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# Assessment of the Impact of Technology-Related Factors of Urban Environment on Population and Long-Term Environmental Tasks for Business

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***Abstract*—The aim of this study was to assess the impact of technology-related factors of the urban environment on population and to establish long-time tasks for business in order to improve the ecological situation. We used the materials from the Federal Budgetary Health Institution "Center for Hygiene and Epidemiology of the Voronezh Region" for 2014-2018. It was established that among the analyzed parameters that determine the complex technology-related load (CL) on the environment – the level of atmospheric air pollution with man-made chemicals, sanitary-chemical parameters of drinking water quality, the level of soil pollution in residential areas, traffic noise – the largest contribution to it is made by air pollution (33.0-58.5%). The assessment of public health risk due to the effects of technology-related factors showed unacceptable risk levels associated with the presence of soot, formaldehyde, chromium$^{+6}$ compounds, nitrogen dioxide and copper oxide in the air, as well as high and extreme risk levels due to the traffic noise. In the conditions of the city, environmental protection measures are required to reduce the level of the influence of these factors on the population; it can be achieved by the involvement of the participants of city-planning business in solving the environmental problems of the city.**

***Keywords—technology-related factors, city, health risk, assessment of the impact of technology-related factors, environmental tasks for business.***

## I. INTRODUCTION

Cities have become the centers of acute environmental problems what results from the high concentration of industrial production, transport and population at a relatively small area. The main environmental problems of large cities include a high level of atmospheric air pollution, deterioration of drinking water quality in water sources, soil pollution with man-made substances, and noise.

In this regard, in order to justify the preferred management environmental decisions, one needs objective information on the levels of risk to public health caused by the adverse effects of technology-related factors.

## II. REVIEW OF LITERATURE

Studies in the field of geoecological diagnostics of the territories of Central Black Earth Region cities of the Russian Federation revealed statistically significant positive correlations proving that increased anthropogenic load on the environment causes a response associated with public health which includes increase of ecologically caused pathologies in urban population [1].

Regional studies performed in the city of Voronezh showed that, despite the implementation of municipal policies and measures to ensure the environmental safety of population, there are problems requiring comprehensive assessment and solution. This is illustrated and confirmed by the data presented in the Medical and Environmental Atlas of the city of Voronezh [2].

Other regional studies focus on the increasing air pollution with motor vehicle emissions [3], the problem of soil pollution in urban areas [4], the impact of man-made pollution factors, and noise associated with traffic [5].

The development of geoinformation support of the regional system of medical and environmental monitoring using data on the state of the environment of the city of Voronezh obtained by organizations of various departments (Rosprirodnadzor, Rospotrebnadzor, Regional Center for Hydrometeorology and Environmental Monitoring) made it possible to have the whole new information [6]. Environmental studies performed in the city of Voronezh were aimed at getting more objective information using methods for assessing the risk to public health due to the impact of technology-related factors of urban environment; results of these studies revealed an aggravating of environmental problems associated foremost with increasing air pollution and traffic noise [7]. The problem of urban noise and air pollution was also mention in hygiene studies which demonstrated increased number of complaints of the population about the impact of these factors [8-9].

In this regard, further studies to assess the impact of technology-related factors of the urban environment on the population and to establish long-time tasks for business in order to improve the ecological situation are relevant and become the goal of this research.

## III. RESEARCH METHODOLOGY

Data selected from the database of regional socio-hygienic monitoring conducted on the basis of the Federal Budgetary Healthcare Institution "Center for Hygiene and Epidemiology of the Voronezh Region" for 2014-2018 was used for thus study. All definitions and measurements of the

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levels of impact of technology-related environmental factors in this database belonged to the accreditation of testing laboratory center of this institution and were performed in accordance with certified methods.

The risk to public health was assessed on the basis of generally accepted methods: R 2.1.10.1920-04 "Guidelines for assessing the risk to public health when exposed to chemicals polluting the environment"; MR 2.1.10.0059-12 "Assessing the risk to public health from the effects of traffic noise", as well as of guidelines "Comprehensive determination of the anthropogenic load on water bodies, soil, atmospheric air in residential development areas" which were developed by Erisman Federal Scientific Center for Hygiene and published in the open scientific press as a monograph [10].

Use of the combination of different methodological approaches in this study ensured the formation of new approach for analyzing the available information on the impact of industrial environmental factors on the health of urban population and made it possible to obtain whole new information for the implementation of the principle of comprehensive support of making reasoned management environmental decisions.

## IV. RESULTS

As a part of regional socio-hygienic monitoring performed at the Center for Hygiene and Epidemiology of the Voronezh Region, systematic environmental monitoring of the city of Voronezh is carried out. In 2014-2018, systematic observations were made at five route monitoring stations for the control of atmospheric air pollution level, at eighteen monitoring points for the control of drinking water quality, at twenty-one monitoring points the control of soil pollution level, and at sixteen monitoring points for the control of noise level. It is not enough for the comprehensive assessment of the environmental situation in the urban district of the city of Voronezh with the area of 596 $km^2$ and the population of 1,054 million people (2019). In this regard, we used in our study the data of non-routine observations for the same period obtained by the Center for Hygiene and Epidemiology of the Voronezh Region during monitoring compliance with hygiene standards and regime at the external boundaries of the sanitary protection zones of enterprises, and also the results of laboratory and instrumental tests carried out as part of investigation of complaints of the population about the unsatisfactory quality of environment, i.e. pollution of the surface layer of atmospheric air, of drinking water, of soil and high noise level. All these data allowed more objectively calculating the average concentrations in environment and assessing the level of noise and man-made risk factors for health.

In accordance with the guidelines for the comprehensive assessment of anthropogenic environmental load, the load coefficient (LC) was calculated which is the sum of the ratios of all considered technology-related factors with the current Russian ecological and hygienic standards for separate environmental objects. Load coefficients were calculated for territories conventionally divided into areas with the predominant contribution of industrial sector to the environmental pollution; areas with the largest traffic flow; relatively safe areas where are no urban transit routes, with a predominant share of the residential sector near the recreational areas.

The coefficients of complex technology-related load in residential areas bordering industrial enterprises and having transit motor flows are significantly higher (LC from 13.29 to 14.65 units) than in relatively safe area (LC = 7.97 units). At the same time, in all types of urban areas, among the analyzed factors including pollution of the surface air layer, sanitary-chemical parameters of drinking water quality, soil pollution of residential areas, and traffic noise, air pollution is a major contribution to the formation of anthropogenic load (from 33.0 to 58.5%).

In accordance with the methodological provisions for assessing the risk to public health due to chemical environmental pollutants, a carcinogenic and non-carcinogenic risk is assessed as the risk of adverse effect (R 2.1.10.1920-04). Calculations are based on the arithmetic mean values of the concentrations of pollutants in the environment for separate city territories for the period of 2014-2018.

The combination of limited in number systematic observation data at specific monitoring points with single observations made at seventy sampling points at different time periods, is characterized by the uncertainty in assessing the level and time of exposure but in general this approach increases the objectivity of the results of the analysis performed.

During the assessment of aerotechnogenic risk associated with fourteen controlled pollutants, it was found that the values of total individual carcinogenic risk in territories with high technology-related load caused by the presence of three carcinogens – chromium$^{+6}$ compounds, soot, and formaldehyde – are from $1\times10^{-4}$, i.e. from 1 case of cancer among 10,000 people, to $1\times10^{-3}$, i.e. 1 case of cancer among 1,000 people. This level of carcinogenic risk is classified as dangerous. An unacceptable level of non-carcinogenic risk (HQ>1) was also found in the industrial area and near urban city highways due to nitrogen dioxide, copper oxide and chromium$^{+6}$ compounds contained in the surface layer of atmospheric air.

Calculations of individual carcinogenic risk from exposure to carcinogenic substances (benzapyrene, cadmium, arsenic, lead) contained in the soils of the residential territory of the city of Voronezh (local contamination foci of residential area) showed that risk levels for population belong to the first risk range (less than $1x10^{-6}$) and are classified as negligible, not requiring any measures to reduce them but subject to periodic monitoring. Calculated values of the risk factors for non-carcinogenic risk (HQ) associated with the presence of eight controlled pollutants – copper, lead, zinc, benzapyrene, cadmium, arsenic, nickel, mercury – in the soil of the urban area ranged from the minimum of $5.07x10^{-9}$ to maximum $2.05x10^{-5}$ what can be described as an acceptable level that does not require risk management measures (i.e., HQ is much less than 1).

The results of the calculation of non-carcinogenic risk to public health revealed that for drinking water, the value of non-carcinogenic risk calculated by the long-term average concentrations of main regional pollutants – iron, manganese, boron compounds, nitrites and nitrates – taking into account daily water consumption of 2 liter recommended by the World Health Organization, is acceptable (HQ = 0.03-0.35<1). Carcinogens in the drinking water of the centralized drinking

water supply system of the city of Voronezh undergo no laboratory control.

With the increase in the number of motor vehicles in the city, traffic noise increases. Measurements were taken in an open area at the boundary of residential development and were put into the database. The analysis of information obtained from the database of socio-hygienic monitoring showed that the equivalent acoustic pressure levels at the control points (sixteen points) were in the range from 28 to 87 dB on the A scale in the daytime, from 28 to 75 dB A in the evening, from 27 to 71 dB A at night. Maximal acoustic pressure levels at the monitoring points were from 28 to 97 dB A in the daytime, from 27 to 85 dB A in the evening, and from 38 to 82 dB A at night. The proportion of measurements with above-limit values (maximum permissible noise level in the residential area) ranged from 29.3 to 76.8%.

At the monitoring points for the control of motor vehicle noise, the risk to public health was at high and even extreme levels. According to our data, the risk to public health from traffic noise assessed in accordance with MR 2.1.10.0059-12 method for the diseases of hearing, nervous and cardiovascular system, is the highest for the diseases of cardiovascular system. As the age increased (along with the supposed time of exposure), the risk increased from an average level (from 0.051 to 0.342 units) to an extreme level (from 0.607 to 1) what was registered at ten out of sixteen monitoring points. The risk of diseases of nervous system associated with traffic noise at the two most unfavorable control points (38 Moskovsky Prospect and 82 Moskovsky Prospect – monitoring points located at the territory with the highest transit traffic flows) ranges from 0.053 to 0.059 units for 65 and 70 years of exposure and is rated as average. At other monitoring points, the risk of diseases of nervous system was assessed as low. The maximal risk of hearing system diseases caused by traffic noise is 0.039 (for 70 years of exposure) and is regarded as a low risk (monitoring point – 38 Moskovsky Prospect).

## V. Conclusion

The results of the assessment of the impact of technology-related factors of urban environment on population revealed unacceptable risk levels associated with the presence of soot, formaldehyde, chromium$^{+6}$ compounds, nitrogen dioxide and copper oxide in the air, as well as high and extreme risk levels due to traffic noise. Taking into account the defined regional characteristics of the impact of technology-related factors of urban environment on population, the priority should be given to reducing emissions of pollutants by industrial enterprises and motor vehicles, as well as to reducing noise level.

Such reduced impact, in addition to improving the production technology and engines of motor vehicles operating on traditional fuels from an environmental point of view, can be achieved by the implementation of reasoned city-planning decisions that are justified from the environmental point of view. Construction companies, especially in the field of housing development, should pay attention to the development of transport infrastructure taking into account modern environmental and sanitary standards of urban planning, to the implementation of noise protection measures in newly built residential buildings. In particular, houses should be designed and built with a special layout where most of the rooms facing the highway should be kitchens, flights of stairs, utility rooms. When implementing noise-reducing window packages in such projects, it is necessary to provide air conditioning ways for residential premises, as the certain opening of a window on a hot day negates the soundproofing effect of a double-glazed window. It is also necessary to improve the legislative framework of the Russian Federation in terms of determining the obligations of business enterprises to participate in solving the environmental problems of modern cities.

## VI. Discussion

Generally, the results of our studies are consistent with the data of other authors who carried out a similar environmental assessment of the impact of technology-related factors on the population of the city of Voronezh and attributed air pollution and increasing levels of road noise to the list of main adverse factors that disturb the population and have a negative impact on its health [3], [7-9].

At the same time, we would like to draw your attention to the fact that the organization of an urban environmental monitoring system requires improvement. Uncertainties in assessing the risk to public health which are typical for almost all studies including our work, are associated with an extremely limited list of controlled pollutants and parameters characterizing the state of environment. In our study, we used data from the Center for Hygiene and Epidemiology of the Voronezh Region which systematically monitors concentrations of only fourteen pollutants in the air, of five sanitary-chemical parameters of drinking water quality and of eight sanitary-chemical parameters of soil, as well as measures noise level. The list of systematically controlled pollutants in environmental objects needs to be increased taking into account current requirements. In particular, it is necessary to perform at least selective studies on laboratory monitoring of drinking water quality for the presence of carcinogenic compounds. This is associated with the increased number of water pipes made of polymeric materials and the current use of chlorine-containing agents to disinfect water what can lead to the formation of organochlorine compounds related to carcinogens (tetrachlorethylene, chloroform, and others).

Attention should be turned to the improving of cooperation between departments in collecting information on the state of city environment, since monitoring is a system that was designed to provide information for establishing main environmental decisions to improve the state of urban environment and to reduce the impact of technology-related risk factors on public health. In this regard, the improvement of mechanisms for implementing decisions to ensure the environmental safety of urban population comes to the fore. State environmental programs cannot solve all problems to the full extent. From our point of view, it is necessary to more actively involve non-state companies including city-planning ones, in solving the environmental problems of urban territories.

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