

ОСНОВИ ПРИРОДОКОРИСТУВАННЯ

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COMPUTATIONAL DYNAMICS OF MUNICIPAL WASTES GENERATION IN ZHYTOMYR CITY

Abstract. *The paper analyzed the practical experience of management of municipal solid waste (MSW) in Ukraine and developed countries of the world is studied. The theoretical volume of solid waste accumulation taking into account statistical factors was analyzed. The proposed method of accumulation of MSW allows predicting its formation from factors and evaluated the morphological composition of MSW. The dependence of the accumulation of solid household wastes on the influence of the main social, environmental and economic factors, which would provide an opportunity to predict their dynamics as the basis of effective management decisions in the field of regional ecological security, has revealed. Provision was made to forecast the volumes of MSW formation in the city.*

Key words: *mathematical model, volume of solid municipal waste, municipal solid waste (MSW), accumulation of MSW, landfill.*

Introduction

Today waste is getting more and more serious problem for people and for the environment. The main task of waste management system is to prevent and minimize waste generation in general. Thus, preventive approach to waste management is used

where the priority is focused on waste generation prevention. Urbanization of the cities, population growth, industrialization, economic prosperity in industrialized and developing countries lead to all types of waste increasing, including solid, industrial and household waste. Moreover, the more complex chemical nature of waste is, the greater danger they carry for people and the environment. Waste management was studied by such Ukrainian and foreign scholars as R. Murray, Dr. Joachim Bomer, H. Jackobsen, M. Kristoferrsen and the works by A.I. Pashentsev [8, 1, 4].

Different aspects of the problem of solid waste are devoted in research of N.V. Abramov, V.M. Belkova, A.V. Gorbatyuk, G.A. Denisov, V.V. Zhurkovich, V.A. Mironenko, V.I. Oshpishcheva, O.M. Trofymchuk, L.V. Rybkina and many other scientists who contributed greatly to the database of waste location and waste management [3, 6, 7, 2, 11, 14, 15]. Today the issue of solid waste disposal is not fully addressed in any country of the world, and within the conditions of urbanization it is still pending task of XXI century.

Analysis of researches and publications in terms of solid municipal waste volumes accumulation forecast

This research paper is an attempt to compare the increasing use of waste management systems varieties in world practice, as well as a description of the state of the national waste management system in Ukraine and regional level of solid waste management system.

In a technological variety of solid waste management systems, it has been established that the most widespread disposal method in the world practice is disposal of waste materials in locations such as landfills. Combustion, recycling and composting of solid waste are less widespread. The most promising technological options for disposal of solid waste can be: a) landfills disposal with meeting environmental standards; b) complex processing with the use of preliminary sorting and processing of residues; c) utilization of resource-valuable fractions. The current system of solid waste management in Ukraine does not meet current requirements and needs to be improved.

Therefore, the main stage of the study was the forecasting and modeling of the volume of solid waste generation in Zhytomyr city.

Material, main findings and their analysis

The research was conducted at the local landfill site in Zhytomyr city. All household wastes of Zhytomyr city are stored on this landfill site without preliminary sorting. The above site became the source of intense pollution of atmosphere and groundwater (and it is a threat of an epidemiologic situation). The process of waste storage there must be improved. According to the data presented at the 12th session of Zhytomyr City Council VI calling, about 12–15 million m³ of different waste has been accumulated from the city landfill operation start (since 1957). The environmental issue of the above huge chemical bomb can hardly be overestimated [12, 13].

Over the years of operation, the landfill waste heap has grown up to 30 meters. Its area is 21.6 hectares (according to the state land allocation act the total area is 21.5670 hectares). The storage area is 18.7 hectares, and the rest of the site is divided

into 6 dump areas, which are still in use. There is containment on the perimeter of the landfill. At the end of 1998 the withdrawal of 10 hectares of land from PJSC "Kroshensky brick plant" was carried out. This land was given to the housing and utilities management services for municipal landfill expansion. Annually about 300 thousand m³ of garbage are exported to the city dump. An access road with a hard covering was built and pass entrance passage system was arranged. The site is located in the northern part of the city on the Andreevskaya street. The distance from the landfill site to residential single-storey private houses is 500 m. Garbage from residential buildings is exported by the CATP-0628 transport. Enterprises and companies that take out waste themselves get pass to the landfill from the firm. A surface survey of waste is carried out before leaving for a dump area in order to prevent the storage of toxic waste. Up to 30 million tons of waste of various hazard classes are buried in the city dump.

Analysis of the state of collection and disposal of solid waste by communal enterprises of Zhytomyr showed that the waste management issue is extremely acute. It is also determined that the landfill of solid waste does not meet sanitary norms and environmental requirements. The lack of a modern landfill for the disposal of domestic waste causes a real threat to the environment.

During the last decade wastes accumulation continues in Ukraine and Zhytomyr is not an exception. The gap between progressive waste volumes and measures aimed at their generation prevention, utilization expansion, treatment and disposal threatens not only environmental crisis aggravation but social situation in general as well. The city of Zhytomyr, in modern conditions, faces difficulties related to solid waste environmental logistics, the main of which are:

- the change of morphological properties of solid waste with an increase in the proportion of components that are not subject to biological decomposition processes (paper, polyethylene, etc.);
- low investment activity of agents of economic activity of ecological logistics of solid waste;
- low level of separate collection of waste by city residents;
- hazardous and specific waste products entering to the containers for solid waste.

The composition of solid waste differs in different countries, cities, villages, and it depends on many factors. The following factors influence the total accumulation of solid waste:

- the degree of buildings construction (the presence of garbage pipes, heating systems, heat energy for cooking, water supply and sewage);
- development of a network of public catering and domestic services;
- the scope of the municipal cleaning of cultural-household and public organizations;
- climatic conditions.

According to the latest data, the solid waste generation ranges between 0.5 and 1.2 kg per person per day. These indicators tend to increase steadily due to the economic development of countries. There are also periods when the production of solid waste is significantly increasing. In the end, it is considered that the rate of solid waste per person per day is 1 kg. The annual accumulation of solid waste in municipal dumps is shown in Fig. 1.

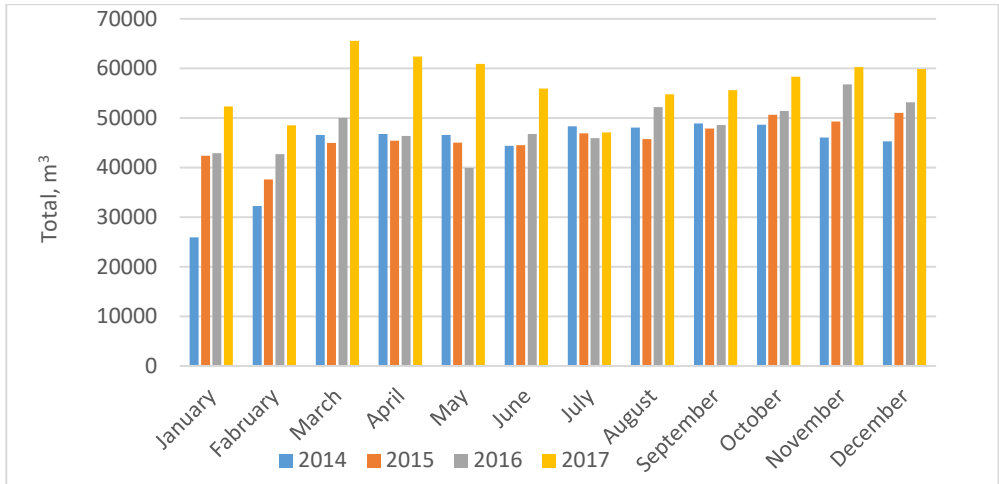


Fig. 1 – Annual changes in the accumulation of solid municipal waste Zhytomyr city (experimental way), m³

According to studies by foreign and domestic specialists, the specific annual accumulation per resident of populated area has a tendency to constant growth, which is explained by an increase of housing stock improvement level and an increase in the number of packaging materials in the landfill.

There is a number of methodological approaches to modeling of solid waste accumulation: component models; models by factors and statistical models. Component models of waste accumulation are assessed based on products use data, sales and actual consumption of products. Models based on factors are based on the analysis of factors that describe the processes of waste accumulation. Examples of used parameters are family income, type of accommodation, type of heating, etc. Statistical models describe the statistical patterns of changes in the volume of solid waste accumulation.

To predict you need to choose the parameters that can be foreseen with high accuracy for a long-term prediction horizon. These may be parameters with high inertia, weakly varying in time, such as population age structure, household size, mortality, etc.; ease of use.

To construct the model, statistical data on the amount of waste accumulation in Zhytomyr landfill was used, which would characterize the processes of the level of arrangement of buildings, the development of the public catering network and household services, the scope the municipal cleaning of the cultural-household and public organizations of the city. Such indicators are the changes in the volume of solid waste accumulation in the landfill during the year.

The obtained experimental data and their features are summarized in the form of linear and nonlinear statistical mathematical models of changes processes in the level of buildings arrangement, the development of the network of public catering and household services, the scope of the municipal cleaning of cultural-household and public organizations. These models are the basis for forecasting the processes of solid household waste accumulation in Zhytomyr, the development and implementation of practical measures aimed at reducing the amount of waste at landfill sites at the final stages of the life cycle.

The method of statistical simulation of changes in the solid waste accumulation amount by the average value for the studied months of the year for the amount of waste accumulation was to choose the type of approximating curve so that the approximating curve best corresponds long-term experimental data. To study the changes in the amount of waste accumulation during January-December, an approximation of their number by the polynomial of the 2nd degree was made and the coefficients of the polynomial were determined, which approximates the experimental data.

The results show that the 2nd grade polynomial reflects the dynamics of changes in the volume of accumulation of wastes during January-December.

Fig. 2–3 shows the results of mathematical modeling and approximation of the dynamics of changes above the indicated indicators. Function (1) describes the general behavior of the indicators change, which is performed approximating their number by the 2nd degree polynomial.

$$W = a_0 + \sum_{i=1}^n a_i \times y^i , \tag{1}$$

Where

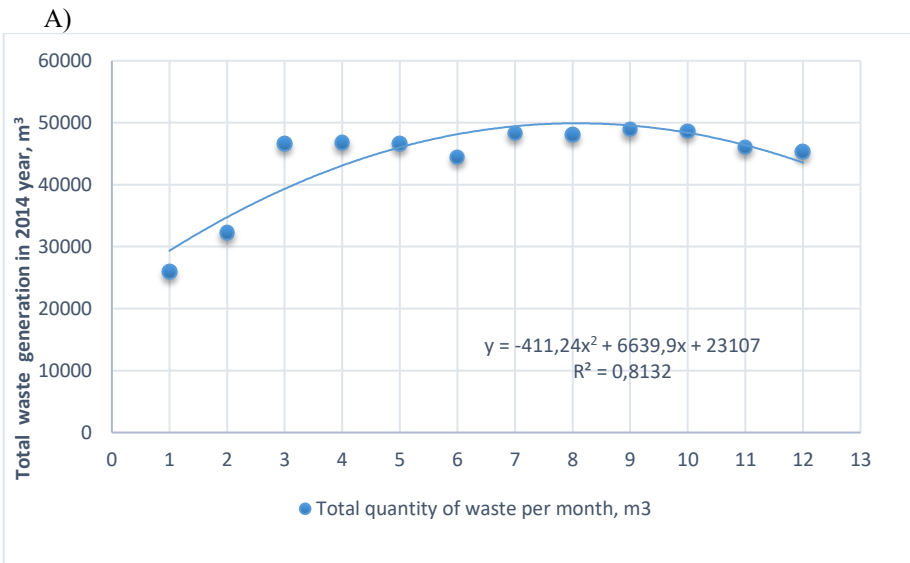
W – the amount of waste accumulation;

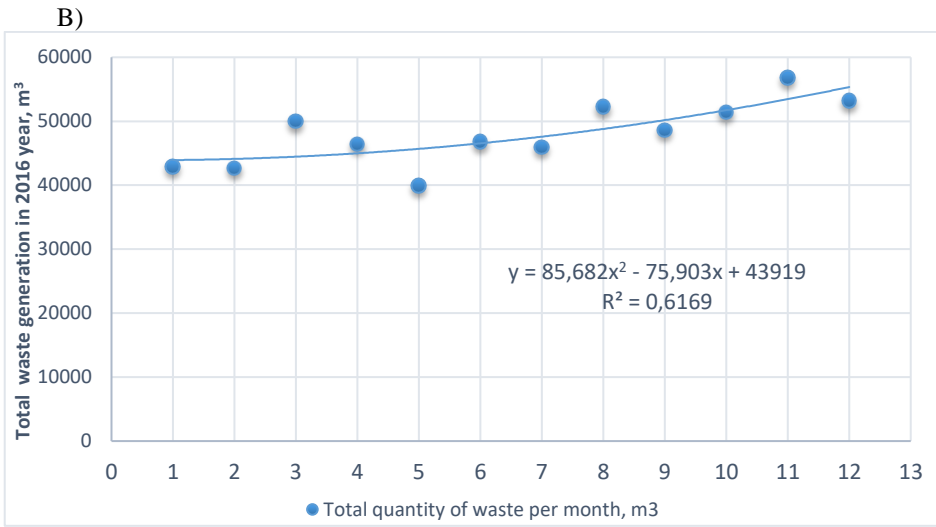
a_0, a_i – the polynomial coefficient;

n – the number of points of experimental data used for approximation;

y – the month number starting from January.

Having analyzed and predicted the seasonal changes in waste accumulation in the landfill, we can predict the volume of waste accumulation for subsequent years, Fig. 3.





A) – 2014; B) –2016

Fig. 2 – Results of mathematical modeling of the dynamics of the amount of waste accumulation, m³ per month: ● – data of experimental studies of the waste amount; solid line – results of approximation

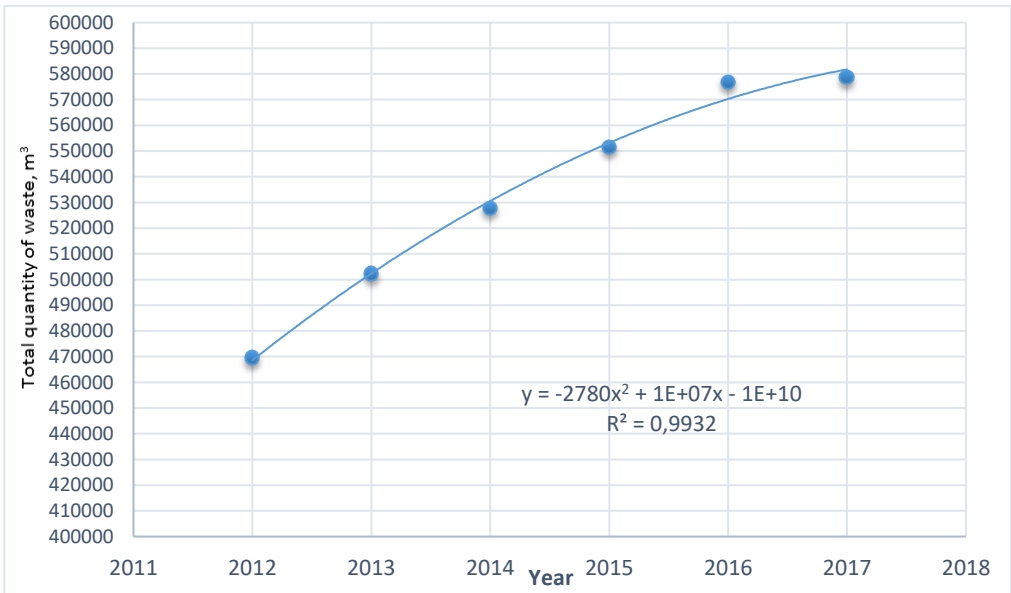


Fig. 3 – Results of the mathematical modeling of the dynamics of waste amount accumulation, m³ per year: ● – data of experimental studies of the annual volume of waste; solid line – approximation results

As a result of approximation of changes in the volume of wastes accumulation, it is established that the line has the form of an exponent and is described by the regression equation:

$$W = 3E-29e^{0,0392x}, \quad (2)$$

where x – the year, and the accuracy of the approximation is $R^2 = 0,9932$.

The methodology allowed to obtain finite initial data that is easy to interpret, compared with expensive and time-stretched techniques, such as the Delphi method. The predicted statistical method corresponds to the indicated requirements. Therefore, the study of the volume of solid waste accumulation is modeled and directed to the city study using a statistical model based on available socio-economic and demographic parameters.

Conclusions

Before conducting further studies, it should be clearly understood that instead of the concept of "solid household waste" it is necessary to introduce the concept of "solid municipal (municipal) waste" – waste generated in residential premises in the process of consumption by individuals, as well as lost goods their consumer properties in the process of their use by individuals in residential premises in order to meet personal and everyday needs. Solid wastes also include waste generated in the course of legal entities activities, individual entrepreneurs and like in the composition of waste accumulated in residential premises in the process of consumption by individuals. Thus, the forecast of solid waste volumes generation is a forecast of accumulation of consumption waste not only by physical but also legal entities and individual entrepreneurs as well.

Thus, the above data show that according to the investigated indicators, Zhytomyr city provides neither improvement nor environmental stability due to the weakness of economic mechanism of influence on optimization of nature use and environmental protection, inconsistent, formal application of "polluter pays" principle, narrowness of the base of environmental taxation, the lack of mechanisms for indexing the normative base, etc.

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Коцюба І.Г., Лико С.М., Лук'янова В.В., Анпілова Є.С.

ДИНАМІКА ОБСЯГУ НАКОПИЧЕННЯ ТВЕРДИХ КОМУНАЛЬНИХ ВІДХОДІВ МІСТА ЖИТОМИР

Анотація. Вивчений практичний досвід поводження з твердими комунальними відходами (ТКВ) в Україні та розвинених країнах світу. Проаналізовано теоретичні обсяги накопичення ТКВ із урахуванням статистичних чинників. Запропонована методика обсягу накопичення ТКВ дозволяє прогнозувати його утворення з чинників та оцінювати морфологічний склад ТКВ. Виявлена залежність накопичення твердих побутових відходів від впливу основних соціальних, екологічних і економічних факторів, які забезпечили б можливість прогнозувати їх динаміку в якості основи ефективних управлінських рішень в області регіональної екологічної безпеки. Створено забезпечення для прогнозування обсягів утворення ТКВ на території міста.

Ключові слова: математична модель, обсяг твердих комунальних відходів, накопичення ТКВ, звалище.

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Вивчений практичний досвід поводження з твердими комунальними відходами (ТКВ) в Україні та розвинених країнах світу. Запропонована методика обсягу накопичення ТКВ дозволяє прогнозувати його утворення з чинників та оцінювати морфологічний склад ТКВ. Створено забезпечення для прогнозування обсягів утворення ТКВ на території міста.

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Kotsiuba I., Lyko S., Lukianova V., Anpilova Y. **Computational dynamics of municipal wastes generation in Zhytomyr city** // Environmental safety and natural resources. – 2018. – Issue 1 (25). – P. 33–43.

The paper analyzed the practical experience of management of municipal solid waste (MSW) in Ukraine and developed countries of the world is studied. The proposed method of accumulation of MSW allows predicting its formation from factors and evaluated the morphological composition of MSW. Provision was made to forecast the volumes of MSW formation in the city.

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