

# Physicochemical analysis of drinking water quality in the central Bosnia canton from 2012 to 2016 (Bosnia and Herzegovina)

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## Abstract

Access to safe drinking water is essential to health and is considered as a basic human right and a component of effective policy for health preservation and protection. The importance of water, sanitation and hygiene to health and development is an issue at a national, regional and local level. Regular monitoring of drinking water quality has great public health significance because various anthropogenic effects, such as industrial development and expanding agriculture, are causing increased usage of pesticides and soil treatment. The aim of this study was, for this reason, to monitor the hygiene safety and quality of drinking water using physicochemical parameters in the Central Bosnia Canton from 2012 to 2016. Totally 5 526 samples of drinking water from city waterworks and other water facilities were sampled and analyzed in the given period. In 2012, a total of 929 drinking water samples were analyzed, of which 69 samples (7.42%) were unacceptable. In 2013, a total of 1 020 samples analyzed (33 unacceptable), in 2014 - 980 samples analyzed (7 unacceptable), in 2015 totally 967 samples analyzed (5 samples unacceptable) and in 2016, 947 samples analyzed (2 unacceptable). Given that the city waterworks and other water facilities are under regular sanitary-technical supervision and are regularly monitored for physicochemical quality, this study has shown that the number of unacceptable drinking water samples has tended to fall each year.

*Drinking water, physicochemical analysis, safe drinking water, water quality*

## Introduction

Providing a sufficient amount of hygienic and safe drinking water is a basic human right for every person and a component of effective policy for health preservation, protection and a healthy environment. Access to drinking water of safe quality ensures the protection of public health and has a direct impact on improving the sanitary and hygienic conditions of the environment (Gržetić and Brčeski 1999; Fawell and Nieuwenhuijsen 2003; WHO 2008). To ensure the satisfactory quality of drinking water, it is necessary to observe the national legislation that defines specific parameters for contaminated and non-contaminated drinking water and the maximum permissible concentration of these parameters, so that safe drinking water must correspond to the stipulated requirements in terms of its physical and chemical properties (Zebec and Senta 2001).

The Ordinance for Healthy and Safe Drinking Water in Bosnia and Herzegovina (Official Gazette of BiH No. 40/10 2010) and the Drinking Water Legislation of the FBiH (Official Gazette of FBiH No. 70/06 2006) prescribe the requirements and standards for safe drinking water that must be fulfilled: the maximum permissible values of the parameters of contamination; the methods used for laboratory testing; and the measures for monitoring the safety of drinking water, all for the purpose of protecting human health (Official Gazette of BiH No. 40/10 2010; Official Gazette of FBiH No. 70/06 2006). Regular monitoring and analysis of drinking water and sanitary protection of city waterworks and other water facilities is of great significance to public health, and is conducted by sanitary inspection through Public Health Institutes (Veljković 2010).

The aim of this paper was to present the results of the physicochemical analysis of drinking water in the Central Bosnia Canton over a period of five years from 2012 to 2016 (Plate I, Fig. 1). The results of the analysis of all the tested parameters were compared with

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the maximum permissible values of their concentrations prescribed by the Rulebook on Healthy and Safe Drinking Water in Bosnia and Herzegovina, on which the assessment of the hygiene and safety of all drinking water samples is based.

### Materials and Methods

This paper presents the results of drinking water analysis in the Central Bosnia Canton (Plate XY, Fig. 1) over the period from 2012 to 2016 for the physicochemical parameters prescribed by the Ordinance for Healthy and Safe Drinking Water (Official Gazette of BiH No. 40 / 10 2010). According to the Ordinance, the physicochemical parameters of drinking water health are: color, odor, taste, residual chlorine, turbidity, pH, conductivity, chloride, permanganate index, ammonia, nitrate, nitrite, iron and manganese. Data collection over the given period was performed by retrospective methods. All collected samples of drinking water were analyzed in the Sanitary Chemistry Laboratory of the Public Health Institute of the Central Bosnia Canton which is accredited by the Accreditation Institute of Bosnia and Herzegovina (BATA) according to BAS EN ISO 17025: 2006. The test methods for these parameters are presented in Table 1.

Table 1. Methods used for physicochemical analysis of drinking water samples

Parameters	Methods	Unit of measure
Color	Visual assessment	-
Odor	Organoleptic assessment	-
Taste	Organoleptic assessment	-
Residual chlorine	O-tolidine colorimetrics	mg·l <sup>-1</sup>
Turbidity	BAS EN ISO 7027-1:2017	NTU
pH reaction	BAS EN ISO 10523:2013	pH jed.
Conductivity	BAS EN 27888:2002	μS·cm <sup>-1</sup>
Chlorides	BAS ISO 9297:2002	mg·l <sup>-1</sup>
Permanganate index	BAS EN ISO 8467:2002	O <sub>2</sub> mg·l <sup>-1</sup>
Ammonia	Nessler's reagent spectrophotometry	mg NH <sub>4</sub> <sup>+</sup> ·l <sup>-1</sup>
Nitrates	SMEWW 22nd 4500-NO <sub>3</sub> B	mg NO <sub>3</sub> <sup>-</sup> ·l <sup>-1</sup>
Nitrites	BAS EN 26777:2000	mg NO <sub>2</sub> <sup>-</sup> ·l <sup>-1</sup>
Iron	Spectrophotometry with 1.10 phenanthroline	μg·l <sup>-1</sup>
Manganese	Spectrophotometry with ammonium persulfate	μg·l <sup>-1</sup>

### Results and Discussion

Number of total, acceptable and unacceptable samples of drinking water sampled in the Central Bosnia Canton over a period of five years and analyzed according to the methods are shown in Table 1. The obtained results of the physicochemical analysis are compared with the reference values prescribed in the Ordinance for Healthy and Safe Drinking Water (Official Gazette of BiH – Bosnia and Herzegovina No. 40/10 2010).

Table 2. Analyzed samples of drinking water from 2012 to 2016 in the Central Bosnia Canton

Year	Total number of drinking water samples	Acceptable samples of analyzed drinking water		Unacceptable samples of analyzed drinking water	
		Numerical	[%]	Numerical	[%]
2012	929	860	92.58	69	7.42
2013	1020	987	96.77	33	3.23
2014	980	973	99.29	7	0.71
2015	967	962	99.49	5	0.51
2016	947	945	99.79	2	0.21
Total	4843	4727	97.60	116	2.39

Table 3. Results of the drinking water analysis from city waterworks and other water facilities in the Central Bosnia Canton from 2012 to 2016

Year	City waterworks			Other water facilities		
	Total number of samples	Acceptable samples	Unacceptable samples	Total number of samples	Acceptable samples	Unacceptable samples
2012	671	630	41	258	230	28
2013	683	661	22	337	326	11
2014	581	575	6	399	398	1
2015	574	572	2	393	390	3
2016	530	529	1	417	416	1
Total	3039	2967	72 [2.37%]	1804	1760	44 [2.43%]

The analyzed drinking water samples presented in Table 3 were sampled from both city waterworks and other water facilities.

(Plate I and II, Fig. 2, 3, and 4) show the total number of analyzed samples, acceptable samples and unacceptable samples of drinking water from city waterworks and other water facilities according to the Ordinance for Healthy and Safe Drinking Water (Official Gazette of BiH No. 40/10, 2010) and the total number of all analyzed, acceptable and unacceptable samples of drinking water from both sources in aggregate in the Central Bosnia Canton from 2012 to 2016.

The analysis of the physicochemical parameters of drinking water samples in 2012 showed that 69 samples or 7.42% of the total of 929 samples analyzed that year were unacceptable. Of the total of 929 samples, totally 671 were sampled from city waterworks, of which 41 samples were not in accordance with the Ordinance for Healthy and Safe Drinking Water. The other 258 drinking water samples were sampled from other water facilities, and 28 of these samples were not in accordance with the Ordinance for Healthy and Safe Drinking Water.

A total of 1 020 samples of drinking water were sampled from waterworks and other water facilities in 2013, of which 33 samples or 3.23% were unacceptable. Of the total number of 1 020 samples, 683 were sampled from city waterworks, of which 22 samples were not in accordance with the Ordinance for Healthy and Safe Drinking Water. The other 337 drinking water samples were sampled from other water facilities, and 11 of these samples were not in accordance with the Ordinance for Healthy and Safe Drinking Water.

Totally 980 samples of drinking water were sampled from waterworks and other water facilities in the Central Bosnia Canton in 2014, of which 7 or 0.71% were unacceptable. Of these 980 samples, 581 were sampled from city waterworks, of which 6 samples were not in accordance with the Ordinance for Healthy and Safe Drinking Water. The other 399 drinking water samples were sampled from other water facilities, and only 1 of these samples was not in accordance with the Ordinance for Healthy and Safe Drinking Water.

Totally 967 samples of drinking water were sampled from waterworks and other water facilities in the Central Bosnia Canton in 2015, of which 5 samples or 0.51% were unacceptable. Of these 967 samples, 574 were sampled from city waterworks, of which 2 samples were not in accordance with the Ordinance for Healthy and Safe Drinking Water. The other 393 drinking water samples were sampled from other water facilities, and 3 of these samples were not in accordance with the Ordinance for Healthy and Safe Drinking Water.

Totally 947 samples of drinking water were sampled from waterworks and other water facilities in the Central Bosnia Canton in 2016, of which 2 samples or 0.21% were

unacceptable. Of these 947 samples, 530 were sampled from city waterworks, of which 1 sample was not in accordance with the Ordinance for Healthy and Safe Drinking Water. The other 417 drinking water samples were sampled from other water facilities, and 1 of these samples was not in accordance with the Ordinance for Healthy and Safe Drinking Water.

From 2012 to 2016, a total of 4 843 samples of drinking water were sampled and analyzed in the Central Bosnia Canton, of which 116 samples or 2.39% were not in accordance with the Ordinance for Healthy and Safe Drinking Water. Of a total of 3,039 sampled and analyzed samples from the city waterworks in the given period, 72 or 2.37% of the samples were unacceptable, while of the total of 1 804 drinking water samples from other water facilities, 44 samples or 2.43% of the samples were not in accordance with the Rulebook mentioned above.

### Conclusions

The results of the physicochemical analysis of drinking water show that the number of unacceptable and contaminated drinking water samples from 2012 to 2016 had a falling tendency and went from 69 unacceptable samples in 2012 to 2 unacceptable samples in 2016 (Fig. 5). Regular sanitary and technical supervision of the city waterworks and other water facilities and regular monitoring of the physicochemical quality of drinking water has great significance for the preservation and protection of public health.

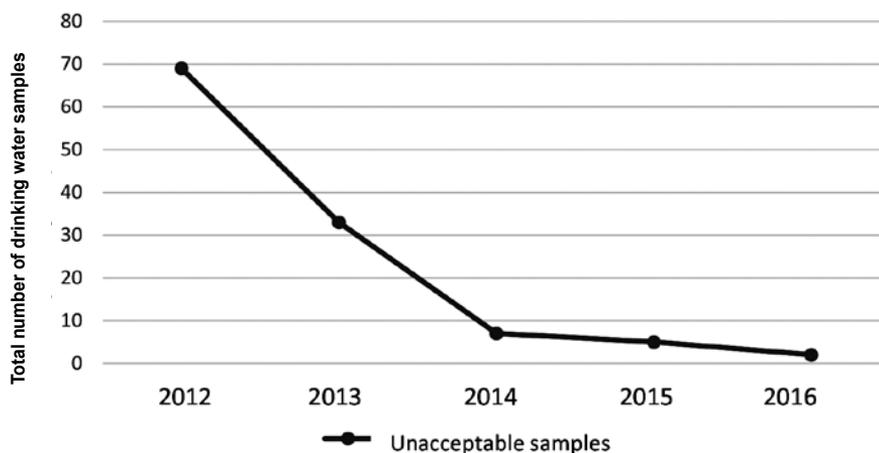


Fig. 5. The total number of unacceptable drinking water samples from 2012 to 2016 in the Central Bosnia Canton decreased.

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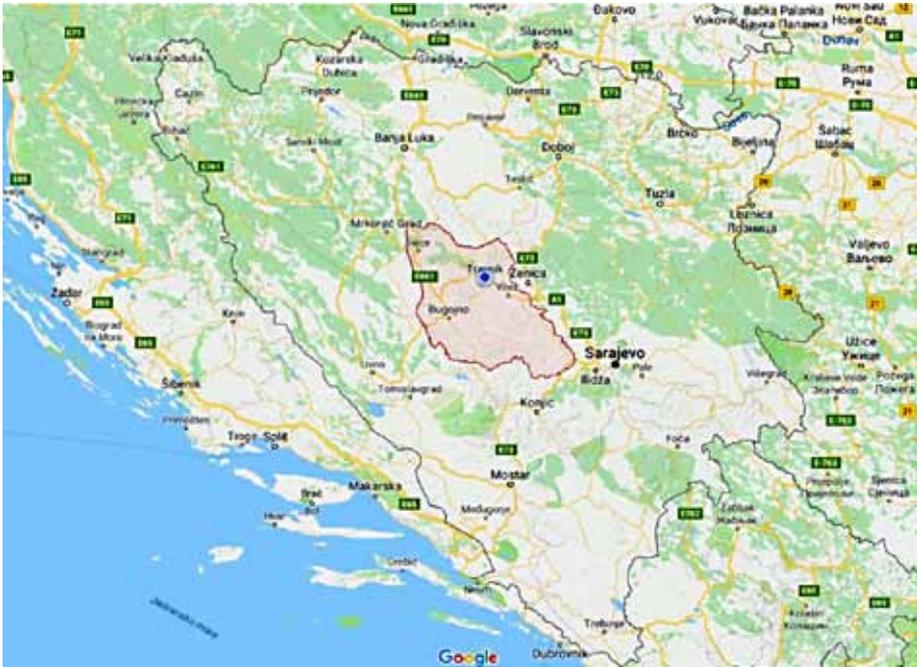


Fig. 1. Location of Central Bosnia Canton, Bosnia and Herzegovina

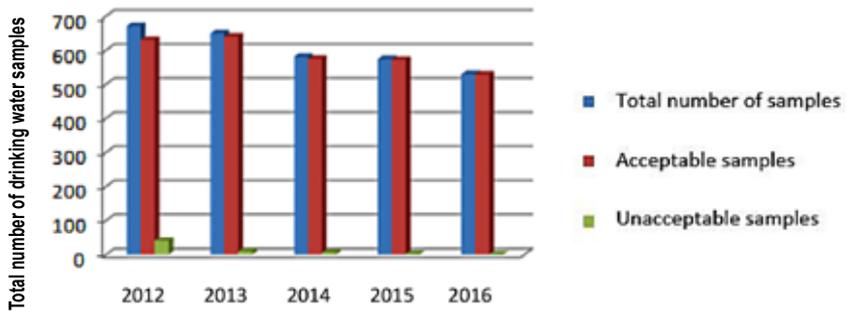


Fig. 2. Total number of samples, acceptable and unacceptable samples from city waterworks in the Central Bosnia Canton over a period of five years

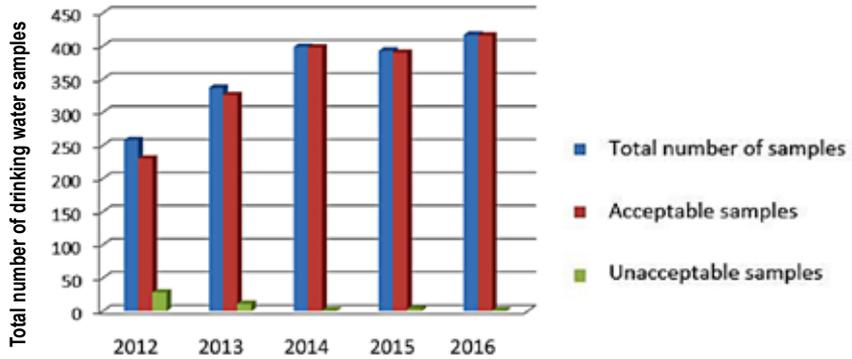


Fig. 3. Total number of samples, acceptable and unacceptable samples from other water facilities in the Central Bosnia Canton over a period of five years

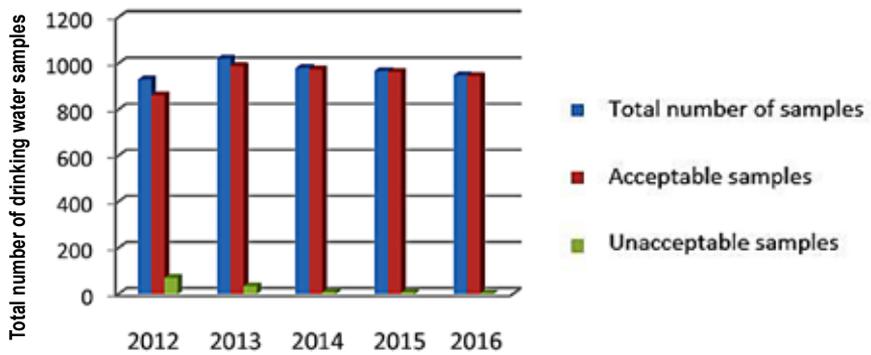


Fig. 4. Total number of samples, acceptable and unacceptable samples of drinking water from city waterworks and other facilities in the Central Bosnia Canton over a period of five years