Research Journal of Agricultural Sciences
Tarım Bilimleri Araştırma Dergisi
E-ISSN: 1308-027X, 10(2): 27-32, 2017, www.nobel.gen.tr

Comparison Of Tap Water With Bottled Natural Spring Water in Terms Of Some Quality Parameters in Erzurum

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Geliş Tarihi: 05 Temmuz 2017
Kabul Tarihi: 10 Eylül 2017

Abstract

Supplying healthy drinking water to meet the growing population needs is one of today's priority issues. Drinking water requirement in cities is largely met by the network water obtained by the treatment of surface waters. Public's interest to bottled water has increased due to the difficulties in access to drinkable water in recent years, desire of consume to healthy water, changes in consumers preferences in the last years.

In this study, some physical, chemical, and microbiological quality parameters of Erzurum tap water and bottled spring water which is sold in Erzurum market are examined according to the national and international standards, compared and obtained results are evaluated

It is evaluated that although tap water parametric values are generally higher than bottled water, both tap water and bottled water are safety and healthy water in terms of examined parameters.

Key words: tap water, bottled spring water, Erzurum province

INTRODUCTION

Although drinking water resources are depleted and contaminated due to the population growth and developing technology, demand of drinking water is increased day by day. Therefore water is one of the most important materials and healthy water supply is one of the priority issue today [1].

Water is different from other foods, it is consumed natural form (ıt is not done anything purifying process such as washing, cooking etc. before consumed). For this reason, water may cause diseases or spread of diseases. Continuously access to healthy and safety drinking water is basic principle to protect public health [1-2]. Therefore water which is consumed form should be healthy, good quality, safe [3-4].

Healthy water; have balanced mineral content, do not have pesticides and organic substances, physical, chemical and microbiological quality comply with standards do not adversely affect human health [5-6]. Daily drinking water requirement is 2,5 L/per person and ıt is increases along with the other water requirement such as cooking, cleaning [2].

Accessing healthy water is everybody's right. Fort his reason drinking water services are supplied by the public in Turkey [7]. Healthy and safety water is supplied by local authority and it is monitored by Ministry of Health

Drinking water requirement in cities is largely met by the network water obtained by the treatment of surface waters and drinking water is transported to the consumers after treatment (such as precipitation, filtration, purification, disinfection) [7]. But faults that occurred in drinking water network and fractures or cracks that occurred on the pipeline are caused quality problems in drinking water [8].

Drinking water standards are complied with the EU directive and determined by Regulation Concerning Water Intended for Human Consumption (enter in force date 17/2/2005) in Turkey.

Difficulty of access to clean drinking water and concern about access to clean drinking water have increased bottled water's demand and have led to emergence of bottled water sector which can be expressed in billions of dollars worldwide [1-9].

It is forbidden to bottling of surface waters for human consumption in our country, but bottled water has been in Turkey market since 1932. It has been hugely developed after 1980, especially due to due to the lack of healthy water supply from network and confidence to local authority which is supply drinking water. Consumers have started to prefer bottled water due to taste, availability, and fashion [9-10-11-12-13]. PET water (which can use and transport everywhere and every time) and carboy bottled water (which can use in-house for drinking and use) have been used in daily life [2-4]. Bottled water consumption is 139 L/per person (60 L/per person for PET&Glass and 79 L/per person for Carboy) in 2015 [14].

Palandöken Dam is activated in 2008 for supplying Erzurum province's drinking water requirement. Drinking water is transported to consumers by network after surface water is treated in the treatment plant. But Erzurum people's concern about drinking water's quality and health has increased and bottled water demand of consumers has increased, als [2-4].

In this study, characteristics and general quality parameters of Erzurum tap water and bottled spring water which is sold in Erzurum market are examined, compared and obtained results are evaluated.

MATERIAL and METHOD

Tap water is outlet water from drinking water treatment plant. The analysis results of tap water (between 01 January 2017 - 30 September 2017 for nine months monthly mean values) are taken from Erzurum Water and Sewerage Administration (ESKİ) website.

Different brand bottled spring waters are sold from Erzurum market. The analysis results of bottled spring water are taken from label on the bottle (between 01 August 2017 - 30 September 2017). The origin location of tap water and bottled spring water are marked on the aerial photograph of Turkey in Figure 1.

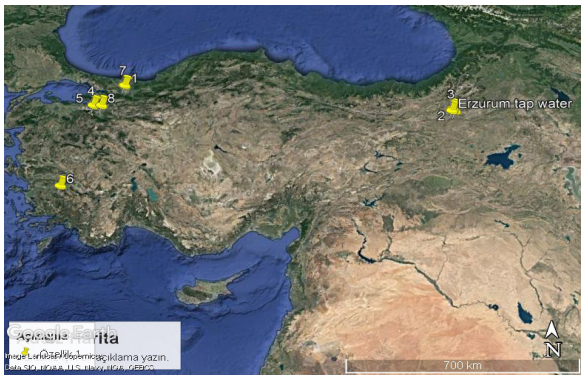

Figure 1. The origin location of tap water and bottled spring water are Erzurum marked on the aerial photograph of Turkey.

Bottled spring water are numbered. Spring water's number and origin locations are shown Table 1.

Table 1. Bottled waters numbers and locations

Number of bottled spring water which is sold in Erzurum market	Location
1	Sapanca/SAKARYA
2	Palandoken/ERZURUM
3	Dumlu/ERZURUM
4	Uludag/BURSA
5	Uludag/BURSA
6	Bozdogan/AYDIN
7	Sapanca/SAKARYA
8	Inegol/BURSA

For statistical analysis; Quantitative data are given as arithmetic mean and standard deviation. Mean values of tap water and mean values of bottled spring water are compared using the Mann-Whitney test. Statistical significance is p 0,05.

RESULTS and DISCUSSION

The analysed results that tap water are shown in Table 2.

The analysed results that bottled spring water which are Erzurum market are shown in Table 3.

Statistical analysis results of data for samples are presented in Table 4.

Turbidity, Appearance, Odour, Taste, pH and Electrical conductivity

Drinking water must be organoleptically acceptable and aesthetically attractive [19]. In general, drinking water to have good physical qualities if it is clear, tastes good, has no smell and is cool. Physical contaminants generally do have not direct health effects themselves; however, their presence may relate to a higher risk of microbiological and chemical contamination which may be harmful to human health [20].

Turbidity can be initially noticed by the naked eye above approximately 4.0 NTU. to ensure effectiveness of disinfection in tap water, turbidity should be no more than 1 NTU and preferably much lower [10].

Tap water and bottled water have acceptable turbidity, appearance, color, odor, taste in this study.

pH is one of the most important operational water quality parameters. pH values higher than 8 are not suitable for effective disinfection and causes slippery feeling while values less than 6.5 water can be acidic and corrosive and metallic taste [19-21].

Tap water's and bottled water's mean pH values are 8,12-7,42 respectively. Tap water's pH values are higher than bottled water, but all samples have acceptable pH values.

Electrical conductivity (EC) is an indicator of the concentration of dissolved electrolyte ions in the water. It does not identify the specific ions in the water. However, significant increases in conductivity may be an indicator that impurities have entered the water.

Tap water's and bottled water's mean electrical conductivity (EC) values are 242,22-98,29 µs/cm respectively. Tap water's electrical conductivity (EC) values are higher than bottled water, but all samples have acceptable electrical conductivity (EC) values.

Chemical Parameters

Fluoride can reduce dental caries and enhance remineralization of early carious lesions(comparison fluoride dosyası). Recommended value for minimum concentration of fluoride in drinking water is approximately 0.5 mg/l [10].

Bottled water did not state fluoride (F) concentration on the label (There is no legal obligation according to the Turkish standards). Tap water's mean fluoride (F) content is 0.04 mg/L. These concentrations are lower than recommended concentrations.

Chloride; Not of health concern at levels found in drinking water. High concentrations of chloride give a salty taste to water [10].

Tap water's and bottled water's mean chloride (Cl) content are 27,01-2,36 mg/L respectively. Tap water's chloride (Cl) values are higher than bottled water, but all samples have acceptable chloride (Cl) content.

Nitrate; in drinking-water may be an important risk factor for methemoglobinemia in bottle-fed infants [10].

Bottled water did not state nitrate (NO_3) concentration on the label (There is no legal obligation according to the Turkish standards). Tap water's mean nitrate content is 0.69 mg/L. They have acceptable nitrate (NO_3) content.

Sulfate; Not of health concern at levels found in drinking-water. The presence of sulfate (SO_4) in drinking-water can cause noticeable taste, and very high levels might cause a laxative effect [10].

Tap water's and bottled water's mean sulfate (SO_4) content are 15,21-5,58 mg/L respectively. Tap water sulfate (SO_4) values are higher than bottled water, but all samples have acceptable sulfate (SO_4) content.

Ammonia; Occurs in drinking-water at concentrations well below those of health concern but ammonia (NH_4) in water is an indicator of possible bacterial, sewage and

Table 2. The analysed results that tap water [15]

Parameter	Jan 2017	Febr. 2017	March 2017	April 2017	May 2017	June 2017	July 2017	August 2017	Sept 2017	Mean value	Standard deviation	EPA [16]	WHO [10]	EC [17]	TS [18]
Turbidity(NTU)	0,32	0,25	0,29	0,25	0,26	0,26	0,31	0,28	0,24	-	0,03	1	-	1	1
Odor	ac	ac	ac	ac	ac	ac	ac	ac	ac	-	-	3TON	-	ac	ac
Color(PC)	1,06	1,00	1,03	1,12	1	1,10	1,39	1,00	1,00	-	0,13	15	-	ac	ac
Taste	ac	ac	ac	ac	ac	ac	ac	ac	ac	-	-	-	-	ac	ac
pH	8,26	8,18	8,20	8,01	8,18	7,95	8,10	8,16	8,02	8,12	0,1	6,5-8,5	-	6,5-9,5	6,5-9,5
Electrical conductivity(µs/cm)	249	249	248	241	215	224	244	251	259	242,22	13,97	-	-	2500	2500
Fluoride(mg/L)	0,05	0,05	0,05	0,04	0,04	0,03	0,04	0,04	0,04	0,04	0,04	4	1,5	1,5	1,5
Chloride(mg/L)	28,5	29,1	29,1	25,0	21,2	24,4	28,1	28,3	29,4	27,01	2,83	250	-	250	250
Nitrate(mg/L)	0,67	0,47	0,73	1,37	0,51	0,81	0,52	0,47	<0,33	<0,69	0,30	10	50	50	50
Sulfate(mg/L)	13,8	14,5	12,7	15,8	18,3	16,3	14,9	15,3	15,3	15,21	1,58	250	-	250	250
Ammonia(mg/L)	<0,01	<0,008	<0,008	<0,008	<0,008	<0,008	<0,008	<0,008	<0,008	<0,008	-	-	-	0,5	0,5
Alüminium(µg/L)	70	60	50	40	40	40	60	70	60	60	10	200	-	200	200
Arsenic(µg/L)	<3,37	<3,37	<3,37	<3,37	<3,37	<3,37	<3,37	<3,37	<3,37	<3,37	-	10	10	10	10
Nickel (µg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-	-	70	20	20
Cadmium (µg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-	5	3	5	5
Chromium(µg/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-	100	50	50	50
Lead (µg/L)	<4,35	5,43	5,52	5,23	4,82	4,33	5,19	<4,35	<4,35	<4,35	0,44	15	10	10	10
Copper (µg/L)	2,90	2,72	<2	<2	2,07	<2	<2	2,19	2,55	<2,55	0,35	1000	2000	2000	2000
Iron(µg/L)	10	10	10	10	10	10	10	10	10	10	0	300	-	200	200
Manganes (µg/L)	3,5	3,70	7,7	9,10	2,68	2,30	3,70	4,00	3,60	3,6	2,32	50	-	50	50
Sodium(mg/L)	21,2	20,8	21,5	19,5	15,6	17,7	20,0	21,0	22,0	22	2,07	-	-	200	200
Magnesium(mg/L)	4,17	4,05	4,10	4,20	3,41	3,41	3,59	3,73	3,81	3,81	0,32	-	-	-	-
Calcium(mg/L)	21,3	20,5	20,5	20,5	19,8	19,7	20,6	20,9	21,0	21	0,52	-	-	-	-
Coliform bacteria	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0/100ml
Escherichia coli	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0/100ml
C. Perfringens	0	0	0	0	0	0	0	0	0	0	-	-	-	0	0/50ml/
Free Chlorine*	0,67	0,64	0,49	0,55	0,51	0,58	0,68	0,71	0,77	0,62	0,10	4	5	-	0,5

*It is stated that free chlorine value is treatment plant outlet water value. Free chlorine value of tap water is 0,2-0,5 mg/L.
ac: acceptable

EPA: Environmental Pro tection Agency WHO: World Health Organisation EC: European Communities Council Directive TS: Turkish Standard (Regulation Concerning Water Intended for Human Consumption)

Table 3. The analysed results that bottled water

Parameter	1	2	3	4	5	6	7	8	Mean value	Standard deviation	EPA [16]	WHO [10]	EC [17]	TS [18]
Turbidity(NTU)	ac	ac	ac	ac	ac	ac	ac	ac	-	-	1	-	1	1
Odor	ac	ac	ac	ac	ac	ac	ac	ac	-	-	3 TON	-	ac	ac
Color	ac	ac	ac	ac	ac	ac	ac	ac	-	-	15	-	ac	ac
Taste	ac	ac	ac	ac	ac	ac	-	ac	-	-	-	-	ac	ac
pH	7,6	7,59	7,42	7,57	7,79	6,8	7,6	7,02	7,42	0,34	6,5-8,5	-	6,5-9,5	6,5-9,5
Electrical conductivity(µs/cm)	144,2	87,7	83,1	124,2	147,1	60	72,9	67,1	98,29	35,03	-	-	2500	2500
Chloride(mg/L)	1,81	8,47	0,43	1,0	1,28	3,6	1,18	1,08	2,36	2,36	250	-	250	250
Sulfate(mg/L)	7,03	3,75	2,72	4,41	11,34	7,9	5	2,45	5,58	3,02	250	-	250	250
Ammonia(mg/L)	TE	0,14	0,05	<0,03	<0,03	TE	TE	<0,03	<0,10	0,06	-	-	0,5	0,5
Aluminium(µg/L)	TE	2,3	<4	<2	13,23	TE	TE	<2	<7,77	7,73	200	-	200	200
Iron(µg/L)	TE	0,92	1,39	<1	<1	5,1	TE	<1	<2,47	2,29	300	-	200	200
Manganes (µg/L)	TE	0,1	1,16	<1	<1	TE	TE	<1	<0,63	0,75	50	-	50	50
Sodium(mg/L)	2,3	4,18	7,34	1,23	1,73	4,9	1,5	1,28	3,06	2,21	-	-	200	200
Oksidasibility	0,5	0,8	1,6	0,68	1,07	0,4	0,5	0,60	0,77	0,40	-	-	5	5
22 de koloni sayımı	0	-	-	0	0	0	-	0		-	-	-	100/ml	100/ml
Coliform bacteria	0	-	-	0	0	0	-	0		-	0/250ml	0/250ml	0/250ml	0/250ml

ac: acceptable EPA: Environmental Protection Agency WHO: World Health Organisation EC: European Communities Council Directive

TS: Turkish Standard (Regulation Concerning Water Intended for Human Consumption)

Table 4. Statistical analysis results of tap water and bottled waters

Samples/ Parameters	Tap water	Bottled water	P<0,05
pH	8,12±0,1	7,42±0,34	0,0003
EC(µs/cm)	242,22±13,97	98,29±35,03	0,.0003
Chloride(Cl)	27,01±2,83	2,36±2,64	0,0003
Sulfate(SO_4)	15,21±1,58	5,58±3,02	0,0003
Sodium(Na)	19,92±2,07	3,06±2,21	0,0003
Ammonia(NH_4)	<0,008±	<0,10±0,06	0,00349
Aluminium(Al)	60±10	<7,77±7,73	0,00049
Iron(Fe)	10±0	<2,47±2,29	0,00019
Manganes(Mn)	3,6±2,32	<0,63±0,75	0,0003

animal waste pollution [10].

Tap water's and bottled water's mean ammonia (NH_4) content are <0,008-<0,10 mg/L respectively. All samples have low and acceptable ammonia (NH_4) content.

Sodium; Not of health concern at levels found in drinking water. However, concentrations in excess of 200 mg/l may give rise to unacceptable taste [10].

Tap water's and bottled water's mean sodium (Na) content are 19,92-3,06 mg/L respectively. Tap water's sodium (Na) values are higher than bottled water, but all samples have acceptable sodium (Na) content.

Magnesium and calcium; Not of health concern at levels found in drinking water. But there is evidence from epidemiological studies for a protective effect of magnesium (Mg) or hardness on cardiovascular mortality [10].

Although calcium (Ca) and magnesium (Mg) intake changes according to age, life stage, gender(10(51-19)), calcium (Ca) and magnesium (Mg) content of drinking water are extremely low and may provide little supplementation towards a person's daily requirement [10].

Tap water's mean calcium (Ca) and magnesium (Mg) content are 19,7-3,41 respectively. Bottled water did not state calcium (Ca) and magnesium (Mg) concentration on the label (There is no legal obligation according to the Turkish standards).

Heavy metals

The presence of heavy metals in drinking water such as lead (Pb), arsenic (As), nickel (Ni), copper (Cu), and zinc (Zn) higher than a certain concentration can cause detrimental impacts on human health. They tend to accumulate in human organs and nervous system and interfere with their normal functions. Therefore, heavy metals in drinking water is an important parameter, and most of the studies on drinking water quality involve investigation of heavy metals [13].

Tap water's and bottled water's mean alüminum (Al), ıron (Fe) and manganese (Mn) content are 50-<7,77; 10-<2,47; 4,48-<0,63 µg /L respectively. Tap water's alüminum (Al), ıron (Fe), manganese (Mn) values are higher than bottled water. Tap water's mean arsenic (As), nickel (Ni), cadmium (Cd), chromium (Cr), lead (Pb), copper (Cu) content are <3,37- <2- <2- <2- <4,33- <2,49 µg/L respectively. Bottled water did not state some heavy metals(As, Ni, Cd, Cr, Pb, Cu) concentration on the label(There is no legal obligation according to the Turkish standards).

Aluminum salts are widely used in water treatment as coagulants to reduce organic matter, color, turbidity and microorganism levels. Such use may lead to increased concentrations of aluminum in finished water.

Iron may also be present in drinking-water as a result of the use of iron coagulants or the corrosion of steel and cast iron pipes during water distribution.

The presence of manganese in drinking-water may lead to the accumulation of deposits in the distribution system. Manganese can be removed by chlorination followed by filtration.

All samples have acceptable heavy metal content.

Free chlorine; Disinfection of household drinking water in developing countries is done primarily with free chlorine. these forms of free chlorine are convenient, relatively safe to handle, inexpensive and easy to dose. Recommendations are to dose with free chlorine at about 2 mg/l to clear water (< 10 nephelometric turbidity units [NTU]) [10].

There is no chlorination process in bottled water and they have not free chlorine. Tap water's mean free chlorine content is 0.62 mg /L and have acceptable free chlorine content.

Microbiological Parameters

Globally, at least 2 billion people use a drinking water source contaminated with faeces. Contaminated drinking water can transmit diseases such diarrhea, cholera, dysentery, typhoid, and polio and ıt is estimated to cause 502 000 diarrhoeal deaths each year [22].

For water resources to be hygienically reliable, it is necessary to determine whether the water has exposed to fecal contamination. For this purpose, some procedures is developed that based on the determination of the presence of the indicator microorganism [23].

Microbiological quality of bottled water is related to total microorganism of spring water and hygienic quality of used bottle. Drinking water may be microbiologically contamined due to the containers in which they are stored, contact with water pump in carboy, period of use and the conditions of use and may be potential risk to public health [24].

For protection of qualities of microbiologicaly clean

bottled water, they should not be exposed to sun light, their cups should not be open, and should be consumed until the expiration date

While Total coliform, Escherichia coli ve C. Perfringens are analysed in tap water before transported to network, Total coliform, Escherichia coli ve 22^0C colony count are analysed in bottled water before bottled

Both tap water and bottled water are suitable for human consumption in terms of microbiological parameters (There are no microbiological parameters in three different brand label's(2,3 and 7)).

Statistical analysis

It is found that difference between mean value of tap water and bottled spring water in evaluated quality parameters is significant($p<0,05$). Because of spring water have natural protection against pollution by the covering layers unlike surface waters, they are usually less polluted or even unpolluted [25-26]. It is expected that the values of quality parameters of spring waters are lower than surface waters.

CONCLUSION

It is seen that tap water and bottled water complies with EPA, WHO, EC, Turkısh national standards (Regulation Concerning Water Intended for Human Consumption) in terms of examined physical, chemical and microbiological (there is no microbiological parameter on three brand label) parameters. They have drinkable qualities in terms of human health

There is significant difference between tap water and bottled water in terms of mean pH, electrical conductivity (EC), chloride (Cl), sulfate (SO_4), sodium (Na), aluminum (Al), iron (Fe), mangane (Mn) values. It is thought that spring water have natural protection against pollution by the covering layers unlike surface waters, they are usually less polluted or even unpolluted [25-26].

Aluminium concentration in the tap water is below to the recommended amount, but ıt is higher than the bottled water. It is thought that Aluminium salts used as coagulants during the water treatment process can increase the amount of Aluminium in the water.

Quality parameters values of Erzurum tap water is published regularly Erzurum Water and Sewerage Administration (ESKİ) website. It is important that in terms of public can reach information about used tap water. But there are only indicator parameters on the bottled water label's that results of analyses are belong to licensing period and old date (There are no microbiological parameters in three different brand label's (2,3 and 7)). There are no major ions and toxic heavy metals concentrations on the label. Major ions and toxic heavy metals which may be present in the drinking water should be written on label to protect of consumers [27]. Results of analyses on the label belong to licensing period and old date.

When ıt is evaluated generally,

Bottling and selling of natural spring water have facilitated access to healthy water. The use of plastic in bottled water (PVC, then PET) makes bottles light and easy to carry. But a liter of bottled water is from 250 – 600 times more costly than a liter of tap water. Used water bottles become the most troublesome issue of solid wastes at present time. Most water bottles are produced from polyethylene terephthalate (PET) which is recyclable but not biodegradable [28]. Transporting bottled water all over the world has obviously a negative impact on the environment, mainly through fuel combustion and the release of polluting particles into the atmosphere [29].

ACKNOWLEDGEMENTS

This article was presented as a poster in 2017 1th International Water Congress in Afyon/TURKEY

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