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Assessment of Non-Carcinogenic Adolescent Health Risk from Drinking Water.

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ABSTRACT

The total hazard index (THI) on peroral ingestion of chemical compounds and elements with drinking water in the selected zones of the city of Kazan indicates high and average risk levels for the adolescents living in the 1st and the 4th zones correspondingly, and low level – for the adolescents from the 2nd and the 3rd zones, and is dangerous for health. According to the results of analysis carried out in all zones the following basic critical organs and systems were identified: blood, CNS, kidneys, the endocrine system, the cardiovascular system, the skeletal system and the teeth.

Keywords: Adolescents, risk, drinking water, risk levels, target organs, peroral route of ingestion

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INTRODUCTION

WHO develops international norms in the field of water quality and human health care in the form of guidelines, which are applied as the basis for standards regulating and setting all over the world. These guidelines contribute to strengthening of public health stimulating the development of standards and regulations with the account of regional conditions (target values based on medical data), the application of preventive approaches to risk management encompassing all the chain from the water intake to a consumer (water safety plan provisions) and carrying out of independent epidemiological surveillance to control the implementation and increase of the effectiveness of the water safety plans and national standards' compliance.

One of the most important ecological factors of the habitat having effect on the population health in the territory under study is the quality of the drinking water provided from the centralized water supply sources. Children and adolescents are most sensitive to the effect of unfavorable environmental factors; therefore the child population health can be a reliable indicator of ecological well-being of the region [1].

So far, carrying out of work on risk assessment with development of the evidence-based methodology for the health risk realization in the form of health impairments (via epidemiological or in-depth medicobiological studies) is of utmost importance. Risk assessment allows narrowing considerably the search both on the influencing factors and probable health impairments of the exposed population and saving significantly time and means for acquisition of the evidence base confirming the availability of harm to health. The child population exposure to environmental pollutants differs considerably from the one observed in adults due to various causes associated with children's activity, behavior and nutrition, physiological peculiarities of metabolism, permeability of the skin integuments , and etc. The analysis of studies on the risk assessment in our country and in the Republic of Tatarstan showed the availability of methodological and toxicometric problems resulting in underestimation of actual health risk level of the child population associated with uncertainties of the exposure assessment, absence of regional and age differences in the factors of exposure and sensitivity to carcinogens [2-4].

Thus, development and application of information on the realization of the child health risk assessment based on standard and regional exposure factors is an urgent field of scientific research. The main document in the RF, in which the principles of the health risk assessment realization are given, is the Guidelines P 2.1.10.1920–04 "Guidelines on the assessment of the population health risk on exposure to environmental chemical pollutants". Currently, the solution of the problem of hygienic assessment of the drinking water quality is impossible without scientific justification and assessment of its safety on the basis of methodology for the assessment of the population health risk. Moreover, approaches applied in risk assessment allow revealing actual sources and causes of the habitat pollution identifying contributions of the ingestion routes and actual hazard factors.

The adolescent age is associated with stress of all body systems on the whole, and it can have an increased sensitivity to various environmental factors effect and to pollution of drinking water in particular.

The aim of the work is to assess the noncarcinogenic health risk for the adolescent population (aged 15-17 years) on peroral ingestion of the chemical compounds with drinking tap water based on regional exposure factors.

MATERIALS AND METHODS

The assessment of noncarcinogenic risk on ingestion of chemical substances with drinking water was carried out for the adolescents aged 13-15 years living in 4 districts (1- Vakhitovsky, 2- Sovetsky, 3- Kirovsky, and 4- Privolzhsky) of the city of Kazan, and that fact allowed minimizing the uncertainties associated with specific regional parameters in exposure assessment. The selection of the research zones was carried out on the basis of arrangement of permanent stations for monitoring the atmospheric air pollution and children's polyclinics (No.1, 2, 3, 4) providing services to these districts with the purpose of subsequent complex assessment of the multi-environmental risk. The risk assessment was carried out according to the data of the Regional Information Fund (RIF) of social and hygienic monitoring and results of the research carried out on

the basis of an accredited laboratory of the Federal State-Funded Healthcare Institution "The Center of Hygiene and Epidemiology in the Republic of Tatarstan" in keeping with Guidelines P 2.1.10.1920-04 [5,6].

The HQ values in the range from 0,11 to 1,0, and HI – from 1,1 to 3,0 were taken for an allowable level of noncarcinogenic effects. Information on regional exposure factors was obtained in the cross-sectional study during the questionnaire survey of 930 adolescents aged from 13 to 15 years). A questionnaire developed by the researchers of the Institute of Fundamental Medicine and Biology of the Kazan (Volga region) Federal University included the following information on the exposure factors: the child body weight/mass (kg), height (cm), the amount of drinking water taken (l/24hrs), the number of water procedures (hand washing) – (times/24hrs), taking a shower (a bath) – times /week, the duration of water procedures (min/24 hrs), exposure time (days/year), spending time outdoors (hrs/24hrs), spending time indoors (hrs/24hrs). A standard formula for calculating an average daily dose and regional exposure factors in peroral ingestion of chemicals with drinking water was used: $I=(C_w*V*EF*ED)/(BW*AT*365)$, where C_W is the substance concentration in water, mg/l, V- the amount of water taken in l/24hrs, EF – exposure frequency, days/year, ED – exposure time, years, BW- body mass, kg, AT – the exposure averaging time, years.

The noncarcinogenic risk (exposure route: per os) is assessed by calculating the hazard quotient (HQ): $HQ = I/RfD$,

where I is an average daily dose of a substance on peroral route , mg/kg, RfD - reference (safe) dose.

To assess the total effect of chemical substances the total hazard index is applied:

$$HI = HQ_1 + HQ_2 + ... + HQn ,$$

where HQq, HQ_2, HQn – hazard quotients of the 1^{st} ,2^{nd} ... n –th chemical substances. The HI is usually calculated only for the substances having effect on the same body organs and systems.
Statistical analysis of the obtained data was implemented in operating system Windows 2007, with the use of standard application program packages Excel 2007 and «STATISTICA v.6.0».

RESULTS

Water supply to the citizens of Kazan is carried out from the "Volzhsky" surface water intake, the underground water intakes and the artesian boreholes. Volzhsky" water intake provides 80% of the city population including Kirovsky (the 3^{rd} zone) and Vakhitovsky districts (the 1^{st} zone) with drinking water. The population of the Soviet district (2^{nd} zone) uses drinking water of a mixed character ("Volzhsky" water intake and the underground water sources Aki, Azino and Solidarnost). The Volga (Privolzhsky) district of the city (4^{th} zone) is provided with mixed water from the water intakes "Mirny", "Tankodrom" and "Volzhsky". We carried out a comparative analysis of the chemical composition of the drinking water in the city zones under study. It was found out in the course of studies that average concentrations of the chemical elements in different city zones didn't exceed the hygienic regulations (MAC), although they vary widely. In our opinion, it is due to their belonging to underground and surface water supply sources, as well as different degree of the worn-out state of the transfer manifolds [7].
The composition of drinking water has an effect on formation of the total risk for the population health and contributes to the increased population morbidity [8].

Analysis of an average content of certain metals (HM) in the sources of the central water supply of the city of Kazan for the period from 2010 to 2015 revealed significant differences between them in the content of zinc and magnesium, which were above the standards in the underground water sources [9-11].

16 pollutants (aluminum, barium, iron, calcium, magnesium, nitrates, (in NO3), nitrites (in NO2), cadmium, manganese, lead, strontium (stable), copper, zinc, fluorides, residual chlorine, oil products (in total), chloroform are on the list of priority substances ingested with drinking water via the peroral route. The key criteria for the choice of priority chemical compounds were high proportion of unsatisfactory samples in hygienic studies, determination of the reference doses (RfD), awareness on critical target organs required for calculating the quotients and other reference values.

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The results of the noncarcinogenic risk assessment of the chemical substances ingestion with drinking water showed that the highest level of the total hazard quotient (HI = 7,5 and 3,5) is observed in the zone of Vakhitovsky (1) and Privolzhsky districts (4). The major contribution to the risk value in the 1st zone is made by oil products -54%, nitrates (in NO3) – 12,8%, chloroform – 9,8%, fluorides – 6,4%, magnesium – 4,7% and iron – 4,7% of total risk value. The 4th zone, where the major proportion of the risk value is also determined by nitrates (in NO3) - 32%, oil products – 29,7%, chloroform -13,2%, chlorine – 9,1%, fluorides – 5,6% ranks second in the risk level. Such tendency is characteristic for the rest city zones: 67,4 – 73,1% of the total risk values accrue to chloroform, fluorides, nitrates, iron, and oil products. According to the criteria for the risk levels the major part of the analyzed chemical substances ingested with drinking tap water almost in all zones have minimum risk level (HQ < 0,1). Analysis of the combined ingestion of chemicals with drinking water showed that the main effect and risk for target organs were caused by the toxic effect of chloroform (liver, kidneys, CNS, hormone system, blood), oil products (kidneys), fluorides (teeth, skeletal system) and nitrates (blood, cardiovascular system), iron (mucosa, skin, blood, immune system)(Table 1).

Table 1: Critical organs and systems according to the results of the noncarcinogenic risk assessment on ingestion of chemical substances with drinking water

Critical organs / systems	Hazard indices (HI) in zones				%, of the HI value in certain zones			
	1	2	3	4	1	2	3	4
Mucosa	0,86	0,16	0,19	0,07	10,64	4,79	4,23	1,01
Skin	0,35	0,16	0,19	0,07	4,33	4,79	4,23	1,01
Blood	0,98	0,54	1,27	1,72	12,13	16,17	28,27	24,80
Immunity	0,35	0,16	0,19	0,07	4,33	4,79	4,23	1,01
GIT	0,05	0,03	0,02	0,04	0,62	0,90	0,45	0,58
Liver	0,73	0,34	0,02	0,45	9,03	10,18	0,45	6,49
Kidneys	0,73	0,39	0,16	1,6	9,03	11,68	3,56	23,07
CNS	0,86	0,4	0,46	0,7	10,64	11,98	10,24	10,09
Biochemical indicators	0,06	0,06	0,06	0,035	0,74	1,80	1,34	0,50
Development	0,06	0,06	0,061	0,035	0,74	1,80	1,36	0,50
Reproductive system	0,06	0,06	0,061	0,035	0,74	1,80	1,36	0,50
Endocrine system	0,86	0,42	0,55	0,49	10,64	12,57	12,24	7,07
Skeletal system	0,54	0,2	0,33	0,23	6,68	5,99	7,35	3,32
Teeth	0,48	0,15	0,29	0,19	5,94	4,49	6,46	2,74
Cardiovascular system	1,11	0,21	0,64	1,2	13,74	6,29	14,25	17,30
Total hazard index (HI)	8,08	3,34	4,492	6,935	100	100	100	100

As far as the total risk value is concerned, the 1st and the 4th zones with the total hazard index (HI) equal to 7,5 and 3,5, which meets the criteria of high and alarming level, are distinguished. [2,10] Ranging in the risk value and percent distribution of the obtained data demonstrates that the major critical organs and systems on peroral route of the chemicals ingested with drinking water are: blood (12,1% - 28,2 %), CNS (10,09% -10,6%), kidneys (3,5% - 23,07%), endocrine system (7,0% - 12,5%), cardiovascular system (6,29% - 17,3%), skeletal system (6,6% – 7,3%) and teeth (2,7% - 6,4%); whereas biochemical indicators, development, reproductive system correspond to the risk level within the values of HI from 0,50 to 1,8.

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DISCUSSION

The results of noncarcinogenic risk assessment on ingestion of chemicals with drinking water showed that the risk value in all zones correspond to the allowable level of noncarcinogenic risk (HQ < 1) for the major part of elements. The excess of the allowable level is observed only for oil products in the 1st zone (4,1) and the 4th zone (1,04) and for nitrates (1,13). However the total hazard index (HI) on combined peroral route of the chemical compounds and elements ingested with drinking water in the selected zones of the city of Kazan indicates a high and an average risk levels for the adolescents living in the 1st and the 4th zones, correspondingly, and a low level – for the adolescents from the 2nd and the 3rd zones, and it is dangerous for health. According to the analysis results in all zones, the main critical organs and systems were identified. They are: blood, CNS, kidneys, the endocrine system, the cardiovascular system, the skeletal system and the teeth. Particular attention should be paid to the total hazard indices in the 1st and the 4th zones. They exceed by a factor of 1,6 – 3,5 the indices in other zones under study. The major contribution to the risk value is made by the following elements: oil products (29,7% - 54,0%), nitrates (in NO3), chloroform and fluorides. Continuous presence and ingestion of chemical substances with drinking water are the hazards having highest priority for the adolescents living in the zones under study in the city of Kazan. Combined long-term effects, even within the limits established by the hygienic regulations, create the danger of chemical load on the human body and are a health risk factor for the adolescents of the city of Kazan.

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REFERENCES

[1] Margot TB., Foos BP. Assessing children's exposures and risks to drinking water contaminants: a manganese case study. Human and Ecological Risk Assessment. 2009; 15; 923-947.

[2] Stepanova NV., Valeeva ER. Main trends in children's population health in the Republic of Tatarstan. Hygiene and sanitation. 2015; 1; 92-97.

[3] Valeeva E.R., Stepanova N.V., Kamalova F.M., Serazetdinova F.I. Current Problems of Adolescent Health in the Republic of Tatarstan. Modern Problems of Science and Education. 2015. No.6-0. P. 239.

[4] Unguryanu TN. Population health risk under comprehensive effect of the drinking water pollutants. Human ecology. 2011; 3; 14-20.

[5] Rakhmanin JA., Onitshenko GG., Kiselev AV. Guidelines for health risk assessment for the population on exposure to chemical substances polluting the environment (P 2.1.10.1920-04). Moscow: Federal Center of the State Committee for Sanitary and Epidemiological Control. 2004; 143.

[6] USEPA 2008. Child-Specific Exposure Factors Handbook. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=199243 . Accessed 3 May 2017 year.

[7] Stepanova NV. Heavy metals: Problems of impact (by the example of Kazan city) part1. B: Stepanova NV. , Valeeva ER., Fomina SF. , Kamalova FM., Tunakova JuA., Faizullina RA. Kazan: LLC Publishing and Printing Complex "Brig" ; 2015: 140

[8] Berezin I I., Mustafina GI. Regional features of the chemical composition of potable water from economic-drinking water supply in Samara city. Proceedings (Izvestiya) of the Samara Scientific Center of the Russian Academy of Sciences (RAS). 2011; 1- 8; 1837-1840.

[9] Stepanova NV., Valeeva ER., Ziyatdinova AI., Fomina SF. Peculiarities of children's risk assessment on ingestion of chemicals with drinking water. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 2016; 7(3); 677-1681.

[10] Onitshenko GG., Novikov SM., Rakhmanin JA., Avaliani SL.The foundations of the population health risk assessment on exposure to chemical substances polluting the environment. Moscow: Research Institute of Human Ecology and Environmental Hygiene; 2002; 408.

[11] Avaliani SL., Novikov SM. Shashina TA., Kislitsin VA., Skvortsova NS. Experience of use of methodology of an assessment of risk to population health for ensuring sanitary and epidemiologic wellbeing: In: Works of the All-Russian Scientific and Practical Conference with the International Participation. Experience in the Use of Risk Assessment Methodology for Public Health to Ensure the Sanitary and Epidemiological Welfare; Angarsk: RIO ATA; 2012; 12-16.