 – 8.8	.39041
Silver	Ppm	.10	.46	.1220	0.1		.08108
Aluminum	Ppm	.12	3.49	1.2950		0.10	.99701
Arsenic	Ppm	.10	6.43	.6165	0.01	0.01	1.48266
Boron	Ppm	8.59	1431.16	3.1079E2		2.4	319.99369
Barium	Ppm	.15	379.49	36.7735	0.7	0.7	99.20961
Beryllium	Ppm	.50	9.16	.9330			1.93643
Bismuth	Ppm	.10	.10	.1000			.00000
Bromine	Ppm	9.44	1702.29	1.7417E2			365.75593
Cadmium	Ppm	0.10	.10	.1000	0.003	0.003	.00000
Chromium	Ppm	0.10	.89	.2045	0.05	0.05 (p) ppm	.19880
Cesium	Ppm	0.10	199.47	10.0685			44.58049
Mercury	Ppm	0.10	.10	.1000	0.001	0.006	.00000
Iodine	Ppm	0.15	78.79	10.9680			18.95153
Lithium	Ppm	0.10	4436.38	2.2392E2			991.51587
Manganese	Ppm	0.10	159.37	8.0935	0.5	0.05	35.60688
Nickel	Ppm	0.16	4.86	1.0611	0.02	0.07	1.12748

Lead	Ppm	0.10	.10	.1000	0.01	0.01	.00000
Rubidium	Ppm	0.10	285.49	15.2500			63.64868
Antimony	Ppm	0.50	2.07	.6115		0.02	.37268
Selenium	Ppm	0.10	1.89	.3820		0.04(p)ppm	.39916
Tin	Ppm	0.10	.10	.1000			.00000
Strontium	Ppm	0.42	1581.72	1.68492			352.96488
Tantalum	Ppm	0.10	.10	.1000			.00000
Thallium	Ppm	0.10	.10	.1000			.00000
Uranium	Ppm	0.10	1.86	.2035		0.03	.39600
Zinc	Ppm	0.10	4.24	.8610	3		1.41462
HCO3	Ppm	4.00	647.00	89.0000			144.00439

Table 5: Summary of the CATIONS levels in Bottled Water Sold in Makkah – Saudi Arabia

S. NO	**CATIONS**										
	Na^{+}	k^{+}	Ca^{+2}	Mg^{+2}	Li	Mn	Hg	Ag	Fe	Cu	Al	Zn
1	21.7	1.2	15.8	14.7	6.83	0.14	<0.1	0.17	0.02	0.05	2.74	<0.1
2	12.4	1.2	4.8	28	<0.1	<0.1	<0.1	<0.1	0.02	0.03	0.68	0.13
3	21	9.5	72	56	16.03	<0.1	<0.1	<0.1	0.02	0.08	0.13	0.20
4	21.5	0.8	16	2.24	0.42	<0.1	<0.1	<0.1	0.02	0.04	1.26	3.73
5	19.2	0.7	22.4	1.7	0.13	<0.1	<0.1	<0.1	0.02	0.07	1.32	0.19
6	22	1.1	12.6	10.2	0.25	<0.1	<0.1	<0.1	0.01	0.04	1.90	0.10
7	23.3	0.4	4.8	5	0.37	0.36	<0.1	<0.1	0.03	0.04	0.70	4.24
8	22.1	0.6	3.5	6.8	0.87	<0.1	<0.1	<0.1	0.05	0.01	0.56	1.32
9	17.2	0.2	19.2	0.56	1.05	<0.1	<0.1	<0.1	0.02	0.02	0.12	<0.1
10	16.5	0.4	12.6	32.6	4.47	<0.1	<0.1	<0.1	0.02	0.02	2.67	<0.1
11	11.7	0.1	16	2.9	<0.1	<0.1	<0.1	<0.1	0.02	0.03	0.88	<0.1
12	20.1	1.1	11.5	5.7	0.81	<0.1	<0.1	0.11	0.01	0.01	1.64	<0.1
13	14.2	1.8	28.8	2.2	1.64	<0.1	<0.1	<0.1	0.02	0.01	3.49	0.49
14	29.5	1	4.8	5.6	0.93	<0.1	<0.1	<0.1	0.02	0.01	0.67	0.97
15	23	0.9	9.6	5.6	1.85	<0.1	<0.1	<0.1	0.03	0.03	0.31	<0.1
16	12.9	0.3	20	6.2	0.25	0.34	<0.1	<0.1	0.01	0.04	2.44	<0.1
17	14.1	5.3	24	19.6	3.09	<0.1	<0.1	<0.1	0.01	0.02	0.36	<0.1
18	76.5	15.8	105.6	54.9	4436.38	159.37	<0.1	<0.1	0.01	0.03	1.47	4.18
19	7.2	0.6	56	14.5	2.83	<0.1	<0.1	<0.1	0.05	0.03	0.32	0.42
20	24.7	0.1	19.2	2.2	<0.1	0.16	<0.1	0.46	0.01	0.02	2.24	0.45

Table 6: Summary of the CATIONS levels in Bottled Water Sold in Makkah – Saudi Arabia

S. NO	**CATIONS**										
	Cd	**Cr**	**Cs**	**Ni**	**Rb**	**Sr**	**Ta**	**Tl**	**U**	**B**	**Ba**	**Be**
1	<0.1	<0.1	<0.1	0.70	<0.1	110.31	<0.1	<0.1	<0.1	350.49	0.48	<0.5
2	<0.1	<0.1	<0.1	<0.1	<0.1	0.42	<0.1	<0.1	<0.1	50.82	0.18	<0.5
3	<0.1	<0.1	<0.1	2.37	<0.1	1581.72	<0.1	<0.1	<0.1	133.59	46.72	<0.5
4	<0.1	<0.1	<0.1	0.66	<0.1	7.25	<0.1	<0.1	<0.1	1431.16	0.40	<0.5
5	<0.1	0.30	<0.1	0.78	<0.1	206.26	<0.1	<0.1	0.13	477.80	1.02	<0.5
6	<0.1	0.24	<0.1	0.49	<0.1	39.72	<0.1	<0.1	<0.1	204.43	0.48	<0.5
7	<0.1	<0.1	<0.1	0.16	<0.1	18.34	<0.1	<0.1	<0.1	619.97	<0.1	<0.5
8	<0.1	0.14	<0.1	0.18	<0.1	35.11	<0.1	<0.1	<0.1	373.57	0.49	<0.5
9	<0.1	<0.1	<0.1	2.21	<0.1	12.60	<0.1	<0.1	<0.1	163.85	0.15	<0.5
10	<0.1	0.15	<0.1	0.56	<0.1	149.09	<0.1	<0.1	<0.1	288.56	0.84	<0.5
11	<0.1	<0.1	<0.1	0.74	<0.1	3.70	<0.1	<0.1	<0.1	559.67	<0.1	<0.5
12	<0.1	0.89	<0.1	0.42	<0.1	89.97	<0.1	<0.1	<0.1	181.75	<0.1	<0.5
13	<0.1	0.21	<0.1	1.03	<0.1	56.18	<0.1	<0.1	<0.1	78.35	3.15	<0.5
14	<0.1	0.12	<0.1	0.19	<0.1	36.69	<0.1	<0.1	<0.1	384.83	0.56	<0.5
15	<0.1	<0.1	<0.1	0.48	<0.1	49.81	<0.1	<0.1	1.86	108.26	3.84	<0.5

16	<0.1	0.11	<0.1	0.84	<0.1	27.72	<0.1	<0.1	<0.1	200.22	0.34	<0.5
17	<0.1	0.43	<0.1	0.86	<0.1	242.62	<0.1	<0.1	<0.1	36.13	1.73	<0.5
18	<0.1	<0.1	199.47	4.86	<0.1	485.15	<0.1	<0.1	<0.1	467.76	185.05	9.16
19	<0.1	0.5	<0.1	2.04	<0.1	206.23	<0.1	<0.1	0.41	8.59	379.49	<0.5
20	<0.1	<0.1	<0.1	0.59	<0.1	10.92	<0.1	<0.1	<0.1	95.94	0.23	<0.5

Table 7: Summary of the ANIONS levels in Bottled Water Sold in Makkah – Saudi Arabia

	ANIONS													
S. NO	**CL**	**F**	**Br**	**I**	**As**	**Bi**	**Pb**	**Sb**	**Se**	**Sn**	**NO2**	**NO3**	**SO4**	**HCO3**
1	41.5	1.6	163.62	78.79	<0.1	<0.1	<0.1	<0.5	0.48	<0.1	0.004	18.1	34	15.00
2	31.8	0.98	16.69	0.15	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	0.004	6.3	67	4.00
3	51.6	1.93	180.14	23.47	0.22	<0.1	<0.1	<0.5	0.73	<0.1	0.006	6.4	74	235.00
4	61.5	1.07	252.50	0.17	<0.1	<0.1	<0.1	<0.5	0.26	<0.1	0.004	5	5	16.00
5	39.7	0.98	110.35	12.11	<0.1	<0.1	<0.1	<0.5	0.33	<0.1	0.005	17.6	32	10.00
6	26.6	0.83	87.00	3.56	<0.1	<0.1	<0.1	<0.5	0.16	<0.1	0.006	17.2	21	51.00
7	37.7	0.72	188.76	2.96	<0.1	<0.1	<0.1	<0.5	0.38	<0.1	0.009	21.1	2	34.00
8	25.8	0.81	94.28	6.36	<0.1	<0.1	<0.1	<0.5	0.26	<0.1	0.028	9.2	14	58.00
9	29	1.09	35.40	0.32	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	0.003	6.8	23	43.0
10	63.5	0.81	67.00	4.59	<0.1	<0.1	<0.1	<0.5	0.55	<0.1	0.002	9.9	32	18.0
11	23.9	0.88	24.10	0.19	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	0.007	5.3	9	27.00
12	27.8	0.38	164.48	6.84	0.42	<0.1	<0.1	<0.5	0.53	<0.1	0.005	9.1	9	52.00
13	35	0.54	27.49	1.05	<0.1	<0.1	<0.1	1.15	0.13	<0.1	0.005	12.2	16	39.00
14	28.6	0.56	80.62	6.97	<0.1	<0.1	<0.1	<0.5	0.43	<0.1	0.005	9.8	17	54.00
15	24.2	0.95	78.33	7.10	0.25	<0.1	<0.1	<0.5	0.31	<0.1	0.006	5.9	49	50.00
16	49.6	1	102.31	3.20	<0.1	<0.1	<0.1	<0.5	0.45	<0.1	0.004	10.6	13	12.00
17	17.9	0.01	71.16	17.26	1.07	<0.1	<0.1	2.07	0.25	<0.1	0.007	6.7	2	142.00
18	278	1	1702.29	42.23	6.43	<0.1	<0.1	0.51	1.89	<0.1	0.012	13.5	25	647.00
19	11	0.63	27.37	1.73	2.54	<0.1	<0.1	<0.5	<0.1	<0.1	0.007	7.9	7	156.00
20	23.8	0.62	9.44	0.31	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	0.004	8.3	9	117.00

4. Discussions

Bottled water is packaged drinking water in plastic or glass containers. People simply trust packaged bottled water for drinking purpose. The findings of our study demonstrated the health acceptability of packaged bottled drinking water of all parameters according to Saudi Arabia Guidelines for Drinking Water. The elements like dissolved ions and complexes, suspended, colloids ions and solid sediments are present in different water bodies. Depending on the biological processes, redox potential, ionic strength, pH, activities of organic and inorganic compounds as well as scavenging processes lead to upsurge in the concentrations of ions in the water [13]. According to WHO based Joint Monitoring Programme-2017 Updates, 71% of the global population uses a safely managed drinking-water services. [14] Whereas two billion people worldwide use drinking-water source contaminated with faeces. Hence, bottled drinking-water has become a healthier choice than tap water for many people as they believe that it contains less contaminant. Nevertheless, some threats can be noted during the process of manufacturing, storage, transport and/or purchase. Due to this probable contamination, present study focused on different parameters of chemicals, microbes, and physical traits in bottled water sold in Makkah Almokarramah, Saudi Arabia (Table-3).

The findings of our study demonstrated the health acceptability of all parameters according to Saudi Arabia Guidelines for Drinking Water. Our study tried to determine the different levels of ions including anions like Chloride, Fluoride, Nitrate, Sulphate, and Phosphorus (Table-4) and cations like Sodium, Ammonium, Magnesium, Potassium, and Calcium (Table-5) contents in water. However, maximum levels of few parameters were reached by some of the brands examined above the acceptable standards.

In this study the maximum concentration of chloride was found to be 278 mg/l measured in twenty collected samples, while in the Saudi standards acceptable level is 250 mg/l. As per WHO guidelines for drinking-water quality (Geneva 1996), the chloride distribution increases in groundwater and drinking-water due to some common chloride salts and high dissolution. As Chloride content in normal food is

0.36 mg/g and an average intake is 100 mg/day on salt-free diet. However, the addition of salt during processing, cooking, or eating can markedly increase the chloride level in food of average dietary intake of 6 g/day, which may rise to 12 g/day due to chloride containing water. In addition, the estimated relative contribution of drinking-water on daily water consumption is 2 litres and an average chloride level in drinking-water of 10 mg/litre is assumed. Although this reported level was found to be insignificant, the metals associated with chloride contribute to heart and kidney diseases. The public drinking water standards require chloride level not to exceed 250 mg/l and also high-level chlorides are harmful to fishes and aquatic communities. The severity of the signs and symptoms caused by chlorine vary according to amount, route and duration of exposure [15].

Total hardness of water depends on the concentration of Calcium and Magnesium and other metal colloids. Hard water is not a health hazard; in fact, the National Research Council (National Academy of Sciences) states that hard water contributes a small amount toward total Calcium and Magnesium human dietary needs. The minimum quantity of hardness measures as 30 ppm and maximum as 460 ppm with variance of 115.43 ppm while as per Saudi standard acceptable level is 200 ppm and according to WHO standard, the total hardness of water is 500 mg/l or ppm. As per the study reports the estimated mean of Magnesium and Calcium available is 24 mg/l and 14mg/l, respectively. In a systemic review of epidemiological studies showed that higher drinking water Magnesium levels may reduce the coronary heart disease mortality risk [16]. According to WHO, the regulatory limit for nitrate, precursor in the formation of N-nitroso compounds in drinking water is 50 mg/L. This allows protecting infant from methemoglobinemia, risk of specific cancers and birth defects related to N-nitroso compounds [17].

Sulphate is one of the major-constitutes of hardness that dissolves to rain water. This reduces to hydrogen sulphide, which wear away metals like Iron, steel, Copper and brass and tarnish silverware, copper and brass utensils. Usually no health risk has been reported; however, a high concentration of sulphate contributes laxative effect with maximum contaminated level of 250 mg/L. Presence of high concentrations of hydrogen sulphide in drinking water may cause nausea, illness and, death in extreme cases.

Permissible limits for drinking water parameters such as pH, temperature, hardness, alkalinity, dissolved oxygen, nitrate and nitrite, chlorides, fluoride, arsenic, lead, cadmium, mercury, chromium, phosphorus, iron (Table-5) and microbiological parameter like faecal coliform bacteria are set by different agencies i.e. APHA, WHO, ISI, CPCB, and ICMR. However, there is a bias in permissible limit of drinking water quality set by different agencies. The standard pH shows 6.85-9.2 mg/dl, turbidity of ISI 10NTU, ICMR 25NTU, CPCB 10 NTU, conductivity 200 mg/l and alkalinity 600 mg/l, provided by central pollution control board. Total hardness and Iron (mg/l) are recommended by WHO of 500, 0.1, ISI 300, 0.1, ICMR 600, 1.0, CPCB 600, 1.0 as standard values. For all metals copper (mg/l): USEPA 1.3, WHO 1.0, ISI0.05, ICMR 1.5, CPCB 1.5; fluorides (mg /l): USEPA 4.0, WHO 1.5, ISI 0.6-1.2, ICMR 1.5, CPCB 1.5; mercury (mg/l): USEPA 0.001, WHO 0.002, ISI 0.001, ICMR 0.001, CPCB no relaxation; cadmium (mg/l): USEPA 0.005, WHO 0.005, ISI 0.01, ICMR 0.01, CPCB no relaxation; Selenium (mg/l): USEPA 0.05, WHO 0.01, CPCB no relaxation; arsenic (mg/l) USEPA 0.05, WHO 0.05, ISI 0.05, ICMR0.05, CPCB no relaxation; lead (mg/l): USEPA WHO 0.05 ISI 0.10 ICMR 0.05 CPCB no relaxation; zinc (mg/l): WHO 5.0, ISI 5.0, ICMR 0.10, CPCB 15.0; and chromium (mg/l): USEPA 0.1, ISI 0.5 CPCB no relaxation.

Limitation of E. coli content in water provides quality and pollution status but the permissible limit has not been provided by different agencies. Other than major metallic colloids dissolved in water, small amounts of silver, aluminium, Arsenic, Boron, Barium, Beryllium, Bismuth, Bromine, Cesium, Iodine, Lithium, Manganese, Nickel, Lead, Rubidium, Antimony, Selenium, Tin, Strontium, Tantalum, Thallium, Uranium contribute risk of water-borne diseases. The metal cations are within the range of <0.1 to 0.5 ppm except the values for Na^+, K^+, Ca^{+2}, Mg^{+2}, Li as demonstrated in Table-5 & Table-6. Other anions such as fluoride, chloride, phosphate, bromide, and sulphate were measured in this study. Set standard limits are reported for those anions in Table-7.

In our study trends in the disease outbreaks associated with commercially bottled water, bulk water purchases, mixed water systems, and unknown water systems were not assessed individually because so few of these outbreaks were reported till now. Too few outbreaks were found to be associated with commercially bottled water to evaluate a seasonal distribution. Although bottled water outbreaks are rarely reported, they do occur [18]. In a study conducted by Gunther and his team [19] demonstrated the causes of outbreaks associated with drinking water in the United States from the year 1971 to 2006, they reported that these disease outbreaks were found to be associated with contaminated commercially bottled water. Four of these outbreaks were the result of inadequate treatment or contamination during the process of bottling, two were because of contamination at the point of use, and one was reported due to the contamination during storage. All commercially bottled water outbreaks were found to be associated with acute gastrointestinal illness. Chemical contaminants were identified in four outbreaks; investigators also reported illness associated with high levels of bromate, a by-product of ozone disinfection. Bacterial contaminants were also identified in two outbreaks. In 1994, one of the studies from Northern Mariana Islands found the non-O1 V. cholerae to be responsible for an outbreak of 11 cases when contamination occurred at a plant providing bottled water for a small community [19]. In 2000, S. sonnei was identified in an outbreak of 58 cases at a New Jersey school, which was associated with contamination of commercially bottled water during on-site storage.

One mixed-system outbreak was reported in the year 2000; it was found to be associated with both individual groundwater systems and commercially bottled water [20]. Some of the bottles of water were marketed as water for infants, and others were marketed as spring water taken from the same geographic area as the individual wells. Investigators identified total 95 cases of acute gastrointestinal illness attributed to S. Bareilly in 10 states. This outbreak was reported due to a combination of factors, including contamination during the bottling process, use of untreated groundwater, deficiencies in treatment of groundwater, and deficiencies in building-specific water treatment.

Reports of outbreaks in Canada and the United States (U.S.) showed that approximately 50% of all waterborne diseases were reported in small non-community drinking water systems (SDWSs). More consistent reporting and descriptions of SDWSs in future outbreak reports are needed to understand the epidemiology of these outbreaks and to inform the development of targeted interventions for SDWSs. [21]. The identification of outbreaks involving small systems is challenging given the typically small number of people exposed and the transient population they often serve, who are less likely to report illness. It is important for bottled water manufacturers, distributors, and consumers to protect and treat water before bottling i.e. during manufacturing, transporting, storing and using excessive amount of chlorine in water might be due to the use of chlorine in disinfection process as it must be a residual amount for later contamination. The residual chlorine should be adjusted according to expected potential risk of contamination to avoid the high concentration which may lead to adverse side effects.

Our findings in study samples also revealed that Zn maximum concentration was 4.24 mg/l. In Saudi standards the permissible maximum concentration is 3 mg/l. Michael and William (2008) [11] mentioned that trace elements such as Cu and Zn which are relatively abundant in their study, are not extremely toxic, and have been determined in other studies are not discussed in detail. In natural surface waters, the concentration of zinc is usually below 10 µg/litre, and in ground waters, 10– 40 µg/litre [22]. In tap water, the zinc concentration can be noted at higher levels as a result of the leaching of zinc from piping and fittings [23]. The most corrosive waters are those of low pH, high carbon dioxide content, and low mineral salts content. In a Finnish survey of 67% of public water supplies, the median zinc content in water samples taken upstream and downstream of the waterworks was found to be below the level of 20 µg/litre; much higher concentrations were reported in tap water, the highest being 1.1 mg/litre [24].

As in this study no microbial contamination was reported. This might be credited to the best disinfection and sterilization of bottled water as usual. There were unacceptable colour; taste and odour in some investigated wells, however, the measurement of these characteristics depends on human sense [25] by Bruvold, 57 consumers from 11 selected California communities studied the taste of locally treated waters. Taste test panels were used. Total mineral content in the water ranged from 50 to 2250 mg/l. Results demonstrated an inverse linear relation between taste quality and mineral content. It is common belief that distilled water is without any taste because of its inherent lack of dissolved oxygen (DO) and mineral salts. However, Bruvold and Pangborn [26] reported that DO has no any specific effects on the taste of odor-free mineral waters and of distilled water. Turbidity is acceptable (as per Saudi Arabia Standards), it was found that turbidity was less than one NTU in all samples, as well as conductivity.

Some of the companies conform to set standards while others do not. There are different types of reasons that can be attributed to both factories and laboratory tests as justified by calculated experimental percentages of errors. It is common finding that factories don't apply or displays what they produced to the market. The concentration in some brands was found to be on higher side than the ones that have been measured in the laboratory. This could be due to multiple factors like transportation of product itself since water industry relies on different types of transporters to deliver their raw materials and product from plants to retail sale points. During this period, the bottled water would be exposed to different temperatures that may sometime reach to 52 degree Celsius, especially in the Gulf region. Some samples were also reported to have earlier production date which may impact on quality. Some samples were left under the sun for too longer period. There are multiple factors that may affect quality of samples chosen from the market and not directly from factory. Laboratory results were found to be different from labelled values for a range of products. Yet this type of difference in result findings raises the query about the credibility of the company to the costumers and public. Overall results of our study are within the range of the international standards. The bottling companies are required to label natural mineral waters with their characteristic chemical composition and most bottled waters are labelled with major-ion and basic physical characteristics.

However, the concentrations of trace elements are rarely provided. Many of the bottling plants get water from springs, which typically discharge young, toxic groundwater from shallow depths of circulation. Others abstract from borehole sources, or from mixtures of sources. Where specified on websites or bottle labels, depths of boreholes used for abstraction is considered in the range of 27–250 m depth (Pauline, 2010) [12]. It was not possible to compare results for a single identifiable water source contained in separate glass and PET bottles as the both the options appear to be rarely informed by the bottling companies. Further analytical studies are required to assess whether the differences observed between the bottle types for this site are statistically significant.

5. Conclusion

The physical and chemical contents of the tested water brands were found within the acceptable limits set for drinking water by World Health Organization and Saudi Arabian Standards. Trace metals were also analyzed in all samples. Comparison of analyzed results with the reported label values showed considerable variations for different parameters. The results revealed high concentration of Bromine (Br) and Lithium observed in all tested samples. It is better to use glass container instead of plastic one.

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References

1. Ahmad Z, Ryan C, Ai P, Sarva P. Concentration of ions in selected bottled water samples sold in Malaysia. Appl Water Sci (2013) 3:67–75.
2. Abdullah, A. S. and Hani, S. F. (2013) Environmental prevalence of pathogen in different drinking water resources in Makkah city Kingdom of Saudi Arabia, Cur. World Environment, vol.8, Issue 1:37-53.
3. Anas, S. Dablool et al. (2014) Physical and Biological Quality of Ground water in Makkah area. International Journal of Innovative Research in Science, Engineering and Technology. Vol 3, Issue 1.
4. Ghrefat, H. A. (2013) Classification and Evaluation of Commercial Bottled drinking water in Saudi Arabia. Research Journal of Environmental and Earth Sciences. 5(4) 210-218.
5. Lalumandier, J. And Ayers, L. (2000) Fluoride and Bacterial contents of bottled water Vs tap water. Arc. Fam.9. 246-250.
6. Malwina, D., Zenta, P. and Jacek, N. (2011) Chemical Quality of Bottled Waters, A review. Journal of Food Science. 76(9).
7. Saleh, M.A. et al. (2008) Chemical, Microbiological and Physical evaluation of commercial bottled waters in Greater Houston area of Texas. Journal of Environmental Science. 43(4) 335-347.
8. Sulaiman, M. et al. (2011) Water Quality of bottled water in the Kingdom of Saudi Arabia, A comparative study with Riyadh municipal water and Zamzam.
9. WHO (2009) Guidelines for drinking water quality Recommendations 2nd edition, Word Health Organization, Geneva. Vol.1.
10. WHO (2011) Drinking water quality standard 4th edition, Word Health Organization, Geneva.
11. Michael Krachler, William Shotyk. Trace and ultratrace metals in bottled waters: Survey of sources worldwide and comparison with refillable metal bottles. Science of the Total Environment 2009, 407: 1086 – 1096.
12. Pauline L Smedley. A survey of the inorganic chemistry of bottled mineral waters from the British Isles. Applied Geochemistry, 25, 1872-1888, 2010.
13. Dawood D. (2014). Determinations of ions (anion and cation) by ion chromatography in drinking water from talkha territory and some its villages, Dakahlia, Egypt. J. Agric. Chem. and Biotechn., Mansoura Univ. 5 (9): 215-226.
14. World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), 2017. Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines.
15. Lei Jiang, P. H. (2016). Magnesium Levels in Drinking Water and Coronary Heart Disease Mortality Risk: A Meta-Analysis. Nutrients., 8(1): 5.

16. Mary H. Ward, 1. R. (2018). Drinking Water Nitrate and Human Health: An Updated Review. International Journal of Environmental Research and Public Health, Jul; 15(7): 1557.
17. Harmsco Europe; Health effects of chlorine exposure; http://harmscoeurope.com/en/clhorine-health-effects
18. U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES Public Health Service Agency for Toxic Substances and Disease Registry; TOXICOLOGICAL PROFILE FOR CHLORINE November 2010.
19. Gunther et al; Causes of Outbreaks Associated with Drinking Water in the United States from 1971 to 2006; Clin Microbiol Rev. 2010 Jul; 23(3): 507–528.
20. Kramer et al. 1996 Surveillance for waterborne-disease outbreaks—United States, 1993-1994; MMWR Surveill. Summ. 45(SS-1):1-33.
21. Lee et al, 2002. Surveillance for waterborne-disease outbreaks—United States, 1999-2000. MMWR Surveill. Summ. 51(SS-8):1-47.
22. Wendy et al, A Systematic Review of Waterborne Disease Outbreaks Associated with Small Non-Community Drinking Water Systems in Canada and the United States; PLoS One. 2015; 10(10).
23. Elinder CG. Zinc. In: Friberg L, Nordberg GF, Vouk VB, eds. Handbook on the toxicology of metals, 2nd ed. Amsterdam, Elsevier Science Publishers, 1986:664-679.
24. Nriagu JO, ed. Zinc in the environment. Part I, Ecological cycling. New York, NY, John Wiley, 1980.
25. S. D. Lin; Tastes and Odors in Water Supplies — A Review; ISWS/CIR-127(77).
26. Bruvold, W. H., and R. M. Pangborn. 1966. Rated acceptability of mineral taste in water. Journal Applied Psychology v. 50(l):22-32.

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