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

REGRESSION DEPENDENCE OF THE RESPIRATORY ORGANS DISEASES MORBIDITY RATE ON THE WASTE INCINERATION PLANT EFFICIENCY

Flue gases of the waste incineration plants can cause the diseases of the respiratory system, as these gases represent complex multicomponent mixture, comprising 27 ingredients. That is why, determination of the regression dependence of the population total morbidity rate of the respiratory organs diseases on the efficiency of the waste incineration plant, that can be used for the prediction of the morbidity rate, is an important scientific-technical problem.

Objective of the research is the construction by means of the regression analysis the regression dependence of the population total morbidity rate of the respiratory organs diseases on the efficiency of the waste incineration plant, which can be used for the prediction of the morbidity rate of this disease. In the process of the research the 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 the sixteen most common variants by the criterion of maximum value of the correlation coefficient was used.

Regression was carried out on the base of the linearizing transformations, enabling to reduce this dependence to linear one. Determination of the coefficients of the regression equations was performed, applying the methods of the least squares, using the developed computer program "RegAnaliz". Regression dependence of the propagation of the total morbidity rate of the respiratory organs diseases on the efficiency of the waste incineration plant was obtained, this dependence can be used for the prediction of the indices of such disease. Graphic dependence of the propagation of the total morbidity rate of the population on the diseases of the respiratory organs diseases on the efficiency of the incineration plant was constructed, it enables to illustrate this dependence and show the sufficient coincidence of the theoretical results and actual ones. It was established that the propagation of the total morbidity rate of the respiratory organs diseases increases exponentially with the increase of the production efficiency of the incineration plant.

Key words: *incineration plant, municipal solid waste, morbidity rate, diseases of the respiratory organs, regression analysis.*

Introduction

Municipal solid waste constitute serious danger for human health and environment [1]. Every year more than 54 milm^3 of MSW are formed on the territory of Ukraine, greater part of the waste is buried on 6107 landfills and dump sites, their total area is almost 7700 ha, waste is only partially recycled or disposed at incineration plants (2 %), unlike the developed countries, which widely introduce modern technologies of recycling and disposing of MSW [2]. Due to the price increase for the organic fuel, in particular, natural gas, the problem of MSW usage as the energy fuel becomes more urgent in Ukraine. In such developed countries as the Denmark and the Netherlands the spreading of the waste burning is 54.3 % and 36.6 % correspondingly [3]. During the period of 1995 – 2014 the spreading of MSW burning in the countries of EC increased almost two times [4]. At the same time it is expedient to dispose MSW at the available thermal power plants with generating capacity of 12 MW, which can operate on the energy fuel (mixture of MSW, dehydrated to 20 % of the relative humidity and coal with parts by mass of 16%) with the calculated lower combustion heat 10.99 MJ/kg [3]. At the same time thermal methods of MSW disposal nowadays received mixed reviews in the world practice, as the technological process of any incineration plant is accompanied by the complex pollution of the atmospheric air. Flue gases of the incineration plants represent multicomponent mixture, in which 27 ingredients are identified and quantitively

determined [6], these components can cause the diseases of the respiratory system and blood circulation system.

Problem set up

According to the text of the Resolution 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 among the priority directions of MSW management in Ukraine [8]. That is why, the determination of the regression dependence of the general morbidity rate of the population on the diseases of the respiratory organs on the efficiency of the incineration plant, which can be used for the prediction of the morbidity rate of these diseases is important scientific-technical problem.

Analysis of the recent research and publications

Regression models of the propagation of such methods of MSW management as the deposition and burning are presented in the paper [7]. Low-combustion heat of MSW is 6.285...8.38 MJ/kg, and if the humidity of MSW is reduced from 43 % to 20 % low combustion heat of MSW is 9.14 MJ/kg, calculated low combustion heat of coal and MSW mixture is 10.99 MJ/kg [5]. In the paper [8] by means of the suggested humidity meter [9] the study of the MSW dehydration processes, using the worm press by means of experiment planning of the 2nd order was carried out, the study enabled to determine adequate quadratic regression models of the dehydration indices on basic impact parameters. In the work [10] the scheme of the dehydration hydraulic drive and MSW compaction in the dust cart during its loading is suggested.

Investigation of MSW combustion properties in the fixed bed [11] revealed the following dependence of the burning speed on the size of the particles: reduction of the average size of the particles from 30 to 10 mm leads to the increase of the fire propagation speed from 0.6 cm/min to 0.8 cm/min, that, in its turn, considerably increases the speed of MSW burning and, thus, controls maximum carrying capacity of the waste at reaching the complete combustion.

Dependence of MSW burning with energy waste treatment propagation in the developed countries on the influencing factors (density of the population of the country, value of gross domestic product per capita, human potential development index, average geographical latitude of the country) is studied in the paper [12]. In the research [13] statistical data regarding the propagation of the methods of MSW burning in Ukraine in 2012 – 2019 are presented.

It was established in the materials of the paper [14] that the number of waste incineration plants in different countries is influenced greatly by gross domestic product, and average geographical latitude has the least influence, human potential development index influences indirectly by means of the effects of the factors interaction, adequate regression dependence of the number of the incineration plants in different countries in the form of quadratic regression in the logarithmic coordinates with the interaction effects of the 1st order is obtained, it can be used for the development of the strategy, complex of machines and equipment for MSW management.

Decreasing tendency of the cerebral strokes morbidity rate both of the adult population on the whole and the population of the active working age are revealed in the research [15] and in [16] the regression dependence of the propagation of the cerebral stroke morbidity rate of the active working age population on the efficiency of the incineration plant has been determined. The paper [17] is devoted to the determination of the regression exponential dependences of the propagation of the diseases of different classes among the adult population of the settlements, adjacent to the site of MSW disposal on the distance to the landfill, which are used for the determination of the safe distance for the location of MSW landfill from the settlements by the indices of the propagation of the pathology of the respiratory organs and diseases of blood circulation system.

The paper [18] contains indices of the respiratory organs general morbidity rate of the population in different years in Darnytsia administrative district of Kyiv, on the territory of this district waste

incineration plant "Energy" is located. However, the authors did not reveal the mathematic dependence of the respiratory organs general morbidity rate on the performance of the waste incineration plant as a result of the analysis of the known publications.

Objective and tasks of the paper

Objective of the paper is the construction by means of regression analysis the regression dependence of the diseases of the respiratory organs general morbidity rate of the population on the efficiency of the waste incineration plant, which can be used for the prediction of the indices of such morbidity.

Method and materials

For the determination of the regression dependence of the diseases of respiratory organs general morbidity of the population on the efficiency of the waste 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 research

Table 1 contains the respiratory organs diseases general morbidity rate of the population in different years in Darnytsia Administrative District of Kyiv, on the territory of this district incineration plant "Energy" is located, determined by the authors of the research [18], depending on the performance of the incineration plant.

Table 1

Indices of the diseases of respiratory organs general morbidity of the population, depending on the efficiency of the incineration plant [18]

Year	2012	2015	2016	2017	2018
Burnt MSW ths. t. [13]	228.5	256.4	259.3	245.6	206.5
Propagation of the diseases of the respiratory organs general morbidity of the population per 10 ths. of population	5526.6	5744	5931.5	5827.4	5682.8

Based on the data of the Table 1 it was planned to obtain paired regression dependence of the diseases of respiratory organs morbidity rate of the population on the efficiency of the incineration plant.

Regression was carried out on the base of the linearizing transformations, which enable to reduce non-linear dependence to linear one. Determination of the coefficients of the regression equations was carried out by means of the least square method [19], using the developed computer program "RegAnaliz" [20], protected by the Certificate of the state registration of the right to the copyright object and described in details in the paper [21, 22].

Program "RegAnaliz" enables to perform the 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 options by the criterion of the maximum correlation coefficient, saving the results in MS Excel and Bitmap format.

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

Thus, by the results of the regression analysis, based of the data from Table 1 the following regression dependence is accepted as the most adequate

$$\Pi_{DRO} = 5608 - 1.69 \cdot 10^{-34} m_{\text{burnt.MSW}}^{15} \text{ [cases per 10 ths of popul.]}, \tag{1}$$

where Π_{DRO} − propagation of the diseases of the respiratory organs general morbidity of the population, cases per 10.000 people; $m_{\text{burnt.MSW}}$ − annual mass of burnt MSW, ths. tons.

Fig. 1 shows actual and theoretical graphic dependence of the propagation of the diseases of the

respiratory organs general morbidity of the population on the performance of the incineration plant.

Table 2

Results of the regression analysis of the dependence of the propagation of the diseases of the respiratory organs general morbidity of the population on the efficiency of the incineration plant

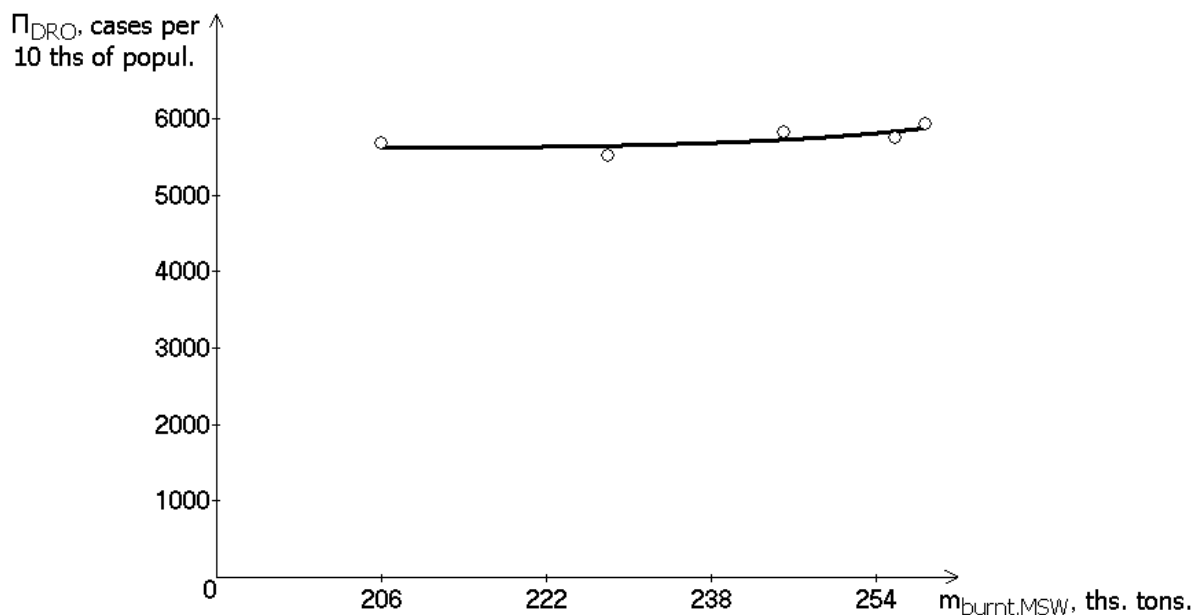| №	Type of regression	Correlation factor R	№	Type of regression	Correlation factor R
1	$y = a + bx$	0.64472	9	$y = ax^b$	0.62606
2	$y = 1 / (a + bx)$	0.63904	10	$y = a + b \cdot \lg x$	0.62895
3	$y = a + b / x$	0.61231	11	$y = a + b \cdot \ln x$	0.62895
4	$y = x / (a + bx)$	0.86327	12	$y = a / (b + x)$	0.63904
5	$y = ab^x$	0.64194	13	$y = ax / (b + x)$	0.60617
6	$y = ae^{bx}$	0.64194	14	$y = ae^{b/x}$	0.60931
7	$y = a \cdot 10^{bx}$	0.64194	15	$y = a \cdot 10^{b/x}$	0.60931
8	$y = 1 / (a + be^{-x})$	0.20751	16	$y = a + bx^n$	0.95166

Fig. 1. Dependence of the propagation of the diseases of the respiratory organs general morbidity of the population on the performance of the incineration plant: actual ○, theoretical —

Comparison of the actual and theoretical data showed that the theoretical propagation of the diseases of the respiratory organs general morbidity of the population, calculated by means of the regression equation (1), does not differ substantially from the data, presented in the research [18], this proves the sufficient accuracy of the dependence obtained before.

Analysis of graphic dependence in Fig. 1, showed that the propagation of the diseases of the respiratory organs general morbidity of the population increases exponentially with the increase of the efficiency of the incineration plant.

Conclusions

Regression dependence of the propagation of the diseases of the respiratory organs general morbidity of the population on the efficiency of the incineration plant has been determined, it can be used for the prediction of the indices of such morbidity.

Graphic dependence of the propagation of the diseases of the respiratory organs general morbidity of the population on the efficiency of the incineration plant has been constructed, it enables to illustrate this dependence and show the sufficient convergence of the theoretical and actual results.

It has been established that the propagation of the diseases of the respiratory organs general morbidity rate of the population increases exponentially with the increase of the efficiency of the incineration plant.

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

Vasenko Tetiana – Assistant with Department of Medical Biology.

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.