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CLIMATE CHANGE & SUSTAINABLE DEVELOPMENT: NEW CHALLENGES OF THE CENTURY

MONOGRAPH

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Mykolaiv – Rzeszow 2021

Petro Mohyla Black Sea National University, Ukraine
Rzeszow University of Technology, Poland

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Olena Mitryasova
Piotr Koszelnik

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The monograph is devoted to problems strategy of sustainable development as a road map of civilization; sustainable development of territories; sustainable use and protection of flora and fauna; environmental biochemistry, physiology and medicine; food technology in the context of sustainable development; monitoring of the atmosphere, hydrosphere and climate management; circular economy; rational use of water resources and wastewater treatment; rational use of land resources and reclamation of disturbed lands; environmental education for sustainable development..
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CONCLUSION

In 2010–2020 from Mariupol to the Sivash Lake, 15 species of bats were recorded at the locations planned for the construction of wind power plants using 6 certified ultrasonic detectors (Pettersson D240x, D500x; LunaBat DFR-1 PRO).

In the study area during the wintering, with limited research in this period, 8 species were found, during the spring and autumn migrations – 13 and in summer – 11 species. In all seasons, the least common were *Plecotus auritus, Myotis daubentonii, Nyctalus lasiopterus* and *Nyctalus leisleri, Hypsugo savii and Barbastella barbastellus.*

The greatest species diversity of bats (n = 10–12) was found in the narrowest gap between the Dnieper River and the Sea of Azov, as well as in the coastal strip, where the main flow of migrating animals takes place.

During migrations in the Ukrainian Pryazovia, bats willingly stop in tree hollows in parks, artificial forests and forest belts, various cliffs and buildings, which they use as temporary hiding places. In some of them they form small colonies and even overwinter.

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THE IMPACT OF CLIMATE CHANGE ON WORKERS IN THE CONSTRUCTION AND ROAD INDUSTRIES WORKING OUTDOORS

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ABSTRACT

This paper presents the algorithm of the system model developed by the authors to assess and predict the acceptability of production risk for workers working outdoors in urban areas. When building the model, a comprehensive approach was used, which takes into account all the influential factors in the context of global climate change. The model consists of two levels of hierarchy. An example of this approach is given for a separate subsystem of the model, which takes into account the subsystem of interaction of temperature and air quality indicators on the health of workers on the example of Darnytska Square in Kyiv based on meteorological data 2013-2020. A scale of classifications between quantitative indicators of industrial risk and indicators of air pollution has been developed. On the example of some large road junctions in Kyiv, the classification of industrial risk from the level of secondary air pollution by formaldehyde due to photochemical transformations in the air under constant weather conditions in 2016 is given as one of the hottest observations in the city. The results will be useful in developing recommendations for the protection of workers' health in the context of global climate change.

Key words: climatic factors, risk, urban area, health of workers, air pollution, highways.

INTRODUCTION

In the context of global climate change, environmental factors pose an additional risk to the health of workers working outdoors. This is primarily workers in the construction and road industries. Factors such as air pollution against the background of abnormal temperatures and increasing noise pollution of urban areas, including due to an increase in the number of mobile transport sources of pollution that run on gasoline and diesel fuel. These factors have led to increased risks to the health of outdoor workers. This requires additional health and work-related measures, starting with personal protective equipment. There is also a need to adjust and bring into line urban planning norms and recommendations. It is necessary to note in addition such dangerous toxicological factor of influence as evaporation of dangerous substances at the raised temperature indicators, for example when working with bitumen and asphalt mix.

The work of many domestic and foreign scientists [1-4, etc.] is devoted to the relationship between global climate change, air pollution and environmental risk to public health in large cities. In these works, on the basis of mathematical processing of long-term monitoring data on air quality indicators and public health indicators, correlations were established, which showed a close relationship depending on temperature indicators. In [5,6] on the basis of a mathematical model of convective polluted jet over a warm surface of roads under constant meteorological conditions, a solution was obtained that allows to obtain data on carcinogenic and non-carcinogenic risks to public health from secondary air pollution by emissions from road transport. gasoline and diesel fuel. The passage of photochemical reactions in the air of urban areas in this case depends on the meteorological conditions of the area, the stability of the atmosphere, temperature, humidity and air velocity.

But in addition to meteorological factors, workers who work outdoors also experience the effects of noise pollution on the body. Works [7,8,9, etc.] are devoted to the risk of noise pollution impact. The research presented in these works concerns the determination of the levels of acoustic pollution from vehicles in large cities, the impact of the levels of this pollution on the human body and the justification of measures to reduce it. Based on the definition of noise, it is noted that noise from vehicles is one of the sources of negative impact on human life and work near noise pollution.

Characteristics of the impact of production conditions at elevated temperatures would be incomplete without taking into account the toxicological effects on workers. According to the latest technologies, the method of "cold asphalt" is used, it includes: PVA, modifier "MAK", Bitumen brand MG or SG 70/130 [10]. The bitumen used as a part of "cold asphalt" belongs to the III class of danger.

Bitumen is dangerous to the health of workers when: it is transported at the maximum temperatures specified in the conditions of transportation and operation; works higher than +60 C are performed [11]. According to the list of occupational diseases approved by the order of the Ministry of Health of Ukraine, the Ministry of Social Protection of Ukraine, the Ministry of Labor of Ukraine from February 2, 1995 N 23/36/9, employees of road repair organizations working in the open with vehicles, bitumen and crushed stone, hand ramming, or electric stove are susceptible to such diseases as: acute chronic intoxication, toxic respiratory damage, skin diseases, allergic diseases, pneumosilicosis, vibration disease, sensorineural deafness, etc. According to [12] recorded, as of 13.07.2016 at an air temperature of +31 C, the asphalt temperature was +53 C. It should be noted that the temperature in the warm season can reach over +31 C, thereby leading to an increase in asphalt temperature, as the effect of heating the asphalt from vehicles and increasing the risk of disease of workers on the above diseases.

The possibilities of these existing solutions allow to obtain relative and quantitative assessments of the impact of individual factors discussed in the above works on public health, but to date has not considered the issue of occupational risk and safety of workers working outdoors in the context of interaction. dangerous factors in the conditions of gradual average annual increase of temperature indicators.

To support management decisions in the planning and reconstruction of the urban environment in accordance with the "Strategy of low-carbon development of Ukraine until 2050" and the introduction of the latest technologies of construction and road works, it is necessary to take into account the degree of industrial risk for outdoor health. acceptability. An integral part of this important and urgent problem is the need to solve a scientific and applied problem, which is to develop a unit for assessing and forecasting the acceptability of industrial risk in the context of global climate change, taking into account all influencing factors for this assessment.

METHODS AND EXPERIMENTAL PROCEDURES

The aim of the work is to build a solution algorithm for assessing and forecasting the acceptability of industrial risk for workers working in the open air of urban areas in order to further make recommendations for the protection of workers' health in the context of global climate change.

To solve this problem, a comprehensive synergetic approach is needed, taking into account all the influential factors that pose a danger to the health of this category of workers. The solution of this problem is possible with the help of a systematic hierarchical two-level model of the formation of industrial risk on workers in the open air, taking into account long-term trends of rising temperatures in global climate change.

A systematic mathematical model for assessing and forecasting the impact of global climate change on employee health involves two basic operations: the formation of many alternatives to the factors of influence and comparison and the choice of options for influencing the value of occupational risk. The system model identifies a complex problem that is able to implement the following basic principles:

- analysis and evaluation of individual processes, elements in subsystems;

- assessment and forecast of the impact of temperature changes on the value of production risk according to regulatory criteria.

At the first level of the hierarchy, the proposed model contains three independent subsystems:

1- Interaction of temperature and air quality indicators on the health of workers.

2- Noise effects on employee health.

3- Toxicological effect on the background of elevated temperatures.

When modeling production risk, the method and accuracy of laying the source information is important

Each subsystem is characterized by its own set of criteria and indicators f_1, f_2, $f_3 \ldots f_n$; q_1, q_2, $q_3 \ldots q_4$; p_1, p_2, $p_3 \ldots p_n$.

THE RESEARCH RESULTS AND DISCUSSIONS

Consider how the performance of each block at the first level of the system model on the example of meteorological factors.

It is known that a rise in temperature has a negative effect on human health, causing heat stroke; tachycardia, excessive sweating, which leads to water and salt imbalance, decreased blood flow to the brain, etc.

The relationship between the data of non-carcinogenic risk of contamination by the main components that exceed the reference doses and temperature indicators on the example of Darnytska Square in Kyiv in terms of 2013-2020 are presented in table 1. It should be noted that at the junction of Darnytska Square in Kyiv recently (2019) overhaul of the roadway was started, the lower layer of asphalt has already been installed.

The algorithm of this model is presented in fig. 1

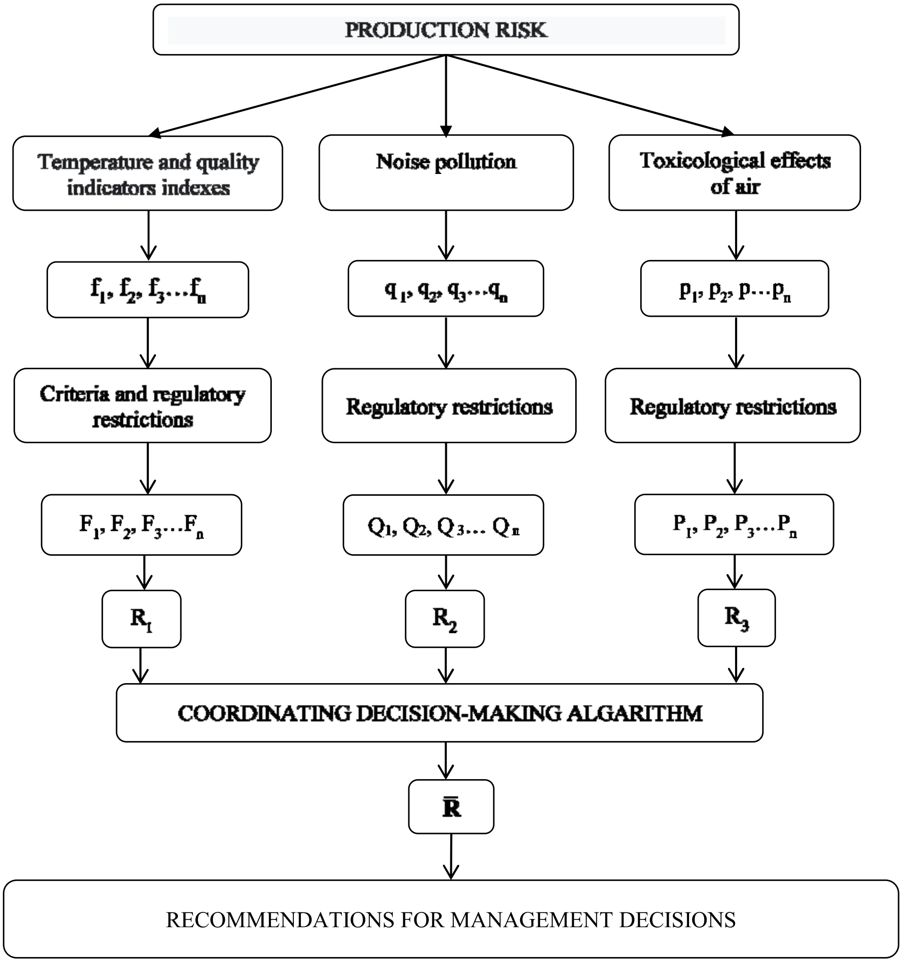

Fig.1. Algorithm of system hierarchical model of assessment and classification of production risk for workers working outdoors

On the example of some indicators of air pollution in urban areas according to individual stationary observation posts in Kyiv, the relationships between the main components of pollution and the average monthly temperature conditions in Kyiv according to the observations of the Central Geophysical Observatory. B. Sreznevsky in terms of 2013-2020 observations. These dependences showed a significant effect of temperature indicators on the indicators of air pollution, both primary and secondary indicators due to photochemical transformations in the air. Some dependences are given, which are a confirmation of this statement. Thus, Figure 2 shows the dependence of the stationary observations on Darnytska Square between the temperature and measurements of the toxic substance CHON in 2016, which was observed as one of the hottest years in recent decades.

Confirmation of the influence of temperature indicators and the dynamics of physicochemical transformations in the air are the dependences presented in Fig. 3, which show the dependences between temperature and NO_x indicators in the air, as well as the interaction of these pollutants, respectively. Moreover, in contrast to the graph CHON = f (t °), the dependence CHON = f (NO_x) is linear with a correlation coefficient of 0.73.

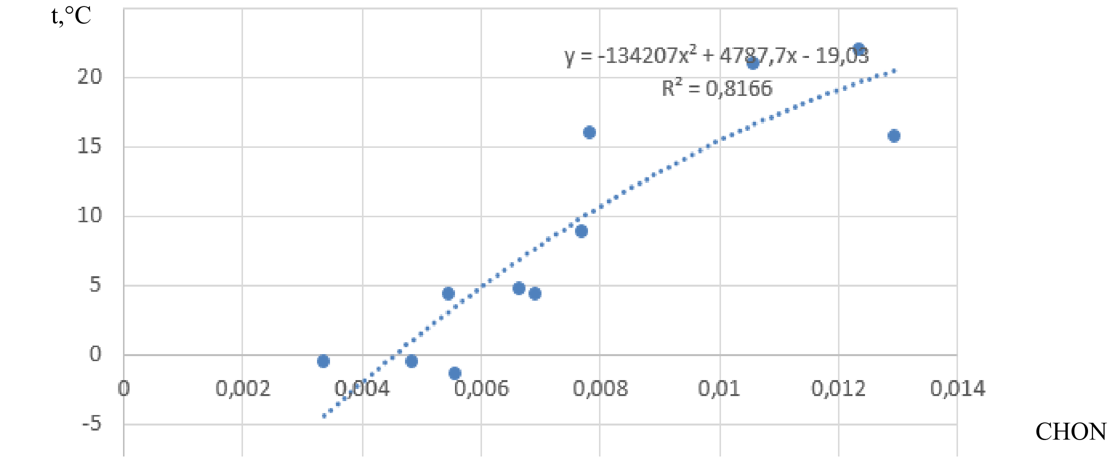

Fig. 2. Polygonal dependence between the indicators of CHON concentration in the air at the station of stationary observations in Kyiv (Darnytska Square) and the average temperature indicators in 2016.

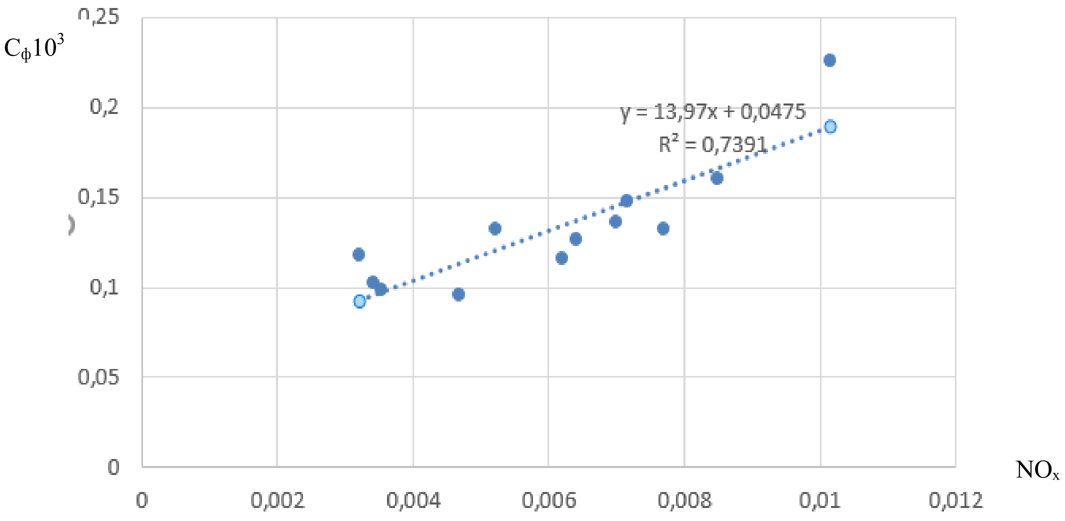

Fig.3. Relationship between the average monthly indicators of SNON concentration in the air at the station of stationary observations in Kyiv (Darnytska Square) and the average monthly NO_x concentrations in 2016

Risks to the health of the population were determined in accordance with the current in Ukraine Guidelines MR 2.2.12-142-2007 [13] on reference concentrations. Non-carcinogenic risk is calculated according to the total criterion of hazard index (HI), which is defined as the sum of hazard factors for exposure to substances (HQ).

As for the measurements of the current year, the average temperature in June 2021, according to the Central Geophysical Observatory. B. Sreznevsky, it was +21.3 °C, which is 1.8 °C above the climatic norm. From 23 to 26 June, as many as 10 temperature records were broken. Marked 6 days with a maximum air temperature above + 30.0 °C.

According to observations at the stationary posts of the Central Geophysical Observatory named after Borys Sreznevsky in the period from June 29 to July 5, 2021 in the air of Kyiv exceeded the maximum allowable concentrations (MPC) for the average daily content in the area of Darnytska Square: suspended solids - 1.0-1.2 times; nitrogen dioxide - 8.5; formaldehyde - 3.1-3.6 times.

Table 1. The value of non-carcinogenic risk under the conditions of chronic exposure to pollutants contained in the air (Darnytska Square) according to the data of July from 2013 to 2020

Substance/critical organs, system mg/m^3	CHON/ respiratory organs, immune.	NO_2/respiratory organs	Dust/respiratory system	Average monthly temperature, t°C	Year	∑HI = HQ
Reference concentration, mg/m^3	0,03	0,04	0,1		-	-
Measured concentration, mg/m^3	0,015	0,166	0,117	20,6	2013	-
HI	5,0	4,15	1,17	20,6	2013	10,32
Measured concentration, mg/m^3	0,016	0,176	0,128	22,3	2014	-
HI	5,3	4,4	1,28	22,3	2014	10,83
Measured concentration, mg/m^3	0,012	0,145	0,139	21,3	2015	-
HI	4,0	3,62	1,39	21.3	2015	10,01
Measured concentration, mg/m^3	0,014	0,172	0,1	22,4	2016	-
HI	4,67	4,30	1,0	22,4	2016	9,97
Measured concentration, mg/m^3	0,014	0,142	0,1	21,1	2017	-
HI	4,67	3,55	1,0	21,1	2017	9,22
Measured concentration, mg/m^3	0,006	0,112	0.09	21,4	2018	-
HI	2,0	2,8	0,9	21,4	2018	5,7
Measured concentration, mg/m^3				20,0	2019	-
HI	2,0	2,8	1,2	20,0	2019	6,0
Measured concentration, mg/m^3	0,0051	0,140	0,1	21,9	2020	-
HI	1,7	3,5	1,0	21,9	2020	6,2

According to estimates of non-carcinogenic risk, its value is 13.3.

Thus, the analysis of monitoring data on existing observation posts in Kyiv in 2013-2021 shows a stable excess of average monthly (from 1.5 and more in winter months and from 3 and more in summer), measured concentrations of such pollutants in the air as CHON, NO_2 and dust in the surface layer of atmospheric air. There is a tendency to increase over the years the concentrations of these pollutants against the background of increasing the number of personal vehicles with gasoline and diesel engines and long-term temperatures due to global climate change.

The data presented in Table 1 show that at elevated temperatures in one of the hottest months of the year, the value of non-carcinogenic risk to the health of workers working on the reconstruction of highways is in the range of 10-100. According to the classification of levels, this level of non-carcinogenic risk is defined as "significant". At this value, the risk is unacceptable for the population, and the production conditions require dynamic control and in-depth study of the sources and possible consequences of adverse effects to address the issue of risk management measures.

Carcinogenic risk according to the existing method [13] is defined as the product of the specific carcinogenic risk of a single pollutant multiplied by its average annual concentration. In the case of inhalation, the average daily intake m (dose rate), attributed to 1 kg of human body weight, is determined by the formula (1):

$$m = \frac{C \times V \times f \times T_0}{P \times T} \tag{1}$$

C - concentration of carcinogen in the environment - in the air, mg/m³;

V - volume of air entering the lungs during the day, m³/day;

f - is the number of days in the year during which the carcinogen is exposed;

T_0 - the number of years during which the effect of the carcinogen;

P - average body weight of an adult, kg;

T - the average time of possible action of the carcinogen, ext.

To establish a scale of classifications between quantitative indicators of industrial risk and indicators of air pollution, the values of actual concentrations of pollutants are used and obtained during their statistical processing. To characterize air pollution on the basis of calculated data, the maximum single concentrations obtained for a specific area of the settlement are usually used in the calculations of emission scattering. Listed in table 2 scale of classifications between quantitative indicators of industrial risk and indicators of air pollution. The formation of this classification was based on the State Sanitary Rules for the Protection of Atmospheric Air of Settlements (from Chemical and Biological Pollution) of the Ministry of Health of Ukraine DSP-201-97.

In the case when you need to know the degree of danger of industrial risk in excess of the concentration of one of the most dangerous pollutants, we use a similar approach for a separate indicator.

As an example, we will give the value of the level of industrial risk from formaldehyde pollution at three road junctions: street Bohatyrska – street Lugova - Marshal Tymoshenko Avenue; street Shcherbakovsky - street Stetsenka - street M. Grechka, street Schuseva - street Olena Telihy - street Melnikova and street Olena Teliga - S. Bandera Avenue - Kurenivka, Kyiv at the level of 2016. The analysis data are presented in table 3. It should be noted that the tables show the value of non-carcinogenic risk of air pollution

Table 2. Levels of assessment of quantitative indicators of industrial risk and indicators of air pollution

Pollution level	Degree of danger (according to the value of production risk)	The frequency of exceeding the reference values of individual pollutants (taken by the largest value)	The value of production risk
Permissible	Safe At this level, the desired (target) value of risk in health and environmental measures	<1	<1
Unacceptable	Slightly dangerous The level of risk is acceptable for production conditions. With the impact on the whole population, dynamic control and in-depth study of the sources and possible consequences of adverse effects is needed to address the issue of risk management measures	>1-2,0	1,0 – 10,0
Unacceptable	Moderately dangerous Dynamic monitoring and in-depth study of the sources and possible consequences of adverse effects are needed to address risk management measures	>2-4,5	10,0 – 50,0
Unacceptable	Dangerous Risk - unacceptable for the population, the production conditions require dynamic control and in-depth study of the sources and possible consequences of adverse effects to address the issue of risk management measures	>4,5-8	50,0 – 100,0
Unacceptable	Very dangerous The risk is unacceptable for working conditions and the population. Measures to eliminate or reduce the risk are needed	>9	>100,0

.

Table 3. The average monthly value of non-carcinogenic risk of formaldehyde air pollution due to photochemical transformations near some car interchanges in Kyiv in 2016.

№	Car junction name	Multiplicity of exceeding the reference values of individual pollutants	Significance of non-carcinogenic risk
1	street Bohatyrska – street Lugova - Marshal Tymoshenko Avenue	January -2.13 February-1.81 March-2.19 April -2.93 May-3.7 June-6.93 July-4.63 August-4.46 September 4.0 October-3.23 November -2.53 December -2.47	January - Moderately dangerous February- Slightly dangerous March- Moderately dangerous April - Moderately dangerous May - Moderately dangerous June - Dangerous July - Dangerous August - Dangerous September - Moderately dangerous October - Moderately dangerous November - Moderately dangerous December Moderately dangerous
2	street Shcherbakovsky - street Stetsenka - street M. Hrechka	January-3.6 February-3.2 March-3.6 April -4.87 May-6.17 June-6.63 July-7.63 August-7.43 September-7.67 October-5.37 November –4.23 December -3.17	January - Moderately dangerous February- Moderately dangerous March - Moderately dangerous April - Dangerous May - Dangerous June - Dangerous July - Dangerous August - Dangerous September is safe October is dangerous November - Moderately dangerous December Moderately dangerous
3	street Schuseva - street Elena Teliga - street Mel′nykova	January-3.7 February-3.07 March-3.7 April -4.93 May-6.3 June-6.76 July-7.76 August-7.57 September-7.03 October-5.46 November –4.3 December -4.17	January - Moderately dangerous February- Moderately dangerous March - Moderately dangerous April - Dangerous May - Dangerous June - Dangerous July - Dangerous August - Dangerous September is dangerous October is dangerous November - Moderately dangerous December Moderately dangerous
4	street Olena Teliga - S. Bandera Avenue - Kurenivka	January-3.3 February-2.76 March-3.3 April -4.43 May-5.67 June-6.07 July-7.0 August-6.67 September-6.33 October-4.93 November –3.87 December -3.73	January - Moderately dangerous February- Moderately dangerous March - Moderately dangerous April - Moderately dangerous May - Dangerous June - Dangerous July - Dangerous August - Dangerous September is dangerous October is dangerous November - Moderately dangerous December Moderately dangerous

The data in Table 3 once again emphasized the interdependence of temperature conditions, the degree of air pollution and, accordingly, the importance of industrial risk for workers in the open air near road junctions. It should also be noted the need for dynamic control during the year on the magnitude of production risk and risk management.

When calculating the indicators of the second subsystem - noise pollution should be guided by a number of current regulations on the impact of excess noise pollution on the employee's body.

For the city of Kyiv today the biggest noise pollution is road transport. As of 2020, about 1,087 ml were registered in Ukraine. auto (subject to re-registration) [14]. This has led to excessive traffic jams and congestion at road junctions, excessive congestion of exhaust gases and excessive noise during congestion of cars and nearby areas. With the increase in the number of cars in the city of Kyiv there is a constant transport collapse [15] exhaust gases and noise pollution significantly reduce the quality of the ecological state of the city, life and work in the areas adjacent to the roads. To understand the origin of vehicle noise, it is necessary to determine what is the largest source of noise in a car. Based on the structure of the car is determined that the main source of noise in the car is the engine. The intensity of noise pollution depends on the type, design and mode of operation of the engine. [16].

Based on the definition of noise, it should be noted that noise from vehicles is one of the sources of negative impact on human life and work near noise pollution [17-20].

The third subsystem of the model uses the method of taking into account toxicological indicators on the degree of their impact on human health depending on temperature indicators, which is presented in [21,22].

The coordinating decision-making algorithm takes into account the significance of the risk to public health according to the formula (2):

$$R = \sum R_i \tag{2}$$

i= 1,2,3.

The value of formula (1) is the sum of the defined values of risk for each subsystem, climatic conditions are taken into account indirectly at the level of the first and third subsystems.

For workers working near highways, you can use a calculator developed by [6] to calculate the concentration of secondary formaldehyde pollution depending on weather conditions (temperature, solar radiation) and the concentration of hydrocarbons that are precursors of formaldehyde formation at constant temperatures.

CONCLUSION

Studies have shown the need to take global climate change into account when determining occupational risk for social workers working outdoors. The analysis of all the influencing factors for the health of workers (air pollution, noise pollution and increased toxic effects of hazardous substances used in the production process) proved the need for a systematic approach to this scientific and practical problem. The proposed hierarchical system mathematical model for determining industrial risk in the context of global climate change allows to take into account all factors and their interaction.

This model allows to improve the system of production risk management on the basis of preliminary assessment and forecasting in the design, construction and reconstruction of urban areas and correctly define measures for the safety of workers.

The calculation of non-carcinogenic risks of air pollution under high temperature conditions on the example of Darnytska Square and some transport interchanges in Kyiv carried out within the first subsystem of the model showed that there is a need for dynamic control for workers working in the open air and in-depth study of the sources and possible consequences of harmful effects on road service workers. Under such conditions, there is a need for further improvement of the air monitoring system in the area of highway overpasses and large intersections in Kyiv by the State Hydrometeorological Service of Ukraine and the State Sanitary and Epidemiological Service of the Ministry of Health of Ukraine. Achieving an acceptable level of risk for workers working outdoors in areas of maximum importance can be achieved by implementing appropriate measures, which in addition to strengthening personal protection measures must also include the organization of traffic, maximum introduction of environmentally friendly modes of transport and use of more environmentally friendly fuel.

Needs a separate further study of the strengthening of toxicological effects of evaporation of hazardous substances in conditions of rising temperatures.

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The book is written for scientists, lecturers, postgraduate students, engineers and students who specialize in the field of environmental researches.
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