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The Influence of the Mineral Composition of Drinking Water on Public Health

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Abstract: *This paper clarifies the influence of mineral composition of drinking ater on public health.* Influence of the water factor on the incidence of the population, the most informative indicators are the frequency and prevalence of individual nosological forms, especially diseases of the urinary, digestive, cardiovascular, musculoskeletal and endocrine systems.

Keywords: Mineral Composition, Water, Public Health, Iodine Prophylaxis.

I. INTRODUCTION

The literature contains numerous data on the relationship with the mineral composition of water of a significant number of diseases of the population [1, 9, 18, 22, 34, 41]. For the human body, in relation to each macro- and microelement, there are limits, a decrease or increase in which in drinking water does not pass without a trace, causing certain physiological changes or pathological conditions.

Natural water is exposed to a variety of rocks, minerals, dissolving them and including a different amount of various chemicals in their composition. With water, a person receives 1–25% of the daily need for chemicals [15]. Chemical elements that enter the human body with water, and especially with mineral water, have a significant physiological value than those that come with food, since the latter lose some of their quantity during the cooking process.

It has been established that with insufficient (up to 0.7 mg/l) intake of fluoride with water in the human body, an increased incidence of dental caries is observed in the population. Such biogeochemical regions exist in a number of regions of Ukraine, on the Kola Peninsula, in the Murmansk and Leningrad regions, in Estonia, Belarus, and Tashkent region. [3, 4, 6, 9, 15]. Water fluoridation leads to a significant reduction in the incidence of dental caries [1, 15]. With an excess of fluorine, fluorosis or spotting of tooth enamel of varying severity is observed [28].

With insufficient intake of iodine, goiter develops, which is typical for some regions of the CIS - Altai, Primorsky Krai, the Carpathians, Irkutsk and other areas [6, 12]. Mass, group and individual iodine prophylaxis led to a significant decrease in morbidity [16, 31].

Some authors [127, 35] believe that when studying the influence of the water factor on the incidence of the population, the most informative indicators are the frequency and prevalence of individual nosological forms, especially diseases of the urinary, digestive, cardiovascular, musculoskeletal and endocrine systems, when observing at least for 3 years.

Comparison of the incidence of salivary stone and urolithiasis in the population with the hardness of drinking water made it possible to establish a certain relationship between them. The highest incidence of these diseases is observed in areas where drinking water has a hardness of 16.0 to 23.0 mg-eq/l, the lowest is in the range of 6.0-7.0 mEq/l. The hardness of drinking water from 7.0 to 16.0 mEq/l characterizes the average level of morbidity [34]. When the hardness of drinking water exceeds 10 mEq/l, there is an increase in local blood flow, the process of filtration and reabsorption in the kidneys changes. This phenomenon serves as a protective reaction of the body, but due to prolonged influence, depletion of regulatory systems occurs. In the end, pathological changes develop (urolithiasis, sclerosis, hypertension) [25].

An increase in the frequency of cardiovascular diseases is associated with excessive intake of sodium chloride. So, in people who have long and constantly used highly mineralized drinking water with a chloride content of 1400 mg/l, there is a tendency to hypertensive conditions, increased vascular reactivity and some features of water-salt metabolism. The population drinking water with a chloride content of 300–400 mg/l did not show any deviations in the state of the cardiovascular system and water and electrolyte balance [2, 8]. Under the influence of drinking water nitrates at a

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concentration of 44.6 mg/l, a disease of water-nitrate methemoglobinemia occurs, which is manifested by cyanosis, an increase in the content of methemoglobin in the blood, and a decrease in blood pressure 124].

The problem of the mineral composition of waters is attracting more and more attention of researchers due to the growing number of reports of an inverse relationship between water hardness and mortality from cardiovascular diseases. Some authors [10, 32, 41] argue that the beneficial effect on the cardiovascular system of hard water is due to the presence of magnesium ions. An epidemiological survey of the population drinking water with a low magnesium content (Ohio, USA) found a higher incidence of coronary disease, as well as cases of sudden death, compared with areas where the population consumes water with a normal content of this microelement [32]. The content of magnesium in the myocardium in those who died from heart attacks was reduced by 12-15%.

There is an opinion [21] that the content of magnesium in the average daily diet is lower than the need for it. This is due to the fact that many modern food products undergo industrial processing (cleaning, fractionation, freezing, refining), they lose trace elements and vitamins even before cooked at home. Due to hard waters, magnesium deficiency can be significantly reduced, and the consumption of soft waters can lead to an even greater magnesium deficiency in the body [33].

Summarizing the literature data, Y. V. Novikov et al. [211 in a review article showed that every 2 mEq/l of hardness is the source of 6-7% of the total intake of magnesium. This coincides with the data, according to which, with a water hardness of 7 mEq/l, an additional 27% of magnesium enters the body. In favor of the role of "aqueous magnesium", according to the authors of [21], it is evidenced by its better digestibility from water (up to 60%) than from food (30%). With this in mind, studies confirming the role of hard water magnesium in reducing cardiovascular pathology are of particular importance.

As a result of studies conducted in areas with high salinity of drinking water, a slowdown in the excretion of water from the body was found in people who used highly mineralized water for a long time [71. With a load not exceeding 1000 mg/l of chlorides, no obvious changes in the body are observed, which is due to the rapid restoration of the level of salts and osmotic pressure in the blood and tissues. At concentrations of the order of 1500-2500 mg/l and higher, the excretion of chlorides is associated with a more intense and prolonged stress on the excretory function of the body and mechanisms for maintaining the constancy of the internal environment. As for sulfates, they do not cause changes in diuresis. The main effect of sulfates is on the stomach in the form of a significant inhibition of the secretory activity of the stomach, starting from a concentration of 1000 mg/l. At sulfate concentrations of 2500 mg/l and above, they are mainly excreted through the intestines, exerting a laxative effect [42].

E. V. Shtannikov et al. [36] found that drinking water with increased mineralization (total mineralization — 3050 ± 10.9 mg/l, hardness — 17.6 ± 3.4 mg-eq/l) is a high-intensity factor that has an adverse effect on the specific functions of the female bod, as menstrual and childbearing, as well as the course of pregnancy and childbirth, the fetus and newborn. The qualitative composition of this water causes an increase in gynecological morbidity, which is directly dependent on long-term consumption of highly mineralized water. It has been experimentally proven [36] that water with increased mineralization also has an embryotoxic effect, manifested by a decrease in body weight of animals, a violation of the regularity of the astral cycle and a prolongation of the estrus stage, an increase in preimplantation death of the egg and fetal weight.

Some researchers [19, 22, 26] point to a number of diseases in the population that consumes soft low-mineralized drinking water. This is typical primarily for hypertension, gastric and duodenal ulcers, chronic gastritis, cholecystitis, nephritis and coronary heart disease. The physical development of children and adolescents is better in an area supplied with water with an optimal salt content. Newborn children in an area supplied with low-mineralized water had a lower level of health. They were more likely to have anemia, hemolytic jaundice, bone fractures, congenital anomalies, and developmental defects.

Some pathological conditions in humans have been confirmed by Y. V. Novikov et al. [22] in animal experiments. The authors emphasize that the presence of heavy metal ions in water and, at the same time, calcium deficiency can be a complex that contributes to the tension of the regulatory and adaptive systems of the body, since the toxicity of metals in soft waters increases. The latter is explained by the ability of calcium to compete with heavy metal ions for a specific protein. In this regard, the more calcium ions in the water, the less protein remains on the share of metals. Therefore, calcium deficiency may be a contributing factor to increased toxicity.

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One of the metals widely distributed in the water of reservoirs is iron, the content of which can reach 20 mg/l [13]. It has been established that water with a high content of iron (1-5 mg/l) has a pronounced adverse effect on human skin, causing dryness and itching. However, with prolonged use of such waters, addiction develops and these effects disappear [14]. According to WHO, iron deficiency occurs in approximately 700 million people on Earth. The results of epidemiological studies indicate its wide prevalence in developing countries. So, in India, anemia was detected in 50% of women, in some parts of Venezuela - in 92% of women and 60% of men. Iron deficiency is less common in developed countries. In the USA, this form of anemia was found in 8.4% of women and 1.2% of men, in Sweden - in 7% of urban women [8].

In recent years, ideas about the etiological role of aluminum in the development of Alzheimer's disease have been discussed in the literature [39, 44]. Foreign authors [40, 43] found that with an increase in the content of this metal in water, mortality from Alzheimer's disease increases significantly. There are data on seasonal fluctuations in the content of aluminum in the blood of people, which the authors associate with the seasonal dynamics of water quality. The diuretic property of aluminum is described. It has been suggested that it may be mutagenic [44]. The cumulative properties of this metal were noted both in experiment [39] and in field observations [37, 38].

Some authors [11, 29] also associate the growth of malignant neoplasms among the population with the quality of drinking water. The low content of sodium, sulfates and chlorides in the water correlates with a high incidence of stomach cancer. The incidence of osteosarcoma is higher in areas where drinking water is poor in calcium and zinc. There is an opinion [11] that an increased content of the indicated water components is more physiological for the organism than their low concentrations.

Experimental studies have proven the effect of bicarbonate-calcium waters on purine metabolism. The intake of such water with a mineralization of 3500 mg/l for several weeks increases the excretion of uric acid in experimental rats compared to the control [5, 23]. In humans, the use of the same waters for 4 weeks also increases the excretion of uric acid. According to the dispensary examination data, in persons who use bicarbonate-calcium waters with a calcium content of 100–150 mg/l, there was a slight increase in the incidence of diseases of the urinary organs, arthritis and metabolic polyarthritis [23]. Drinking water with a high calcium content (100–150 mg/l) significantly slows down the exchange of this element in bone tissue, which may indicate increased or excessive calcification of bone tissue [5]. With prolonged use of water with a high content of carbonate ion (1000 mg/l), rats develop chronic gastritis, duodenitis, and colitis with an atrophic process in the glandular apparatus [20]. Apparently, prolonged exposure to a high concentration of carbonate ion leads to a change in the permeability of the mucomucosal barrier, since the secretory activity of the integumentary epithelium and epithelium of the glands is disturbed. In addition, it has been proven that a low content of calcium ions also adversely affects the kidneys and stomach [17] and requires adjustment of the hygiene regulations for some metals, in particular arsenic and aluminum [25].

As shown by the sanitary-gerontological experiment, despite the great adaptive capabilities of the body in relation to the action of drinking water with different ionic composition, in animals that consumed water with a total salt content of 2000 mg/l, there is an acceleration of aging processes [30]. The reason for this, apparently, is the long-term stress of the body's compensatory mechanisms.

Thus, when studying the influence of the mineral composition of drinking water on the health of the population, research on experimental animals occupies an important place. True, the data obtained in the experiment do not always coincide with the results of epidemiological observations, medical examinations and dispensary examinations of the population. Meanwhile, a huge material of toxicological experiments has been accumulated, including the substantiation of the MPC of harmful substances containing various information about changes in the body of animals, which opens up the possibility of directed study of the health status of the population in natural conditions in connection with the content of chemicals in water.

Despite the significant work done to study the effect of the mineral composition of drinking water on public health, not all researchers have come to unambiguous conclusions and conclusions regarding the minimum and optimal salt content in drinking water. A number of conflicting data have been published in the literature on the effect of water of various mineral composition on the cardiovascular, digestive, urinary and other physiological systems of the body. This state of the issue, on the one hand, is explained by the diversity of the mineral composition of drinking water, in which there are different quantitative ratios of ions, and on the other hand, by the fact that a significant amount of mineral salts

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is received by the human body and experimental animals not only with water, but also with food products. In addition, the mechanism of action of drinking water is not always clear, but the vast scientific research material accumulated in the world literature leaves no doubt that this action is diverse and poses a danger to human health.

Information about the role of "aqueous" magnesium in the prevention of cardiovascular diseases cannot be considered sufficiently complete. According to foreign authors [33], there is practically no information on the conditions of water use, sanitary and hygienic characteristics and interpretation of the mineral composition of drinking water in the surveyed areas. There is also a lack of experimental data obtained on animals on the role of different concentrations of magnesium in waters of various compositions with corresponding concentrations of macro- and microelements in the development of cardiovascular pathology. In this regard, the assumption that magnesium deficiency in water is the main factor in the adverse effects of soft water cannot be considered fully justified, since it may contain other elements (cadmium, lead, etc.) that have a harmful effect on the cardiovascular system. [21].

Having analyzed the presented material, it is necessary to agree with the opinion of Y. V. Novikov et al. [22] about the practical significance and expediency of using an integrated approach to studying the effect of the mineral composition of drinking water on the health of the population, taking into account the mathematical processing of morbidity rates, the identity of social and hygienic conditions, data from medical examinations, dispensary examinations of the population, as well as the results of studies on experimental animals.

Therefore, the study of the influence of the mineral composition of drinking water on the health of the population must be directly linked to the effectiveness of existing measures to protect surface and underground water sources from pollution and the effectiveness of drinking water purification methods. The results obtained will make it possible to substantiate the forecast for the near and long term regarding the impact on the state of human health of one or another source of domestic drinking water supply.

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