HYGIENIC ASSESSMENT OF IMPACT ON PUBLIC HEALTH AIR POLLUTION IN VIEW OF THE COMBINED ACTIONS OF CHEMICALS IN THE AREA OF THE CHEMICAL INDUSTRY

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The article presents the results of air pollution study in the area of chemical industry. The results of evaluating possible impact of chemical pollution on the population health are reflected by the parameter values: complex indicator “R” public health risk (reflexive, chronic, and combined risk at the reflexive and chronic action), hazard index and combined action coefficient. The comparative characteristic of the received data is provided by the degree of air pollution during the evaluation, taking into account the combined effect of chemicals and during the evaluation without the combined action of chemicals. The possibility of using the results to predict the changes in the population health status and to plan epidemiological studies is determined.

Key words: atmosphere chemical pollution, combined action of chemicals, combined risk of chemicals, combined action coefficient.

Fast growth of cities, construction and reconstruction of industrial enterprises as well as expansion of residential areas at the expense of the land adjacent to the enterprises and other facilities determine the need for the assessment of the city-planning decisions in terms of its negative impact on public health. Atmospheric air pollution can have a significant effect on the health of local residents [1, 2]. Air pollution, as reported by the World Health Organization, is the most important individual environmental risk factor for the population of the European Region [3, 4]. Increased atmospheric air pollution (other conditions being equal) results in a 6-7% increase in the rate of respiratory infections caused by non-specific influence [5, 6].

In order to make town-planning decisions in the future with the account for potential unfavorable effects determined by air pollution, it is also necessary to take into account the multi-component nature of atmospheric air pollution [5, 6, 7, 8].

In the Republic of Belarus, the decision on potential allocation of new facilities in close proximity to residential areas depends to a great extent on the results of the assessment of the health risks associated with the pollutants emitted into the air by the facility. The assessment involves multiple regulatory and technical documents in this area and follows an established procedure. Health risk assessment for city-planning decisions conducted in the Republic of Belarus is an example of collaborative work between environmental agencies and health organizations thus reflecting the strategy and priorities of the World Health Organization [4].

The health risk assessment methodology is used to analyze the city-planning decisions for the existing (reconstructed) and projected facilities with the account for the multi-component nature of air pollution. Risk assessment is also used to plan preventive activities aimed at protecting the public from the unfavorable impact of chemicals emitted by the facility.

Purpose: assess the impact of the atmospheric air pollution on public health with the account for the combined effect of chemicals in the location of a chemical enterprise.
**Research materials:** analysis of the main stages of technological production process; graphic materials on the location of the sources of emission from the main industrial enterprises in the residential areas and the areas that need protection; simulation of the outspread of chemicals emitted by the enterprise in the atmospheric air, and analysis of public health risks associated with these chemicals; results of the in-process supervision of polluted atmospheric air in the area of the enterprise location; background concentrations of chemical pollutants in the area of the enterprise location.

**Obtained Results.**

In order to determine the groups of priority chemical pollutants emitted by the industrial entities and to determine the branches of the natural economy that present the biggest hazard in terms of air pollution, we studied the materials of the surveys and risk analysis in 219 residential areas of the Republic of Belarus. Based on the research findings, it was determined that the following chemicals are the biggest air pollutants: nitrogen oxides, carbon monoxide, particulate matter of different fractions, heavy metals (mercury, lead, cadmium) and volatile organic compounds. We identified the fastest growing industries – major contributors to the air pollution in the residential areas. Subsequent to the results of the analysis, we selected an enterprise specializing in the production of urea-formaldehyde resins, adhesives, paints and other organic substances, located in the town of Borisov in Minsk Region. The enterprise is located in an industrial area of Borisov, a town created by the enterprise, bread-baking complex, meat-processing complex, and a number of other industrial enterprises occupying the total area of 13.1446 hectares. Residential areas are located in close proximity to these enterprises. According to [9], the sanitary protection zone (hereinafter – SPZ) of the enterprise is 500 m. It includes:

- To the north – a food-producing plant (bread-baking complex);
- To the East – a waste ground, then a railroad precinct, then another waste ground, and 130-150 m from the external border of the enterprise (330-350 m from the polymeric petroleum resin production facility) – a residential neighborhood down Sennaya Str.
- To the South – industrial facilities;
- To the West – industrial park;
- To the North-West within 200 m – a residential neighborhood down Stroiteley Str.
- To the South-West – a free-standing residential area down Demina Str. with two residential houses.

The enterprise estate has 232 (organized and non-organized) emission points, gross emission totals 46 988 tons per year. These emission points emit 40+ hazardous substances, including class 1 hazard substances – 0.03% of the gross emission, class 2 hazard substances – 27.39%, class 3 hazard – 9.56%, and class 4 hazard – 62.08%.

To assess the air pollution concentration in the area of location of the enterprise, the following territories were selected: the borders of the enterprise grounds (currently, the SPZ borders), nearby residential area – 130-150 m from the border line of the enterprise ground and a residential area affected by the enterprise at 210 m from the enterprise ground.

As a result of the calculation of the chemical dispersion at the border of the production site of the enterprise, at the border of the nearby residential area (130-150 m) and at the distance of 210 m from the site border, the maximum concentration of the emitted substances did not exceed the hygienic standards, except for solid particles and formaldehyde (0.89-1 and 1.08-1.1 in fractions of MAC respectively). The average annual concentrations for all the 32 substance did not exceed the hygienic standards. In-sight supervision did not reveal any excess of the hygienic standards.

We conducted an assessment of the air pollution with the use of complex factor P and complex air pollution index in terms of 5 priority substances (hereinafter – CAPI) – see Table 1.

To assess potential health effects caused by the emitted chemicals, we calculated the health risks associated with the emitted substances. The results of the assessment of health risks associated with clean concentrations of pollutions are shown in Table 2.

To analyze potential unfavorable effects under combined action of chemicals, we used the following indicators: combined risk of chemical action, hazard index, combined action coefficient [5, 10].

We calculated the value of combined risk of reflex effects for the whole mix of chemicals emitted by the enterprise, based on the multiplication of probabilities method [11]:

\[ \text{Risk}_{\text{sum}} = 1 - (1 - \text{Risk}_1)(1 - \text{Risk}_2) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldOTS
low concentrations is characterized by similar non-specific effects resulting in the necessity of mandatory use in this case of the aggregate risk calculation equation for all the substances in the emission, and has a potential toxic chronic action [11]. For acute action, we used a similar hypothesis.

The values of combined risk are shown in Table 3.

The values of the combined reflex and chronic effects of the full mix are higher as compared to the maximum risks of reflex and chronic effects from one substance from the mix. It is necessary to keep in mind that immediate effects occur in reflex responses among the most sensitive persons, i.e. the persons who are most affected by certain substances prove to be more sensitive to other substances as well. For this reason, potential immediate risk following combined exposure may be equal to the maximum risk of a certain mixture among all the active ingredients, even though it is necessary to take into account total chemical reactivity [11].

To assess total chemical reactivity, we used the combined action coefficient (hereinafter – CAC) for the chemical substances that compose the emission from the enterprise [5, 10, 12].

When assessing the level of air pollution with the use of CAC in the location of the enterprise, we identified 11 summation groups including 4 groups with above-standard CAC values – see Table 4.
For the group of substances emitted by the enterprise, we calculated the hazard index associated with the reflex and chronic action with the account for the critical organs and systems affected by the substances in the mix – see Table 5 [13].

The highest hazard index values (high) were recorded for the respiratory organs at the border of the enterprise site under both reflex and chronic exposure as well as in the residential area under reflex exposure (Table 5).

**Conclusion:**

In the Republic of Belarus, the largest amount of emission causing the biggest harm to the environment in terms of air pollution is produced by the following industries: transportation, communication, food, chemical, and agriculture. These are the fastest growing industries. The following substances are prevalent in the composition of the emission: nitrogen oxides, ammonia, sulfur dioxide, carbon monoxide, particulate matter of different fractions, heavy metals (mercury, lead, cadmium) and volatile organic compounds. Composition of the emission and the emitting industries are typical of the overall trends in the republic.

Maximum isolated risks from the emitted substances were recorded for saturated hydrocarbon of the aliphatic series C_{11}-C_{19} and are at the level of satisfactory risk under reflex exposure, and causing concern – under chronic exposure. Combined risk from all the emitted substances under reflex exposure is at the level of satisfactory risk, under chronic – at the level “hazard”. The obtained high values of the hazard index for the respiratory organs: under chronic exposure – 6.34, under reflex – 9.27.

The obtained results confirm the need to account for the combined action and summation effects of the chemical substances when making city-planning decisions and changing the sizes of the SPZ which is best realized through risk assessment. The data obtained through risk assessment (the values of combined risk, hazard index, and CAC) also help to reveal potential unfavorable effects on health, identify the areas for further epidemiological research, develop preventative measures to protect public health [14].

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