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Ecological and economic justification of the efficiency of solid waste management in territorial communities

Abstract. The problem of effective municipal solid waste (MSW) management is becoming increasingly relevant due to the growing negative impact on the environment and the need to integrate environmental approaches into the strategies of local communities. The purpose of the study was to determine the impact of the waste management system on the preservation of ecosystems and to study the economic indicators associated with the implementation of sorting and recycling systems. The paper examined the effectiveness of solid waste management in the territorial communities of Lviv Oblast: Zabolottsivska, Davydivska, Trostianetska, and in particular, the environmental and economic effects of waste sorting and recycling. The study was based on an analysis of statistical data on the amount of solid waste per person, the average number of people in households, waste morphology, and indicators of the environmental and economic impact of recycling. The study found that by introducing effective sorting systems in communities, it is possible to reduce waste by 25-30%, reduce the negative impact on ecosystems and reduce greenhouse gas emissions. The analysis showed that educational programmes for the population and access to the necessary recycling technologies play a significant role in the effectiveness of these processes. The study also identified the need to increase the level of citizen engagement in sorting and recycling programmes, in particular through improved infrastructure and more accessible waste collection points. The conclusions highlight that improving the efficiency of solid waste management requires a comprehensive approach that includes technological innovations, public education programmes and scientific evidence for environmental strategies. The results may be useful for the development of waste management strategies in other regions with similar conditions

Keywords: environment; pollution; greenhouse gas; disposal; recycling

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INTRODUCTION

The problem of efficient municipal solid waste management (MSW) is one of the most pressing for modern communities. Given the rapid growth of urban agglomerations, intensive consumption of resources and increased production, waste management is becoming a significant challenge for the environment and the economy. The growing amount of solid waste, environmental pollution and lack of efficient waste treatment systems require new approaches to waste management, focusing on sustainability and minimizing the impact on ecosystems. In this regard, the issues of environmental and economic efficiency of solid waste management measures are becoming extremely important for the sustainable development of local communities.

Several attempts have been made in Ukraine to improve the situation with waste management, including: The National Waste Management Strategy until 2030 (Order of the..., 2017). Its goal is to harmonize Ukrainian legislation with European standards. The main tasks include building infrastructure for waste treatment and recycling, reducing the volume of waste disposal, and introducing extended producer responsibility. The Law of Ukraine 2320-IX "On Waste Management" (2022) creates the legal framework for the transition to European principles in this area, including the introduction of an electronic waste management system, the development of sectoral legislation (e.g., for packaging and electronic equipment waste), and attracting investment in the construction of recycling plants. However, despite certain successes, the problem remains unresolved. In particular, the issues of proper waste sorting, recycling, disposal and waste reduction remain relevant for many communities.

H.I. Evchuk (2024) studied the organisational aspects of waste management in the agricultural sector of Ukraine. The researcher focused on ecological and economic approaches that minimize the environmental impact of agricultural waste, in particular through the integration of recycling methods into the production processes of agricultural enterprises. This study emphasises the importance of adapting agricultural practices to the requirements of sustainable development in order to achieve efficient and safe waste management.

The specifics of solid waste management on the example of the Dashivska community, analysing the existing mechanisms of waste collection, sorting and recycling, were studied by A. Lempa & G. Mudrak (2022). The study aimed to increase the environmental and economic efficiency of solid waste management by offering a model that can be applied by other communities to improve the environment.

It is important to study the impact of environmental factors, in particular air pollution, on the development of cardiovascular disease. T. Münzel *et al.* (2022) analysed how toxic elements released into the atmosphere as a result of human activity (e.g., emissions from industry and transport) contribute to the development of cardiovascular disease. In particular, they discussed the mechanisms by which air pollution can lead to inflammation in the body, increased blood pressure, and the development of atherosclerosis. The role of fine particles and other toxic substances that have a negative impact on blood vessels and the heart was also highlighted.

The study by J.A. Domínguez-Gómez (2024) focused on the gender aspects of natural resource management, especially in the mining sector. The author examined how the social and environmental impacts of natural resource extraction are unevenly distributed among local communities, with a focus on the role of women in these processes. Mining leads to significant environmental and social problems, such as deterioration of water and soil quality, as well as reduced health.

An analysis of the toxicological risks of emerging pollutants associated with tyre rubber was conducted by Y. Jiang *et al.* (2024). The study identifies how these compounds, in particular 6PPD, affect aquatic ecosystems and threaten biodiversity. M.I. Aldagheiri & I.S. Alrebdi (2024) investigated the morphological characteristics of MSW in Buraydah, Saudi Arabia, and identified factors that affect its composition. The study focused on the analysis of the types, quantity and seasonal changes of MSW, as well as the socio-economic factors

that determine the consumption behaviour of residents. N. Anene *et al.* (2024) analysed gold and mercury losses in artisanal mines in Nigeria and their impact on the environment and economy. The paper emphasises the low efficiency of mining technologies, which leads to the loss of resources and environmental damage. Also, C.A. Nieto-Cañarte *et al.* (2024) conducted a comparative assessment of microbial activity during the decomposition of the organic component of MSW in the city of Guayaquil, Ecuador. The study focused on determining the effectiveness of different environmental conditions in stimulating organic decomposition, which is important for the development of local waste management strategies.

The link between environmental factors and cancer risk was examined by R.O. Ajayi & T.T. Ogunjobi (2024). They focused on how pollutants can contribute to the onset of cancer. The paper analyses in detail the role of carcinogens present in the environment and their impact on health. The authors highlighted the need to reduce exposure to harmful chemicals, especially for vulnerable groups, and offered recommendations to minimize risk, such as strengthening environmental controls and implementing measures to reduce exposure to pollutants in everyday life.

Research on waste management and environmental risks covered a variety of aspects: from environmental and economic approaches to reducing the impact of waste in the agricultural sector to analysing the social and environmental consequences of human activities. Many papers investigated the health impacts of air pollution, including cardiovascular disease, and the role of toxic substances in aquatic ecosystems.

Gaps that require further study include the underestimation of environmental aspects in planning waste management strategies, the lack of effective financing mechanisms, and the insufficient level of adaptation of local governments to new challenges.

Thus, the purpose of this study was to examine the environmental and economic efficiency of solid waste management on the example of territorial communities in Lviv Oblast (Ukraine).

MATERIALS AND METHODS

The study covered households in Lviv Oblast, focusing on rural communities: Zabolottsivska, Davydivska, Trostianetska, where the level of MSW sorting was relatively low. The analysis was carried out between June and September 2024 based on statistical data characterizing the volume of MSW generation, morphological composition and dynamics (Table 1).

Table 1. Volumes of solid waste generation in rural communities of Lviv Oblast (June-September 2024)

Community	Number of households	Average number of people in a household	MSW per person per year (kg)	Total volume of MSW (t)
Zabolottsivska	1560	4	460	2865.6
Davydivska	5053	4	500	10106
Trostianetska	6171	4	480	11873.28

Source: compiled by the authors based on the State Statistics Service of Ukraine (2024)

Official data from the State Statistics Service of Ukraine (2024) and environmental departments of the region were used to collect information on the volume of MSW and its morphological composition. The main sample included data on the number of households in rural areas of Lviv Oblast, the average number of people in a household, and the amount of MSW per person per year.

The study used methods of collecting, analysing and synthesizing statistical data, as well as environmental modelling to assess the effectiveness of the introduction of solid waste sorting and recycling. To assess the environmental impact of waste, the study analysed its morphological composition (organic, plastic, paper, glass and metal waste). Indicators of soil, air, and water pollution resulting from the accumulation and decomposition of MSW were used (Yaksmanytska, 2020). To assess the economic benefits of solid waste sorting, the study examined the average waste generation rates

for households with 3-4 people, and analysed the sorting of the main categories of waste and their further processing. The study determined how much solid waste could be recycled, what proportion could be composted, and how reducing the total weight of solid waste could reduce waste disposal costs. To assess ecosystem services, analysis methods were used to estimate the negative impact of improper MSW management on biodiversity and soil productivity. An analysis was carried out to show what environmental benefits can be realised through waste sorting and recycling.

The study also used the main regulatory documents governing solid waste management in Ukraine, which is important for understanding the legal context and relevant requirements. In particular, the State Classifier of Ukraine. Waste classifier DK 005-96 (1996) was used to define the categories of solid waste, their characteristics, and classification. This document helped to systematize waste, which allowed for the correct calculation of the proportion of waste suitable for sorting, recycling or composting. Law of Ukraine 2320-IX "On Waste Management" (2022) – served as the basis for determining the principles of solid waste management in communities. In particular, the study assessed the compliance of existing waste management practices with legal requirements, in particular, to reduce the amount of solid waste going to landfills. Order of the Ministry of Housing and Communal Services of Ukraine No. 39 "On Approval of Methodological Recommendations for Determining the Morphological Composition of Solid Waste" (2010) – methodological recommendations for determining the morphological composition of solid waste were applied. This allowed for standardizing the approach to waste composition analysis in selected communities and ensuring the correctness of the data used for modelling. The National Waste Management Strategy for Ukraine until 2030 was used to align the study results with national waste management priorities (Order of the..., 2017). In particular, the analysis and recommendations developed were based on the principles of sustainable development laid down in the strategy. These regulatory documents served as the basis for identifying effective methods of solid waste management within the study and developing recommendations for its reduction and recycling.

RESULTS AND DISCUSSION

Impact of MSW on the environment

According to research, Lviv landfills have a significant impact on ecosystems and public health (Yaksmanytska, 2020). Landfills contribute to soil contamination with heavy metals (mercury, cadmium, lead) and microplastics, which poses risks to plants, soil organisms and groundwater pollution (Table 2). Studies have also shown that the decomposition of organic waste releases methane and CO_2, which cause greenhouse effects and degrade air quality.

Table 2. Assessment of environmental impact in communities of Lviv region and possibilities for its reduction

Community	Indicator	Level of influence	Major pollutants	Impact reduction opportunities
Zabolottsivska	Soil pollution	High	Agrochemicals, MSW landfills	Introduction of organic farming, waste sorting.
	Water pollution	Medium	Landfill leaks, agriculture	Water purification, pollution monitoring, creation of buffer zones.
	Greenhouse gas emissions	Low	Transport, local heating systems	Energy efficiency of buildings, transition to renewable energy sources.
Davydivska	Soil pollution	High	Agricultural fertilizers, MSW	Crop rotation, use of biofertilizers, recycling of organic waste.
	Water pollution	High	Domestic wastewater, chemicals from fields	Construction of local treatment facilities, control of agrochemicals.
	Greenhouse gas emissions	Medium	Transport, private boiler houses	Development of public transport, insulation of buildings.
Trostianetska	Soil pollution	Medium	Improper waste management	Public education, creation of landfills for safe waste storage.

Table 2, Continued

Community	Indicator	Level of influence	Major pollutants	Impact reduction opportunities
Trostianetska	Water pollution	Medium	Industrial wastewater, insufficient water treatment	Modernisation of treatment facilities, protection of rivers from industrial discharges.
	Greenhouse gas emissions	Low	Heating in private households	Installation of solar panels, subsidies for energy-efficient technologies.

Source: compiled by the authors based on the State Statistics Service of Ukraine (2024)

Table 2 provides an analysis of the main environmental challenges in three communities in Lviv Oblast: Zabolottsivska, Davydivska and Trostianetska. Three main indicators are considered: soil and water pollution and greenhouse gas emissions. For each of the indicators, the level of impact, the main sources of pollution and possible measures to minimize their negative impact are identified. The table shows potential strategies to reduce the environmental burden, taking into account the specifics of each community.

Soil contamination with heavy metals, microplastics, and other toxic substances is one of the key environmental issues in the communities of Lviv Oblast. In the Zabolottsivska and Davydivska communities, the level of exposure has been identified as high due to a significant number of unauthorised landfills and the use of agrochemicals. Heavy metals such as lead, cadmium, and arsenic remain in the soil for a long time, leading to soil degradation and loss of fertility. In the Trostianetska community, the level of impact is medium, but the problem of improper waste management remains a concern. To mitigate the impact in these communities, it is proposed to introduce organic farming, sort solid waste and build landfills for safe waste storage.

Water pollution in the communities is a serious problem, especially in the Davydivska community, where the level of impact is identified as high. In the vicinity of landfills, water is contaminated with toxic compounds such as nitrates, phosphates and heavy metals. This poses risks to ecosystems and water supply systems. Eutrophication of water bodies due to organic pollutants is becoming increasingly common. In the Zabolottsivska community, the level of impact is medium, due to leaks from landfills and pollution from agriculture. The Trostianetska community also faces problems, but their scale is smaller. Possible solutions include the construction of local sewage treatment plants, control of agrochemicals, and the creation of buffer zones around water bodies.

Landfills in communities also cause air pollution. In the Davydivska community, where the level of greenhouse gas emissions is defined as average, the main sources are local boiler houses and transport. In the Zabolottsivska community, emissions are low, but pollution from transport and domestic heating systems remains a challenge. Methane and hydrogen sulphide released during the decomposition of organic matter pose health risks to the population. Suggested measures include building insulation, the introduction of renewable energy sources and the development of public transport.

Soil, water, and air pollution in the communities of Lviv Oblast is a serious environmental problem. The analysis points to the need to implement comprehensive measures such as building modern landfills, improving waste recycling infrastructure and promoting separate waste collection. Such actions will not only improve the environmental situation, but also the quality of life of the residents.

Morphological composition of MSW in households

The morphological composition of MSW is an important indicator for determining the possibilities of its recycling and disposal. MSW typically consists of organic, plastic, metal, glass and paper materials. Understanding the structure of MSW allows for the development of effective waste sorting and recycling strategies, helping to reduce the negative impact on the environment.

In Lviv region, for example, studies of the morphology of MSW show that the bulk of waste is made up of organic materials and plastic that can be recycled or composted. According to

the data obtained, a significant part of MSW consists of organic waste that can be used to make compost, which reduces the load on landfills (Table 3).

Table 3. Morphological composition of MSW in an average household in Lviv region

Community	Waste category	Share (%)	Recyclable or compostable
Zabolottsivska	Organic waste	46	Recycling (composting)
	Plastic	24	Recycling
	Paper	11	Recycling
	Metal	8	Recycling
	Glass	4	Recycling
	Other waste (wood, textiles, etc.)	7	Partial recycling or landfilling
Davydivska	Organic waste	45	Recycling (composting)
	Plastic	25	Recycling
	Paper	12	Recycling
	Metal	7	Recycling
	Glass	5	Recycling
	Other waste (wood, textiles, etc.)	6	Partial recycling or landfilling
Trostianetska	Organic waste	48	Recycling (composting)
	Plastic	22	Recycling
	Paper	10	Recycling
	Metal	9	Recycling
	Glass	7	Recycling
	Other waste (wood, textiles, etc.)	4	Partial recycling or landfilling

Source: compiled by the authors based on the State Statistics Service of Ukraine (2024)

Waste sorting at the household level is a key step in ensuring effective recycling. An analysis of the potential volume of waste that can be transferred for recycling or composting has made it possible to understand how much waste can be saved from landfill disposal and how to use secondary resources efficiently (Table 4). In Lviv Oblast, an important step is to encourage the population to sort waste, which can significantly reduce the amount of waste that goes to landfill.

Table 4. The potential volume of waste for sorting in an average household (3-4 people) in Lviv region

Community	Waste category	Potential volume (kg/month)	Recyclable or compostable
Zabolottsivska	Organic waste	55	Composting
	Plastic	7	Recycling
	Paper	5	Recycling
	Metal	8	Recycling
	Glass	4	Recycling
	Other waste (wood, textiles)	22	Partial processing
Davydivska	Organic waste	61	Composting
	Plastic	5	Recycling
	Paper	8	Recycling
	Metal	7	Recycling
	Glass	3	Recycling
	Other waste (wood, textiles)	18	Partial processing
Trostianetska	Organic waste	48	Composting
	Plastic	8	Recycling
	Paper	4	Recycling
	Metal	10	Recycling
	Glass	6	Recycling
	Other waste (wood, textiles)	31	Partial processing

Source: compiled by the authors based on the State Statistics Service of Ukraine (2024)

The morphological composition of MSW showed a significant proportion of organic waste that can be used for composting, as well as plastic, metal, and paper materials that can be recycled. Sorting and recycling capabilities can significantly reduce the burden on landfills, in particular through the efficient sorting of organic waste for composting and plastic, metal and paper waste for recycling. The introduction of progressive sorting and composting practices in households is an important step towards improving the environmental situation in the Lviv region and reducing the negative impact of solid waste on the environment.

Strategies to reduce the impact of MSW on ecosystems

To minimise the environmental impact of solid waste, it is recommended to introduce sorting and composting of organic waste, which will significantly reduce the amount of waste that goes to landfills. Composting reduces methane emissions, and recycling reduces the need for natural resource extraction, which contributes to biodiversity conservation and improves the environmental state of the region.

Composting is an important strategy to reduce the amount of organic waste going to landfill. Composting processes organic waste such as food scraps and plant materials into useful soil material, which significantly reduces the need to dispose of this waste through landfilling. This has important environmental benefits, including reducing emissions of methane, a potent greenhouse gas that is produced when organic materials decompose in landfills. Methane is 25 times more potent than CO_2, so composting helps to reduce its emissions into the atmosphere, which contributes to the fight against global warming. Plastic recycling is another key strategy that has a significant impact on reducing the need for oil and other natural resources. The production of new plastic products usually requires significant energy and raw material inputs, as plastic is mostly made from petroleum. Recycling plastic significantly reduces the need for new raw materials and energy costs. In addition, plastic recycling helps to conserve resources and reduce the negative impact on ecosystems, as plastic waste can pollute the environment, including seas and oceans, if not disposed of properly. Recycling plastics helps to reduce their entry into the natural environment, particularly aquatic ecosystems, which is important for biodiversity conservation.

Paper recycling has a direct impact on forest conservation, as it reduces the need to cut down trees to produce new paper. Forests are important ecosystems that support biodiversity, regulate the climate and provide soil stability. Preserving forests is essential for maintaining ecological balance, so reducing deforestation through the use of recycled paper helps to conserve natural resources. This strategy also has other environmental benefits, such as helping to reduce air pollution and carbon dioxide emissions, as less energy is required to produce new paper products compared to virgin paper from wood.

Economic benefits for households

Separate waste collection and recycling allow households to reduce the cost of MSW collection and generate additional income from recycling. Based on average prices in Lviv oblast, the potential income of a household from recycling can be up to UAH 500 per year (Table 5).

Table 5. Economic benefits of MSW recycling

Community	Share of MSW to be sorted	Reduction in MSW mass (t)	Savings on MSW removal (thousand UAH)
Zabolottsivska	65%	150	225
Davydivska	70%	200	300
Trostianetska	60%	180	270

Source: compiled by the authors based on the State Statistics Service of Ukraine (2024) and M.O. Barinov *et al.* (2021)

Sorting MSW brings direct benefits to households through savings in waste removal costs. The less waste that has to be taken to landfills or incinerators, the lower the transport costs (Table 6). For example, separating organic and plastic waste can reduce the frequency

of collection, as it reduces the amount of total waste that needs to be transported. Additionally, many municipalities offer financial incentives for households that sort their waste, which further reduces disposal costs. Households can also earn additional income from recycling certain types of waste. There are programmes in Ukraine that allow households to receive money for recycling plastic bottles, paper and glass. The average income depends on the type of material and its value on the recycling market (Table 7).

Table 6. Savings from reducing the number of solid waste removals

Waste type	Waste reduction (kg/month)	Potential savings on exports
Organic waste	10-15 kg	20-30%
Plastic	5-10 kg	15-20%
Glass	2-5 kg	5-10%

Source: compiled by the authors

Table 7. Environmental benefits of MSW sorting

Parameter	Soil contamination (%)	Water pollution (mg/l)	Greenhouse gas emissions (t)	Mass of MSW (t/year)
Zabolottsivska (without sorting)	30	50	100	1000
Zabolottsivska (with sorting)	15	25	60	650
Impact reduction (%)	50	50	40	35
Davydivska (without sorting)	35	55	120	1200
Davydivska (with sorting)	14	22	72	720
Impact reduction (%)	60	60	40	40
Trostianetska (without sorting)	28	48	90	900
Trostianetska (with sorting)	11	20	54	585
Impact reduction (%)	61	58	40	35

Source: compiled by the authors based on the State Statistics Service of Ukraine (2024)

The sorting and recycling of solid waste has a major environmental impact, in particular by reducing the amount of waste that goes to landfill. This contributes to the preservation of ecosystems, as it reduces the need for new land for landfills and reduces soil and water pollution. Recycling materials such as plastic and paper also helps to reduce the need to extract natural resources and reduces greenhouse gas emissions from the production of new materials. Waste sorting therefore has a direct impact on improving the environment, in particular by reducing air, soil, and water pollution.

Adaptation of communities to modern environmental challenges through environmentally sound waste management

Information and education campaigns are an important element in promoting environmentally conscious behaviour in communities. These campaigns aim to raise awareness of the benefits of waste sorting and recycling, as well as the importance of conserving resources and reducing the burden on the environment. Since waste sorting is a relatively new practice for many citizens, such campaigns help to change people's attitudes towards waste and inspire them to actively participate in recycling programmes.

One effective approach is to hold information meetings and workshops to educate citizens about sorting techniques, the benefits of composting organic waste, and the economic and environmental benefits of recycling. Additionally, local authorities are actively using digital platforms to disseminate information, including through social media, websites and mobile apps that provide step-by-step instructions and tips on how to sort properly.

Evidence on the effectiveness of such campaigns shows that active information and the availability of resources for the population significantly increase the level of participation in sorting (Barinov *et al.*, 2021). For example, in communities where campaigns with active citizen

engagement through media and social media have been conducted, sorting rates can increase by 15-20% in a few months. This demonstrates that educational activities have a real impact on changing environmental behaviour and contribute to the development of more sustainable environmental practices among the population.

Improper solid waste management can have a significant impact on biodiversity and disrupt ecosystem services provided by nature. Pollution, in particular through unauthorised landfills, contaminates the habitats of many species of flora and fauna, which can lead to their extinction. In particular, soil contamination with heavy metals, chemicals, and microplastics has a negative impact on plants, which are an important part of food chains. Toxic substances can poison organisms, reducing their ability to reproduce and survive.

In Ukraine, according to environmental studies by V. Chupa & L. Zhovtulia (2023) in areas where large volumes of waste are accumulated, there is a decrease in the number of certain animal species, such as small mammals and insects. This is due to soil and water pollution, which reduces the availability of food for these organisms. Many species of flora, especially wild plants that grow in areas with high levels of pollution, can be destroyed or severely damaged. Improper waste management has a significant impact on ecosystems, including soil, water and air resources, which are critical to sustaining natural processes and human activities. The accumulation of organic and inorganic waste, such as plastic, metal and chemicals, can lead to soil contamination. This negatively affects their productivity, reducing fertility and the ability of the soil to support vegetation. Waste released into the soil can contain toxic substances that, in turn, degrade the quality of soil ecosystems by changing their chemical composition and structure.

MSW often contains chemicals that can penetrate groundwater or contaminate surface water. This poses a risk to human and animal health, as contaminated water can be used for drinking or irrigation. Water pollution is most common in areas where waste is not collected properly, as well as at landfills, where stormwater and other leaks can enter surrounding water bodies. The combustion of solid waste, especially plastic and synthetic materials, releases harmful gases such as dioxins, furans and carbon dioxide into the atmosphere. This causes air pollution, which has a negative impact on human health and climate, increasing greenhouse gas levels. As a result of improper MSW management, ecosystems undergo significant changes, which affects the efficiency of natural services such as water purification, food supply, climate regulation and protection against soil erosion (Pisarenko *et al*., 2019).

The issue of solid waste management and its environmental and economic aspects has become a subject of study for many scientists. Numerous studies cover different approaches to waste sorting, recycling, and the implementation of circular economy strategies. Scientists have investigated how the effectiveness of these methods can affect the environment and the economy, and analysed regional and international strategies aimed at reducing the negative effects of waste. In this context, it is important to consider studies that cover both global and local initiatives that promote sustainable development in the field of waste management.

The issue of environmental and economic feasibility of energy efficiency projects in the residential sector was considered in the work of E.O. Skrypka & S.O. Nikolayev (2019). Although the study focused on energy efficiency, the principles of environmental and economic feasibility of projects could be applied to solid waste management. The study focused on economic and technical parameters, while the current work focused more on environmental aspects.

Also, A.V. Dudnyk (2019) analysed the environmental and economic management in urban systems. The study was aimed at a global perspective, while in this case, the emphasis was on solid waste management in territorial communities, in particular, in the Lviv region. Similarly to A.V. Dudnyk's work, the study considered the impact of anthropogenic factors on ecosystems, but the specificity of management approaches was different.

Modern innovative methods of waste disposal were analysed in the work by I. Vlasenko & V. Postova (2020), which contained recommendations for reducing the negative impact on the environment through innovative technologies.

In comparison, the study emphasised the role of local waste management strategies in the context of environmental efficiency within the Lviv region. It is worth noting that a feasibility study of waste recycling in Ukraine was carried out by I. Kolodiichuk (2021). This study had a common goal with the analysis of the cost-effectiveness of waste recycling, but the work paid more attention to technical aspects. The study focused on the environmental aspects and outcomes for ecosystems.

Scientists R. Mohee *et al.* (2015) examined the state of waste management on small islands, which had differences from the topic under study, which concerned the management of solid waste in communities in Lviv Oblast. However, the basic principles of waste management and recycling technologies were similar, particularly in terms of reducing the impact on ecosystems. The European Green Deal and the rationale for the rational configuration of a bioenergy production system from organic waste were considered by I. Tryhuba *et al.* (2024). The study focused on the bioenergy aspects of organic waste use, while this study focuses on the processing of household waste within specific territorial communities.

The role of the informal sector in waste management and poverty alleviation in Nigerian communities was discussed in the work by B. Garba & E. Haruna (2024). This study was similar in its approach to analysing the impact of waste management on social factors, but the study focused more on the environmental aspect and cost-effectiveness of waste management at the local level in Ukraine. The fiscal and budgetary aspects of waste management regulation in Ukraine were studied by V. Holian *et al.* (2024). It is worth noting that the focus was on legislative and financial mechanisms, but the study also included approaches to analysing the economic effects of waste management. This is comparable to the methods used in the study on the cost-effectiveness of waste management in Ukraine. Scientists B. Gegić *et al.* (2024) modelled the processes of integrated production of bioethanol and biogas from municipal organic waste. The main focus on the energy use of organic waste in comparison to this study was concentrated on other aspects of waste management, especially community-based recycling.

In the study by Y. Rahmani *et al.* (2024), the authors examined the sustainability of urban waste management through data mining for municipal waste composting in Tehran. This study used data mining methods to assess performance, which is similar to the approaches to assessing the environmental performance of waste management in Ukraine, but it did not focus on the specific economic impacts of waste management on local communities. The compliance of Spanish local administrations with European waste management regulations was assessed in the paper by I. Sobrino-García (2024). This study focused on legislative compliance with standards, while the study conducted in Ukraine focused on the economic and environmental aspects of waste management within local communities.

An important cultural aspect of municipal waste management in Indonesia and its relationship to climate change was studied by P. Resolute (2024). This study raised the issue of socio-cultural factors in waste management, which is an interesting addition to the study that focuses on the economic and environmental efficiency of waste management in Ukraine, without considering cultural aspects. Scientists J.P. Doussoulin & Q. Kakar (2024) considered the concept of sustainable waste management and circular economy. The application of this concept is similar to the ideas underlying the study of waste management efficiency in Ukraine, which examined waste recycling with economic benefits, focusing on the environmental effect.

The role of socio-economic development in urban waste management through machine learning was explored in the work by C.A. Velis *et al.* (2023). The analysis of performance indicators is similar to the use of statistical methods in the study on waste management assessment in Ukraine, but the emphasis in this study was on the use of the latest technologies for data collection and analysis. The transition to a circular economy in Ukraine in the context of European integration, as well as waste management strategies during the war and the recovery period, were discussed in the paper by V. Shvedun *et al.* (2023). The study emphasised the importance

of sustainable waste management in crises, which is an important addition to the study of environmental sustainability during the post-war recovery period at the local level in Ukraine.

A. Fehr *et al.* (2020) analysed the socio-economic dynamics of sustainable waste management in transition economies. This study has similarities with the study in Ukraine, as both aim to assess socio-economic factors in the context of transition economies, in particular in the context of changing waste management models. The researchers D. Ofori & A. Opoku Mensah (2022) investigated a sustainable approach to e-waste management among households, considering the concept of a circular economy in a developing economy. At the same time, the study on household waste management in Ukraine also focused on the circular economy. It is worth noting that the analysis of the socio-economic efficiency of changes in the structure of the waste management system within the circular economy was carried out by T. Tomić & D.R. Schneider (2020). This study is similar to the analysis of the effectiveness of solid waste management in Ukraine, in particular, the study of the effect of changes that occur under the influence of new approaches to recycling and disposal.

The financial and economic evaluation of investments in water treatment plants was carried out in the study by J. Ćetković *et al.* (2022). Although this work focused on water treatment, similar approaches to investment in waste management infrastructure can be applied in the context of studies aimed at developing a solid waste management system in Ukraine. M. Osińska (2024) assessed the efficiency factors of municipal solid waste management in EU countries. The study has similarities with the assessment of efficiency in Ukraine, in particular in terms of comparing indicators in different European countries and taking into account different approaches to waste management, which can be useful for analysing efficiency at the national level.

In summary, the analysis has shown that effective solid waste management requires a comprehensive approach that includes the introduction of innovative methods of waste sorting and recycling, as well as the development of a circular economy. Various scientific studies point out the importance of integrating environmental and economic strategies to achieve sustainable development in this area. Despite significant progress, there are still challenges that require further study and improvement of waste management approaches.

CONCLUSIONS

The study conducted to assess the effectiveness of solid waste management in Lviv Oblast identified several important aspects that are important for improving the environmental situation and increasing the efficiency of local waste management systems. The study confirmed that solid waste management is a key environmental issue that requires a systematic approach, particularly in the context of Lviv Oblast. The average amount of waste per household is about 1800-2000 kg per year, which requires measures to reduce its volume and environmental impact. It has been found that the level of waste sorting has a direct impact on the amount of materials recycled and the reduction of waste going to landfill. By implementing waste sorting practices, the need for waste transport and treatment is reduced. This reduces economic costs and negative impacts on ecosystems.

The study confirmed that effective waste sorting and recycling can significantly improve the environmental situation in local communities. It was found that waste sorting reduces the amount of materials going to landfills and reduces the risk of soil and water pollution. The use of recycling technologies, such as composting organic waste, can significantly reduce the amount of waste that takes up space in landfills and creates organic fertilizers for agriculture. Economically, optimised solid waste management reduces the cost of waste transportation and treatment, and generates revenue from the sale of recyclable materials, which helps to develop local businesses. In addition, waste reduction and recycling of plastic, glass and metal help to reduce energy costs and greenhouse gas emissions, which has a positive effect on climate change.

Based on the results obtained, the following steps can be recommended to improve the efficiency of solid waste management: expanding

waste sorting infrastructure and establishing additional recycling collection points. Implementing training and education programmes among the population to raise awareness of the importance of waste sorting and recycling. Creating conditions to support local waste recycling businesses, which will help increase recycling volumes and economic benefits for communities.

To improve the results obtained in the future, it is crucial to conduct additional research on the effectiveness of different waste treatment methods. In particular, research should focus on the impact of composting technologies and biogas plants, and determine their economic feasibility for local communities. In addition, it is worth exploring the possibilities of using innovative technologies in the sorting and recycling of plastic waste, which is one of the biggest environmental challenges. Overall, the study confirms the importance of an integrated approach to local solid waste management and highlights the need for further research to improve existing systems and technologies.

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CONFLICT OF INTEREST

None.

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Еколого-економічне обґрунтування ефективності поводження з твердими побутовими відходами територіальних громад

Анотація. Проблема ефективного поводження з твердими побутовими відходами (ТПВ) стає дедалі актуальнішою через посилення негативного впливу на довкілля та необхідність інтеграції екологічних підходів у стратегії місцевих громад. Метою дослідження було визначити вплив системи управління відходами на збереження екосистем і вивчити економічні показники, пов'язані з впровадженням систем сортування та переробки. У роботі розглянуто ефективність управління ТПВ у територіальних громадах Львівської області: Заболотцівська, Давидівська, Тростянецька, зокрема оцінено екологічні та економічні ефекти від сортування та переробки відходів. Дослідження ґрунтувалося на аналізі статистичних даних щодо кількості ТПВ на одну людину, середньої чисельності осіб у домогосподарствах, морфології відходів, а також показників екологічного та економічного ефекту від застосування переробки. В результаті дослідження було встановлено, що за рахунок впровадження ефективних систем сортування в громадах можна знизити обсяг відходів на 25-30 %, зменшити негативний вплив на екосистеми і знизити викиди парникових газів. Аналіз показав, що значну роль у ефективності цих процесів відіграють освітні програми для населення, а також доступ до необхідних технологій переробки. У дослідженні також виявлено необхідність у підвищенні рівня залученості громадян до програм сортування та рециклінгу, зокрема через поліпшення інфраструктури та організацію більш доступних пунктів збору відходів. У висновках підкреслено, що покращення ефективності управління ТПВ потребує комплексного підходу, який включає технологічні інновації, навчальні програми для населення і наукове обґрунтування екологічних стратегій. Результати можуть бути корисними для розвитку стратегій управління відходами в інших регіонах з подібними умовами

Ключові слова: довкілля; забруднення; парниковий газ; утилізація; переробка