Central Asian Journal of Medicine

CRITERIA FOR EVALUATING POLLUTION OF WATER BODIES, DRINKING WATER AND POPULATION MORBIDITY

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ABSTRACT

The article is devoted to the criteria development for assessing the surface water bodies pollution levels, drinking water and the risk of the spread of intestinal infections among the population. The developed criteria are based on the principle of priority maintaining importance the health of the population living in anthropogenic pollution conditions. The proposed criteria are based on the ranking, in points, of estimated indicators according to their health hazard degree. Four main pollution gradations are proposed: allowable-1, moderate-2, high-3 and extremely high-4. Accordingly, with the proposed gradation, the health hazard level for the pollution degree is assessed as permissible, causing concern, dangerous and extremely dangerous. It is proposed to use the methodology of the developed criteria for zoning, according to the health hazard degree, of contaminated surface water bodies and drinking water in order to reduce the incidence of intestinal infections in the population.

Key words: surface water bodies, drinking water, water quality indicators, maximum permissible concentration, intestinal infections, public health.

INTRODUCTION

The water quality of water bodies for household drinking, communal-domestic, and recreational water use is formed under the influence of both natural and anthropogenic factors [2, 3]. The main contribution to the pollution of water bodies is made by enterprises of ferrous and non-ferrous metallurgy, chemical,

petrochemical industries, energy, wastewater from agricultural enterprises and settlements [6, 8].

In modern conditions, the problem of providing the population with clean water is becoming increasingly relevant, and the study of the state of water bodies is one of the most important tasks [10, 11]. In many regions, polluted water bodies, which are sources of drinking and recreational water use, pose a serious threat to public health, causing a high incidence of intestinal infections and increasing the risk of chemical factors affecting the human body. Minimizing the risk of the water factor to health can be achieved by developing criteria for evaluating water bodies based on the degree of chemical and bacterial contamination of water [9, 12].

The developed criteria for drinking water in Russia differ significantly from international indicators or have blurred formulas, which creates certain problems for their use, and in this regard, recommendations for harmonizing the documentation have been developed [7].

In Russia, hazard criteria for substances were developed, which were used to scientifically substantiate more than 1700 maximum permissible concentrations (MPC's) and permissible exposure limits (PELs) of chemical pollution of surface water bodies. The classification was based on criteria characterizing the real danger of substances depending on their toxicity, cumulative properties, and ability to cause long-term effects [5].

One of the key tasks of ecology today is to develop criteria for assessing the impact of polluted water on the health status and to scientifically substantiate a set of measures for the protection of water bodies used for domestic, drinking, cultural, and recreational water use [1, 4].

Objective of the study. The purpose of this study was to develop criteria for assessing the levels of pollution of surface water bodies, drinking water, and the risk level of intestinal infections spreading among the population by waterways to improve environmental monitoring of water bodies.

Research material and methods. Research methods included: studying the results of analyses of drinking water quality for chemical and microbiological indicators of administrative districts of the republic for 2019-2024 in accordance with the requirements of GOST 134:2024 «Sources of centralized household drinking water supply. Hygienic, technical requirements and selection rules» and GOST 133:2024 «Drinking water. Hygienic requirements and quality control».

Research results. The developed methodology and criteria for assessing the levels of pollution of water bodies, drinking water, and the incidence of intestinal infections among the population are based on the principle of prioritizing the health of the population living in conditions of anthropogenic pollution. The

proposed method and criteria for assessing environmental pollution levels are based on existing standards and regulations in the field of water protection, drinking water, and public health. Four main gradations of surface water pollution levels have been proposed: permissible-1, moderate-2, high-3, and extremely high-4. According to the proposed gradation, the level of health hazard, the degree of pollution, is assessed as permissible, causing concern, dangerous, and extremely dangerous.

The tables we developed present indicators that have specific quantitative expressions and are used for monitoring by environmental protection agencies and Sanitary and Epidemiological Surveillance Centers.

Criteria for assessing the levels of pollution of water bodies

As is known, when developing the maximum permissible concentrations (MPC's) of harmful substances in water bodies, 3 limiting indicators of harmfulness are standardized: organoleptic, general sanitary, and sanitary-toxicological. These indicators were taken because they characterize the water quality of water bodies as recreational facilities and sources of household drinking water supply for the population. In this case, we ranked the indicators according to their quantitative significance: the sum of points up to 23 points - permissible pollution level, 24-46 points - moderate pollution level, 47-69 points - high pollution level, 70-92 points - extremely high pollution level. The criteria for assessing the level of pollution of water bodies by the degree of danger to public health are presented in Table 1.

Table 1 Criteria for assessing the level of pollution of water bodies

№	Indicators	Degree of health danger			
		1	2	3	4
1.	Toxicological indicator: degree of excess	<1 (5)*	1,1-3 (10)	3,1-10 (15)	>10 (20)
2.	Percentage of water samples containing intestinal infection pathogens	0 (5)	0,1-5 (10)	5,1-9 (15)	>9 (20)
3.	Mineralization, mg/l	<1000 (4)	1001-2000 (8)	2001-3000 (12)	>3000 (16)
4.	Organoleptic properties (odor, flavor) - in points	<2 (3)	2,1-3 (6)	3,1-4 (9)	>4 (12)
5.	the number of coliform bacteria (coli index)	$<1x10^4$ (3)	$1x10^4$-$1x10^5$ (6)	$1x10^5$-$1x10^6$ (9)	$>1x10^6$ (12)
6.	BOD_{20}, mg/l	<3 (2)	3,1-6 (4)	6,1-8 (6)	>8 (8)
7.	Dissolved oxygen, mg/L	>4 (1)	4-3 (2)	2,9-2 (3)	<2 (4)
Sum of evaluation points		<23	24-46	47-69	70-92

**Note: The values of the assessment scores are given in parentheses.*

The toxicological indicator, which indicates the degree of exceeding the established permissible limits for harmful substances in the water of reservoirs, is of greatest importance. This indicator is particularly important for chemical substances that are standardized according to the sanitary-toxicological limiting indicator of harmfulness. It can be determined from the list of permissible concentrations of harmful substances in the water of sanitary-domestic water bodies. Therefore, this indicator has a high significance level from 5 to 20 points.

Determining the criteria for the epidemic danger of water bodies is based on assessing the degree of bacterial contamination of the water. In this case, it is necessary to use the number of coliform bacteria (coli index value) and the presence of pathogenic enterobacteria (%) - causative agents of intestinal infections - in water bodies. Coli index values ranged from 3 to 12 points, and the percentage of water samples containing pathogenic enterobacteria ranged from 5 to 20 points.

The value of the water mineralization indicator of water bodies is of great importance. It is known that increased water mineralization can cause various diseases in the population. The presence of salts in water bodies deteriorates the organoleptic properties of the water, and it should also be noted that the degree of water mineralization practically does not change during the water treatment process at water supply facilities. The mineralization indicator is ranked in the evaluation table from 4 to 16 points.

It is known that the deterioration of the organoleptic properties of water in reservoirs can occur due to the appearance of unpleasant tastes and odors, which negatively affects the sanitary conditions of water use by the population. The organoleptic properties of water are assessed on a 5-point scale from 3 to 12 points.

To characterize and assess the sanitary regime of water bodies, we propose indicators of Biochemical oxygen demand (BOD) and the content of dissolved oxygen in the water. With a high level of water pollution by organic substances in the water, the BOD_5 and BOD_{20} values increase. Accordingly, the concentration of dissolved oxygen in the water decreases. Both of these indicators indicate a slowdown in the processes of natural self-purification of water and the levels of pollution of water bodies with organic substances. These indicators are ranked in the evaluation table at 2-8 and 1-4 points, respectively.

Criteria for assessing the quality of drinking water.

The evaluation table 2 presents the most informative indicators, which have a quantitative expression and characterize, on the one hand, the quality of drinking water, and on the other hand, the level of provision of the population with tap water.

Table 2 - Criteria for assessing the quality of drinking water

№	Indicators	Degree of health danger			
		1	2	3	4
1.	Toxicological indicator: degree of excess	<1 (5)*	1,1-3 (10)	3,1-7 (15)	>7 (20)
2.	Total stiffness, mg-eq/l	<10 (5)	10,1-13 (10)	13,1-16 (15)	>16 (20)
3.	Mineralization, mg/l	<1000 (4)	1001-2000 (8)	2001-2500 (12)	>2500 (16)
4.	Percentage of non-compliance for coliform bacteria (coli-index)	<1 (3)	1,1-6 (6)	6,1-10 (9)	>10 (12)
5.	TMC in 1 ml of water	<100 (2)	101-300 (4)	301-500 (6)	>500 (8)
6.	Percentage of provision with tap water	100-80,1 (1)	80-60,1 (2)	60-40,1 (3)	<40 (4)
Sum of evaluation points		<20	21-40	41-60	61-80

**Note: The values of the assessment scores are given in parentheses.*

According to the degree of priority and all proposed indicators, the most significant are the toxicological indicator and the total water hardness, ranked in the evaluation table from 5 to 20 points.

The toxicological indicator has the greatest significance and is ranked according to the degree of exceeding the established MPC for harmful substances in the water of reservoirs by 4 ranks depending on the levels of water pollution for its hazard to public health.

The indicator of total water mineralization is ranked in the evaluation table from 4 to 16 points, and the number of coliform bacteria (coli-index) is ranked from 3 to 12 points, respectively. The lowest scores are the percentage of the population's provision with tap water and the TMC (number of saprophytes) in the water. These indicators are ranked from 1 to 4 and from 2 to 8 points.

The overall hardness and mineralization indicators of drinking water were selected taking into account the increased salinity level of water supply sources, as well as a number of technical problems related to the desalination and softening of drinking water. When grading these indicators, the requirements of GOST 950:2011 «Drinking Water. Hygienic requirements and quality control» and recommendations of the World Health Organization (WHO). In the evaluation table, these indicators are ranked from 5 to 20 and from 4 to 16 points, respectively.

The number of coliform bacteria (coli index) and TMC (total microbial count) indicators of drinking water characterize the degree of bacterial contamination and the degree of its epidemiological hazard. These indicators are based on the requirements of GOST 950:2011: coli-index not more than 3, the total number of microbes in 1 ml of water - not more than 100. Both indicators characterize the

sanitary and technical condition of water treatment plants and the effectiveness of drinking water disinfection. In the evaluation table, these indicators are ranked from 3 to 12 points and from 2 to 8 points, respectively.

The percentage indicator of the population's provision with tap water reflects the conditions of water use. The inclusion of this indicator in the assessment table is due to the insufficient coverage of the population with centralized water supply systems, the widespread use of water bodies with a high level of chemical and bacterial pollution for drinking purposes. This indicator is the least priority and has the lowest gradation - from 1 to 4 points.

The sum of the assessed scores up to 20 points characterizes the quality of drinking water as a permissible level of pollution, 21-40 points - a moderate level of pollution, 41-60 points - a high level of pollution, and 61-80 points - an extremely high level of pollution.

Criteria for assessing the indicators of the population's incidence of intestinal infections.

The need to consider the indicators of the population's incidence of intestinal infections is related to the epidemiological situation of the territories and the degree of pollution of water bodies and drinking water, which can lead to the risk of developing the disease among the population.

When selecting criteria for assessing the morbidity levels of the population of administrative districts and cities, it is necessary to consider intestinal infections, in the epidemiology of which the role of the water factor and the degree of microbial contamination of the environment are high. Such infectious diseases include typhoid fever, paratyphoid fever, viral hepatitis «A» and acute intestinal infections (AII).

The gradation of selected infectious diseases by the degree of danger to health was carried out according to intensive morbidity indicators per 100,000 population (Table 3).

Table 3 - Criteria for assessing the incidence of intestinal infections among the population (100,000 people)

№	Indicators	Degree of health danger			
		1	2	3	4
1.	Typhoid fever	<2 (5)*	2,1-4 (10)	4,1-8 (15)	>8 (20)
2.	Paratyphoid fever	<1 (5)	1,1-2 (10)	2,1-4 (15)	>4 (20)
3.	Acute intestinal infections	<300 (5)	301-400 (10)	401-500 (15)	>500 (20)
4.	Hepatitis «A»	<200(5)	201-300 (10)	301-600 (15)	>600 (20)
Sum of evaluation points		<20	21-40	41-60	61-80

**Note: The values of the assessment scores are given in parentheses.*

When ranking, it is necessary to take into account the maximum levels of the population's incidence of intestinal infections over the past five years. The sum of assessment points up to 20 points indicates a permissible level of danger, 21-40 points indicates a moderate level of danger, 41-60 points indicates a high level of danger, and 61-80 points indicates an extremely high level of danger in the population's incidence of intestinal infections.

Conclusions.

1. Criteria for assessing the pollution of water bodies, drinking water, and the incidence of intestinal infections among the population, based on ranking in points of assessment indicators by the degree of their danger to health, have been developed.

2. Four main gradations of pollution have been proposed: permissible-1, moderate-2, high-3 and extremely high-4; accordingly, the level of health hazard for the degree of pollution is assessed as permissible, alarming, dangerous, and extremely dangerous.

3. The developed criteria can be used for regionalization based on the degree of danger to health, polluted surface water bodies, and drinking water to reduce the incidence of intestinal infections among the population.

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