

**O. V. Bereziuk, Dr. Sc. (Eng.), Associate Professor; S. M. Horbatiuk,
Cand. Sc. (Biology), Associate Professor;
T. I. Shevchuk, Candidate of Medicine, Associate Professor; I. V. Khliestova**

DEPENDENCE OF GENERAL INCIDENCE OF BRONCHIAL ASTHMA ON ANNUAL PERFORMANCE OF THE INCINERATION PLANT

Bronchial asthma can be caused by the pollution of the environment, in particular, with flue gases of the incineration plants. Flue gas represents compound mixture of 27 components, that is why, the determination of the regression dependence of the population incidence of bronchial asthma on the performance of the incineration plant is relevant scientific-technical problem, which can be used for the prediction of the incidence of the disease. The objective of the research is the construction, by means of regression analysis, the regression dependence of the indices of general incidence of bronchial asthma on the performance of the incineration plant, it can be used for the prediction of the incidence of the disease. In the process of research method of regression analysis of the results of single-factor experiments and other paired dependences with the selection of the most adequate type of function from sixteen most widely used variants by the criterion of maximum value of the correlation coefficient 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 regression equations was performed, using the method of the least squares by means of the developed computer program "RegAnaliz". Regression dependence of the general incidence of the population of bronchial asthma on the performance of the incineration plant was obtained, the dependence can be used for the prediction of the indices of the incidence of such disease. Graphic dependence of general incidence of the population of bronchial asthma on the performance of the incineration plant was constructed. It enables to illustrate this dependence and show the sufficient coincidence of the theoretical results with actual. It is established that the prevalence of general incidence of the population of bronchial asthma grows with the increase of the performance of the incineration plant according to hyperbolic dependence.

Key words: incineration plant, municipal solid waste, incidence rates, bronchial asthma, regression analysis.

Introduction

Municipal solid waste (MSW) represent serious threat for human health and the environment [1]. Annual volume of MSW formed on the territory of our country exceeds 54 mil. m³, greater part of this volume is buried on 6107 landfills and dumps, their total area is 7700 ha, only small portion of the waste is either recycled or disposed at incineration plants (2 %), unlike highly developed countries, where modern technologies of waste recycling and disposal are widely used [2]. As a result of the increase of organic fuel prices, particularly, natural gas, problem of MSW usage as energy fuel becomes relevant. In such countries as Denmark, Netherlands the share of waste incineration is 54.3 % and 36.6 %, correspondingly [3]. During the period of 1995 – 2014 the usage of MSW burning in the countries of EU increased almost two times [4]. It is expedient to dispose MSW at available municipal TPP [5] with generation power of 12 MW, they can operate at the energy fuel (mixture of MSW, dehydrated to 20 % of relative humidity and coal with weight part 16 %) with the calculated low combustion value of 10.99 MJ/kg [6]. Nowadays thermal methods of MSW disposal gained controversial assessment in world practice as the technological process of any incineration plant is accompanied by complex pollution of the atmospheric environment. Flue gases of the incineration plants represents complex multicomponent mixture, 27 ingredients are identified in this mixture [7], they can cause the diseases of the respiratory organs [8 – 10], in particular, bronchial asthma.

Problem set-up

According to the Decree of the Cabinet of Ministers of Ukraine № 265 organization of the control over the operating and closed landfills of MSW to prevent harmful impact on the environment and human health is one of the priority directions of MSW management in Ukraine [11]. That is why, determination of the regression dependence of the indices of bronchial asthma incidence of the population on the performance of the incineration plant is relevant scientific-technical problem, which can be used for the prediction of the indices of such disease.

Analysis of the recent research and publications

Research [12] contains the regression models of such methods of MSW management usage as burial and incineration. According to data, published in the materials of the paper [6], low combustion value of MSW is 6.285...8.38 MJ/kg, and on the condition of decreasing the MSW humidity from 43 % to 20 % low combustion value of MSW is 9.14 MJ/kg, calculated low combustion value of the mixture of coal and MSW – 10.99 MJ/kg. In the study [13] using the suggested humidity meter [14] the investigation of the processes of MSW dehydration by means of the worm press, using experiment planning of the second order was carried out, the study enabled to determine adequate quadratic regression models of the dehydration indices from the basic impact parameters. In the paper [15] the scheme of the hydraulic drive for dehydration and compaction of MSW during their loading into the body of the dustcart was patented.

Study of the properties of MSW burning in the stationary layer is carried out [16], it was determined that the reduction of the average size of particles from 30 to 10 mm leads to increase of flame propagation from 0.6 cm/min to 0.8 cm/min, this, in its turn, greatly increases the rate of MSW burning and controls maximum carrying capacity of the waste at reaching the complete burning.

In the materials of the paper [17] the dependence of MSW burning spread with the energy disposal in the developed countries on such factors of influence as the density of population, value of gross domestic product per capita, index of human potential development, average geographic latitude of the country. The work [18] contains statistical data regarding the spread of the methods of MSW burning in Ukraine in 2012 – 2019.

It was established in [19] that the number of incineration plants in different countries is mostly influenced by GDP per capita and the least impact is exercised by the average geographical latitude, index of human potential development influences indirectly by means of the effects of factors interaction. Adequate regression dependence of the number of incineration plants in different countries is obtained in the form of quadratic regression in logarithmic coordinates with the effects of the interaction of the first order, it can be used in the process of development of the strategy, complex of machine and equipment for MSW management.

The authors of the paper [20] revealed the trend to the decrease of the incidence rates both of the adult population on the whole and working age population, with cerebral strokes, in the paper [21] regression dependence of the cerebral strokes incidences of the working age population on the performance of the incineration plant was determined. In the paper [22] regression power dependence of the respiratory systems diseases among the adult population of the settlements, adjacent to the places of MSW disposal on the distance to the landfill was determined, the dependence is used for the determination of the safe distance for the location of MSW landfills from the settlements according to the indices of spreading the pathology of the respiratory organs.

It is noted in the paper [23] that special attention among the respiratory diseases should be paid to the indicating pathology of high degree of dependence on the factors of the environment, in particular, allergic diseases (allergic rhinitis, bronchial asthma). In the materials of the study [24] the interaction between the dynamics of the bronchial asthma incidence and level of the technogenic loading of the atmospheric air by basis industrial pollutants is observed, as the peaks of the emissions of the polluting substances and growth of the incidence coincide in time. The research

[25] studies the correlation connection between bronchial asthma incidence among the children population of the city Khmelnytskyi and pollution of the atmospheric air during 2006 – 2010. Average correlation connection ($R = 0.45$) in the period 2006 – 2010 and strong connection ($R = 0.89$) – in the period 2008 – 2010 is established between these indices. Materials of the paper [26] show strong direct correlation connection between the degree of air pollution with the dust and general level of bronchial asthma incidence of the adult population ($R = 0.88$), blood circulation system ($R = 0.91$), coronary heart disease ($R = 0.89$), allergic rhinitis ($R = 0.72$).

The research [27], contains indices of bronchial asthma general incidence of the population in different years in Darnytsia administrative district of Kyiv, where the incineration plant “Energy” is located. However, specific mathematical dependences of bronchial asthma incidence of the population on the performance of the incineration plant as a result of the analysis of the known publications the authors did not reveal.

Objective and tasks of the paper

Objective of the paper is to construct by means of regression analysis the regression dependence of the indices of bronchial asthma general incidence of the population on the incineration plant performance, which can be used for the prediction of the disease indices.

Methods and materials

For the determination of the regression dependence of the indices of bronchial asthma general incidence on the performance of the incineration plant the following methods are used: regression analysis of the results of single-factor experiments and other paired dependences, computer simulation.

Results of the studies

Table 1 contain bronchial asthma incidence rate in different years in Darnytsia administrative district, city of Kyiv, where the incineration plant “Energy” is located, determined by the authors of the papers [27, 28], depending on the performance of incineration plant.

On the base of the data from Table 1 it was planned to obtain paired regression dependence of bronchial asthma incidence rate of the population on the performance of the incineration plant.

Regression was performed on the base of linearized transformations, which enable to reduce non-linear dependence to linear. Determination of the coefficients of the regression equations was performed applying the method of least squares [29], using the developed computer program “RegAnaliz” [30], protected by the Certificate of state registration of the rights to the copyright object and is described in details in the works [31, 32].

Table 1

Bronchial asthma incidence rate of the population depending on the performance of the incineration plant [27, 28]

Year	2011	2013	2014	2015	2016	2017	2019	2021	2022
MSW burn, ths. tons [18]	252.5	150.5	152.8	256.4	259.3	245.6	199.5	110.9	129.8
Bronchial asthma incidence among the population per 10 ths. of population	80.2	79.6	79	80.7	80.9	80.8	79.8	78.6	78.9

Program “RegAnaliz” enables to perform regression analysis of the results of single-factor experiments and other paired dependences with the selection of the most adequate type of function from 16 most widely spread variants by the criterion of maximum correlation factor, the results will be stored in the format MS Excel and Bitmap.

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

Table 2

Results of the regression analysis of the dependence of bronchial asthma general incidence of the population on the performance of the incineration plant

№	Type of regression	Correlation factor R	№	Type of regression	Correlation factor R
1	$y = a + bx$	0.95730	9	$y = ax^b$	0.95489
2	$y = 1 / (a + bx)$	0.95767	10	$y = a + b \cdot \lg x$	0.95442
3	$y = a + b / x$	0.94135	11	$y = a + b \cdot \ln x$	0.95442
4	$y = x / (a + bx)$	0.99992	12	$y = a / (b + x)$	0.95767
5	$y = ab^x$	0.95749	13	$y = ax / (b + x)$	0.94289
6	$y = ae^{bx}$	0.95749	14	$y = ae^{b/x}$	0.94213
7	$y = a \cdot 10^{bx}$	0.95749	15	$y = a \cdot 10^{b/x}$	0.94213
8	$y = 1 / (a + be^{-x})$	0.53370	16	$y = a + bx^n$	0.95313

Thus, according to the results of regression analysis, on the base of the data from Table 1, the following regression dependence is taken as the most adequate:

$$\Pi_{BA} = \frac{m_{b,MSW}}{0.07256 + 0.01212m_{b,MSW}} \text{ [cases per 10 ths. of pop.],} \quad (1)$$

where Π_{BA} – bronchial asthma general incidence of the population, cases per 10 ths. of population;
 $m_{b,MSW}$ – annual mass of burnt MSW, thousands of tons.

Fig. 1 shows actual and theoretical graphic dependence of bronchial asthma general incidence on the performance of the incineration plant

Comparison of actual and theoretical data showed that theoretical dependence the general incidence of bronchial asthma on the performance of the incineration plant, calculated by means of the regression equation (1) does not differ greatly from the data, presented in [27, 28], this proves the sufficient accuracy of the obtained dependence.

Analysis of the graphic dependence in Fig. 1 showed that the incidence of bronchial asthma among the population, grows with the increase of the performance of the incineration plant in accordance with the hyperbolic dependence.

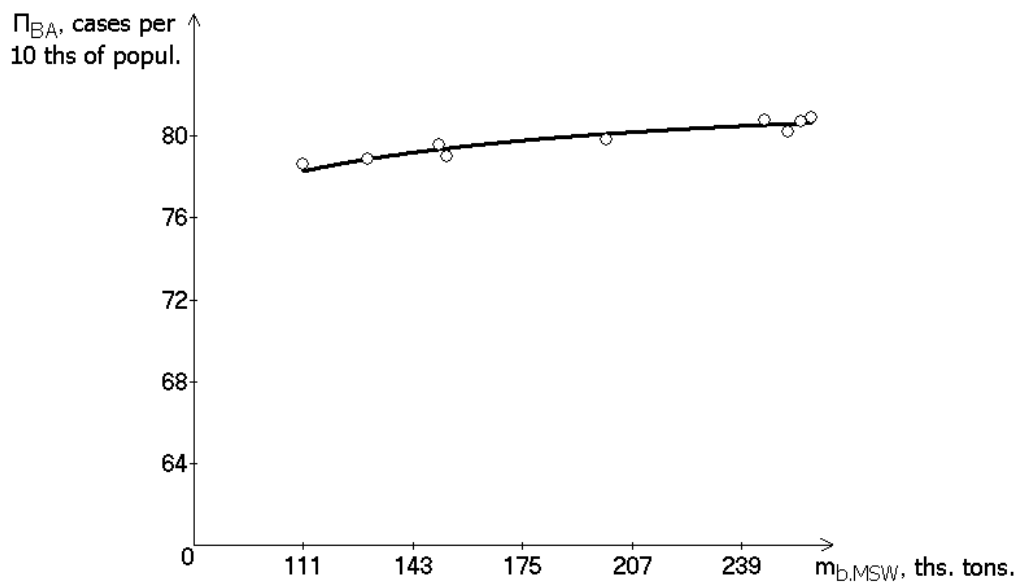


Fig. 1. Dependence of bronchial asthma incidence of the population on the performance of the incineration plant:
 actual ○, theoretical —

Conclusions

Regression dependence of bronchial asthma incidence of the population on the performance of the incineration plant was determined, it can be used for the prediction of the disease incidence rate.

Graphic dependence of bronchial asthma incidence on the performance of the incineration plant was constructed, it enables to illustrate this dependence and show the sufficient coincidence of the theoretical and actual results.

It was established that bronchial asthma incidence rate grows with the increase of the incineration plant performance in accordance with the hyperbolic dependence.

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Bereziuk Oleh – Dr. Sc. (Eng.), Associate Professor, Professor with the Department of Health and Safety, Pedagogy of Safety, e-mail: berezyukoleg@i.ua.
Vinnytsia National Technical University.

Horbatiuk Svitlana – Cand. Sc. (Biology), Associate Professor with Department of Medical Biology.

Shevchuk Tetiana – Cand. of Medicine, Associate Professor with the Department of Medical Biology.
Vinnytsia M. I. Pirogov National Medical University.

Khlietova Iryna – Intern doctor, general practitioner of poly-expert department of scientific-research institute of rehabilitation of people with disabilities.

Scientific-research institute of rehabilitation of people with disabilities, city of Vinnytsia.