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QUALITY CONTROL OF DRINKING WATER

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ABSTRACT

The main purpose of this paper was to control the quality of drinking water, which is distributed to the city of Zenica. Sampling, methods of testing and interpretation of the results were realized in accordance with Regulation on the hygiene of drinking water, "Official Gazette of B&H", number: 40/10, 43/10, 30/12 [6]. JP "VIK" doo Zenica the sampling of water supply for drinking water is doing at 33 locations in the water supply network, 3 larger reservoirs, 10 small reservoirs outside the urban zone and two major sources. In our case, the samples of water were taken on seven different locations, in the zone of central water supply. Sampling was performed on places with substantial consumption of water, such as: Hospital, Zenica milk industry, Hotel Dubrovnik, Travnička street, Podurije, Metalno i Radakovo. Based on our examination, we can conclude that the drinking water in Zenica city has very good quality.

1. INTRODUCTION

Water was always a symbol of life for all human beings. One of the basic human rights is the right to drinking water and health safe water is very important for the preservation of human health. Without water no living creature can survive, and fresh water is essential for all forms of human activity. According to the total amount of water on the Earth's surface, water is one of the most common substances. The total amount of water on earth is estimated at about 1.36 billion cubic kilometers, of which only about 37.55 million cubic kilometers or 2.78% is fresh water, while the remaining 97% consists of seas and oceans. According to the final water budget that is available to a human is only 0.3% of the total volume of water on Earth [3]. By drinking water, the human body is being supplied with certain substances, which are essential for life. The water in its composition contains a number of chemical elements such as C, H, O, N, S, P, Ca, Mg, K, Na, and macro-elements, and only 0.1% are trace elements: Fe, Zn, Cu, Ni, I, Mn, F, etc. The quality of natural waters is variable, because products of human activity are constantly in interaction with the soil, water and air and thus bring a variety of pollution. Water quality is determined on the basis of examination of its physical, chemical and biological characteristics.

One of the most important tests is the metal content in the water and in particular heavy metals. In the city of Zenica on seven locations which are mentioned in Abstract were tested physical parameters such as: temperature, colour, taste, turbidity, pH value and electrical conductivity and chemicals parameters, which include: $KMnO_4$ consumption, ammonia, nitrates, nitrites, chlorides, sulfates, residual chlorine and aluminum (for water in which was used as a coagulant). Within the periodic analysis the samples were subjected to measurement of the concentration of some heavy metals such as: manganese and lead.

2. SAMPLING AND TESTING SAMPLES OF DRINKING WATER

The main objective of sampling is to provide a representative sample for analysis. The methodology of the water sample depends on the purpose of analysis, the type of water which is to be analyzed, and is determined by planning. Water sample is treated in such a way that during sampling, transport and duration of analysis the composition of the sample does not change. If the water sample is representative, it is enough to sample it once. If the composition of the sources changes in time, sampling is performed at specified time intervals, and if the composition of the sources changes more in space, than in time, sampling is done at several locations.

2.1. The purpose of sampling

The purpose of the water sampling can be:

- determination of the quality of water (measurement of the concentration of certain components in water),
- the water quality control (monitoring one or more parameters within certain defined values, wherein the number of sampling depends on the possibility of occurrence of deviations from the set conditions, or if a deviation has occurred, from the length of the state),
- identification of the sources of water pollution (determination of contamination of an unknown source, mainly by an accidental discovery of periodic sampling).

Before any extensive sampling, it is necessary to develop a sampling plan, which should contain the following information:

1. The sampling point, which includes creating a map to identify the location,
2. Sampling frequency,
3. Origin of samples (drinkable/tap water, water sources, water from the tanks),
4. The number of samples,
5. The approximate duration of sampling,
6. Sampling procedures,
7. Processing, and preservation of samples and therefore, planning of chemicals, laboratory packaging and analytical equipment and
8. Data on the person who carried out the sampling.

In addition, the plan should include methods of processing the results obtained and the type of statistical parameters to be used for each sample. Before starting the program, a preliminary sampling is recommended [9].

By Monitoring programs of water intended for human consumption must:

- to check that the measures are in place because of the control of the risks to human health in the entire chain of supply of water, from the basin through the abstraction, purification and storage, to distribution, effectiveness, so that the water in the point of an alignment is safe and clean,
- provide information on the quality of the water that is delivered for human consumption in order to prove the fulfillment of the obligations that are set up and respect the values of the parameters set out in the Annex and of the Regulation on the sanitary quality of drinking water [7],
- determine the most appropriate way of reducing the risk to human health [8].

According to the Regulation [8] two kinds of the water analysis are provided, with a different scope and the frequency: basic analysis (tracking control) and periodic analysis (audit tracking). The purpose of tracking control is to obtain information on the organoleptic and microbiological quality of drinking water as well as to obtain information on the efficiency of water treatment (particularly to disinfection) which are used to determine whether to comply with the relevant values of the parameters defined by this Regulation. This analysis includes: aluminum (when used as a flocculant), ammonia, color, conductivity, Clostridium perfringens (only if water comes from the water surface sources or has been affected by the water), an E. coli, the pH, the iron (if using as an a flocculant), nitrite (if applicable chloramination), fragrance, Pseudomonas aeruginosa (only if the water is offered for sale in bottles or containers), the flavor, the number of colonies at 22 and 37 ° C and the turbidity of the coliform bacteria. The aim of the audit trail is to provide the required information for determining whether all values of the parameters are in accordance with the present Regulation [8].

2.2. Sampling points

Determination of the number and location of sampling is a very important item in any program of sampling and depends on the ultimate goals of sampling. In determining the place of sampling the water, it is important that the samples are representative of the water in that place. The selected location must be safe and accessible for staff and equipment. For public water facilities and water supply sampling is done at three levels: at the source, reservoir and from the network itself. The sampling plan is made so as to cover the entire water system, taking into account that samples are taken in the vicinity of buildings with high consumption, such as: schools, hospitals, central part of the city, the tubes for main water supply of some neighbourhoods, etc. In Zenica the sampling of water supply for drinking water is done at 33 locations in the water supply network, 3 larger reservoirs, 10 small reservoirs outside the urban zone and two major sources. Laboratory is internal and verified by the Ministry of Health of Zenica-Doboj Canton. In addition, periodic follow up is done by Cantonal Public Health Institute Zenica-Doboj Canton. In the Table 1 are given all points of sampling water in VIK Zenica, but also the reservoirs, on which the control of drinking water is performed.

Table 1. The sampling Items of drinking water in VIK Zenica with reservoirs

Label	Location	Label	Location	Label	Location	Label	Location
T-1	*Hospital*	**T-9**	*Željezarski Reservoir*	**T-18**	*K.P.Z.*	**T-29**	*Paviljon*
T-2	*Home and family*	**T-10**	*Tetovo*	**T-19**	*Raspotočje*	**T-30**	*Gornji brist*
T-3	*Pehare*	**T-12**	*Travnička*	**T-20**	*Metalno*	**T-31**	*Gračanica*
T-4	*ZIM*	**T-13**	*Broda*	**T-22**	*Bilimišće*	**T-32**	*Vražale*
T-5	*Chanel*	**T-14**	*Čajdraš*	**T-23**	*Lukovo*	**T-33**	*Zvečaj*
T-6	*Blatuša*	**T-15**	*Mokušnice*	**T-24**	*Radakovo*	**I-1**	*Zmajevac*
T-7	*Željeznička S.*	**T-16**	*Podurije*	**T-25**	*Klopče*	**I-2**	*Crkvice*
T-8	*Hotel Dubrovnik*	**T-17**	*Horse pipe*	**T-28**	*Hamida*	**R-1 i R-2**	*Reservoirs Zmajevac i Crkvice*

2.3. Testing of samples of drinking water

In this paper, or its experimental part samples of drinking water were taken and analyzed from the city water distribution network in Zenica. Sampling, testing methods and interpretation of results were done in accordance with the Regulation on the sanitary quality of drinking water, "Official Gazette of B&H", No. 40/10, 43/10, 30/12 [7]. Sampling was conducted at seven different locations within the zone of water supply of the municipality Table 2 while the analysis of samples were carried out in the laboratory of JP "VIK" doo Zenica. Quality control of some heavy metals was monitored in the long run. On the samples basic and periodic analysis were carried out.

From the core of the analysis, the following physical parameters were tested: temperature, colour, taste, turbidity, pH value and electrical conductivity, and chemical parameters, which include: $KMnO_4$ consumption, ammonia, nitrates, nitrites, chlorides, sulfates, residual chlorine and aluminum (for water in which was used as a coagulant). Within the periodic analysis the samples were subjected to measurement of the concentration of certain heavy metals such as: manganese and lead.

Table 2. Places at which the sampling was completed and sample codes

Number	Sample code	Place of sampling
1.	**T-1**	**Hospital**
2.	**T-4**	**Zenica Milk industry (ZIM)**
3.	**T-8**	**Hotel Dubrovnik**
4.	**T-12**	**Travnička street**
5.	**T-16**	**Podurije**
6.	**T-20**	**Metalno**
7.	**T-24**	**Radakovo**

In the Table 3 the results of content specifically manganese and lead and on Diagram 1 are presented the results of the analysis of six samples from the above locations. Determining the concentration of manganese in the samples was performed by spectrophotometric method using specific reagents, or ascorbic acid, an alkali cyanide and PAN indicator. For determination of the

concentration of lead, manganese and aluminum in the samples, a complex method was used, which was conducted on a spectrophotometer HACH, USA, DR/2000th.

In Tables 4 and 5 the results of the analysis are presented of physical and chemical parameters of samples taken from seven locations. Each point is sampled six times, three times in September and three in October. Sampling was done at sites with greater water consumption, such as schools, hotels, hospitals etc. As we can see in the tables, all of the results of the analysis tests of physical and chemical parameters of the seven samples are below the permissible value, prescribed in the Regulation. While sampling the measurement of the temperature of the water and residual chlorine was taken at the sampling site, while the other measurements of physical-chemical correctness was made in the laboratory. Measurement of residual chlorine in the samples was carried out by chlorine comparator and a colorimeter. Some parameters, respectively: color, ammonium, nitrite, nitrate, sulfate, and aluminum, have been analyzed by a spectrophotometric method. Consumption of $KMnO_4$ and chloride concentrations were performed by titration method. Determination of aluminum in samples is mandatory only for the water in which the process of conditioning used an aluminum as the role of the coagulant. In our case it is a sample T-1, that was taken in the Cantonal Hospital. Only water from the source of Babina river goes through this stage of processing, so therefore the control of the concentration of metals in the water of this spring is necessary.

Table 3. Results of content manganese and lead in drinking water (source VIK Zenica)

Number	Date	Location	Manganese	Lead
Allowed values of parameters	*Year 2017*		*< 50*	*< 10*
Units			*µg/l*	*µg/l*
1.	04.01.	Hospital	0.0	1.0
2.	24.01.	ZIM	1.0	1.0
3.	13.03.	Podurije	14.0	0.0
4.	21.08.	Podurije	2.0	1.0
5.	03.10.	Metalno	12.0	2.0
6.	30.10.	Radakovo	1.0	0.0

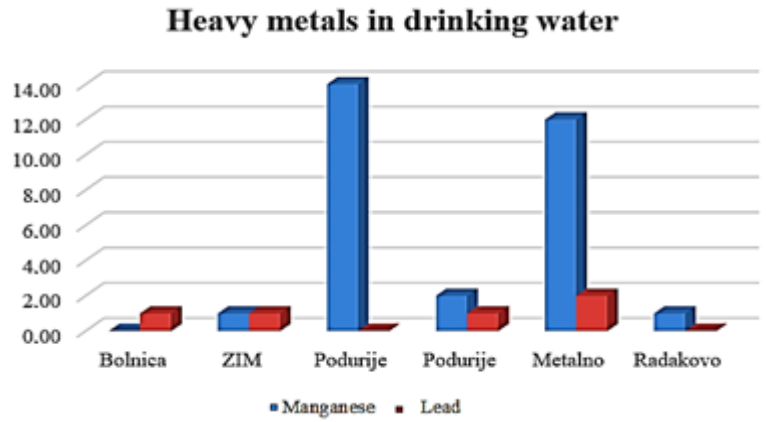

Diagram 1. The content of manganese and lead into drinking water

Table 4. The results of the physical parameters of drinking water (source VIK Zenica)

Number	Date	Location	Temp.	Colour	Flavor	Turbidity	pH value	Conductivity
Allowed values	*Year 2017*			*Acceptable for consumers*	*Acceptable for consumers*	*Acceptable for consumers*	*≥6,5 i ≤9,5*	*< 2500 (on 20°C)*
Units			*°C*	*Pt-Co*	*organoleptic*	*°N.T.U.*	*pH unit*	*mS/cm*
1.	02.09.	Hospital	20	0°	without	0.49	7.86	384
2.	09.09.	Hospital	18	0°	without	0.59	7.77	381
4.	04.10.	Hospital	16	0°	without	0.94	8.18	395
5.	07.10	Hospital	17	0°	without	0.2	8.14	407
6.	11.10.	Hospital	16	4°	without	0.76	8.12	395
8.	13.09.	ZIM	17	0°	without	0.24	7.56	291
9.	19.09.	ZIM	15	0°	without	0.46	7.54	368
10.	13.10.	ZIM	14	0°	without	0.22	8.36	295
12.	31.10.	ZIM	11	0°	without	0.36	8.07	286
13.	11.09.	Hotel D.	18	0°	without	0.21	7.52	291
14.	19.09.	Hotel D.	16	0°	without	0.44	7.63	295
15.	25.09.	Hotel D.	18	0°	without	0.85	7.58	292
18.	24.10.	Hotel D.	17	0°	without	0.53	8.2	289
19.	08.09.	Travnička	22	0°	without	0.28	7.56	290
20.	14.09.	Travnička	19	0°	without	0.23	7.6	292
21.	19.09.	Travnička	18	0°	without	0.34	7.67	394
23.	13.10.	Travnička	16	0°	without	0.28	8.34	297
24.	25.10.	Travnička	15	0°	without	0.5	8.17	281
25.	08.09.	Podurije	18	0°	without	0.29	7.56	290
27.	21.09.	Podurije	16	0°	without	0.62	7.54	286
29.	09.10.	Podurije	14	0°	without	0.27	8.16	290
30.	19.10.	Podurije	14	0°	without	0.25	8.17	296
31.	07.09.	Metalno	20	0°	without	0.15	7.52	290
32.	13.09.	Metalno	19	0°	without	0.28	7.83	290
33.	19.09.	Metalno	19	0°	without	0.25	7.63	305
35.	13.10.	Metalno	14	0°	without	0.19	8.34	295
36.	24.10.	Metalno	12	0°	without	0.31	8.2	297
38.	11.09.	Radakovo	18	0°	without	0.46	7.75	340
39.	18.09.	Radakovo	16	0°	without	0.21	7.52	381
40.	06.10.	Radakovo	16	0°	without	0.42	8.16	296
41.	12.10.	Radakovo	15	0°	without	0.26	8.14	309
42.	24.10.	Radakovo	15	0°	without	0.32	8.1	296

Table 5. Results of chemical parameters of drinking water (source VIK Zenica)

Number	Date	Location	Consumption $KMnO_4$	Ammonium NH_4^+	Nitrites	Nitrates	Chlorides	Sulphates	Al	Residual chlorine
Allowed values of parameters	*Year 2017*		*< 5*	*< 0,5*	*< 0,5*	*< 50*	*< 250*	*< 250*	*< 200*	*< 0,5*
Units			*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*µg/l*	*mg/l*
1.	06.09.	Hospital	4.23	0.013	0.000	3.960	7.00	26.0	40	0.25
2.	13.09.	Hospital	2.53	0.000	0.003	6.600	12.00	26.0	40	0.25
3.	20.09.	Hospital	3.13	0.000	0.003	3.960	15.00	22	30	0.25
5.	11.10.	Hospital	4.39	0.013	0.007	3.960	9.00	22	50	0.25
6.	25.10.	Hospital	4.43	0.013	0.003	3.960	11.00	24	80	0.1
8.	13.09.	ZIM	2.21	0.000	0.003	2.640	6.00	11		0.35
9.	19.09.	ZIM	4.06	0.000	0.000	3.520	9.00	18		0.35
10.	13.10.	ZIM	2.59	0.000	0	2.640	8.00	11		0.35
12.	31.10.	ZIM	2.84	0.000	0.000	2.200	6.00	12		0.4
13.	11.09.	Hotel D.	1.90	0.000	0.000	4.400	9.00	12		0.4
14.	19.09.	Hotel D.	2.32	0.000	0.000	2.640	7.00	8		0.3
15.	25.09.	Hotel D.	1.90	0.000	0.000	2.200	8.00	10		0.3
17.	13.10.	Hotel D.	2.87	0.000	0	3.080	6.00	9		0.3
18.	24.10.	Hotel D.	1.50	0.000	0.000	2.640	7.00	10		0.4
19.	08.09.	Travnička	0.86	0.000	0.000	3.080	6.00	8		0.2
20.	14.09.	Travnička	1.35	0.000	0.003	3.960	6.00	8		0.2
21.	19.09.	Travnička	2.61	0.000	0.000	3.080	8.00	10		0.3
23.	13.10.	Travnička	1.72	0.000	0	3.080	8.00	8		0.35
24.	25.10.	Travnička	2.36	0.000	0	3.080	9.00	9		0.35
25.	08.09.	Podurije	1.55	0.013	0.003	4.840	10.00	12		0.3
27.	21.09.	Podurije	1.84	0.000	0.003	2.200	7.00	12		0.25
29.	09.10.	Podurije	2.66	0.000	0.000	5.280	7.00	13		0.4
30.	19.10.	Podurije	1.50	0.000	0.000	2.200	5.00	10		0.35
32.	13.09.	Metalno	1.58	0.000	0.000	3.960	6.00	11		0.1
33.	19.09.	Metalno	2.03	0.000	0.000	2.200	9.00	12		0.1
35.	13.10.	Metalno	2.59	0.000	0	3.960	6.00	11		0.2
36.	24.10.	Metalno	2.11	0.000	0.003	2.200	8.00	11		0.3
38.	11.09.	Radakovo	3.16	0.000	0.000	3.520	9.00	19		0.35
39.	18.09.	Radakovo	3.01	0.013	0.003	3.960	11.00	28		0.35
41.	12.10.	Radakovo	1.49	0.000	0.000	3.080	10.00	14		0.35
42.	24.10.	Radakovo	2.41	0.000	0.000	3.520	7.00	12		0.4

3. CONCLUSION

Based on the controlled and analyzed samples of drinking water on the physical and chemical parameters from seven locations listed in VIK Zenica which are: Hospital, Zenica milk industry (ZIM), Hotel Dubrovnik, Travnička street, Podurije, Metalno and Radakovo and from obtained laboratory results we can conclude that:

- The analyzed samples of drinking water have chemical parameters in accordance with the allowed values of the Regulation on sanitary drinking water "Official Gazette of B&H", No. 40/10, 43/10, 30/12 [7].
- The analyzed samples of drinking water have physical parameters in accordance with the allowable values of the Regulation on the sanitary quality of drinking water "Official Gazette OF B&H", No. 40/10, 43/10, 30/12 [7].
- The analyzed samples of drinking water from five locations listed in VIK Zenica which are: Hospital, Zenica milk industry, Podurije, Metalno and Radakovo concentration of lead and manganese in accordance with the values allowed by the Regulation on the quality of water for drinking "Official Gazette of B&H", No. 40/10, 43/10, 30/12 [7].

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