

ANALYSIS OF STUDIES ON THE MORPHOLOGICAL COMPOSITION  
OF DOMESTIC WASTE IN UKRAINE

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**Abstract.** The article presents the results of the analysis of the studies conducted on the quantitative and qualitative characteristics of household waste generated in the territories of several regional centers of Ukraine. The data on the component composition of domestic waste typical for Ukrainian cities are generalized. The influence of the quality indicators of individual waste fractions on the further choice of operations and methods of household waste treatment within the framework of the waste management system is analyzed. On the basis of the collected data, the expediency and relevance of the experimental studies conducted in the context of the current war in Ukraine, global environmental problems, and the global energy crisis are substantiated.

**Keywords:** domestic waste, morphological composition, energy potential, environment, resource components, landfill.

## 1. Introduction

The current reality of war in Ukraine requires that national security issues, which include energy and environmental components, be addressed as a matter of priority. One of the strategic goals of our country is to join the European Union in the near future, which requires the implementation of European programmes, laws, regulations, strategies and concepts in many key areas of Ukrainian society. In order to achieve this goal, the authorities need to carry out a number of reforms and make appropriate changes to national legislation, including in the field of environmental protection.

The state of the environment and the negative anthropogenic impact on it is one of the main problems facing Ukraine today. The research on the volume of generated wastes, their morphological composition and management has become relevant in the last ten years, especially in the current period, when the war is still going on and the possibility of providing traditional resources to various spheres of production and economic activity has decreased due to the rapid increase in prices and unavailability of traditional energy resources. Therefore, the aim of this paper is to analyse and summarise the results of existing studies on the quantitative and qualitative composition of domestic wastes in the regional centres of Ukraine (Vinnytsia, Chernihiv, Lviv, Dnipro, Khmelnytskyi, Poltava, Zhytomyr) with further assessment of their resource potential for the possibility of using them as raw materials for certain production sectors. At the same time, the possibility of replacing significant amounts of traditional resources with renewable resources, which are separate fractions of household waste, and further transition to a closed-loop economy (Barinov et al., 2021) at the state, regional and local levels will be considered.

## 2. Theoretical part

Today Ukraine is still one of the countries with the largest volume of waste generation and

accumulation among European countries, and the existing waste management system is very outdated and does not meet the requirements of the concept of greening production and consumption. This requires increased attention to solving waste management problems at local/regional and national levels. The main focus should be shifted to the regional (local) level, as the decentralization process completed in the country and the requirements for the development of regional waste management plans create conditions and opportunities for an integrated approach to solving this problem in each particular region or municipality, taking into account its specifics and strategic development guidelines.

The volume of waste generation in Ukraine and the dynamics of its formation indicate an increase, which significantly increases environmental risks and requires a new approach to waste management, while ensuring economic and environmental safety in the regions. Due to the increase in the area of landfills, most of which are unauthorized, the role and importance of waste recovery processes is growing in order to utilize their resource potential and reduce their negative impact on the environment.

The problems related to the collection, processing and disposal of domestic waste are similar in almost all regions of Ukraine. Today, one of the main reasons for the environmentally hazardous situation in a number of regions of Ukraine is the imperfect system of domestic waste collection and transportation (hereinafter – DW), which needs to be improved and constantly adapted to the growing amount and variety of domestic waste due to the increase in urban population, changes in the volume of housing stock, specifics of retail trade and production (Rehionalnyi plan., 2023).

One of the factors that determines the effectiveness of the waste management system is the analysis of the morphological composition of waste and the infrastructure for collection and subsequent management of certain types of recyclable materials from DW. Determination of the morphological composition of waste is currently carried out in two directions: 1) determination of component composition of DW (qualitative characteristics); 2) general standards of accumulation and assessment of energy characteristics of waste for the implementation of energy-saving technologies.

### 3. Materials and Methods

In the course of the analysis presented in this paper, we used the methods of comparative analysis of

the collected data and the method of generalization and qualitative assessment of the results in order to further determine the resource potential of individual components of DW.

The choice of DW processing technologies is largely determined by its composition and generation rates. The most sensitive to the composition of municipal solid waste are the following processing technologies: sorting, recycling, biothermal composting and incineration. Relatively less sensitive to the composition of waste is the technology of landfilling, provided that the requirements of DBN B.2.4-2-2005 are met.

Taking into account the requirements of the national legislation and the urgent need for energy autonomy at the local level, the introduction of energy-saving technologies, especially in the field of solid waste treatment/processing, is one of the most urgent issues. However, the first condition for choosing the optimal technological solution is the availability of research results on the morphological composition of HW and the energy characteristics of its individual components.

Accordingly, this article analyzes the results of studies on the morphological composition of DW in individual cities of Ukraine, most of which are presented in the draft regional waste management plans for the period up to 2030, namely for Poltava, Vinnytsia, Chernihiv, Dnipro and Khmelnytskyi regions. The systematized results of these studies are presented in Table 1.

It is worthwhile to focus on the assessment of each component separately in terms of the specific volumes of their generation in the total mass of waste and the determination of the range of fluctuations inherent in Ukrainian cities.

The systematized data in Table 1 show the following important aspects of the quantitative and qualitative composition of municipal waste.

*Organic waste (food, agricultural and horticultural waste)* accounts for a significant share of total waste, ranging from 27.02 % in Khmelnytskyi to 65.1 % in Lviv. On average, the volume of organic waste is more than 40 % of the total waste generated and is the component with the highest moisture content. It should be noted that the moisture content of domestic waste is one of its main physical properties, which depends on the ratio of its main components (morphology, mainly the amount of food waste and paper), source of generation, season, climatic conditions, collection methods and temporary storage (Barinov et al., 2021). When moisture enters into the total mass of solid waste, it has a negative impact on other components: it

significantly increases the moisture content of paper and cardboard, which reduces their energy potential several times, contaminates plastic, glass, metal, textiles, wood and green waste with organic decomposition residues, and at the same time biological processes that occur with organic waste in natural conditions at certain ambient temperatures significantly increase the

total mass of waste. The most optimal method of processing organic waste is recycling, namely composting and anaerobic digestion with subsequent use of compost in agricultural activities in the form of fertilizers. However, the best option for managing organic waste is its mandatory “separation” (separate collection) from all other “dry” components.

Table 1

### Morphological composition of domestic waste typical for Ukrainian cities

Name of the sample component	Name of the city							Total for Ukraine
	Vinnytsia <sup>1</sup>	Zhytomyr <sup>2</sup>	Chernihiv <sup>3</sup>	Lviv <sup>4</sup>	Dnipro <sup>5</sup>	Khmelnytskyi <sup>6</sup>	Poltava <sup>7</sup>	
1	2	3	4	5	6	7	8	9
Percentage of the total mass, %								
Organic waste (vegetables, fruits, garden waste, etc.)	41.39	33.33	35.7	65,1	39,36	27.02	49.7	27.02–65.1
Paper and cardboard	7.2	14.27	8.6	Recyclable materials 14,2	5.4	2.5/2.53	2.8	2.5–14.27
Polymers (plastic, plastics)	9.4	22.99	10.3		8.97	10.35	29.4	9.4–29.4
Glass (dishes, containers, lamps, bottles, etc.)	9.8	7.44	9.1		8	14.29	6.3	6.3–14.29
Ferrous metals	2.1	2.91	1.7		1.01	0.34	1,3	0.34–1.3
Non-ferrous metals					0.18	0.9	0	0.18–2.91
Textile	–	0.34	1.1		4.03	10.19	4.8	0.34–10.19
Wood	–	–	0.4		2.53	4.86	0	0.4–4.86
Hazardous waste (batteries, dry and electrolytic batteries, solvent and paint containers, mercury lamps, TV kinescopes)	0.66	–	–	–	0.07	1.48	1.2	0.07–1,48
Bones, leather, rubber	–	0.47	1.1	–	2.21	–	1.6	0.47–2.21
Remaining domestic waste after removal of components	29.49	10.62	Non-sorted 32.0	Other wastes	Non-sorted		2.9	2.9–32.0
					10.75	6.09		

Continuation of Table 1

1	2	3	4	5	6	7	8	9
Combined packaging	–	–	–	–	2.44	–	–	–
Street litter, stones	–	–	–	–	14.72	–	–	–
Green waste	–	7.64	–	–	–	7.84	–	7.64–7.84
Construction waste	–	–	–	–	–	11.66	–	–
Total mass of the DW sample	100	100	100	100	100	100	100	100

Table explanation: <sup>1</sup> – calculated data using the method of assumptions based on the Report of the project “Waste Management - ENPI East. Waste Management Strategy in Zakarpattia Region for a 15-year period”, 2011; Subregional Waste Management Strategy for Poltava Region, 2016; Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Reform of Municipal Services in Eastern Ukraine, 2016; Report on the results of the study of the morphological composition of solid waste in the Tulchyn target region. DESPRO project, 2012; Tacis project of the European Union “Improvement of the Solid Waste Management System in Donetsk Region of Ukraine”. <sup>2</sup> – results of experimental studies on the morphological composition of household waste at the authorized landfill of the city of Zhytomyr, conducted in 2009, 2013 and 2015 (Kotsiuba, 2017). <sup>3</sup> – results of experimental studies on the volume of waste generation and its morphological composition, conducted during the development of the Chernihiv Sanitary Cleaning Scheme, 2014. <sup>4</sup> – results of the studies under the Project “Research of New Environmental Impacts in the Context of the COVID-19 Epidemic in Ukraine” are implemented by Zero Waste Lviv in partnership with Ecoltava and Fama Research Agency with expert support from the international organization Zero Waste Europe. It is being implemented within the framework of the Initiative for the Development of Environmental Policy and Advocacy in Ukraine, implemented by the International Renaissance Foundation with the financial support of the Embassy of Sweden in Ukraine. <sup>5</sup> – results of on-site measurements of the morphological composition of DW conducted by the Ukrainian Research Institute for the Development and Implementation of Municipal Programs and Projects (2017) “Study of the characteristics of domestic waste generated in residential buildings in the city of Dnipro”. <sup>6</sup> – statistical data from the Regional Waste Management Plan (hereinafter referred to as the RWMP) in Khmelnytskyi region for the period up to 2030. <sup>7</sup> – results of experimental studies conducted by Ecoltava in August and November 2022.

*Paper and cardboard waste*, whose content in the total weight of DW ranges from 2.5 % (Khmelnyskyi) to 14.27 % (Zhytomyr). It should be noted that the volume of this fraction largely depends on the type of urban housing development and is characterized by a significant rate in apartment buildings, and a low level of paper and cardboard waste is inherent in one-story private buildings, where this resource is used in houses with stove heating.

*Polymer waste*: the highest percentage of total DW is observed in the studies in Poltava (29.4 %), while the lowest is 8.7 % in Dnipro. In addition, after analyzing the dynamics of changes in the content of polymer waste in the DW (based on the results of studies in Poltava), we come to a natural conclusion about the steady increase in the percentage of polymers in the total mass of waste, which is primarily due to the predominant choice of more convenient and affordable polymer packaging materials for various food products.

*Glass waste*: its share in the total weight of DW ranges from 6.3 % (Poltava) to 14.29 % (Khmelnyskyi). This type of waste is the most suitable for reuse after recovery processes.

*Waste components such as textiles* (0.34 % (Zhytomyr) – 10.19 % (Khmelnyskyi)), *wood* (0.4 % (Chernihiv) – 4.86 % (Khmelnyskyi)), *leather, rubber, bones* (0.47 % (Zhytomyr) – 2.21 % (Dnipro)) make up a small percentage of waste. Dnipro)) make up a small percentage compared to the above, but textiles and wood are valuable energy resources that, when choosing a method of heat treatment (combustion), can be used as components of renewable fuels for heat and power generation.

It is also necessary to pay special attention to such a component as “*green waste*” which is generated in the process of landscaping adjacent territories and public green spaces. The studies carried out during the development of the draft “Regional Waste Management Plan in Poltava Oblast up to 2030” allowed to estimate the potential volumes of green waste (Rehionalnyi plan., 2023; Holik et al., 2023; Illiash, Holik, 2023) from each territorial community of the region and to determine its significant potential in the total waste mass. This type of waste has an energetic value when used as biomass to meet the needs of heat and power

or agriculture. Therefore, the creation of a system of separate collection and disposal of green waste from the territories of settlements is a rather important component of household waste management at the local level. Unfortunately, today in most settlements of Ukraine this waste is not separately collected, so its share in the organic waste is included as garden waste.

It is useful to consider the concept of “recyclable materials” separately. After analyzing the results of experimental studies in Lviv, it was determined that such components as paper and cardboard, polymers, ferrous and non-ferrous metals, glass, textiles and wood were not divided into separate fractions, as in the case of other cities, but were estimated as a whole, with a rate of 14.2 %. In other words, the above-mentioned components are recyclable materials, which is a cheaper raw material base – a resource that can potentially replace natural sources of many substances and materials. In addition, the process of collecting secondary raw materials in a separate container when sorting by population of DW is one of the most profitable and effective options for separate collection that can be proposed at the first stage of development of sanitary cleaning schemes for populated areas.

Thus, the assessment of the qualitative and quantitative characteristics of the components of DW allows to predict the volume of formation of certain resource-value fractions that have energy potential and can be used, for example, as fuel for solid fuel boilers for the needs of small-scale heat and power generation, namely private households, administrative buildings, health care, educational and public catering facilities (Holik et al., 2023; Illiash, Holik, 2023). In addition, components such as paper and cardboard, textiles and wood are of natural origin (biodegradable elements) and can be used for briquettes after simple technological preparation. On average, these components make up about 11.5 % (Holik et al., 2023) of the total mass of DW and can be an energy potential for autonomous energy systems of low power (boiler houses of schools, kindergartens, hospitals, administrative buildings, apartment buildings, private households).

The growth of the mass of the energy potential of natural origin can be increased by the green waste, which is generated in the territories of municipalities and mostly disposed of in landfills and dumps, and which is not included in the total amount of household waste, thus contributing to the increase of the area of waste disposal sites.

The components of DW: plastics, rubber, bones, leather, together with the components of natural origin mentioned above, can be subjected to the processing

process, taking into account the European experience of using the above fractions in the form of RDF (Refuse Derived Fuel) (Holik et al., 2023). RDF is used in the form of: sorted and shredded fuel mixture, compressed pellets or briquettes, in municipal heat and power as an alternative and renewable energy source, providing a reduction of negative impact on the environment and reducing the volume of solid waste disposal.

#### **4. Results and Discussion**

In Ukraine's populated areas, the main problems in the field of solid waste management are related to the further growth of its negative impact on the environment and human health due to the deterioration of sanitary cleaning of settlements, the growing number of landfills and dumps, and significant volumes of unauthorized solid waste storage almost throughout the country. It should be noted that the accumulation of solid waste in all regions of Ukraine and in the country as a whole is characterized by the fact that in the most densely populated and industrialized regions with a high percentage of urban population, the volume of accumulated waste is much higher than in agricultural regions. It should be noted that organic waste, polymers, paper and cardboard, and glass predominate in the structure of solid waste. There is also a regularity: the larger the rural population and the private sector, the higher the percentage of organic and food waste. In recent decades, there has been an increase in the volume of plastic packaging and plastic food packaging, mainly high and low density polyethylene and polyethylene terephthalate (PET bottle) (Nasirov, 2018).

It should be noted that the change in the composition of DW by season is mainly due to an increase in the content of food waste in summer and fall. This is due to an increase in the consumption of fruit and vegetables by the population. Experience shows that the share of paper and polymeric packaging waste in the composition of DW increases. In addition, the content of glass packaging is constantly changing.

The morphological composition of modern DW differs significantly from that of several decades ago. The widespread use of packaging materials and semi-finished products in everyday life by most people has led to a simultaneous increase in the content of paper and polymers. Important external factors influencing the composition of DW are climatic conditions, living standards and the level of development of the market for recycled materials. In addition, the morphological

composition of waste also depends on the specifics of its sources; it changes significantly not only over time but also depending on the specific area where the waste is collected (urban, rural, mixed zone).

## 5. Conclusions

The current organization of waste management in Ukraine has a number of significant shortcomings and requires comprehensive and rational methods of improvement with responsible and comprehensive implementation at the regional and local levels.

Important factors of instability that influence the morphological composition of municipal waste in settlements and should be taken into account when creating a municipal waste management system at the local level are as follows:

1) seasonal dependence on the generation of organic waste and garden waste, which constitute a significant percentage of the total mass of household waste, and the lack of sustainable composting practices;

2) severe socio-economic instability of the commercial sector, which is a significant generator of waste (up to 10-30%);

3) specifics of the retail trade, which involves the use of various packaging materials and semi-finished products in the daily life of most of the residents, leads to an increase in the share of paper and polymer waste, which, in turn, causes an increase in the volume of DW generation, which imposes specific requirements on the system of waste collection and disposal from the territories of the populated areas.

Thus, taking into account the current legislative requirements in the field of waste management, the first step at the local level is to introduce a system of separate collection of solid waste in the territories of settlements, educating the inhabitants about the importance of separating waste with resource value. Another important aspect is the political will of local self-government bodies (hereinafter referred to as LSG) to understand the need to create effective waste management systems at the local level at all stages, as well as to direct the efforts of local authorities to minimize the negative environmental impact of landfills and dumpsites by reducing the amount of waste to be disposed. Thus, the task of increasing the level of personal responsibility of each person at their own level for the impact of waste as a “product” of human activity on the environment is relevant.

In addition, LSG have all the necessary rights and means to promote and encourage the development of local production of materials from recycled raw materials (development of the resource recycling industry) (Barinov et al., 2021) and the use of resource-rich components of DW in various sectors of the economy. In this way, local authorities can find effective and rational solutions to some urgent problems: energy independence of small-scale energy facilities, which is extremely important in today's military realities in the context of possible blackouts, replacement of natural non-renewable expensive traditional fuels with alternative ones, and the introduction of a closed-loop economy.

Realization of the value of resources containing DW and assessment of their potential becomes possible when analyzing studies on the actual volumes of waste generation and morphological composition, which was conducted in this paper.

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