DRINKING WATER QUALITY IN CITY OF BANJA LUKA, BOSNIA AND HERZEGOVINA – CASE STUDY

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Abstract
The paper presents the situation of system for public drinking water facilities "Waterworks" of Banja Luka city, including the current situation and new projects and facilities. The goal of the case study is to analyse and evaluate the results of basic physicochemical parameters of drinking water produced during the period of two years – 2013 and 2014. The data includes the seasonal sampling champagnes of two years, during the months January, April, Jul and October. It is important to have continual and controlled monitoring and evaluation of the wells, raw water wells and drinking water quality therefore it can be affected under negative impact of the dynamic natural change and anthropogenic activities. According to basic physicochemical parameters the population of Banja Luka is drinking water of good quality. During the research correlation and covariance of basic physicochemical parameters was evaluated.

Introduction
Water is an elementary component of every living being, strategic and economic resource of the area development. Supplying the population with sufficient amounts of high quality and hygienically safe drinking water is one of the basic prerequisites of good health. In addition, to well-known physiological significance for life, water plays a major role in human pathology because through it can transmit many infectious diseases that are manifested as a waterborne disease. Drinking water of low quality can have hazardous and illicit health effect.Valorisation of the quality of drinking water is done by controlled recommended values acorrding to national law and bylaws. The most important global act which refers to drinking water quality guidelines is the act of World Health Organization *Strategy on water quality and health [1]*.Banja Luka is the largest city in Republika Srpska entity, and second largest in Bosnia and Herzegovina. It is located in the north western part of the country. The city lies on the River Vrbas and it is the source of raw water for drinking water production [2]. According to the 2013 census the Settlement of Banja Luka has 150,997 inhabitants [3] while the City of Banja Luka, which represents Banja Luka's wider area (municipality), has 199,191 inhabitants [4].Banja Luka covers some 96.2 km^2 of land on the banks of Vrbas River. The city is located at 44.78°N 17.19°E. Banja Luka is at 163 m above sea level, surrounded by hills. The source of the Vrbas River is about 90 km to the south. The tributary rivers Suturlija, Crkvena, and Vrbanja flow into the Vrbas at Banja Luka. Adopted technology at the new facility "Novoselija 2" of Water Supply in Banja Luka, is derived based on the results of the pilot plant, and based on the research of water

quality of the river Vrbas and analysis of the existing plant.Raw water of Vrbas River is the primary source for production of drinking water for Banja Luka city area.The system of wells accounts for 35 l/s and from facility "Novoselija 1" 700 1/s.For more complex procedures that are required in the organization of water supply of larger towns and cities hydrological research requires a careful examination of hydrological and hydraulic characteristics of underground aquifers with wells, as well as knowledge of the physicochemical and microbiological characteristics of water.

Figure 1: Waterworks Banja Luka - Novoselija 2

Before the construction of all equipment and supporting facilities for water supply are carefully examined for the risk factors, because the properties of the water must be met strict national and international criteria for drinking water quality. In the first phase of field investigation examined the conditions in which the water is located, reveals the possible existence of direct and indirect pollutants that can distress the quality of water.

Experimental

Field tests include studies of physicochemical properties of water and controlling of water samples according to national and international standard methods and prepared for further laboratory analysis [5]. Table 1 show the limit values for basic physicochemical parameters which refer to drinking water quality [6].

Table 1. Limit values for basic physicochemical parameters [6]

Physicochemical parameters	Treated water	Raw water
Temperature [°C]	8-12	
Odour [-]	no	
Taste[-]	no	
Silicate turbidity [mg]; Turbidity [NTU]	< 5 ; < 1,2	< 10 ; < 2,4
Colour [Pt-Co°]; Water containing humic matter	10 ; (-)	20° ; < 40 °
pH [-]	6,8-8,5	6,8-8,5
TSS [mg/l]	< 800	< 1000
$KMnO_4$, [mg/l]; Water containing humic matter	< 8 ; (-)	< 12 ; < 20
Chemical oxidation demand [O_2/l]	< 2	< 3
Electroconductivity [μScm^{-1}]	< 500	< 600
Dissolved oxygen [%]	85	85

When constructed water supply systems by-law provides guidelines for analyses of wells, raw water quality and, after compulsory disinfection procedure, drinking water.

Examination and control of the physicochemical and microbiological properties should be performed according to strict rules and national recommendations. Permanent and continual quality monitoring provides insight into the changes in quality of water.

In BiH, the quality of drinking water is defined by the guidelines of the by-law on the sanitary quality of drinking water with maximum levels of physicochemical and microbiological components of drinking water [6].The characteristic flow on the gaging station can range from 1218 to 13 m^3/s. The catchment area is characterized by significant rainfall caused large

fluctuations in water level. The flow can be high in the spring and in the autumn, a "small" in the summer and winter period. The main capacity of the source (about 1000 l/s drinking water) is in Novoselije, located about 6 km upstream from the city centre, on the right bank of the river Vrbas.At the source "Novoselija 'drinking water is produced in two ways:
"New Plant" - the abstraction of water through open catchment situated on the river Vrbas and then the treatment of raw water by a conventional method, with capacity of 600 l/s (Phase I facilities). A technological process consists of coagulation with aluminium sulphate, filtration at a rapid sand filters, clean and disinfection with chlorine in the final stage and dispatched to a consumer via Ø 1000 mm pipeline [7]. Sludge removal is performed automatically, and clarification phase is carried out the method of coagulation. To reduce the natural turbidity aluminium sulphate is diminutively used ($Al_2(SO_4)_3x18H_2O$).Filtration takes place in the filter station containing quick-sand filters gravity. Due to the constant requests for connection to the water supply of new consumers and to meet the needs of a sufficient quantity of hygienic drinking water in the period up to 2020, access to the expansion of production capacity by construction of the second phase of the "Novoselija 2", additional 800 l/s [6].

Results and discussion

Based on the results of the comparative analysis of the drinking water quality from the "Waterworks" Banja Luka for the period 2013/2014, it can be concluded that the parameters are within the reference range according to the *Bylaw on the sanitary quality of drinking water* (Of. Gazette of R.S. no. 75/15). In 2013/2014 624 water samples were collected for analyses, 312 samples per year. All analytical analyses of samples were carried out in the Laboratory "Waterworks" Banja Luka. All the results are shown in the Figure 2.

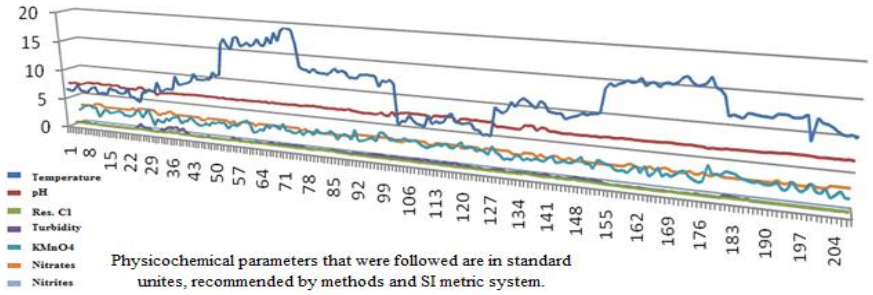

Figure 2. Results of physicochemical parameter analyses

Physicochemical parameters that were followed are in standard unites, recommended by methods and SI metric system.The statistical data for the basic physicochemical parameters in the form of correlation and covariance parameters are shown in the tables 2 and 3.The water temperature in the in 2013 ranged from 5.1 to 20.9 C, and during 2014 from 17.4 to 6.1ºC. The pH value ranged from 7.39 to 8.24. The water is free from ammonia and manganese. In the sample from January 2013 $Fe^{3+}_{(aq)}$ appears in the amount of 0.03 mg/l, while in 2014 iron is found repeatedly in the values of 0.01- 0.02 mg/l, which is within the limits prescribed by the Regulations. The value of nitrate in this period was stable and ranged from 2.7 mg/l NO_3 to 3.5 mg/l. Water is a tasteless and odourless. According to results the concentration of chlorine is in the range of 0.5 to 0.7, while the concentration of residual chlorine in the supply pipeline ϕ 1000 the range from 0.30 to 0.60 mg /l.It should be noted that in January and April 2013 turbidity increase was recorded. Turbidity in 2013 ranged from 0.10 to 1.37 NTU, while the values for 2014 ranged from 0.08-1.08 NTU.

Table 2. Calculation of correlation of basic physicochemical parameters

	T	pH	Res. Cl	Turbidity	$KMnO_4$	Nitrates	Nitrites	EC 20ºC
T	1							
pH	-0.4266626	1						
Res. Cl	-0.166355	0.0458896	1					
Turbidity	-0.2046064	0.0012955	0.2277727	1				
$KMnO_4$	0.0254763	0.0776327	-0.0762613	0.1730386	1			
Nitrates	-0.3829857	0.1980637	0.0879477	0.2385592	-0.0222994	1		
Nitrites	-0.2668514	-0.2178082	0.1743107	0.1433833	-0.1383575	0.154945	1	
EC 20ºC	0.0795733	0.2379349	0.0257393	-0.1350725	0.2002378	-0.1857596	-0.2114198	1

Table 3. Calculation of covariance of basic physicochemical parameters

	T	pH	Res. Cl	Turbidity	$KMnO_4$	Nitrates	Nitrites	EC 20ºC
T	13.65678							
pH	-0.346817	0.048382						
Res. Cl	-0.036039	0.000592	0.003437					
Turbidity	-0.169294	6.38E-05	0.00299	0.05013				
$KMnO_4$	0.051398	0.009322	-0.00244	0.021151	0.298034			
Nitrates	-0.330734	0.01018	0.001205	0.012482	-0.002845	0.054607		
Nitrites	-0.001357	-6.59E-05	1.41E-05	4.42E-05	-0.000104	4.98E-05	1.89E-06	
EC 20ºC	5.375841	0.956763	0.027585	-0.552866	1.998406	-0.793559	-0.005317	334.203

Conclusion

During the researched period the basic physicochemical parameters of the quality of the final product were within the national standards. According to the efficient system of raw water conditioning and continuous monitoring of the system, the drinking water in Banja Luka that is distributed to the population is of hygienic and adequate healthy quality level. The system for conditioning water in the "Water Supply" Banja Luka managed on the optimal way, the increase of turbidity was minimised and disinfection have been successfully optimised, and therefore the population of Banja Luka have access to satisfactory quality of drinking water. Even in the "emergency" situations when extreme care and good organization is require, the facility "Novoselija" is successful managed.

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