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HEALTH RISKS ASSOCIATED WITH THE QUALITY OF DRINKING WATER FACED BY SARANSK POPULATION, THE REPUBLIC OF MORDOVIA

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Laboratory studies carried out in Saransk within socio-hygienic monitoring have shown that Saransk residents are impacted by a negative water peroral factor (drinking water from the centralized water supply). The level of carcinogenic risk in the city district exceeds the Deminimis level - $1*10^{-6}$; however, it is within below the maximum acceptable risk (< $1*10^{-4}$). The main contributors to the individual carcinogenic risk are chrome (YI) and cadmium. Higher non-cancer risks associated with peroral consumption of drinking water from the centralized water supply are experienced by children and some adults (hazard quotient >1.0).

Taking into account combined exposure to chemical contaminants in drinking water, children are expected to experience higher general toxic effects affecting the skeletal system, cardiovascular system, and the digestive tract.

Key words: *Drinking water, chemical contaminants, health risk, Saransk.*

Saransk is the capital of the Republic of Mordovia, a large political, administrative, economic, research, cultural and sports center of Privolzhie Federal District. The city is located on the Insar River (the Volga basin), 642 km to the east of Moscow. The population is 329 thous. people. Area – 394.3 sq. km. The city is made up of 4 residential neighborhoods: central, northwest (Svetotekhstroy), northeast (Khimmash), and southwest.

The population has been growing since 2007. The death rate per mille has decreased from 19.5 (2010) to 11.0. The infant mortality rate per mille totaled 7.1, a 17% decrease as compared to 2012. The natural increase is negative: the population loss per mille is at -0.9. The average life expectancy in the Republic of Mordovia is 68.4 years (females – 75.3, males – 61.9). The average age is 40.5 years. Circulatory diseases (more than 50%) and cancer are still the main causes of death. The population morbidity is characterized by higher levels of new growths, eye diseases, including appendages of the eye, diseases of the skin and subcutaneous tissue, diseases of the musculoskeletal system, and the urogenital system.

The city water supply uses the underground water from the higher and partially middle Carbon of the Mordovia Deposit. The water supply system is made up of five water intake facilities and small group wells located in the city. The water pipelines have various degrees of deterioration (according to Saranskgorvodokanal), ranging from 2% to 100%, which has a negative effect on the quality of drinking water in the residential areas.

The chemical content of the water is rather permanent due to its protection from the obvious sources of external contamination; however, the

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natural content of fluorine, borium, and strontium in water exceed the hygienic standards. Drinking water contains lead, cadmium, and chrome that have a high carcinogenic effect and a negative impact on public health. As a result, there is a threat of damage to the health of people who consume drinking water of poor quality on a regular basis [1,4,6,8]. The presence of such threat is proven by a number of studies conducted in Russia and abroad [2,3,7,8,10].

This situation calls for the necessity of monitoring and assessment of the level of carcinogenic and non-cancer health risks under exposure to the chemical substances consumed with drinking water from a centralized water supply.

Materials and methods. Following the Guidelines to the Assessment of Public Health Risks under Exposure to Environmental Chemical Contaminants, and the WHO Guidance Documents [5, 9], an assessment of the quality of drinking water for the period of 2010-2012 was conducted in 2013, based on the results of laboratory studies, within a socio-hygienic monitoring, at 22 control points scattered across the city districts (the districts have various sources of water supply). The studies were conducted by the Center of Hygiene and Epidemiology of the Republic of Mordovia using standardized methods.

The level of carcinogenic risk from contaminated drinking water was evaluated in terms of content of the following substances: lead, cadmium, and chrome (YI).

Results. Individual risk was registered in the range $1*10^{-5}$ - $1*10^{-7}$, which corresponds with the maximum acceptable risk, i.e. the upper limit of acceptable risk. According to the calculations, the average total carcinogenic risk in Saransk equals $5.7*10^{-5}$, for adult population -$5.0*10^{-5}$, for children aged 0-6– $6.4*10^{-5}$. Risk range – II.

The magnitude of the population carcinogenic risk (PCR) reflecting additional (to the background) number of cases of malignant growth that can appear in the course of a lifetime as a result of the impact of the analyzed peroral water factor totals 17 cases for Saransk population of 297.9 thous. people.

It was found that cancer morbidity in Saransk can be determined by the content of lead, chrome (YI), and cadmium in drinking water. The conducted analysis of cancer hazard revealed that the biggest contributors to the development of individual carcinogenic risk are chrome (YI) and cadmium. Saransk residents are exposed to the negative impact of peroral water factor (drinking water from the centralized water supply system). The level of carcinogenic risk in all the districts of Saransk exceed the Deminimis level - $1*10^{-6}$.

Elevated levels of non-cancer risks associated with peroral consumption of drinking water from the centralized water supply in Saransk are faced by children and some adults (HI> 1).

Table 1.

Individual carcinogenic risk (CR) and total carcinogenic risk (Rsum) with peroral consumption of chemical substances in Saransk

#	Substances	CR (adults)	Risk range	CR (children aged 0-6)	Risk range
Central residential district (Leninsky)					
	Lead	$5.0*10^{-7}$	I	$6.3*10^{-7}$	I
	Cadmium	$1.4*10^{-5}$	II	$1.6*10^{-5}$	II
	Chrome (YI)	$3.0*10^{-5}$	II	$5.4*10^{-5}$	II
Rsum*		$4.47*10^{-5}$	II	$7.6*10^{-5}$	II
North-West (Svetotekhstroy)					
	Lead	$5.4*10^{-7}$	I	$6.3*10^{-7}$	I
	Cadmium	$4.3*10^{-6}$	II	$5.0*10^{-6}$	II
	Chrome (YI)	$4.7*10^{-5}$	II	$5.5*10^{-5}$	II
Rsum*		$5,18*10^{-5}$	II	$6.0*10^{-5}$	II
Oktyabrsky District (Khimmash)					
	Lead	$5.6*10^{-7}$	I	$6.5*10^{-7}$	I

	Cadmium	$4.4*10^{-6}$	II	$5.1*10^{-6}$	II
	Chrome (YI)	$4.7*10^{-5}$	II	$5.5*10^{-5}$	II
Rsum*		$5.19*10^{-5}$	II	$6.0*10^{-5}$	II
South-West					
	Lead	$5.4*10^{-7}$	I	$5.7*10^{-7}$	I
	Cadmium	$4.4*10^{-6}$	II	$5.1*10^{-6}$	II
	Chrome (YI)	$4.7*10^{-5}$	II	$5.5*10^{-5}$	II
Rsum*		$5.19*10^{-5}$	II	$6.0*10^{-5}$	II

*Total carcinogenic risk (Rsum = CRPb + CRCd + CRC

Table 2.

Population carcinogenic risk (PCR) associated with peroral consumption of the substance in Saransk

City District		Population size	Individual risk	Population risk;
Central Residential District (Leninsky District + South-	Population at	103287	$5.8*10^{-5}$	5.99 (5.79)
	Adults	86698	$4.83*10^{-5}$	4.18 (4.8)
	Children (0-6)	6845	$6.8*10^{-5}$	0.46 (6.7)
North-West (Sveto-tekhstroy)	Population at	94880	$5.6*10^{-5}$	5.3 (5.6)
	Adults	78244	$5.18*10^{-5}$	4.05 (5.17)
	Children (0-6)	7625	$6.0*10^{-5}$	0.45 (5.9)
Oktyabrsky District	Population at	99757	$5.6*10^{-5}$	5.58 (5.59)
	Adults	82760	$5.19*10^{-5}$	4.29 (5.18)
	Children (0-6)	7328	$6.0*10^{-5}$	0.43 (5.86)
Saransk	Population at	297924	$5.7*10^{-5}$	17 (5.7)

Hazard index HI> 1 associated with contaminated drinking water (adults) was registered in South-West Saransk and is determined mainly by fluorides and strontium, to a lesser degree – borium. This means that the adult population residing in South-West faces non-cancer risks (HQ fluorides – 0.9; HQ strontium – 0,2; HI skeletal system – 1,1; HI summary -1,2) as a result of drinking water from the city centralized water supply system.

Hazard index HI> 1 associated with contaminated drinking water (children 0-6, sensitive group) was registered in South-West Saransk, North-West Saransk, Oktyabrsky District, and Leninsky District, and is determined by the presence of fluorides, strontium, borium, and nitrates in the drinking water.

Children are the most susceptible population group in Saransk in terms of the general toxic impact of chemicals in drinking water from the city centralized water supply system. Taking into account the combined impact of the group of contaminants contained in the drinking water, the critical organs and systems, including the skeletal system, cardiovascular system, and the digestive tract, are expected to experience higher general toxic effects. Saransk residents are facing a higher probability of non-cancer effects.

Consequently, the results of the conducted risk assessment show that the chemical content of drinking water does not provide zero hazard to public health. The reason for that is the content of chemicals in the drinking water that have general toxic and carcinogenic properties. Consequently, it is recommended to develop and implement additional activities aimed at drinking water preparation and quality control in the city.

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