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A Comparison of Physio-Chemical and Microbiological Properties of Tap and Bottled Drinking Water in Saudi Arabia

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Abstract: In the Kingdom of Saudi Arabia (KSA), there are two types of drinking water, tap water, and bottled water. In order to find which water is good for human health, a comparison study performed between tap water and bottled water in the KSA. The data of tap water obtained from the previously published papers for three different regions, Central Region (Riyadh City), East Region (Dammam City), and West Region (Jeddah). The water bottled data collected for 20 different brands of KSA. And the comparison is made with respect to the physical properties (like pH, Turbidity, and TDS), chemical properties (like chlorine, sulfates, and heavy metals) and microbiological count (Total Coliform). The data also compared with the standards of the Environmental Protection Agency (EPA). After the comparison, it found that bottled water is of higher quality when compared to tap water. Statistically, there

was a significant difference between tap water and bottled water, which supports our results that bottled water is better for human use.

Keywords: tap water, bottled water, Saudi Cities, microbiological count, physico-chemical properties, total Coliform.

INTRODUCTION

Water is the most important element for the survival of life; it makes the earth different from other planets. About 71% of the earth's crust is covered with water, in which 96.5% of water is sea/ocean water, and 2.5% is the freshwater. Out of this 2.5 percent of fresh water, 69.7% is glaciers, 30.1% is groundwater, and only 1.2 percent is fresh surface water[1]. Water is such a valuable resource for human beings; 60% of the bodyweight consists of water[2]. It allows our body to perform the process of metabolism, elaboration of food, and elimination of waste. Every day we restock our metabolic reserve by drinking water or eating wet food. But the water we drink must be of good quality and not harmfulto the health[3].

Like other arid region countries, the Kingdom of Saudi Arabia (KSA) is also suffering from the scarcity of water and limited resources to fulfill the demand[4]. The KSA mainly depends on the desalination of groundwater or seawater in order to meet the requirements[5]. The desalinated water provided to the population of KSA as tap water. On the other hand, in the KSA, bottled water is widely consumed, where it preferred over tap water[6].

The drinking water should meet the standards in order to be healthy for human use. If the drinking water has impurities, like physical, chemical, or microbial, and the drinking water doesn't meet the standards, so it will be really harmful to human life. According to the Epidemiological study, water chemical impurities can cause cardiovascular disease, reproduction diseases, cancer, and even it can cause death[3]. There are several chemical element impurities in the drinking water, such as chlorine (Cl), sulfates (SO4), copper (Cu), cadmium (Cd), chromium (Cr), lead (Pb), and nickel (Ni). These elements are essential for the human body; i.e., they should be present in the drinking water but within the standard limit. If they exceed the limit, then the water will be harmful to human health and cause the diseases mentioned above.

In addition to this, the microbial contamination in drinking water can cause some severe diseases such as hepatitis, typhoid, cholera, etc[7]. There are some physical properties of water, such as pH, TDS, and Turbidity; if these properties disobey the standards, then it will be harmful to human health. The pH measures the acidity and basicity of water. It has the measuring range from 0-14; if the pH of a component increased from 7, the component is basic, and if it decreased from 7 then it shows the component is acidic; at the scale of 7, the component is neutral. If the pH deviates from the standards, then, it changes the taste of water, bitter when it is basic and sour when it is acidic. The pH of water will determine the ability of water to dissolve the heavy metals and other chemical constituents. Low pH water will allow the metals to dissolve more and high pH[8]. While the Total Dissolved Solids (TDS)

is another physical property of water that indicate the number of salts and organic matter. This quantity also in relation to the chemical and microbial contamination; the more amount of TDS than the standards shows that there are higher chemical and microbial impurities[9]. It is essential to check out the physical, chemical, microbial impurities in water either bottled or taped.

In the present study, the physio-chemical and microbial properties of tap water and bottled water compared, and these properties are also compared with the standards of the Environmental Protection Agency (EPA).

MATERIALS AND METHODS

The physio-chemical and biochemical properties of tap water of three cities of three different regions, Riyadh (central region), Dammam (eastern region), and Jeddah (western region), are compared with the bottled water of twenty different brands of KSA. The data is obtained from previously published papers, the tap water data of Riyadh is obtained from the published article by Al-Omran et al.[5], the tap water of Jeddah is obtained from published paper Hussein et al.[10], and the tap water data of Dammam obtained from published article Alharbi et al.[11]. The data of bottled water obtained by collecting samples of twenty different brands of the KSA. The sample collection followed by the "Saudi Arabia Standard (407/1989)" and "Gulf Standard (111/1989)." The name of the brands not mentioned in the paper. Some basic chemical components including Chloride (Cl-) and, SO_4 anions are measures by the

Figure 1: *Map of KSA*

"Ion Chromatography Metrohum USA" while the heavy metals such as Cu, Cd, Cr, Pb, and Ni measured by "Atomic Absorption Spectrophotometer (AAS) Varian Spectr AA110 USA." For the microbial analysis, the Membrane Filtration method utilized in order to find out Total Coliform. The drinking water standards followed that are described by the Environmental Protection Agency (EPA)[12]. These data compared and plotted the graphs for the comparison and graph plotting, IBM® SPSS software.

Statistical Testing: The physio-chemical data of tap water of all the cities of different regions and the physio-chemical bottled water of all twenty brands statistically tested; either there is a significant difference present between the data or not. For the statistical SPSS analysis of the data, "Independent Student's T-Test" is performed. Student's T-Test is an inferential statistical tool used to find out the significant difference in the mean of two data groups[14].

$$t = \frac{\left|\underline{x_1} - \underline{x_2}\right|}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

By following the above formula, we obtained the t-value. Now, for the testing, we have a null hypothesis, H_0, which leads to the no statistically significant difference between the data of samples.

There is another parameter known as a critical value; it is obtained with the help of t-table, mentioned in Appendix A, by using the values of probability value (p-value) and degree of freedom. The p-value for the t-testing set at 0.05, and the following formula obtains the degree of freedom (df);

$$Degree\ of\ Freedom = df = n_1 + n_2 - 2$$

The value found by the cross-section of the p-value 0.05 column and obtained the degree of freedom value is known as the critical value.

If the t-value is greater than the critical value, it shows there is a significant difference exist between the means of two data sets, tap water, and bottled water. This SPSS analysis is applied for the bottled water and the tap water of Dammam, Riyadh, and Jeddah cities, having sample sizes of about 36, 113, and 34, respectively.

The critical value for the SPSS analysis between bottled water and the Riyadh tap water is 1.674, for the SPSS analysis between the bottled water and the Jeddah water is 1.66, and the critical value for the SPSS analysis between bottled and Dammam tap water obtained about 1.675, as mentioned in the

Appendix A. If the values of the t-value increased to their data set's critical value, then it will reject the null hypothesis, Ho and this will confirm the data has a significant difference.

Data:

J. Chem. Bio. Phy. Sci. Sec. D ; May 2020 – July 2020, Vol. 10, No. 3; ; 325-343
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Table 1: *Data of Bottled Water*

Serial Number	Properties	Mean Value	Standard Deviation
Physical Properties			
1	pH	6.9	0.39
2	Turbidity (NTU)	0.168	0.74
3	TDS (mg/L)	96.75	172.92
Chemical Properties			
4	Chloride (mg/L)	38.85	56.21
5	Copper (mg/L)	0.0315	0.019
6	Cadmium (mg/L)	0.1	0
7	Chromium (mg/L)	0.2045	0.1988
8	Lead (mg/L)	0.1	0
9	Sulfate (mg/L)	29.35	24.5
10	Nickle (mg/L)	1.06	1.127
Microbial Properties			
11	Total Coliform (CFU/100 mL)	0	0

Table 2: *Data of Tap Water of Riyadh, KSA*[5]

Serial Number	Properties	Mean Value	Standard Deviation
Physical Properties			
1	pH	7.93	0.1
2	Turbidity (NTU)	0.5	0.69
3	TDS (mg/L)	601.7	62.1
Chemical Properties			
4	Chloride (mg/L)	0.16	0.09

5	Copper (mg/L)	0.01	0.01
6	Cadmium (mg/L)	0	0
7	Chromium (mg/L)	0.01	0
8	Lead (mg/L)	0.02	0.2
9	Sulfate (mg/L)	65	128
10	Nickle (mg/L)	2.11	2.05
Microbial Properties			
11	Total Coliform (CFU/100 mL)	7.93	N/A

Table 3: *Data of Tap Water of Jeddah, KSA*[10]

Serial Number	Properties	Mean Value	Standard Deviation
Physical Properties			
1	pH	7.89	32.7
2	Turbidity (NTU)	32.7	2.7
3	TDS (mg/L)	194.17	52.36
Chemical Properties			
4	Chloride (mg/L)	85.66	35.4
5	Copper (mg/L)	108.7	12.63
6	Cadmium (mg/L)	31.31	7.68
7	Chromium (mg/L)	0.18	0.23
8	Lead (mg/L)	0.97	5.51
9	Sulfate (mg/L)	7.39	3.81
10	Nickle (mg/L)	5.88	4.29
Microbial Properties			
11	Total Coliform (CFU/100 mL)	20	N/A

Table 4: *Data of Tap Water of Dammam, KSA*[11]

Serial Number	Properties	Mean Value	Standard Deviation
Physical Properties			
1	pH	7.259	0.506
2	Turbidity (NTU)	0.83	0.80
3	TDS (mg/L)	21.60	5.26
Chemical Properties			
4	Chloride (mg/L)	127.56	217.33
5	Copper (mg/L)	0.01	0.02
6	Cadmium (mg/L)	0.00	0.00
7	Chromium (mg/L)	0.002	0.002
8	Lead (mg/L)	0.09	0.52
9	Sulfate (mg/L)	161.39	161.18
10	Nickle (mg/L)	0.005	0.006
Microbial Properties			
11	Coliform count (CFU/100 mL)	1.08	N/A

RESULTS AND DISCUSSION

By making the compression of each of the physio-chemical and microbial component of bottled water and tap drinking of Riyadh, Jeddah, and Dammam and also compare them to the standards of "Environmental Protection Agency (EPA)," found the result on the basis we can either bottled water is better or tap water for human health.

The pH range declared by EPA is 6.5 to 8.5; our tap water, as well as our bottled water, is fulfilling that range. The tap water of Dammam has a pH of about 7.26, Riyadh has a pH of about 7.93, and Jeddah has a pH of about 7.89 & Bottled Water has a pH of about 6.9, as shown in **Figure 2**. But the bottled water has a pH near to the neutral so that we can say, the bottled water is a bit better.

According to the EPA, the turbidity of drinking water should not be more than 5 NTU, and the comparison between Riyadh, Dammam, and Jeddah tap water gave us significant results having low NTU of turbidity. It noticed that tap water from the Dammam region has the highest turbidity of about

32.7 NTU, which is not allowable, while the bottled water has the lowest, as shown in **Figure 3**. Here, we can conclude that the bottled water is better as compared to the tap water with respect to turbidity.

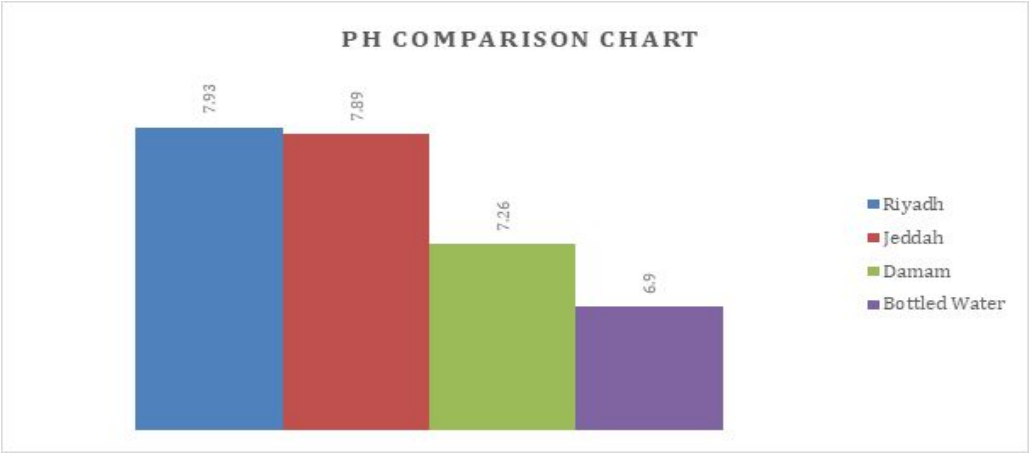

Figure 2: pH Comparison Chart

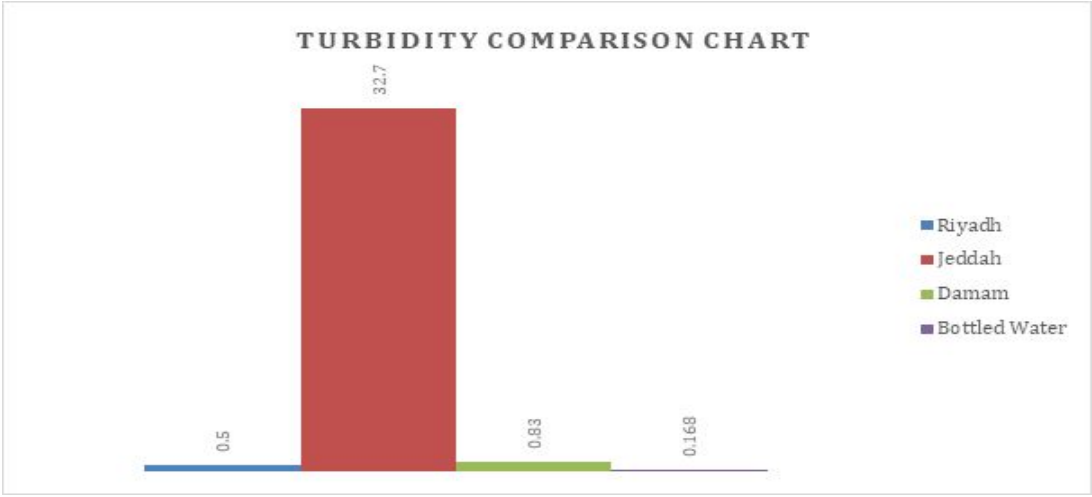

Figure 3: Turbidity Comparison Chart

Total Dissolved Solids should not increase more than 500 mg/L; EPA sets this standard. During the comparison, it observed that the Riyadh tap water has TDS is 601.7 mg/L, more than the standard while Jeddah has 194.17 mg/L, Dammam tap water has TDS about 21.6 mg/L and bottled water has 69.75 mg/L.

According to EPA, the allowable limit of chlorine is 250 mg/L, and the Riyadh, Jeddah, Dammam tap water and Bottled water has 0.16 mg/L, 85.66 mg/L, 127.56 mg/L, and 38.85 mg/L respectively. All

the drinking water we have is fulfilling the requirement of EPA standards, but the Riyadh tap water has a quite low concentration of chlorine, which can be problematic because there should be some concentration of chlorine, which keeps the water safe from bacteria

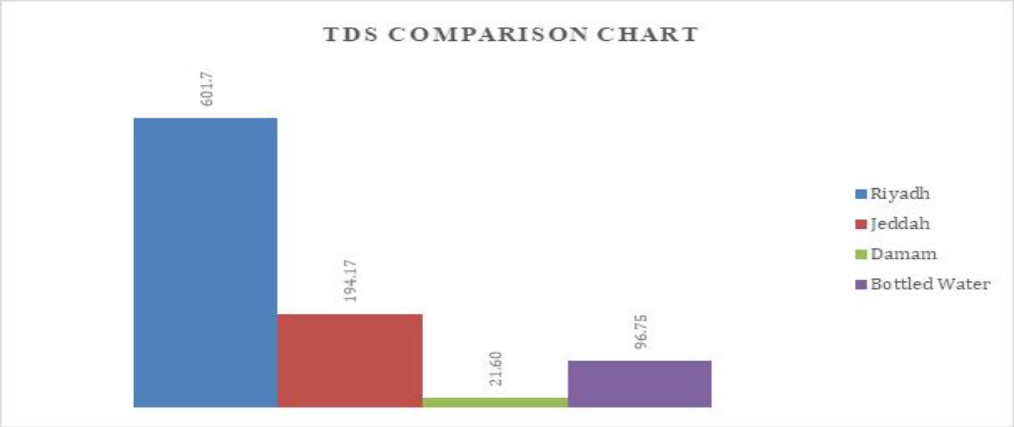

Figure 4: TDS Comparison Chart

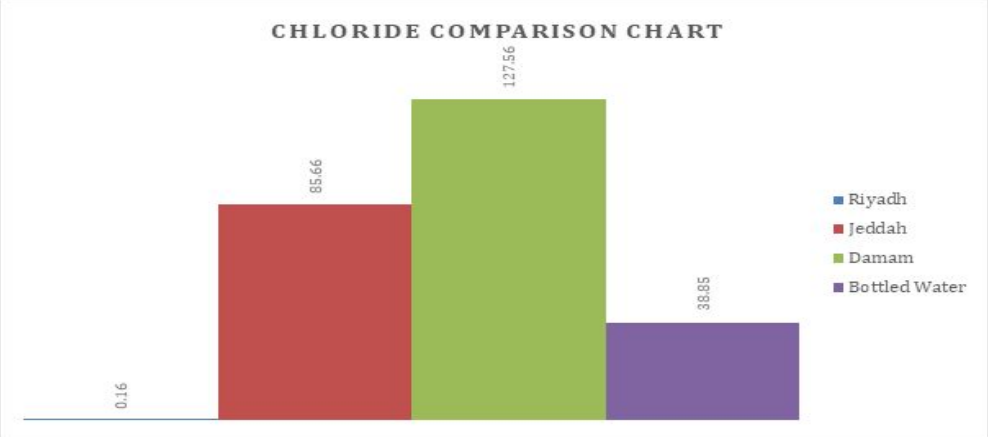

Figure 5: Chloride Comparison Chart

The tap water of Riyadh showing that there is 65 mg of Sulfates present in every liter. The Jeddah and Dammam tap water has 7.39 mg/L and 161.39 mg/L respectively, while the bottled water in the KSA has 29.35 mg/L of Sulfates. All the water is showing the concentration of Sulfates within the limit prescribed by EPA, which is 250 mg/L. If the concentration of sulfates increases from the standards limit, it can cause dehydration to infants.

Heavy metals are harmful to human health; the better the number of heavy metals in drinking water better for human health. The Environmental Protection Agency (EPA) set standards for the heavy metals in drinking water, Copper (Cu) should not more than 1 mg/L of drinking water while the Cadmium (Cd) should be less than 0.005 mg/L, Chromium (Cr) should be less than 0.1 mg/L, Lead (Pb) should be less than 1.3 mg/L, and Nickle should not be more than 0.1 mg/L.

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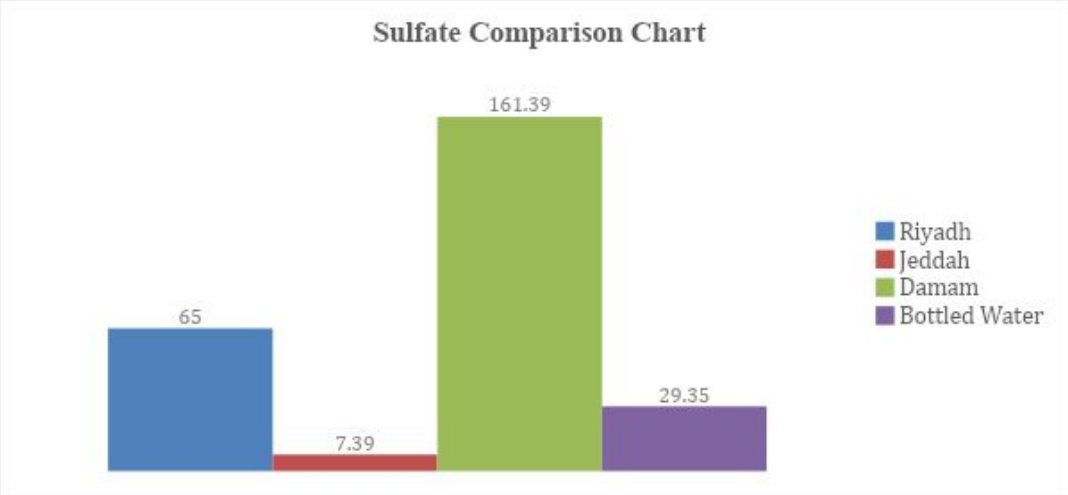

Figure 6: Sulfate Comparison Chart

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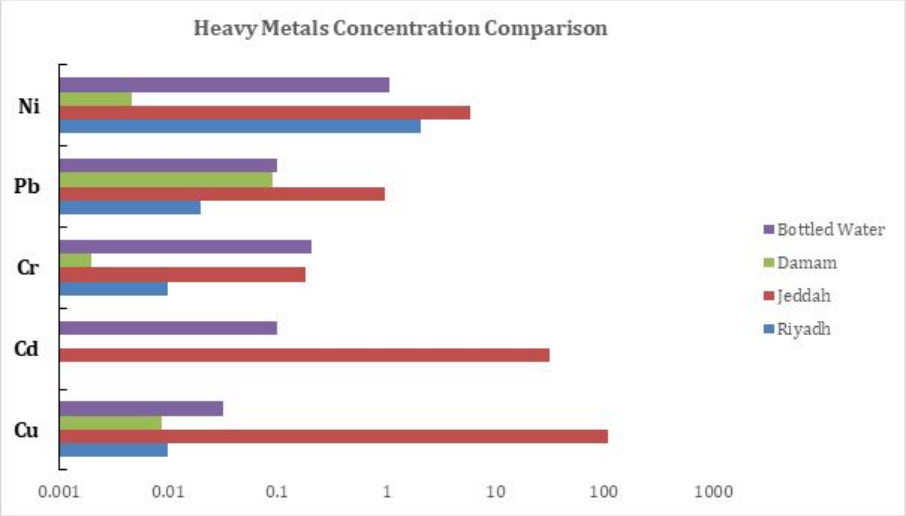

Figure 7: Heavy Metal Concentration Comparison Chart

On comparison we obtained that the Riyad tap water has copper about 0.01 mg/L, Jeddah water has 109 mg/L, which is not acceptable, Dammam tap water has 0.01 mg/L, and the Bottled Water in KSA has 0.0315 mg/L of Copper (Cu). Cadmium (Cd) has zero mg/L in Riyadh water, 31.31 mg/L in Jeddah water, not acceptable, in Dammam water it is absent, and bottled water found with 0.1 mg/L of Cadmium (Cd). As far as the concern about the Chromium, the Riyadh tap water has 0.01 mg/L of Cr, the Jeddah tap water found 0.18 mg/L, Dammam tap water found 0.002 mg/L, and Bottled water in KSA found 0.2045 mg/L Chromium (Cr). The Lead is toxic to human health; it found 0.01 mg/L in Riyadh water, 0.97 mg per liter in Jeddah water, 0.09 mg/L in Dammam water, quite high concentration of Lead, 0.1 mg/L in Bottled water. At last, there is the comparison of Nickle present in drinking water, Riyadh tap water has 2.11 mg/L, Jeddah tap water has 5.88 mg/L, Dammam tap water has 0.005 mg/L, and the Bottled water in KSA has 1.06 mg/L. By this comparison, we can conclude that the bottled water is better than the tap water of Riyadh, Dammam, and Jeddah.

According to the standards of EPA, there should be no Bacteria in the drinking water, and the Total Coliform should be zero CFU/100 mL of drinking water. As per comparison, the tap water of KSA found with the Bacteria, the tap water of Jeddah observed with the most concentration of Coliform about 20 CFU per 100 mL. The tap water from Riyadh and Dammam observed with 0.92 CFU/100 mL and 1.09 CFU/100 mL, respectively, of Total Coliform. The bottled water found no traces of Coliform, so bottled water is better for health.

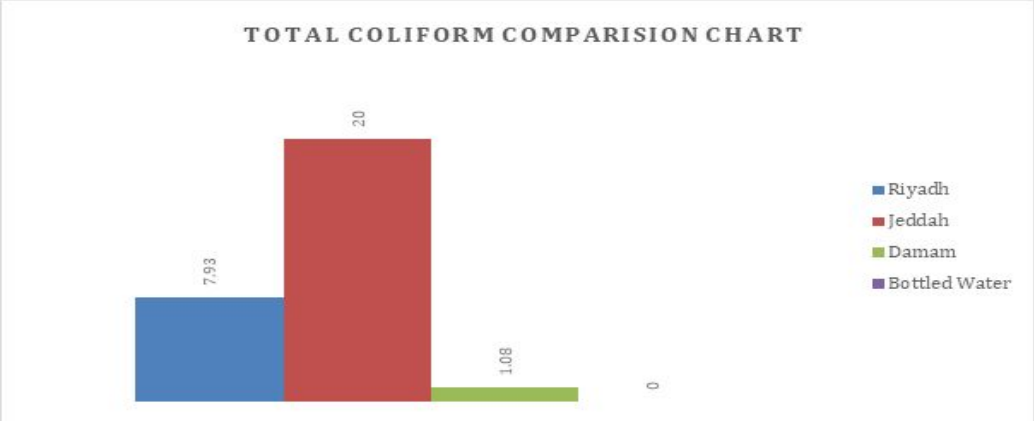

Figure 8: Total Coliform Comparison Chart

By the results of the comparison of bottled water data with the tap water of Riyadh, Jeddah, and Dammam, it found that the bottled water seems better as compared to the tap water. Tap water from each region has some parameters that violate the limitations of EPA standards and make the tap water unhealthy for human health. Tap water of Jeddah has very high turbidity, Riyadh tap water has high TDS and very low Chloride ion concentration, tap water of Jeddah has a high concentration of heavy metals. In addition to this, all tap water is unhealthy for human health due to the high impurity of bacteria (Coliform), the Jeddah tap water seems the most unhealthy water while the Riyadh and Dammam tab water is also harmful due to the microbial impurity. But the bottled water has nothing wrong with the physio-chemical properties, and the bottled water has zero microbial impurity. In this regard, the bottled water is completely fulfilling the EPA standards, and it is quite suitable for human health.

For the statistical SPSS analysis, a student's t-test utilized on the means of two data groups, bottled water and tap water of Riyadh, Jeddah, and Dammam cities, in order to find out either the difference between the data is significant or not. As we perform the SPSS analysis on the bottled water and tap water of Riyadh, we found only the turbidity and sulfate data isn't significant, and all other data are significant.

Table 5: T-Test Results for Bottled Water and Riyadh Water

Serial Num	Properties	Mean Value	Standard Deviation	Mean Value	Standard Deviation	T-Value	Data Significance
Physical Properties							
		Bottled Water		**Riyadh's Tap Water**			
1	pH	6.9	0.39	7.93	0.1	11.60	Significant
2	Turbidity (NTU)	0.168	0.74	0.5	0.69	1.65	Not Significant

3	TDS (mg/L)	96.75	172.92	601.7	62.1	12.61	Significant
Chemical Properties							
4	Chloride (Cl^-) (mg/L)	38.85	56.21	0.16	0.09	3.08	Significant
5	Copper (mg/L)	0.0315	0.019	0.01	0.01	4.71	Significant
6	Cadmium (mg/L)	0.1	0	0	0	N/A	N/A
7	Chromium (mg/L)	0.2045	0.1988	0.01	0	4.37	Significant
8	Lead (mg/L)	0.1	0	0.02	0.2	2.4	Significant
9	Sulfate (mg/L)	29.35	24.5	65	128	1.62	Not Significant
10	Nickle (mg/L)	1.06	1.127	2.11	2.05	2.47	Significant

The SPSS analysis performed for the Jeddah's Tap Water and Bottled water, and we found the result that there is only one parameter, Chromium hasn't the significant difference when it compared to the data of bottled water, it confirms our comparison results because the Jeddah tap water has a very lesser amount of sulfate in water as compared to the other waters. There is also have a lesser difference between the mean values of Jeddah tap water and bottled water. It shows the Jeddah tap water is better than the bottled water with respect to the presence of sulfate anions. Except for the sulfate anions, all the other physio-chemical parameters have a significant difference.

Table 6: T-Test Results for Bottled Water and Jeddah Water

Serial Number	Properties	Mean Value	Standard Deviation	Mean Value	Standard Deviation	T-Value	Data Significance
Physical Properties							
		Bottled Water		**Jeddah's Tap Water**			
1	pH	6.9	0.39	7.89	32.7	10.08	Significant
2	Turbidity (NTU)	0.168	0.74	32.7	2.7	107.32	Significant
3	TDS	96.75	172.92	194.17	52.36	2.50	Significant

	(mg/L)						
Chemical Properties							
4	Chloride Ions (Cl^-) (mg/L)	38.85	56.21	85.66	35.4	3.60	Significant
5	Copper (mg/L)	0.0315	0.019	108.7	12.63	91.46	Significant
6	Cadmium (mg/L)	0.1	0	31.31	7.68	43.20	Significant
7	Chromium (mg/L)	0.2045	0.1988	0.18	0.23	0.495	Not Significant
8	Lead (mg/L)	0.1	0	0.97	5.51	1.678	Significant
9	Sulfate (mg/L)	29.35	24.5	7.39	3.81	4.00	Significant
10	Nickle (mg/L)	1.06	1.127	5.88	4.29	10.13	Significant

T-test performance on the bottled water and Dammam tap water shows that there is a parameter, namely, lead, found not significant because in the Dammam tap water has 0.09 mg/L, there is only the difference of 0.01digit which can neglected, and we can say the bottled and the tap water, both have the same concentration of Lead that's why the there is no significant difference. In contrast, all other physio-chemical parameters have a significant mean difference with the bottled water.

Table 7: T-Test Results for Bottled Water and Dammam Water

Serial Number	Properties	Mean Value	Standard Deviation	Mean Value	Standard Deviation	T-Value	Data Significance
Physical Properties							
		Bottled Water		**Dammam's Tap Water**			
1	pH	6.9	0.39	7.259	0.506	2.91	Significant
2	Turbidity (NTU)	0.168	0.74	0.83	0.80	3.09	Significant

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3	TDS (mg/L)	96.75	172.92	21.60	5.26	1.94	Significant
Chemical Properties							
4	Chloride (Cl^-) (mg/L)	38.85	56.21	127.56	217.33	2.25	Significant
5	Copper (mg/L)	0.0315	0.019	0.01	0.02	4.53	Significant
6	Cadmium (mg/L)	0.1	0	0.00	0.00	N/A	N/A
7	Chromium (mg/L)	0.2045	0.1988	0.002	0.002	4.56	Significant
8	Lead (mg/L)	0.1	0	0.09	0.52	0.09	Not Significant
9	Sulfate (mg/L)	29.35	24.5	161.39	161.18	4.69	Significant
10	Nickle (mg/L)	1.06	1.127	0.005	0.006	4.19	Significant

The overall SPSS analysis result is showing that the data of the bottled and the tap water of all three regions have a significant difference, which means that it is confirming our comparison results that the bottled water is better than the tap water. The t-testing isn't applied for the T. Coliform because the mean value of T. Coliform in the bottled water data is zero, so, it will always provide a significant result. By going through both comparisons, simple data comparison and the student's t-test comparison we can get the same results and in this connection, we can conclude that the bottled water is better than the tap water in Riyadh, Jeddah, and Dammam cities of Central, Eastern and Western regions of the KSA.

Table 8: Critical Value for T-Test of Bottled Water and Jeddah Tap Water

df	.25	.20	.15	.10	.05	.025	.02	.01	.005	.0025	.001	.0005
1	1.000	1.376	1.963	3.078	6.314	12.71	15.89	31.82	63.66	127.3	318.3	636.6
2	0.816	1.061	1.386	1.886	2.920	4.303	4.849	6.965	9.925	14.09	22.33	31.60
3	0.765	0.978	1.250	1.638	2.353	3.182	3.482	4.541	5.841	7.453	10.21	12.92
4	0.741	0.941	1.190	1.533	2.132	2.776	2.999	3.747	4.604	5.598	7.173	8.610
5	0.727	0.920	1.156	1.476	2.015	2.571	2.757	3.365	4.032	4.773	5.893	6.869
6	0.718	0.906	1.134	1.440	1.943	2.447	2.612	3.143	3.707	4.317	5.208	5.959
7	0.711	0.896	1.119	1.415	1.895	2.365	2.517	2.998	3.499	4.029	4.785	5.408
8	0.706	0.889	1.108	1.397	1.860	2.306	2.449	2.896	3.355	3.833	4.501	5.041
9	0.703	0.883	1.100	1.383	1.833	2.262	2.398	2.821	3.250	3.690	4.297	4.781
10	0.700	0.879	1.093	1.372	1.812	2.228	2.359	2.764	3.169	3.581	4.144	4.587
11	0.697	0.876	1.088	1.363	1.796	2.201	2.328	2.718	3.106	3.497	4.025	4.437
12	0.695	0.873	1.083	1.356	1.782	2.179	2.303	2.681	3.055	3.428	3.930	4.318
13	0.694	0.870	1.079	1.350	1.771	2.160	2.282	2.650	3.012	3.372	3.852	4.221
14	0.692	0.868	1.076	1.345	1.761	2.145	2.264	2.624	2.977	3.326	3.787	4.140
15	0.691	0.866	1.074	1.341	1.753	2.131	2.249	2.602	2.947	3.286	3.733	4.073
16	0.690	0.865	1.071	1.337	1.746	2.120	2.235	2.583	2.921	3.252	3.686	4.015
17	0.689	0.863	1.069	1.333	1.740	2.110	2.224	2.567	2.898	3.222	3.646	3.965
18	0.688	0.862	1.067	1.330	1.734	2.101	2.214	2.552	2.878	3.197	3.611	3.922
19	0.688	0.861	1.066	1.328	1.729	2.093	2.205	2.539	2.861	3.174	3.579	3.883
20	0.687	0.860	1.064	1.325	1.725	2.086	2.197	2.528	2.845	3.153	3.552	3.850
21	0.686	0.859	1.063	1.323	1.721	2.080	2.189	2.518	2.831	3.135	3.527	3.819
22	0.686	0.858	1.061	1.321	1.717	2.074	2.183	2.508	2.819	3.119	3.505	3.792
23	0.685	0.858	1.060	1.319	1.714	2.069	2.177	2.500	2.807	3.104	3.485	3.768
24	0.685	0.857	1.059	1.318	1.711	2.064	2.172	2.492	2.797	3.091	3.467	3.745
25	0.684	0.856	1.058	1.316	1.708	2.060	2.167	2.485	2.787	3.078	3.450	3.725
26	0.684	0.856	1.058	1.315	1.706	2.056	2.162	2.479	2.779	3.067	3.435	3.707
27	0.684	0.855	1.057	1.314	1.703	2.052	2.158	2.473	2.771	3.057	3.421	3.690
28	0.683	0.855	1.056	1.313	1.701	2.048	2.154	2.467	2.763	3.047	3.408	3.674
29	0.683	0.854	1.055	1.311	1.699	2.045	2.150	2.462	2.756	3.038	3.396	3.659
30	0.683	0.854	1.055	1.310	1.697	2.042	2.147	2.457	2.750	3.030	3.385	3.646
40	0.681	0.851	1.050	1.303	1.684	2.021	2.123	2.423	2.704	2.971	3.307	3.551
50	0.679				1.676	2.009	2.109	2.403	2.678	2.937	3.261	3.496
60	0.679				1.671	2.000	2.099	2.390	2.660	2.915	3.232	3.460
80	0.678				1.664	1.990	2.088	2.374	2.639	2.887	3.195	3.416
100	0.677	0.845	1.042	1.290	1.660	1.984	2.081	2.364	2.626	2.871	3.174	3.390
1000	0.675	0.842	1.037	1.282	1.646	1.962	2.056	2.330	2.581	2.813	3.098	3.300
z*	0.674	0.841	1.036	1.282	1.645	1.960	2.054	2.326	2.576	2.807	3.091	3.291

Critical Value 1.66

Table 9: Critical Value for T-Test of Bottled Water and Riyadh Tap Water

df	.25	.20	.15	.10	.05	.025	.02	.01	.005	.0025	.001	.0005
1	1.000	1.376	1.963	3.078	6.314	12.71	15.89	31.82	63.66	127.3	318.3	636.6
2	0.816	1.061	1.386	1.886	2.920	4.303	4.849	6.965	9.925	14.09	22.33	31.60
3	0.765	0.978	1.250	1.638	2.353	3.182	3.482	4.541	5.841	7.453	10.21	12.92
4	0.741	0.941	1.190	1.533	2.132	2.776	2.999	3.747	4.604	5.598	7.173	8.610
5	0.727	0.920	1.156	1.476	2.015	2.571	2.757	3.365	4.032	4.773	5.893	6.869
6	0.718	0.906	1.134	1.440	1.943	2.447	2.612	3.143	3.707	4.317	5.208	5.959
7	0.711	0.896	1.119	1.415	1.895	2.365	2.517	2.998	3.499	4.029	4.785	5.408
8	0.706	0.889	1.108	1.397	1.860	2.306	2.449	2.896	3.355	3.833	4.501	5.041
9	0.703	0.883	1.100	1.383	1.833	2.262	2.398	2.821	3.250	3.690	4.297	4.781
10	0.700	0.879	1.093	1.372	1.812	2.228	2.359	2.764	3.169	3.581	4.144	4.587
11	0.697	0.876	1.088	1.363	1.796	2.201	2.328	2.718	3.106	3.497	4.025	4.437
12	0.695	0.873	1.083	1.356	1.782	2.179	2.303	2.681	3.055	3.428	3.930	4.318
13	0.694	0.870	1.079	1.350	1.771	2.160	2.282	2.650	3.012	3.372	3.852	4.221
14	0.692	0.868	1.076	1.345	1.761	2.145	2.264	2.624	2.977	3.326	3.787	4.140
15	0.691	0.866	1.074	1.341	1.753	2.131	2.249	2.602	2.947	3.286	3.733	4.073
16	0.690	0.865	1.071	1.337	1.746	2.120	2.235	2.583	2.921	3.252	3.686	4.015
17	0.689	0.863	1.069	1.333	1.740	2.110	2.224	2.567	2.898	3.222	3.646	3.965
18	0.688	0.862	1.067	1.330	1.734	2.101	2.214	2.552	2.878	3.197	3.611	3.922
19	0.688	0.861	1.066	1.328	1.729	2.093	2.205	2.539	2.861	3.174	3.579	3.883
20	0.687	0.860	1.064	1.325	1.725	2.086	2.197	2.528	2.845	3.153	3.552	3.850
21	0.686	0.859	1.063	1.323	1.721	2.080	2.189	2.518	2.831	3.135	3.527	3.819
22	0.686	0.858	1.061	1.321	1.717	2.074	2.183	2.508	2.819	3.119	3.505	3.792
23	0.685	0.858	1.060	1.319	1.714	2.069	2.177	2.500	2.807	3.104	3.485	3.768
24	0.685	0.857	1.059	1.318	1.711	2.064	2.172	2.492	2.797	3.091	3.467	3.745
25	0.684	0.856	1.058	1.316	1.708	2.060	2.167	2.485	2.787	3.078	3.450	3.725
26	0.684	0.856	1.058	1.315	1.706	2.056	2.162	2.479	2.779	3.067	3.435	3.707
27	0.684	0.855	1.057	1.314	1.703	2.052	2.158	2.473	2.771	3.057	3.421	3.690
28	0.683	0.855	1.056	1.313	1.701	2.048	2.154	2.467	2.763	3.047	3.408	3.674
29	0.6				1.699	2.045	2.150	2.462	2.756	3.038	3.396	3.659
30	0.6				1.697	2.042	2.147	2.457	2.750	3.030	3.385	3.646
40	0.				1.684	2.021	2.123	2.423	2.704	2.971	3.307	3.551
50	0.679	0.849	1.047	1.299	1.676	2.009	2.109	2.403	2.678	2.937	3.261	3.496
60	0.679	0.848	1.045	1.296	1.671	2.000	2.099	2.390	2.660	2.915	3.232	3.460
80	0.678	0.846	1.043	1.292	1.664	1.990	2.088	2.374	2.639	2.887	3.195	3.416
100	0.677	0.845	1.042	1.290	1.660	1.984	2.081	2.364	2.626	2.871	3.174	3.390
1000	0.675	0.842	1.037	1.282	1.646	1.962	2.056	2.330	2.581	2.813	3.098	3.300
z^*	0.674	0.841	1.036	1.282	1.645	1.960	2.054	2.326	2.576	2.807	3.091	3.291

Critical Value = 1.674

Table 10: Critical Value for T-Test of Bottled Water and Dammam Tap Water

df	.25	.20	.15	.10	.05	.025	.02	.01	.005	.0025	.001	.0005
1	1.000	1.376	1.963	3.078	6.314	12.71	15.89	31.82	63.66	127.3	318.3	636.6
2	0.816	1.061	1.386	1.886	2.920	4.303	4.849	6.965	9.925	14.09	22.33	31.60
3	0.765	0.978	1.250	1.638	2.353	3.182	3.482	4.541	5.841	7.453	10.21	12.92
4	0.741	0.941	1.190	1.533	2.132	2.776	2.999	3.747	4.604	5.598	7.173	8.610
5	0.727	0.920	1.156	1.476	2.015	2.571	2.757	3.365	4.032	4.773	5.893	6.869
6	0.718	0.906	1.134	1.440	1.943	2.447	2.612	3.143	3.707	4.317	5.208	5.959
7	0.711	0.896	1.119	1.415	1.895	2.365	2.517	2.998	3.499	4.029	4.785	5.408
8	0.706	0.889	1.108	1.397	1.860	2.306	2.449	2.896	3.355	3.833	4.501	5.041
9	0.703	0.883	1.100	1.383	1.833	2.262	2.398	2.821	3.250	3.690	4.297	4.781
10	0.700	0.879	1.093	1.372	1.812	2.228	2.359	2.764	3.169	3.581	4.144	4.587
11	0.697	0.876	1.088	1.363	1.796	2.201	2.328	2.718	3.106	3.497	4.025	4.437
12	0.695	0.873	1.083	1.356	1.782	2.179	2.303	2.681	3.055	3.428	3.930	4.318
13	0.694	0.870	1.079	1.350	1.771	2.160	2.282	2.650	3.012	3.372	3.852	4.221
14	0.692	0.868	1.076	1.345	1.761	2.145	2.264	2.624	2.977	3.326	3.787	4.140
15	0.691	0.866	1.074	1.341	1.753	2.131	2.249	2.602	2.947	3.286	3.733	4.073
16	0.690	0.865	1.071	1.337	1.746	2.120	2.235	2.583	2.921	3.252	3.686	4.015
17	0.689	0.863	1.069	1.333	1.740	2.110	2.224	2.567	2.898	3.222	3.646	3.965
18	0.688	0.862	1.067	1.330	1.734	2.101	2.214	2.552	2.878	3.197	3.611	3.922
19	0.688	0.861	1.066	1.328	1.729	2.093	2.205	2.539	2.861	3.174	3.579	3.883
20	0.687	0.860	1.064	1.325	1.725	2.086	2.197	2.528	2.845	3.153	3.552	3.850
21	0.686	0.859	1.063	1.323	1.721	2.080	2.189	2.518	2.831	3.135	3.527	3.819
22	0.686	0.858	1.061	1.321	1.717	2.074	2.183	2.508	2.819	3.119	3.505	3.792
23	0.685	0.858	1.060	1.319	1.714	2.069	2.177	2.500	2.807	3.104	3.485	3.768
24	0.685	0.857	1.059	1.318	1.711	2.064	2.172	2.492	2.797	3.091	3.467	3.745
25	0.684	0.856	1.058	1.316	1.708	2.060	2.167	2.485	2.787	3.078	3.450	3.725
26	0.684	0.856	1.058	1.315	1.706	2.056	2.162	2.479	2.779	3.067	3.435	3.707
27	0.684	0.855	1.057	1.314	1.703	2.052	2.158	2.473	2.771	3.057	3.421	3.690
28	0.683	0.855	1.056	1.313	1.701	2.048	2.154	2.467	2.763	3.047	3.408	3.674
29	0				1.699	2.045	2.150	2.462	2.756	3.038	3.396	3.659
30	0				1.697	2.042	2.147	2.457	2.750	3.030	3.385	3.646
40	0.681	0.851	1.050	1.303	1.684	2.021	2.123	2.423	2.704	2.971	3.307	3.551
50	0.679	0.849	1.047	1.299	1.676	2.009	2.109	2.403	2.678	2.937	3.261	3.496
60	0.679	0.848	1.045	1.296	1.671	2.000	2.099	2.390	2.660	2.915	3.232	3.460
80	0.678	0.846	1.043	1.292	1.664	1.990	2.088	2.374	2.639	2.887	3.195	3.416
100	0.677	0.845	1.042	1.290	1.660	1.984	2.081	2.364	2.626	2.871	3.174	3.390
1000	0.675	0.842	1.037	1.282	1.646	1.962	2.056	2.330	2.581	2.813	3.098	3.300
z*	0.674	0.841	1.036	1.282	1.645	1.960	2.054	2.326	2.576	2.807	3.091	3.291

Critical Value = 1.675

CONCLUSION

The comparison is made between the bottled water and tap drinking water within the three cities, Riyadh, Jeddah, and Dammam, of three different regions. Data of bottled water is obtained by "Ion Chromatography Metrohum" and "Atomic Absorption Spectrophotometer." The comparison made in two different ways; first, the data is compared to bottled data and tap water data of each city, and the graph is a plot with respect to each parameter. Almost all the graphs are showing that bottled water is in accordance with the EPA standards of drinking water, and it is better for human health as compared to tap water. While the student t-test also performed to find out the significant difference between the data. The probability set for the t-test about 0.05, and the critical value found by using the t-table. By performing both comparisons, we found that bottled water is better for tap water.

FUTURE WORK

The bottled water is better for health, but it is remaining in the plastic bottles for a very long time under the high temperature of KSA. Due to this, there might be some plastic emulsion in the water bottles, and this causes the bottled water harmful to human life. In this connection, we need to make a research on the water bottles that keep in store for an extended period of time under high temperature and check out what effect the plastic bottles made on the water quality.

REFERENCES

1. P.H.Gleick, *Water in Crisis: A Guide to the World's Fresh Water Resources,* Pacific Institute for Studies in Development, Environment, and Security, Stockholm Environment Institute, Eds.; Oxford University Press: New York, 1993.
2. The Water in You: Water and the Human Body https://www.usgs.gov/special-topic/water-science-school/science/water-you-water-and-human-body?qt-science_center_objects=0#qt-science_center_objects (accessed Jun 17, 2020).
3. K.F.Abed, S.S.Alwakeel, Mineral and Microbial Contents of Bottled and Tap Water in Riyadh, Saudi Arabia. **2007**, 6.
4. A.M.Al-Omran, S.E. El-Maghraby, A.A. Aly, M.I. Al-Wabel, Z.A. Al-Asmari, M.E.Nadeem, Quality Assessment of Various Bottled Waters Marketed in Saudi Arabia. *Environ. Monit. Assess.* **2013**, *185* (8), 6397–6406.
5. A. Al-Omran, F. Al-Barakah, A. Altuquq, A. Aly, M. Nadeem, Drinking Water Quality Assessment and Water Quality Index of Riyadh, Saudi Arabia. *Water Qual. Res. J.* **2015**, *50* (3), 287–296.
6. H.A.Nounou, S.M. Ali, M.A. Shalaby, R.G. Asala, The Threats of Microbial Contamination and Total Dissolved Solids in Drinking Water of Riyadh's Rural Areas, Saudi Arabia. **2013**, *7* (4), 8.

7. M. Maurya, C. Shah, H. Patel, D. Nagar, M.A. Patel, Review: Effect of Water Pollution on Human Health. **2019**.
8. pH and Water https://www.usgs.gov/special-topic/water-science-school/science/ph-and-water?qt-science_center_objects=0#qt-science_center_objects (accessed Jun 17, 2020).
9. *Guidelines for Drinking-Water Quality*, 2nd ed.; World Health Organization, International Program on Chemical Safety, Eds.; World Health Organization: Geneva, 1993.
10. H. Maged . M.H.H.Hussein, Domestic Water Quality in Jeddah, Saudi Arabia. *J. King Abdulaziz Univ. Eng. Sci.* **2012**, *23* (1), 207–223.
11. F.A. Alharbi, F. A. Alshikh, M. Alshukri, I.A.I. Mohamed, O.; Aga, I.M. Abdel-Magid, Quality of Household Water Storage Tanks: Case Study with Emphasis on Dammam Metropolitan Area In the Eastern Region. **2017**, *4* (2), 14.
12. EPA. *Drinking-Water Standards and Health Advisories Tables*; United States Environmental Protection Agency: Washington, USA, 2018.
13. Saudi Arabia Map, Map of Saudi Arabia https://www.mapsofworld.com/saudi-arabia/ (accessed Jun 17, 2020).
14. M. Mahbobi, Introductory *Business Statistics with Interactive Spreadsheets*, First Canadian; BCcampus, 2010.

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