HEALTH RISK ASSESSMENT PROBLEMS IN THE SETTING OF CHEMICAL POLLUTION OF THE ENVIRONMENT

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Existing approaches to health risk assessment focus, primarily, on the comparative priority of pollutants and their sources in the environment. But these approaches cannot be used to predict real changes in the mortality or morbidity rates of the population living in a given territory, and therefore cannot be used to develop health-prevention measures aimed at preserving or restoring human health. In this regard, in this study it is proposed to use the concept of mitigation (in this context, actions aimed at reducing environmental pollution) and the concept of adaptation (actions aimed at reducing the vulnerability of populations to environmental pollution). The existing risk assessments can be used to develop mitigation measures, but are not much instrumental in development of adaptation measures, which need to concentrate on early diagnosis and prevention of diseases caused by environmental pollution, as well as on the development of rehabilitation measures. It has been noted that hygiene and epidemiological research has not paid enough attention to the differences between these areas of public chemical and radiation safety. Yet, better targeting when assessing the risk will help to more effectively design interventions to manage these risks.

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ПРОБЛЕМЫ ОЦЕНКИ РИСКА ЗДОРОВЬЮ ПРИ ХИМИЧЕСКОМ ЗАГРЯЗНЕНИИ ОКРУЖАЮЩЕЙ СРЕДЫ

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Подходы к оценке риска здоровью позволяют характеризовать прежде всего сравнительную приоритетность загрязняющих веществ и источников их поступления в окружающую среду, но не могут быть использованы для предсказания реальных изменений уровней смертности или заболеваемости населения, проживающего на конкретной территории, а следовательно, и для разработки медико-профилактических мероприятий, направленных на сохранение или восстановление его здоровья. В обзоре предложено при анализе влияния загрязнения окружающей среды на здоровье населения использовать такие понятия, как митигация (в данном контексте это действия, направленные на снижение загрязнения окружающей среды) и адаптация (действия, направленные на снижение уязвимости населения при загрязнении окружающей среды). Существующие оценки риска эффективно могут быть использованы для разработки мероприятий по митигации, но не позволяют разрабатывать мероприятия по адаптации, основные направления которых — ранняя диагностика и профилактика заболеваний, обусловленных загрязнением окружающей среды, а также разработка реабилитационных мероприятий. Отмечено, что в исследованиях в области гигиены и эпидемиологии не уделяется достаточного внимания различиям между этими направлениями обеспечения химической и радиационной безопасности населения. Вместе с тем более точное определение целей при оценке риска поможет более эффективно разрабатывать мероприятия по управлению этими рисками.

Ключевые слова: загрязнение окружающей среды, риски здоровью, обеспечение химической безопасности

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Chemical and biological risk monitoring is one of the priorities of the state policy in the field of chemical and biological security [1]. It is also important to justify and implement medical and preventive measures for persons exposed to adverse effects of hazardous chemical and biological factors in potentially hazardous chemical and biological facilities and territories, and in areas impacted by these adverse factors.

Currently, human health risk assessment is understood as a quantitative measure of the probability of the development of adverse effects on human health or the health of future generations resulting from exposure to environmental factors [2, 3]. Traditionally, the analysis of chemical and radiation risks distinguishes between carcinogenic and non-carcinogenic effects.

In assessing the risk of developing non-carcinogenic effects, it is generally assumed that there is a threshold value (reference level of exposure) for radiation dose or concentration of a chemical below which exposure does not markedly increase health risk to sensitive populations. A risk below 1×10^{-5} is acceptable [2–4]. Exceeding the reference level increases the probability of developing adverse effects. However, it is not possible to estimate this probability, so the characteristics of the degree of adverse effect using threshold doses and concentrations are called hazard quotient and indices, which emphasises their difference from the traditional concept of risk as a quantitative assessment of the probability of a harmful effect developing [2]. These indicators are calculated as follows. A hazard quotient is calculated for a specific pollutant in a component of the environment (soil, ambient air, water, etc.) as the ratio of the averaged dose of that substance ingested by a human body to the corresponding threshold value. The hazard index is defined as the sum of the hazard quotients of all contaminants acting simultaneously. It is assumed that if the hazard quotient of a substance is less than 1, then if it is ingested daily over a lifetime, the probability of a person developing adverse effects is negligible. The values of the quotients and hazard indices are due to the interaction mechanisms of the substances concerned and the living organism. The threshold concentration is the minimum concentration that causes an adverse effect in at least one organ or system that is referred to as critical for such exposure. Threshold concentrations are usually determined in experiments on small animals (rats, mice). The human threshold concentrations are recalculated using appropriate reserve factors due to the significantly lower metabolic rate in human body and the uncertainty associated with extrapolating data from animal stidues that are taxonomically distant from humans (different order within the Mammals [2]. Hazard indicators describe a substance that has the potential to contaminate the environment. They are not related to the duration or other characteristics of exposure (such as climatic), nor do they depend on whether the substance has been acting on any living organism [2]. In contrast, risk is the result of exposure to a pollutant under certain conditions, characterized by the duration of exposure and the condition of the organism exposed to it.

Under the influence of some environmental pollutants, both chemical and radiation, biological effects have been revealed (first of all, damage to the genetic apparatus), the probability of the appearance of which is proportional to the influencing dose, while the severity of the manifestation does not depend on it. This is apart from non-carcinogenic effects for which appropriate concentration and dose thresholds can be established. Because such damage contributes to the development of cancer, these effects are called carcinogenic effects. To quantify the frequency of such stochastic effects, the hypothesis of a linear non-threshold dependence of the probability of developing negative effects on the exposure dose has been adopted. This hypothesis is based on extrapolating the effects of high exposure doses to much lower doses [2, 3]. For a chemical substance that is carcinogenic and can induce direct damage to the genome (genotoxic carcinogen), the main parameter in assessing carcinogenic risk is the carcinogenic potential of the substance. It represents the degree of increase in carcinogenic risk as a function of increasing the exposure dose of a substance (slope of a straight line constructed by linear extrapolation for several points characterizing the dependence of carcinogenic risk on the exposure dose and obtained under experimental conditions). In the case of radiation contamination, coefficients 5.6×10^{-2} Sv^{-1} [5] or 5.5×10^{-2} Sv^{-1} [6] are used to assess the dose-response relationship for carcinogenic risk.

When analyzing the carcinogenic and non-carcinogenic effects of chemical factors, first of all, the state of the so-called critical organs and systems is analyzed, the critical organs and systems are the organs and systems that are most sensitive to the investigated conditions according to experimental studies and in which specific negative changes occur that entail specific effects [3, 7].

In recent decades, however, numerous studies have shown that both chemical contamination and prolonged low-dose radiation exposure induce the development of oxidative stress and inflammation in the human body, the main target organs being the blood vessels. This points to the limited informative value of using the concept of "critical organs" [8–10].

As noted by many researchers, traditional approaches to risk assessment and analysis, including the use of the hazard index concept, are most valuable for the comparative characterisation of environmental exposures in different areas or over different time periods; they are also useful for comparing the effectiveness of environmental measures [2–4]. Using such risk assessments researchers are able to obtain quantitative characteristics of possible damage, compare the potential consequences of exposure to pollutants, identify priority sources of danger, and rank residential areas by the degree of influence of the factors in question [4, 11]. However, it should be noted that such approaches cannot be used to predict real changes in the mortality or morbidity of the population living in a particular area [3]: indeed, they do not take into account the factors that characterize the vulnerability of the population to the effects of pollution, such as the proportion of children and the proportion of the elderly, the degree of unfavorable natural and climatic conditions and the standard of living of the population. As these factors can significantly influence morbidity and mortality rates from some common causes [12–15], such approaches cannot be used to develop medical and preventive measures aimed at maintaining or restoring the health of the population living or working in the contaminated area.

It is therefore constructive, when analyzing the impact of environmental pollution on public health, to use such concepts that are widely used in the analysis of the negative impact of climate change, such as mitigation and adaptation [16]. Mitigation, in this context, refers to actions aimed at reducing environmental pollution, and adaptation refers to actions aimed at reducing the vulnerability of population to environmental pollution, inevitable at this technological age. It should also be noted that existing risk assessments, which primarily characterize the comparative priority of particular pollutants and sources of their release into the environment, can be effectively used to develop mitigation measures. Yet, they are not so useful for the development of adaptation measures, which focus primarily on early diagnosis and prevention of the main diseases caused by environmental pollution, and on development of rehabilitation and recovery measures, including those that curb negative changes in the body at the inception stage.

Despite the large number of studies in the fields of hygiene and epidemiology, the scientific literature does not pay enough attention to the differences between these significantly different areas of ensuring chemical and radiation safety of the population: there are only a few publications. One way of developing risk assessment methodology should be to link existing health risk assessments with the results of epidemiological studies [17].

In epidemiological studies aimed at analyzing the impact of environmental pollution on health, such concepts as attributable risk, relative risk, additional population risk, and additional share of population risk are traditionally used. Relative risk is the ratio of morbidity (mortality) indicators of persons exposed to and not exposed to a polluting factor, and attributive (additional) risk is the difference between the corresponding morbidity (mortality) indicators.

An analysis of publications on health risk assessments due to environmental pollution reveals significant problems that lead to an underestimation of the actual risk to public health. This may come from the emphasis on cancer, diseases of the respiratory and digestive organs, skin, eye, etc. [17, 18] although the findings of numerous modern studies indicate that environmental pollution has the greatest impact on morbidity and mortality from circulatory diseases [8–10, 19, 20]. Among such studies it is necessary to single out those that show that workers of chemically hazardous facilities have an earlier development and wider spread of circulatory system diseases of atherogenic nature [19, 20]. In addition, this group of workers is at increased risk of hepatobiliary damage [21] and of developing various forms of immune-mediated pathology [22]. In this regard, many authors point out that in order to strengthen the monitoring of the health of workers at particularly hazardous chemical production facilities, it is necessary to expand the range of diagnostic tests both at the time of hiring and in subsequent dynamic monitoring [20-23].

Another problem contributing to the underestimation of actual risk is the presence of modulating factors, such as natural-climatic and socio-economic factors, which significantly affect the vulnerability of populations to the effects of pollution [12, 24]. It is well known that cold climates remain the cause of elevated concentrations of pollutants, as many of the toxicants carried by warm air currents from low- and mid-latitude regions are deposited when they collide with cold Arctic air masses. In permafrost conditions, self-purification processes of natural objects are significantly slowed down, mobility of soil solutions and circulation of surface water are limited, the rate of physical and chemical reactions and the intensity of biological (microbial) degradation and assimilation of pollutants are reduced. The synergistic effects of cold and air pollution accelerate human disease and ageing in high latitudes, affecting the circulatory system to the greatest extent. The climatic features of the polar latitudes (low ambient temperature and strong winds) induce an increase in thermogenesis and, as a result, an increase in the concentration of reactive oxygen species and other free radicals, and also cause adaptive changes in the respiratory system, which indirectly contribute to an increase in the negative impact of air pollution [13–15]. Since with moderate cooling, pulmonary ventilation significantly increases, for gases absorbed in the respiratory tract (for example, sulfur dioxide, hydrogen fluoride, etc.), this leads to an increase in the absorbed dose, and the lengthening of the inhalation phase when breathing cold air further contributes to an increase in the settling of suspended particles [13–15]. In addition, during cooling, the functional activity of the adrenal glands and the level of their blood supply increase, which, apparently, causes the accumulation of toxic substances in them with the simultaneous action of cooling and pollutants. [25].

The additional influence of socioeconomic conditions on the risk of major non-communicable diseases and the increased vulnerability to the negative impact of environmental pollution in populations with low socioeconomic status has been shown in many studies [12, 26].

In this regard, it seems appropriate to develop approaches to the integral assessment of the impact of all exposure factors (chemical, physical, natural-climatic, socio-economic). This kind of exposure risk for non-communicable diseases does not determine the risk for a particular individual, like the SCORE scale [27], but aims to identify areas whose populations have an increased risk of developing certain non-communicable diseases. In these areas, in addition to measures aimed at mitigating environmental pollution, actions are needed to increase the adaptation of the population by reducing its vulnerability to the impact of negative factors. This implies, on the one hand, additional medical and preventive measures aimed at the early detection of markers of the development of relevant non-communicable diseases, and, on the other hand, clarification of which particular exposure factors may have a dominant influence. The purpose of this is to narrow down the pool of people who need additional medical and prophylactic measures.

As we see, despite the sufficiently long period of research and the existence of a plethora of whitepapers written using different approaches, the task of assessing the chemical and radiation risks to public health remains relevant, taking into account all the main factors involved. The solution of this problem requires a joint effort of specialists in various fields: hygienists, toxicologists, radiologists, cardiologists, as well as physicists, mathematicians, biologists, and geographers.

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