SECTION 6. ONCOLOGY

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6.1 Prevalence dependence of malignant tumors in the population on air pollution levels

Air pollution in industrial regions of Ukraine poses a serious threat to the environment and public health, as numerous epidemiological studies have revealed a link between air pollution and a wide range of adverse effects on public health. Also, dust emissions significantly worsen the ecological state of the environment, cause premature failure of industrial equipment and housing and communal services [232-239]. Of particular interest, from the point of view of sanitary and epidemiological well-being of the population, are the health risks associated with fine particles with a diameter of less than 10 and 2.5 microns, as they are able to penetrate deep into the lungs, however, particles with a diameter of less than 2.5 microns can even enter the bloodstream, which primarily leads to diseases of the cardiovascular and respiratory systems [240-248], and also causes damage to other organs. Various social groups such as the elderly, pregnant women, children and people with asthma may have more serious health consequences from exposure to polluted ambient air. The main source of ambient air pollution is the combustion of fuels in various sectors of the economy, including transport, energy, industry, construction, utilities [249-256] and agriculture [257-261], as well as in everyday life.

The World Health Organization (WHO) has established that 3.7 million new cases of cancer are detected in European countries annually. Malignant neoplasms are the second largest cause of death in Europe, causing almost 2 million deaths annually. Oncodermatological pathology occupies a significant place in the structure of cancer incidence in the population and is often characterized by an aggressive and unpredictable course. Among its individual forms, melanoma is particularly aggressive, accounting for 3-5% of all primary skin cancers. Its specific weight in the mortality structure from all oncodermatological diseases reaches 80% of deaths. At the same time, the incidence of malignant skin neoplasms depends to some extent on air quality.

According to the Resolution of the Cabinet of Ministers of Ukraine No. 303, a revision of the standards for the content of pollutants in atmospheric air is provided for due to changes in national legislation and the legislation of the European Union regarding the limitation of the content of pollutants in exhaust gases and the influence of physical factors of mobile sources of atmospheric air pollution. According to the classification of the International Agency for Research on Cancer, benzo[a]pyrene is considered a compound that is definitely carcinogenic to humans. The presence of this substance in atmospheric air is considered by experts as one of the key indicators of the aerogenic carcinogenic load on humans.

One of the most dangerous of the entire range of atmospheric air pollutants is fine dust with a particle diameter of up to 10 microns. Such dust is solid particles that can remain suspended in the air for a long time, are not effectively captured by existing purification devices and spread in the air over considerable distances.

In accordance with WHO recommendations, threshold exposure limits have been established in EU countries for fine dust with a diameter of less than 10 microns. For the average daily concentration, the threshold level of 50 $\mu g/m^3$ must not be exceeded more than 35 times during the year, the average annual concentration should not exceed the level of 40 $\mu g/m^3$. However, in the countries of Eastern Europe, the Caucasus and Central Asia, monitoring of suspended particles with a diameter of less than 10 microns is very limited: only a small number of monitoring stations are available in Belarus and Uzbekistan (Tashkent, Nukus), and in Ukraine, there are none at all.

The atmospheric air of settlements contains large amounts of fine dust, consisting of soot, cement crumb and other fine particles, which have an irritating, fibrogenic, allergenic and toxic effect on the human body. The nature of the impact depends on the physicochemical properties of dust particles, such as shape, solubility, degree of hardness, chemical composition. The chemical activity of dust in relation to the human body is determined by its specific surface area.

Toxic fine dust emissions under the influence of sunlight and ozone can form new, even more toxic compounds in the atmosphere. At the same time, atmospheric turbulence and wind do not always have time to remove dust emissions from the air basin of enterprises, which are increasing due to the intensification of production.

In the article [262], an improved mathematical model of pollutant concentrations in the leachate of municipal solid waste (MSW) landfills was proposed, and in the work [263], the mathematical model of specific energy consumption for cleaning MSW landfill soils from heavy metal contamination was improved. In the materials of the work [264], a regression hyperbolic dependence of the concentration of benzo[a]pyrene in MSW landfill soils on the measurement depth was determined, with the help of which it was determined that the dangerous depth of chemical contamination of MSW landfill soils with benzo[a]pyrene is 152 mm. In the materials of the article [265], a regression dependence of the concentration of petroleum products in soils on the distance to the MSW landfill was proposed, which made it possible to determine that the safe distance for MSW landfills from agricultural lands in terms of the level of chemical contamination of soils with petroleum products is 66 m. In [266], a regression dependence of the concentration of lead in soils on the distance to the MSW landfill was determined, with the help of which it was determined that the distance from the MSW landfill at which soil contamination with lead does not exceed the background level (the boundary of the weak pollution zone) is 526 m. The scheme of the meter for the concentration of explosive gases in the air was proposed in the scientific paper [267].

The materials of the scientific article [268] are devoted to the determination of regression power dependences of the prevalence of diseases of different classes in the adult population of settlements adjacent to the MSW disposal site on the distance to the landfill, which are used to determine the safe distance for the placement of MSW landfills from settlements according to the prevalence of diseases of the circulatory system and respiratory pathologies.

The author of the article [269] proposed a methodology for engineering calculations that can be used during a practical lesson “Study of environmental pollution by municipal solid waste and calculation of parameters of machines and equipment to minimize the negative impact on it” in the discipline of life safety, which will contribute to the deepening of knowledge on environmental protection issues of future specialists.

The results of modeling the specific energy consumption of cleaning soils of municipal solid waste landfills from heavy metal contamination are given in the article [270], and the determination of energy consumption for cleaning soils around municipal solid waste landfills from heavy metal contamination is published in the work [271].

The dependence of the level of bacteriological soil contamination on the distance to the municipal solid waste landfill is determined in the article [272].

Table 1 shows the incidence rates of malignant skin neoplasms in the city of Kyiv in different years, determined in [273], depending on the mass of pollutant emissions into the atmospheric air [274].

Table 1

Population indicators of malignant skin neoplasms in Kyiv depending on the mass of pollutant emissions into the atmospheric air [273, 274]

Year	2010	2012	2013	2014	2015	2016
Mass of pollutant emissions into the atmosphere, thousand tons	227.1	275.2	277.9	265.3	254.5	259.2
Prevalence of malignant skin neoplasms per 100 thousand population	45.4	51	56	51.9	50.9	49.2

Table 2 shows the incidence rates of respiratory cancer in the population of Kyiv for different concentrations of benzoapyrene in ambient air [275].

The regression data were carried out on the basis of linearization transformations, which allow reducing the nonlinear dependence to a linear one. The coefficients of the regression equations were determined by the least squares method using the developed computer program "RegAnaliz", which is protected by a certificate of copyright registration for the work [276], and is described in detail in the works [277, 278].

Table 2

Incidence rates of respiratory cancer in the population of Kyiv for different concentrations of benzo[a]pyrene in ambient air [275]

Concentration of benzo[a]pyrene $C_{20}H_{12}$ in atmospheric air, ng/m^3	1.99	2.65	2.82	3.00	3.09	3.18
Prevalence of respiratory cancer per 100 thousand population	24.5	28.5	34.4	26.5	26.2	35.7
Concentration of benzo[a]pyrene $C_{20}H_{12}$ in atmospheric air, ng/m^3	3.57	3.79	3.97	4.10	4.81	
Prevalence of respiratory cancer per 100 thousand population	30.8	31.6	31.8	37.7	38.1	

The computer program "RegAnaliz" allows for regression analysis of the results of single-factor experiments and other pairwise dependencies with the selection of the best type of function from the 16 most common options according to the criterion of the maximum correlation coefficient with saving the results in MS Excel and Bitmap format.

The results of the regression analysis are given in Table. 3, where the cells with the maximum value of the correlation coefficient *R* are marked in gray.

Therefore, according to the results of the regression analysis based on the data in Tables 1 and 2, the following regression dependencies were finally accepted as the most adequate [279, 280]:

$$P_{MSN} = \frac{1}{0.03719 - 6.696 \cdot 10^{-5} m_{PE}} \text{ [cases per 100 thousand people];} \quad (1)$$

$$P_{RC} = \frac{C_{BP}}{0.04961 + 0.01694 C_{BP}} \text{ [cases per 100 thousand people],} \quad (2)$$

where P_{MSN} – the prevalence of the population's incidence of malignant skin neoplasms, cases per 100 thousand people;

m_{PE} – annual mass of pollutant emissions into the atmospheric air in Kyiv, thousand tons;

P_{RC} – prevalence of respiratory cancer in the population, cases per 100 thousand people;

C_{BP} – concentration of benzo[a]pyrene $C_{20}H_{12}$ in atmospheric air, ng/m^3.

Table 3

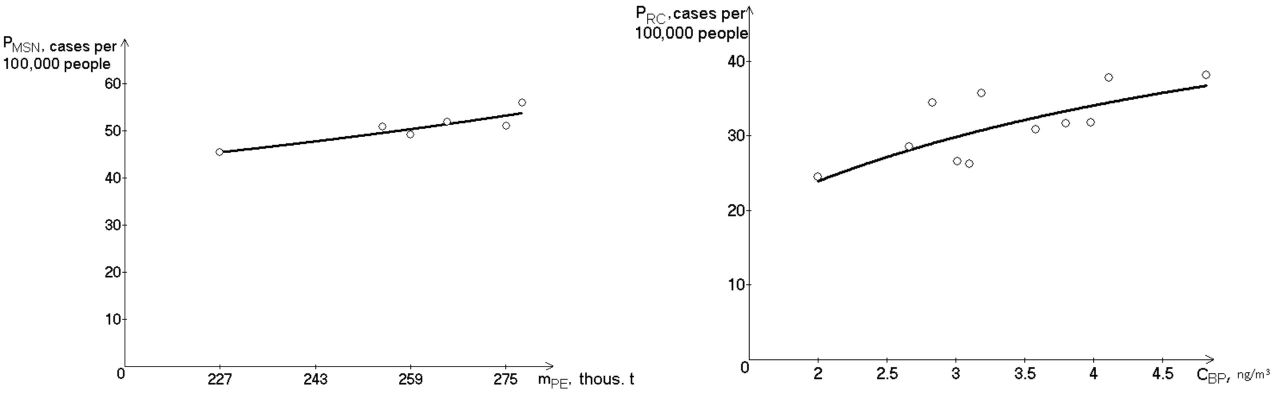
Results of regression analysis of the dependence of the prevalence of malignant neoplasms in the population on the levels of atmospheric air pollution

No.	Type of regression	Correlation coefficient R	
		$P_{MSN} = f(m_{PE})$	$P_{RC} = f(C_{BP})$
1	y = a + bx	0.87954	0.73041
2	y = 1 / (a + bx)	0.90099	0.73504
3	y = a + b / x	0.87396	0.70527
4	y = x / (a + bx)	0.35951	0.78037
5	$y = ab^x$	0.89097	0.73327
6	$y = ae^{bx}$	0.89097	0.73327
7	$y = a \cdot 10^{bx}$	0.89097	0.73327
8	$y = 1 / (a + be^{-x})$	0.80173	0.71440
9	$y = ax^b$	0.88952	0.73349
10	y = a + b·lg x	0.87710	0.72412
11	y = a + b·ln x	0.87710	0.72412
12	y = a / (b + x)	0.90098	0.73504
13	y = ax / (b + x)	0.89927	0.73572
14	$y = ae^{b / x}$	0.88732	0.72088
15	$y = a \cdot 10^{b / x}$	0.88732	0.72088
16	$y = a + bx^n$	0.88122	0.72544

Figure 1 shows the actual and theoretical graphical dependences of the prevalence of malignant neoplasms in the population on the levels of atmospheric air pollution.

Comparison of actual and theoretical data showed that the theoretical prevalence of malignant neoplasms in the population, calculated using the obtained regression equations (1, 2), do not significantly differ from the data given in the works [273-275], which confirms the previously determined sufficient accuracy of the obtained dependencies.

Thus, regression dependencies of the prevalence of malignant neoplasms in the population on the levels of atmospheric air pollution for the following diseases were determined: malignant neoplasms of the skin and respiratory cancer, which can be used to predict the indicators of such morbidity.



a) b)

Figure 1. Dependences of the prevalence of malignant neoplasms in the population on the levels of atmospheric air pollution: actual ○, theoretical — a) malignant neoplasms of the skin, b) respiratory cancer