Assessment of urban environment safety for public health

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Abstract. The article describes the results of scientific research in the sphere of urban techno-sphere pollution caused by industrial enterprises activity and vehicles gases. It is shown that transport influences greatly the air environment pollution in Russian cities. Methodological approaches to assessing the health risks for urban residents are described. The main statements of the methodology managing the health risks of the urban population are given.

1 Introduction

Forming comfortable conditions for people's life in large cities of Russia is one of the strategic tasks of the state, scientists and society. The health risk of urban residents is the main quantitative characteristic of the urbanized environment state when studying the ecological and social system "man – natural environment". The connection between the categories "danger" and "risk" is expressed by the logical chain "danger - manifestation of danger - negative effect - risk [1].

Currently, the population of many Russian cities is experiencing a significant impact of adverse man-made factors, one of which is urban vehicles. So, according to statistical data [2], the contribution of cars to urban pollution is 68-85% (table 1), which determines the research theme.

Table 1. The vehicles impact to the air pollution in Russian cities

Cities	Specific gravity of transport pollution, %
Sochi	85
Tyumen	84
Tambov	81
Voronezh	78
Krasnodar	74
Rostov on Don	68

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According to the data of analytical laboratory made by the company "PROMEX", in the town Shakhty of Rostov region, road transport gases accounts about 70% of emissions from the total amount of air pollution. The list of the main atmospheric pollutants of the urban atmosphere according to statistic data contains cars' exhaust gases and the following elements and compounds: formaldehyde, lead, benzapyrene, volatile hydrocarbons. A detailed study carried out by many researchers concerning the impact of emissions on the environment made it possible to establish that there is a stable causal relationship between the presence of these pollutants in the atmosphere and the people's health states.

The given results define the system analysis of urban environment pollution sources of motor transport negative influencing the people's health within the research frames.

At the present stage of the science development the problem under consideration has not been studied systematically yet. The absence of a scientifically grounded methodology for assessing road transport risks is the convincing evidence of the fact. [2, 3]. This situation made the authors of this article present the results of their scientific work on this issue.

2 Methodology of assessing the vehicle impact on urban people's health

The authors of the article points out the scientific position that the program of research work should contain logically connected stages, including the formation of fundamental principles, the choice of methods and means of observation, the development of a scientific hypothesis, the modeling solution, the creation of an algorithm for processing and generalizing the research results. The essence of the hypothesis is that a complex set of observations and analysis of materials based on a method justified by experimental and theoretical research means using system analysis and synthesis provides a reliable estimation of the people's health risks from vehicle pollution and subsequent effective risk management.

The following statements are put forward as basic methodological principles:

- a systematic approach to the construction of observation system, the analysis of objects, factors and links;
- the principle of scientific adequacy;
- rational combination of research methods;
- the principle of formalization of all interpretation procedures and the use of the corresponding mathematical apparatus;
- the principle of a compromise between the expected accuracy and the complexity of the implementing methodology used;
-the principle of the investigation object specificity.

It is important to point out that the application of the above described principles is determined by the definition of environmental safety as a system and, accordingly, the need to study all the elements of a given structure, their interrelations, forms and interactions. The analysis of the research results makes it possible to pick out the most complete and objective information.

So, rational combination of methods provides high efficiency of the primary information. The analysis of practical materials shows that the complex application increases the reliability of the obtained data results at minimum 10-15% compared to the study carried out by means of the most sophisticated private methods using physical field or a mathematical principle of one kind [4].

The use of the fourth methodological principle allows us to formulate the problems more clearly and form an effective algorithm of the research work. Achieving a compromise between the indicators of risk assessment and the amount of performed work is possible due to the fact that specialists need to find a balance within the framework of the

"price-quality" formula. At the same time, the assessment of negative impacts of emissions should be based exclusively on quantitative and qualitative criteria reflecting the direct impact of harmful substances on the urban people's health. From the position of the risk theory - this procedure represents the establishment of probable development and levels of negative consequences caused by the impact of a complex of factors of the urban techno-sphere.

The generalization of the analysis of road transport risks, assessment of parameters and risk management can be determined by the logic of a single decision-making process. To achieve the research goal it is necessary to perform the following tasks: to identify sources and risk factors (analysis stage); to carry out their behavior forecast; to formulate effective ways of reducing risks (risk management).

The stage of risk assessment should include the following mathematical procedures: calculating the frequency of negative events and its consequences for public health, as well as their combination. The dose-response relationship is the main operation of quantitative relationship between the impact dose and the population's disease [7]. The essence of this method is that on the basis of priori information about the characteristics of vehicles, its technical condition, conditions and operating modes, the sections of the road network characterized by the maximum negative impacts on the urban environment, different areas are determined. Then, the calculation of the pollutants emission is carried out in the investigated areas. The next stage is to assess the consequences of pollutant emissions of successfully operated vehicles, as well as in cases of potential accidents.

Assessment of the transport impact on human health risk, according to the authors, should be carried out by using an analytical complex that includes the following criteria:

- carcinogenic potential of harmful emission, characterizing an individual carcinogenic risk or the degree of increasing probability of developing cancer when inhaled by a chemical having a carcinogenic effect;
- safe concentration of the substance under acute impact;
- reference concentration under chronic inhalation impact;;
- maximum permissible one-time concentration;
-maximum daily permissible concentration;
- indicative safe levels of impact;
- indicators of dependencies "dose-response" .

One of the main positions of the author's methodology as its "cornerstone", is the use of modeling imitation in the health risk analysis. The rational complex should include the following forms: pollution models, models of interacting vehicle emissions with the environment and the human body, mathematical models (dependencies) of the "dose-response" type, etc. Simulation allows the authors to quickly and reliably estimate the current situation and perform the necessary calculations with relatively low labor intensity.

3 Results of experimental studies

To test the working hypothesis and approbation of the developed methodological statements, a complex of experimental works in the town Shakhty was conducted by the authors. The choice of the research object is conditioned by the fact that motor transport is one of the main air pollutants in the region.

When developing the observation methodology, a method of medical-ecological mapping was applied taking into account the multifaceted anthropogenic influence on nature and man. A characteristic feature of the methodology is that the expert basis is consisted of the territorial features of the cause-effect relationships between the state of people's health and the negative factors of environment impacts affecting it.

Ten control points were selected situated near the most loaded highways located in all districts of the town (Table 2).

Table 2. List of control points on the highways of the town Shakhty

№ points	The town district	The address of control point
1	Center	Sovetskaya street, 134
2	Center	Sovetskaya street, 170
3	Center	Sovetskaya street, 55
4	Center	Karl Marx avenue, 110
5	Micro district “Parkovaya”	Parkovaya street, 54
6	Micro district “Sotsgorod”	Chernokozov avenue, 95
7	Micro district “Sotsgorod”	Mayakovskiy street, 105
8	Center	Pobeda Revolutsii avenue, 130
9	Artyom	Lenin Comsomol avenue, 32
10	Center	Pobeda Revolutsii avenue, 85

At each control point, the assessment of the atmosphere state was made by using a set of indicators including the following pollutants: nitrogen dioxide, benzene, benzapyrene, suspended substances, ethyl-benzene, dimethyl-benzene, lead compounds, sulfur dioxide, carbon monoxide, formaldehyde and ethyl-benzene.. The quantitative characteristics of air pollution, paying attention that emission amount depends on the engine types of the same class of vehicles (bus, car, etc.) were determined using the calculation method. According to the received data, the greatest volume of emissions is made by trucks and cars using gasoline fuel. The results of the analysis allow substantiating organizational and technical measures for traffic flows management in the town and the choice of the passenger transport means.

As a result of the analysis of the materials, a list of priority chemicals was developed to carry out a risk assessment of the urban population from transport pollution. The list includes the following elements and compounds: phenol, nitrogen dioxide, formaldehyde, chlorine, carbon monoxide, lead, nitrates and suspensions.

Emissions of harmful substances into the atmosphere from vehicles were determined by calculating method on the basis of the following characteristics: traffic intensity and traffic flow structure; mode of traffic in space-time coordinates. At the same time, the average daily traffic intensity was estimated by taking into account the daily intensity variation.

Determining impact levels from road transport emissions were based on a comprehensive study, including the following factors:

- The territorial location of pollutants emission sources;
- Distribution of techno-sphere pollution sources;
- The average annual, average daily and maximum single concentration of pollutants in control points influencing the human body.

When assessing the level of health risks to the urban population affected by vehicle emissions, the following leading indicators were taken into account: the impact of vehicles, traffic intensity; exceeding the maximum permissible concentration (MPC) of chemicals in the atmosphere.The primary assessment of urban atmosphere pollution with chemicals at control points was carried out by a standard method – in the terms of the excess multiplicity of MPC.

The estimation of air pollution level was carried out by using the indicators that Roshydromet established to assess the atmospheric air pollution relative to the average level of pollution in Russian cities:

- standard index – maximum single concentration of the pollutant for the observation period;
- the highest frequency of cases exceeding the MPC for the research period;
- a complex index of atmospheric air pollution (IAAP).

As a result of monitoring studies, priority atmosphere pollutants of the town Shakhty were established: nitrogen dioxide (61.5%), suspended substances (18%), and benzapyrene (18%). The greatest excess of MPC is noted among suspended substances (3.27 times), nitrogen dioxide (2.8 times) and benzapyrene (2.4 times). Priority urban areas in which the greatest excess of hygienic standards observed in 2015 were the following districts: the center and the micro district "Sotsgorod". The atmospheric pollution index, calculated by 9 ingredients of substances, is estimated at 3.63.

A joint analysis of the actual results of measurements and scientific publications allowed the authors to formulate the main provisions of the methodology of assessing the urban population health risk. The situation should be considered in the multidimensional environment of the techno-sphere danger, which includes the following variables: spatial coordinates; time (hour, day, etc.); substances - pollutants; sources of harmful emissions; directional effects on human body systems. The conceptual model of the hygienic assessment of the urban population health risk as the impact of vehicles presents a detailed algorithm consisting of logically sequential steps of collecting and analyzing information for making management decisions. The complex of the described solutions is aimed at the realization of the objective function - reducing the impact of road transport emissions on the health of the urban population. The developed model objectively reflects the system of interrelated actions of supervisory bodies, hygienists and special organizations that must collect and analyze information on road pollution and its impact on the residential environment. The model analogue of the real processes in the system "truck emissions - human health", as well as a number of other models on which risk analysis is based, has been developed taking into account fundamental methodological approaches being an important element of regional monitoring [4, 8-11]. The analysis of the received factual data by means of using the monitoring system makes it possible to assess the situation in real time, identify problem areas of the pollution impact, and justify the optimal solutions for risk reduction.

Based on the results of the proposed assessment, a system of management of the people's health risks from the vehicles impacts has been constructed. It is important to note that, at the same time, the principle of consistency and uniformity of procedures must be observed, according to which the final phase of the risk assessment must simultaneously be the first link in the risk management procedure.

The proposed health risk management model is shown in the diagram in Fig. 1.

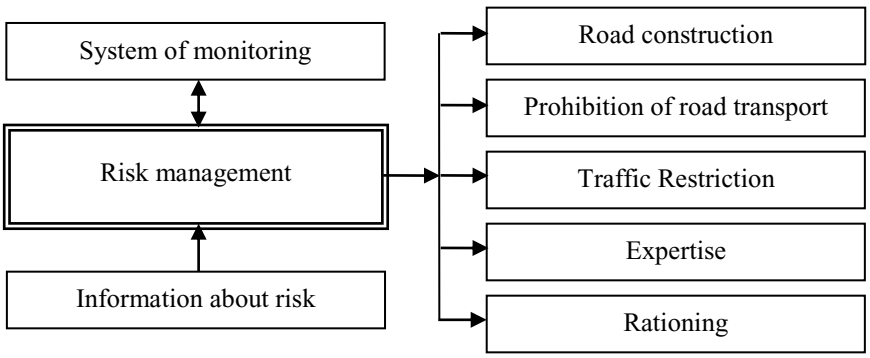

Fig. 1. Model of urban health risk management

The application of the presented model allows developing an effective evaluation system of the vehicles impact on the people's health and to form management decisions reducing the risks. Successful implementation of the developed method of estimating public health risk, as practice shows, is provided by a set of organizational and technical conditions reflecting in methodological provisions adapted to real situations. In particular, the perspective direction is the models of hygienic assessment and management of public health risk when performing architectural and planning works in residential districts of large cities.

4 Discussion

This article presents the main approaches to assessing the people's health risk in Russian cities due to the impact of transport pollution. The developed theoretical and methodical statements do not contradict the fundamental theories of mathematics, ecology and techno-sphere safety. A characteristic feature of the proposed methodology is the possibility of optimizing control decisions depending on the current ecological state of the urban environment. The difference of author's recommendations from previous studies is the implementation of logically interrelated procedures, including risk analysis and assessment, and management of the urban population health risk. The working hypothesis is confirmed in the process of experimental and methodological work by using the formulated methodological principles.

5 Conclusion

Based on the research results, it can be concluded that the use of methods and tools constituting the author's methodology allows conducting an objective assessment of the levels of environmental safety in the urban environment, including the health risk of the population from road pollution. The proposed methodology can be used in all "big" cities, because it is developed on the basis of integrated system analysis and theory of life safety and the established trends in the system "pollution impact - the risk to human health" which are known to be universal in nature.

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