**Physical, chemical and biological parameters of drinking water quality of the City of Velika Gorica water supply facility**

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**Abstract**

The paper deals with the physical, chemical and biological parameters of drinking water quality sampled at the City of Velika Gorica water supply facility in 2015 and 2016. Special attention was payed to the influence of the season on the water quality parameters and the presence of atrazine in drinking water by monitoring its concentration in relation to the MDK (maximum permitted concentrations) prescribed by the relevant Ordinance (Official Gazette 125/2013). All results of the analysis of physical and chemical parameters in 2015 and 2016 showed lower values compared to MDK, except atrazine in 2016, whose concentration in one sample was 0.1 μg / L, which is at the MDK boundary. Of the biological parameters, no Escherichia coli, total coliforms, enterococci, Pseudomonas aeruginosa were isolated in one sample of drinking water, while aerobic bacterial values at 22 and 37 ° C were below MDK values and at these concentrations were not a hazard to human health. According to the results of the analysis, no significant influence of rainfall over the seasons was noticed on the above parameters. All the analyses from 2015 and 2016 have shown that the water is health-friendly for drinking and that it complies with the provisions of the relevant Ordinance.

**Keywords:** analysis, drinking water quality, atrazine

**Introduction**

Water is a unique and irreplaceable natural resource of limited quantities and uneven spatial and temporal distribution (Biondić, 2009). Nearly 97.5% of the water on Earth is salty, and only about 2.5% is fresh water. Of the total amount of fresh water, 69.9% are "trapped" in the form of eternal ice and snow, and part is bound in organisms, is in the atmosphere, or makes moisture in the soil, which practically means that it is unavailable to human needs. The remainder of 30.1% of the total amount of fresh water on Earth makes the liquid fresh water. Of these, only about 1% are found in rivers, fresh lakes and wetlands, and 99% is groundwater (Mayer, 2004). The water surface on the planet is 71%. From the fact that life on Earth itself began in the water, Biondić (2009) states that all forms of life and all human activity are more or less related to water and from this it clearly derives the importance of man's relationship to water.

Economic development and urbanization lead, on the one hand, to a great increase in water demand and, secondly, to the endangerment of water resources and the water environment. Water can thus become a limiting factor of development and threat to human health and the sustainability of natural ecosystems (Biondić, 2009). Bermanec (2015) states that good and healthy drinking water is the water of good sensory properties (without colour, turbidity and odour) without the presence of substances in concentrations that could harm the human body (chemically correct water) and without water-borne pathogens (microbiologically correct water). The Council Directive 98/83 / EC (IP1) on the quality of water intended for human consumption aims to protect human health from the negative effects of any pollution of water intended for human consumption, by ensuring its health and cleanliness.

The aim of the paper is to use the available data to determine the drinking water quality of the Velika Gorica watercourse based on "A" and "B" water analysis on the examined quality parameters and only the atrazine, "C" analysis. The assumption is that the impact on the prominent parameters of drinking water quality has precipitation opportunities and human activity expressed through agricultural, industrial and traffic pollution from the environment due to the position of Velika Gorica water supply facility.

**Material and Methods**

The Velika Gorica water supply system consists of five wells where 60 000 m3 of water per day are collected for the needs of 50.000 inhabitants, or 75% of the population. The water supply system provides drinking water to the town of Velika Gorica and the surrounding settlements, the Orle, Kravarsko and Pokupsko municipalities, and it complements the water supply system of the City of Zagreb and Lekenik Municipality. The location of the water supply facility is uninhabited, covered by private-owned farmland with the cultivation of field crops (zone II), except in the first protection zone owned by the City of Velika Gorica. The water supply facility feature is the exceptional density of roads surrounding it and the industrial and commercial facilities, and they make the boundary of the II. sanitary protection zone (Gorenc et al., 2009). In addition to the road, near the water supply facility is Franjo Tuđman Airport (only a few hundred meters) and the City of Zagreb (about 10 km).

In the laboratory of the Zagreb County Public Health Institute, samples of water from the water supply facility of Velika Gorica were processed. For comparison of the influence of rainfall on water quality parameters at annual seasons, samples were taken monthly in 2015 and 2016. The analyses include the physical parameters of water quality, the turbidity (HRN EN ISO 7027: 2001) and water temperature (thermometry). In addition to the physical properties, the chemical parameters are analysed: nitrates (HRN EN ISO 10304-1: 2009), chlorides (HRN EN ISO 10304-1: 2008), electrical conductivity (HRN EN 27888: 2008) and pH value (HRN EN ISO 10523:2012) and atrazine (analysed by the Croatian Institute of Public Health (HZJZ), while for the biological parameters aerobic bacteria were analysed (At 37 ° C / 48 h / HRN EN ISO 6222-2000), aerobic bacteria (22 ° C / 72 ° C) (HRN EN ISO 6222-2000) and mandatory presence of the pathogen: Escherichia coli (HRN EN ISO 9308-1:2014), total coliform (HRN EN ISO 9308-1: 2014), enterococci (HRN EN ISO 7899-2: 2000), Pseudomonas aeruginosa (HRN EN ISO 16266-2008). The data obtained were processed by statistical method using the Statistics 8.0 (Statsoft.Inc 1984 - 2008). The results were tested by Student's t-test where a P value < 0.05 was selected to indicate significance. The data for the maximum permissible concentration (MDK) of the processed parameters are taken from the Annex I. of the Ordinance on compliance parameters and methods of analysis of water for human consumption (OG / 125/2013, 141/2013, 128/2015). The obtained results are in conformity with the requirements of Article 5 of the Law on Water for Human Consumption (OG 56/2013, 64/2015). For the purposes of the research, data on precipitation from the Croatian Meteorological and Hydrological Service (DHMZ) for the years 2015 and 2016 were used for the measuring station Zagreb - Pleso Airport.

**Results and Discussion**

For the parameters of turbidity and water temperature between 2015 and 2016 there is no statistically significant difference (P ≥0.05), but in relation to the MDK values of the applicable Ordinance (IP2), as shown in Table 1, there is a statistically significant difference at the level P <0.05. Water turbidity, as stated by Mayer (2004), is common in surface waters after heavy rains or sudden snow melting, while in groundwater very rarely occurs due to the filtration process during groundwater passage through an aqueous medium with interstitial porosity and gravel layer around the filter part of the well, and then, when seen, it usually warns of a badly designed, badly constructed or damaged well. Results from Table 1 are common for water temperature. Groundwater has a relatively uniform temperature throughout the year, and external influences are greatly mitigated. This illustrates very well the relation between the water temperature of the Sava River and the groundwater temperature at the Stara Loza reservoir, which is about 1 km from the Sava River and is in a good hydraulic connection with it. Long-term measurements show that river water temperatures typically range from + 4 °C in mid-winter to + 28 °C during the summer. At the Stara Loza reservoir, the temperature of the groundwater is between + 8 °C and + 12 °C during the year. Thus, at a distance of only 1 km from the river, annual change in river water temperature amplitude of about 24 °C is mitigated to only 4 °C for groundwater (Mayer, 2004). The colour and smell of water in 2015 and 2016 comply with the applicable Ordinance (IP2) and its amendment (IP3). According to Mayer (2004), the colour and smell of water are only physical manifestations of other types of contamination (eg. contamination with P. aeruginosa, sweet smell and bluish pigment).

Table 1: Results of the analysis of physical (a1, b1, c1) and chemical (A1, B1, C1) parameters of drinking water quality of all the wells of Velika Gorica water supply system

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter** | **Statistical characteristic** | **2015**  **a1** | **2016**  **b1** | **MDK**  **c1** | **a1,b1,c1**  **A1,B1,C1**  **\*P <0.05** |
| **Turbidity**  n=36 |  | 0.37 | 0.45 | 4 NTU | **a1c1\*;**  **b1c1\*** |
| s | 0.16 | 0.32 | 4 NTU |
| s | 0.027 | 0.053 | 4 NTU |
| **Water Temperature**  n=36 |  | 12.17 | 10.71 | 25°C | **a1c1\*;**  **b1c1\*** |
| s | 2.1 | 4.4 | 25°C |
| s | 0.35 | 0.73 | 25°C |
| **Nitrates**  n=35 |  | 22.83 | 21.6 | 50 mg/L | **A1C1\*;**  **B1C1\*** |
| s | 2.31 | 8.24 | 50 mg/L |
| s | 0.39 | 1.39 | 50 mg/L |
| **Chlorides**  n=36 |  | 22.31 | 19.14 | 250 mg/L | **A1C1\*;**  **B1C1\*** |
| s | 5.91 | 8.55 | 250 mg/L |
| s | 0.99 | 1.43 | 250 mg/L |
| **Electrical Conductivity**  n=36 |  | 632.67 | 485.92 | 2500 µS/cm/20°C | **A1B1\*;**  **A1C1\*;**  **B1C1\*** |
| s | 131.89 | 308.25 | 2500 µS/cm/20°C |
| s | 21.98 | 51.38 | 2500 µS/cm/20°C |
| **pH**  n=36 |  | 7.08 | 6.27 | 6.5 – 9.5 | **A1C1\*;**  **B1C1\*** |
| s | 1.22 | 2.55 | 6.5 – 9.5 |
| s | 0.20 | 0.43 | 6.5 – 9.5 |

NTU - Nephelometric Turbidity Unit

\* - statistically significant difference

The results of the analysis of the chemical parameters of drinking water quality (Table 1) show that between 2015 and 2016 there are no statistically significant differences, except for electrical conductivity values, which are significantly lower in 2016 than in 2015 (P <0.05). The values of chemical parameters in both years were statistically significantly lower than MDK (P <0.05). For the water supply facility Prelog, Glumac et al. (2009) indicate that the average nitrate values for the period 2006-2008 amounted to 32 mg/L, which was the result of intensive agricultural production in the zone of water supply, and that it would therefore have to go to land purchase to extend the water protection zone. Similar situation exists in the Velika Gorica water supply system. Table 1 shows that chloride concentrations are extremely low in relation to MDK. Štambuk-Giljanović et al. (2008) state that chloride concentrations above 250 mg/L in drinking water can cause corrosion in the water supply system and an unpleasant taste of water. Measured electrical conductivity indicate the degree of mineralization of water and confirm that it is drinking water (<1000 μS/cm) (IP4). According to Šimunić (2013), the best pH value is between 6 and 7.5, which is the case in the Velika Gorica water supply system. The results of the analysis showed that atrazine concentrations were lower than MDK (IP2), except for November, 2016, when the MDK at the well No3 reached the limit, and at the well No2 had concentration of 0.09 μg/L. We can assume that because of the higher precipitation levels in October and November 2016, there has been a greater amount of rainwater in the groundwater, causing the rise of deep waters, since in December 2016, when the rainfall is extremely low, the concentrations are significantly lower than MDKs. Gorenc et al. (2009) state that atrazine in the Velika Gorica water supply system has been analysed since 2001. Atrazine concentrations peaked in 2004 when the values ranged from 0.09 to 0.13 μg/L and the mean value was 0.11 μg/L for the well No2. Since 2005, the atrazine concentration drops steadily . This trend is also visible in 2016, with atrazine concentrations significantly lower than in 2004. Also, Gorenc et al. (2009) state that the Velika Gorica water supply system has three sanitary protection zones. The second zone consists of several agricultural land that is being cultivated, there is no insight into their treatment and there is a constant risk of potential groundwater contamination. Therefore, it should go to the purchase of agricultural land from another sanitary zone and thus permanently solve this problem. The concentration of atrazine in 2016 did not exceed the value of MDK. Rainfall, although in some months abundant, for example between May and October 2015 and February 2016 (Table 2), did not have an impact on the results of the analysis with respect to MDK.

Table 2: DHMZ data for monthly precipitation (mm) in 2015 and 2016, measuring station Zagreb - Pleso (IP5)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year/Month | I. | II. | III. | IV. | **V.** | VI. | VII. | VIII. | IX. | **X.** | XI. | XII. |
| **2015.** | 73.3 | 95.4 | 30.5 | 30.7 | **151.1** | 59.7 | 91,.5 | 61.2 | 95.7 | **195.3** | 47.6 | 3.1 |
| **2016.** | 73.7 | **157.4** | 51.7 | 53.9 | 100.8 | 132.5 | 57.6 | 74.0 | 56.6 | 112.7 | 100.9 | 2.1 |

The results of biological parameters analysis of aerobic bacteria at 37 °C/ 48h and 22 °C/ 72h in 2015 and 2016 are shown in Table 3. In either sample of drinking water were not isolated Escherichia coli, total coliforms, enterococci, Pseudomonas aeruginosa, while the values for aerobic bacteria at 22 and 37 °C were below the MDK values and at these concentrations were not a hazard to human health. An abnormal increase in the number of bacteria can be a timely indication of contamination of any origin (Šušnjara et al., 2011).

Table 3: Analysis results for aerobic bacteria (bct.) in 2015 and 2016

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Year | Parameter | Quantification limit | No of samples below quantification limit | No of samples above quantification limit | Range  /min.-max./ samples>quantification | MDK |
| **2015.** | Aerobic bct/ 37°C/48h | <1 | 27 | 8 | 1 – 16 cfu/ml | 20 cfu/  ml |
| Aerobic bct/ 22°C/72h | <1 | 23 | 12 | 1 – 3 cfu/ml | 100 cfu/ml |
| **2016.** | Aerobic bct/ 37°C/48h | <1 | 22 | 9 | 1 – 16 cfu/ml | 20cfu/ ml |
| Aerobic bct/ 22°C/72h | <1 | 13 | 18 | 1 – 51 cfu/ml | 100 cfu/ml |

**Conclusion**

All results of the analysis of the physical and chemical parameters of drinking water in 2015 and 2016 were lower than the MDK values, except atrazine, which in one case was 0.1 μg/L, which is at the MDK boundary. Of the biological parameters, no Escherichia coli, total coliforms, enterococci, Pseudomonas aeruginosa were isolated in the samples of drinking water, while aerobic bacterial values at 22 and 37 °C were below MDK values and at these concentrations were not a hazard to human health. Rainfall in 2015 and 2016 during the seasons did not have a significant impact on the health of drinking water on the basis of determined physical, chemical and biological parameters, but it was noted that during the months of increased rainfall they further reduced their concentrations due to the resulting dilution. Purchase of land from the second sanitary protection zone is required in order to permanently eliminate the potential hazard of water contamination in the water supply system from any source.

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