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PHYSICAL, CHEMICAL AND MICROBIOLOGICAL ANALYSES OF WATER FOUNTAINS IN VILLAGES, ZONGULDAK CENTRAL DISTRICT

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Abstract. This study was conducted in 23 villages of the central district of Zonguldak in 2016, aiming to evaluate the compatibility of the quality of water which is used in villages. Samples obtained from the water resources of the villages and consumed in the fountains were analysed according to the physical, chemical, and microbiological standards specified in the legal regulations. 7 fountains per village were selected randomly and 161 samples were collected. All of the samples were in compliance with the standards of taste and odour qualities, pH and electrical conductivity. None of the samples were suitable for the amount of free residual chlorine. 34 (21.1%) of 161 samples for turbidity, 20 (12.4%) samples for aluminum, 3 (1.9%) samples for colour parameter, 129 (80.1%) samples for Coliform bacteria, 74 (46.0%) samples for *Escherichia coli*, 14 (8.7%) for Clostridium perfringens (+ spores) were not suitable according to standards. When all the parameters were evaluated together, 131 (81.4%) samples were not suitable for drinking and using. Coliform bacteria and *Escherichia coli* levels were significantly higher in fountains on roads than fountains in settlements. It was determined that the presence of a protected area around the water resource was not a significant effect on bacteriological pollution. As a result, it can be connoted that fountains in rural areas in Zonguldak should be controlled, monitored and disinfected in order to protect public health.

Keywords: village, fountains, water pollution, public health, rural areas.

AIMS AND BACKGROUND

Water, which accounts for 70% of the human body, is a vital resource for living organisms. All cellular and functional mechanisms of body need water. Humankind can live only for a few days without water[1]. Healthy water should contain the necessary minerals in a required amount and should not contain microorganisms and toxic chemical substances that cause illnesses[2]. Access to sufficient quantities of clean and high quality water is becoming increasingly difficult due to population growth, pollution, rapid urbanisation and uncontrolled industrialisation. 'Unsafe water, sanitation, and hygiene' have been determined as one of the five major risk

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factors that leads to deaths and DALYs by WHO, and this risk factor is globally responsible for 4.2% of DALYs and 3.2% of deaths[3]. The physical, chemical and biological characteristics of drinking and using water in Turkey has been defined in 2005 by the 'Regulation of Water for Human Consumption' (RWHC) (Ref. 4).

Although accessing healthy water is a basic right for all people, it is hard to obtain this opportunity for the undeveloped and developing countries or low socio-economic groups. In addition, unsafe water resources make up an important problem especially for rural areas[5]. It is known that water resources in rural areas are more vulnerable to agricultural activities, livestock activities, and organic pollutants resulting from the impact of solid and liquid waste. This can lead to microbiological contamination of water resources[6].

Zonguldak, which is situated on the northwest coast, is a city in the Western Black Sea Region of Turkey. Zonguldak province has a rugged terrain structure; 56% of the province is covered with mountains, 31% with plateaus and 13% with plains (Fig. 1). Zonguldak, with its abundant rainy climate, is very rich in terms of surface water resources. In the villages of Zonguldak, which have dispersed geographically, the water obtained from nearby resources is widely used without being analysed and controlled[7]. The purpose of this study is to evaluate microbiological, physical and chemical characteristics of water acquired from fountains which are actively used in 23 villages of the central district of Zonguldak province according to standards determined by the RWHC.

Fig. 1. Zonguldak satellite image

EXPERIMENTAL

This descriptive study was performed in 23 villages located in the central district of Zonguldak, and the budget of the study was financially supported by the Bulent Ecevit University Department of Scientific Research Projects. In this study, 161 water samples were collected on March-April 2016, from 7 fountains per village. The number of water samples was determined according to the budget of the research and fountains were selected by using simple random sampling. Of the fountains, 129 (80.1%) are in the settlement area and 32 (19.9%) are on the roads. Physical and chemical analyses (smell, taste, ammonium, free residual chlorine, pH, conductivity, turbidity, aluminum, colour) were performed in Bulent Ecevit University Science and Technology Application and Research Centre and the microbiological analyses (Coliform bacteria, *Escherichia coli*, *Clostridium perfringens*) were performed in Public Health Laboratory of the Ministry of Health. The physical, chemical and microbiological analyses of the samples were conducted to find out whether they were conformed with the standards specified in the RWHC. Data were evaluated with SPSS for Windows 19.0, the descriptive data were presented as arithmetical mean ± standard deviation and frequencies. Independent samples t-test was used in comparison of groups, and $p < 0.05$ was accepted as significant.

RESULTS AND DISCUSSION

In 161 water samples, pH values were between 6.50–8.79. Electrical conductivity values were between 21–1020 μS/cm and all of the samples were suitable for the standards of taste and odour properties, pH and electrical conductivity. The free residual chlorine levels of the samples were not compatible with the values prescribed in the RWHC. Although pathogens in drinking water can easily be controlled by disinfection, it is reported that 3.7% of deaths in the world are related to polluted drinking water[8]. Chlorine is an effective disinfectant widely used in disinfection of water and it is ensured that the free residual chlorine level should be 0.2–0.5 mg/l in the drinking and using water in Turkey[3]. In this study it is realised that the villagers did not accept chlorination in general. Most people who live in the rural areas of Turkey, refrain from chlorination as they think the chlorine spoils the taste of water and harms the plants, when used in watering. This might be the reason of why chlorination is not used in the villages of Zonguldak.

It has been determined that 34 of the 161 samples (21.1%) were not suitable for the evaluation of the turbidity parameter. Many factors from sediments to suspended materials such as vegetal residues, clay, mud, water algae, small animal species can be reason of turbidity. Substances which cause turbidity in water may lead to microbiological pollution. Also turbidity can occur in water due to excessive microorganism generation[9].

In our study, it is found that 20 (12.4%) of 161 water samples exceeded the limit value of 0.2 mg/l for aluminum and that the aluminum levels of the samples were not compatible with the values prescribed in the RWHC. Aluminum has low acute toxicity effect, and information about chronic exposure is limited, but it is reported that it can cause fatigue, bone pain and anorexia due to interaction with phosphorus metabolism. There is not strong evidence for its carcinogenic, teratogenic or mutagenic effects. The potential health effects of aluminum in drinking water are increasingly being debated, especially as aluminum is associated with Alzheimer disease or dialysis encephalopathy. Some studies emphasise that drinking water with high aluminum can be related with high risk for Alzheimer disease[10–12]. The standards also indicate that drinking water should be colourless. In our study 3 (1.9%) of 161 samples were not suitable for the colour parameter. Results of physical and chemical evaluation of water samples are presented in Table 1.

Table 1. Physical and chemical evaluation of water samples

Physical and chemical characteristics	Compatible (%)	Not compatible (%)
Turbidity	127 (78.9%)	34 (21.1%)
Aluminum	141 (87.6%)	20 (12.4%)
Conductivity	161 (100%)	–
pH	161 (100%)	–
Colour	158 (98.1%)	3 (1.9%)
Taste	161 (100%)	–
Smell	161 (100%)	–
Free chlorine	–	161 (100%)

Water used for human consumption should have no indicator bacteria (Coliform bacteria, E*scherichia coli* and *Clostridium perfringens*). The RWHC in force in Turkey is coherent with World Health Organisation standards. Microbiological limit values of various water species are given in the RWHC as follows: Coliform bacteria: 0 cfu (colony forming unit)/100 ml, *Escherichia coli*: 0 cfu/100 ml, *Clostridium perfringens* (+ spores): 0 cfu/100 ml.

In our study, it was determined that 129 (80.1%) samples contained different levels of Coliform bacteria from 1 to 960 cfu/100 ml, 74 (46.0%) samples contained 1 to 560 cfu/100 ml *Escherichia coli* and 14 (8.7%) samples contained 1 to 3 cfu/100 ml *Clostridium perfringens* (+ spores), and these samples were evaluated as not compatible for the standards determined in the RWHC. The results of microbiological analysis are presented in Table 2.

Table 2. Microbiological analyses of water samples according to villages

Village	Coliform bacteria		*Escherichia coli*		*Clostridium perfringens* (+spores)	
	min–max	not compatible	min–max	not compatible	min–max	not compatible
Kabalakli	0–58	6	0–27	4	0	–
Himmetoglu	1–94	7	0–1	2	0–1	1
Sapca	0–16	5	0–13	1	0	–
Sofular	0–48	6	0–12	5	0	–
Koroglu	0–56	3	0–1	1	0	–
Cukuroren	1–98	7	0–10	1	0	–
Eceler	0–43	6	0–8	3	0	–
Kaleoglu	0–58	6	0–25	3	0	–
Ayvatlar	4–173	7	0–11	6	0–3	2
Saraycik	0–80	6	0–18	5	0	–
Karapinar	1–123	7	0–30	3	0–1	4
Haciali	0–58	7	0–6	4	0	–
Korucuk	0–105	6	0–60	3	0–1	1
Osmanli	0–36	6	0–20	5	0	–
Keller	25–960	7	0–560	4	0–3	3
Kumtarla	0–310	6	0–20	4	0	–
Taşçılar	0–85	6	0–70	4	0	–
Kardesler	0	–	0	–	0–1	1
Alancik	0–32	5	0–26	4	0	–
Olukyanı	0–396	6	0–120	6	0–2	2
Sarimsak	0–27	5	0–12	5	0	–
Karadere	0–85	3	0–50	1	0	–
Cagli	0–13	6	0	–	0	–
Total	0–960	129	0–560	74	0–3	14

Many reasons such as lack of chlorination of water in the villages, lack of protection areas around water resources and squalidity of the fountains where water is provided cause microbiological pollution. In this study it has been observed that the fountains were very old and uncared. It has been determined that water supply pipes in some fountains were not made of appropriate materials. In some villages, animal feces were poured into common areas of the village or in their own gardens for a certain period of time, then were used as fertiliser for agricultural purpose. This is thought to lead to microbiological contamination of many water resources and water systems in the villages, resulting in fecal pollution.

There was a significant difference in the amount of Coliform bacteria and *Escherichia coli* between the 129 fountains in the settlements and the 32 fountains in the roads (p = 0.048 for Coliform bacteria, p = 0.042 for *Escherichia coli*). There was no significant difference in *Clostridium perfringens* (+spores) amount

(p = 0.367) as it can be seen in Table 3. There was no significant difference in the amount of microorganisms when compared to the presence of protection area around the fountain source (Table 4).

Table 3. Level of microorganism according to where fountains are found

Microorgansims	Fountains in settlement	Fountains on road	p
Coliform bacteria	29.1±92.4	51.6±122.3	0.048
Escherichia coli	9.2±50.4	18.0±59.2	0.042
Clostridium perfringens (+spores)	0.1±0.3	0.2±0.6	0.367

Table 4. Microorganism levels according to presence of protected area at source

Microorganisms	Water source protected	Water source not protected	p
Coliform bacteria	27.1±24.7	39.4±73.3	0.651
E. coli	6.6±6.7	14.9±38.3	0.740
Clostridium perfringens (+spores)	0.2±0.3	0.1±0.2	0.091

After the evaluation, when all the parameters are taken into account, 131 (81.4%) of the 161 water samples were not suitable for use according to the standards specified in the RWHC, only 30 (18.6%) fountains were found suitable.

CONCLUSIONS

In this study, only 18.6% of the samples taken from villages in rural areas were found suitable and safe to use. This poses a significant risk for those living in the area and threatens the health of the population. The absence of disinfection in the examined water samples is the foreground as the main factor leading to the existence and continuity of bacteriological pollution. Elimination of the negative perceptions of users, especially for chlorine, and regular controls are imperative and indispensable for the protection of individual and community health.

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