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Health safety of water for human consumption in the city of Čabar in the period of 2012-2016

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Ina **KELAVA**[1], Ivana **ŠUTIĆ**[2], Valentino **PAVIŠIĆ**[3], Nataša **SALAĆ**[4], Aleksandar **BULOG**[4*]

[1] University of Rijeka, Faculty of Medicine, Braće Branchetta 20, 51000 Rijeka, Croatia

[2] Department of Family Medicine, University of Rijeka, Faculty of Medicine, Braće Branchetta 20, 51000 Rijeka, Croatia

[3] Department of Physiology and Immunology, University of Rijeka, Faculty of Medicine, Braće Branchetta 20, 51000 Rijeka, Croatia

[4] Department of Public Health, University of Rijeka, Faculty of Medicine, Braće Branchetta 20, 51000 Rijeka, Croatia

[*] *Corresponding author*
Assoc. Prof. Aleksandar Bulog, PhD, Bsc Sanitary engineering
Department of Public Health, University of Rijeka, Faculty of Medicine, Braće Branhetta 20, 51000 Rijeka, Croatia
E-mail: aleksandar.bulog@zzjzpgz.hr

ABSTRACT

Introduction: The water supply network of the Čabar area (Čabar is a little place in Gorski kotar, mountain part of Croatia) has been carrying bacteriological contamination for many years. The aim of the paper is to present a five-year microbiological profile of drinking water used for supplying the field area. **Methods:** The collected data for Čabar, Gerovo, Prezid and Tršće water sourses were obtained from the Department of Public Health, Primorsko-Goranska County. Data were statistically processed and interpreted for the period from January the 1st 2012. to December the 31 st2016. The number of tested samples is 435 and the analyzed parameters are temperature, color, turbidity, pH, conductivity, KMnO4 consumption, ammonia, coliform bacteria, *Escherichia coli, Enterococci*, colonies at 37 °C and colonies at 27 °C, *Pseudomonas aeruginosa* and free chlorine. **Results:** The highest number of bacteriologically defective samples in the five-year period was in Čabar's water supply with 33% of defective samples compared to the total number of measurements and the Gerovo water supply with 29%. The contaminated samples contain *Escherichia coli* (fecal contamination indicator) and are most present in the Čabar water supply (28%), followed by Gerovo (24%), Tršće (10%) and Prezid (9%). **Conclusion:** Due to fecal contamination, these water supply systems are unsafe for human health because they are the potential causes of the hydric epidemic and need to continue to invest in the protection of sources and sanitary-technical maintenance of the water supply system with regular chlorination.

Key words: fecal contamination, water supply, water for human consumption, health sanitation

INTRODUCTION

Human's need for water, especially for drinking, is constantly increasing due to urbanization, industrialization, population growth and irrational consumption. For the last hundred years, the use of water for human consumption has increased 7 times, mostly due to the needs of industry and food production. Sea and oceans make up 97.5% of the total amount of water on Earth while fresh water accounts for 2.5% [1]. Out of these available fresh water supplies it fell 1.74%. It results that 0.76% of the total mass of fresh water on Earth, which is not all environmentally acceptable for use. Carnations and constant snow cover about 10% of the world's mainland and contain about 70% of the world's quantity of fresh water [1]. The largest amount of available fresh water that can be used for water supply is land-flowing water. Groundwater is the largest resource of drinking water and makes 90% of the available world resources [1]. Millions of people all around the world suffer and may die from diseases caused by water contamination. The largest number of victims are children in developing countries, particularly in Asia and Africa [2]. Because of the large number of diseases and mortality of people due to lack of supply with potable water and non-hygienic conditions, water is considered to be the leading cause of mortality among environmental causes. Precisely because of the great link between health and sanitary water, water management is part of public health [3]. Potable water is considered to be healthy and good if it has good sensory properties, which means it must be free of mute, smell and color . In addition to satisfactory sensory properties it should not contain, in a number that would pose a risk to human health, parasites, microorganisms, as well as their developmental forms. It should not contain harmful substances that may be harmful to human health [3].

Because of the large number of diseases and mortality of people due to lack of supply with potable water and non-hygienic conditions, water is considered to be the leading cause of mortality among environmental causes.

Water intended for human consumption is, according to the Law on Water for Human Consumption (OG 64/15), which has been in its original state or after processing intended for drinking, cooking or other household purposes, irrespective of its origin and irrespective of whether they come from a water tank, tank, or public water supply system. This is also the water used in food-producing industries that are produced, processed or placed on the market of products or substances intended for human consumption unless it has been determined by the competent authority that the water quality can not be affected in its final form, on food safety [4]. Potable water quality, apart from the purity and quality of the water source itself, also depends on the way the water is purified and disinfected, as well as on the quality of the water supply system itself and the water supply network. Healthy water quality depends on the sanitary-technical and hygienic conditions that must be met to ensure that the water used for supplying the population is healthy [5].

The water supply system implies a water supply system for the human consumption, which constitutes a watercourse (arranged and protected), a conditioning device, a pumping station and a water supply system, and a main supply pipeline and a water supply system for transporting water from the waterworks to the consumer [4].

In Primorsko-Goranska County, for the needs of the Ministry of Health, the drinking water is controlled by the Institute of Public Health of Primorsko-Goranska County. The Department that performs control within the Institute is the Department for Control of Drinking Water and Water in Nature. According to the Ministry of Health's instructions only processed water is controlled at the place of consumption. Water samples are mostly taken in public facilities, for example in schools and in public shows. All results obtained by testing are regularly sent to the water supply, sanitary inspection and the Ministry of Health. The results are also publicly available to everyone on the Institute's website: www.zzjzpgz.hr. Gorski kotar occupies the western part of the Republic of Croatia and a third of the land area of the Primorsko-Goranska County. It is naturally very rich in water. Lake Lokvarsko, Lepenica and Bajer are Lake Gorski kotar. The water wealth is crowned by the watercourses of the river Kupa, Čabranka and Dobra. It belongs to the most exquisite parts of the state. Relatively speaking, it is distinguished and characterized by its low population density and its prominent depopulation. Although it belongs to the Primorsko-Goranska County, where there is an excellent water supply system, a number of samples have been observed for a long period of time in analyzes of water for human consumption [6]. The water supply of the Čabarsko area is characterized by a large number of smaller water supply systems, which are concerned with sources of less tolerance. Sanitary-technical maintenance of such systems as well as disinfection is greatly hampered by dispersion and multiplicity. During 2012, the first phase of installation of automatic chlorine in the area of Prezid and Tropet-Parga began. This has greatly improved water quality. The second phase of construction was continued in 2013. It was supposed to be for the area of Mandla-Žagar-Plešac and Gerovo, but only in the territory of Gerovo and Tršće the main part was realized [7, 8].The aim of this paper is to present the status of the water supply system of the Čabar area in the five-year period from January the 1st 2012. to December the 31st 2016. The water supply network of Gorski Kotar and, therefore, the areas of Čabar belonging to it, have for a long time followed a bad picture of health testing of water for human consumption showing the microbiological contamination of the water supplying the area. By reviewing the five-year results, it will be apparent how much the change in the legal regulations as well as the installation of automatic chlorinates have influenced the health of drinking water and how it was in the past five years.

The water supply of the Čabarsko area is characterized by a large number of smaller water supply systems, which are concerned with sources of less tolerance. Sanitary-technical maintenance of such systems as well as disinfection is greatly hampered by dispersion and multiplicity.

MATERIALS AND METHODS

All collected data were analyzed in the Department of Public Health Primorsko-Goranska County. The data obtained are a summary of total measurements during the five-year period from January the 1st 2012 to December the 31st 2016. For the purposes of this paper, the data are systematized in four parts by analyzing microbiological status of samples of the potable water of four water sourses of Čabar area for Čabar, Gerovo, Prezid and Tršće. All water samples were taken at places of consumption, most commonly in public parlors, kindergartens or

schools. Samples were taken most frequently once a month by 2013, while from 2014 to 2016 the number of samples was dependent on the amount of water delivered in m^3/day. In the data obtained a total of 1,107 measurement results for Čabar, 1,899 results for Gerovo, 2,210 results for Tršće and 2,218 results for Prezid within the examined five-year period were analyzed. The collected data for Čabar, Gerovo, Prezid and Tršće water sourses were obtained from the Department of Public Health, Primorsko-Goranska County. Data were statistically processed and interpreted for the period from January the 1st 2012. to December the 31st 2016. The number of tested samples is 435 and the analyzed parameters are temperature, color, turbidity, pH, conductivity, KMnO4 consumption, ammonia, coliform bacteria, Escherichia coli, Enterococci, colonies at 37 °C and colonies at 27 °C, *Pseudomonas aeruginosa* and free chlorine.

RESULTS

Table 1 shows the values of indicators obtained by the health check of human health water quality for Čabar watercourse in the period from January the 1st 2012. to December the 31 st2016. For the sake of better visibility, red paint has been shown to show defective number of samples. 64 samples were tested in the Čabar waterway during the five-year period. The water temperature in the five-year period did not exceed the permissible value of 25 °C, which means that the water complied with the prescribed values of the Ordinance. The minimum measured water temperature was 6.5 °C, while the maximum measured temperature was 18.0 °C. The water color was satisfactory and in all measurements it was 0 mg/L Pt/Co, while the maximum permissible concentration was 20 mg/L Pt/Co. pH values are optimal for water for human consumption. The minimum measured value was 7.7, while the maximum measured value was 8.3. The measured values did not exceed the maximum permissible value of 9.5. The conductivity of the samples ranged from 243 μS/cm/20 °C (min.) up to 437 μS/cm/20°C (max.) and it is a characteristic for the water from the river Čabranka. The maximum permissible concentration is 2500 μS/cm/20 °C. Based on this we conclude that the water complied with the prescribed conductivity values. Utility KMNO4 (potassium permanganate), which is an indicator of the presence of organic substances in water consuming oxygen for oxidation, was low and did not exceed the maximum permissible concentration of 5.00 mg/L O_2. The minimum measured value was 0.31 mg/L O_2, while the maximum measured value was 3.54 mg/L O_2. Values for ammonia in water samples were low. The maximum measured value was 0.012 mg/L NH_4, much lower than the maximum permissible concentration of 0.500 mg/L NH4 given in the ordinance. The only microbiological parameter that did not have a defective sample was Pseudomonas aeruginosa but it started to be controlled as an indicator until 2014, so it should be taken into account that these measurements are not the values of this indicator for the period from 2012 to 2013 [9].

Table 1. Results of the health check results of the Čabar water supply from January the 1st 2012 to December the 31st 2016

Indicators	Measuring unit	Total	Min.	Max.	MDK	Incorrect samples
Water temperature	°C	18	6.5	18.0	25.0	0
Water colour	mg/L Pt/Co	61	0	0	20	0
Water turbidity	NTU	61	0.32	18.60	4.00	4
pH value	pH value	61	7.7	8.3	9.5	0
Water conductivity	μS/cm/20 °C	61	243	437	2500	0
Consumption of $KMnO_4$	mg/L O_2	61	0.31	3.54	5.00	0
Ammonium	mg/L NH_4	61	0.000	0.012	0.500	0
Coliform bacteria	Broj/100 mL	64	0	1300		21
Escherichia coli	broj/100 mL	64	0	1300		19
Enterococci	broj/100 mL	64	0	260		17
Colonies at 37°C	broj/1 mL	62	0	560	20	16
Colonies at 22°C	broj/1 mL	62	0	560	100	13
Pseudomonas aeruginosa	broj/100 mL	14	0	0		0
Free chlorine	mg/L	64	0.00	0.86	0.50	6

Table 2. Results of the health examination of the Tršće water supply system from January the 1st 2012 to December the 31st 2016

Indicators	Measuring unit	Total	Min.	Max.	MDK	Incorrect samples
Water temperature	°C	23	9.9	17.3	25.0	0
Water colour	mg/L Pt/Co	134	0	0	20	0
Water turbidity	NTU	134	0.17	5.60	4.00	3
pH value	pH jedinica	134	7.9	8.5	9.5	0
Water conductivity	μS/cm/20 °C	134	166	438	2500	0
Consumption of $KMnO_4$	mg/L O_2	134	0.00	2.10	5.00	0
Ammonium	mg/L NH_4	134	0.000	0.013	0.500	0
Coliform bacteria	Broj/100 mL	134	0	640		14
Escherichia coli	broj/100 mL	134	0	390		14
Enterococci	broj/100 mL	134	0	80		9
Colonies at 37°C	broj/1 mL	125	0	680	20	12
Colonies at 22°C	broj/1 mL	125	0	1000	100	6
Pseudomonas aeruginosa	broj/100 mL	11	0	2		1
Free chlorine	mg/L	134	0.00	4.40	0.50	24

Table 3. Overview of the results of the medical examination of the Prezid water supply system from January the 1st 2012 to December the 31st 2016

Indicators	Measuring unit	Total	Min.	Max.	MDK	Incorrect samples
Water temperature	°C	25	3.3	18.0	25.0	0
Water colour	mg/L Pt/Co	120	0	0	20	0
Water turbidity	NTU	120	0.10	6.20	4.00	3
pH value	pH jedinica	120	7.3	8.4	9.5	0
Water conductivity	μS/cm/20 °C	120	328	442	2500	0
Consumption of $KMnO_4$	mg/L O_2	120	2.00	3.53	5.00	0
Ammonium	mg/L NH_4	120	0.000	0.012	0.500	0
Coliform bacteria	Broj/100 mL	123	0	260		12
Escherichia coli	broj/100 mL	123	0	260		11
Enterococci	broj/100 mL	123	0	300		9
Colonies at 37°C	broj/1 mL	116	0	120	20	7
Colonies at 22°C	broj/1 mL	116	0	560	100	3
Pseudomonas aeruginosa	broj/100 mL	15	0	0		0
Free chlorine	mg/L	123	0.00	4.30	0.50	5

DISCUSSION

Water for human consumption can be influenced by various pollutants as a potential source of hydrocypic epidemic, which is a major threat to the general population. This suggests that great care and supervision of a water-based system depends on many factors, and this task is extremely complex and belongs to the public health field of action [10]. The water network of Čabar area has been carrying bacteriological contamination for many years. This paper analyzes the health and safety of water for the consumption of water supply Čabar, Gerovo, Tršće and Prezid in a five-year period from January the 1st 2012 to December the 31st 2016. All these sites are supplied with water from the Central Water Supply System. The parameters for water temperature (°C), color (mg/L Pt/Co), turbidity (NTU), pH value (pH unit), conductivity (μS/cm/20 °C), $KMnO_4$ (mg / L (number/100 mL), number of colonies at 37 °C and number of colonies at 22 °C (number/1 mL), Pseudomonas aeruginosa (number/100 mL) and free chlorine (mg/L). The water for human consumption in all four water sources met the requirements of the Ordinance for basic physio-chemical parameters. The measured water values for water temperature, color, conductivity, consumption $KMnO_4$ and ammonia did not exceed the maximum permissible concentrations during the period from 01.01.2012 until 31.12.2016. Based on this, we conclude that the water used for supplying the field area was safe in all measurements for the specified parameters. The water was inadequate in 10 measurements. In Čabar 3 watercourse, they are a health defective sample due to the turbidity of the water. In the water supply of Gerovo water turbidity was the cause of malfunction in one measure-

ment. The turbidity exceeded the permissible values in three measurements for the Prezid watercourse as well as for the Tršće watercourse, where there are also only three defective samples of turbidity during a five year period. During the five-year period in four watercourses, water turbot has emerged as a cause of malfunction of water in a small number, therefore it is not a problem for water used for supplying the field area. Water pH values in most measurements were correct and characteristic for the water of this area having a naturally lower pH value. Only in the Gerovo watercourse the pH value of the samples did not meet the requirements of the Ordinance in three measurements in five years [11].

CONCLUSION

Comparing the number of bacteriological inadequate samples with respect to the number of tested samples of the four water sources we can conclude that the water supply Čabar has the largest number of bacteriologically inadequate water samples in the five year period from January the 1st 2012 to December the 31st 2016. Out of a total of 64 tested bacteriologically inadequate samples were found in the Čabar water supply. This means that the water for human consumption of the Čabar water supply was bacteriologically inadequate in 33% of the measurements.

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