MONITORING THE QUALITY AND SAFETY OF DRINKING WATER IN THE TOWN OF KICHEVO TROUGH PHYSICAL – CHEMICAL AND MICROBIOLOGICAL ANALYSIS

[1] Vezirka Jankuloska, [2] Blagica Bliznakovska [1] Gorica Pavlovska

[1] Faculty of Technology and Technical Sciences, Veles,
University "St Kliment Ohridski", Bitola, Macedonia
[2] Faculty of Technology and Metallurgy, Skopje
University "St Cyril and Methodius", Skopje, Macedonia

Email: vezirka.jankuloska@uklo.edu.mk

Abstract

The spring of the river Studenchica (north-western part of R.Macedonia) is the only one source of drinking water which supplies Kichevo, Drugovo, Vraneshtica, Plasnica, Macedonski Brod, Dolneni, Krushevo and Prilep, and thermal power plant Oslomej, a total of 150,000 people.

The quality and safety of the drinking water from Kichevo, is observed by physical-chemical analysis and microbiological parameters contained in drinking water, taken from seven measuring points through established measuring network.

From the analysis of drinking water taken from seven measuring points in town Kichevo, it is determined, at any time, if there is deviation from the maximum allowable concentrations (MAC) of the individual investigated parameters.

Keywords: drinking water, physical-chemical, microbiological, water quality

Introduction

Water in nature contains various ingredients which determines its quality and convenience to a particular purpose. In order to determine the water quality or the extent of its pollution, we have to determine different ingredients or different chemical, physical and biological parameters that should be in accordance with appropriate standards for water quality [1]. At the same time the necessity of monitoring of drinking water should be in accordance with the Directive on the quality of drinking water for human consumption (98/83/EC) [2]. The standards are designed to enable the provision of clean and safe water for consumption and thus to provide protection of human health. These standards are based on scientifically acceptable level of toxicity parameters attending on human health [3]. The physical properties of water are determined relatively quickly and easily, but they present only a rough estimate of the quality of drinking water. Most commonly determined following physical properties are: temperature, smell, taste, color, density, turbidity [4]. The most important chemical parameters which are determined: dry residue, alkalinity, aciditet, hardness of water, dissolved

oxygen, oxygen consumption etc. [5-6]. Such a basic indicator of bacteriological water quality set is the total number of bacteria in 1 cm ^{3}. All natural drinking waters contain a large amount of bacteria, but the water are ready for drinking, should not contain more than 100 cm^3 microorganisms in water. After disinfection, the bacterial content should be reduced to 10 cm^3 microorganisms and even less. The presence of E.coli is an indicator that the water is contaminated with human and animal faeces and therefore this bacteria should not be detected. If in the 100 cm^3 of water can not be ascertained E.coli bacteria, the water is safe for drinking [7]. For each parameter of the following groups, there are standards for maximum allowable concentrations (MAC). To be accepted as health safe water is necessary, laboratory results of all parameters to be within the allowable limits of MAC and comply with applicable regulations for quality and health safety of drinking water.

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Materials and Methods

Samples of water taken from seven measurement points covering the whole city were analyzed. The samples were taken from objects that are supplied with drinking water, such as educational institutions, kindergartens and objects for food production. The established measuring places where are take samples drinking water are as follow: MP-1 Location "Deveana", MP-2-Kindergarden "Olga Miceska"; MP-3 Primary school "Vladimir Polezhinoski"; MP-4 The bread store "Zhitokaraorman"; MP-5 School "Mirko Mileski ", MP-6 The bread store "Center"; MP-7-City market (Fig.1).

Following this order and markings of the measuring stations for samples of drinking water, analyzed physico-chemical and microbiological

parameters will be shown appropriately in results and discussion. Taking samples of water for physical–chemical analysis and bacteriological analyzes were performed by standard methods for laboratory testing of drinking water, given in Rulebook and are in accordance with the ISO standard procedures [8].

In Table 1, are shown analyzed physical and chemical parameters in drinking water and the method used for analysis. The samples of drinking water from seven measuring points in the city Kicevo are determined following microbiological parameters, according to ISO standard procedures: Most probable number of coliform bacteria in 100 ml (ISO 9308-2:1990), coliform bacteria from fecal origin in 100 ml (ISO 9308-2:1990), total number of bacteria of 37 ^{o}C in 1 ml (ISO 6222:1999), enterococci in 100 ml (ISO 7899-2:2000), sulfite reducing klostridi in 100 ml (ISO 6461-2:2002).

Fig. 1. Map of the town Kichevo with measuring points where was taken test for analysis

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18-19 October 2013, Plovdiv

Table 1. Analyzed physical and chemical parameters in water and used methods for analysis

Parameters	Method of analysis
Smell and taste	Organoleptic
Color (degrees Pt-Co)	Organoleptic
pH-activity of the hydrogen ion	ISO 10523:1994
Conductivity	Conductometar
Turbidity (NTU)	Turbiditymeter
Dry residue	Gravimetrically
Chloride	ISO 9297
Residual chlorine	Indicator ortho-toluidines
Ammonium	Spectrophotometric
Nitrites	Spectrophotometric
Nitrate	Colorimetric
COD-Chemical oxygen consumption	Classic analytical methods
BOD biological oxygen consumption	ISO 8467

Results, Discussion

According to the established measurement network of seven measuring points tagged in Kicevo and the incurred physical-chemical analysis for residual chlorine (mg/l), color, smell, taste and turbidity in drinking water, obtained presented in table 2.

Table 2. Physical-chemical analysis of drinking water at seven measuring points

ANALYSIS	MP- 1	MP- 2	MP- 3	MP- 4	MP- 5	MP- 6	MP – 7	MAC
Chlorine residual (mg/l)	0,40	0,50	0,50	0,50	0,40	0,40	0,40	1,00
Color	No color	No color	No color	No color	No color	No color	No color	
Smell	No smell	No smell	No smell	No smell	No smell	No smell	No smell	
Taste	Typical	Typical	Typical	Typical	Typical	Typical	Typical	
Turbidity	Clear	Clear	Clear	Clear	Clear	Clear	Clear	

The analysis for the presence of residual chlorine in drinking water was confirmed to be under the maximum limits and is 0,40 mg/l for measuring points MP-1, MP-5, MT-6 and MP-7 and 0,50 mg/l for measuring points MP-2, MP-3 and MP-4 which fulfilled legal provisions.

The color and turbidity are parameters which give visual deficiency of drinking water. In all samples taken from seven measurement points does not contain turbidity and coloration. The analysis showed that drinking water from all seven measuring points has typical taste and smell.

The results from analysis of pH, dry residue, electrolytic conductivity, consumption of $KMnO_4$, ammonia, nitrates, nitrites and chlorine in drinking water are presented in table 3.

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18-19 October 2013, Plovdiv

Table 3. Physical-chemical analysis of drinking water

ANALYSIS	MP-1	MP-2	MP-3	MP-4	MP-5	MP-6	MP-7	MAC
pH	8,00	7,90	8,00	8,00	8,00	8,00	8,00	9,5
Dry residue	110,0 mg/l	110,0 mg/l	110,0 mg/l	110,0 mg/l	110,0 mg/l	110,0 mg/l	111,0 mg/l	3,500 mg/l
Electrolytic conductivity 20°C	226,0 mS/sm	227,0 mS/sm	226,0 mS/sm	227,0 mS/sm	226,0 mS/sm	226,0 mS/sm	226,0 mS/sm	8.000 mS/sm
Consumption of $KMnO_4$	3,20 mg/l	3,20 mg/l	3,80 mg/l	3,20 mg/l	3,84 mg/l	3,52 mg/l	3,20 mg/l	8,00 mg/l
Amonia	0,000 mg/l	0,000 mg/l	0,000 mg/l	0,000 mg/l	0,000 mg/l	0,000 mg/l	0,000 mg/l	0,500 mg/l
Nitrite	0,000 mg/l	0,000 mg/l	0,000 mg/l	0,000 mg/l	0,000 mg/l	0,000 mg/l	0,000 mg/l	0,030 mg/l
Nitrate	0,0 mg/l	0,0 mg/l	0,0 mg/l	0,0 mg/l	0,0 mg/l	0,0 mg/l	0,0 mg/l	50,0 mg/l
Chlorine	5,7 mg/l	5,0 mg/l	5,7 mg/l	4,2 mg/l	5,0 mg/l	5,0 mg/l	6,4 mg/l	250,0 mg/l

pH of drinking water only in measuring point MP-2 is 7.90 while in other six points it is equal to 8.00. It shows that none of pH values does not exceeds MAC. Quality drinking water from source to consumer, must be a neutral balanced pH calcium content and alkalinity in order not to act corrosive and not to produce large scale quantities. The knowledge of pH value is also important to predict the reactions between chlorine used for disinfection and nitrogen compounds present in the water that are forming detrimental hloramin [9-10].

Determination of dry residue indicates decreased or increased presence of dissolved or dispersed suspended organic and inorganic substances in drinking wate. According to the results of the analysis the dried residue is 110 mg/l in six measuring points and MP-7 is a certain value of 111 mg/l. The total amount of dry residue of drinking water is within the MAC and confirms that drinking water has a small amount of dissolved substances.

The measured values of conductivity of drinking water does not exceed the maximum allowable concentration value in two measuring points MP-2 and MP-4 is 227 mS / sm while the other is 226 mS / sm. But is permissible values of MAC which shows that the water is high purity and has small amount of dissolved ions.

The determination of the consumption of potassium permanganate in water is one of the oldest methods used that estimated load of water environments with organic matter. According to the legal restrictions in our country it is 8 mg/l and in emergency situations and to 12 mg/l. Following the analysis, produced the largest consumption of KMnO4 3,84 mg/l in drinking water by measuring point MP-5, the two measuring points marked MP-3 and MP-6 is 3,52 and 3,8 mg/l KMnO4 and minimum consumption of 3,2 mg/l KMnO4 in the four measurement points. Consequently in the drinking water in town of Kicevo consumption of potassium permanganate is within the maximum permissible concentrations. If this parameter exceeds allowable values, the overall analysis of the quality of drinking water should include a separate analysis of organic substances that contribute to increased oxygen demand such as: total organic carbon, fat and oils, petroleum hydrocarbons, tannins and lignin, total organochlorine compounds and others. But in our case, these analyzes were not needed because the consumption of $KMnO_4$ is within the acceptable range.

In the classic hygiene-chemical analysis of drinking water, the presence of ammonia and compounds derived from it, nitrates and nitrites are considered as indicators of chemical water pollution. The origin of nitrogen substances in the water as possible from the atmosphere or by the decomposition of organic matter and nitrogen fertilizers under the action of bacteria or chemical reactions. From performed chemical analyzes for determining the presence of

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18-19 October 2013, Plovdiv

nitrogen compounds in drinking water obtained negative results, i.e. not detected the presence of ammonia, nitrites and nitrates, which indicates that there is no direct organic and possibly fecal contamination as a result of waste organic matter decomposition.

Almost all the natural waters contain chlorides.

Chloride affect the taste and gives corrosive properties to water and it is necessary their determination. Drinking water usually can contain up to 30 mg/l chloride, while at higher values of 200 mg/l becomes salty and over 250 mg/l is unbearable taste and smell. Determined concentrations of chloride in seven measuring points analyzed in Kicevo retains in allowed limits, from 4,2 mg/l to 6,4 mg/l measured in MP-7 or City market place [11].

Organoleptic analysis confirmed that drinking water has no high concentrations of chloride in accordance with the assessment that is without taste and smell.

When discussing the quality of drinking water, the first and one of the important aspects is considered hygienic safety or water does not contain bacteria, viruses and other mikroorganzimi carriers of diseases like typhus, dysentery, cholera enterocolitis etc.

Drinking water taken from seven measuring points in the town Kichevo is bacteriological safe. It showed the negative results from bacteriological analysis (table4).

Table 4. Bacteriological analysis of drinking water

ANALYSIS	MP-1	MP-2	MP-3	MP-4	MP-5	MP-6	MP-7	MAC
Number of colonies of microorganisms 37 ^{o}C in 1 ml	0	0	0	0	0	0	0	20
Total coliform bacteria in 100 ml of 37°C	0	0	0	0	0	0	0	-
Coliform bacteria of fecal origin in 100 ml of 44°C	0	0	0	0	0	0	0	-
Streptococci from fecal origin	0	0	0	0	0	0	0	-
Clostridium perfringens including and spores	0	0	0	0	0	0	0	-

Drinking water does not contain microorganisms, coliforms, faecal streptococci origin and development forms. All this shows that the applied water disinfection with chlorine, makes water in Kichevo, seen from microbial aspect, correct or usable as drinking water. In accordance the applied disinfectants on tested seven measuring points in the city Kichevo considered safe from a microbiological aspect in terms of physico-chemical parameters of water works with special quality that meets Macedonian and European standards for drinking water.

Conclusion

In the seven established measurement points in the city of Kichevo analyzed drinking water meets all criteria in accordance with the Regulations for quality and safe drinking water. Drinking water has no color, smell and turbidity, has a characteristic taste and did not contain nitrogen compounds (ammonia, nitrites and nitrates). The concentration of chloride is in the maximum allowed concentrations and bacteriological analysis shows that there is no presence of coliform bacteria, bacteria of faecal origin. In all seven measurement places there are no significant variations in the value of the examined parameters and it can be concluded that drinking water in Kichevo is good quality and safe to use.

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18-19 October 2013, Plovdiv

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