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CONTENTS

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BALANCED MINERAL COMPOSITION AS AN INDICATOR OF DRINKING GROUNDWATER QUALITY FOR INDUSTRIAL-AND-URBAN AGGLOMERATIONS IN THE NORTHWESTERN BLACK SEA REGION

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ABSTRACT: *The hygienic aspect of drinking groundwater safety and quality can be defined by the indices of epidemic safety, sanitary, chemical and radiation indices, as well as the optimal content of mineral substances, i.e. a mineral composition adequate to the physiological need of a human organism: total hardness, total alkalinity, the content of iodine, potassium, calcium, magnesium, sodium, solid residual and fluorine. The paper in question provides assessment of the possible influence of drinking groundwater mineral composition on the public health for industrial-and-urban agglomerations in the Northwest Black Sea Region. The values of almost all indices defining the balanced mineral composition deviate from optimal value range in the ground water. The concentrations of calcium, magnesium and sodium ions in the groundwater decrease after treatment in pump-rooms, which further provokes development of the diseases associated with deficiency of these elements. Fluoride deficiency in drinking water, both from surface and ground sources of water-supply, requires substantiation of appropriateness to perform the water fluorination and other means of prevention of caries among public at large. Long-term consumption of drinking groundwater with an imbalance of essential mineral components can be one of the negative impact factors for the on public health.*
Keywords: *groundwater, mineral substances, optimal content, balance of water composition, public health.*

INTRODUCTION

The study area is geologically confined to the Black Sea depression. The geological structure includes the deposits from Cretaceous to Quaternary periods of almost 2000 meter thickness, which overlie the Precambrian crystalline basement. According to the zoning of underground hydrogeological system of Ukraine, this area is located within the North Black Sea stratal water basin [1]. This basin is characterized by large diversity and variability of the lithological sedimentary deposits. Profile unevenness of deposits and frequent alternation of aquifers and impervious rock called forth the formation of a large number of isolated aquifers associated with Cretaceous, Paleogene, Neogene and Quaternary sediments. The water of Neogene sediments is the most studied and widely used. Variability in the groundwater mineralization and chemical composition is also typical for the North Black Sea artesian basin.

Regarding provision of the population with expected drinking groundwater resources, the Odessa and Mykolayiv provinces (Oblasts) have the lowest values, and the Kherson Oblast – the highest values (second only to the Chernihiv Oblast): the Odessa province – 0.28 m^3 daily per capita, the Mykolayiv Oblast – 0.33 m^3 daily per capita, the Kherson Oblast – 4.01 m^3 daily per capita (the average for Ukraine is 1.27 m^3 daily per capita). As regards provision of the population with commercial drinking groundwater resources, the Odessa and Mykolayiv Oblasts are also characterized by the lowest rates, and the Kherson Oblast – by the highest rates in Ukraine: the Odessa Oblast – 0.18 m^3 daily per capita, the Mykolaiv Oblast – 0.06 m^3 daily per capita, the Kherson Oblast – 0.74 m^3 daily per capita (the average for Ukraine is 0.33 m^3 daily per capita) [2].

Administrative regions of this area take one of the last places in Ukraine for the resources of the local river run-off: the Odessa Oblast – 0.35 km^3 per year, the Mykolaiv Oblast – 0.57 km^3 per year, and the Kherson Oblast – 0.14 km^3 per year [3]. Moreover, the industrial-and-urban agglomerations, inhabitated by the major part of the Northwestern Black Sea Region population, are usually remote from the surface water sources (Odessa – 40 km, Mykolaiv – 73 km). In this regard, the groundwater is an alternative source of drinking water. Therefore, its quantitative and qualitative assessment is a very topical issue.

The paper is aimed at assessment of the balance in a mineral composition of drinking groundwater for industrial-and-urban agglomerations in the Northwestern Black Sea Region as a possible influence on the public health.

The hygienical aspect of drinking water safety and quality can be defined by the indices of epidemic safety, sanitary, chemical and radiation indices, as well as the optimal content of mineral substances which determine the adequacy of its mineral composition to the physiological need of a human organism. According to the sanitary rules and regulations, which have been in force in Ukraine since 2010, namely "Hygienic Requirements for Drinking Water Intended for Human Consumption" [4], the drinking water quality indices are the following: total hardness, total alkalinity, the content of iodine, potassium, calcium, magnesium, sodium, solid residual and fluorine (Tab. 1).

Table 1 – The indices of balanced mineral composition of drinking water [4]

Indices	Measuring unit	The range of optimal values
Total hardness	$mmol/dm^3$	1.5 – 7.0
Total alkalinity	$mmol/dm^3$	0.5 – 6.5
Iodine (Iodide ion, I^-)	mcg/dm^3	20 – 30
Potassium (K^+)	mg/dm^3	2 – 20
Calcium (Ca^{2+})	mg/dm^3	25 – 75
Magnesium (Mg^{2+})	mg/dm^3	10 – 50
Sodium (Na^+)	mg/dm^3	2 – 20
Solid residual	mg/dm^3	200 – 500
Fluorine	mg/dm^3	0.7 – 1.2

MATERIAL AND METHODS

Description of the indices of balanced mineral composition of the drinking water from surface and underground sources is provided as a result of the research carried out by: the Branch of 'Infoxvodokanal' for 2006-2007 and 2010-2014, and State Enterprise 'Ukrainian Scientific Research Institute of Transport Medicine attached to the Ministry of Health of Ukraine' for 2001-2011 (Odessa); Municipal Utility Enterprise (MUE) 'Mykolayivvodokanal' for 2005-2014 (Mykolaiv); MUE 'The Industrial Direction of Water and Sewage Utilities of Kherson' for 2015 (Kherson). In addition, the data on particular indices of balanced mineral composition of drinking water were obtained from the published sources. The research outcomes were generalized and represented in the tables and graphs being built by means of the Excel program. Furthermore, the methods of statistical, comparative geographic and cartographic data analysis were used.

RESULTS AND DISCUSSION

The main source of centralized water supply for Odessa and surrounding areas is the water from the Dniester River. An alternative source of drinking water supply for Odessa agglomeration is the stratal (artesian) groundwater related to Upper Sarmatia Miocene aquifer, which lies on about 120-130 m depth. The consumers are supplied with the groundwater through 15 pump-room complexes located in various parts of Odessa: #1 – Gagarin Ave.; #2 – Peremohy Park; #3 – the 6th Station of the Large Fountain; #4 – 1 Academician Glushko Str.; #5 – 14 Marshal Zhukov Str.; #6 – the 25th Chapaivska Division Str., build. 1; #7 - 1 Rabin Str.; #8 – 25 Dalnytska Str.; #9 - Starobazarnyi Square; #10 - Mechnykov Square; #11 – 71 Krymska Str.; #12 – Mykhailovskyi Square; #13 – ‘Vympel’ Cinema; #14 – Gorkyi Park; #15 – Prokhorovskyi Square. Every day about 50 thousand inhabitants of Odessa consume more than 20 m^3 of water from pump-room complexes.

The technology for water treatment which is used in pump rooms consists of the following purification stages: 1) mechanic and catalytic filtering (Fe^{2+}, Mn^{2+} and H_2S oxidation, removal of fine-dispersed suspended particles); 2) reverse osmotic desalination of the part of water volume (removal of Ca^{2+}, Mg^{2+}, Na^+, SO_4^{2-}, Cl^-, HCO_3^-, and microorganisms); 3) mixing of the water, purified by reverse osmosis, with the water after mechanical filtration in a certain ratio, aimed at bringing the values of total hardness, mineralization, Na^+, SO_4^{2-} and Cl^- content to the hygienic standards; 4) ozonation of the water, balanced in mineral composition, to ensure its microbiological quality, deodorization, degasation, saturation with O_2, and oxidation of organic and inorganic substances; 5) adsorption treatment of ozonated water at the filters with activated carbon, resulting in removal of O_3, oxidated organic and some inorganic compounds; 6) secondary ozonation of the water prior to delivering it to the end-users [5].

The graphs for the average monthly values of the indices for balanced mineral composition of the drinking groundwater in Odessa, which have been drawn according to the research for the period of 2006-2007, show a more complex distribution pattern compared to similar graphs for the tap water [6, 7]. The distribution pattern for these parameters may largely depend on the data array components, i.e. the data on a specific indicator for various pump rooms. Herewith, the natural hydrodynamic and hydrogeochemical zonality of the groundwater, the operating conditions and other factors need to be considered.

In this regard, the data on the average yearly values of some indices for balanced mineral composition of the groundwater before and after treatment in particular pump-room complexes within Odessa are of interest (Tab. 2).

The values of certain parameters (hardness, alkalinity) for 2015 in particular pump rooms (# 2, 4, 13 and 14) did not differ significantly from the average values given in the Tab. 2. Seasonal fluctuations are typical for the values of such groundwater indices as total hardness, Ca^{2+} concentration (the confidence probability α is 70-50% or less), and the most constant values were observed for alkalinity and Na^+ content (the confidence probability α is 90% or higher). The groundwater purification efficiency usually ranges 19.5 - 76.2% (depending on the initial water quality), except for the water from the pump room #11, where the purification efficiency comprises 96.8 - 99.2%, i.e. the saltish water is fully desalinated [5].

71 artesian well, the water of which is used for household and drinking purposes by a small part of the population, is operated on the territory of Mykolaiv. For solid residual, total hardness and other indices of balanced mineral composition, the groundwater parameters are usually higher than the maximum rate (Tab. 3).

Water supply of the city of Kherson is provided by groundwater. The main source of water supply is an Upper Sarmatia aquifer. The total number of artesian wells is 151 (with the depth ranging from 80 to 100 m), about half of which are in operation. The drinking groundwater quality meets the requirements [4] in 47 wells, where the water volume is 12.9 mln. m^3 per year. The groundwater quality meets the requirements [4] for certain parameters in 44 wells, which are running with permission of the sanitary and epidemiological station (the volume is 9.1 mln. m^3 per year). The groundwater inflows into the water supply network over 820 km long. It should be noticed that Pontian Upper Miocene aquifer, which had been used for dumping household sewage until the late 1960s, is a source of pollution, since the polluted water overflows into the Upper Sarmatia aquifer through the annular space of unserviceable wells. The groundwater of the Upper Sarmatia aquifer is polluted with nitrates (250 mg/dm^3, while the standard is 45 mg/dm^3).

Beginning of intensive development of the Upper Miocene aquifer complex in the Dnipro Basin area within the Kherson Oblast fell on 1965-1975, when a large number of water intake wells was drilled. As a result of a survey for operating wells performed under the works on prospecting of drinking groundwater in 2002-2010, it was found that by course of the average values of indices in time there was a change in the hydrogeochemical type of aquifers from freshwater (SO_4^{2-} - HCO_3^- - Cl^- , Ca^{2+} - Mg^{2+} - Na^+) to saltish water (SO_4^{2-} - Cl^- , Na^+- Mg^{2+}) [9]. During the specified time the changes in some indices of balanced mineral composition of the groundwater are also defined (Tab. 4).

Table 2 – Average annual (2001-2010) values of certain indices of balanced mineral composition of the groundwater from pump rooms in Odessa before (a numerator) and after treatment (a denominator), according to [5]

# of a pump room	Total hardness, mmol/dm^3	Total alkalinity, mmol/dm^3	Ca^{2+}, mg/dm^3	Na^+, mg/dm^3	Solid residual, mg/dm^3
1	4.37 ± 0.24 1.61 ± 0.03	4.24 ± 0.22 1.80± 0.03	35.8 ± 3.0 ***13.0***↓ ± 0.36	***212.0***↑ ± 18.5 ***94.5***↑ ± 1.6	***795.0***↑ ± 54.6 331.0 ± 15.1
2	3.39 ± 0.10 ***1.04***↓ ± 0.06	5.40 ± 0.31 1.66 ± 0.02	***23.6***↓± 1.7 ***7.33***↓ ± 0.41	***274.0***↑ ± 29.5 ***84.3***↑ ± 1.4	***916.8***↑ ± 56.7 279.2 ± 9.8
3	3.73 ± 0.07 ***1.44***↓ ± 0.04	4.75 ± 0.20 2.23 ± 0.01	31,8 ± 1.4 ***12.6***↓ ± 0.36	***211.0***↑ ± 9.1 ***101.6***↑ ± 2.1	***779.1***↑ ± 34.9 341,1 ± 8,5
4	2.15 ± 0.37 ***1.25***↓ ± 0.03	5.12 ± 0.49 4.12 ± 0.02	***13.7***↓ ± 2.1 ***8.96***↓ ± 0.31	***220.0***↑ ± 16.9 ***168.5***↑ ± 2.9	***681.8***↑± 39.4 468.9 ± 24.3
5	3.78 ± 0.10 1.54 ± 0.02	4.32 ± 0.22 1.94 ± 0.02	34.5 ± 1.6 ***14.50***↓ ± 0.48	***192.7***↑± 7.1 ***87.1***↑± 1.4	***709.2***↑± 27.1 313.4 ± 8.2
6	4.59 ± 0.21 ***1.28***↓ ± 0.03	4.32 ± 0.20 1,29 ± 0,01	41.1 ± 1.4 ***11.55***↓ ± 0.5	***193.2***↑ ± 23.9 ***63.8***↑ ± 1.1	***750.3***↑ ± 66.2 238.3 ± 10.9
7	2.99 ± 0.14 ***0.97***↓ ± 0.03	5.11 ± 0.23 1.68 ± 0.01	***20.8***↓ ± 1.3 ***7.43***↓ ± 0.46	***241.0***↑ ± 22.5 ***81.3***↑ ± 1.3	***782.6***↑ ± 59.6 270.6 ± 10.3
8	4.50 ± 0.19 2.06 ± 0.10	4.31 ± 0,36 2.49 ± 0.02	31.81 ± 1.9 ***14.10***↓ ± 0.76	***230.1***↑ ± 18.0 ***127.1***↑ ± 2.2	***789.0***↑ ± 82.7 448.8 ± 16.3
9	***7.38***↑± 0.22 2.15 ± 0.06	3.84 ± 0.25 1.78 ± 0.02	52.7 ± 3.0 ***15.10***↓ ± 0.53	***176.0***↑± 43.1 ***95.8***↑ ± 1.7	***857.2***↑ ± 121.0 360.8 ± 13.4
10	4.82 ± 0.17 1.53 ± 0,02	4.35 ± 0.38 1.57 ± 0.03	31.6 ± 2.2 ***11.50***↓ ± 1.14	***241.0***↑ ± 34.2 ***85.4***↑ ± 1.3	***880.0***↑ ± 65.5 308.2 ± 15.3
11	***8.74***↑ ± 0.35 **0.97**↓ ± 0,03	***8.11***↑ ± 0.31 1.68 ± 0.01	49.4 ± 6.5 ***7.43***↓ ± 0.46	***1102,8***↑ ± 86,1 ***81.3***↑ ± 1.3	***3543.4***↑ ± 170.3 270.6 ± 10.3
12	4.89 ± 0.12 1.50 ± 0.06	4.23 ± 0.36 1.49 ± 0.01	***35.6***↓ ± 7.4 ***10.34***↓ ± 2.24	***236.1***↑ ± 35.6 ***87.1***↑ ± 1.6	***820.1***↑ ± 106.0 311.2 ± 12.9

13	4.05 ± 0.06 1,69 ± 0,05	4.62 ± 0.29 1.98 ± 0.02	35.6 ± 2.1 ***15.50***↓ ± 0.6	***211.4***↑ ± 23.3 ***93.4***↑ ± 1.5	***768.7***↑± 26.4 342.7 ± 13.5
14	2,60 ± 0,07 ***0.63***↓ ± 0.03	4.78 ± 0.24 1.17 ± 0.01	***19.8***↓ ± 1.7 ***4.71***↓ ± 0.28	***214.9***↑ ± 16.6 ***58.8***↑ ± 1.0	***729.3***↑ ± 112.1 ***197.0***↓ ± 11.1
15	***7.18***↑ ± 0.28 2.24 ± 0.12	3.80 ± 0.37 1.40 ± 0.02	53.0 ± 1.4 ***15.0***↓ ± 1.0	***170.4***↑ ± 28.0 ***65.4***↑ ± 1.1	***817.1***↑ ± 87.9 289.3 ± 20.0

Note: ↓ - below the minimum norm / standard (*minN*), ↑ - above the maximum norm (*maxN*) [4]

Table 3 – Certain indices of balanced mineral composition of the water from particular wells in Mykolaiv, according to [8]

Indicator	Wells					
	#1	#2	#3	#4	#5	#6
Solid residual (mineralization), mg/dm^3	***3328***↑	***1976***↑	***1585***↑	***3709***↑	***2824***↑	***6073***↑
Total hardness, $mmol/dm^3$	***13.2***↑	4.5	2.6	***15.1***↑	***10.5***↑	***24.0***↑

Table 4 – Some indices of balanced mineral composition of the groundwater in the Upper Miocene aquifer complex of the Dnipro Basin within the Kherson Oblast, according to [9]

Indicator	1965-1975 (*n* = 62)	2002-2010 (*n* = 30)
Solid residual (mineralization), mg/dm^3	930.0	***2120.0***↑
Calcium (Ca^{2+}), mg/dm^3	70.4	***149.3***↑
Magnesium (Mg^{2+}), mg/dm^3	***62.0***↑	***151.4***↑
Total hardness, $mmol/dm^3$	**8.9**↑	**20.0**↑
Sodium (Na^+), mg/dm^3	169.7	***312.6***↑

Review of the published data provides evidence that the balanced mineral composition of drinking water is a factor that significantly affects public health.

Heightened concentrations of iron, boron and bromine, which are not included into the list of balanced composition indices for drinking water [4] but belong to essential (iron) and conditionally essential (boron and bromine) microelements, were registered in the groundwater of Upper Sarmatia aquifer in Odessa [10]. The excessive iron (Fe^{2+}) can be removed by mechanical catalytic filtration. The average boron content in the groundwater before treatment ranges from 0.64 ± 0.05 mg/dm^3 to 5.22 ± 0.18 mg/dm^3. The content of bromine (bromide anion) ranges from 0.10 mg / dm^3 to 2.0 mg/dm^3. After treatment boron and bromine concentration in the groundwater is below the required value (≤ 0.5 mg/dm^3 and ≤ 2.5 mg/dm^3 respectively), but the above-standard values are periodically observed at all pump rooms, since the efficiency of boron removal by means of existing technology is 20 - 65.42 % and bromine anion removal – 21.74 - 90.16 %. Therefore, it is reasonable to remove boron and bromine by reverse osmosis in two stages or by electrodialysis and reverse osmosis consecutively [5]. This is important because excessive boron in the environment causes an endemic disease of human and animal alimentary canal, accompanied by enteritis, diarrhea, weight loss, general weakness, disturbance of carbohydrate and protein assimilation [10, 11], and the excessive bromine contributes to the circulatory system diseases, suppression of the thyroid gland and blocking of iodine flux into it.

While the groundwater from most of wells in Mykolaiv and Kherson is characterized by abnormal values of total hardness, the average values of *total hardness* of the groundwater before treatment at all pump rooms in Odessa are within the standard range, except for the pump rooms # 9, 11 and 15, where the value of this indicator was slightly higher than the standard maximum (see Tab. 2). After the groundwater treatment the average values of hardness at 8 pump-room complexes were within the normal limits, and at the rest of them – below the minimum standard (*minN*). These data indirectly indicate calcium and magnesium surplus (but not their correlation) in groundwater used for drinking purposes in most of the pump rooms. Magnesium and possibly calcium come into the human body mainly as constituents of drinking water. Internal use of hard drinking water leads to the disturbed process of intestinal fat absorption owing to formation of insoluble calcium and magnesium soaps during the saponification of fats.

In some authors' opinion [12], the heightened hardness of drinking water contributes to the increase in circulatory system diseases. According to the World Health Organization materials, the epidemiological studies conducted in various countries over the past 50 years have shown a link between the growing number of circulatory system diseases, followed by a fatal outcome, and soft water consumption [13], but there are quite a few papers in which the point is that such indices of drinking water, as hardness, calcium and magnesium content do not affect the incidence of the circulatory system diseases [14]. Soft drinking waters sometimes have a high natural content of sodium, but its excess is an additional factor in the development of some forms of hypertension.

Average values of *total alkalinity* in the groundwater from pump-room complexes in Odessa do not go beyond the standard range both before and after treatment (see Tab. 2), which is a positive factor for the public health. A slight excess of the standard value of total alkalinity was registered only for groundwater from the pump room #11 before purification. The use of alkaline drinking water is known to contribute to higher life expectancy by 20-30%.

Calcium content in the groundwater of Odessa in 2006-2007 was within the range of its standard values, i.e. it did not reach the minimum standard level (*minN*) [7, 15, 16]. The same pattern is observed for the average annual values for 2001-2010, except for the pump rooms #7 and #14 (see Tab. 2), however, Ca^{2+} concentration in the water from all the pump rooms after treatment is below the minimum standards (*minN*) [4]. According to the data for 1965-1975, Ca^{2+} content in the groundwater from the Upper Miocene aquifer complex of the Dnipro Basin (within the Kherson Oblast) was within the standard, but according to the data for 2002-2010 the content almost 2 times exceeded the maximum standard (75 mg/dm^3) [4]. A wide body of opinion that the occurence of Ca^{2+} in drinking water contributes to induration of the arteries, formation of kidney stones and liver diseases, is not confirmed by the factual evidence. Having high physiological activity, Calcium performs various functions in the organism, such as bone formation, mineralization of teeth, regulation of intracellular processes, regulation of nerve conduction and muscular contractions, and maintenance of stable cardiac activity. High calcium in the body may be the reason for arthritis, osteodystrophy, osteofibrosis, muscle weakness et al. Calcium deficiency is the cause of 147 diseases (osteoporosis, tachycardia, arrhythmia, albication of hands and feet, renal and hepatic colics, hyperexcitability, etc.). For instance, osteoporosis, a disease that ranks 10th on mortality among adults, is caused by calcium deficiency in the body [13].

Magnesium content, similarly to the value of total hardness, in the waters from the pump-room complexes within Odessa in November and December 2006 and January-March 2007 was slightly lower than the minimum standard value (*minN*) [7, 15, 16]. Magnesium is the most constitutive intracellular element. The normal level of magnesium in the body is necessary for many vital processes; magnesium reinforces the immune system. Excessive amounts of magnesium cause a laxative effect. As magnesium concentration in the blood decreases, the symptoms of neural excitation and even seizures are observed. Reduction of magnesium content in the body results in the increased calcium content while a surplus of magnesium leads to calcium and phosphorus deficiency. Since the major part of magnesium is ingested with food, the question on significance of magnesium concentration in drinking water is debatable. However, such form of magnesium has a higher bioaccumulation factor than magnesium received from food. Magnesium content in drinking water is assumed to be a decisive factor for those people who consume it in small amounts with food, but drink the magnesium-rich water. A connection between magnesium content in water and *Mg* in a cardiac muscle, a skeletal muscle and coronary arteries is revealed [13].

As for *sodium* concentration, an apparent excess of the maximum normal value (*maxN*) both before and after treatment of the groundwater is traced throughout the observation period in all urban agglomerations under the study (see Tab. 2, 3, 4). If we consider the content of Na^+ as a physicochemical indicator of drinking water safety and quality, the groundwater meets the requirements (≤ 200 mg/dm^3) [4]. Sodium is known to be of importance in intracellular and intercellular exchange. Sodium and potassium correlation is in charge of two important interconnected processes: maintenance of a constant osmotic pressure and a constant volume of fluid. Sodium consumption in large quantities leads to the loss of potassium. Therefore, a balanced intake of these substances (Na^+ and K^+) is of particular significance. The main purpose of Na^+ is maintenance of water-salt balance in the cells of a human body, normalization of neuromuscular activity and renal function. In addition, sodium keeps mineral substances soluble in the blood. Excess sodium can cause hyperexcitability, hypersensitivity and hyperactivity. In some cases, excessive thirst, hyperhidrosis and frequent urination unusual for this particular person are likely to appear. Most of sodium is included in chlorides, and therefore the high sodium content correlates with the heightened mineralization of drinking water.

Solid residual is the amount of dissolved substances, mainly minerals, in 1 dm^3 of water. The fraction of organic matter in the solid residual makes up no more than 10%, so we can assume that this indicator defines a total mineralization of water. The waters from Upper Sarmatia aquifer on the predominant part of Odessa agglomeration are fresh and light saltish. The most mineralized water relates to the areas, located to the north of Peresyp district, as evidenced by the highest content of solid residual (almost 4 g/dm^3) in the water from pump room #11. In addition to high mineralization, the heightened values of hardness, alkalinity, potassium and sodium content are typical of such ground water, that is why they can be used for drinking purposes only after further treatment. The treated ground water is characterized by the average content of solid residual within the standard optimal range. The groundwater from the studied wells in Mykolaiv usually exceeds the maximum standard for the value of solid residual (see Tab. 3). A significant excess of the maximum norm (*maxN*) is also typical for the groundwater from Upper Miocene aquifer in Kherson [4]. The drinking water with heightened mineralization affects gastric secretion and disturbs a water-salt balance that leads to various adverse physiological abnormalities in the body (heat exhaustion under hot weather, disturbed sense of quenching the thirst, increased hydrophily of tissues, change in gastric secretion, reinforced motor functions of the stomach and intestinal peristalsis etc.). On the other hand, a long-term consumption of low-mineral water may bring to some adverse physiological disturbances in the human organism, particularly, to the decreased chloride content in tissues etc. [12].

The *fluoride* content both in river and tap water as well as in groundwater within industrial-and-urban agglomerations of the Northwestern Black Sea Region usually does not reach the minimum standards (*minN*) [4]. The physiological role of fluoride consists in its plastic function, participation in blood formation and regulation of immunogenesis, functioning of the endocrine glands, development of collagen, bone and cartilaginous tissue. Fluoride deficiency is thought to be the primary cause of caries and hypofluorosis occurrence (late teething, a fluoride-dependent osteoporosis, etc.). F^- concentration in water of less than 0.5 mg/dm^3 is one of the major causes of tooth decay. It is believed that F^- concentration in the drinking water of more than 1.5 - 2 mg/dm^3 is also detrimental to the public health. Under the use of water with F^- concentration ≥ 5 mg/dm^3 fluorosis occurs in almost all of the population. If in the temperate climate the use of drinking water with F^- concentration of 4 - 8 mg/dm^3 does not provoke the symptoms of bone fluorosis, in the subtropical and tropical climate fluoride concentration of above 5 mg/dm^3 calls forth osteoporosis and skeletal deformation. The major part of fluoride gets into the human organism with water and food (bread, fish, meat, tea, etc.). Additionally, fluoride can also be ingested with toothpaste. [17] Since fluoride is a microelement with a relatively abrupt transition from the physiologically beneficial concentrations to the concentrations provoking a toxicosis, then convincing arguments both from supporters and opponents of drinking-water fluorination as well as on the use of fluorinated toothpastes are offered in Ukrainian and foreign publications.

CONCLUSION

As a result of the research the following can be concluded:

- Deviation from optimal value range is typical for almost all the identifiable parameters of balanced mineral composition of groundwater in the studied industrial-and-urban agglomerations, yet after the groundwater treatment calcium, magnesium and sodium concentrations are significantly decreased, which further provokes development of the diseases associated with deficiency of these elements;
- Additional treatment of groundwater only partially solve the problem of balancing the mineral components of drinking water, and in some cases may even aggravate the problem;
- Fluoride concentration in drinking water from surface and ground sources of water-supply does not reach the minimum standards, that requires substantiation of appropriateness to perform the water fluorination, use fluorinated toothpastes and other means of prevention of caries and other diseases among public at large.
- Long-term consumption of drinking groundwater with an imbalance of the mineral composition can be one of the negative impact factors for the public health, so there is a need for further special studies.

REFERENCES

1. Kamzist Zh.S., Shevchenko O.L. *Gidrogeologija Ukraïny* [Hydrogeology of Ukraine]. – Kyiv: INKOS, 2009. – 614 p.
2. *Strategija vykoristannja resursiv pytnyh pidzemnyh vod dlja vodopostachannja:* u 2 t./ za red. E.A. Stavickogo, G.I. Rud'ka, Є.O. Jakovleva [Strategy of the use of drinking groundwater resources for water supply. In 2 volumes. Edited by E.A. Stavytskyi, G.I. Rudko, Ye. O. Yakovlev.] Volume 1. – Kyiv-Chernivtsi: Bukrek 2011. – 347 p.
3. Jacik A.V. *Vodogospodars'ka ekologija: u 4 t., 7 kn*. [Water Management Ecology]. – Kyiv: Geneza, 2003. – Vol. 1, books 1-2. – 400 p.
4. SanPiN 2.2.4-171-10. *Derzhavni sanitarni normy ta pravyla «Gigiєnichni vymogy do vody pytnoï, pryznachenoï dlja spozhyvannja ljudynoju»* [State sanitary rules and regulations "Hygienic requirements for drinking water intended for human consumption"]. Kyiv, 2010, 12 p.
5. Petrenko N.F., Sozinova O.K., Vlasjuk G.V., Opanasenko V.M. *Gigiєnichna ocinka kombinovanogo zastosuvannja membrannyh ta ozono-sorbcijnyh metodiv ochyshhennja ta znezarazhennja vody, shho vykoristovujut'sja na bjuvetnyh kompleksah m. Odesy* [Hygienic evaluation of the combined use of ozone and membrane-sorption methods of purification and disinfection of the water used at pump-room complexes in the Odessa city]. *Prychornomors'kyj ekologichnyj bjuleten'– Black Sea Ecological Bulletin*, 2012. – no. 4(46). – pp.160-170.
6. *Medyko-gidrogeohimichni chynnyky geologichnogo seredovyshha Ukraïny. Za red. prof. G.I. Rud'ka* [Medical-hydrogeochemical factors of geological environment in Ukraine. Ed. Prof. G.I. Rudko]. Kyiv – Chernovtsy: Bukrek Pbl., 2015.- 724 p.
7. Safranov T.A., Polishhuk A.A., Volkov A.I. (Eds.).*Fiziologicheskaja polnocennost' mineral'nogo sostava pit'evyh vod Odesskoj aglomeracii* [Physiological adequacy of the mineral composition of drinking water in Odessa agglomeration]. *Vìsnik Odes'kogo deržavnogo ekologìčnogo unìversitetu - Bulletin of Odessa State Environmental University*, 2013, no. 15, pp. 5-16.
8. Smirnova S.M., Smirnov V.M., Bagatjuk D.V. *Ocinka mozhlyvosti vykoristannja pidzemnyh dzherel vody v jakosti pitnoï vody na prykladi mikrorajonu Ternovka mista Mikolaєva* [Assessment of capacities to use the ground water

sources for drinking purposes on a case study of Ternovka microdistrict of Mykolaiv]. *Naukovij visnik MDU imeni V.O. Suhomlins'kogo, biologichni nauki*. – *Scientific Bulletin of Mykolayiv State University named after V. Sukhomlynsky, biological sciences*, 2014. – Vol. 6.2(107). – pp. 57-63.
9. Sherbak O.V., O.P. Lobasov, L.O. Kalinichenko. *Evoljucija makrokomponentnogo skladu pytnyh pidzemnyh vod v umovah tehnogenezu na terytoriï Hersons'koï oblasti* [Evolution of macrocomponent composition of drinking groundwater under technogenesis in the Kherson Oblast]. *Visnyk ONU, geografichni ta geologichni nauky - Bulletin of Odessa National University, Geography and Geology*, 2014. – Vol. 19. – no.3. – pp. 289-298.
10. Avcyn A.P., Zhavoronkov A.A. *Mikrojelementozy cheloveka*: *monografija* [Human Microelementoses: monograph]. Moscow: Medicine Pbl., 1991, 496 p.
11. *Profilaktychna toksikologija ta medychna ekologija / Za red. akad. NAMN Ukraïny I.M. Trahtenberga* [Practical toxicology and medical ecology. Ed. Trakhtenberg, I.M.]. Kyiv: Avicena Publ., 2010. – 248 p.
12. Akulov K.I., K.A. Bushtueva, Goncharuk E.I. (Eds.). Kommunal'naja gigiena [Communal hygiene]. Moscow: Medicina Publ., 1986, 608 p.
13. *Vstup do medychnoï geologiï. U dvoh tomah / Za redakcieju G.I. Rud'ka, O.M. Adamenka* [Introduction to medical geology / In two volumes]. Ed. G.I. Rudko & O.M. Adamenko]. Kyiv: Akadempres Pbl., 2010.
14. Ivanov A.V., Tafeeva E.A., Davletova N.H., Vavashkin K.V. *Sovremennye predstavlenija o vlijanii pit'evoj vody na sostojanie zdorov'ja naselenija* [Current views on the influence of drinking water on public health condition].*Voda: himija i ekologija - Water: chemistry and ecology*. 2012, no. 3, pp. 48-53.
15. *Medyko-gidrogeohimichni chynnyky geologichnogo seredovyshha Ukraïny. Za red. prof. G.I. Rud'ka* [Medical and hydrogeochemical factors of the geological environment in Ukraine. Ed. Prof. G.I. Rudko]. Kyiv – Chernovtsy: Bukrek Pbl., 2015.- 724 p.
16. Safranov T.A. *Fiziologichna povnocinnist' mineral'nogo skladu pidzemnyh pytnyh vod jak factor formuvannja zdorov'ja naselennja (na prykladi Odes'koï aglomeraciï)* [Physiological adequacy of the mineral composition of drinking ground water as a formation factor for the population health (with Odessa agglomeration taken as an example)]. *Nadrokorystuvannja v Ukraïni – The use of mineral resources in Ukraine*. Kyiv, 2014, pp. 284-291.
17. Bardov V.G., Fedorenko V.I., Bilec'ka E.M. (Eds.). *Osnovy ekologiï: pidruchnyk* [Fundamentals of ecology: textbook]. Vinnitsa: Nova Kniga Publ., 2013, 424 p.