

DRINKING WATER QUALITY INDICATORS

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Abstract: The quality of drinking water is currently a pressing issue, which plays a special role in the initiative of environmental protection, ecology and hygienics. When any sector of modern industry is developing, its activities are associated with a possible risk of contamination of water used by the population as drinking water, and with generation of industrial wastewater polluted with chemically aggressive agents, which are dangerous to human health. The authors of this paper produce an assessment of risks with respect to the indicators of the olfactory-reflex effect of drinking water samples obtained in Kazan. The research results allow for an assessment of the level of health risk, which the city residents would face because of drinking water ingestion, and for a specification of polluting substances through sensory evaluation.

Keywords: drinking water, risk, organoleptic indicators

Introduction. Special attention should be paid to the evaluation of risk and assessment of drinking water quality with regard to the indicators characterized by an olfactory-reflex effect of exposure. General principles of calculations, as well as exposure and reference doses are given in the R 2.1.10.1920-04 Guide on Human Health Risk Assessment from Environmental Chemicals. Instructional guidelines MP 2.1.4.0032-11.2.1.4 on Drinking Water and Water Supply to Populated Areas set forth general principles of the integral estimate of drinking water in centralized water supply systems in terms of chemical safety. An unbiased and complete evaluation of drinking water is crucially important for determining its quality using various methods and risk management tools. The environmental exposure leads to a transition in the system of assessing drinking water quality according to a principle of establishing the qualitative or quantitative characteristics of matters that are toxic to human health. Contamination of drinking water is a very pressing issue causing much concern for the humanity. According to the data of the World Health Organization, the remaining quantity of clean drinking water, which could be consumed without pretreatment, is as low as one percent. But the use of poor-quality drinking water may have a severely adverse impact on the body and cause a risk of various diseases. Contamination of drinking water sources has been particularly intensive in the past few decades. Notably, pesticide contamination is difficult to identify due to its low concentration. A human body accumulates toxic substances, which, over time, give rise to a variety of diseases,

including cancers. Heavy-metal contamination of domestic water is dangerous because these metals are not removed from the body, but accumulate in it. Besides, such a dose may be a thousand times higher than that in the environment. Early on, it is very difficult to detect the accumulation of toxic substances, not until their amount in a body reaches a dangerous concentration. If it happens, it is almost impossible to remedy the situation.

Relevance. Ensuring the sensory properties of drinking water is the main goal of water conditioning and purification in the conditions of a centralized water supply. Identification of the threshold concentrations of polluting agents affecting the odor and taste of water is reduced to the Weber-Fechner law, in which the sensational intensity is proportional to the logarithm of the substance concentration. Sensations resulting from the interaction between the receptors in the oral cavity and substances dissolved in water are perceived as gustatory sensations, also registered through the olfactory perception. The differences between gustatory and olfactory sensations are minimal; therefore, a combined method is used for assessing water quality. The principal stages of risk assessment include hazard identification, exposure assessment, dose-effect relationship analysis and risk characterization. The first stage is an identification of hazardous chemical or radioactive substances in the water of the area of interest, which are regarded as adverse environmental factors. Screening assays with a qualitative risk assessment may be used while examining drinking water and preparing quality assurance programs. The identified hazard indexes are used to recognize and diagnose the following:

- risk factors affecting water quality in water conditioning and supply;
- frequency of testing and a specific location of check points;
- presence of abiotic and human-made chemicals in water, affecting human health;
- types of adverse effects of the analyzed chemical and radioactive substances.

The sanitation condition of the site for collecting water in a specific area, control over the arrangements and quality in accordance with the list of hazardous substances, as well as observance of the protected zones, allow for an impartial qualification of the surface water source. The quality of drinking water depends on various factors, which include land farming methods, liquid and solid waste presence, and industrial wastewater discharge within an unacceptable radius of drinking water withdrawal. Localities and unauthorized landfill sites may also affect the chemical composition of drinking water (Sanitary Rules and Regulations 2.1.4.1110-02).

Problem Statement. The population finds that the main issue with water quality is its unsatisfactory odor and taste. The organoleptic indicators are evaluated on a five-point scale, and each score suggests the likelihood of the risk of drinking water being contaminated. A sensory evaluation was conducted in accordance with GOST R 57164-2016 Drinking water. Methods for determination of odor, taste and turbidity. This method is based on the ability of a person to sense and perceive substances dissolved in water as smells, tastes and off-tastes. The sensory evaluation was performed through a straightforward procedure of recognizing smells, tastes and off-tastes, i.e. according to the sensation of a perceived taste. These indicators were

evaluated by expertise in the room for sensory analysis, where the temperature and relative air humidity were 21°C-22°C and 68%-71%, respectively. The temperature of each water sample was 20±2°C. Among other matters, this study was intended to provide a rationale for the scientific approach to the integrated estimate of risks to the health of Kazan residents due to the effects of chemically aggressive compounds, which could be contained in drinking water, and to create a universal unified algorithm for the implementation of this approach. The expert group consisted of 7 efficient, objective people with professional and qualimetric competence. The degree of opinion consistency of the experts was confirmed by the concordance coefficient, which was 0.9. This coefficient indicates a very high consistency of estimates of the experts.

Results. The paper contains the data on drinking water quality and risk assessment. Water samples were taken in different districts of Kazan. The places of water withdrawal are shown in Figure 1. Table 1 presents the data on risk assessment of the studied samples by odor and taste. At the initial stage of the sample examination, the authors produced a model of risk assessment by odor and taste, as well as the a priori probability of risk detection depending on the selected districts of Kazan. The intensity of the contaminant concentration determining the taste and odor varies on average by 2 points. Furthermore, according to the instructional guidelines MP 2.1.4.0032-11. 2.1.4, the water samples were analyzed to determine color index, turbidity value, pH-value and salt composition (table 1).



Fig. 1 – Places of Water Withdrawal on the Map of Kazan (Samples 1-8)

Color of the examined water samples was evaluated in accordance with GOST 31868-2012. In this regard, the authors determined the optical density of the analyzed samples using a spectrophotometer at a wavelength of 380 nm, and then recorded the color using a chrome-cobalt scale (as a reference). Turbidity was determined according to GOST R 57164-2016. The applied method is based on the recording of scattered rays when the luminous flux passes in the visible or near-infrared spectral region through a water sample containing suspended particulate matter (a nephelometric method). The transition from formazin turbidity units (FTU) was done on the assumption that 1 FTU corresponds to 0.58 mg/dm by kaolin.

The hydrogen ion concentration of the samples was determined using a laboratory pH meter GMH 3531 Greisinger. In addition, the authors defined salt composition affecting the sensory (aesthetic) properties of water as required by GOST 4245-72 (chloride content), GOST 31940-2012 (sulfate content) and GOST 18309-2014 (phosphate-PO₄ content).

Table 1 – Organoleptic Indicators of Water

Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9
Intensity in points								
1	0	2	2	2	2	1	1	2
Degree of odor and taste								
very low	very low	low	low	low	low	not perceived	very low	low
Released odor and taste								
not perceived by a consumer, but detected by a specialist	detected by a consumer when pointed out					none	detected by a consumer when pointed out	
A priori probability risk of detection								
0,03	0,04	0,15	0,15	0,15	0,15	0	0,03	0,16
Color, degree								
15	10	18	17	20	19	16	15	20
Turbidity, mg/dm								
1.044	0.58	1.16	1.218	1.45	1.508	1.392	0.986	1.334
Hydrogen ion concentration, pH								
6.08	6.80	6.09	5.96	6.78	6.75	6.77	6.78	6.85
Chlorides, mg/l								
102	88	107	110	130	137	129	104	112
Sulfates, mg/l								
85	74	90	94	100	114	108	89	97
Phosphates-PO ₄ , mg/l								
0.81	0.63	1.25	1.32	2.11	2.47	2.34	0.88	1.29

Table 2 – Probabilistic Risk P_{rob} Indicators by Sensory Evaluation of the Tested Samples

Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9
By odor and flavor								
-0.06	0	-0.32	-0.32	-0.32	-0.32	-0.08	-0.06	-0.32
By color $P_{rob} = -3.33 + 0.067 \cdot C$, where C is color of water (in color degrees)								
-2.33	-2.66	-2.124	-2.191	-1.99	-2.057	-2.258	-2.33	-1.99
By turbidity $P_{rob} = -3 + 0.25 \cdot T$, where T is turbidity of water samples								
-2.74	-2.86	-2.71	-2.69	-2.64	-2.62	-2.65	-2.75	-2.67
By hydrogen ion concentration, pH if $pH \leq 7$, then $P_{rob} = 4 - pH$, if $pH > 7$, then $P_{rob} = -11 + pH$								
-2.08	-2.80	-2.09	-1.96	-2.78	-2.75	-2.77	-2.78	-2.85
By salt composition, $P_{rob} = -2 + 3.32 \cdot \lg(\text{Concentration} / \text{standard})$, where the standard $MCL_{chlorides} = 150 \text{ mg/l}$; $MCL_{sulfates} = 150 \text{ mg/l}$; $MCL_{phosphates} = 3.5 \text{ mg/l}$.								
Chlorides, mg/l								
-2.56	-1.98	-2.49	-2.45	-2.21	-2.13	-2.22	-2.53	-2.42
Sulfates, mg/l								
-2.82	-3.02	-2.74	-2.67	-2.59	-2.39	-2.47	-2.75	-2.63
Phosphates-PO ₄ , mg/l								
-4.11	-4.47	-3.49	-3.41	-2.73	-2.51	-2.58	-3.99	-3.44

The sensory and chemical analysis of water allowed for an estimation of risk indicators in conformity with the law of normal probability distribution using the appropriate formulas. The data are listed in Table 2. Probability of risk, P_{rob} is presented as an intermediate value and is necessary to convert the concentration of a hazardous

substance into the health risk caused by it. Translation of P_{rob} values into risk degrees (Risk) was done in accordance with Appendix 5 to the instructions guide 2.1.4.10-11-2-2005 Human Health Risk Assessment from Chemicals Polluting Drinking Water. Note that, in risk assessment, the olfactory-reflex effect makes it possible to select a maximum value from all groups of the found values. This approach is based on the individual characteristics of human receptors and the reactions described by the Weber-Fechner law.

Conclusion. Based on the acquired data, it follows that the overall assessment of the risk of olfactory-reflex responses for all samples is different and is within the range of 0.001-0.476; the top-priority assessment factors are odor and taste for sample 1, pH for sample 4, color for samples 5 and 9, turbidity and salt composition for sample 6. The evaluation model for the overall organoleptic risk of drinking water from various districts of Kazan showed that, if ingested with drinking water, the number one polluting agents may be the cause of the above-limit value of the total hazard index and may lead to a potential risk of diseases of hematopoietic system, digestive system and skin of the city residents. In this regard, it is necessary to pay special attention to the technical condition of the existing water supply networks in some districts of Kazan, to improve technological processes and to introduce new modern methods of drinking water purification.

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