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# Method of Assessing the Potential Risk to the Health of the Population During Recreational Water Withdrawal

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**ABSTRACT**

The use of polluted water bodies for recreation poses a risk of infectious diseases. This fact necessitates taking into account bacteriological indicators to determine the danger of recreational water use. The aim of the article was to develop a new method for assessing the potential risk to population health during recreational water use. A new method for assessing the potential risk to population health during recreational water use has been proposed, which combines the identification of potential risk according to chemical and bacteriological indicators. A new classification of water hazard levels according to the values of risk to population health has been developed. The value of the potential risk to the population health during the recreational use of 6 beaches in the urbanized territories of the city of Kharkiv and its suburbs (Ukraine) was obtained. It was established that bacteriological contamination has the probability of a very large impact on public health (hazard class 5). To compare the methods of assessing the risk to population health during recreational water use, the hazard index (NI) was determined according to the chemical indicators of the quality of water bodies in the city of Kharkiv. The use of the assessment of the potential risk to population health for the environmental regulation of the discharge of pollutants into a water body with wastewater is justified.

**Keywords:** health risk to the population, water body, recreational water use, infectious diseases, hazard classification.

## INTRODUCTION

When pollutants infiltrate into surface and groundwater, i.e. lakes, rivers and oceans, water contamination occurs. Water sources can be contaminated by a large number of various substances, both synthetic (Malyovanyy et al. 2013; Sakalova et al. 2019) and biological (Nykyforov et al. 2016; Malovanyy et al. 2016). Rivers can contain traces of pollutants, starting from anti-pollution tablets to pesticides and oil, lakes of our planet, rivers, streams and groundwater are often a "chemical cocktail". Surface water is also the end point for biological wastes in the form of domestic wastewater, animal excrements and wastewater, flavored with rich living reagents, additives and farms. Widespread contaminants that reach the ocean contain pesticides, herbicides, chemical additives, detergents, oil, sewage water, plastics and other solid substances (Bobylev et al. 2014). Many of these pollutants are collected in the depths of the ocean, where they are consumed by other marine organisms and introduced into the world's food supply. It was found that the remains

of pharmaceuticals that are consumed by humans, but are not fully processed by our bodies, eventually end up in the fish that we eat (Pohrebennyk et al. 2016; Styskal et al. 2016).

One of the most dangerous types of harmful human impact on nature is pollution of the Earth, especially of water bodies, atmosphere and soil (Matukhno et al. 2019; Belokon et al. 2017). The use of water bodies for bathing leads to the occurrence of infectious diseases in patients. That is why, it is important to conduct a continuous and effective monitoring of surface water contamination (Odnorih et al. 2020). The incidence of water-borne diseases associated with recreational water use during the Dutch bathing season was correlated with the number of days with temperatures above 25°C ($r$ = 0.8–0.9) (Schets et al. 2011). However, in order to determine the impact of polluted water bodies used for recreation on the increase of population morbidity, it is necessary to conduct laboratory tests of surface water quality. Changes in the climate in Kharkiv region and changes in hydrological indicators of the Oskil River in Ukraine were investigated (Vasenko et al. 2016). Forecast models were developed by Holt-Vinters method. The predicted temperature increase by 1.9°C was obtained, which can lead to decrease of precipitation, runoff volume and water consumption. Increase in air temperature and decrease in runoff modulus have a significant adverse effect on the formation of surface water quality and on the development of invasions. This is not safe for recreational water supply and drinking water supply. Infectious diseases constitute a major health problem in many areas susceptible to flooding, especially where infectious diseases are already endemic. The authors of the work (Nga and Fukushi 2015) characterized and quantified the risks to human health due to different level of influence of pathogenic microorganisms that are found in water during the period of war. On the basis of the analysis of the scenarios pertaining to influence on flooding levels, in which direct and indirect contact with the polluted water is expected, and an assessment of the probability of a gastrointestinal infection based on established dose-response ratios for a key pathogen present in flooded water (E. coli). It was assumed that residents cannot leave the area during the flood, but these assumptions have not been verified, so the results of the work (Nga and Fukushi 2015) may be overestimated or underestimated. Waterborne pathogens infect people in different ways: through the skin and mucous membranes, through inhalation of aerosols, aspiration and ingestion. Clinical manifestations of these infections vary from superficial skin lesions to fatal systemic infections. The survival of many waterborne pathogens is influenced by climate, season, and other environmental conditions and the level of sanitation. Types and number of organisms vary depending on salinity, pH, temperature and other characteristics of water. The risk of waterborne pathogens contamination depends on the duration and type of exposure, the concentration of organisms in water and human immunity (Boggild and Wilson 2015).

The work (Bridle et al. 2019) provides an up-to-date review of the detected G. duodenalis agglomerations, subgroups, hosts and locations and potential routes of infection. On the basis of epidemiological data, the consequences for public health in Great Britain were discussed. Identification of all possible sources of contamination, notification of changes that may adversely affect the quality of water and provision of adequate information to the population are important preventive measures for the protection of public health. The aim of this article was to develop a new method of assessing the potential risk to the health of the population during the recreational water supply. In order to achieve this goal, it is necessary to solve the following tasks: to develop a new method of assessing the potential risk to the health of the population during the recreational watercourse; to substantiate the use of the assessment of the potential risk to public health for environmental regulation of the discharge of pollutants to the water body with wastewater; to evaluate the potential risk to the health of the population during recreational water consumption of municipal beaches in Kharkiv (Ukraine).

## MATERIALS AND METHODS

The methods of ecological risk assessment of surface water pollution are devoted to a large number of scientific works (Shakhman and Loboda 2016; Yurasov et al. 2012). The definition of potential risk as the main indicator of assessment of drinking water quality was given in (Kryzinska, 2015). A new approach to environmental risk assessment of surface water deterioration has been proposed (Rybalova and Artemiev, 2017). The new methodology is based on the determination of ecological standards of surface water

quality taking into account landscape and geographical peculiarities of river basins (Vasenko et al. 2017). The authors (Rybalova et al. 2018) presented three new methods of assessing the environmental risk of surface water degradation at the national, regional and local levels. Environmental risk of surface water degradation at the state level was assessed by adding the integral indicator of surface water status and the integral indicator of anthropogenic pressure. The basis of the methodology of assessment of the risk of disturbance of the stability of water ecosystems is to identify all parameters of the state of surface water quality that exceeds environmental standards, using the model of probit-regression. The assessment of environmental risk for watercourses of the Siversky Donets basin in the Kharkiv region (Ukraine) showed a high level of risk for the Uda River water ecosystem. However, the works (Rybalova and Artemiev, 2017, Rybalova et al. 2018) did not consider the impact of the impaired surface water on the health of the population. The water quality and environmental risk patterns were analyzed by a quantitative assessment of physical and chemical and microbial contaminants in the El Novillo and San Marcos river systems on the eastern outskirts of Mexico (López et al. 2020). The results showed that the water quality varies geographically and seasonally. On the basis of the national and international criteria, the quarterly average indicators of water quality analyzed allow assuming that the water in these river systems is of low quality and poses a high ecological risk for aquatic life on the example of the piedmont seaweed (Enhydra lutris nereis). An important addition to this work would be to identify the risks to human health due to the use of impaired surface water for bathing.

In most countries of the world, it is considered that the risk to the health of the population is the main indicator of insecurity. The method of population health risk assessment depending on surface water quality according to the methodology of the U.S. Environmental Protection Agency (EPA US) (Integrated Risk Information System (IRIS)) is used most widely. The study (Ting Wu et al. 2017) assessed the quality of surface and drinking water by hydrochemical indicators. They analyzed 161 water samples, including 88 drinking water (DW) and 73 surface water (SW) from nine cities in Xi'an, Yan'an, Xining, Lanzhou, and Urumqi in the eastern part of China. The health risk to the population was assessed according to the EPA US methodology. The carcinogenic risk from the impact of Cr was at the acceptable level according to the USEPA limit. The non-carcinogenic risk in surface waters was estimated at a low level. The authors conclude that there is a toxic effect on human health due to low concentrations of chemical substances in local arid and dry areas. The conclusion is contrary to the calculations, but probably based on the experience of the investigators. A detailed study was presented in the paper (Aithani et al. 2019). The authors investigated the concentration of 19 microelements in the main sources of drinking water from nine main basins of Chinese rivers: the Yangji River, the Huanghe River, the Huai River, the Hai River and the Liao River. Water quality and human health risk were assessed using statistical analysis, as well as Water Quality Index (WQI), Hazard Quotient (HQ), Hazard Index (HI), Carcinogenic Risk (CR) and Monte Carlo simulation. On the basis of the low WQI values, all nine river basins were categorized as "excellent water quality". When assessing the non-carcinogenic risk, the HI values for both adults and children were within safe limits (<1.0), indicating the absence of a toxic effect on the human body through daily oral intake and dermal absorption. In contrast, the CR values for As exceeded the Chinese limit of $1.0\times10^{-6}$. The authors' conclusions indicate that the use of surface water for drinking water supply can become a risk for the health of the population, so during the regulation and management, it is necessary to focus on the monitoring and assessment of these indicators in the main river basins of China. Microbiological indicators of surface water quality were not considered in this work, which is a shortcoming for the general conclusion about the risk level of drinking water from the main river basins of China. The methods of assessing the risk to public health as a result of recreational water consumption in accordance with the methodology of the EPA US (IRIS) do not take into account bacteriological indicators. The contamination indicators of of Ukrainian and American monitoring systems do not match, especially for surface waters; therefore, in the work (Ribalova and Belan 2014) the methodology of complex assessment of the risk for the health of the population during the contamination of the natural environment was improved. However, the main disadvantages of the American method of risk assessment for the health of the population due to recreational water consumption (IRIS, Guide 2004) are the following: the determination

of the risk index is based on a simple weighing of the multiplicity of excess reference doses without taking into account the risk class; the concept of a threshold-free risk (i.e., any substance at any concentration affects human health) leads to a reduction of risk values; specific diseases are indicated for each pollutant which may be increased in comparison with the background sickness rate, but sometimes they are very vague conclusions about the diseases, especially when determining the risk to the health of the population during recreational water consumption; bacteriological contamination of surface water, which is an important factor in the occurrence of infectious diseases, is not taken into account. The works (Movchan et al. 2013, Vasenko et al. 2015) have adapted the American methodology of non-cancerogenic risk assessment for population health to the Ukrainian system of surface water quality monitoring, but the impact of bacteriological indicators is not considered in these works either. Thus, the methods of identifying the risks of recreational water consumption require improvement, which is an urgent task, especially in such a complex epidemiological situation, which has developed in many countries nowadays.

## Method of assessing the potential risk to public health during recreational water supply

In order to determine the potential risk to public health, it is necessary to understand that exceeding the standards of hydrochemical and bacteriological parameters of surface water quality can lead to increased incidence of disease among the population. Therefore, to calculate the potential risk to the health of the population, only the indicators of surface water quality exceeding the standards are accepted. The sample-regression models are often used to determine the "dose-effect" relationship in order to assess the probability of negative consequences. The authors of this study suggest assessing the potential risk for public health (*Risk*) by calculating the probability of hydrochemical indicators according to formula (1), by bacteriological indicators according to formula (2):

$$\Pr ob = -2 + 3.32 \times lg(I^h) \quad (1)$$

where: $I^h$ – multiple of exceeding sanitary and hygienic standards for hydrochemical indicators of surface water quality, magnitude without fluctuations;

$$\Pr ob = -3 + 2.32 \times lg(I^b) \quad (2)$$

where: $I^b$ – multiple of the excess of sanitary hygienic standards of bacteriological indicators of surface water quality, the unmolded value.

Potential risk for the health of the population during the complex impact of environmental pollution is assessed by the rule of multiplication of contingencies, where the multiplier is not the value of the risk to health, but the values that characterize the probability of its absence:

$$Risk = 1 - (1 - Risk_1) \times (1 - Risk_2) \times \ldots (1 - Risk_n) \quad (3)$$

where: $Risk$ – is the potential risk of complex impact of contaminating substances;
$Risk_1$,..., $Risk_n$ – potential risk of impact of each individual contaminating substance;
n – number of contaminating substances.

Classification of the levels of risk of recreational water supply systems by the values of the potential risk is shown in Table 1. The methods of potential risk assessment are very promising, because they allow identifying areas of elevated environmental hazards based on adequate assessment of the impact of adverse environmental factors on the health of the population and producing the necessary management decisions on the priority of implementation of environmental protection measures. It should be noted that as a result of bathing in impaired water bodies, there is a possibility of occurrence of infectious diseases due to

**Table 1.** Classification of recreational water supply risk levels according to the value of the potential risk to the health of the population

| Risk | Hazard class | Risk characteristics |
|---|---|---|
| <0.1 | 1 | Insignificant impact on population health |
| 0.1–0.19 | 2 | Weak impact on population health |
| 0.2–0.59 | 3 | Significant impact on population health |
| 0.6–0.89 | 4 | High impact on population health |
| 0.9–1.0 | 5 | Very high impact on population health |

excessive standards of bacteriological indicators. However, the methodology of population health risk assessment (IRIS, Guidelines 2004) does not provide for the assessment of risk factors by bacteriological indicators, which is a significant drawback of this methodological approach.

### Using the potential risk to public health in environmental rationing of wastewater discharges

In the case when a section of a water body used for recreational purposes is located in the zone of influence of a controlled point source of anthropogenic pollution, the proposed method of assessment of potential risk can be used for environmental regulation of wastewater discharges. As a criterion for the permissible composition of natural water in the control point of the water body, one should take a set of values of the maximum possible concentrations of pollutants {Ci}, which, if the quality condition of other environmental objects is maintained, will not lead to the transition of the risk value *Risk* to the next class of hazard (Table 1). Generally, a source of technogenic pollution has several wastewater outlets. For this reason, it is reasonable to calculate the standards for the discharge of pollutants with wastewater using the optimization method (Proskurnin 2015). The optimization criterion is the sum of the wastewater treatment costs:

$$Z = \sum_{i=1}^{m} f_i\left(\{x_{ij}\},\{q_i\}\right) \rightarrow min \qquad (4)$$

where: $i$, $m$ – index and number of wastewater outlets, respectively;
$j$ – index of a pollutant;
$\{x_{ij}\}$– set of concentrations of substances in wastewater, g/m$^3$;
$\{q_i\}$ – set of values of wastewater flow rates in all outlets, m$^3$/s;
$f_i$ – cost of wastewater treatment, c.u./m$^3$.

The constraints of the optimization task are determined by the need not to exceed the permissible level of water pollution of the water body in the control point, the principle of not worsening the existing quality of natural water, as well as the technological capabilities of wastewater treatment plants. In a general case, the system of limitations can be written as follows:

$$\begin{cases} y_j \le y_j\left(C_j\right); \\ x_{ij} \le F_{ij}\,, \\ x_{ij} \ge 0; \\ \sum_{i=1}^{m} q_i = Q; \end{cases} \qquad (5)$$

where: $y_j$ – design concentration of a pollutant in the reference point of the water body g/m$^3$;
$F_{ij}$ – actual (at the moment of the ecological standardization) concentration of the substance in wastewater g/m$^3$;
$Q$ – total flow of wastewater, m$^3$/s.

The function $y_j(C_j)$ takes into account the background pollution of the water body and its assimilative capacity (Proskurnin et al. 2017). The optimization variables in the problem are quantitative and qualitative characteristics of wastewater – the values of $x_{ij}$ and $q_i$. If the functions $y_j$ and $f_i$ are linear, this optimization problem is a linear programming problem and can be solved by the simplex method. Otherwise, the problem is solved by one of the linear programming methods.

## RESULTS AND DISCUSSION

### The results of the assessment of the potential risk to population health during recreational water use of the city beaches of Kharkiv (Ukraine)

The qualitative condition of surface waters according to hydrochemical and bacteriological indicators in the summer of 2020 on 6 beaches of the city of Kharkiv is investigated, places of selection are marked on the map (Figure 1). The results of analyses of water samples are presented in Figure 2. The potential risk to population health during recreational water use of the city beaches of Kharkiv in terms of hydrochemical and bacteriological indicators are presented in Table 2. The conducted calculations indicate that it is very dangerous to use the Petrenkivsky water reservoir for bathing (which is located in the city of Kharkiv on the Krasnodarska street), because the value of the potential risk to the population health corresponds to class 5 due to bacteriological contamination (Table 2, Figure 3). Population health risk during recreational water consumption in accordance with the EPA US concept (IRIS) is assessed only by hydrochemical indicators by

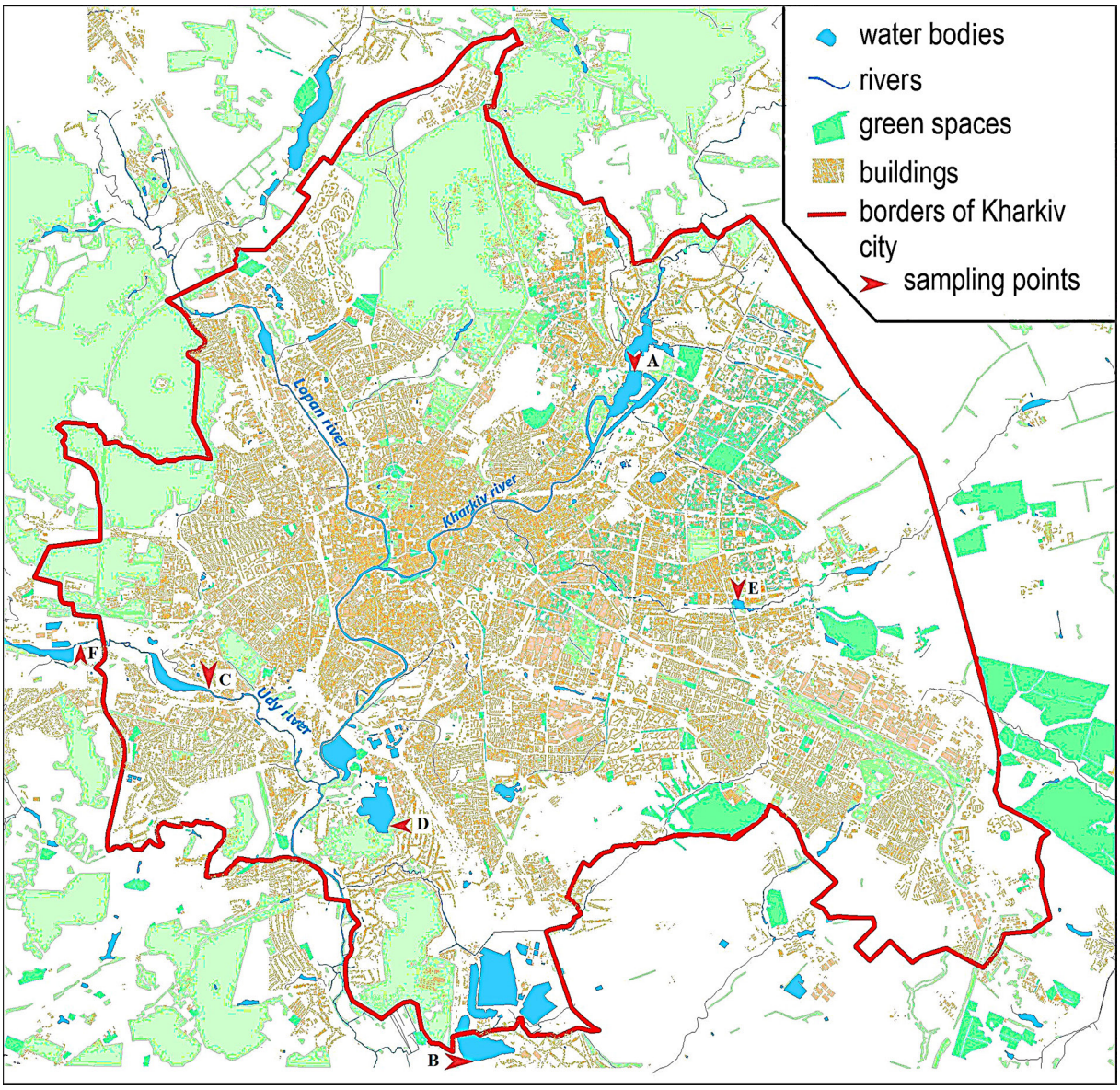


**Figure 1.** Sampling map: A – Zhuravlivsky Hydropark (public bathing place); B – Bezlyudovskoe reservoir (paid beach); C – Zhovtnevy Hydropark (the Udi River, near the bridge over the dam); D – the Lake Osnovyanske (the Lake Komsomolske, public beach); E – Petrenkivsky pond (Krasnodarska Street, intersection of Traktorobudivnykiv Avenue); F – Beach of the Udi river, near Pisochyn township (pedestrian bridge)

summing the multiplicity of excess of reference doses or reference concentrations, which has nothing in common with the theory of probabilities. To compare two different approaches to the assessment of the risk to the health of the population, Table 3 presents the results of the risk assessment for the health of the population during recreational water-circulation on the beaches of Kharkiv in accordance with the EPA US method.As the results of the assessment of the potential risk to the health of the population during the recreational water-conservation on the beaches of Kharkiv have shown (Table 3), the highest risk values are found in the bacteriological indicators; this proves the necessity of taking into account sanitary and bacteriological examinations during risk assessment.

## Discussion on the use of a new method of assessing the potential risk to the health of the population

An analysis of the literature shows that the use of polluted surface water for recreation can lead to spread of infectious diseases, which is especially dangerous during climate change and an increase in average air temperature in many

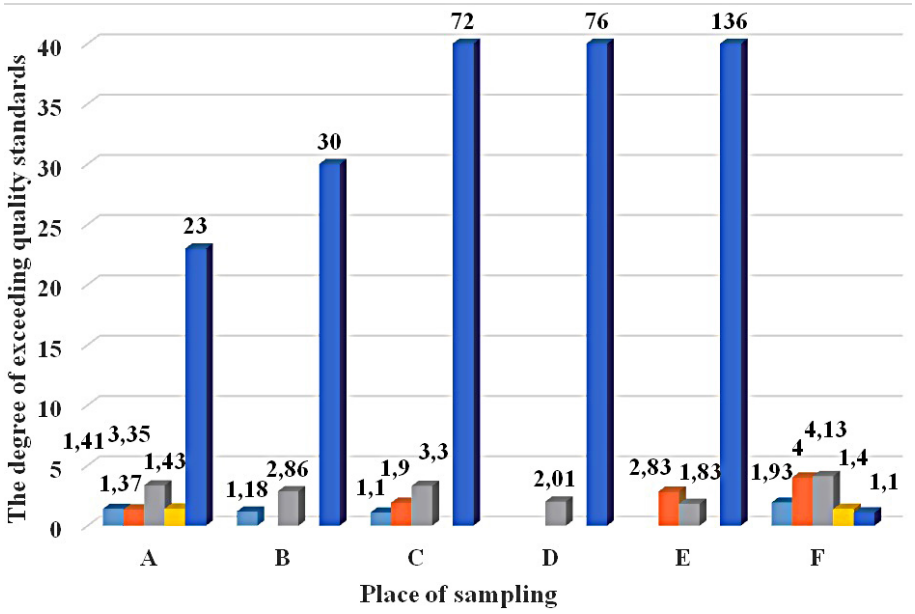


**Figure 2.** Exceeding surface water quality standards on the beaches of Kharkiv: 1 – Chemical oxygen demand (HSC); 2 – Phosphates (in terms of $PO_4^{3-}$); 3 – Biochemical oxygen demand ($BSC_5$); 4 – Oil and oil products; 5 – Index of lactose-positive Escherichia coli

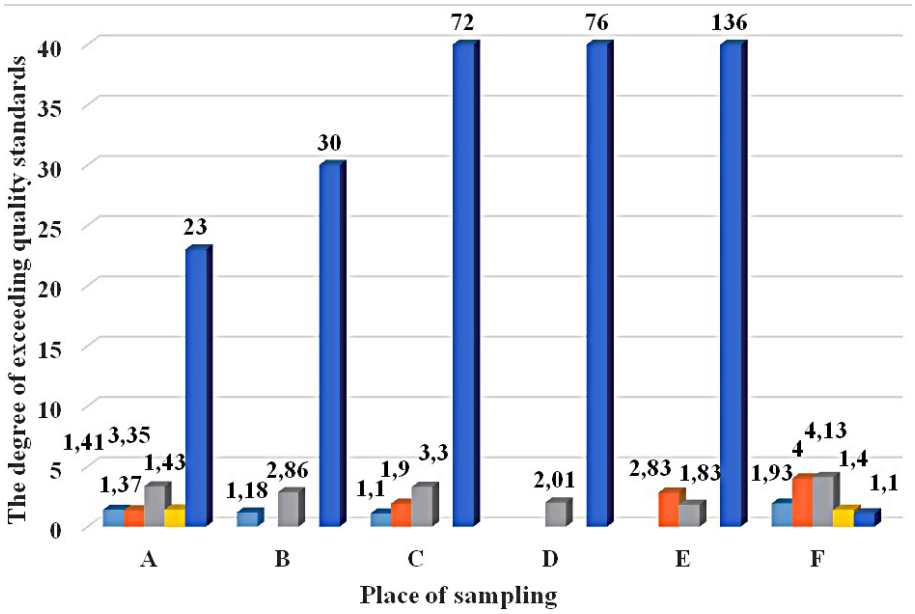


**Figure 3.** Petrenkovsky pond (Kharkiv, Krasnodarska street, intersection of Traktorobudivnykiv ave.)

countries of the world (Schets et al. 2011, Vasenko et al. 2016, Nga and Fukushi 2015, Boggild and Wilson 2015). Increased incidence of infectious diseases due to recreational water use is an urgent problem for most countries of the world. This problem has recently increased in connection with the COVID-19 pandemic (Marazziti et al. 2021, Hashimoto et al. 2020). The study of the impact of contaminated surface waters on the development of COVID-19 infections is insufficiently developed and the State Institution "Kharkiv Regional Laboratory Center of the Ministry of Health of Ukraine" does not analyze the status of recreational waters for the amount of incubators of this type of infections. The analysis of data on the excess of standards for contamination of surface waters, above all bacteriological indicators, shows the probability of an increase in

**Table 2.** Potential risk to population health during recreational water use of urban beaches in Kharkiv

| n/n | Place of sampling | Risk | Class | Risk characteristics |
|---|---|---|---|---|
| 1 | Zhuravlivsky Hydropark (public bathing place) | 0.79 | 4 | High impact on the health of the population |
| | Potential risk to population health from contamination with chemical reagents | 0.51 | 3 | Significant impact on the health of the population |
| | Potential risk to population health from bacteriological contamination | 0.56 | 3 | Significant impact on the health of the population |
| 2 | Bezlyudivske water reservoir (paid beach) | 0.78 | 4 | High impact on the health of the population |
| | Potential risk to the population health from contamination with chemicals | 0.34 | 3 | Significant impact on the health of the population |
| | Potential risk to the population health from bacteriological contamination | 0.66 | 4 | High impact on the health of the population |
| 3 | Zhovtnevy Hydropark (the Udi River, in the area of the bridge over the paddles) | 0.95 | 5 | Very high impact on the health of the population |
| | Potential risk to population health from contamination with chemical reagents | 0.49 | 3 | Significant impact on the health of the population |
| | Potential risk to population health from bacteriological contamination | 0.90 | 5 | A very high impact on the health of the population |
| 4 | The Lake Osnovyanske (the Lake Komsomol'ske, public beach) | 0.93 | 5 | A very high impact on the health of the population |
| | Potential risk to the population health from contamination with chemical reagents | 0.16 | 2 | Weak impact on the health of the population |
| | Potential risk to population health from bacteriological contamination | 0.91 | 5 | A very high impact on the health of the population |
| 5 | Petrenkivsky pond (Krasnodarska Street, intersection of Traktorobudivnykiv Avenue) | 0.98 | 5 | A very high impact on the health of the population |
| | Potential risk to the population health from contamination with chemical reagents | 0.40 | 3 | Significant impact on the health of the population |
| | Potential risk to population health from bacteriological contamination | 0.97 | 5 | A very high impact on the health of the population |
| 6 | Beach of the Udi river, near Pisochyn township (pedestrian bridge) | 0.83 | 4 | High impact on the health of the population |
| | Potential risk to the population health from contamination with chemical reagents | 0.83 | 4 | High impact on the health of the population |
| | Potential risk to population health from bacteriological contamination | 0.002 | 1 | Insignificant impact on the population health |

such infectious diseases as intestinal infections, viral hepatitis A, dysentery, etc.

In accordance with the well-known EPA USASA (IRIS) population health risk assessment method, the non-cancer risk index (HI) provides a means to determine the greatest risk of disease incidence in individual systems and organs of humans. However, the list of diseases, which is suggested by this method, is subject to refinement, because it is known that during the use of untreated surface water for recreation the most widespread diseases are acute intestinal diseases, salmonellosis, dysentery, viral hepatitis A and leptospirosis. The U.S. EPA (IRIS) approach to population health risk assessment includes the estimates of carcinogenic risk and risk index for other diseases caused by the contact with contaminating agents which may be transmitted to the human body by various routes: oral, ingestion and inhalation. The practical application of this methodological approach revealed a number of problems that need to be solved in order to adapt the American method of population health risk assessment to the current Ukrainian system of monitoring the quality status of surface waters. To assess the hazard index (HI) in accordance with the international methodology of risk assessment for public health (IRIS), the multiplicity of excess of the average daily dose (LADI or I) to the limit dose of the pollutant substance that causes non-cancerous disease is assessed. The Guidelines (2004) for calculation of the hazard ratio (HQ) in the appendixes contain the reference concentrations for chronic inhalation exposure and critical organ systems which are affected by an individual contaminating agent. Unfortunately, reference concentrations as well as reference doses are absent in methodological recommendations (Guidance 2004) for many substances that contaminate surface waters. Therefore, in order to adapt the

**Table 3.** Risk to the health of the population during recreational water-circulation on the beaches of Kharkiv

| Sampling location | Total HI hazard index for adults/children | Hazard class | Risk level characteristics |
|---|---|---|---|
| Zhuravlivsky Hydropark (public bathing place) | 6.73/6.75 | 4 | There is a risk of developing unpleasant effects among the majority of the population |
| Bezlyudivske water reservoir (paid beach) | 4.83/4.84 | 3 | There is a risk of developing adverse effects among particularly susceptible population groups |
| Zhovtnevyi Hydropark (the Udi River, in the area of the bridge over the paddles) | 5.69/5.69 | 4 | There is a risk of developing unpleasant effects among the majority of the population |
| The Lake Osnovyanske (the Lake Komsomol'ske, public beach) | 3.35/2.8 | 3 | There is a risk of developing adverse effects among particularly susceptible population groups |
| Petrenkivsky pond (Krasnodarska Street, intersection of Traktorobudivnykiv Avenue) | 5.81/5.82 | 4 | There is a risk of developing unpleasant effects among the majority of the population |
| Beach of the Udi river, near Pisochyn township (pedestrian bridge) | 10.86/10.87 | 5 | Mass complaints, the emergence of chronic diseases |

American methodology of non-carcinogenic health risk assessment in the work (Movchan et al. 2013) it was suggested that in those cases where there is no information about the reference (safe) dose (RfD) or reference concentrations (RfC), the following formula should be used (Movchan et al. 2013):

$$HQ = \frac{C_i}{C_{mpc}} \quad (6)$$

where: $C_i$ – average concentration of the *i*-th contaminating substance, mg/m$^3$;
$C_{mpc}$ – maximum permissible concentration of the *i*-th contaminating substance, mg/m$^3$.

Population health risk assessment according to the EPA USA method (IRIS) during recreational water consumption on the beaches of Kharkiv showed that the risk values correspond to 3, 4 and 5 classes of risk (Table 3). However, the calculation of risk for the health of the population does not take into account the value of bacteriological indicators, which are very significant for the occurrence of infectious disease. Indices of insecurity are determined taking into account critical organs and systems that are susceptible to the negative impact of the studied chemicals. The authors conducted a study of the quality status of surface water for hydrochemical and bacteriological indicators in the summer of 2020 on 6 beaches of the city of Kharkiv. It showed that the index of lactose-positive Escherichia coli exceeds the norm by dozens of times. Thus, on the beach of the Petrenkivsky pond, which is located on Krasnodarska street in Kharkiv, the lactose-positive intestinal pathology index is 136 times higher. A new methodology for assessing the potential risk to public health during recreational water consumption was proposed, which has significant advantages compared with the traditional international approach EPA USA (*Risk*) (IRIS): bacteriological contamination of surface waters is taken into account to assess the potential risk to public health; to determine the potential risk, only the substances exceeding the normative values are taken into account, since only in this case there is the possibility of receiving an infectious disease; to determine the potential risk to public health we use models of probit regressions other than a simple summation of the frequency of exceeding the reference doses or limit permissible concentrations; potential risk value indicates the probability of uncomfortable effects in humans, but not the specific diseases; a classification of the levels of risk of recreational water use, which allows prioritizing the implementation of environmental measures, was developed. Therefore, the new method of assessing the potential risk to the health of the population is promising and can be used to make management decisions in the field of environmental protection, safety of nature conservation and creation of comfortable living conditions for the population.

## CONCLUSIONS

A new method of assessing the potential risk to the health of the population during recreational water consumption using a model of probit-regression was presented. Potential risk to the health of the population involves the identification

of excessive standards of hydrochemical and bacteriological indicators, because in this case there is a possibility of occurrence of infectious diseases.

The classification of the levels of risk of recreational water management by value of the potential risk, which allows allocating water bodies to one of the nine classes, enabling to prioritize the implementation of environmental measures, has been developed. An assessment of the potential risk to public health during recreational water consumption in the city of Kharkiv (Ukraine) revealed that three beaches belong to the 4th class of risk (high impact on public health) and three beaches belong to the 5th class of risk (very high impact on public health). The highest value of potential risk is observed due to bacteriological indicators, since on most of the beaches they exceed the norms by 23, 30, 72, 76 and even 136 times. This fact leads to the necessity of taking into account the bacteriological indicators for the assessment of the potential risk for the health of the population during recreational water consumption.

Limitations of the optimization problem are determined by the need of not exceeding the permissible level of water pollution of the water body in the control point, the principle of not worsening the existing quality of natural water, as well as the technological capabilities of treatment facilities. Optimization variables in the problem are quantitative and qualitative characteristics of wastewater, as well as the risk to the population health. Application of the suggested method of assessing the potential risk to the population health is an important issue for ensuring comfortable living and recreation conditions.

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