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ANALYSIS OF ALTERNATIVES FOR SORTING HOUSEHOLD WASTE IN RURAL AREAS: AT HOME OR AT THE LANDFILL

Purpose. To assess the economic and environmental feasibility of different scenarios for sorting solid waste (pre-sorting in the home and sorting at landfills) and to determine the optimal solution for a rural community, taking into account the specifics of local conditions.

Methods. The calculation of the economic effect of implementing each waste collection scenario, as well as analysis of the regulatory framework for waste management.

Results. The study assesses the waste composition and determination of the economic potential of recyclable materials in Lypkuvativka village of Novovodolazka community in Kharkiv region. The paper describes a comparative analysis of the economic and environmental aspects of two approaches to waste sorting in rural Ukraine: advance sorting in households and sorting of mixed waste directly at landfills. Pre-sorting provides higher quality of recyclable materials and increases community income through the sale of sorted resources, consequently reducing the amount of landfilled waste. Sorting mixed waste at a landfill is less efficient due to high contamination with organic fractions, which reduces the recyclability of the recyclables.

Conclusions. The introduction of advance waste sorting in rural areas of Ukraine is economically and environmentally quite feasible, although it requires initial investment in separate collection containers. In addition, it is necessary to conduct awareness-raising activities with the population.

KEYWORDS: *waste management, sorting, secondary raw materials, rural community, economic benefit, environmental impact*

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Introduction

With the rapid growth of both large and small urban areas, as well as their populations, the volume of municipal solid waste (MSW) continues to increase steadily. This trend poses significant challenges for local governments and public utility services.

In addressing this issue, modern society increasingly confronts with the task of MSW disposal—a task made more difficult by the growing variety of modern packaging, synthetic materials, and plastics that decompose slowly in nature. Once introduced into soil and water systems, these wastes decompose under the influence of physical and chemical environmental factors, becoming hazardous to the natural environment and, directly, to human health.

To meet the annual needs of a single person, approximately 40 tons of mineral resources are extracted from the Earth. In the best-case scenario, people use only 3–5% of these resources effectively, while the rest contributes to environmental pollution. However, we can transform even this type of pollution into an opportunity. Examples include the processing of mining waste, the extraction of useful substances from slagheaps, and—more widely—the recycling of various polymers.

Many countries that are now leaders in waste recycling and disposal once faced the same problems Ukraine faces today. For instance, in the 1980s, Germany did not practice waste sorting; they either incinerated or buried the waste. The situation began to change only in 1991, when the German government adopted legislation requiring manufacturers to use packaging that is recyclable or biodegradable [1].

In Japan, waste is efficiently recycled into numerous useful products: sportswear, school uniforms, stationery, furniture, and more [1].

Sweden recycles 99% of its waste, with the majority used as fuel for power plants. Sweden even imports waste from other countries, such as Ireland, Norway, and Italy, because it does not generate enough waste domestically [1].

Austria has adopted biotechnology solutions, such as fungal enzymes capable of breaking down plastic and polyester. This allows for a circular plastic economy, where waste from one product is used to create another [1].

In Brazil, the government engaged low-income populations in waste collection: in exchange for six bags of sorted waste, people receive one bag of food. As a result, they collect around 400 tons of waste monthly for recycling, and the city of Curitiba became a world leader in household waste collection [1].

India, which faces acute pollution challenges, has found innovative uses for waste: for example, they use plastic bags and candy wrappers in road construction [1].

In Finland, you can return hazardous waste such as light bulbs and batteries to any store that sells them. Supermarkets are equipped with machines that accept bottles and glass containers, issuing a receipt that customers can redeem at checkout. Every pharmacy accepts expired medicines. Additionally, clothing collection points are located throughout the country, with donations often sent to countries in need through the Red Cross [1].

Europeans are learning to embrace reusable items: bringing fabric bags to stores, using personal cups for takeaway coffee, and replacing plastic straws with reusable alternatives. While these changes may seem minor, their impact is significant—one plastic straw can take 500 years to decompose, despite being used for only a few minutes [2].

The European Parliament approved legislation banning certain single-use plastic products in the EU starting in 2021, including disposable cutlery and cotton swabs. It is projected that by 2029, 90% of plastic bottles will be recycled and reused [2].

In Germany and the Netherlands, new stores sell products like pasta, spices, and juices in paper packaging.

In Belgium, there is a ban on plastic bags, so citizens rely on bags made from recycled materials [2].

Municipal solid waste (MSW) management remains one of the most pressing challenges of sustainable development, both in urban and rural communities across Ukraine [3]. However, rural areas often face exacerbated issues due to the lack of proper infrastructure for waste collection and disposal. This leads to the proliferation of unauthorized landfills, which harm the environment by contaminating soil and groundwater, while also wasting potentially valuable recyclable materials [4].

Problem Statement. In Ukraine, more than 27 billion tons of solid waste have already accumulated, occupying over 1.6 million square kilometers of land – an area equivalent to one-tenth of Ivano-Frankivsk region's territory – land otherwise suitable for economic use. The issue of municipal solid waste (MSW) disposal is one of national importance. According to the Resolution of the Cabinet of Ministers of Ukraine No. 554 dated June 27, 1995, titled *"On the list of types and objects of activities that pose increased environmental danger,"* the problem of destruction, processing, storage, burial, and utilization of all types of industrial and domestic waste ranks third in priority, after nuclear energy and nuclear industry concerns.

Currently, Ukraine is home to tens of thousands of landfills, many of which are unauthorized. In the absence of designated waste collection infrastructure, residents often dump their waste into forest belts, ravines, and gullies [5]. Even registered MSW landfills pose environmental risks if they lack sorting and recycling facilities. However, unauthorized dumpsites are far more dangerous due to the complete

absence of oversight, environmental protection measures, and tax contributions [6]. While Ukraine has nearly 6,000 official landfills, the number of illegal (uncontrolled) dumps is estimated to be as high as 30,000, covering approximately 7% of the country's territory. The total volume of waste stored at all landfills—including industrial sites—exceeds 450 million tons annually, a significant portion of which is classified as hazardous [6].

Unauthorized dumpsites often contain waste of extremely high hazard levels. These sites are usually located in close proximity to residential areas—in forest belts, along highways, riverbanks, or within steppe zones—without consideration for sanitary regulations. Toxic substances contaminate large areas, threatening rare species of flora and fauna. Moreover, nearby settlements suffer from polluted drinking water and pungent odors from toxic emissions. In response, Ukraine's Ministry of Ecology and Natural Resources has launched an interactive online map of illegal landfills, where users can report coordinates of discovered dumpsites [6].

A review of scientific literature on unauthorized landfills can shed light on the scale of environmental contamination and its implications for human health and ecosystems.

Studies on illegal landfills are diverse and include scholarly journal articles, books, field reports, and research findings. For example, Mahajan Rinnie [7] notes that in recent years, the global issue of MSW management has gained significant attention. The problem is more acute in developing countries, where a lack of capital and resources has rendered existing waste generation, sorting, storage, collection, and disposal methods unsustainable. Unregulated dumping and open burning of waste are common practices in such regions, posing serious environmental and health risks. These practices lead to severe air, water, and soil pollution, increasing mortality and disease rates. Mahajan's study [7] examines the environmental consequences and public health risks of improper waste management, with a specific focus on environmental sustainability rather than economic or social factors. The author emphasizes the urgent need to shift toward ecologically responsible and sustainable waste management in order to preserve ecosystems, support green economies, and uphold social equity for both current and future generations.

Further research [8] aims to understand better the impact of leachate infiltration on groundwater quality at an uncontrolled municipal landfill in Zhoukou, Henan Province, China. The study examined inorganic pollution in surface and groundwater samples collected from the site, analyzing isotopic composition and concentrations of various physical and chemical parameters. Irrigation return flows during summer months influenced the groundwater quality in shallow aquifers. The author has developed a two-dimensional advective-dispersive transport model, using MODFLOW and MT3DMS to assess contamination transport mechanisms [8]. Simulation of chloride migration using steady state and transient flow models showed that, even after 13 years of landfill operation, the contamination plume remained mostly confined to the upper aquifer. The limited migration distance, despite high chloride concentrations, pointed to additional local sources of salinity in the aquifer system.

Another study [9] emphasizes how seasonal water table fluctuations and vertical hydraulic gradients significantly influence plume migration beneath landfills. These dynamic conditions control contaminant transport and redox conditions in groundwater systems.

A distinct group of studies explored humic substances in groundwater near landfills. In [9], experiments were conducted to isolate and analyze dissolved organic carbon (DOC) fractions—humic acids, fulvic acids, and hydrophilic substances—from landfill-contaminated groundwater. Around 82–83% of total DOC was recovered from samples, with fulvic acids accounting for 60%, hydrophilic fractions 30%, and humic acids 10%. Each fraction made a significant contribution to overall DOC content and differed in molecular weight distribution.

Study [10] investigates the attenuation characteristics of landfill leachate observed at two uncontrolled landfill sites in South Korea. Both sites contain municipal solid waste but lack a proper bottom liner and leachate treatment system. The two landfills differ in age, waste volume, and—most importantly—in their hydrogeological conditions. One site, the Cheonan landfill, is located on an open plain, while the other, the Wonju landfill, is in a valley.

The article [10] provides detailed insights into the attenuation processes and redox conditions of leachate at both uncontrolled landfills.

Variations in different parameters were studied along the groundwater flow path and were monitored monthly over the course of a year. Typical anaerobic conditions were within the landfills. Generally, higher concentrations of pollutants

were during the dry season, while these levels decreased significantly during the wet season. Notably, the considerable reduction in chloride (Cl) concentrations during the rainy season suggests that dilution or mixing is one of the dominant mechanisms of leachate attenuation.

However, the detailed behavior of variations differed between two landfill sites and largely depended on the permeability of surface and subsurface layers. Some rainfall infiltrates the site at landfills with moderate surface permeability, but most rainwater is lost due to rapid surface runoff. In the case of the Cheonan landfill, a nearly impermeable clay silt surface (a rice field) adjacent to the landfill boundary prevents direct infiltration of rainwater. As a result, the redox conditions in the groundwater were strongly influenced by the state of the upper landfill layer, while the less permeable materials beneath the rice fields caused leachate dispersion within the lower downgradient zone.

At the Wonju landfill, there are three distinct zones with different levels of permeability: the landfill area itself, an open sandy field, and a rice field. The roles of the landfill and rice field at this site were very similar to those at Cheonan. The highly permeable sandy field, which absorbed significant quantities of rainwater, played a key role in controlling the redox conditions in the downgradient zone and in governing contaminant migration [10].

Despite the adoption of the National Waste Management Strategy of Ukraine until 2030 [11], many issues in this area remain unresolved.

Ukrainian researchers pay significant attention to the problem of unauthorized landfills. For example, a group of scientists from the Odesa State Environmental University [12] conducted a study on the accumulation of plastic waste in the waters of the northwestern Black Sea. During the study, they surveyed the territories of Odesa and Mykolaiv regions and created a cartographic scheme of MSW landfill locations—both authorized and unauthorized. Their research found that “a significant portion of plastic waste—primarily from unauthorized municipal solid waste dumpsites—is carried by air currents into river systems and, in the case of proximity to the coastline, directly into the waters of the Black Sea” [12].

These are just a few examples of scientific publications that may be useful for studying the issue of unauthorized landfills. It is crucial to rely on research and publications from responsible and credible sources to obtain the most accurate and reliable information.

Landfills are areas of land where household, construction, and other types of waste are stored illegally. In some cases, such dumpsites are deliberately set on fire to reduce the volume of waste. This practice is highly inappropriate, as burning waste severely harms the ecosystem—damaging soil, biota, and polluting the atmosphere.

Unauthorized dumpsites are not equipped with systems for groundwater protection, biogas and leachate capture and treatment, as is the case with engineered landfills. As a result, they fail to prevent the negative environmental impacts of waste accumulation.

Responsibility for the creation of such dumpsites lies with the waste owner, who is legally obliged to comply with waste handling regulations and prevent environmental pollution.

If violations of legal requirements regarding the transportation, storage, disposal, or burial of waste are identified, offenders are subject to administrative liability under Article 82 of the Code of Administrative Offenses of Ukraine. Improper waste management is punishable by a fine ranging from twenty to eighty non-taxable minimum incomes (UAH 340 to 1360) for individuals, and from fifty to one hundred minimum incomes (UAH 850 to 1700) for officials and individual entrepreneurs [5].

In cases where unauthorized dumpsites lead to soil contamination, violators are subject to Article 52 of the Code of Administrative Offenses. This article states that the degradation of agricultural or other land and its pollution by industrial or other waste is punishable by the same range of fines: UAH 340 to 1360 for individuals and UAH 850 to 1700 for officials and business representatives.

Under Article 73 of the Code of Administrative Offenses, littering of forests is subject to a fine ranging from UAH 425 to 850 for individuals, and UAH 850 to 1700 for officials.

Criminal liability is provided for in cases of land pollution or degradation, particularly when it results in danger to the environment or to human life and health. According to Article 239 of the Criminal Code of Ukraine, such actions may be punished by a fine of up to 200 non-taxable minimum incomes (up to UAH 3400), or by disqualification from holding specific positions or engaging in certain activities for up to three years.

Civil liability, regardless of whether administrative or criminal charges are applied, requires compensation for damage caused by violations of waste management legislation. This

damage may affect both human health and the environment [5].

Disciplinary liability applies to individuals who violate waste management legislation in the course of performing their official job duties.

Waste located at unauthorized dumpsites is considered ownerless, as its generator is unknown. In such cases, responsibility for the proper handling and elimination of the waste lies with local self-government authorities.

If an unauthorized landfill is located outside a residential area, the responsibility for its removal falls under the jurisdiction of local state administrations.

Landowners on whose property ownerless waste is discovered are required to notify local authorities within five calendar days. Such waste must be formally registered and placed on record.

The grounds for classifying waste as ownerless and recording it include:

1. Notifications from landowners or land users regarding the presence of such waste;
2. Reports from citizens, businesses, organizations, or media outlets;
3. Results of inspections conducted by the State Environmental Inspectorate of Ukraine and the State Service of Ukraine on Food Safety and Consumer Protection [5].

Upon receiving such notifications, local authorities and regional administrations are required to determine the quantity, composition, properties, and estimated value of the waste, as well as its level of environmental and health risk, and to take measures to identify the waste owners. Where necessary, law enforcement agencies and relevant specialists may be involved.

In the event of discovering an unauthorized dumpsite, it is necessary to report it to the local government or state administration in whose territory it is located.

Additionally, a formal complaint should be submitted to the State Environmental Inspectorate with a request to conduct an inspection for compliance with waste management regulations and to calculate the damages incurred by the state caused by violations of environmental law [5].

Waste management is a system of measures involving the collection, transportation, processing, and secondary use or disposal of waste, as well as oversight of the entire process. Waste is the end result of human activity. Such measures are essential for reducing the harmful impact of waste on human health and the environment.

Thanks to organized waste management systems, it is now possible to extract secondary raw materials from waste. These systems encompass solid, liquid, gaseous, and radioactive substances, with various treatment methods and potential for future reuse [13, 14].

The use of secondary raw materials helps address the following key challenges:

- Conservation of non-renewable natural resources such as water, plant, and animal resources;
- Creation of low-waste production processes;
- Reduction of energy consumption;
- Improvement of the overall environmental situation [13, 14].

This gives rise to the urgent need for the development of a comprehensive waste management system that ensures:

- Implementation of measures to protect public health and the environment from the negative effects of waste processing;
- Systems that eliminate the risk of environmental harm and health hazards for residents living near waste treatment facilities;
- Conditions that prevent harm to workers, damage to equipment, or loss of property during waste disposal operations [13].

The purpose of this study is to evaluate the economic and ecological feasibility of different scenarios for sorting municipal solid waste (MSW) and to determine the most optimal solution for a rural community, considering local environmental and socio-economic conditions.

Study Area and Methodology

The focus of this research is the MSW management system in the village of Lypkuvatyvka, located within Novovodolazka community of Kharkiv region.

Subject of Study: This research examines the economic and environmental characteristics of waste sorting at two levels:

- Household-level source separation; and
- On-site sorting directly at an unauthorized landfill.

Methods of Research

- Waste Composition Assessment:
  We conducted on-site analysis of mixed waste composition at the investigated landfill by selectively weighing and classifying waste into categories (organic

matter, plastics, glass, metals, paper, electronics, etc.).

– Economic Calculation:
The total annual volume of waste at the dumpsite was estimated, and potential revenue from the sale of recyclable materials was calculated. We compared two scenarios:
  - Early (source-level) sorting
  - Late (landfill-level) sorting

Evaluation considered potential financial returns and the degree of contamination affecting recyclability [15].

– Legal and Regulatory Analysis:
Review of National legislation, including the Law of Ukraine "On Waste Management" [3], and local regulations governing MSW collection and transportation. Additionally, considering of best practices and guidelines for organizing waste separation in rural areas and small towns [16].

The obtained data through fieldwork at the unauthorized landfill and via a survey of local residents regarded their willingness and ability to separate waste. Economic estimates used average market prices for recyclable materials (plastic, paper, metals, and glass) at the time of the study.

Research Results

The research was conducted at an unregulated landfill located within Novovodolazka rural community (Fig.). Specifically, the study site is in the village of Lypkuvatyvka. This location is notable not only for its permanent residents but also for a significant number of seasonal visitors (summer residents). These two population groups—local villagers and seasonal dacha owners—are roughly equal in number and are geographically separated by a system of three natural ponds fed by springs.

There is a working hypothesis that dacha owners are more environmentally conscious and responsible in their approach to waste disposal, as they tend to maintain cleanliness to enjoy the natural surroundings they visit.

During the fieldwork stage, measurements of the contaminated area were carried out using Geographic Information Systems (GIS) tools. The estimated dimensions of the landfill are 200 meters by 80 meters. The total surface area of the site is approximately 1.6 hectares [17].

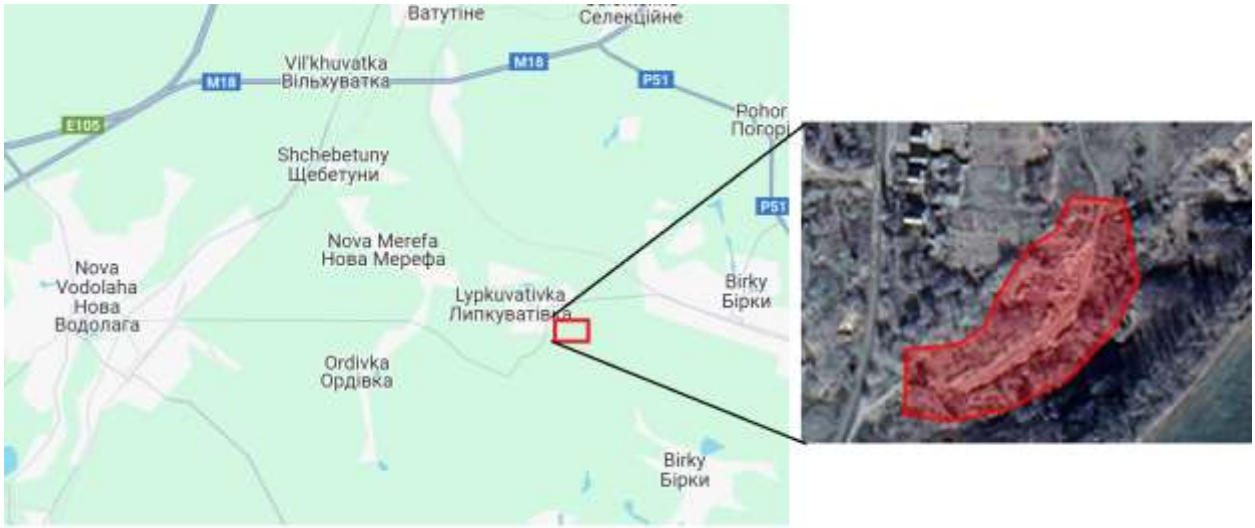

Fig. – Location of an unauthorized landfill

The village of Lypkuvatyvka, located within Novovodolazka community in the Kharkiv region, illustrates a typical situation: mixed waste (including organic matter, plastics, glass, metals, wood, and paper) accumulates without proper sorting, rendering part of the materials unsuitable for recycling.

As increasing the collection and recycling rates is critical to achieving circularity, it is essential to identify the categories of waste that are most relevant for processing and recovery [18]:

- Textiles, due to the complexity of textile value chains, the influence of fast fashion, the currently limited reuse of textile prod

ucts, and their significant contribution to waste accumulation and greenhouse gas emissions from industrial wastewater. There is also a need to stimulate demand for environmentally sustainable clothing.

- Electronics, which, when handled through safe and appropriate procedures, represent a valuable opportunity for reuse and remanufacturing, leading to a broader supply of OPSYS-pattern affordable products and enabling the recovery of valuable materials from electronic waste.
- Construction and demolition waste, which will gain particular importance in the context of Ukraine's post-war reconstruction process.
- Plastics, whose unsustainable consumption continues to grow and which constitute a major component of Ukraine's chemical product imports. Strategies to increase the use of recycled plastics, reduce plastic waste, and limit microplastic pollution are essential.
- Batteries, where the expansion of electromobility is giving rise to new value chains. The new Draft Law on Batteries and Accumulators addresses issues related to recycled content, the recovery of valuable materials, and the safe disposal of battery waste. WE need further measures to combat the use of single-use batteries and align national regulations with the emerging EU legislative framework.

Agriculture remains a vital sector of Ukraine's economy. This sector holds considerable potential for improving food processing, storage, and distribution to prevent losses. It may also serve as a source of by-products for use in industrial and energy processes [18].

Minerals and metals are critical raw materials for society, used across nearly every sector of the global economy. Their extraction and subsequent processing will play a key role in enabling clean technologies, sustainable mobility, and digital solutions—all of which are necessary for the transition of all industrial sectors toward climate neutrality and a circular economy.

Despite both European and national legislative requirements [3, 19] mandating separate collection and recycling of household waste, the implementation of such practices in small communities is often hindered by limited financial and technical resources. Consequently, this study examines two alternative waste-sorting scenarios:

- Scenario A: Early-stage (source-level) sorting within households;
- Scenario B: Sorting of mixed waste directly at the dumpsite.

To assess the recoverability of materials disposed of at the unauthorized landfill, we conducted a series of seasonal field inspections. The results enabled the estimation of the average waste composition and the potential value of recyclable materials.

According to the findings, the average composition of 100 kg of mixed waste is as follows:

- Biodegradable waste: 50%
- Plastics: 10%
- Cardboard: 10%
- Glass: 5%
- Metals: 3%
- Wood: 5%
- Electronics: 2%
- Other mixed residuals: 15%

The substantial share of organic waste and cardboard, along with recyclable fractions such as plastics, glass, and metals, indicates a high potential for resource recovery. However,in the absence of source separation, a significant proportion of these materials becomes contaminated and loses value.

Comparison of Two Waste Sorting Approaches

Scenario A: Early Sorting in Households

Advantages:

- Minimal contamination of recyclable fractions by organic matter, enabling higher resale value;
- Reduced volume of waste requiring landfill disposal;
- Positive impact on public awareness and consumer behavior [20].

Disadvantages:

- Initial investment required for purchasing collection containers;
- Need for broad-based public education and engagement campaigns.

Scenario B: Sorting Mixed Waste at the Dumpsite

Advantages:

- Possibility of recovering a portion of recyclable materials from already accumulated waste;
- Potential for job creation for individuals involved in manual sorting (if conducted at a formal sorting facility).

Disadvantages:

- Significant contamination of recyclables (e.g., plastics and paper) with organic matter;

- Higher operational costs for manual sorting and transportation;
- Lower revenues from recyclables due to reduced material quality.

Economic Assessment of the Scenarios. According to preliminary estimates, the annual volume of waste generated in the village of Lypkuvatyvka (2,000 residents × 250 kg per person per year) amounts to approximately 500 metric tons (500 000 kg).

Under Scenario A (early sorting at the household level), approximately 90% of recyclable fractions (plastics, cardboard, glass, metals) can be recovered and sold at relatively high market prices, due to the high material purity. If the system is properly implemented, the total annual revenue from the sale of these recyclables could exceed 650 UAH [15].

Under Scenario B (sorting mixed waste at the dumpsite), the recoverability of recyclable materials drops to around 60%, resulting in reduced annual revenue of approximately 435 UAH [15]. In addition, this scenario requires further investment in sorting infrastructure, wages for sorting staff, and costs associated with mitigating environmental risks.

Environmental Aspects. Early sorting significantly reduces the volume of mixed waste, thereby lowering the load on the landfill. In contrast, sorting at the dumpsite increases the risk of contamination, as valuable components are degraded and organic matter contributes to the generation of **leachate** and **greenhouse gases**. Thus, source-level separation plays a critical role in preventing unauthorized waste disposal and minimizing environmental harm.

Conclusions

This study identified key factors contributing to the emergence of unauthorized landfills, including insufficient waste management infrastructure, lack of alternative disposal methods, and limited public understanding of the environmental consequences of illegal dumping—such as soil, water, and air pollution, as well as loss of biodiversity and ecosystem degradation.

Source-level sorting demonstrated greater economic efficiency, with potential annual revenues exceeding 650,000 UAH, compared to 435,000 UAH from dumpsite-level sorting.

From an environmental standpoint, early sorting reduces the volume of mixed waste and prevents contamination of recyclable materials with organic matter.

The success of early sorting initiatives depends on investment in physical infrastructure (containers, logistics systems) and public education campaigns.

While dumpsite sorting may serve as a short-term transitional measure, a shift toward source separation is essential for long-term sustainability.

The findings support the development of separate waste collection systems in rural communities, offering not only ecological benefits but also opportunities for additional local revenue generation through the sale of secondary raw materials.

Conflict of Interest

The authors declare no conflict of interest regarding the publication of this manuscript. Furthermore, the authors have fully adhered to ethical norms, including avoiding plagiarism, data falsification, and duplicate publication.

***Authors Contribution*:** all authors have contributed equally to this work

References

1. Waste Management Abroad: International Experience. Ukrainian Ecological Alliance. (2024, June 21). Retrieved from http://ukrecoalliance.com.ua/upravlinnia-vidkhodamy-za-kordonom-mizhnarodnyy-dosvid/ (in Ukrainian)
2. "Landfill of Ideas" or How Europeans Recycle Waste. European Union in Ukraine. (2024, June 21). Retrieved from https://euukrainecoop.medium.com/звалище-ідей-або-як-європейці-переробляють-відходи-ad4e6a1dbf1c (in Ukrainian)
3. Law of Ukraine "On Waste Management." (2023). Verkhovna Rada of Ukraine Bulletin (VVR), (17). Retrieved from https://zakon.rada.gov.ua/laws/show/2320-20#n802
4. State Statistics Service of Ukraine. Environmental indicators (2023). Retrieved from http://www.ukrstat.gov.ua (in Ukrainian)

5. Unauthorized Dumpsites: Health and Environmental Hazards and Recommendations. Environment People Law. (2024, June 21). Retrieved from https://epl.org.ua/human-posts/styhijni-zvalyshha-shkoda-zdorov-yu-i-dovkillyu-ta-rekomendatsiyi/ (in Ukrainian)
6. Landfills and Their Impact on the Environment. (2024, June 21). Retrieved from https://www.re-line.com.ua/statti/smittezvalyshha-ta-dovkillya/ (in Ukrainian)
7. Mahajan Rinnie. (2023). Environmental and Health Impacts of Open Dumping of Municipal Solid Waste: A Case Study of Khon Kaen Municipality, Thailand. *Journal of Environmental and Public Health*, 18(1), 18-29. http://dx.doi.org/10.12944/CWE.18.1.3
8. Han, D.M., Tong, X.X., Jin, M.G., Emily, H., Tong, C.S., Song, X.F. (2013). Evaluation of organic contamination in urban groundwater surrounding a municipal landfill, Zhoukou, *China. Environ. Monit. Assess.* 185 (4), 3413–3444 http://dx.doi.org/10.1016/j.gexplo.2013.09.008
9. Christensen, J.B., Jensen, D.L., Gron, C., Filip, Z., Christensen, T.H. (1998). Characterization of the dissolved organic carbon in landfill leachate—polluted groundwater. *Water Res.* 32, 125–135. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0043135497002029
10. Lee, J.Y., Cheon, J.Y., Kwon, H.P., Yoon, H.S., Lee, S.S., Kim, J.H., Park, J.K., Kim, C.G., (2006). Attenuation of landfill leachate at two uncontrolled landfills. *Environ. Geol*. 51, 581–593. Retrieved from https://link.springer.com/article/10.1007/s00254-006-0353-7
11. National Waste Management Strategy in Ukraine until 2030 (approved by the Resolution of the Cabinet of Ministers of Ukraine No. 820), (2017, November 8). Retrieved from http://za-kon2.rada.gov.ua/laws/show/820-2017-p (in Ukrainian)
12. Safranov, T. A., Berlinsky, N. A., & Zmienko, D. M. (2020). Plastic of the Solid Domestic Waste on the Coastal Zone of the Northwestern Part of the Black Sea as a Component of Marine Littre. *Visnyk of V. N. Karazin Kharkiv National University. Series "Ecology"*, (23), 57-66. https://doi.org/10.26565/1992-4259-2020-23-06 (in Ukrainian)
13. Bani, M.S., Rashid, Z.A., Hamid, K.H.K., Harbawi, M. E. Alias, A.B., & Aris, M. J. The Development of Decision Support System for Waste Management: a Review. *World Academy of Science, Engineering and Technology*. 2009. (25), 161 - 168. Retrieved from https://scispace.com/pdf/the-development-of-decision-support-system-for-waste-1df8tg354q.pdf
14. Maksymenko, N. V., Gololobova, O. O., Sonko S. P., Stolov, V. O. & Shiyan, D. V. (2024). Utilization of vegetative waste from green infrastructure of cities "in-situ Volume 1415, Issue 12024 Article number 012127. *IOP Conf. Ser.: Earth Environ. Sci., 1415(12024}*, 012127. Retrieved from https://iopscience.iop.org/article/10.1088/1755-1315/1415/1/012127
15. EOS Data Analytics. NDVI Analysis for Environmental Assessment. (2023). Retrieved from https://eos.com/
16. Pestova, I. O. (2015). Methodology for assessing the state of vegetation of urbanized areas using multispectral satellite images. Kyiv
17. Stolov, V. O. (2024). Environmental and Social Aspects of the Formation of Unauthorized Landfills. In: *Environmental Protection: Collection of Scientific Papers from the 20th All-Ukrainian Taliev Readings. Kharkiv: V. N. Karazin National University*. 193–194. Retrieved from https://ekhnuir.karazin.ua/handle/123456789/19452 (in Ukrainian)
18. Waste Classifier DK 005-96. Retrieved from https://ips.ligazakon.net/document/FIN7371 (in Ukrainian)
19. European Commission. Green Infrastructure – Enhancing Europe's Natural Capital (2013). Retrieved from https://ec.europa.eu
20. Kravchenko, Ye. I., Stolov, V. O., Maksymenko, N. V. (2025). Determination of public opinion on the organisation of waste collection and sorting systems in rural areas. In N. V. Maksymenko, N. I. Cherkashyna (Eds.). *Ecology is a priority* : All-Ukrainian English-speaking student conference, Kharkiv (2025, March 14, pp.56-57). Kharkiv: V. N. Karazin National University. Retrieved from https://ekhnuir.karazin.ua/handle/123456789/20978

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АНАЛІЗ АЛЬТЕРНАТИВ СОРТУВАННЯ ПОБУТОВИХ ВІДХОДІВ У СІЛЬСЬКИХ РАЙОНАХ: ВДОМА ЧИ НА СМІТТЄЗВАЛИЩІ

Мета. Оцінка економічної та екологічної доцільності різних сценаріїв сортування твердих побутових відходів (завчасне сортування в оселі та сортування на сміттєзвалищах) та визначення оптимального рішення для сільської громади з урахуванням специфіки місцевих умов.

Методи. Розрахунок економічного ефекту від реалізації кожного сценарію збору відходів, а також аналіз нормативно-правової бази управління відходами.

Результати. Дослідження базується на оцінюванні складу відходів і визначенні економічного потенціалу вторинної сировини у с. Липкуватівка Нововодолазької громади Харківської області. Виконано порівняльний аналіз економічних і екологічних аспектів двох підходів до сортування відходів у сільській місцевості України: завчасного сортування в домогосподарствах та сортування змішаних відходів безпосередньо на сміттєзвалищах. Виявлено, що завчасне сортування забезпечує вищу якість вторинної сировини й підвищує дохід громади за рахунок продажу відсортованих ресурсів, а також зменшує обсяг захоронюваного сміття. Сортування змішаних відходів на сміттєзвалищі є менш ефективним через високу забрудненість органічною фракцією, що знижує придатність вторсировини до переробки.

Висновки. Запровадження завчасного сортування відходів у сільській місцевості України є економічно й екологічно доцільнішим, хоч і потребує первинних інвестицій у контейнери для роздільного збору. Крім того, необхідно вести інформаційно-просвітницьку роботу з населенням.

КЛЮЧОВІ СЛОВА: *управління відходами, сортування, вторинна сировина, сільська громада, економічна вигода, екологічний вплив*

Конфлікт інтересів

Автори заявляють, що конфлікту інтересів щодо публікації цього рукопису немає. Крім того, автори повністю дотримувались етичних норм, включаючи плагіат, фальсифікацію даних та подвійну публікацію.

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Список використаної літератури

1. Управління відходами за кордоном: міжнародний досвід. *«Український екологічний альянс»*. URL: http://ukrecoalliance.com.ua/upravlinnia-vidkhodamy-za-kordonom-mizhnarodnyy-dosvid/ (дата звернення: 21.06.2024).
2. «Звалище ідей» або як європейці переробляють відходи. *Європейський Союз в Україні*. URL: https://euukrainecoop.medium.com/звалище-ідей-або-як-європейці-переробляють-відходи-ad4e6a1dbf1c (дата звернення: 21.06.2024).
3. Закон України Про управління відходами. Відомості Верховної Ради (ВВР), 2023, № 17. URI https://zakon.rada.gov.ua/laws/show/2320-20#n802
4. Державна служба статистики України. Екологічні показники 2023. URL: http://www.ukrstat.gov.ua
5. Стихійні звалища: шкода здоров'ю і довкіллю та рекомендації. *Екологія Право Людина*. URL: https://epl.org.ua/human-posts/styhijni-zvalyshha-shkoda-zdorov-yu-i-dovkillyu-ta-rekomendatsiyi/ (дата звернення: 21.06.2024).

6. Сміттєзвалища та їх вплив на довкілля (дата звернення 19.04.2024). https://www.reline.com.ua/statti/smittezvalyshha-ta-dovkillya/
7. Mahajan Rinnie. Environmental and Health Impacts of Open Dumping of Municipal Solid Waste: A Case Study of Khon Kaen Municipality, Thailand. *Journal of Environmental and Public Health.* 2023. 18(1). P. 18-29. DOI: http://dx.doi.org/10.12944/CWE.18.1.3
8. Han, D.M., Tong, X.X., Jin, M.G., Emily, H., Tong, C.S., Song, X.F., Evaluation of organic contamination in urban groundwater surrounding a municipal landfill, Zhoukou, China. *Environ. Monit. Assess*. 2013. Vol. 185. N 4. P. 3413–3444. DOI: http://dx.doi.org/10.1016/j.gexplo.2013.09.008
9. Christensen, J.B., Jensen, D.L., Gron, C., Filip, Z., Christensen, T.H. Characterization of the dissolved organic carbon in landfill leachate—polluted groundwater. *Water Res.* 32, 1998. P.125–135. URL: https://www.sciencedirect.com/science/article/abs/pii/S0043135497002029
10. Lee, J.Y., Cheon, J.Y., Kwon, H.P., Yoon, H.S., Lee, S.S., Kim, J.H., Park, J.K., Kim, C.G., 2006. Attenuation of landfill leachate at two uncontrolled landfills. *Environ. Geol*. Vol. 51. P. 581–593. URL: https://link.springer.com/article/10.1007/s00254-006-0353-7
11. Національна стратегія управління відходами в Україні до 2030 року (схвалено розпорядженням Кабінету Міністрів України від 8 листопада 2017 р. N 820). URL: http://zakon2.rada.gov.ua/laws/show/820-2017-p (дата звернення: 20.04.2024 р.).
12. Сафранов Т. А., Берлінський М. А., Змієнко Д. М. Пластик твердих побутових відходів прибережної зони північно-західного Причорномор'я як складова морського сміття. *Вісник Харківського національного університету імені В. Н. Каразіна серія «Екологія».* 2020. № 23. С. 57-66. DOI: https://doi.org/10.26565/1992-4259-2020-23-06
13. Bani M.S., Rashid Z.A., Hamid K.H.K. et al. The Development of Decision Support System for Waste Management: a Review. *World Academy of Science, Engineering and Technology.* 2009. № 25. P. 161 - 168. URL : https://scispace.com/pdf/the-development-of-decision-support-system-for-waste-1df8tg354q.pdf
14. Maksymenko N. V., Gololobova O. O., Sonko S. P., Stolov V. O. and Shiyan D. V. (2024) Utilization of vegetative waste from green infrastructure of cities "in-situ Volume 1415, Issue 12024 Article number 012127. *IOP Conf. Ser.: Earth Environ. Sci.* 1415 012127 URL: https://iopscience.iop.org/article/10.1088/1755-1315/1415/1/012127
15. EOS Data Analytics. NDVI Analysis for Environmental Assessment. 2023. URL: https://eos.com/
16. Pestova I. O. Methodology for assessing the state of vegetation of urbanized areas using multispectral satellite images. Kyiv. 2015.
17. Столов В.О. Екологічні та соціальні аспекти утворення несанкціонованих сміттєзвалищ. *Охорона довкілля*: зб. наук. статей XX Всеукраїнських наукових Таліївських читань. Харків: ХНУ імені В. Н. Каразіна, 2024. С. 193-194. URL: https://ekhnuir.karazin.ua/handle/123456789/19452
18. Класифікатор відходів ДК 005-96. URL: https://ips.ligazakon.net/document/FIN7371
19. European Commission. Green Infrastructure – Enhancing Europe's Natural Capital (2013). URL: https://ec.europa.eu
20. Kravchenko Ye. I., Stolov V. O., Maksymenko N. V. Determination of public opinion on the organisation of waste collection and sorting systems in rural areas. Ecology is a priority: All-Ukrainian English-speaking student conference, march 14, 2025, Kharkiv / Ed.: N. V. Maksymenko, N. I. Cherkashyna. – Kharkiv: V. N. Karazin National University, 2025. – P. 56-57 (PDF) URL: https://ekhnuir.karazin.ua/handle/123456789/20978

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