

THE IMPACT OF THE MINERAL WATER COMPOSITION ON THE POPULATION HEALTH

Olena Stadnichuk

PhD, Hetman Petro Sahaidachnyi National Army Academy,
e-mail: stadnichyk-o@ukr.net, <http://orcid.org/0000-0002-9710-9015>, Ukraine

Liliia Kropyvnytska

Assistant Professor, PhD,
Drohobych State Pedagogical University named after Ivan Franko,
e-mail: kropililiya@ukr.net, <http://orcid.org/0000-0002-4419-3727>, Ukraine

Liudmyla Kucher

Assistant Professor, PhD,
Hetman Petro Sahaidachnyi National Army Academy,
e-mail: lrkucher1@gmail.com, <http://orcid.org/0000-0002-9592-7135>, Ukraine

Ivan Martyniuk

PhD, Hetman Petro Sahaidachnyi National Army Academy,
e-mail: ivanmartyn@i.ua, <http://orcid.org/0000-0001-5996-7687>, Ukraine

Mykola Platonov

PhD, Hetman Petro Sahaidachnyi National Army Academy,
e-mail: nickolas.82@ukr.net, <http://orcid.org/0000-0003-4547-9273>, Ukraine

Abstract. Studied the issues of the water quality suitable for consumption in some mountainous regions of Lviv region, in particular in Skolivsky, Turkovsky, and Starosambirsky districts. The obtained results based on the main hydrochemical indicators show the water quality meets the requirements for the degree of pollution of the hygienic classification of water objects. The conditions for the habitat of hydrobionts and terrestrial biota are normal. Most water samples have a weakly alkaline reaction, indicating a possible high content of hydrocarbonates. Concerning the hardness, all studied samples are soft and medium hard water types. The value of total alkalinity of water samples ranges from 1.8 to 6.1 mmol/m³, which corresponds to the physiological integrity of the composition of drinking water. Sulphate ions and chloride ions are present in almost all natural waters, their content is mainly due to chemical weathering with sedimentary rocks during oxidation of sulfides, dissolution of sulfur-containing and chlorine-containing minerals.

It has been investigated the sequence between hardness of water and non-infectious diseases in the studied regions. Constant consumption of such water may cause a danger to the population suffering from cardiovascular disease, blood congestion, myocardial infarction.

Keywords: water hardness, mountainous areas, mineral composition, hydrochemical parameters.

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Introduction

Indicator of socioeconomic development of the country determines the social well-being of a person, his ability to fully realize his potential in individual and social activities. At the same time, one of the determining factors is the state of health of a person, which largely

depends on the level of observance and ensuring environmental norms in the country. It is also known that water, being one of the key components of ensuring the normal functioning of the human body, is also extremely sensitive to environmental ecology. This is clearly demonstrated by the "theory of infinitely dilute solutions", when, the presence of scanty amounts of water-soluble substances in water, the physical parameters of the solution obtained are significantly changed. Therefore, scientific research into the dependence of the state of health and viability of the population on the quality of water, which directly affects the health of the population, becomes relevant.

Providing the population with water suitable for consumption is one of the prior problems, the solution of which is necessary for maintaining health, improving the living conditions of the population. The use of water that does not meet the hygienic requirements for the content of minerals is a threat of development of various diseases, the level of which is constantly increasing (*Prokopov, et al., 2016*).

Areas of inappropriate mineral composition of drinking water from underground water intakes are in Dnipropetrovsk, Kirovograd, Kherson, Odesa, Lviv regions. In Lviv region, up to 95% of the needs of commercial drinking water supply are carried out at the expense of groundwater, the quality of which depends on the characteristics of soil and rock minerals, the nature of the source and the degree of anthropogenic load (*Ukrainian Government Portal, 2019*). The population of the mountain areas of the Lviv region mainly exploits wells and springs, the quality of which also depends on the purity of groundwater.

Contacting with various breeds, minerals, natural waters dissolve them and increase mineralization. A person receives 1-25% of the daily requirement of chemicals with water. Reducing or exceeding the content of an element in water tends to result in physiological changes, and in some cases, the root cause of the formation of pathological conditions (*Prodanchuk, et al., 2006; Pocock, 1980; Neutra, 1999*).

One of these vital human chemical elements is calcium and magnesium, which ensure the normal functioning of all systems and organs. It is obvious that the study of their content in water, suitable for consumption, as indicators of its physiological value, as well as determining their possible effects on the occurrence of certain diseases is relevant.

The aim of the study was to analyze the possible influence of the chemical composition of water on human health. The object of the study was the natural waters consumed by the inhabitants of the mountainous regions of the Lviv region taken from the sources and wells. To achieve the goal, the following tasks were set: determination of the content of general hydro-chemical parameters in the water samples under study; assessment of the physiological completeness of the water samples studied and the possible impact of water consumption on human health; comparing the results with non-infectious diseases that are typical for the population of some mountain regions of Lviv region.

The research was conducted in 20 settlements in three mountainous regions of Lviv oblast (Table 1) during 2016-2018. Water samples, which the population uses for domestic needs, were taken from wells and sources in the impenetrable period.

The selection of water samples and the study of organoleptic and physico-chemical parameters of inorganic components were carried out in accordance with standard methods, and the obtained results were compared with the indicators of the physiological completeness of the mineral composition of drinking water, recommended by DSanPiN 2.2.4-171-10 «Guidance requirements for drinking water intended for human consumption».

Table 1

Sample Location and Number

Sample No	Location	Sample No	Location
Starosambirsky region			
1	Velyka Linyna v.	3	Strilbychi v.
2	Bilychi v.	4	Khyriv v.
Turkivsky region			
5	Zavadivka v.	8	Verkhnia Yablunka v.
6	Bitlia v.	9	Turka
7	Yavora v.	10	Turka
Skolivsky region			
11	Tukhlia v.	16	Oporets v.
12	Tukholka v.	17	Skole
13	Holovetsko v.	18	Hrebeniv v.
14	Holovetsko v.	19	Korosten v.
15	Nyzhnie Husne v.	20	Verhnie Synevdyne v.

Research results

The main mineral water ions are HCO_3^- , Cl^- , SO_4^{2-} , Ca^{2+} , Mg^{2+} , whose origin in the investigated objects is connected mainly with the dissolution of salts that form rocks and soils. Results of the study of general hydro-chemical parameters are given in Table 2.

As can be seen from the results all the hydro-chemical parameters are within the normal range. The exception is the dry residue (total mineralization) index in sample No. 20. All waters have a weakly alkaline reaction (except for samples No. 3, 4, 5, 8, 9, 11) indicating a possible higher content of hydro-carbonates. In total hardness, all samples under study are soft and medium-hard water types. The value of the total alkalinity of water samples ranges from 1.8 to 6.1 mmol/m³, which corresponds to the physiological integrity of the composition of drinking water.

Sulphate ions and chloride ions are present in almost all natural waters, their content is mainly due to chemical weathering with sedimentary rocks during oxidation of sulfides, dissolution of sulfur-containing and chlorine-containing minerals.

Calcium is the dominant cation for weakly mineralized waters, and with increasing mineralization, the relative content of Ca^{2+} decreases. Almost all samples of investigated water contain calcium within the limits of physiological values. Exceptions are Sample No. 15, where calcium content is twice less, and samples No. 5, 6, 8, where calcium content exceeds physiological value, but is at the upper limit of normative (indicator) indicators. Magnesium is present in all investigated samples of water, quantitatively - does not exceed the normative values, but on the indicators of physiological completeness - on the lower limit.

The mineral composition of water can be considered simultaneously as the possibility of obtaining the necessary macro- and microelements for human life, as well as the potential cause of the development of certain non-infectious diseases (Zorina, 2018; Prodanchuk, et al., 2006). Some authors (Fleming, 1994; Haring, 1981) note that the mineral composition of water: total hardness, sulfates, chlorides, total mineralization (dry residue), are low intensity factors have a non-specific indirect effect on the human body. With prolonged consumption

of such water the water-salt balance of the organism changes, the balance of physiological processes with the possible occurrence of diseases of the circulatory system is disturbed.

Table 2

Average hydro-chemical parameters of investigated water samples for 2016-2018

№ samples	Organoleptic indicators			Physico-chemical indicators (inorganic components)							
	Smell points	Colour, points	Taste, points	pH	Dry residue (total mineralisation), mg/dm ³	Total hardness, mmol/m ³	Total alkalinity, mmol/m ³	CL ⁻ , mg/dm ³	SO ₄ ²⁻ , mg/dm ³	Mg ²⁺ , mgr/m ³	Ca ²⁺ , mg/m ³
	≤3	≤25	≤3	6,5 ÷ 8,5	1000 ÷ 1500	7,0÷10,0 (1,5÷7,0)*	≤6,5 (0,5÷6,5)*	250÷350	250÷500	30 (10÷50)*	100 (25÷75)*
1	0	22	1	6,8	165	4,3	2,5	350	residue	21,9	45,2
2	0	10	1	7,3	195	4,2	6,4	12,2	32,5	28,3	59,8
3	0	15	0	8,3	240	4,5	3,2	12,8	72,1	3,3	48,6
4	1	30	2	8,8	998	4,1	4,5	112,6	298,2	23	49,7
5	2	20	1	8,2	295	2,6	0,9	17,3	25,1	26,5	98,7
6	0	20	1	7,6	215	2,1	1,6	18,3	236,3	10,2	94,2
7	2	45	0	7,9	225	4,2	2,6	138,4	residue	30,2	67,2
8	0	30	0	8,4	250	4,6	3,4	residue	250,2	25,4	100,5
9	1	20	0	8,5	1450	7,2	4,6	73,1	165,1	27,8	39,5
10	0	25	0	7,8	1380	5,8	3,7	282,5	80,2	15,7	48,6
11	0	10	1	8,2	352	1,8	5,6	30,3	115,2	20,3	48,2
12	0	15	0	7,6	384	2,4	3,2	46,5	115,3	13,7	35,2
13	0	20	2	7,1	348	2,1	4,3	10,5	18,2	18,5	26,1
14	1	15	1	7,3	345	1,8	2,6	34,2	16,8	22,8	68,9
15	2	10	1	7,3	425	2,4	4,7	35,5	15,3	2,3	12,3
16	1	10	1	7,8	20,1	1,9	3,5	65,1	21,6	14,6	65,2
17	0	22	1	7,5	810	5,9	3,8	20,1	15,2	10,2	39,5
18	0	18	0	7,6	650	3,5	4,2	35,6	58,2	1,8	56,3
19	0	10	0	6,2	120	3,8	2,8	28,1	48,2	18,2	42,2
20	0	10	0	6,1	1750	4,1	6,1	27,1	55,1	12,4	30,2

* - indicators of physiological value

It is proved that water hardness also indirectly affects the emergence of non-infectious diseases such as gastro-duodenitis, ulcer, urolithiasis, gallstone, hypertonic disease, cardiovascular diseases, and the like. There is an inverse relationship between hardness of water and mortality from cardiovascular diseases. The risk of myocardial infarction and mortality from coronary heart disease increases with the consumption of soft water with a low content of magnesium (Maciejowski, 2015; Luoma, et al., 1983), which is confirmed by epidemiological surveys in the United States and in the United Kingdom (Schroeder, 1960; Pocock, 1980). The relationship between the content of magnesium in water and in the cardiac and skeletal muscles, coronary arteries, etc. was revealed.

However, in the mild water there are also other elements presented (lead, cadmium, etc.) that can also have a negative effect on the cardiovascular system. Calcium deficiency also increases the toxicity of heavy metals present in water. Prolonged consumption of solid water from 12.0 to 23.0 mmol/m³ leads to the depletion of regulatory systems with the subsequent development of pathological changes, in particular genito-urinary diseases, kidney diseases, hypertension, sclerosis and others (Theophanides, 1990; Durlach, 1989; Luoma, 1983; Landin, 1989; Rubenowitz, 1998).

Hydrocarbonate calcium water affects purine metabolism. According to the dispensary survey, there was a certain increase in the incidence of urinary organs, arthritis and exchange-type polyarthritis in persons consuming water containing calcium 100-150 mg/l. Excess calcium leads to increased or excessive calcification of bone tissue.

In Ukraine, one of the biggest problems is the incidence among the population of cardiovascular diseases. According to the Ministry of Health (*moz.gov.ua*), the incidence of the population of Ukraine on diseases of the blood circulation system in the years 2015-2017 amounted to an average of 6.99 thousand patients per 100 thousand population, and in the Lviv region - 9.3. In the structure of the morbidity of the population on cardiovascular diseases accounts for more than 30% of all diseases, including among the able-bodied population - 24%, retirement age - 50%. The prevalence rates of diseases in the Lviv region do not differ from the structure of distribution in Ukraine.

The main diseases that are typical for the population were diseases of the circulatory system (32,1%), respiratory organs (19,0%) and diseases of the digestive system (7,9%). The change in the index of total water hardness and calcium and magnesium ion content during 2015-2018 was analyzed and their dynamics compared with the state of morbidity in the studied areas was compared (Table 3).

Table 3

The dynamics of some physicochemical indices of investigated water samples during 2015-2018

Administrative-territorial unit	Year	Total hardness, mmol/m ³	Mg ²⁺ , mg/m ³	Ca ²⁺ , mg/m ³	Dynamics of blood circulation system diseases, %
Skolivsky region	2015	3,7	22,8	60,5	32,1
	2016	3,6	20,6	51,2	32,6
	2017	3,4	16,6	48,1	34,1
	2018	2,9	13,5	42,4	35,1
Turkivsky region	2015	5,1	35,6	100,2	31,5
	2016	4,9	30,2	94,3	32,1
	2017	4,7	28,5	90,5	32,6
	2018	4,4	22,6	74,8	33,5
Starosambirsky region	2015	4,6	25,6	55,6	29,1
	2016	4,5	24,9	52,3	31,2
	2017	4,4	20,6	50,8	31,5
	2018	4,3	19,1	48,6	32,6

As it is seen during the study period, a decrease in the total hardness and the content of magnesium ions in water samples is observed. This can be caused by natural factors: in the conditions of increasing precipitation and temperature increase, processes of chemical weathering of rocks are activated (*Kropyvnytska, 2016; Stadnichuk, 2018; Kropyvnytska, 2013*). The content of calcium ions remains at one level.

Changes in saline composition correspond to changes in the hydrological seasons: reduction of concentration in many periods (spring flood, summer-autumn floods) and increase in the range of concentration. The level of illness of the circulatory system increased during the investigated period, which correlates with the indicators of water hardness. Among the diseases of the circulatory system the most common are hypertension - 41% and ischemic heart disease - 28%.

Conclusion

There were studied 20 samples of water suitable for consumption in the territory of three mountain regions of Lviv region, in particular four 4 samples in the Starosambirsky, 6 in Turkovsky and 10 in the Skolivsky region. The obtained results showed that according to the basic hydrochemical parameters the water quality meets the requirements for the degree of pollution of the hygienic classification of water objects and the conditions for the living environment of the existence of hydrobionts and terrestrial biota are normal. According to the hardness indexes, the water studied belongs to the soft and medium-type type. Constant consumption of such water can cause a danger to the population suffering from cardiovascular diseases, blood congestion, and myocardial infarction. The results of the analysis of the accumulated data do not leave doubt about the connection between the chemical composition of drinking water and the state of health of the population. The influence of water on the health of the population is determined by the mineral composition and concentrations of macro- and trace elements. The negative influence of overestimated concentrations and individual impurities present in water on the organism of the population is due to the combined effect of its constituents and is multidirectional, which may manifest itself as a voltage regulating and adaptive systems, and clinically expressed pathological changes in various organs and systems.

Study of the connection and mechanism of these change requires an integrated approach with the use of experimental studies, taking into account the conditions of water use, sanitary-hygienic characteristics and mineral content of drinking water, as well as social and hygienic factors.

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