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REGRESSION DEPENDENCE OF THE INCIDENCE OF RESPIRATORY CANCER OF THE POPULATION OF KYIV AS A RESULT OF AIR POLLUTION WITH BENZOPYRENE

Rapid improvement of modern industrial technologies and automobile transport led to important qualitative and quantitative changes in the composition and volumes of harmful emissions into the atmosphere. Impact of a number of harmful anthropogenic factors, including carcinogens, in particular, benzopyrene may cause the development of oncologic diseases. Determination of the regression dependence of the respiratory cancer incidence rate on the pollution of the atmospheric air with benzopyrene is relevant scientific-technical problem. Objective of the given research is determination of the regression dependence of the respiratory cancer incidence rate of the population on the pollution of the atmospheric air with benzopyrene, it can be used for the prediction of the incidence rate of the disease. In the process of the research method of regression analysis of the results of single-factor experiments and other paired dependences with the usage of the rational type of function from sixteen most widely-used variants by the criterion of maximum value of the correlation factor was used. Regression was performed on the base of linearized transformations, which enable to reduce non-linear dependence to linear one. Determination of the coefficients of the regression equations was carried out, applying the method of the least squares with the help of the developed computer program "RegAnaliz", protected by the Certificate of state registration of the right to the copyright object. Adequate regression hyperbolic dependence of the respiratory cancer incidence rate of the population on the pollution of the atmospheric air with benzopyrene was obtained, it can be used for the prediction of such incidence rate. Graphic interpretation of the dependence of respiratory cancer incidence rate of the population on the pollution of the atmospheric air with benzopyrene was constructed, which enables to illustrate this dependence and show the sufficient coincidence of theoretical results with actual.

Key words: incidence rate, respiratory cancer, chemical pollution, concentration of benzopyrene, atmospheric air, regression analysis, regression dependence.

Introduction

Rapid improvement of modern industrial technologies and automobile transport led to important qualitative and quantitative changes in the composition and volumes of harmful emissions into the atmosphere. This exercises constant impact on human as a result of a number of harmful anthropogenic factors, including carcinogens, that may cause the development of oncologic diseases [1]. Most important factor is presence of carcinogens of the class of polycyclic aromatic hydrocarbon, in particular, their main representative – benzopyrene. This substance, that has the property of being carcinogen of the local action under the inhalation effect, promotes the development of the malignant formations, mainly in respiratory system. According to the conclusions of the experts of International cancer agency, oncopathology is one of the indicators of ecological ill-being of the territory: chemical carcinogenic factors of the environment, mode of life and production condition the stipulate the development of almost 80 % of all malignant formations [2].

Problem set-up

According to the Resolution of the Cabinet of Ministers of Ukraine № 303 as a result of changes in national legislation and legislation of European Union regarding the limitation of the content of the pollutants in the exhaust gases and impact of physical factors of the mobile sources of atmospheric air pollution [3] revision of the standards of polluting substances content in atmospheric air is provided. In accordance with the classification of the International agency for

research on cancer benzopyrene is considered as human carcinogen [4]. Presence of this substance in atmospheric air is considered by the specialists as one of the key indices of aerogenic carcinogenic loading on human. That is why, determination of regression dependence of population respiratory cancer incidence rate as a result of atmospheric air pollution with benzopyrene, which can be used for the prediction of such incidence, is relevant scientific-technical problem.

Analysis of the recent research and publications

In the materials of the paper [5] stable, long-lasting pollution of the atmospheric air of the populated areas by the carcinogens of the priority classes: polycyclic aromatic hydrocarbons (benzopyrene), nitrosamines (nitrosodimethylamine and nitrosodiethylamine), heavy metals (cadmium, chromium, nickel, lead [6]), formaldehyde is established.

The study [7] contains single-factor mathematic models of concentrations for each separate from the priority substances in the filtrate of the landfills of SMW. In the research [8] improved mathematical model of polluting substances concentration in the filtrate of SMW landfills has been obtained, it can be used for the development of the strategy, complex of machines and equipment for solid municipal waste management.

Logarithmic regression dependences of the specific energy consumption for cleaning the soils of solid municipal waste landfills as a result of the pollution with heavy metals on decreasing the concentration of cadmium, lead and zinc are determined, they are used for the construction of mathematical model of specific energy consumption for cleaning the soil of the landfills from heavy metals pollution [9]. In the paper [10] the improved mathematical model of specific energy consumption for cleaning the soil of solid municipal waste landfills from heavy metals pollution is suggested, it can be used for the development of strategy, complex of machines and equipment for solid municipal waste management. Logarithmic regression dependences of specific energy consumption for soils of solid municipal waste landfills cleaning from the pollution of heavy metals on the concentration of cobalt, copper, nickel, chromium, vanadium, manganese are determined, they enable to evaluate energy consumption for cleaning the polluted soils from these substances.

It is noted in the paper [11] that the most toxic substance (among the polluting substances of the first hazard class) is the representative of the class of polycyclic aromatic hydrocarbons – benzopyrene, which in nano-quantity enables to exercise carcinogenic, mutagenic and other negative impacts on living organisms.

Author of the study [12] suggested the technique of engineering calculations which can be used during practical class «Study of the environmental pollution by solid municipal waste and calculation of the parameters of machines and equipment, needed for minimization of negative impact on the environment» on the subject of life safety, it will deepen knowledge of future specialists in the field of the environmental protection.

Prospects of using radio electronic devices for measuring the parameters of the environmental pollution are considered in the research [13], paper [14] contains functional diagram of the system of gas analysis for the control of the pollution of atmospheric air, its program realization is performed

Materials of the study [15] present the data, regarding the concentrations of benzopyrene in the soils of Mykolaiv landfill of solid municipal waste (village Velyka Korenykha, Mykolaiv region), obtained, using the method of high efficient liquid chromatography. In paper [16] the method of regression analysis for the determination of the regression hyperbolic dependence of benzopyrene concentration in the soils of the landfill of solid municipal waste on the depth of measuring is used, by means of this dependence it was determined, that the dangerous depth of chemical pollution with benzopyrene of the soils of solid municipal waste landfill is 152 mm.

The study [1] contains the respiratory cancer incidence rate of the population of Kyiv for various values of benzopyrene concentration in atmospheric air.

Objective and task of the paper

Objective of the paper is determination of the regression dependence of the respiratory

cancer incidence rate on atmospheric air pollution with benzopyrene, the dependence can be used for the prediction of incidence rate.

Methods and materials

For the determination of regression dependence of respiratory cancer incidence rate on atmospheric air pollution with benzopyrene the following methods were used: regression analysis of the result of single-factor experiments and other paired dependences, computer modeling.

Results of research

Table 1 presents the respiratory cancer incidence rate of the population of Kyiv for various values of benzopyrene concentration in atmospheric air [1]. On the base of the data of Table 1 it was planned to obtain paired regression dependence of respiratory cancer incidence rate on the pollution of the atmospheric air with benzopyrene.

Table 1

Concentration of benzopyrene in the soils of SMW landfill [1]

Concentration of benzopyrene $C_{20H_{12}}$ in atmospheric air, ng/m^3	1.99	2.65	2.82	3.00	3.09		3.18
Respiratory cancer incidence per 100 thous of population	24.5	28.5	34.4	26.5	26.2		35.7
Concentration of benzopyrene $C_{20H_{12}}$ in atmospheric air, ng/m^3	3.57	3.79	3.97	4.10	4.81		
Respiratory cancer incidence per 100 thous of population	30.8	31.6	31.8	37.7	38.1		

Regression was performed on the base of linearized transformations, which enable to reduce non-linear dependence into linear one. Determination of the coefficients of regression equations was carried out, using the method of least squares [17] by means of the developed program "RegAnaliz" [18], protected by the Certificate of state registration of the right for copyright object, described in the paper [19].

Program "RegAnaliz" enables to perform the regression analysis of the results of single-factor experiments and other paired dependences with the selection of the rational type of function from sixteen most widely used variants, by the criterion of maximum coefficient of correlation, results are stored in the format MS Excel and Bitmap.

Results of the regression analysis are presented in the Table 2, grey color indicates the cell with maximum value of the correlation coefficient R .

By the results of regression analysis, on the base of the data from Table 1, the following regression dependence is finally accepted as the most adequate:

$$\Pi_{RC} = \frac{C_{BP}}{0,04961 + 0,01694C_{BP}} \text{ [cases per 100 thous of population.],} \quad (1)$$

where Π_{RC} – is respiratory cancer incidence, cases per 100 thousand of population; C_{BP} – concentration of benzopyrene $C_{20H_{12}}$ in atmospheric air, ng/m^3 .

Table 2

Results of regression analysis of the dependence of respiratory cancer incidence rate of the population on the pollution of atmospheric air with benzopyrene

№	Type of regression	Correlation coefficient R	№	Type of regression	Correlation coefficient R
1	$y = a + bx$	0.73041	9	$y = ax^b$	0.73349
2	$y = 1 / (a + bx)$	0.73504	10	$y = a + b \cdot \lg x$	0.72412
3	$y = a + b / x$	0.70527	11	$y = a + b \cdot \ln x$	0.72412
4	$y = x / (a + bx)$	0.78037	12	$y = a / (b + x)$	0.73504
5	$y = ab^x$	0.73327	13	$y = ax / (b + x)$	0.73572
6	$y = ae^{bx}$	0.73327	14	$y = ae^{b/x}$	0.72088
7	$y = a \cdot 10^{bx}$	0.73327	15	$y = a \cdot 10^{b/x}$	0.72088
8	$y = 1 / (a + be^{-x})$	0.71440	16	$y = a + bx^n$	0.72544

Fig. 1 shows actual and theoretical graphic dependence of respiratory cancer incidence on the pollution of atmospheric air with benzopyrene.

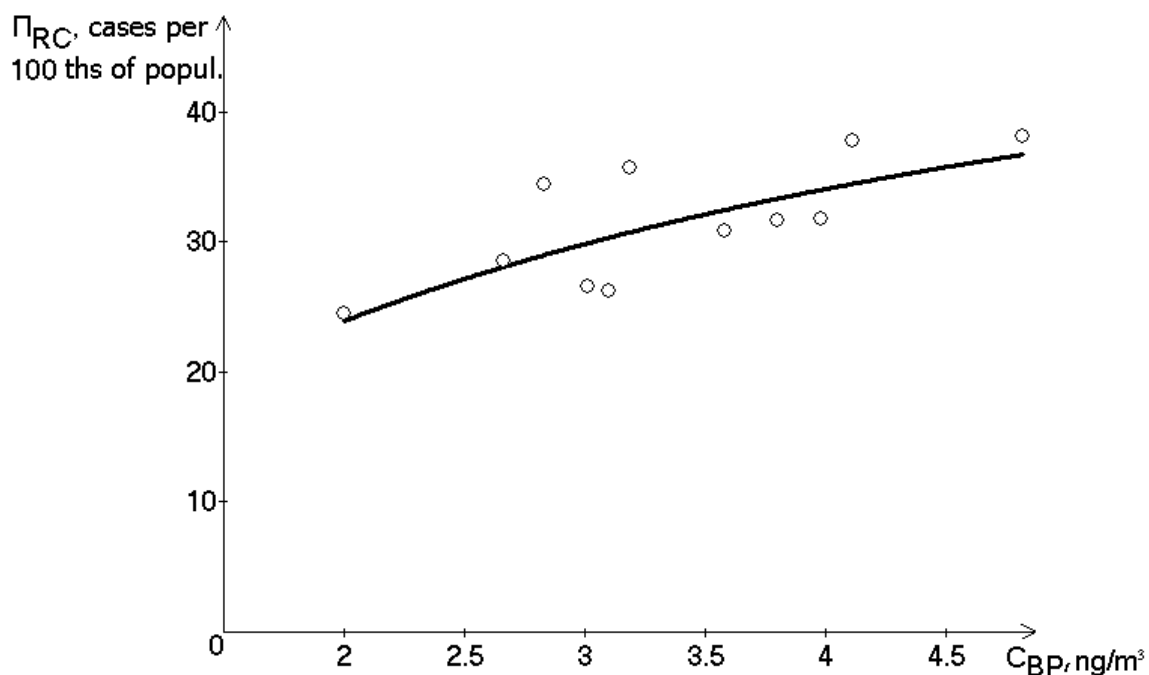


Fig. 1. Change of respiratory cancer incidence rate on the pollution of atmospheric air with benzopyrene

Comparison of actual and theoretical data showed that theoretical incidence of respiratory cancer incidence of the population on the pollution of atmospheric air with benzopyrene, calculated by means of regression equation (1), does not differ greatly from the data, presented in the paper [1], this proves the sufficient accuracy of the obtained dependence.

Conclusions

1. Regression dependence of the respiratory cancer incidence rate on the pollution of atmospheric air with benzopyrene is determined, it can be used for the prediction of the incidence rate of the disease.
2. Graphic dependence of respiratory cancer incidence rate of the population on the pollution of the atmospheric air with benzopyrene is constructed, it can illustrate this dependence and show the sufficient coincidence of theoretical results with actual.
3. It is established that the prevalence of the respiratory cancer incidence grows with the increase of benzopyrene concentration in atmospheric air according to hyperbolic dependence.

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