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FEATURES OF ATMOSPHERIC AIR POLLUTION IN A NON-INDUSTRIAL CITY: RISK FOR THE POPULATION

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Abstract. Features of atmospheric air pollution in a non-industrial city: risk for the population. Serdyuk A.M., Hushchuk I.V., Chernychenko I.O., Lytvychenko O.M. *Purpose – to study the territorial features of atmospheric air pollution of the regional administrative center without specific industrial sources of pollution, to determine carcinogenic and non-carcinogenic risks for the population. The study was carried out in Rivne. The results of our own observations, the materials of the State Institution "Rivne Regional Laboratory Center of the Ministry of Health of Ukraine", the materials of the Central Geophysical Observatory of the Ministry of Emergency Situations in Ukraine were analyzed. It was found that in the atmospheric air of Rivne, a regional center with a number of industrial facilities of communal property and a developed road network, the presence of chemical compounds of different classes is stably recorded, the concentrations of which in 20-40% of the samples exceed the MPC and reference concentrations. Territorial indicators of the content of harmful substances are in the following relationship: motorway ≥ industrial zone > park zone. Hygienic assessment of air quality by MPC criteria allows it to be classified as slightly hazardous. According to the criteria of carcinogenic and non-carcinogenic risks, air pollution in the city is not safe for the population and requires the adoption of preventive measures. It was shown that with exposure of detected air pollution there is a rather high probability of damage to the respiratory system of the body and the appearance of congenital malformations, as well as the development of cancer pathology. Hazard assessment of air pollution by carcinogenic and non-carcinogenic risks indicators is more informative and critically significant for determining its effect on public health.*

Реферат. Особенности загрязнения атмосферного воздуха непромышленного города: риск для населения. Сердюк А.М., Гущук И.В., Черниченко И.А., Литвиченко О.Н. *Цель – изучение территориальных особенностей формирования загрязнения атмосферного воздуха областного административного центра без имеющихся специфических промышленных источников загрязнения, определение канцерогенного и неканцерогенного рисков для населения. Исследование проводили в г. Ровно. Проанализированы результаты собственных наблюдений, материалы ГУ «Ровенский областной лабораторный центр МЗ Украины», Центральной геофизической обсерватории Министерства по чрезвычайным ситуациям в Украине. Установлено, что в атмосферном воздухе г. Ровно, областном центре с рядом промышленных объектов коммунальной собственности и развитой сетью автодорог, стабильно регистрируется наличие химических соединений различных классов, концентрации которых в 20-40% проб превышают ПДК и референтные концентрации. Территориальные показатели содержания вредных веществ находятся в такой зависимости: автомагистраль ≥ промышленная зона > парковая зона. Гигиеническая оценка качества воздуха по критериям ПДК позволяет классифицировать его как слабо опасный. По критериям канцерогенного и неканцерогенного*

рисков, загрязнение воздушной среды города не является безопасным для населения и требует принятия профилактических мер. Показано, что при воздействии обнаруженного загрязнения воздуха существует довольно высокая вероятность повреждения дыхательной системы организма и появления врожденных пороков развития, а также развития раковой патологии. Оценка опасности загрязнения атмосферного воздуха по показателям канцерогенного и неканцерогенного рисков является более информативной и критериально значимой для определения влияния его на здоровье населения.

The problem of quality of atmospheric air remains urgent for the population of any settlement.

Many domestic and foreign researchers note the leading etiological role of atmospheric air pollution in relation to other environmental objects in determining environmental factors and their impact on population health and quality of life [5, 7, 8, 10, 11].

In the Report of WHO Experts "Risk Reduction, Promoting a Healthy Lifestyle" [9] 5.0% of deaths from tracheal, bronchial and lung cancer, 2.0% of cardiopulmonary diseases, and 1.0% of respiratory infections are associated with atmospheric air pollution with small particles.

But it is important to note that atmospheric air pollution and its danger to the population have been identified in most studies on the example of large or industrialized cities with specific sources of pollution [2, 6, 7]. At the same time, this kind of research in the territory of small settlements was practically not carried out, which complicates extrapolation of the data available.

The aim of the work was to study the territorial features of the formation of atmospheric air pollution of the regional administrative center without the presence of specific industrial sources of pollution and to determine its carcinogenic and non-carcinogenic risk to the population.

MATERIALS AND METHODS OF RESEARCH

The studies were conducted in Rivne, a regional center with a number of communal property enterprises with 2.8 thousand tons or 11.5 kg of total emissions per capita per year. But specific gravity of industrial emissions is much lower than that of motor vehicles. Thus, in 2017, emissions to atmospheric air from stationary sources reached 14.9 thousand tons, while from mobile – 45,5 tons [1].

In order to evaluate the actual atmospheric air pollution, the results of our own research, the materials of the State Institution «Rivne Regional Laboratory Center of the Ministry of Health of Ukraine» and the Central Geophysical Observatory of the Ministry of Emergency Situations of Ukraine «On the State of Air Pollution for 2017-2018» were analyzed.

Danger assessment and risk identification for the population caused by pollution were carried out, guided by international methodological approaches tested by us [3, 4].

RESULTS AND DISCUSSION

The analysis of the materials obtained revealed the presence of stable compounds of different classes in atmospheric air in Rivne, quantitative measurement of which allows to determine features of their territorial distribution. The highest concentrations of the identified substances, the total list of which contains 9 compounds (dust, nitrogen and sulfur dioxide, carbon monoxide, phenol, formaldehyde, hydrogen fluoride, benz/a/pyrene and ammonia) were observed in the industrial area and near highways, the lowest - in the recreation park zone. During the annual cycle the excess of sanitary-hygienic standards of compounds was noted in 20-40% of samples (Table 1).

The most frequently excess of maximum permissible concentrations (MPC) was observed in dust, reaching 3.3 multiplicity by the average concentrations and 5.6 – by the maximum ones. By average concentrations, excess of hygiene standards was also recorded for nitrogen dioxide, formaldehyde, ammonia and phenol – in the range of 1.2-1.5 multiplicity, while by maximum – for all identified compounds (Table 2).

Similar or the like data are also obtained when comparing real concentrations with reference ones.

To address the degree of danger of registered air pollution, the indicators of carcinogenic and non-carcinogenic risk for the population were determined in the work [3, 4].

Non-carcinogenic risk characterization was performed using the hazard quotient (HQ) criterion, and hazard indices (HI) were calculated as the sum of the hazard coefficients of individual substances for the completeness of the determination of the harmful effects of pollution resulting from the combined action of the entire spectrum of substances.

Considering that under real conditions, concentrations of hazard substances in the air are not constant, to calculate the risk we were quided by the risk time-averaged and averaged data for the city.

Based on the results of the calculations (Table 2), it is evident that, despite the fact that the MPC of the individual substances in atmospheric air of Rivne is insignificant, the general hazard index for the population is quite high (15.5) by the average daily concentrations. Dust (HQ=5.0) and ammonia (HQ=4.0) have the highest proportion in the formation of non-

carcinogenic risk; formaldehyde (HQ=1.5) and nitrogen dioxide (HQ=1.2) also play a significant role. According to generally accepted international classification of non-cancerous risk, these compounds form high and alarming levels of risk [3, 4], since hazard quoitents and indices at levels higher than 1 indicate the likelihood of development of harmful effects in the organs and systems of the human organism, which increases proportionately to their growth (Tables 3, 4).

Table 1

Average daily concentrations of priority substances in the atmospheric air of Rivne

Chemical compounds	Content in the air, mg /m^3			Class of danger	Average daily MPC, mg / m^3	Reference concentration, RfC, mg / m^3
	minimum	average	maximum			
dust	0.21	0.5	0.84	3	0.15	0.1
nitrogen dioxide	0.024	0.048	0.082	2	0.04	0.04
sulfur dioxide	0.02	0.03	0.06	3	0.05	0.05
carbon monoxide	0.1	2.4	5.0	4	3.0	3.0
phenol	0.001	0.004	0.012	2	0.003	0.006
formaldehyde	0.001	0.0046	0.008	2	0.003	0.003
hydrogen fluoride	0.001	0.004	0.012	2	0.005	–
benz/a/pyrene, ng/ m3	0.2	0.9	1.2	1	1.0ng/m^3	1.0 ng/m^3
ammonia	0.03	0.4	0.7	2	0.2	0.1

As can be seen from the tables, the respiratory system of the human body (HI=13.8) and congenital malformations (HI=6.7) are the most vulnerable to the existing quantitative and qualitative composition of air pollution.

Table 2

Critical assessment of air pollution in Rivne

Chemical substances	Multiplicity of excess of MPC		Multiplicity of excess of reference concentrations, HQ	
	by averaged concentrations	by maximum concentrations	by averaged concentrations	by maximum concentrations
dust	3.3	5.6	5.0	8.4
nitrogen dioxide	1.2	2.5	1.2	2.5
sulfur dioxide	0.6	1.2	0.6	1.2
carbon monoxide	0.8	1.7	0.8	1.7
phenol	1.3	4.0	0.7	2.0
formaldehyde	1.5	2.7	1.5	2.7
hydrogen fluoride	0.8	2.4	0.8	2.4
benz/a /pyrene	0.9	1.2	0.9	1.2
ammonia	1.5	3.5	4.0	7.0
∑	11.9	24.8	15.5	29.1

Considering the danger of the oncogenic effect and understanding its social significance, we analyze the carcinogenic risk of individual compounds. Of the carcinogenic substances identified in the atmospheric air in Rivne are benz/a/pyrene and formaldehyde, for which the carcinogenic potential was defined on the basis of dose-effect dependencies (Table 5).

Table 3

Critical organs and systems that are primarily affected by studied compounds

Compound	Critical organs / systems
dust	respiratory organs, congenital malformations
nitrogen dioxide	respiratory system, blood (MetHb formation)
sulphur dioxide	respiratory system
carbon monoxide	blood, CVS, congenital malformations, CNS
phenol	CVS, kidneys, CNS, liver, respiratory system
formaldehyde	respiratory system, eyes, immune system, cancer
hydrogen fluoride	respiratory system, bone system
benz/a/pyrene	immune system, birth defects, cancer
ammonia	respiratory system

According to the estimated indicators, the carcinogenic risk is in the range from 1.15×10^{-4} to 6.20×10^{-5}, where formaldehyde plays the leading role. In general, such results indicate that even in the case of a small excess of the MPC, the carcinogenic risk slightly exceeds the allowable level and reaches alarming levels. Considering that the effect of these factors occurs against the simultaneous inhalation effect of nitrogen dioxide and phenol especially, which are modifiers of carcinogenesis, that is manifested in the enhancement of the carcinogenic effect, and Rivne, like the whole Rivne region, belongs to the territory of high radiation control, and these results cannot be ignored.

Table 4

General characteristics of non-carcinogenic risk by criteria of damage to critical organs and systems due to inhalation exposure to studied compounds in Rivne

Critical organs and systems of the body	Total hazard index HI
respiratory system	13.8
congenital malformations	6.7
immune system, cancer	2.4
blood	2.0
CNS, CVS, eyes	1.5
the bone system	0.8
liver, kidney	0.7

Table 5

Carcinogenic risk due to air pollution in Rivne

Compound	Near the motorway	Near industrial enterprises	Park area	In the whole city
formaldehyde	1.13×10^{-4}	9.88×10^{-5}	2.6×10^{-5}	6.1×10^{-5}
benz /a/pyrene	1.91×10^{-6}	1.63×10^{-6}	1.0×10^{-6}	1.3×10^{-6}
∑	1.15×10^{-4}	1.00×10^{-5}	2.7×10^{-5}	6.2×10^{-5}

Therefore, in assessing the situation in Rivne as a whole, it can be noted that by the total pollution index, calculated as the sum of the ratios of real concentrations to their MPCs, adjusted for the hazard class of compounds, air pollution in the city is considered to be slightly dangerous. However, even under such conditions, chemical pollution of the air poses a threat to the health of the population in terms of carcinogenic and non-carcinogenic risk. The way this may affect health indicators of the population will be shown in the following publications on the issues of quantitative and qualitative characteristics of the disease incidence and determining of environmental component in their formation.

CONCLUSIONS

1. In the atmospheric air of Rivne, a regional center with a number of industrial objects of communal property and a developed network of highways, the presence of chemical compounds of different classes is steadily registered, the concentrations of which in 20-40% of samples exceed the corresponding MPCs and reference concentrations. Territorial indicators of the content of harmful substances are as follows: motorway ≥ industrial zone> park zone.
2. Hygienic assessment of air quality by the criteria of the MPC allows to classify it as slightly dangerous.
3. According to the criteria of carcinogenic and non-carcinogenic risk, the air pollution of the city is not safe for the population and requires preventive measures. It is shown that due to the influence of the detected air pollution of the city there is a rather high probability of damage to the respiratory system and the occurrence of birth defects, as well as the development of cancer pathology.
4. Conflict of interests. The authors declare that there is no conflict of interest.

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