SECTION 4. PREVENTIVE MEDICINE

DOI: 10.46299/ISG.2023.MONO.MED.2.4.1

4.1 The dependence of respiratory diseases incidence indicators on municipal solid waste management

Municipal solid waste (MSW) poses a serious threat to health and environmental safety. Every year, more than 54 million m^3 of MSW are generated on the territory of Ukraine, the main part of which is buried in 6,107 landfills and landfills with an area of almost 7,700 hectares and is only partially processed or disposed of in incineration plants (about 2%), in contrast to highly developed countries, which are known for a wide introduction of modern technologies for processing and disposal of MSW. During 1999-2014, the total area of landfills and landfills in Ukraine increased 3 times. The area of overloaded landfills and landfills that violate environmental safety standards has increased by almost 2 times and by more than 3.1 times, contaminating them, which poses a threat to the safety of life, health and human activity. Landfills are also objects of intensive ecological load on the environment and can pose a danger of contamination by microorganisms (bacteria of Escherichia coli, streptococci, staphylococci and roundworms) of adjacent land plots [158], which are pathogens and carriers of diseases [159]. MSW landfills are also sources of long-term negative impact on the environment with highly toxic leachate [160] and landfill gas, which contains greenhouse gases and toxic substances [161].

Mathematical models for forecasting volumes of MSW generation and areas of landfills and landfills in Ukraine are proposed in article [162]. As a result, it was established that the total area of landfills and landfills, as well as those that do not meet eco-safety standards, increases over time approximately according to an exponential law, and the area of overloaded landfills and landfills, both those that meet and those that do not meet the standards of eco-safety grows almost linearly every year. In order to reduce the rate of growth of landfill areas, a technological operation of MSW compaction is performed during loading into a dustcart [163, 164]. A high MSW compaction factor ensures more efficient use of the landfill area [165]. In work [160],

a wider nomenclature of the sanitary and bacteriological composition of MSW in the spring (Escherichia coli bacteria, streptococci, staphylococci, and roundworms) was revealed due to the presence of staphylococci and ascaris, which were absent in MSW during summer composting. In the work [166] it is indicated about the significant contamination of soils by heavy metals due to the burial of MSW. Modeling of the specific energy costs of cleaning the soil of MSW landfills from contamination by heavy metals was carried out in the article [167], as a result of which logarithmic regression dependences of the specific energy costs of cleaning the soil of MSW landfills due to heavy metal contamination on the reduction of cadmium, lead and zinc concentrations were proposed, which were used to build a mathematical model of the specific energy consumption of cleaning landfill soils from contamination with heavy metals. In work [168], the regression dependence of the activity of biological processes in MSW on the degree of their compaction over time was obtained, with the help of which it was established that the activity of biological processes in MSW depends most on their density, least on time. The article [169] improved the mathematical model in the form of a logarithmic dependence of the concentrations of pollutants in the leachate of MSW landfills. In work [170], mathematical models of the dependence of the concentration of saprophytic bacteria in the soil on the distance to the MSW disposal site were built, which made it possible to establish that as the landfill approaches, the concentration of saprophytic aerobic bacteria, necessary for the biochemical reactions of the decomposition of the organic fraction of MSW in the places of their disposal, significantly decreases and self-cleaning of the soil from foreign organic substances. In work [171], it was found that the negative impact of landfills on the environment significantly affects the living conditions of the population, including health indicators, and the trend of increasing morbidity rates of the population according to disease classifications was revealed as the distance to the landfill decreases.

In connection with the increase in the price of organic fuel, especially natural gas, the problem of using MSW as an energy fuel is becoming more urgent in Ukraine. In such developed countries as Denmark and the Netherlands, the prevalence of waste incineration is 54.3% and 36.6%, respectively [172]. Only during the period 1995-

2014, the prevalence of MSW incineration in the EU countries increased almost 2 times [173]. At the same time, it is expedient to dispose of MSW at existing municipal CHP plants with a generating capacity of 12 MW, which can operate on energy fuel (mixtures of MSW dehydrated to 20% relative humidity and hard coal with a mass fraction of 16%) with an estimated lower calorific value of 10.99 MJ/kg [174]. At the same time, thermal methods of MSW disposal have currently received an ambiguous assessment in world practice, since the technological process of any waste incineration plant is definitely accompanied by complex pollution of the atmospheric environment. The flue gases of waste incineration plants are a complex multicomponent mixture, in which 27 ingredients have been identified and quantified [175], which can lead to diseases of the human respiratory and circulatory systems.

Regression models of the prevalence of such methods of municipal solid waste management as burial and incineration are given in the article [176]. The lower heat of combustion of municipal solid waste is 6.285...8.38 MJ/kg, and under the condition of reducing the humidity of MSW from 43% to 20%, the lower heat of combustion of municipal solid waste is 9.14 MJ/kg, the estimated lower heat of combustion of a mixture of coal and MSW is 10.99 MJ/kg [174]. In work [177], with the help of the proposed moisture meter [178], a study of the processes of municipal solid waste dehydration by a screw press was carried out using the planning of a second-order experiment, which made it possible to determine adequate quadratic regression models of dehydration indicators from the main influence parameters. The work [179] proposed a hydraulic drive scheme for dewatering and compacting MSW in a dustcart during their loading.

A study of the burning properties of MSW in a stationary layer [180] established the following dependence of the burning speed on the particle size: a decrease in the average particle size from 30 to 10 mm leads to an increase in the flame propagation speed from 0.6 cm/min to 0.8 cm/min, which, in turn, significantly increases the MSW burning rate and, therefore, controls the maximum throughput of waste when complete combustion is achieved.

The dependence of the prevalence of MSW incineration with energy utilization in developed countries on influencing factors (population density of the country, gross domestic product per capita, human potential development index, average geographical latitude of the country) was investigated in the article [181]. The work [182] provides statistical data on the prevalence of MSW incineration methods in Ukraine in 2012-2019.

In the materials of the article [183], it was established that the number of waste incineration plants in different countries is most affected by GDP per capita, and the least by the average geographical latitude, and the human potential development index affects only indirectly through the effects of the interaction of factors, and an adequate regression dependence of the number was also obtained of waste incineration plants in different countries in the form of quadratic regression in logarithmic coordinates with the effects of 1st-order interactions, which can be used during the development of a strategy, a complex of machines and equipment for MSW management.

A tendency towards a decrease in the incidence of cerebral strokes, both in the adult population as a whole and in the working-age population, was revealed in [184], and in the article [185], the regression dependence of the incidence of cerebral stroke in the working-age population on the productivity of the waste incineration plant was determined. The work [186] is devoted to the determination of the regression degree dependences of the prevalence of diseases of various classes in the adult population of settlements adjacent to the place of MSW removal from the distance to the landfill, which are used to determine the safe distance of placement of MSW landfills from settlements based on the prevalence of respiratory diseases and diseases of the system blood circulation

The work [187] shows, in particular, the indicators of the general morbidity of the population in different years for diseases of the respiratory organs in the Darnytskyi administrative district of Kyiv, on the territory of which the waste incineration plant "Energia" is located.

In the table 1 shows the average prevalence of diseases of different classes in the adult population of settlements adjacent to the MSW disposal site, determined by the

author [171], depending on the distance between the border of the settlement and the MSW landfill.

Table 1

Prevalence of respiratory diseases in the adult population of settlements adjacent to the site of municipal solid waste disposal [171]

Distance to the landfill, m	490	750	900
Pathology prevalence of respiratory organs, cases per 10,000 people	6869	6384	1859

In the table 2 shows the indicators of the general morbidity of the population in different years for diseases of the respiratory organs in the Darnytskyi administrative district of Kyiv, on the territory of which the waste incineration plant "Energia" is located, determined by the authors of the work [187], depending on the productivity of the waste incineration plant.

Table 2

Indicators of the general morbidity of the population for diseases of the respiratory organs depending on the productivity of the waste incineration plant [187]

Year	2012	2015	2016	2017	2018
MSW burned, thousand tons [182]	228.5	256.4	259.3	245.6	206.5
Prevalence of general incidence of respiratory diseases per 10,000 population	5526.6	5744	5931.5	5827.4	5682.8

Regressions were performed on the basis of linearizing transformations, which allow to reduce the non-linear dependence to a linear one. The coefficients of the regression equations were determined by the method of least squares using the developed computer program "RegAnaliz", which is protected by a certificate of copyright registration for the work [188], and is described in detail in the works [189, 190].

The "RegAnaliz" program allows you to carry out regression analysis of the

results of univariate 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 shown in the table 3, where cells with the maximum value of the correlation coefficient R are marked in gray.

Table 3

The results of the regression analysis of the dependence of the prevalence of respiratory diseases on the methods of municipal solid waste management

No.	Type of regression	Correlation coefficient R		No.	Type of regression	Correlation coefficient R	
		$P_{RD} = f(x)$	$P_{RD} = f(m_{inc.MSW})$			$P_{RD} = f(x)$	$P_{RD} = f(m_{inc.MSW})$
1	$y = a + bx$	0.83127	0.64472	9	$y = ax^b$	0.76431	0.62606
2	$y = 1 / (a + bx)$	0.79456	0.63904	10	$y = a + b \cdot \lg x$	0.78826	0.62895
3	$y = a + b / x$	0.74623	0.61231	11	$y = a + b \cdot \ln x$	0.78826	0.62895
4	$y = x / (a + bx)$	0.83914	0.86327	12	$y = a / (b + x)$	0.79456	0.63904
5	$y = ab^x$	0.80956	0.64194	13	$y = ax / (b + x)$	0.70275	0.60617
6	$y = ae^{bx}$	0.80956	0.64194	14	$y = ae^{b / x}$	0.72040	0.60931
7	$y = a \cdot 10^{bx}$	0.80956	0.64194	15	$y = a \cdot 10^{b / x}$	0.72040	0.60931
8	$y = 1 / (a + be^{-x})$	0.74630	0.20751	16	$y = a + bx^n$	0.99990	0.95166

So, according to the results of the regression analysis based on the data in the table 1 and 2, the following regression dependencies [186, 191] were finally adopted as the most adequate:

$$P_{RD} = 6909 - 1.786 \cdot 10^{-32} x^{12} \text{ [cases per 10,000 people];} \quad (1)$$

$$P_{RD} = 5608 - 1.69 \cdot 10^{-34} m_{inc.MSW}^{15} \text{ [cases per 10,000 people],} \quad (2)$$

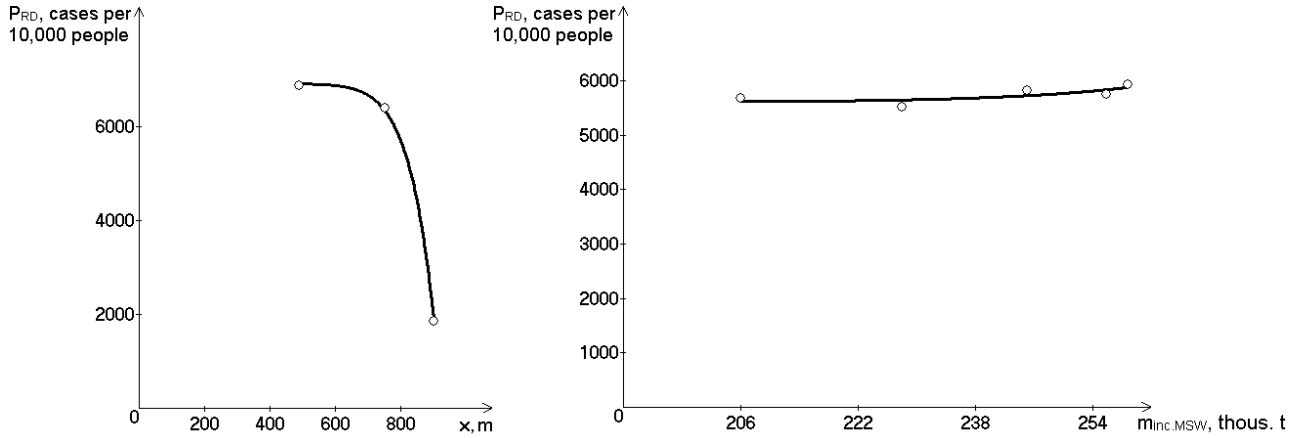
where P_{RD} – prevalence of respiratory diseases, cases per 10,000 people;

x – distance from the settlement to the MSW landfill, m;

$m_{inc.MSW}$ – annual mass of incinerated MSW, thousand tons.

Figure 1, a shows the actual and theoretical graphical dependence of the prevalence of respiratory diseases in the adult population of settlements adjacent to the MSW disposal site from the distance to the landfill, and figure 1, b shows the

prevalence of the general incidence of respiratory diseases in the population on the productivity of the waste incineration plant.



a) b)

Figure 1. Dependencies of the prevalence of respiratory diseases: actual ○, theoretical — a) on the distance to the landfill site, b) on the productivity of the waste incineration plant

A comparison of actual and theoretical data showed that the theoretical prevalence of respiratory diseases, calculated using regression equations (1, 2), differ insignificantly from the data given in the works [171, 187], which confirms the previously determined sufficient accuracy of the obtained dependencies.

In 2017, for the adult population (18-100 years old) of Ukraine, the average incidence rates were: respiratory diseases 1532.05 per 10 thousand [192]. By substituting the average statistical (background) data on the prevalence of respiratory diseases in the regression equation (1), we will determine the safe distance of placement of municipal solid waste landfills from the borders of settlements based on the prevalence of respiratory diseases:

$$x_{RD} = \sqrt[1,2]{\frac{6909 - P_{RD}}{1.786 \cdot 10^{-32}}} = \sqrt[1,2]{\frac{6909 - 1532.05}{1.786 \cdot 10^{-32}}} = 905 \text{ (m)}.$$

So, the graded regression dependence of the prevalence of respiratory diseases

in the population on the ways of handling municipal solid waste has been determined, which can be used to predict indicators of such morbidity, in particular, to determine the safe distance of placement of municipal solid waste landfills from settlements based on indicators of the prevalence of respiratory diseases.