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DEPENDENCE OF THE DISEASES SPREADING ON THE DISTANCE BETWEEN THE RESINDENTIAL AREA AND SOLID DOMESTIC WASTE LANDFILL

In recent years in Ukraine, the total area of the solid domestic waste dumps and landfills, including the overloaded ones, which violate the norms of ecological safety and are the objects of the intensive ecological loading has grown. This may cause the pollution of the environment with harmful substances: heavy metals, microorganisms (colibacilli bacteria, streptococci, staphylococci, ascarids), high toxic filtrate, landfill gas, etc., giving rise to diseases. Determination of the regression dependences of various diseases incidence among the adult population of the residential areas, adjacent to the disposal sites on the distance to the solid domestic waste dump is an actual scientific engineering problem. The aim of the research is the determination of the regressive dependences of various diseases incidence among the adult population of the residential areas, adjacent to the disposal sites on the distance to the solid waste dump. In the process of the research the method of the regression analysis of single-factor experiments results and other pair dependences with the selection of the best type of function from the sixteen the most spread variants by the criterion of the maximum value of the correlation factor was used. The regression was carried out on the base of the linearized transformations, which enable to reduce the non-linear dependence to linear one. The determination of the coefficients of the regression equations was carried out, applying the method of the least squares by means of the developed computer program "RegAnaliz". Adequate regression power dependences of the diseases of various types incidence among the adult population of the residential areas, adjacent to the disposal sites on the distance to the dump are obtained. These dependences are used for the determination of the safe distance for the location of the solid domestic waste dumps from the residential areas by the indices of the pathology incidence of the respiratory system and diseases of the circulatory system. Graphic dependences of various types of the diseases spreading among the adult population of the residential areas, adjacent to the disposal sites on the distance to the dump, these dependences allow to illustrate these dependences and show the sufficient convergence of the theoretical results with the actual data.

Key words: *landfill, solid waste dump, solid domestic waste, spreading of the diseases, pathologies of the respiratory system, diseases of the circulatory system, regression analysis.*

Introduction

Solid domestic waste (SDW) represent serious danger for the health and security of the environment [1]. Every year more than 54 mil. m^3 of solid domestic waste are formed on the territory of Ukraine, greater part of the waste is buried on 6107 solid waste dumpsites and landfills, area of which is almost 7700 ha, only part of the waste is partially processed or disposed at the incineration plants, unlike highly developed countries, they widely use modern SDW recycling technologies [2]. In the period of 1999 - 2014 the total area of the solid waste dumpsites and landfills in Ukraine increased almost 3 times. The area of the overloaded dumpsites and landfills increased almost 2 times, the area of the dumpsites and landfills where the norms of ecological safety are violated, threatening the pollution of the environment by the harmful substances, in particular, as a result of polluting the soils with heavy metals, which together with the filtrate can penetrate to the ground waters increased 3.1 times, this creates hazard for life safety, human health and people activity. Landfills are also the objects of the intensive ecological loading on the environment, and may become source of pollution with microorganisms (colibacilli bacteria, streptococci, staphylococci and ascarids) of the adjacent plots of land [3], these microorganisms are disease agents and disease carriers [4]. Solid domestic waste dumpsites are also the sources of the long-lasting negative impact on the environment with the high-toxic filtrate [5, 6] and landfill gas,

which contains green house gases and toxic substances [7].

Problem set-up

According to the Order of the Cabinet of Ministers of Ukraine № 265 the implementation of the control over the functioning and closed solid domestic waste dumpsites to prevent harmful impact on the environment and human health is among the priority directions of solid domestic waste disposal in Ukraine [8]. That is why, determination of the regression dependences of different types of the diseases incidence among the adult population of the residential areas, adjacent to SDW disposal sites on the distance to the dumpsite, is actual scientific-engineering problem.

Analysis of the recent research and publications

Mathematical models of the forecast of SDW volumes formation and areas of the dumpsites and landfills in Ukraine are suggested in the paper [9]. As a result of studies it was established that the total area of the dumpsites and landfills increases approximately by the exponential law and the area of the overloaded dumpsites and landfills increases annually almost linearly. In order to decrease the rate of the dumpsites growth, the technological operation of SDW compaction during loading into the dumpcart is carried out [10, 11]. High compaction coefficient of SDW provides efficient usage of the area of the dumpsite [12, 13]. In [3] the wider range of sanitary biological composition of SDW in spring is revealed (bacteria colibacilli, streptococci, staphylococci and ascarids) due to the presence of staphylococci and ascarids, not available in SDW during summer composting. In [14] considerable pollution with heavy metals of the soils as a result of SDW burial was noted. Modeling of the specific energy consumption for soil of the dumpsite cleaning from heavy metals pollution is performed in the paper [15], as a result the logarithmic regression dependences of the specific energy consumption for dumpsites soils cleaning on the reduction of cadmium, lead, zink concentration, used for the construction of the mathematical model of the specific energy consumption for cleaning the soils of the dumpsites from heavy metal pollution. In the research [16] the regression dependence of the activity of biological processes in SDW on the degree of their compaction in the course of time is obtained, by means of this regression it is determined that the activity of biological processes in SDW mainly depends on the density of the waste and at least – on the time. In the paper [17] the mathematical model in the form of the logarithmic dependence of the polluting substances concentrations in the filtrate of SDW dumpsites is improved. In the research [18] mathematical models of saprophytic bacteria concentration in the soil dependence on the distance to the SDW dumpsite are constructed, these models enabled to determine that with the dumpsite approaching, the concentration of the saprophytic aerobic bacteria, necessary for biochemical reactions of the decomposition of the organic fraction of SDW greatly decreases in the places of burial and self cleaning of the soil from foreign organic substances occurs. In the research [19], it was determined that the negative impact of the landfills on the environment greatly influences the living conditions of the population, including health indices, it was also revealed the trend of increasing the incidence rate of the population by the classifications of the diseases in case of the decrease of the distance to the landfill. However, the authors did not reveal the specific mathematical dependences of various types of diseases spreading among the adult population of the residential areas, adjacent to the landfills.

Aim and tasks the paper

Aim of the paper is the construction by means of regression analysis the regression dependences of different types of the diseases incidence among the adult population of the residential areas, adjacent to the disposal sites of SDW on the distance to the dumpsite, these dependences can be used for the determination of the safe distance for the dumpsite location from the residential areas by the indices of different classes of the diseases incidence.

Methods and materials

For the determination of the regression dependences of different types of the diseases incidence among the adult population of the residential areas, adjacent to the disposal sites on the distance to the dumpsite the following methods are used: regression analysis of the results of single-factor experiments and other pair dependences, computer modeling.

Results of the research

Table 1 shows the averaged incidence of various types of diseases among the adult population of the residential areas, adjacent to the disposal sites, determined by the author of the research [19], depending on the distance between the limits of the residential area and solid domestic waste dumpsite. On the base of the Table 1 data, it was planned to obtain pair regression dependences of various types of diseases incidence among the adult population of the residential areas, adjacent to the disposal sites on the distance to the dumpsite.

Table 1

Incidence of various types of diseases among the adult population of the residential areas, adjacent to the disposal sites of solid domestic waste [19]

Distance to the SDW dumpsite, m	490	750	900
Incidence of the respiratory system pathology, cases per 10 ths . of population	6869	6384	1859
Incidence of the diseases of the circulatory system, cases per 10 ths. of population	7394	5455	4121

Regression was carried out on the base of the linearized transformations, which enable to reduce the non-linear dependence to linear one. Determination of the coefficients of regression equations was performed by the method of the least squares, applying the developed computer program "RegAnaliz", which is protected by the Certificate of the state registration of the rights to the copyrights object and is described in details in the paper [20].

Program "RegAnaliz" enables to perform the regression analysis of the results of single factor experiments and other pair dependences with the selection of the best type of function from 16 most widely spread variants by the criterion of maximum correlation coefficient, saving the results in the format MS Excel and Bitmap.

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

Thus, by the results of the regressive analysis on the base of the data, presented in Table 1, the following regressive dependences are accepted as the most adequate:

$$П_{PRS} = 6909 - 1{,}786 \cdot 10^{-32} x^{12} \text{ [cases per 10 ths. of population];} \quad (1)$$

$$П_{DCS} = 9596 - 0{,}2024 x^{1{,}5} \text{ [cases per 10 ths. of population],} \quad (2)$$

where $П_{PRS}$ – is the incidence of the pathology of respiratory system, cases per 10 ths. of population;

$П_{DSC}$ – is the incidence of the diseases of the circulatory system, cases per 10 ths. of population;

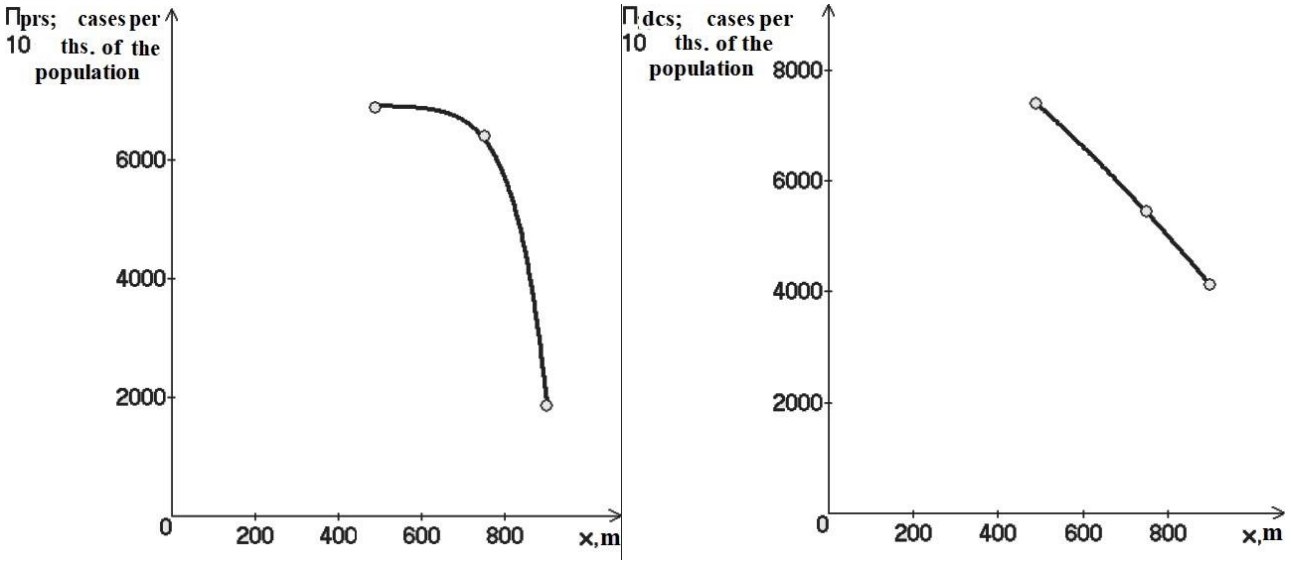
x – is the distance from the residential area to SDW dumpsite, m.

Fig. 1 presents the effective and theoretical graphic dependences of various types of diseases incidence among the adult population of the residential areas, adjacent to the disposal sites of SDW on the distance to the dumpsite.

Table 2

Results of the regression analysis of the dependences of various types of diseases incidence among the adult population of the residential areas, adjacent to the disposal sites of SDW on the distance to the dumpsite

№	Type of regression	Correlation coefficient R		№	Type of regression	Correlation coefficient R	
		$П_{PRS} = f(x)$	$П_{DSC} = f(x)$			$П_{PRS} = f(x)$	$П_{DSC} = f(x)$
1	$y = a + bx$	0,83127	0,99888	9	$y = ax^b$	0,76431	0,97933
2	$y = 1 / (a + bx)$	0,79456	0,97715	10	$y = a + b \cdot \lg x$	0,78826	0,99272
3	$y = a + b / x$	0,74623	0,98268	11	$y = a + b \cdot \ln x$	0,78826	0,99272
4	$y = x / (a + bx)$	0,83914	0,98192	12	$y = a / (b + x)$	0,79456	0,97715
5	$y = ab^x$	0,80956	0,99153	13	$y = ax / (b + x)$	0,70275	0,93828
6	$y = ae^{bx}$	0,80956	0,99153	14	$y = ae^{b / x}$	0,72040	0,96396
7	$y = a \cdot 10^{bx}$	0,80956	0,99153	15	$y = a \cdot 10^{b / x}$	0,72040	0,96396
8	$y = 1 / (a + be^{-x})$	0,74630	0,98272	16	$y = a + bx^n$	0,99990	0,99996



a) b)

Fig. 1. Dependence of the various types of diseases incidence among the adult population of the residential areas, adjacent to the disposal sites of SDW on the distance to the dumpsite: effective ○, theoretical — a) incidence of the pathologies of respiratory system, b) incidence of the diseases of the circulatory system

Comparison of the effective and theoretical data showed that the theoretical incidence of various types of diseases among the adult population of the residential areas, adjacent to the disposal sites of SDW on the distance to the dumpsite, calculated by means of the regression equations (1, 2), do not differ greatly from the data, presented in the research [19], that proves the previously determined sufficient accuracy of the obtained dependences.

In 2017 for the adult population of Ukraine (18 – 100 years) statistically average morbidity rates were: pathologies of respiratory system – 1532.05 per 10 ths. [21], diseases of the circulatory system – 495.74 per 10 ths. [22]. According to the Order of Ministry of Healthcare of Ukraine of 04.10.2018 № 1802 «On approval of changes to the Order of Ministry of Healthcare of Ukraine of July 10 2007 № 378», registered in Ministry of Justice of Ukraine on October 31 2018 №1240/32692 – form №12 «Report of the diseases, registered in the survey area of the treatment-prophylactic establishment», is cancelled [23]. That is why, statistical data regarding the diseases and morbidity rate for 2018 and 2019 are missing. Substituting statistically-average (background) data of the diseases incidence in the regression equations (1, 2) we determine the safe distances of the SDW dumpsites location from the residential areas by the indices of the pathology of the respiratory systems and diseases of the circulatory system incidence:

$$x_{PRS} = \sqrt[12]{\frac{6909 - \Pi_{PRS}}{1{,}786 \cdot 10^{-32}}} = \sqrt[12]{\frac{6909 - 1532{,}05}{1{,}786 \cdot 10^{-32}}} = 905\ (m);$$

$$x_{DSC} = \left(\frac{9596 - \Pi_{DSC}}{0{,}2024}\right)^{2/3} = \left(\frac{9596 - 495{,}74}{0{,}2024}\right)^{2/3} = 1264\ (m).$$

Conclusions

Regression exponential power dependences of various types of diseases incidence among the adult population of the residential areas, adjacent to the disposal sites of SDW on the distance to the dumpsite are determined, these dependences are used for the determination of the safe distance of the dumpsite location from the residential areas by the indices of the pathology of respiratory system and diseases of the circulatory system incidence.

Graphic dependences of various diseases incidence among the adult population of the residential areas, adjacent to the disposal sites of SDW on the distance to the dumpsite are constructed, these dependences allow to illustrate these dependences and show sufficient coincidence of the theoretical results with the actual results.

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