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5. ECOLOGY AND ENVIRONMENTAL PROTECTION

THE QUALITY OF DRINKING SPRING WATER AS A FACTOR INFLUENCING THE HUMAN HEALTH

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Abstract. *Determination of the quality of drinking spring water of the Kharkiv city to establish the level of safety for human consumption. **Research.** In the laboratory, the main characteristics of water quality from four urban drinking water sources were determined, and the dynamics were determined in connection with the changes of the seasons. The **results** were obtained. It is established that with change of season the chemical composition of spring water changes. In particular, in all spring water samples, pH, alkalinity, turbidity, total mineralization, and nitrate and nitrite content increased. Hardness exceeding the limit values in summer water samples decreased in autumn samples: 4.1 times in the water from the Hlibokiy Yar spring, 3.1 times in the spring water in Sarzhyn Yar, and in the spring water in the “Yunost” park with 4.2 times. In the Zhukovsky spring the water hardness has remained the same - 10 mmol / dm³.*

Keywords: *water supply, groundwater, spring water quality, natural springs, natural resources, water use.*

I. INTRODUCTION

The urgent issue today is to provide the population with quality drinking water. The Kharkiv region and directly the city of Kharkiv belong to the water scarce region. Centralized water supply provides all the needs of the population for drinking water. The quality of the resource that consumers receive by water supply is a problem for many cities and Kharkiv in particular. The population prefers spring of drinking natural water, considering them as the best alternative.

An important source of spring water is groundwater sources. Rain and melting water infiltrate the soil, which act as a kind of geochemical barrier for pollutants, and further enter the underground horizons where ground water is formed. Thus, it can be argued that their chemical composition is formed both under the influence of natural and anthropogenic factors. The discharge of water from aquifers occurs at the point of their exit to the surface, through various springs. These waters have always been in demand by the population and are considered to be much cleaner than in surface water. Therefore, the determination of the environmental safety of drinking spring water is relevant today and needs to be studied.

II. ANALYTICAL REVIEW OF LITERATURE

The study of groundwater was started by M. V. Lomonosov. In his writings, he formulated a number of scientific provisions on groundwater, outlined theories of their origin and described the process of circulation. The first information about the groundwater of Ukraine is in the works of I. F. Livakovsky, O. V. Gurov, N. D. Boryasyak, M. O. Sokolovsky. Already at the beginning of the twentieth century, the most studied hydrogeologically were the northern and northeastern regions of Ukraine [5].

The development of the volume of knowledge about hydrogeological conditions of Ukraine and groundwater in particular is connected with the theoretical works of V. I. Vernadsky, F. P. Savarensky, A. F. Lebedev. Questions of dynamics and significance of groundwater in the hydrosphere are highlighted in their works by M. M. Pavlovsky, G. M. Kamensky, N. I. Golstikhin and O.I. Lange. [5].

Modern ideas about the underground hydrosphere, the search for fresh groundwater, their protection against pollution, were developed and set out in the scientific works of N. M. Frolov, A. B. Sitnikov and others [5].

The first estimations of the amount of groundwater belong to the second half of the nineteenth and early twentieth centuries. Currently, according to A. Sokolov, there are 23.4 million km³ in the crust to the depths available for human exploration. This volume includes water in a free, solid, vapor state [6].

If speaking about terminology, we say “ground waters” as natural waters, which lay on the first from the surface of the earth a water-resistant layer, which is characterized by uniformity in lithological composition and filtration properties. Soil aquifers are unloaded into various surface watercourses and reservoirs. At the same time they also come to the bottom surface in the form of sources [6].

The issue of water quality supplied to the population by a centralized water supply network is an ongoing and urgent one. The main problems of such a system are cost demanding, interruption, but most importantly, water quality. Among the reasons for the deterioration of water quality we can mention the following: outdated water supply system, their sanitary status, vulnerability of the system to external factors (if contamination occurs at a certain interval of the network, all water supply systems further down the network, including the consumer - are at risk) [4].

In researching the issue of providing the Kharkiv residents with quality drinking water, scientific publications were analyzed, which highlight the current problems of water supply in cities. In particular, in the study N. B. Kravchenko et al. (2015) [7], it was determined that the population is actively using sources of natural drinking water for economic needs. The results of sociological surveys were presented in the paper: “The calculation of the rating of closed drinking water sources in Kharkiv by socio-economic indicators (without taking into account ecological indicators) showed that the best from the point of view of the consumer is the “Sarzhin Yar” spring, the worst - the spring in the “Yunost park” [7, p. 84-88]. Thus, this problem is more than urgent for Kharkiv residents and therefore requires continuous monitoring studies to determine compliance with drinking water requirements and to clarify their environmental safety [7].

Biochemical composition, specific indicators, alkalinity, rigidity and other indicators can directly affect the environmental quality of spring waters and, as a consequence, human health [8]. For example, the use of water with increased rigidity can lead to diseases of the gastrointestinal tract, cardiovascular diseases, skin diseases and can affect the strength of hair and nails. According to sociological surveys, the population regularly uses spring water without preparation (boiling or boiling) [9].

Hence – there is a necessity to monitor the quality of spring water, in accordance with the hygienic requirements for drinking water intended for human consumption [3].

III. OBJECT, SUBJECT MATTER AND METHODS OF RESEARCH

Annotation: Determination of the quality of drinking spring water of the city of Kharkiv to establish the level of safety for human consumption

Object of research: natural drinking spring waters of Kharkiv.

Subject of research: ecological quality and safety of spring waters of Kharkiv.

Research methods: field, laboratory, methods of atomic absorption spectrometry, statistical methods of data processing.

Tasks of work:

- perform field research, select samples of drinking spring water;
- carry out laboratory tests with the help of equipment and determine the main indicators of the chemical composition of Kharkov spring drinking water;
- to determine the variability of chemical indicators of spring water depending on the change of seasons;
- determine the environmental quality of spring water.

IV. WORK RESULTS

IV.1. Analysis of the results of the study of the quality of spring water selected in different seasons

To study the quality of drinking spring water, samples were taken at different seasons (summer and fall 2019) from groundwater springs located in Moscovsky (Hlibokiy Yar spring), Shevchenkivsky (spring Sarzhin Yar) and Kholodnogorsky (spring in “Yunost” park) districts, as well as on the territory of Zhukovsky village (Zhukovsky spring) within Kharkiv. Water from these springs is used by the townspeople for drinking and domestic purposes. Determination of spring water quality indices was performed on the basis of the Research Laboratory of Analytical Ecological Researches of the V. N. Karazin Kharkiv National University. Zhukovsky spring and spring in “Yunost” park are shown on the figures 1 and 2.



Figure 1. - Zhukovsky spring



Figure 2. - Spring in “Yunost” park

Analyzes of drinking water samples from city springs were performed according to the following indicators: pH value, electrical potential, nitrate content, chloride, ammonia, nitrite content, transparency, turbidity, water hardness [1].

The concentration of heavy metals (Fe, Zn, Cu, Mn, Cd, Cr) in water samples was determined using the MHA-915 MD atomic absorption spectrometer.

At the first stage of research in summer 2019, samples of drinking spring water were sampled in the field and the results of laboratory tests of their chemical composition were analyzed. The results are shown in table 1.

Table 1

Results of the study of drinking water from springs (summer 2019)

Indicator	Units of measurement	Spring name				MPC*
		Zhukovsky	Hlibokiy Yar	Sarzhin Yar	“Yunost” Park	
pH	-	6,85	6,264	6,672	6,456	6,5 - 8,5
Nitrates	mg/dm ³	34	40	34	41	50
Alkalinity	mmol/dm ³	8,1	4,8	6,5	8,5	0,6 – 0,5
Transparency	point	24	24	25	24	30
Ammonia	mg/dm ³	0,044	0,04	0,04	0,04	2,0
Nitrites	mg/dm ³	0,001	0,001	0,001	0,04	3,3
Turbidity	mg/dm ³	0,99	0,99	0,99	0,99	1,5
Hardness	mmol/dm ³	10	16,4	19,8	32,6	1,5 – 10
Electric potential	-	6,10	6,96	5,78	6,45	-
Fe	mg/dm ³	0,0201	0,000100	0,021000	0,002000	0,3
Zn	mg/dm ³	0,04	0,042800	0,008300	0,021000	0,1
Cu	mg/dm ³	0,0001	0,000600	0,000700	0,001500	1
Mn	mg/dm ³	0,0002	0,000300	0,000600	0	0,1
Cd	mg/dm ³	0	0	0	0	0,01
Cr	mg/dm ³	0	0	0	0	0,05

* - MPC (Maximum Permissible Concentration) according to Hygienic requirements for drinking water intended for human consumption [2].

■ - indicators that exceed the standards.

The results of spring water studies show that the pH ranges from 6.26 in the water samples from the Hlibokiy Yar spring to 6.85 in the Zhukovsky spring. All samples of spring water are characterized in terms of pH as neutral.

The measured electric potential indicates the level of mineralization of water. This parameter has no regulatory value. The highest level of mineralization was found in water from the Hlibokiy Yar source - 6.96, and the lowest in the water from the spring of Sarzhin Yar - 5.78. In this case, it can be argued that the highest content of dissolved salts is observed in the deep water of the Hlibokiy Yar.

The reference level of nitrates should not exceed 50 mg/dm³. It ranges from 3.4 mg/dm³ in the water of the Zhukovsky spring and in the water of the Sarzhin Yar spring to 4.1 mg/dm³ in the water of the Kholodnogorsky spring. No excess samples were found in any of the samples.

In terms of transparency, spring water is rated on a 30 point scale [2], and the set values are 24 - 25 points, which is a sign of clear, transparent water with no impurities and low turbidity.

Ammonia and nitrite content were determined in the water samples. Ammonia was normal (up to 2.0 mg/dm³) [2] and was the same in all samples - 0.04 mg/dm³.

Nitrite concentration is 0.001 mg/dm³ in all selected water samples at the rate of 3.3 mg/dm³.

The results of the analyzes showed that the selected waters are characterized by increased hardness: in the water from the Hlibokiy Yar spring - 1.5 times, in the water of the Sarzhyn Yar spring - 2 times, and in spring water in Yunost Park - 3 times and is 32.6 mmol/dm³. The indicator does not exceed the norm [2] only in the sample of water from Zhukovsky spring and is 10 mmol/dm³.

Determination of heavy metal concentrations by atomic absorption spectrometry showed that no excess was detected according to MPC [2]. The content of Cd and Cr in the samples has not been determined. Deficiency of Cd consumption can adversely affect hydrocarbon metabolism, activation of a number of enzymes, synthesis in the liver of hippuric acid, as well as metabolism of Zn, Cu, Fe, Ca. Cr is an important trace element for the human body and regulates hydrocarbon metabolism and controls blood glucose.

Studies have shown that the highest levels of nitrates, nitrites, alkalinity and stiffness were detected in a sample of water from a spring in Yunost Park.

There is no reliable explanation for the reasons for these indicators, but attention should be paid to the sanitary condition of this spring. When sampling, the local population was interviewed for their personal experience after visiting this spring. It was found that only one of the three faucets brought out for use by the spring is suitable for water abstraction and is used by the public. And the water selected only from it on organoleptic indicators can be used as drinking. Other faucets come from poor quality water and are considered environmentally hazardous by users.

The second stage of the research was to analyze the samples selected from the investigated springs in October 2019. The obtained results are presented in Table 2.

Table 2.

Results of the study of water from sources (October 2019).

Indicator	Units of measurement	Spring name				MPC*
		Zhukovsky	Hlibokiy Yar	Sarzhin Yar	“Yunost” Park	
pH	-	7,2	6,9	6,8	6,8	6,5 - 8,5
Nitrates	mg/dm ³	22	32	26	35	50
Alkalinity	mmol/dm ³	8,15	6,0	7,6	10,5	0,6 – 0,5
Transparency	point	24	24	24	24	30
Ammonia	mg/dm ³	0,04	0,2	0,04	0,04	2,0
Nitrites	mg/dm ³	0,001	0,2	0,001	0,001	3,3
Turbidity	mg/dm ³	1	1	1	1	1,5
Hardness	mmol/dm ³	10	4,0	6,2	7,65	1,5 – 10
Electric potential	-	5,74	7,08	6,17	6,85	-
Fe	mg/dm ³	0,00180	0	0,00240	0,00110	0,3
Zn	mg/dm ³	0,06210	0,09780	0,09360	0,08890	0,1
Cu	mg/dm ³	0,00010	0,00020	0,00020	0,00030	1
Mn	mg/dm ³	0,00030	0,00070	0,00010	0,00050	0,1
Cd	mg/dm ³	0	0,00010	0,00040	0	0,01
Cr	mg/dm ³	0,00010	0	0,00020	0,00050	0,05

* - MPC (Maximum Permissible Concentration) according to Hygienic requirements for drinking water intended for human consumption [2].

According to the results of a study of water from springs, the pH ranges from 6.8 in Sarzhyn Yar and in Yunost Park to 7.2 in Zhukovsky spring. The indicator is not characterized by a large amplitude of changes among different spring.

Total mineralization ranges from 5.74 mg/dm³ in the Zhukovsky spring to 7.08 mg/dm³ in the Hlibokiy Yar.

The nitrate content does not exceed the limit values and ranges from 22 mg/dm³ in Zhukovsky spring to 35 mg/dm³ in the spring of "Yunost" park.

Transparency is the same in all samples and reaches a high value - 24 out of 30 possible points. And turbidity, respectively - 1 mg/dm³, the water samples are almost completely transparent.

Ammonia content in all water samples from the springs becomes 0.04 mg/dm³, except for the Hlibokiy Yar - 0.2 mg/dm³. All measured values meet standards [2].

The determination of nitrites also showed compliance with the standards and, like ammonia, differed only in the Hlibokiy Yar - 0.2 mg/dm³ and in all other springs - 0.001 mg/dm³.

According to the results of the analysis of autumn water samples, none of the samples is characterized by increased hardness and range from 10 mmol/dm³ in water samples from Zhukovsky spring to 4 mmol/dm³ - in water from the Hlibokiy Yar spring. Heavy metals in water springs do not exceed the standards.

IV.2. Spring water quality dynamics

Within the final - the third stage of the research, the changes that occurred in the chemical composition of the waters and the studied springs were analyzed. The results are shown in Tables 3 and 4.

Table 3

The results of the dynamics of the chemical composition waters of the Zhukovsky spring and the Hlibokiy Yar spring

Indicator	Units of measurement	Spring name				MPC*
		Zhukovsky		Hlibokiy Yar		
		Summer	Fall	Summer	Fall	
pH	-	6,85	7,2	6,264	6,9	6,5 - 8,5
Nitrates	mg/dm ³	34	22	40	32	50
Alkalinity	mmol/dm ³	8,1	8,15	4,8	6,0	0,6 - 0,5
Transparency	point	24	24	24	24	30
Ammonia	mg/dm ³	0,044	0,04	0,04	0,2	2,0
Nitrites	mg/dm ³	0,001	0,001	0,001	0,2	3,3
Turbidity	mg/dm ³	0,99	1	0,99	1	1,5
Hardness	mmol/dm ³	10	10	16,4	4,0	1,5 - 10
Electric potential	-	6,10	5,74	6,96	7,08	-
Fe	mg/dm ³	0,0201	0,00180	0,000100	0	0,3
Zn	mg/dm ³	0,04	0,06210	0,042800	0,09780	0,1
Cu	mg/dm ³	0,0001	0,00010	0,000600	0,00020	1
Mn	mg/dm ³	0,0002	0,00030	0,000300	0,00070	0,1
Cd	mg/dm ³	0	0	0	0,00010	0,01
Cr	mg/dm ³	0	0,00010	0	0	0,05

* - MPC (Maximum Permissible Concentration) according to Hygienic requirements for drinking water intended for human consumption [2].

■ - indicators that exceed the standards.

With the change of seasons, and accordingly the temperature regime, the chemical indicators of water from the springs have changed.

In water from Zhukovsky spring and Hlibokiy Yar increased the pH, alkalinity, turbidity. Nitrate content decreased from 34 mg/dm³ to 22 mg/dm³ in water samples from Zhukovsky spring and from 40 mg/dm³ to 32 mg/dm³ in water from the Hlibokiy Yar spring.

The water hardness of 10 mmol/dm³ remained unchanged only in the water from the Zhukovsky spring, and the total mineralization and ammonia content decreased from 6.1 mg/dm³ to 5.74 mg/dm³ and from 0.44 mg/dm³ to 0.40 mg/dm³, respectively.

Ammonia levels in water from the Hlibokiy Yar spring increased from 0.04 mg/dm³ to 0.2 mg/dm³, as well as the level of total mineralization from 6.96 mg/dm³ to 7.08 mg/dm³.

The water hardness index from the Hlibokiy Yar spring decreased from 16.4 mmol/dm³ to 4 mmol/dm³. In the summer of June, the rate of rigidity exceeded the norm by 1.5 times, and in the fall - the figure was within the norm [2].

Table 4

Dynamics of chemical composition of waters
from a source in Sarzhin Yar and from a spring in Yunost Park

Indicator	Units of measurement	Spring name				MPC*
		Sarzhin Yar		"Yunost" Park		
		Summer	Fall	Summer	Fall	
pH	-	6,672	6,8	6,456	6,8	6,5 - 8,5
Nitrates	mg/dm ³	34	26	41	35	50
Alkalinity	mmol/dm ³	6,5	7,6	8,5	10,5	0,6 – 0,5
Transparency	point	25	24	24	24	30
Ammonia	mg/dm ³	0,04	0,04	0,04	0,04	2,0
Nitrites	mg/dm ³	0,001	0,001	0,04	0,001	3,3
Turbidity	mg/dm ³	0,99	1	0,99	1	1,5
Hardness	mmol/dm ³	19,8	6,2	32,6	7,65	1,5 – 10
Electric potential	-	5,78	6,17	6,45	6,85	-
Fe	mg/dm ³	0,021000	0,00240	0,002000	0,00110	0,3
Zn	mg/dm ³	0,008300	0,09360	0,021000	0,08890	0,1
Cu	mg/dm ³	0,000700	0,00020	0,001500	0,00030	1
Mn	mg/dm ³	0,000600	0,00010	0	0,00050	0,1
Cd	mg/dm ³	0	0,00040	0	0	0,01
Cr	mg/dm ³	0	0,00020	0	0,00050	0,05

* - MPC (Maximum Permissible Concentration) according to Hygienic requirements for drinking water intended for human consumption [2].

■ - indicators that exceed the standards.

After analyzing the dynamics of changes in chemical indicators of the spring waters of Sarzhin Yar and water from the spring of "Yunost" park, it can be stated that the pH increased to 6.8 in the waters of both springs, the alkalinity index increased by 1 unit in the water of the Sarzhin Yar spring and by two units in the water of the "Yunost" park spring, and reached 7.6 mmol/dm³ and 10.5 mmol/dm³ respectively, turbidity, and total mineralization. At the same time, indicators of nitrate content, stiffness and nitrite content in the "Yunost" park spring decreased. Ammonia, transparency, and nitrite content in Sarzhin Yar remained unchanged.

It can be concluded that the most affected value is water hardness. The dynamics of the indicator is shown in Figure 3.

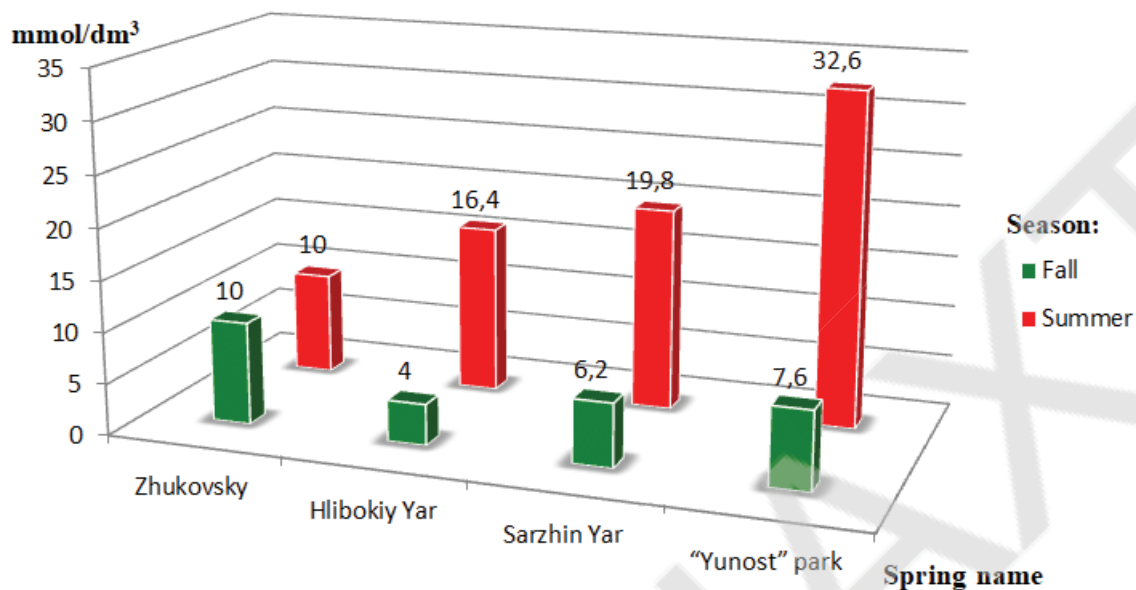


Figure 3. - Dynamics of spring water hardness index (Summer - Fall 2019)

Experimentally, it is certainly proved that the hardness of spring water increases in summer and decreases in fall. Considering the dependence of groundwater on rainwater and meltwater that run-off through the earth's surface. Studying the dynamics of the change in the water hardness index, we see that the underground aquifer, which is discharged through the Zhukovsky spring, is the least connected to the water that is leaking, because the hardness has not changed with the change of the seasons. The water hardness index in other sources has dropped to a safe level for consumption.

V. CONCLUSIONS

As a result of the conducted research it was established the following:

1. Spring water is one of the most valuable resources for the population produced by groundwater. Determining their quality is an important aspect of environmental monitoring. In order to establish the environmental safety of the Kharkiv spring water, four water samples from four popular drinking water springs in the summer and autumn were selected.

2. Analyzes of selected samples of spring drinking water in the city of Kharkov were carried out according to the main indicators of chemical composition: pH level, total mineralization, nitrate content, nitrite content, ammonia, alkalinity, rigidity. The concentration of heavy metals (Fe, Zn, Cu, Mn, Cd, Cr) was determined on the atomic absorption spectrometer of MGA-915 MD. Indicators of the chemical composition of spring waters meet the standards, except for exceeding the stiffness index in summer water samples: from the Hlibokiy Yar - 1.5 times, in the water of the spring in Sarzhyn Yar - 2 times, and in spring water in "Yunost" park - in 3 times and is 32.6 mmol/dm³. The indicator does not exceed the norm only in the sample of water from Zhukovsky spring and is 10 mmol/dm³.

3. It is established that the composition of spring waters changes throughout the year. The pH, alkalinity, turbidity, and general mineralization are increasing. The content of nitrates and nitrites is reduced. Given the excess of water hardness in the samples taken in the summer, it should be noted that in the autumn the indicator normalized and decreased in the water from the Hlibokiy Yar spring - 4.1 times, in the spring water in Sarzhyn Yar 3.1 times, and in the spring water in the "Yunost" park with 4.2 times. Only the water hardness of the Zhukovsky spring remained stable and is 10 mmol/dm³, both in summer and autumn samples.

4. The analysis of the quality and environmental safety of the samples showed that the quality of spring water changes with the seasons. In the summer, the quality of the spring water under study is lower due to the high water hardness index. It can be assumed that the hardness increases with the increase in ambient air temperature in summer. Rainfall decreases, moisture evaporates, and the quality of fluid infiltrating the soil and entering aquifers deteriorates. Therefore, water from these springs should be further treated for domestic use. You can use sedimentation or filtering as recommendations.

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