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Methical Approaches to the Comprehensive Assessment of Environmental Risks on the Health of the Population of the Megacity

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Abstract

This article considers methodological approaches to a comprehensive assessment of the impact of environmental factors on the health of a megacity population for the purpose of making targeted management decisions. We propose a methodology for constructing a Risk Assessment Map (RAM) in tabular and graphical (using GIS technologies) variants and consider using data from the ecological and hygienic monitoring. The stage of risk mapping consists of systematization and generalization of data on emissions of leading industrial enterprises, power engineering and motor transport objects, taking into account the main meteorological conditions and objective characteristics of the impact of pollution of environmental objects on the health status of the population in various areas of the megacity. By the method of expert assessments, we suggest assigning ranks for each criterion of the risk factor being evaluated, followed by the derivation of the general rank of the risk probability. **(International Journal of Biomedicine. 2017;7(4):315-318.)**

Key Words: risk • environmental factors • public health • risk mapping • risk assessment • risk probability • risk impact

Introduction

One of the most characteristic features of the modern development of civilization is urbanization. The concentration of a large number of industries, vehicles, buildings and people in the limited territory of a modern city creates an urbanized residential environment that is significantly different in quality from the natural human habitat. [1,2]

The formation of anthropogenic load in urban areas is characterized by considerable variability in exposure to the multisided and total effects of chemical elements. In the hierarchy of factors in the urbanized environment that create environmental risks for public health, the leading place belongs to air pollution by harmful chemicals from various sources. In addition to harmful emissions from stationary sources, it is necessary to take into account the significant contribution of motor vehicles to the contamination of the surface layer of the atmosphere. More than 200 particularly toxic substances (sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), aldehydes, ketones, alcohols, ethers,

hydrocarbons, heavy metals) have been detected in the exhaust gases from automotive vehicles. In summer, the toxicity of air increases due to photochemical reactions, with a sharp increase in the concentrations of NO_2, ozone, aldehydes and organic peroxides. [3,4] In addition to automobile exhaust, chemical, fine dust, and aerosol contaminants contribute to increasing pollution due to deterioration of the road surface, tires, and brake pads, and the leakage of motor oils and process fluids. [5]

The rapid growth of the car fleet in megacities has led to an increase of more than 50% in the amount of harmful impurities in the air and an increase in noise levels on urban highways by 5-10 dB. [6] One of the negative characteristics of transport noise is its spread over vast areas and almost constant impact throughout the day. The problem of the harmful effects of environmental factors on the health of the population is becoming increasingly important every year. Risk is the probability and severity of an adverse effect/event occurring to people or the environment following exposure, under defined conditions, to a risk source(s). [The probability of adverse effects caused under specified circumstances by an agent in an organism, a population or an ecological system]. [7] Identifying cause-effect relationships between habitat risks and pathological changes in the health status of a population or an individual is one of the tasks of hygienic diagnosis. A key element in the methodology

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of hygienic diagnosis is the analysis and assessment of the risk of adverse environmental factors for public health.[8]

In the methodology of risk analysis, there are two main, interrelated, but fundamentally different components:

1) Risk assessment for human health as a medical, biological and hygienic task. The four basic steps in the risk assessment process as defined by the NAS are:

Hazard identification — characterization of innate adverse toxic effects of agents.

Dose-response assessment — characterization of the relation between doses and incidences of adverse effects in exposed populations.

Exposure assessment — measurement or estimation of the intensity, frequency, and duration of human exposures to agents.

Risk characterization — estimation of the incidence of health effects under the various conditions of human exposure. [9]

2) Risk management as a complex social, economic and political task.

All the data obtained after the risk analysis are transferred to the organizations responsible for risk management to develop targeted management solutions aimed at preventing or minimizing the impact of the risk on the health of the exposed population.

During the implementation of the first stage, the goals and objectives of the planned studies should be clearly formulated; then it is necessary to identify the risks existing in the study area. One of the effective and visual tools of such work is the development of Risk Assessment Map (RAM).

Stage of risk mapping

In order to prioritize activities aimed at minimizing environmental risks in large urban agglomerations, it is necessary to identify all major sources of environmental pollution, including sources in the adjacent areas, due to the possibility of spatial distribution of the pollution, and to determine the number of exposed populations.

The following is the structure of environmental risks for the health of the megacity population:

- Chemical factors (the pollution of atmospheric air, drinking water, soil, food products by xenobiotics)
- Physical factors (noise, vibration, electromagnetic radiation, radiation)
- Biological factors (bacteria, viruses, fungi, rickettsia)
- Social factors (working and living conditions)

In the course of ongoing research and expert work at the stage of hazard identification, the composition of all potentially hazardous environmental factors that could have a negative impact on the health of the population is determined. Then a list of priority (most dangerous) factors is formed. Identification of factors involves identifying the most significant qualitative and quantitative characteristics:

- Place of risk factor occurrence
- Source of risk factor occurrence
- Emission (emission volume, parameters necessary for calculating the maximum one-time and average annual concentrations)

- Points of influence (primarily polluted environment, transport media, accumulating or transforming chemicals)
- Level of interrelations between factors (synergism, antagonism)
- Critical organs and systems of the human body that are affected by the risk factor
- Probability of risk factor occurrence (acceptable, unacceptable risk)
- Effect of exposure to a risk factor (carcinogenic risk, non-carcinogenic risk)

The leading criteria for the selection of priority (indicator) pollutants are: (1) their toxic properties and the amount of a substance entering the environment; (2) high persistence of a substance in an environmental object; (3) ability for bioaccumulation and inter-environment migration, which causes simultaneous contamination of several environmental objects and spatial distribution of the pollution; and (4) the ability to cause harmful effects in the human body (irreversible, remote, having high medical and social significance). At this stage, the potentially affected population size is determined and characterized.

Once the list of priority factors is formed, it is advisable to develop a conceptual model of the study territory to set the goal and tasks of assessing the risk of environmental factors for the health of the exposed population. It can be a graphic or descriptive representation of the possible interrelationships between the exposed population groups, sources of environmental pollution, and routes of exposure to pollutants (initially polluted environments; the environments transporting, storing or transforming chemicals; the pathways of possible entry of potentially hazardous chemicals into the human body from contaminated media).

It is necessary to pay attention to the temporal focus of research. The temporal focus of research on risk assessment can be retrospective, current and prospective. If the research is aimed at assessing the health risk of a population caused by a particular object, for example an industrial enterprise, the most important source is information about the qualitative and quantitative composition of the emissions of this object, their spatial and temporal characteristics. In addition to stationary sources of emissions, the influence of vehicles on the contamination of the surface layer of the atmosphere of the study area is also taken into account. In this case, retrospective studies will include an assessment of the risk caused by the previous impacts of chemicals contained in emissions from industrial facilities polluting the environment in the region. The current risk assessment will be related to the chemical contamination of environmental objects at the time of the study. A prospective risk assessment will determine the levels of risk over a certain time period under a specific scenario of chemical contamination of environmental objects.

The following methodology is proposed for constructing RAM of the impact of the megacity environment on the health of the population. Based on the data obtained, an RAM is formed. An RAM can be constructed both in tabular and in graphical form. To build a tabular map, all the risk factors selected for further investigation are summarized in a single table (Table 1). Risk factors are placed on the

lines, and their quantitative and qualitative characteristics are indicated in the columns (i.e. a source of occurrence, possible effect of exposure, probability of manifestation of the effect, degree of danger, etc.), and medical-demographic indicators (morbidity, mortality) among exposed population. The number of characteristics given is not constant; in each case there should be an individual approach depending on the features of the study area, the nature of the environmental risk factors (chemical, physical, biological, social), their sources, emissions, the number of the potentially exposed population, and the causal relationship between the exposure level of the risk factor and the number of cases or the severity of adverse effects that have occurred in the studied population.

For systematization and generalization of data on emissions of leading industrial enterprises, power engineering, and motor transport objects, we use the data of ecological and hygienic monitoring, taking into account the main meteorological conditions and objective characteristics of the effect of environmental object pollutions on the health of the population in different areas of the megacity.

The number of qualitative and quantitative variables and indicators is determined by a group of researchers and experts. Then, by the method of expert assessments, we suggest assigning ranks for each criterion of the risk factor being evaluated, followed by the derivation of the general rank of the risk probability. Based on the obtained ranks, RAM of the impact of the megacity environment on the health of the population is formed (Table 2).

The map is filled out by putting a value of "general rank" in the cells corresponding to a certain level of the risk probability. We recommend the construction or correction the RAM at least once a year.

Based on the RAM, management decisions are made:

1. Risks that are in the first columns of probability and danger (unlikely and acceptable) are controlled. In accordance with these risks, it is necessary to develop a plan of measures to prevent the transition into the category of permissible or dangerous.

2. Risks located in the second columns (likely and permissible) require systematic monitoring and development of the annual action plan.

3. For the risks in the third columns (very likely and dangerous), a plan of immediate (priority) measures should be developed to minimize their impact on the environment and the health of the exposed population.

RAM of the impact of the megacity environment on the health of the population can be represented in graphical form. To do this, when evaluating analytical data, it is recommended to use GIS technologies to visually display the location of potential pollution sources and sampling points relative to residential areas. This will allow to determine the degree of representativeness of the potential exposure of the studied risk factors to the population and to justify the extrapolation of the obtained data to the entire study area.

The methodology for constructing RAM of the impact of the megacity environment on the health of the population using GIS technologies consists of the following stages:

- Selection of the licensed GIS software for building RAM;

- Putting the results of calculating risks on the GIS platform and building RAM.

Conceptually, RAM can be presented in the form of an "Atlas of ecological and sanitary-epidemiological risks on the health of the population of the megalopolis."

Table 1.

Risk factors selected for constructing RAM of the impact of the megacity environment on the health of the population

| Risk factor (RF) | Source of RF | Route of impact | | | | Exposed population (people) | Critical organs and systems | Health effects corresponding to various hazard categories | Carcinogenic hazard index (for carcinogens) | Non-carcinogenic hazard index (for non-carcinogens)* | Reference levels for acute and chronic effects ** |
		Level of RF emission	Perceiving environment (the object of the environment)	Impact point (the place of potential human contact with RF)	Ways of RF entering into the human body						
1	2	3	4	5	6	7	8	9	10	11	12

* risk of development of non-carcinogenic effects is carried out on the basis of hazard ratio calculation;
** in contrast to the MPC, are recommendatory criteria and are used exclusively for the purpose of assessing the possible impact of chemicals on public health

Table 2.

RAM of the impact of the megacity environment on the health of the population

| Risk factor RF | Probability of occurrence of RF | | | Hazard of RF | | |
	unlikely	likely	very likely	acceptable	permissible	dangerous

Thus, the development and application of RAM of the impact of the megacity environment on the health of the population helps to better evaluate the medical and environmental situation in the megacity, determine the mutual influence of environmental factors, and assess the population health risks.

Forecasting the hygienic and epidemiological situation with the assessment of population health risks during the development of town planning decisions contributes to the selection of optimal management solutions aimed at optimizing the environment and minimizing the impact of the risk on the health of the exposed population.

Competing interests

The authors declare that they have no competing interests.

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