RISK ASSESSMENT OF DRINKING WATER CONSUMPTION FROM PUBLIC FOUNTAINS FROM THE ASPECT OF PHYSICOCHEMICAL AND MICROBIOLOGICAL ANALYSIS

ORIGINAL SCIENTIFIC ARTICLE

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ABSTRACT:
The paper deals with the assessment of risks related to drinking water quality, the analysis of physicochemical and microbiological parameters that are key to assessing human safety and health. Through a detailed analysis of these parameters, the paper investigates whether the appropriate physicochemical and microbiological parameters are within the framework defined by the regulation, and whether they may pose a threat to human health.
Physicochemical parameters include aspects such as pH values, electrical conductivity, oxidizability, concentrations of various chemical compounds (such as nitrates, nitrites, ammonia, chlorides, heavy metals, etc.) and represent the degree of pollution by chemicals that may pose a threat to human health, while microbiological parameters relate to the presence of pathogenic bacteria, viruses and parasites that can cause various diseases in humans.
The paper uses data from laboratory analyses of water samples monitored at 32 locations in the Tuzla Canton during two seasons. Through this assessment, the paper highlights the importance of regular monitoring of drinking water quality, as well as the implementation of adequate measures to prevent potential health hazards for users.

KEYWORDS: public water fountains, physical-chemical analysis, microbiological analysis

INTRODUCTION

Human health and well-being are closely linked to the state of the environment. A quality environment provides basic needs such as fresh air and water. Water is one of the most important substances in the environment and an irreplaceable resource for households, agriculture, industry, etc.[1]. The safety and quality of drinking water are important indicators of public health, whether the water is used for drinking, food production, recreation or some other activity. Therefore, it is crucial to ensure the safety of water for human consumption in order to preserve the health and well-being of the population, and prevent disease [2]. Analyzes of drinking water must be carried out continuously and effectively in order to ensure its health integrity and to remove any possible defects and threats to human health in time. Concern for the quantity and quality of water has become an indicator of concern for the health of every inhabited environment. It determines the quality of the environment and defines the status of its ecological capital [3]. Insufficient care leads to the pollution of natural sources, and the main problem is the lack of complete protection of water sources from harmful influences and other forms of pollution that can reach underground water from the surface. The quality of water depends on several factors, namely: hydrogeological origin, biological specificity of the environment, quantitative variations, quality of processing in all parts and the state of the water supply network. Public water fountains are also susceptible to pollution and various external influences, and poor quality drinking water at public water fountains can affect people's health. This is precisely why there is a need for continuous monitoring of the health safety of water.

In order to examine the health safety of drinking water, it is necessary to analyze the physical, chemical and microbiological parameters and check whether they are in accordance with the relevant regulations. Therefore, this study aims to evaluate the quality of water from public taps as a type of local water facilities that are outside the monitoring system, and which represent a significant environmental risk factor, i.e. to examine whether they are in accordance with legal regulations and to investigate the correlation between the monitored parameters in order to define more adequate management and maintenance measures for public taps.

MATERIALS AND METHODS

The material used in this work was water taken from public fountain in the Tuzla Canton from 32 locations in the period March and July 2024. Sampling was carried out by health technicians according to the Regulation on Natural Mineral and Natural Spring Waters (Official Gazette of Bosnia and Herzegovina No. 26/10 and 32/12) and the Regulation on the Health Safety of Drinking Water ("Official Gazette of Bosnia and Herzegovina No. 40/10, 43/10 and 30/12). The water sample for physical - chemical and microbiological analysis was taken in sterile glass bottles with a volume of 1 L (for microbiological analysis), and a volume of 2 L (for physical - chemical analysis). The water was delivered to the laboratory for further analysis during the same day and preserved at +4 until the analysis was performed. First, organoleptic parameters such as color, odor, and taste were determined, followed by physicochemical parameters: pH value, oxidative capacity, dry residue, electrical conductivity, ammonia, residual chlorine, chlorides, nitrites, nitrates, iron, manganese.

Color, odor and taste were determined organoleptically, pH value by electrochemical method (ISKRA MA 5705 pH meter), and washed residue by gravimetric method. $KMnO_4$ consumption was determined by boiling in an acidic medium and titration according to Kűbel – Tiemann, electrical conductivity in a conductometer (EUTECH instruments Con 510), residual chlorine was determined colorimetrically (chlorine comparator), and chlorides by argentometric titration. Amounts of ammonia, nitrite, nitrate, iron and manganese were determined by spectrophotometric method (UV-VIS Spectrophotometer Lamda 25).

Bacteriological analysis included analysis of *Escherichia coli*, *Enterococcus faecalis*, *Pseudomonas aeruginosa, coliform bacteria* and the total number of microorganisms at 37 °C in one milliliter of water and the total number of microorganisms at 22 °C in one milliliter of water. All analyses were performed according to accredited BAS methods and in accordance with the Regulation on Natural Mineral and Natural Spring Waters (Official Gazette of Bosnia and Herzegovina No. 26/10 and 32/12).

RESULTS AND DISCUSSION

The results of the physicochemical analysis are shown in Tables 1. and 3., while the results of the microbiological analysis are shown in Tables 2. and 4.

Table 1. Results of physical and chemical parameters of public water fountains for the March

Ord. number	Name of water fountain	Parameters / unit of measure											
		pH value	Oxid. mg/L	Dry resid.	El. cond. 25º µS/cm	El. cond. 20ºC µS/cm	NH_4^+ mg/L	Res. chlorine	Cl^- mg/L	NO_2^- mg/L	NO_3^- mg/L	Fe µg/L	Mn µg/L
1.	S1	7.77	0.56	172	310	278	0	0	0.35	<0.001	1.85	0	0.016
2.	S2	7.46	0.8	332	555	497	0	0	7.8	<0.001	14.22	0	0.018
3.	S3	7.01	0.8	318	547	490	0	0	3.9	<0.001	8.54	0	0.016
4.	S4	7.05	0.8	375	747	669	0	0	16.31	<0.001	26.48	0.01	0.0118
5.	S5	7.03	0.8	375	778	697	0	0	13.68	<0.001	13.58	0.01	0.013
6.	S6	7.48	0.72	489	844	756	0	0	3.9	<0.001	5.2	0	0.015
7.	S7	6.91	1.12	318	582	522	0	0	6.59	<0.001	7.48	0	0.017
8.	S8	6.93	0.4	451	855	775	0	0	41.48	<0.001	21.13	0	0.013
9.	S9	6.93	0.4	313	539	483	0	0	12.05	<0.001	20.99	0	0.012
10.	S10	7.42	0.8	164	247	213	0	0	0.71	<0.001	3.66	0	0.015
11.	S11	7.7	0.4	142	247	246	0	0	5.18	<0.001	5.86	0.01	0.017
12.	S12	7.45	0.4	596	1088	975	0.97	0	174.06	<0.001	<0.60	0.03	0.016
13.	S13	8.44	1.12	511	816	731	0	0	2.48	<0.001	24.89	0.01	0.017
14.	S14	7.75	0.8	329	737	660	0	0	3.9	<0.001	1.34	0	0.011
15.	S15	7.05	0.72	285	557	499	0	0	3.19	<0.001	5.47	0	0.0011
16.	S16	7.23	0.32	275	614	550	0	0	5.67	<0.001	9.81	0	0.001
17.	S17	7.69	0.4	303	599	537	0	0	7.44	<0.001	31.53	0	0.014
18.	S18	6.78	0.32	203	381	341	0	0	5.67	0.043	17.79	0	0.014
19.	S19	7.57	0.4	297	566	507	0	0	9.43	<0.001	17.8	0	0.013
20.	S20	6.63	1.2	1710	3235	2899	0	0	175.83	0.036	<0.60	0.26 mg/L	0.031
21.	S21	7.15	1.2	78	169	151	0	0	1.06	<0.001	<0.60	0	0.013
22.	S22	7	0.4	154	365	318	1.55	0	2.34	<0.001	<0.60	0.02	0.009
23.	S23	7.21	0.48	480	824	738	0	0	4.25	<0.001	1.96	0	0.015
24.	S24	6.47	0.8	199	330	296	0	0	21.62	<0.001	33.74	0	0.013
25.	S25	7.32	1.2	304	548	491	0	0	7.3	<0.001	9	0	0.018
26.	S26	7.76	1.2	194	350	314	0	0	23.4	<0.001	20.77	0	0.015
27.	S27	7.52	0.24	359	677	607	0	0	7.44	<0.001	21.54	0	0.014
28.	S28	*	*	*	*	*	*	*	*	*	*	*	*
29.	S29	6.83	0.32	106	155	139	0	0	2.13	<0.001	<0.60	0	0.016
30.	S30	7.08	0.24	412	658	590	0	0	26.94	0.007	24.95	0.01	0.014
31.	S31	6.82	0.48	523	591	530	0	0	26.23	0.002	36.84	0	0.017
32.	S32	7.48	0.64	167	285	255	0	0	0.35	0.002	7	0	0.016

*Sample S28 was analyzed only in July at the request of citizens.

Table 2. Values of microbiological parameters of drinking water from public taps for March

Ord. number	**Name of water fountain**	**Type and number of bacteria isolated from the water sample**						
		Escerihia coli	***Coliform bacteria***	***Enterococcus faecalis***	***Pseudomonas aeruginosa***	**The total number of microorganisms at 22ºC**	**The total number of microorganisms at 37ºC**	***Clostridium perfrigenis***
1.	S1	0	0	0	0	0	0	0
2.	S2	0	0	0	0	0	0	0
3.	S3	0	0	0	0	0	0	0
4.	S4	12	35	45	0	70	14	0
5.	S5	0	0	0	0	0	0	0
6.	S6	0	0	0	0	0	0	0
7.	S7	0	0	0	0	0	0	0
8.	S8	0	0	0	0	46	15	0
9.	S9	0	20	0	0	30	10	0
10.	S10	0	0	0	0	0	0	0
11.	S11	0	0	0	0	0	0	0
12.	S12	0	0	0	0	0	0	0
13.	S13	0	0	0	0	0	0	0
14.	S14	0	0	0	0	0	0	0
15.	S15	0	0	0	0	0	0	0
16.	S16	0	0	4	0	31	5	0
17.	S17	0	0	0	0	0	0	0
18.	S18	0	0	0	0	0	0	0
19.	S19	0	0	0	0	0	0	0
20.	S20	0	0	0	0	0	0	0
21.	S21	0	0	14	0	16	5	0
22.	S22	0	0	36	0	10	6	0
23.	S23	0	0	0	0	0	0	0
24.	S24	0	0	0	0	0	0	0
25.	S25	0	0	0	0	0	0	0
26.	S26	0	0	63	0	30	10	0
27.	S27	0	0	0	0	0	0	0
28.	S28	*	*	*	*	*	*	*
29.	S29	0	0	4	0	13	4	0
30.	S30	0	0	0	0	0	0	0
31.	S31	0	0	0	0	0	0	0
32.	S32	0	0	0	0	0	0	0

*Sample S28 was analyzed only in July at the request of citizens.

Table 3. Results of physical and chemical parameters of public water fountains for the July

Ord. number	Name of water fountain	Parameter / Unit of measure											
		pH value	Oxid. mg/L	Dry Resid.	El. cond. 25°C µS/cm	El. cond. 20°C µS/cm	NH_4^+ mg/L	Res. chlorine mg/L	Cl^- mg/L	NO_2^- mg/L	NO_3^- mg/L	Fe µg/L	Mn µg/L
1.	S1	7.75	0.88	151	306	274	0	0	0.35	<0.001	2.27	0	0.015
2.	S2	7.32	0.64	293	556	507	0	0	5.88	0.002	16.75	0	0.014
3.	S3	7.01	0.64	283	558	500	0	0	5.32	0.001	7.96	0	0.013
4.	S4	7.2	1.44	335	752	674	0	0	18.29	0.01	3.74	0.02	0.019
5.	S5	7.17	0.56	368	797	714	0	0	19.28	0.003	12.55	0	0.013
6.	S6	7.58	0.8	485	848	760	0	0	4.75	<0.001	5.91	0	0.018
7.	S7	7.2	0.32	254	588	527	0	0	6.74	0.001	6.83	0	0.017
8.	S8	7.16	0.8	370	859	770	0	0	40.41	0.02	21.5	0.01	0.014
9.	S9	7.51	1.2	291	476	415	0	0	12	0.001	0	0	0.11
10.	S10	7.72	0.56	117	236	211	0	0	0.92	<0.01	3.75	0	0.017
11.	S11	7.57	0.8	141	271	243	0	0	4.96	0.004	5.73	0	0.018
12.	S12	8.55	1.2	514	1356	1215	1.05	0	141.8	<0.001	<0.60	0.03	0.016
13.	S13	6.58	0.4	156	302	271	0	0	4.4	<0.001	9.68	0	0.013
14.	S14	7.94	1.2	508	815	730	0	0	3.9	<0.001	24.04	0.01	0.008
15.	S15	7.37	0.4	364	717	642	0	0	3.55	0.004	<0.60	0	0.016
16.	S16	7.31	0.64	271	552	495	0	0	3.9	<0.001	5.3	0	0.014
17.	S17	7.43	1.36	248	642	575	0	0	10.49	0.006	25.21	0.02	0.017
18.	S18	7.48	1.2	239	586	525	0	0	8.15	0.012	30.96	0.02	0.016
19.	S19	7.19	0.96	198	368	330	0	0	5.53	<0.001	14.37	0	0.014
20.	S20	7.56	0.4	302	562	504	0	0	9.93	<0.001	16.1	0.01	0.017
21.	S21	6.35	0.8	1146	2383	2135	0.1	0	113.65	0.004	0.89	0.38 mg/L	0.047
22.	S22	6.52	0.4	82	163	146	0	0	0.71	<0.001	0.667	0	0.012
23.	S23	8.41	0.4	168	335	300	1.15	0	2.13	<0.001	<0.60	0	0.016
24.	S24	7.41	0.64	386	801	718	0	0	3.9	<0.001	<0.60	0	0.016
25.	S25	7.32	0.4	230	657	598	0	0	22.69	0.023	35.13	0.01	0.014
26.	S26	7.48	0.4	253	533	478	0	0	5.67	<0.001	9.08	0	0.014
27.	S27	6.17	0.8	173	344	308	0	0	21.62	0.001	21.34	0	0.013
28.	S28	7.75	0.56	325	666	597	0	0	7.09	<0.001	17.8	0	0.017
29.	S29	7.26	0.48	67	143	128	0	0	2.13	<0.001	<0.60	0	0.015
30.	S30	7.46	0.56	179	668	599	0	0	28.57	<0.001	28.8	0	0.007
31.	S31	6.78	0.4	341	617	553	0	0	26.45	<0.001	38.18	0	0.08
32.	S32	7.38	0.8	144	296	265	0	0	0.71	0.001	6.97	0	0.12

Table 4. Values of microbiological parameters of drinking water from public water fountains for the July

Ord. number	Name of water fountain	Type and number of bacteria isolated from the water sample						
		Escerihia coli	*Coliform bacteria*	*Enterococcus faecalis*	*Pseudomonas aeruginosa*	The total number of microorganisms at 22ºC	The total number of microorganisms at 37ºC	*Clostridium perfrigenis*
1.	S1	40	70	39	0	30	14	0
2.	S2	0	49	4	0	80	14	0
3.	S3	21	30	20	0	30	10	0
4.	S4	0	45	63	0	130	49	0
5.	S5	0	21	8	0	30	5	0
6.	S6	47	90	83	0	115	30	0
7.	S7	0	12	67	0	110	37	0
8.	S8	0	53	21	0	185	60	0
9.	S9	4	35	16	0	30	0	0
10.	S10	0	0	0	0	0	0	0
11.	S11	0	0	14	0	120	20	0
12.	S12	30	79	46	0	110	30	0
13.	S13	0	0	0	0	39	10	0
14.	S14	0	0	0	0	0	0	0
15.	S15	0	0	0	0	0	0	0
16.	S16	53	160	46	0	0	30	0
17.	S17	47	96	65	0	0	112	0
18.	S18	6	30	32	0	40	15	0
19.	S19	0	0	0	0	0	0	0
20.	S20	4	39	12	0	90	10	0
21.	S21	0	0	0	0	0	0	0
22.	S22	0	0	0	0	0	0	0
23.	S23	0	0	0	0	0	0	0
24.	S24	0	43	15	0	27	7	0
25.	S25	29	56	44	0	112	23	0
26.	S26	6	76	28	0	29	19	0
27.	S27	18	45	39	0	64	16	0
28.	S28	0	23	29	0	40	15	0
29.	S29	0	56	0	0	30	12	0
30.	S30	4	15	14	0	30	17	0
31.	S31	0	0	0	0	0	0	0
32.	S32	0	0	0	0	0	0	0

Table 5. Chemical parameters that may be present in drinking water and their maximum allowed concentrations

Parameter	Unit	MAC
pH value	pH unit	6.5 i 9.5
Eletrical conductivity	µS/cm at 20ºC	2500
Consumption $KMnO_4$ (Oxidizability)	mg/L O_2	5.0
Manganese	µg/L	50
Iron	µg/L	200
Chloride	mg/L	250
Free residual chlorine	mg/L	0.5
Nitrate	mg/L	50
Nitrite	mg/L	0.5
Ammonia	mg/L	0.5

Table 6. Microbiological parameters of health safety of drinking water sold in bottles or containers

Microbiological parameter	Unit of measure	MAC
Escherichia coli	number/250	0
Enterococcus faecalis	number/250	0
Pseudomonas aeruginosa	number/250	0
The total number of microorganisms at 22ºC	number/1 mL	100
The total number of microorganisms at 37ºC	number/1 mL	20

The analysis of organoleptic parameters (smell, taste and colour) showed that most samples meet the requirements prescribed by the Regulation for both seasons, except for sample S20, which showed an unusual smell for both analyzed seasons, and sample S12 in July, a smell associated with H_2S. Sample S18 in July did not have a satisfactory color, i.e. the appearance of the water color is yellow. The basic requirement for water quality is that it be odorless, tasteless and colourless. The presence of an odor most often indicates a qualitative defect in the water, because the smell of water mainly comes from dissolved organic and inorganic substances in the water, while the taste of water is most often a sign of water defect, and is determined by the mineral composition, gas content and temperature [4].

The results of the physical and chemical parameters of the water are shown in Table 1. and Table 3. The results of the analysis vary depending on the location and the season. When it comes to pH value, as an important chemical indicator of water quality, it is noticeable that during the month of March a lower pH value was recorded (6.63-8.44), and a slightly higher pH value of 6.58-8.55 for the month of July. Namely, the lowest pH value of 6.47 was recorded for sample S24 in the month of March, while the highest pH value of 8.44 was recorded for sample S13 in the same month. The lowest pH value for the month of July was recorded for sample S21, pH value 6.35, while the highest pH value was recorded for sample S12, pH value 8.44.

The values of oxidability for all analyzed samples were within the limit values. Increased values compared to the others were observed for samples S20, S21 and S25 for the month of March, and samples S4 and S17 for the month of July. The values of electrical conductivity measured at 20ºC were within the limit values (conductivity <2500 μS/cm) at 20ºC, except for sample S20 whose electrical conductivity value for the month of March was 2899 μS/cm at 20ºC, and for sample S21 for the month of July 2135 μS/cm at 20ºC. The conductivity of water depends on the type of ions present in the water, their concentration, mobility, charge, etc. [5,6]. Increased values of electrical conductivity may be the result of increased nitrate or ammonia values in groundwater, which is probably the case with sample S20 and S21. The increased values of certain parameters in the month of March are to some extent expected since the amount of precipitation that contributes to the washing and increased mobilization of various contaminants from the atmosphere, the surface layer of the soil and water to the aquifers increased during the spring.

One of the chemical indicators of “fresh” fecal pollution is ammonia, which is formed as a result of the mineralization of organic matter [7]. According to the Regulation on Natural Mineral and Natural Spring Waters (Official Gazette of Bosnia and Herzegovina No. 26/10 and 32/12), the limit value in drinking water is 0.5 mg/L, which further indicates that in samples S12 and S22 for the month of March, and S12 and S23 for the month of July, we have higher concentrations of ammonia than allowed. The values of chloride, free chlorine, nitrate and nitrite were within the allowed limits for both analyzed seasons.

For samples S20 and S21, a higher concentration of iron than the maximum permitted by the regulations was determined, i.e. 0.26 mg/L in March and 0.38 mg/L in July. The increased iron values can be partly attributed to corrosion occurring in the pipes through which the water passes to reach the consumer, since earlier research in Egypt has shown that tap water has higher concentrations of iron compared to bottled water [8,9]. Manganese values for all analyzed samples in both analyzed seasons were within the permitted limits.

Microbiological analysis for the month of March showed a higher number of isolated *Escherichia coli* and *Enterococcis faecalis* bacteria for samples S4, *Enterococcus faecalis* for samples S21, S22, S26 and S29, while for the month of July an increased number of isolated microorganisms was recorded for almost all analyzed samples of public taps. Otherwise, total *coliform bacteria* and *E. Coli* are used as indicators of fecal pollution, and since the summer period carries risks of contamination due to more favorable conditions for pathogen reproduction and increased anthropogenic activity, a higher number of microorganisms is expected in this period [10].

CONCLUSION

The treatment of HeLa, H460, and HCT116 cell lines with essential oil from pink pepper fruit demonstrated a dose-dependent decrease in cell growth. At the lowest concentrations of 0.01 μL/mL and 0.1 μL/mL, the essential oil had no effect on cell viability, with the growth percentage (PG) remaining at 100%. However, at a higher concentration of 1 μL/mL, a significant cytotoxic effect was observed, resulting in a 100% reduction in cell growth.

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