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Using of Municipal Mains Water for Drinking Water in an Urban Region under Uncertain Economic, Social, Cultural and Health Impacts

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ABSTRACT The primary intent of this study is to determine factors that affecting drinking water and consumer choice. As of the moment, 44.9 percent of households use Municipal Mains Water. Use rates of other drinking water types including fountain, bottled and purifier are 27.2 percent, 21.5 percent and 6.4 percent, respectively. However according to laboratory results regarding some criteria the best drinking water are bottled, purifier, fountain and municipal main waters, respectively and even though bottled water for thirty-four percent of households and fountain water for twenty-nine percent of households seems more safe drinking water. All water is potable, but some problems with the smell and taste of the municipal mains water are available. If municipalities solve this problem, they will increase the satisfaction of the community.

INTRODUCTION

Water is the most important element comes after from oxygen which gives breathing and exhalation to people while water is an essential part of a healthy life and indispensable for the sustainability of ecosystems and the survival of future generations (Abu-Hola 2009).

Two-thirds of the world constitutes from water area, and the amount of water in these areas is 1.4 billion km^3. The proportion of fresh water sources in the total water in the world is 2.5 percent. More than sixty-eight percent of these freshwater resources are estimated to take place in the ice and glaciers (UN 2007; Cicek and Atol 2009; Hare 2014).

Also, water is an indispensable element of human life, as the characteristics of water are essential for human health. The formation, of the presence and quality features of the water is the subject of hydrogeology (Varol et al. 2008).

Characteristics of drinking water are divided into four groups (Yaman 2013). This includes:

1. *Physical and appeal to the senses features:* temperature, clarity, taste and smell.
2. *Chemical properties:* oxygen, nitrogen, carbon, phosphate and pH values.
3. *Bacteriological characteristics:* bacterial testing is provided and checked whether various bacteria (coliform) in the water. If there are coliform in the water, it shows that drinking water mixes with the sewage water.
4. *Microscopic features:* small aquatic creatures cannot be seen with eyes, but they can be seen with the aid of a microscope.

The continuous incensement of the world population and wasteful use of resources will expose to water shortage in the future for one of every two people. This situation will require population planning for efficient use of resources and make more studies (Anonymous 2009; Cicek and Atol 2009).

Because of population growth, industrialization and increasing use of energy, reach to consumer's healthy drinking water is crucial. As a result of use more technology of the humanity to meet the needs of the growing population in recent years, the wasteful use of natural sources, and access to clean natural water sources are difficult (Varer Kutanis 2010). Households that want healthier water wants to drink are creating the more demand for alternative water sources (Bates et al. 2008; Lyytimäki and Assmuth 2015). The vast majority of households consume bottled water where families consider that the municipal mains water distribution system and water quality insufficient (Ferrier 2001; Doria 2006; Espinosa-Garcia et al. 2015). Both bottled water and purifiers markets are increas-

ing day after day to meet more trusty water demand, and the municipalities used as a permanent advertising tool in the municipal election campaign in developing countries.

In many types of research made in the past, emphasized they have factors on water consumption amount of households are effective. These factors are drinking water consumption quantity, household size, age and education level of the individual, the income level of the individual, make a shower frequency and time of individuals, frequency of use in the dishwasher and the washing machine, access ease to water and charges of water and certain attitudes and behaviors of consumers (Renwick and Green 2000; Inman and Jeffrey 2006; Willis et al. 2011; Drewnowski al. 2013).

In order to meet the water needs a growth population since 2008 with the addition of Palandoken dam water to mains water, households began to increase reproach about unhealthy and poor quality of water in Erzurum province. After this year, the number of families using bottled water and purifiers has grown exponentially every year. Present aim of the study is to determine the effective factors over drinking water choices of the households in Erzurum province. Also, so that households' reproach may be the truth, all of the drinking waters have been subjected to analysis. Thus, the municipalities will set a new some presentation strategy at the request of the households. Results of this research are expected to contribute to the continuation of higher quality and healthier life of families.

MATERIAL AND METHODS

Material

The main material of the research was obtained by conducting face-to-face interviews with 400 households in July-December 2014 and water samples collected from the households and fountains in February 2015 in Erzurum province. Many local and foreign studies were used as the second data source, and the survey forms of this research were prepared according to the objective of the study.

Methods

Sampling Method

The number of samples was determined with the information obtained from the households affairs. In order to calculate the sample size, the following equation was used (Newbold 2011).

$$n = \frac{Np(1-p)}{(N-1)\sigma_{px}^2 + p(1-p)} = 384 \quad (1)$$

Where,

n = sample size (384),

N= population (the number of Erzurum city center population) (388,093),

p = percentage making a choice (50% used for sample size needed),

$Z_{\alpha 2}$: = z value (1.96 for 95% confidence level),

σ^2_{px} : variance

$$\sigma_{px}^2 = \left(\frac{r}{z_{\alpha/2}}\right)^2 = \sigma_{px}^2 = \left(\frac{0.05}{1.96}\right)^2 = (0{,}0255)^2 \text{ and } \quad (2)$$

r: deviation from the average (5%)

Participants and Setting

This study was carried out 384+16 (400) surveys, and participants were randomly selected from three districts of the city center which they were Aziziye (in the west-side), Yakutiye (in the east and north sides) and Palandoken (in the south-side). The surveys were received from total 400 households in forty-three neighbourhoods of three districts. Also, a separate second group took a water sample from a house in each neighbourhood at random. The number of surveys allocated to the Aziziye, Palandoken and Yakutiye districts was 43, 167 and 190, respectively, for a total of 400. Also, number of water samples assigned to neighbourhoods of the Aziziye, Palandoken and Yakutiye districts were 6, 14 and 23, respectively, for a total of 43. In addition to these examples, waters of two famous fountains outside the city center and making the most sales for bottled water companies in the market, six of these were analysed.

Instrumentation

The numbers of questionnaires were 28, those developed from previous studies while the surveys were presented in four sections of Turkish language to the participant. Section one associated with socioeconomic and demographic factors. Section two related to preferences and quality of drinking water. Section three linked with drinking water used quantity and expenditure of households. Section four connected with attitude and behaviour of the family about water used. Those questions were asked of individu-

als through fifty-two questions in 5-point Likert scale.

Pilot Study

Before starting work on the water, analysis has been made on two trial analyzes for resolve all the shortcomings. Also, ten pre-consumer surveys were designed and tested after the necessary corrections, and then final form was supplied to individuals.

Data Collection

Water samples were collected from households in every neighbourhood as municipal mean water, foundation water and purified water. In collecting these samples, a lecturer on water quality expert has followed all the steps. Completion of the laboratory work took in 2 weeks. Also, in the consumer survey phase, individuals were spent 30-40 minutes to complete survey and data was controlled and collected by two assistant doctors. Completion of the survey took in 6 months. After all data had been entered into the computer, it was analysed using the SPSS 20 program.

Statistical Analyses

Excel computer program was used for calculating the values of the data and in their sequencing. SPSS 20 statistical package program was used to logit and $X^{\text{-square}}$ analyses.

The first step, points (the best quality 5, lowest quality 1 in form groups of five) were given substances effect on drinking water quality. Collected all samples were ranked to quality score. All samples were evaluated according to their main water groups and listed according to drinking water quality point.

The second step according to water quality, socio-demographic and economic characteristics of consumers was determined to correct preference in these four types drinking water.

The third step, $X^{\text{-square}}$ analyses used for determining household' socio-demographic, economic and health-related attitudes and behaviours the relationship between correct preference of consumers.

Ethical Consideration and Human Rights

Permission from the individuals was obtained before the survey process began. The aim of this study was explained to all persons before starting the interview, and they were informed about this study. Survey research was carried out without taking the name of the individuals. Questions were asked about supporting each other in order to get accurate information from consumers. When the survey started, the researchers said "You can leave without giving any reason from the survey at any stage of the survey". In this survey, surveyors have avoided questions that may be disrupting to the consumers psychology.

RESULTS

Drinking Water Analysis Results

In Table 1 is given laboratory analysis results for drinking water. As a consequence of study toxic substances such as Plumbous (Pb), Selenium (Se), Arsenic (As), Chrome (Cr^{+6}) and Cyanide (CN) can be found in all drinking water type. However, none of the substances have been observed in the studies. Also, all of the parameters values were below the detection limit in Erzurum province.

High quantity of NO_3-N is an indication of chemical fertilizer mixed with water and it is highly damaging to human health (Farhadinejad et al. 2014). NO_3-N content of drinking water must be below of 10 mg/L according to TSI and WHO, respectively.

High quantity of NO_2-N shows that the water is getting mixed with contamination water high levels of nitrates or nitrites in drinking water lead to health problems. NO_2-N content of drinking water must be below of 0.50 and 1.0 mg/L according to TSI and WHO, respectively.

Inorganic pollutants such as ammonia-nitrogen (NH_3-N) caused a problem in taste and odor of drinking water. The NH_3-N levels are under recommended value (0.5 mg/L) of TSI.

Iron and manganese which can be found in drinking water can cause undesirable color and turbidity. It is recommended that drinking water has no more than 0.2 mg/L of iron by TSI and WHO. The researchers analyzed all of the examples in the study, and the iron content of the drinking water is below the recommended level.

Characteristically, as sulphate (SO_4^{2-}) the anions also play a crucial role in the quality of drinking water and affect the human health. All the natural waters include it. $SO4^{2-}$ compounds

Table 1: Laboratory analysis results for drinking water

	Drinking water type	NO_3-N (mg/L)	NO_2-N (mg/L)	NH_3-N (mg/L)	Fe (mg/L)	SO_4 (mg/L)	pH	Cl (mg/L)	$CaCO_3$ (mg/L)
Aziziye	Average	0.28±0.03	0.05±0.01	0.08±0.02	0.00±0.00	5.33±0.60	6.9	3.45±1.31	55.91±2.04
	House	0.17±0.09	0.02±0.01	0.07±0.03	0.01±0.01	4.33±3.41	7.0	4.70±0.99	60.82±0.46
	Fountain	0.43±0.06	0.03±0.02	0.08±0.01	0.00±0.00	5.36±0.96	6.7	2.47±0.62	50.20±2.46
	Purified	0.18±0.12	0.12±0.01	0.07±0.01	0.00±0.00	5.62±3.25	6.5	3.64±1.23	60.04±2.41
Yakutiye	Average	0.47±0.06	0.07±0.02	0.07±0.02	0.02±0.003	5.05±0.34	7.0	4.45±0.96	70.23±6.26
	House	0.28±0.03	0.05±0.01	0.07±0.02	0.01±0.001	7.67±1.57	7.1	4.82±0.63	70.42±6.47
	Fountain	0.91±0.06	0.12±0.02	0.08±0.03	0.01±0.001	11.51±5.85	6.9	4.21±1.48	330.89±14.05
	Purified	0.21±0.02	0.05±0.03	0.06±0.02	0.05±0.02	3.09±2.12	6.8	2.91±1.44	140.91±15.42
Palandoken	Average	0.17±0.08	0.03±0.01	0.07±0.01	0.01±0.00	2.66±0.30	6.8	2.74±1.23	40.54±2.57
	House	0.18±0.08	0.04±0.02	0.07±0.02	0.02±0.01	6.51±1.87	6.9	4.88±0.71	60.93±0.67
	Fountain	0.21±0.07	0.03±0.01	0.07±0.001	0.01±0.001	0.57±0.04	6.7	1.87±0.54	40.41±0.91
	Purified	0.11±0.06	0.02±0.01	0.07±0.01	0.00±0.00	1.24±2.13	6.7	2.78±1.23	110.32±13.63
Bottled water	A FIRM	0.19±0.001	0.00±0.00	0.24±0.02	0.00±0.00	0.02±0.001	7.3	0.8±0.01	50.6±2.45
	B FIRM	0.07±0.001	0.00±0.00	0.24±0.02	0.00±0.00	0.01±0.001	7.3	1.5±0.01	50.4±2.50
	C FIRM	0.08±0.001	0.00±0.00	0.28±0.02	0.00±0.00	0.02±0.001	7.3	1.5±0.01	60.8±3.02
	D FIRM	0.08±0.001	0.00±0.00	0.23±0.01	0.00±0.00	0.01±0.001	7.3	1.4±0.01	10.2±0.01
	E FIRM	0.09±0.001	0.00±0.00	0.25±0.03	0.00±0.00	0.01±0.001	7.3	1.2±0.01	30.4±0.03
Famous	Fountain1	0.10±0.001	0.00±0.00	0.25±0.03	0.00±0.00	0.01±0.001	7.3	1.5±0.01	30.4±0.09
	Fountain 2	0.10±0.001	0.00±0.00	0.25±0.03	0.00±0.00	0.01±0.001	7.3	1.7±0.01	30.2±0.11
TSI (Turkish Standards Institute)		10	0.50	-	0.2	150	6.5-9.5	-	-
WHO (World Health Organization)		10	1.0	0.5	0.2	150	6.5-8.5	10	500

are important pollutes for drinking water such as taste, toxin, smell and corrosion problems (Sen and Aksoy 2015). If the sulphate concentration in a water source is less than 10 mg/L, it is an indication that the water source is fresh and unpolluted. All of the sulphate inclusion amounts were below the WHO and TSI permissible limits.

In general, water with pH < 7 is considered acidic and with pH > 7 is considered alkaline. The proper range for pH in drinking water systems is from 6.5 to 8.5. In this limit, pH has no direct effect on consumer health, but it affects water quality (WHO 2006).

Chlorine (Cl_2) widely used to disinfect drinking water and swimming pool water and to control bacteria (WHO 2006). Cl_2 has some advantages as a disinfectant, because of its cheapness, efficiency, and ease of measurement, both in laboratories and in the field (Elshima Mohammed 2015).

The hardness of drinking water ($CaCO_3$) can be analyzed in 4 parts. In the first, if $CaCO_3$ is < 50 mg/L for water, this water may be soft water. In the second, if $CaCO_3$ is between 50-149 mg/L should be moderately hard water. In the third, hard water is characterized in 150-300 mg/L. In the final, if $CaCO_3$ is higher than 300 mg/L for water, this water may be hard water (Rubenowitz-Lundin and Hiscock 2013). According to $CaCO_3$ content, best waters are the bottled water, the municipal mains water (house), the purified water and the fountain water.

The Criteria Taken into Account by Consumers in Drinking Water

There are the four consumed types of drinking water in Erzurum province. These are the municipal mains water, bottled water, the purified waters and the fountain water. One or more of these drinking waters are preferable regarding some criteria such as hygiene, taste, minerals content, price, and access easiness.

In Table 2 shows the preference of consumers in terms of some criteria According to the

Table 2: Drinking water criteria and drinking water choice of cross-tabulation cases

	Using state of the type of water	*The most important common criteria for drinking water of households (%)*					
		Price	*Hygiene*	*Minerals content*	*Taste*	*Easiness of access*	*Total*
Users of the municipal mains water (UMW)	Non-preferred for no time	0	1.79	0.77	0.77	0	
	Preferred for all the time	5.79	25.43	2.12	9.65	1.93	**44.92**
	Generally preferred	1.45	15.43	2.61	4.63	1.26	
	Occasionally preferred	1.45	14.1	2.41	6.96	1.45	
	Total	8.69	56.75	7.91	22.01	4.64	
	χ^2 *test of inpedence*	15.814	16.94	13.693	8.624	15.849	
	df	12	12	12	12	12	
	p	0.2	0.252	0.321	0.735	0.198	
Users of the Bottled water (UBW)	Non-preferred for no time	0.77	0.61	0.19	0.9	0	
	Preferred for all the time	0.48	13.03	1.93	5.31	0.77	**21.52**
	Generally preferred	2.41	14.55	1.93	7.5	2.12	
	Occasionally preferred	5.03	28.56	3.86	8.3	1.75	
	Total	8.69	56.75	7.91	22.01	4.64	
	χ^2 *test of inpedence*	16.173	19.183	18.23	15.432	25.502	
	df	12	12	12	12	12	
	p	0.183	0.084	0.109	0.219	0.013	
Users of the purified waters (UPW)	Non-preferred for no time	7.53	48.89	7.23	17.37	3.67	
	Preferred for all the time	0.20	3.86	0.68	1.45	0.19	**6.38**
	Generally preferred	0.48	2.07	0	1.16	0.19	
	Occasionally preferred	0.48	1.93	0	2.03	0.59	
	Total	8.69	56.75	7.91	22.01	4.64	
	χ^2 *test of inpedence*	20.755	22.909	22.316	18.421	8.663	
	df	12	12	12	12	12	
	p	0.054	0.029	0.034	0.104	0.731	
Users of the fountain water (UFW)	Non-preferred for no time	0.48	4.45	0.52	2.9	1.16	
	Preferred for all the time	2.12	14.67	3.05	5.6	1.74	**27.18**
	Generally preferred	4.34	25.29	2.94	8.88	0.76	
	Occasionally preferred	1.75	12.34	1.4	4.63	0.98	
	Total	8.69	56.75	7.91	22.01	4.64	
	χ^2 *test of inpedence*	12.899	22.337	12.434	7.422	23.652	
	df	12	12	12	12	12	
	p	0.376	0.0334	0.437	0.829	0.023	

first choice of households in drinking water, the household used to municipal mains water, fountain water, bottled water and purified water, 44.9 percent, 27.2 percent, 21.5 percent and 6.4 percent, respectively. Also, all consumers have given the most importance to hygiene criteria from the properties of drinking water. Hygiene criteria for 56.8 percent of households are the most important criteria for drinking water. This criteria was followed with twenty-two percent, 8.7 percent, 7.9 percent, and 4.6 percent by taste, mineral content, prices and easiness of access, respectively. The criteria of drinking water taken into account of used municipal mains water in the first preferences are hygiene (56.6%), taste (21.5%), price (12.9%), the minerals content (4.7%) and easiness of access (4.3%), respectively. The criteria taken into account for always users of bottled water are hygiene (60.6%), taste (24.7%), the minerals content (8.9%), easiness of access (3.6%) and price (2.2%), respectively. The criteria taken into account for always users of purified water are hygiene (60.5%), taste (22.7%), the minerals content (10.7%), price (3.1%) and easiness of access (3.0%), respectively. The criteria taken into account for always users of fountain water are hygiene (54.0%), taste (20.6%), the minerals content (11.2%), price (7.8%) and easiness of access (6.4%), respectively.

DISCUSSION

Served drinking waters in Erzurum province a generally are not significant differences in

terms of health, but there are considerable differences in terms of quality. As is known healthy water supply has an important place in the growth of individual healthy. Therefore, consumers have given the hygiene criteria more importance than other the properties of drinking water. Wright et al. (2004) and Nicholas et al. (2015) said that water-related diseases continue to be one of the major health problems globally. Also, TURKSTAT (2014) has announced that the rate of waterborne diseases in 0-6 age children is twenty-seven percent. Bates et al. (2008) said that in the last ten years, some people in developing countries to achieve more hygienic drinking water have turned to alternative drinking water varieties outside the municipal mains water.

The second most important feature of drinking water is the taste criteria for the household. Huerta-Saenz et al. (2011) stated that bottled water was perceived to be hygienic, taste better and safer than municipal mains water by many consumers. These perceptions over qualities of drinking water seemed to affect water-drinking preferences and consumption quantity.

The third and fourth most important features of drinking water are the prices or the minerals content criteria for the household. When the price criteria for municipal mains water consumer and the minerals content for the other customer is critical to the third level. The price criteria are important fourth level for the fountain and purified water user. Also, price criteria for bottled water consumer are important in the fifth level. Minerals content is given ranks 4^{th} in for municipal mains water users. Azlan et al. (2012) said that consumers are perceived that tap water qualities is lower than bottled water and natural source. Also, users consider the price of tap water cheaper than bottled drinking and natural source. Also, Rylender (2014) said that mineral content is important for consumers in drinking water. Minerals in drinking water should be as far as needed. Therefore, both less and much is negatively affects human health.

The most unimportant features of drinking water are the price or the easiness of access criteria for household. Price is the second most unimportant criteria for bottled water users and easiness of access criterion is the most unimportant for the others all consumer. O'Reilly and Dhanju (2014) said that many customers are using municipal mains water as drinking water. Because of the consumer can reach out any moment in the house to this water.

If NO_3-N content of drinking water is between 0 to10 mg/L, it is safe for humans and livestock and if between 11 to 20 mg/L; it is not safe for human infants (Mahler et al. 2007). High quantity of NO_3-N leads to blue baby syndrome also called methemoglobinemia in infants (Sadhu et al. 2014). Because NO_3-N values in all samples are much lower from feared value, there is no reason for distress for any of the drinking waters. According to NO_3-N content, best waters are the bottled water, the purified water, the municipal mains water (house) and the fountain water.

With nitrate or nitrite contaminated of the municipal mains water can occur poisoning generally in infants which they are drinking the municipal mains water (Sadhu et al. 2014). Because of NO_2-N values in all samples are much lower from scared values; there is no reason for distress for all of the drinking waters. According to NO_2-N content, the best waters are the bottled water, the municipal mains water (house), the fountain water and the purified water.

NH_3-N has a harmful effect on humanity. This substance containing more than 0.2 mg/L of ammonia would be occurrence oxygen depletion in the disinfection (Hasan et al. 2011). According to NH_3-N content, the best waters are the purified water, the municipal mains water (house), the fountain water and the bottled water.

Iron (Fe) leads to narrowing and blockage section in the drinking water pipeline. Also, they cause undesirable changes in color and taste of the product in many industries (Topbaev 2015). According to Fe content, the best waters are the bottled water, the purified water, the fountain water and the municipal mains water (house).

The concentrations of the major ions were very below the permissible limits given by the WHO. Like NO_3 the primary sources of SO_4^{2-}, contamination were over-application of fertilizers, sewage disposal, manure applications and wastewater of livestock farms (Khan et al. 2015). According to SO_4^{2-} content best waters are the bottled water, the purified water, the fountain water and the municipal mains water (house).

Many studies emphasized that the ideal pH level for pure drinking water must be near to 8 (Romero-García et al. 2012). According to pH content best waters are the bottled water, the

municipal mains water (house), the fountain water and the purified water.

Cl_2 is generally present at less than 10 mg/L and often less than 1 mg/L (WHO 2006). According to Cl_2 content, the best waters are the bottled water, the fountain water, the purified water and the municipal mains water (house).

The most ideal waters to drink are medium hard water (Rubenowitz-Lundin and Hiscock 2013). According to $CaCO_3$ content, the best waters are the bottled water, the municipal mains water (house), the purified water and the fountain water.

CONCLUSION

Since 2008, for the reason of blending to mains drinking the water of Palandoken dam water, drinking water consumption habits of households gradually changed and bottled and purified water consumption demand has increased. There are the four consumed types of drinking water in Erzurum province. These are the municipal mains water, bottled water, the purified waters and the fountain water. One or more of these drinking waters are preferable in terms of some criteria as in general hygiene, taste, minerals content, price and access easiness. According to the first choice of households for drinking waters; 44.9 percent of households drinks to the municipal mains water, 27.2 percent of households drink fountain water, 21.5 percent of households consume bottled water, and 6.4 percent of households drink the purified water. The individuals, who do not use municipal mains water to drink because of inadequate hygiene, taste and mineral content. Therefore, these consumers are taking into account to other alternative three water type for drinking water. They have preferred one of these alternatives regarding price and ease of transportation. As well as other of drinking water in the municipal mains water is not concerned any negative about hygiene in water analysis. However, regarding mineral content which affects the taste of water, it has some shortcomings. Taking into account water analysis and consumer surveys in Erzurum province, the best drinking waters are listed as the famous fountains, bottled waters, purified water, neighborhood fountains and municipal water, respectively.

RECOMMENDATIONS

Because famous fountains are far, bottled water and purification devices require a certain cost, and the alternative of municipal mains water is neighborhood fountains for some households. In recent years, municipalities have reduced problems regarding watercolor and odor problem but continuous problems on taste significantly. Therefore, if municipalities improve the taste of drinking water, people will be returning to the taste of missed water in homes in Erzurum province.

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