

The research of fluoride ions concentration in household water supply

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Abstract. Poor quality water is the second risk factor after poverty for diseases dynamics. Fluorine is important for human health, and since the main route for its introduction into the body is water, hygienic assessment of drinking water quality based on the content of this microelement at the regional level is very relevant, thus it has become our research objective. Eight districts of the region are characterized by such fluoride content in water which is significantly lower than optimal values; five districts by the concentrations exceeding maximum permissible values; and only three districts by approximately optimal average values. Different concentration of fluoride in the regional water supplies depends on the natural factor of this geographical zone. To provide the population of the region with high-quality drinking water a complex of various measures including the development and implementation of programs for improving local water supplies are required.

1 Introduction

Poor quality water is the second risk factor after poverty for diseases dynamics. Therefore, the most important task in creating population sanitary and epidemiological well-being in the Russian Federation is to provide high-quality drinking water safe in terms of epidemiology (microbiological composition) and harmless in terms of its chemical composition. At the same time, potable water should also be useful since it considerably determines water-salt metabolism of the organism (up to 10% of mineral substances enter with drinking water). Fluorides are given special importance, as these substances come only with water (in food they are in a poorly digestible form) [1]. Fluorine is a world widely spread microelement in groundwater. At the same time, according to N. V. Kanatnikova and G. L. Zakharchenko, its concentration is constant in most artesian wells. Both factors are equally unfavorable for human body - the lack and the excess of this microelement [2]. The lack of fluoride in the body is can cause dental caries. The increase in the fluoride ions concentration in potable water over 1.5 mg/l causes to another dental disease - fluorosis; over 5 mg/l - decreases calcium and phosphorus exchange in the bone tissue, protein and carbohydrate metabolism is disrupted, central nervous system inhibition processes are facilitated, potassium depletion occurs in tissues, etc.

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Since fluorine is essential for human health, and its main route into the body is via water, thus hygienic assessment of the drinking water quality based on this microelement content at the regional level is very relevant, so it has become the research objective.

2 Materials and methods

This report contains the research data received by the Department of Biology and Ecology of the Vladimir State University in 2018. During the period, about 150 samples of municipal water supplies in the Vladimir region were analyzed. Most of them were sampled in the largest localities (mainly regional and district centers). The fluoride ions amount in water was determined applying capillary electrophoresis (Federal Environmental Regulations 14.1.2:4.157-99). The regional zoning map was compiled based on fluoride ions content in municipal water supplies using the ArcView 3.1 GIS program,

3 Results

Mainly underground aquifers are used as water sources for municipal supply in the region. The water in most of them contains a number of chemical elements with the concentration exceeding or almost exceeding the permissible values for drinking water (hardness, iron, manganese, mineralization). This circumstance is stipulated by the specifics of geochemical composition of water-bearing rocks, the peculiarities of the underground water regime, as well as the gradual mining of mineralized waters from deep horizons.

The map of natural geochemical anomalies compiled by the Department for Subsurface Resource Management in Central Federal district [3] included the Vladimir region, in particular, Alexandrov, Kirzhach, Kolchugino, Petushky, Sobinka, Sudogoda and Suzdal districts into the fluorine-bearing province of the mid carboniferous deposits in addition to the Tver, Moscow and Ryazan regions. It means that underground water used for domestic drinking water supply in these areas contains or may contain an excessive amount of fluoride ions. The presence or absence of the latter in the water of municipal water supply in these areas also depends on another important circumstance – the availability of water treatment and purification systems for removing harmful components in these locations.

Basing on the fact that health is affected not only by high concentrations of this element, but by low concentrations as well (but this information is not available in the region), we have studied the drinking water quality dealing with the presence of fluoride in it. The results of the maximum (C_{\max}) and minimum (C_{\min}) concentrations of fluoride ions in the water of municipal water supply in the Vladimir region are presented in the table.

The WHO guidelines for drinking water quality recommend 1.5 mg/l. Fluoride optimal concentration is considered to be 1 mg/l for the midland of our country, 1.2-1.5 mg/l for the Northern regions, and 0.5-0.7 mg/l in the southern regions. Basing on these guidelines and the received data, we compiled the map reflecting the average content of fluoride ions in the municipal water supply of the Vladimir region (Fig.) [4].

4 Discussion

The conducted research revealed that fluoride ions content in the municipal water supply of the region is characterized by significant differentiation. Groundwater chemical composition is formed under the influence of numerous different natural factors and has its own regional characteristics in different geographical zones; it is usually characterized by an excessive or insufficient content of certain macro- or microelements and therefore is

rarely balanced in a favorable ratio for human body. Fluoride deficiency in the body causes dental caries, its incidence decreases with the increase of fluoride ion concentration in water up to 1 mg/l. Eight districts of the region were characterized by fluoride content in water is significantly lower than the optimal values. These areas are Yuriev-Polsky, Suzdal, Kameshkovo, Vyazniki, Gorokhovets, Selivanovo, Melenki, Kovrov districts and Vladimir city. Since most water supplies contain little fluoride (less than 0.5 mg / l), fluoridation is one of the ways to increase its content in potable water. In five districts namely Alexandrov, Kolchugo, Petushki, Sobinka, Sudogoda districts and Raduzhny town, the excess of the maximum permissible concentrations of fluoride ion was detected. The excessive fluoride content in the water of these areas depends on the natural factor of this geographical zone, its geochemical anomaly, and is proved by data published by the Department Subsurface Resource Management in Central Federal district.

Water containing more than 1.5 mg/l of fluoride ion affects human body adversely, causing fluorosis, the disease referred to the geochemical endemics. Fluorosis should be prevented in all areas characterized with fluoride excess in potable water sources, but primarily where fluoride ions content exceeds MPC. To avoid negative consequences, it is recommended to remove excess fluoride from drinking water. The treatment methods based on the principles of adsorption, ion exchange, coagulation-precipitation, membrane separation, electrolytic defluorination, electro dialysis [5-8], etc. can be applied.

Table 1. The content of maximum (C_{max}) and minimum (C_{min}) concentrations of fluoride ions in the water of the household water supply of the regions of the Vladimir region.

Administrative district	C_{max} , mg/l	C_{min} , mg/l	C average, mg/l
Alexandrovsky	1,95	1,41	1,67±0,28
Vyaznikovsky	0,21	0,14	0,17±0,04
Gorokhovetsky	0,27	0,12	0,17±0,07
Goose-crystal	1,41	0,17	0,78±0,49
Kameshkovsky	0,85	0,15	0,38±0,27
Kirzhachsky	1,14	0,05	0,67±0,52
Kovrovsky	0,32	0,17	0,23±0,06
Kolchuginsky	2,21	1,02	1,52±0,5
Melenkovsky	0,55	0,34	0,47±0,11
Murom	1,33	0,96	1,15±0,26
Petushinsky	2,75	0,66	1,51±0,82
Selivanovsky	0,38	0,31	0,34±0,06
Sobinsky	2,15	1,21	1,77±0,49
Sudogda	2,28	1,65	1,79±0,2
Suzd	0,98	0,11	0,29±0,22
Yuryev-Polsky	0,36	0,15	0,28±0,11
Raduzhny town	2,36	1,59	1,91±0,4
Vladimir city	0,77	0,16	0,47±0,35

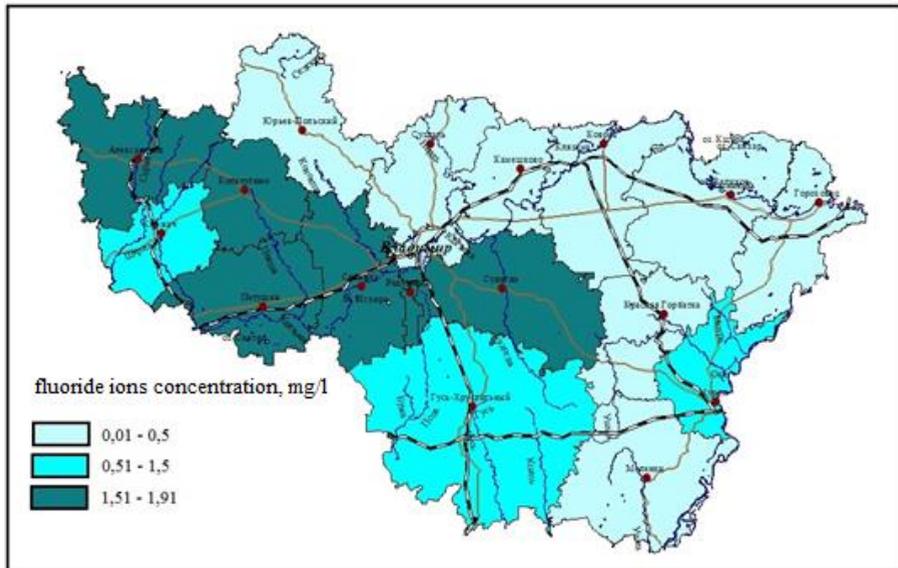


Fig. 1. Ranking of the territory of the Vladimir region by the content of fluoride ions in the water of household water supply.

Only three districts in the region are characterized by the average values for the fluoride ions content close to optimal values. They are Kirzhach, Gus-Khrustalny and Murom districts. It is interesting to note that Kirzhach and Suzdal districts belonging to the field of fluorine-bearing province, according to our research, do not exceed in the fluoride ions content. As for Suzdal district (and here we primarily mean the regional center – Vladimir city), there underground water are probably mixing with surface water at the water treatment facilities, as a result fluoride ions concentration significantly reduces.

5 Conclusion

The research revealed significant differentiation in terms of fluoride ions concentration in water of municipal supply in the Vladimir region. A whole complex of various measures including the development and implementation of programs for improving the localities water supply are required to provide population of the region with high-quality potable water.

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