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INVESTIGATION OF THE INFLUENCE OF WATER HARDNESS ON THE DEVELOPMENT OF INTERNAL DISEASES

Abstract

The aim of our research is to investigate water hardness (determined by concentration of calcium and magnesium ions) in districts of Lutsk and define its impact on the human body. In this paper, several theoretical and practical research methods were applied, such as theoretical (analysis of literature on the topic), experimental (determination of water hardness by method of complexonometrics), statistical analysis of quantitative indicators (method of mathematical statistics). To determine water hardness water samples in different districts of Lutsk were collected, and calculation of total water hardness was carried.

Introduction

Total water hardness is mainly determined by concentration of calcium and magnesium ions, which are contained in water and exist in the form of carbonates, bicarbonates, chlorides and sulfates.

Water hardness is measured in milligram equivalents per 1 liter: hardness of 1 mh.ekv / L corresponds to the content of 28 mg / l CaO or 20.16 mg / l MgO. Water of hardness to 3.5 mh.ekv / L is called soft, 3.5 to 7 mh.ekv / l - average, over 7 mh.ekv / l solid and over 14 mh.ekv / l - very solid (Габович 1983). According to the Decree "Concerning the state sanitary rules and regulations" Hygienic requirements for drinking water intended for human consumption acceptable water hardness equals to 10 mh.ekv / l (Даценко 1999).

Material and method

Since total hardness of water is caused by the availability of calcium and magnesium in water, these elements can be regarded as essential in patho-etiology of diseases of the internal organs. Therefore, the lack of calcium in water contributes to the increase in absorption and toxic effects of heavy metals (cadmium, lead, mercury, aluminum etc.). Heavy metals compete with calcium in the cell because they use its metabolic ways to penetrate the body and replace calcium ions in important regulatory units, thus preventing their proper operation.

Moreover, hard water plays part in emergence and development of nephrolithiasis. A certain connection exists between rate of urolithiasis disease and drinking water hardness level (Hikōepr 2011).

The highest incidence of these diseases occurs in areas where drinking water has a hardness of 16.0 to 23.0 mEq / l. When the hardness of drinking water varies from 7.0 to 16.0 mEq / L there is an average level of incidences.

The consumption of drinking water with hardness more than 10 mEq / L usually leads to increase of the local blood flow and changes the kidneys filtration and reabsorption processes. This is indication of protective reaction of the body (Hikōepr 2011).

The second most important anions in water after calcium anions are those of magnesium. Magnesium lowers blood cholesterol level, influences the nervous system stimulation, prevents the occurrence of kidney stones and normalizes the activity of muscles. The physiological significance of magnesium is determined by the fact that together with calcium and phosphorus metabolism, it provides bone and muscle metabolism, is involved in the synthesis of proteins and nucleic compounds, regulates the transmission of nerve impulses to muscles, and has antyspastychnu vasodilator effect, increases the secretion bile and intestinal activity, prevents calcification of vessel sides, pathological changes in kidneys tissues. The daily demand of magnesium varies from 60 to 450 mg. (Проданчук et al., 2006). The lack of it contributes to such diseases as myocardial infarction. Average daily diet contains less magnesium than it is demanded, because of food treatment (cleaning, fractionation, freezing, refining), that causes partial loss of minerals and vitamins. The food cooked in hard water, is partially enriched with magnesium and calcium. The use of softened water may decrease the quantity of magnesium. Optimal magnesium content in drinking water of high quality is 1:2 - 1:3 of calcium content, but no more than 30 dmg/m³ (Hikōepr 2011).

Organism gets additionally 21 - 24% of magnesium with drinking water, which hardness is 7 mEq / L. Only 30% of magnesium as well as calcium is absorbed with food, whereas 60% -with drinking water.

Last reaffirms particular importance of solid magnesium treatment in reducing cardiovascular disease.

Recently numerous epidemiological research carried out in England, the USA, Japan and other countries (Наказ Міністерства охорони здоров'я України 2010) have found that there is an inverse connection between the level of water hardness and mortality rate caused by cardiovascular disease. In some places, positive changes were observed after a few years after the water hardness had been increased artificially, and on the contrary artificial water softening turned out to have negative impact on human health in other areas. In one region of Florida rainwater supply was replaced by deep wells water supply and 4 year after mortality rate from cardiovascular diseases has decreased by half. Mechanism of protective effect of hard water is still not fully investigated. It is not proved if it can be explained by the availability of calcium, magnesium or any accompanying micronutrients or conversely, by their absence in hard water. While most researchers tend to define a protective role, mainly of calcium which together with magnesium is a component of enzyme system infarction and regulates electrolyte balance. Decreased levels of calcium in blood (changing the Ca/Mg) entails the continuation of Q-T interval on ECG, susceptibility to arrhythmias and risk of sudden death. What is more, in the serum of the population that consumes soft water, the calcium level is lowered. There is evidence that in countries located on Precambrian rock formations, groundwater is soft, and the incidences of cardiovascular disease is higher than in areas with limestone rocks, where groundwater are enriched with calcium and trace elements. According to the authors, the value of water as a source of calcium for the human body is more than once thought. The fact that only 30% food calcium is absorbed, whereas 90% drinking water calcium. Noteworthy, vegetables, cooked in soft water, lose a significant amount of calcium and those cooked in hard water, become even calcium enriched by settling it on the surface of vegetables. Thus, regulation of hardness and concentrations of calcium and magnesium in the water has now become complicated.

Therefore, the aim of our research is to investigate water hardness in districts of Lutsk and define its impact on the human body.

In this paper, several theoretical and practical research methods were applied, namely:

- **Theoretical** (*analysis of literature on the topic*).
- **Experimental** (*determination of water hardness by method of complexonometrics*).
- **Statistical analysis of quantitative indicators** (*method of mathematical statistics*).

To determine water hardness water samples in different districts of Lutsk were collected. In total 150 water samples were taken (at least 5 samples from each district). The research was conducted using complexonometric titration. Each sample was titrated with the working trilon-B solution and the indicator black T eriochrome. Stable pH was maintained with ammonium buffer mixture. Triple parallel titration were performed. Average water hardness was calculated for each sample.

Calculation of total water hardness was carried using the formula:

$$T_{\text{заг}} = \frac{C_{\text{трилонБ}} \cdot V_1 \cdot 1000}{V_2}$$

where:

V1 - volume of solution trilon, ml ;

V2 - volume of water analyzed, ml;

C - concentration of trilon-B solution, mol equiv / l.

The results illustrated there are two categories of tap water in Lutsk:

- **water of medium hardness** (hardness of 5.4 to 7.0 mEq / L), consumed in Dubnivska, Rivnenska, Glushets, Lesi Ukrainki, Stepan Bandera streets, Vidrozhennya and Sobornosti prospects, DPZ and 40 quarter districts (area A).
- **hard water** (hardness 7.0 to 8.0 mEq / L). This water is supplied to other districts of Lutsk (area B).

Tap water in Lutsk meets the maximal allowed concentration according to total water hardness.

Results

Since we found that in the city of Lutsk water is hard, the next step was to test hypothesis that the development of cholelithiasis is connected with water hardness. That is why patient records of department of minimally invasive surgery of the City Clinical Hospital № 2 were examined, which were diagnosed with cholelithiasis. In 2012, these were 153 such patients. It was found that 11% of all operated (18 pers.) lived on Sobornosti prospect, 7.8% (12 people) living on the Konyakina street, 5.9% “ (9 pers.) – Vidrozhennya prospect, 5.2% (8 people) - on the Kravchuk street. These areas belong to the area A. Thus, the hypothesis of connection between cholelithiasis and level of water hardness was not confirmed in our research.

Conclusions

To sum up, we conducted an experiment of water hardness in Lutsk. We have created a map of water hardness. We have found out that tap water is of high hardness, but meets the maximal allowed concentration. Connection between development of kidney stone disease and consumption of hard water has not been proved.

Literature

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