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MUNICIPAL SOLID WASTE MANAGEMENT: CHALLENGES AND PERSPECTIVES

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ABSTRACT

The volume of solid waste in Azerbaijan has been increasing annually due to urbanization and the rising number of multi-apartment residential buildings. Currently, limited financial resources and a low level of public awareness regarding waste sorting constitute major challenges to the sustainable development of the sector. Moreover, the waste management system is hindered by issues of centralization and inadequate coordination.

This article demonstrates that, rather than focusing solely on recycling, Azerbaijan is pursuing integrated and pragmatic solutions, including waste sorting at the source, the implementation of advanced landfill technologies, thermal treatment methods, and the conversion of waste into energy and economic resources.

The analysis highlights that key prerequisites for modernization encompass shifts in social behavior patterns, the adoption of digital technologies, the transition to tariff models such as PAYT ("pay-as-you-throw"), and enhanced citizen participation. Furthermore, a management framework grounded in circular economy principles, alongside support from international financial institutions, is strategically essential for the sustainable advancement of the waste management sector.

Keywords: Municipal solid waste, waste policy, waste processing, recycling, Azerbaijan, Baltic states, Germany, Kazakhstan.

JEL codes: Q50, Q53, Q57

INTRODUCTION

As the urbanization process accelerates in Azerbaijan and population migration toward urban centers intensifies, the demand for quality, accessibility, and efficiency in public services-particularly the management of municipal solid waste (MSW)—has significantly increased.

The natural decomposition of MSW leads to the emission of greenhouse gases (GHGs) such as carbon dioxide and methane, which have a serious impact on global climate change. Notably, landfill sites generate higher levels of these gases compared to alternative technologies. Hoang and Fogarassy (2020) point out that ineffective waste management results not only in technical issues but also in social and institutional problems, such as blocked drainage systems, increased flooding, and the creation of environments conducive to disease outbreaks. Similarly, Ferronato and Torretta (2019) argue that due to limited resources, the waste management strategies applied in low-income countries are often ineffective, posing significant risks to both environmental and public health. On the other hand, Xue, Zhang, and Li (2021) emphasize that energy recovery from landfill gas represents an ecologically and economically efficient approach to waste management.

Existing research shows that comprehensive and systematic reviews of MSW management in Azerbaijan are still limited. Most studies tend to focus primarily on technical and regulatory aspects, whereas a holistic analysis of waste management—within the context of policy, financial resources, technology, and institutional mechanisms—is of critical importance.

This conceptual paper assesses the current state, emerging challenges, and institutional gaps in municipal solid waste (MSW) management in Azerbaijan, and presents development directions and reform proposals for sustainable and digitized management models. The document places particular emphasis on analyzing the successful practices of Germany and the Baltic states and exploring how these experiences can be adapted to Azerbaijan’s context.

Within the scope of the research, the scientific and regulatory frameworks of Azerbaijan, Kazakhstan, Estonia, Latvia, Lithuania, and Germany were examined. Searches conducted using terms such as "municipal solid waste," "MSW management," "waste treatment, " and their equivalents in local contexts during the 2022–2024 period yielded over 5,000 documents. Following initial screening, approximately 100 articles specifically related to MSW in Azerbaijan were selected, with around 90 of them used as primary sources for in-depth analysis. In addition, relevant legislative acts of the Republic of Azerbaijan, Cabinet of Ministers’ decisions, and reports from "Tamiz Shahar" JSC were included among the core references for the study.

Ultimately, this review paper aims to formulate practical improvement directions and recommendations tailored to Azerbaijan’s realities, taking into account the current challenges in MSW management.

LITERATURE REVIEW

Municipal solid waste (MSW) management has become a key area of focus within the broader shift toward sustainable urban development. Across the European Union, varying national approaches to implementing circular economy principles have produced diverse outcomes. Germany is frequently highlighted in the literature as a leading example, owing to its advanced legal framework, high recycling rates, and well-developed infrastructure. In contrast, the Baltic states—Estonia, Latvia, and Lithuania—demonstrate incremental progress within more constrained policy and infrastructural contexts.

This section reviews the MSW management experiences of Germany and the Baltic region to identify practical lessons and challenges relevant to countries like Azerbaijan. Key themes include legal and operational structures, recycling performance, and infrastructural limitations. The comparative analysis underscores both the effectiveness of long-term institutional planning and the persistent barriers to EU target compliance, offering valuable insights for designing adaptive, phased waste management strategies.

Germany is widely recognized for its advanced municipal solid waste (MSW) management system. As of 2022, the country achieved a recycling rate of 67.7%, surpassing the EU’s 2020 target of 65% (Umweltbundesamt, 2023). This success is attributed to robust legal frameworks such as the Circular Economy Act and operational mechanisms like the dual system ("Yellow Sack"), which ensures efficient separation and collection of packaging waste (Umweltbundesamt, 2023).

While Germany stands out as a leader, other European countries are also making measurable progress in adapting similar sustainable practices—particularly in the Baltic region.

Estonia, while still behind Germany, has made important progress. In 2023, the country recorded a recycling rate of 37.9% and a per capita MSW generation of 373 kg (Statistics Estonia, 2023). Policy efforts are currently focused on circular economy strategies including waste prevention, eco-design, and community repair networks. However, Estonia still struggles to meet EU-mandated recycling targets, largely due to insufficient separation at source and limited regional infrastructure (Statistics Estonia, 2023).

Neighboring Latvia has demonstrated more rapid development in recent years, although infrastructure gaps still constrain further performance improvements.

Latvia's performance in waste management has improved substantially in recent years. The recycling rate rose from around 25% in 2015 to approximately 40% in 2020 (European Environment Agency, 2022). This increase is partly due to better waste classification and the inclusion of exported waste in recycling statistics. Nevertheless, landfill dependency remains high, and additional investment in sorting facilities and digital tracking is needed (European Environment Agency, 2022).

Lithuania's situation offers a contrasting example, highlighting the continued challenges facing even reform-oriented Baltic countries in achieving EU benchmarks.

Lithuania continues to face challenges in MSW management despite targeted reforms. The country ranked 25th among EU member states in terms of recycling efficiency as of the

most recent EU performance review (Ecsite, 2012). Public awareness initiatives and waste separation programs have helped raise performance, but Lithuania remains below the EU's 50% recycling target, underscoring the need for stronger enforcement and infrastructure improvements (Ecsite, 2012).

In summary, the experiences of Germany and the Baltic states illustrate both the potential and limitations of MSW reform, offering valuable lessons for Azerbaijan in designing a phased, regionally adapted waste management strategy.

MATERIAL

In recent years, the rapid pace of urbanization, industrialization, and rising levels of consumption have led to a significant global increase in the volume of municipal solid waste (MSW). The continuation of this trend poses a serious threat to ecological balance and public health, leads to inefficient use of resources, and places immense pressure on the resilience of waste management infrastructure. Managing MSW is not merely a technical or financial issue; it is a multifaceted challenge linked to strategic governance and environmental sustainability.

According to projections by the United Nations, by 2050, 68% of the global population will reside in urban areas, which will further escalate waste generation levels (UN DESA, 2018). A World Bank report states that in 2020, the amount of solid waste generated daily worldwide reached 2.01 billion tons, and this figure is expected to rise to 3.4 billion tons by 2050 (World Bank, 2018). These statistics underscore the urgent need to optimize waste management systems and implement environmentally efficient models.

Inefficient management of MSW can result in a host of issues, including the contamination of soil and water resources, the release of harmful gases into the atmosphere, the spread of diseases, and the degradation of biodiversity. Conversely, effective MSW management creates economic potential by enabling the recovery and reuse of valuable resources that would otherwise be discarded. In this context, circular economy approaches have emerged as one of the primary pillars of modern waste policy.

Municipal solid waste management (MSWM) is globally recognized as one of the key pillars of sustainable urban development. As population growth, consumption levels, and urbanization accelerate, pressure on the environment increases, prompting many countries to adopt Integrated Solid Waste Management (ISWM) strategies. These strategies aim to minimize environmental harm, ensure resource recovery, and implement circular economy principles. International practices in this area vary across different institutional models, technological capacities, and public engagement levels.

The European Union (EU) is among the most advanced and systematic actors in waste management. The EU Waste Framework Directive (2008/98/EC) and Landfill Directive (1999/31/EC) define a waste hierarchy—prevention, reuse, recycling, recovery, and disposal—and are reinforced by the principle of Extended Producer Responsibility (EPR).

For instance, Germany's "Green Dot" system ensures a high level of waste sorting and recycling. As a result, as of 2023, Germany recycles more than 65% of its municipal solid waste,

ranking among the world leaders in this field. Sweden, on the other hand, has advanced waste-to-energy (WtE) technologies, keeping the share of waste sent to landfills below 1%, while using WtE as a major source of urban heating supply.

Japan is known for its meticulous waste sorting and high-tech incineration systems. Waste in Japan is divided into more than 10 categories (burnable, non-burnable, PET bottles, hazardous materials, etc.) and is closely tied to public participation. The country's highly efficient incineration plants operate with minimal emissions, ensuring environmental compliance and sustainability.

South Korea, by implementing a Volume-Based Waste Fee (VBWF) system, has succeeded in reducing the volume of waste and increasing recycling rates. Since consumers pay based on the amount of waste they generate, the system creates a strong economic incentive for waste reduction. As a result, the national recycling rate has reached 59%. In major cities like Seoul, the use of smart bins and digital monitoring systems enables real-time tracking of waste volume and disposal behavior, further enhancing the effectiveness of the system.

In many developing countries, serious challenges persist in the field of waste management. Key issues include weak infrastructure, the dominance of the informal sector, low levels of public awareness, and institutional fragmentation. In countries such as India and Nigeria, recycling is predominantly carried out by informal waste collectors, which creates both social and environmental risks.

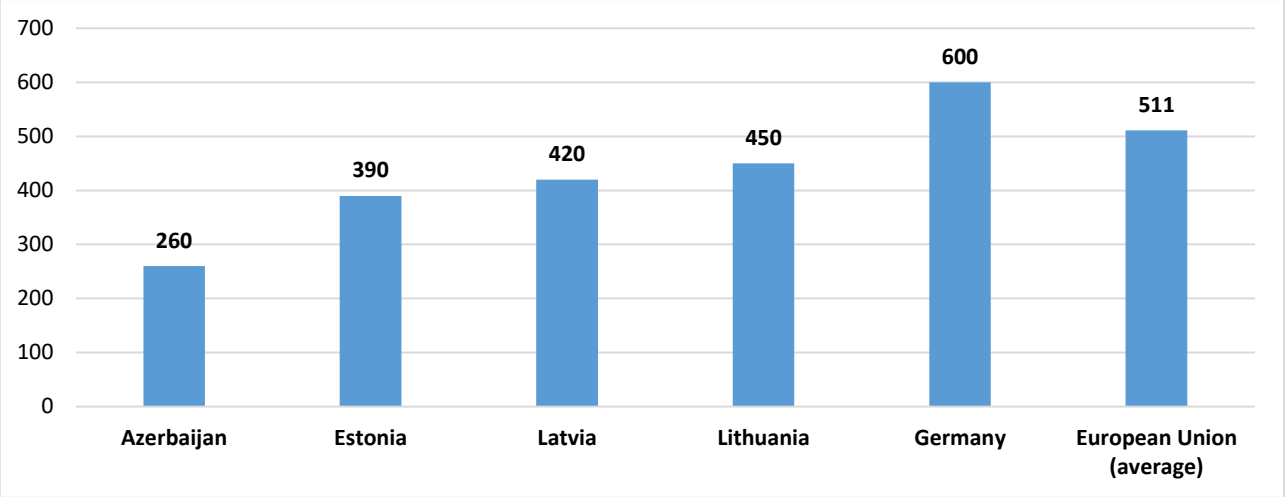
Nevertheless, there are successful examples in some developing countries. In Rwanda, particularly in the capital city Kigali, public cleanliness is maintained through strict regulatory standards and nationwide monthly clean-up campaigns known as *"Umuganda."* Brazil, on the other hand, has increased both social inclusion and recycling rates by integrating waste picker cooperatives into the official waste management system.

Efficient household waste management today is one of the core elements of environmental protection and sustainable development policy. The experiences of different countries demonstrate that institutional frameworks, technological capabilities, and levels of public participation vary significantly—and as a result, so do waste generation volumes and recycling performance. The per capita amount of municipal solid waste serves as a key indicator of these differences and often reflects both the maturity of waste management systems and the degree of resource circularity.

The chart presented offers a comparative overview of the per capita household waste generation in 2023 for Azerbaijan and several European Union (EU) countries. In Azerbaijan, this figure stood at 260 kg, whereas in Estonia it was 390 kg, Latvia – 420 kg, Lithuania – 450 kg, and Germany – 600 kg. The EU average was 511 kg.

These figures are not only indicative of consumption levels and the degree of urbanization, but also closely linked to the functionality of formal waste registration systems and recycling infrastructure. Countries such as Germany, Lithuania, and Estonia, which report high per capita waste figures, also demonstrate high recycling and energy recovery rates.

Figure 1. Per capita municipal solid waste in 2023 (kg)



Note. Source: **State Statistical Committee.** (2023). *Public Utilities: Waste*. Baku: Center for Analysis of Economic Reforms and Communication of the Republic of Azerbaijan.
Eurostat. (2024). *Municipal waste generated per capita*. Retrieved April 10, 2025, from https://ec.europa.eu/eurostat/databrowser/view/cei_pc031/default/table

Estonia, Latvia, and Lithuania—former members of the Soviet Union—have made significant progress in waste management over the past three decades within the framework of European Union (EU) integration. Their shared historical background with Azerbaijan makes them suitable comparators. Germany, on the other hand, is included due to its status as a global benchmark with advanced waste management practices and its leading role in the European waste management system.

This visual comparison shows that the volume of waste generated in Azerbaijan is lower, yet this can be attributed to low levels of waste separation and recycling, despite the existing quantity of household waste.

Municipal solid waste management is a key component of urban infrastructure, and tariffs play a vital role in financing the collection, processing, and disposal of waste. Research indicates a correlation between waste generation and income levels—high-income countries tend to generate more waste per capita, but also possess more advanced waste management systems.

According to the World Bank, approximately 2.01 billion tons of municipal solid waste are generated globally each year, and this figure is expected to rise to 3.4 billion tons by 2050—a rate of growth twice as fast as the population increase over the same period (Silpa et al., 2018). This projected rise underscores the urgent need to implement effective tariff systems that can accurately account for and distribute the environmental costs of waste generation.

In international practice, the determination of waste tariffs is mainly carried out through two systems.

The first is the single-tier payment system. This system represents the simplest payment model. It consists of only one type of fee. A classic example is the fixed-rate system. This refers to a fixed fee determined through a certain calculation algorithm and paid as a total amount,

regardless of the actual amount of waste generated or the services used. Therefore, this model does not create any incentives to reduce waste volume or to encourage source separation efforts.

The second system is the multi-tiered payment system. In this system, waste charges are applied through a payment model consisting of two or more components. Multi-component waste payment models are best suited to implementing the "polluter pays" principle.

In effectively functioning Pay-As-You-Throw (PAYT) systems, the payment consists of two main components: a fixed charge and a variable charge. The fixed charge reflects the fixed (unavoidable) costs of waste management services and is applied regardless of service usage. The variable charge, on the other hand, is based on the actual amount of collected waste.

The implementation of waste payments through the Pay-As-You-Throw (PAYT) system is considered the most appropriate option for ensuring the fair payment of waste management services. This approach, which has been successfully implemented in many countries around the world, has proven to be highly effective in reducing waste volumes and encouraging source separation through the creation of economic incentives.

Various schemes are used when implementing PAYT systems. The main types include:

- Volume-based schemes: Waste charges are calculated based on the capacity of designated containers.
- Bag-based schemes: Waste charges are based on the number of special waste bags used; for example, only waste placed in pre-paid bags is collected.
- Weight-based schemes: Waste charges are determined based on the weight of waste collected in a specific container.
- Frequency-based schemes: Waste charges are calculated according to the frequency with which containers are emptied.

Naturally, each scheme has its advantages and limitations. It should also be noted that the successful implementation of any PAYT system requires the provision of a convenient and efficient infrastructure for source-separated waste collection. In addition, proper public awareness and active citizen participation are crucial for the system’s effectiveness.

Against this backdrop, the prioritization of municipal solid waste (MSW) management has become increasingly evident in national policy agendas, particularly in contexts where environmental, demographic, and economic pressures converge.

Municipal solid waste (MSW) management has become a strategic priority worldwide due to its critical role in environmental protection, public health preservation, and efficient resource utilization. In this context, the issue of waste management has emerged as one of the key policy priorities of the Republic of Azerbaijan in recent years—driven by increasing urbanization, industrialization, and population density. The growing volume of MSW, its associated environmental and sanitary-epidemiological risks, as well as the potential for reuse, necessitate a systematic regulatory framework and scientifically grounded approaches.

The initial institutional and legal foundations for waste management in Azerbaijan began to take shape in the late 1990s. Key legislative milestones include the adoption of the Law on Environmental Protection in 2002 and the Law on Public Sanitation and Hygiene, which came into force in 2007. Since the 2010s, more complex approaches have begun to develop, encompassing waste sorting, recycling, and energy recovery phases.

According to Decision No. 74 of the Cabinet of Ministers of the Republic of Azerbaijan**,** dated April 21, 2005, the *"Rules for the Sanitary Cleaning of Urban and Other Residential Areas, Temporary Storage, Regular Transportation, and Disposal of Municipal Waste"* define the directions of waste management and identify the responsible institutions. Specifically, the collection, accumulation, and transportation of waste fall under the institutional responsibility of the municipal housing and utilities departments of city and district executive authorities, settlement representatives, and local municipalities.

Until 2005, tariffs for waste transportation and disposal services were determined by a Cabinet decision titled *"On the Approval of Tariffs for Use of Residential Space in State and Public Housing and for Housing and Utility Services."* Since then, following an amendment to that decision, tariffs have been regulated by the Tariff Council of the Republic of Azerbaijan under the decision "*On the Regulation of Tariffs for the Collection, Transportation, and Disposal of Municipal Solid Waste."* The most recent amendment to this regulation was made on June 29, 2024, and tariffs were differentiated for residential and non-residential consumers, as well as for Baku and other administrative regions.

Table 1. Tariffs for municipal solid waste collection, transportation, and disposal services

№	Type of Service	Consumer Group	Unit of Measure	Tariff (AZN, incl. VAT)
1.	Collection, transportation, and disposal of municipal solid waste			
1.1.	Within Baku city	Residential	Per person/month	1,00
		Non-residential	Per cubic meter	15,00
			Per ton	68,30
1.1.1.	Including disposal of MSW		Per cubic meter	3,60
			Per ton	16,40
1.2.	Other administrative regions	Residential	Per person/month	0,70
		Non-residential	Per cubic meter	12,00
			Per ton	54,60
1.2.1.	Including disposal of MSW		Per cubic meter	2,50

Note. Source: Extract from Decision No. 8 of the Tariff Council of the Republic of Azerbaijan, dated June 29, 2024

https://e-qanun.az/framework/57164

RESULTS

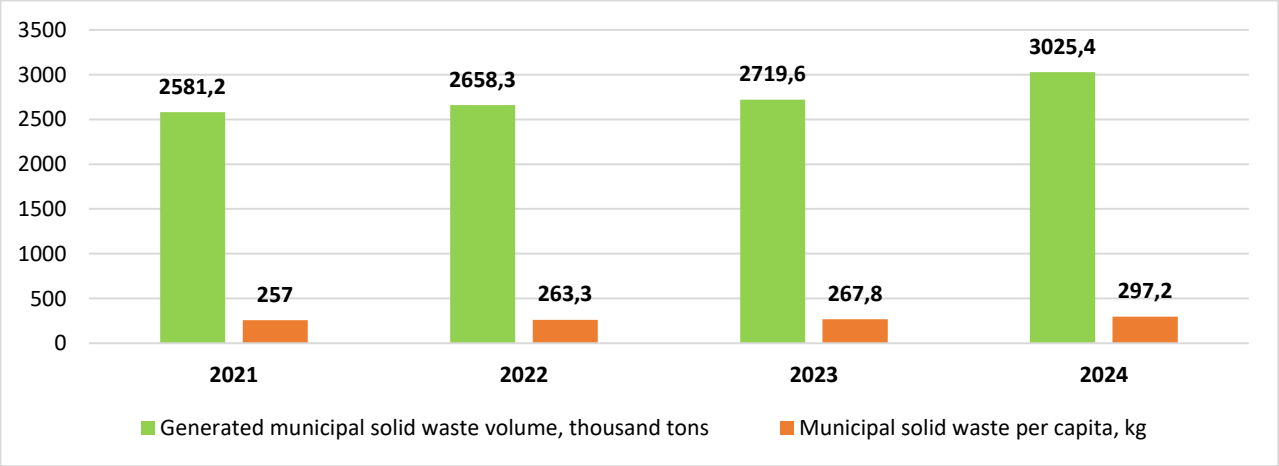
In Azerbaijan, the tariff model applied to municipal solid waste (MSW) is based on a fixed-rate system. The tariffs regulated by the Tariff Council do not differentiate by waste type for either the residential or non-residential sectors. This approach does not provide any incentives for waste reduction or pollution prevention. In this context, a re-evaluation of tariffs based on the type of waste generated by non-residential users, as well as a transition to a multi-component payment system, is essential.

The national policy in this area extends beyond environmental protection and is closely connected to economic diversification, the implementation of the circular economy model, the execution of the green energy strategy, and efforts to improve public health and regional social well-being. Recycling MSW for use as secondary raw materials can support alternative resource supply for the country’s industrial and construction sectors, while energy production from waste may contribute to national energy security. At the same time, improper waste management can lead to soil and water pollution, disease outbreaks, and ecosystem degradation, all of which pose significant risks to human capital development and overall social welfare.

In 2024, a total of 4,365.0 thousand tons of waste was generated in Azerbaijan, of which 69.3% was municipal solid waste and 30.7% originated from various types of industrial production (State Statistical Committee).

According to an analysis based on data from the State Statistical Committee, the volume of MSW generated in the country increased by 17.2% (444.2 thousand tons) between 2021 and 2024, reaching 3,025.4 thousand tons. However, the amount of MSW utilized annually does not exceed 0.6 thousand tons, indicating that only a very small fraction is processed or recycled. In line with the general trend, this negative growth dynamic in waste volume also contributes to additional environmental pressure, as reflected in per capita indicators.

Figure 2. Comparative ındicators on municipal solid waste generation in Azerbaijan (in thousand tons and kilograms)



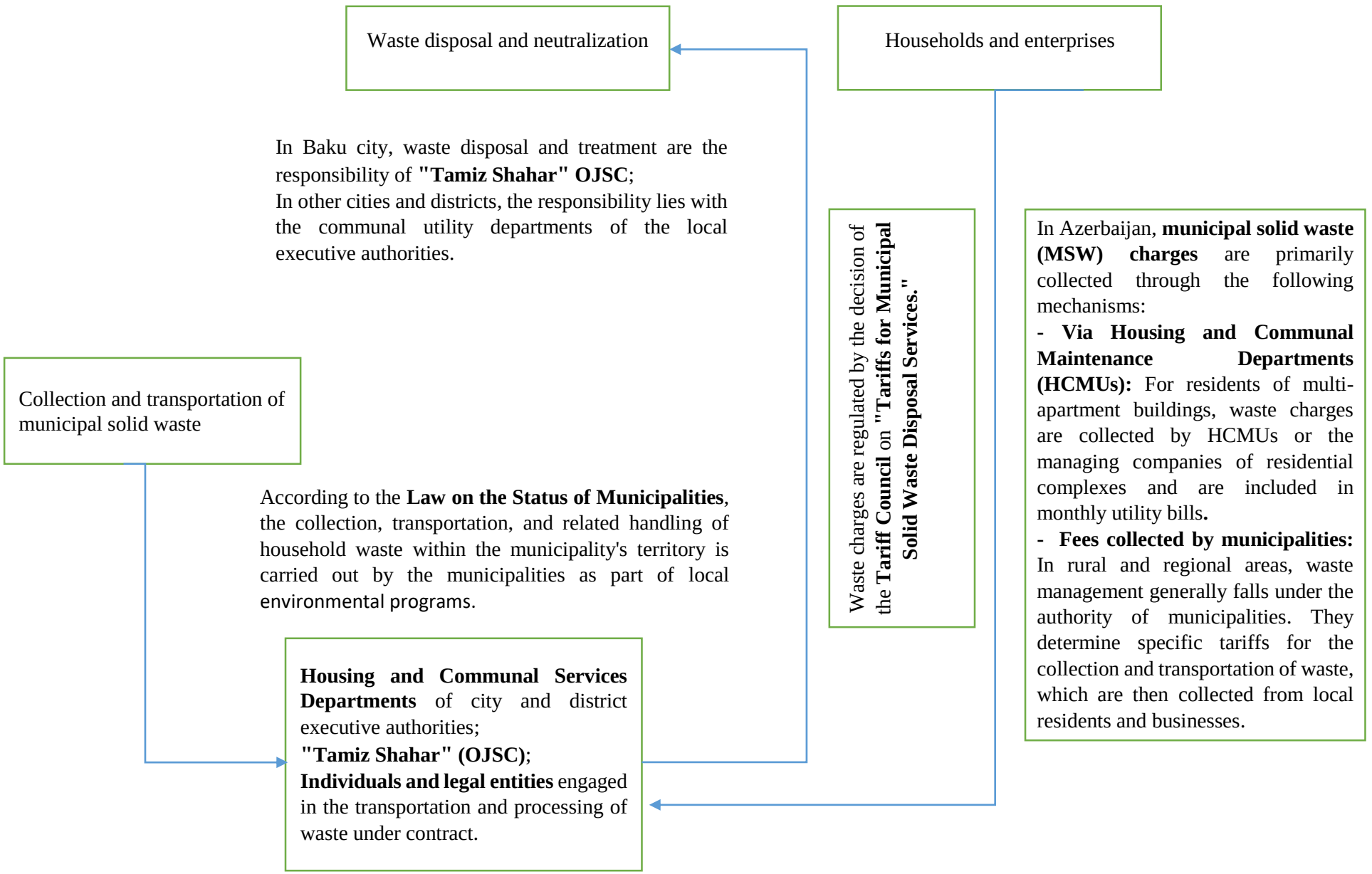
Note. Source: State Statistical Committee of the Republic of Azerbaijan
https://www.stat.gov.az/source/environment/

As shown in the chart, the per capita volume of municipal solid waste (MSW) increased by 40.2 kg between 2021 and 2024. For comparison, in 2023, the average per capita amount of household waste in European Union (EU) countries was approximately 511 kg, nearly twice as high as in Azerbaijan. According to the results of statistical analyses based on available data, more than 70% of the household waste collected by municipal services nationwide is generated in Baku and the Absheron Peninsula.

There is currently no unified approach to municipal solid waste management (MSWM) in Azerbaijan. Different stages of the waste management process—from collection to disposal—are handled by various institutions. MSWM in the country is generally divided into three zones: Baku city, urban areas, and rural areas (Huseynova, 2023). In Baku, the placement and disposal of waste are carried out by the "Tamiz Shahar" Open Joint-Stock Company (OJSC). Furthermore, under a Presidential Decree dated June 22, 2021, the collection, transportation, placement, and disposal of all MSW generated in the city of Shusha, as well as the collection and transportation of MSW from the Gala settlement in Baku, were assigned to "Tamiz Shahar" OJSC.

In other districts and cities, responsibility lies with the communal utility departments under the local executive authorities (see Diagram 1).

Scheme 1. Household waste management structure in Azerbaijan



DISCUSSION

Studying international experience in improving household waste management mechanisms is of strategic importance for Azerbaijan. In particular, the establishment of recycling facilities in regional centers, the implementation of waste sorting and digital monitoring systems, and the promotion of public participation and incentive-based payment mechanisms can significantly enhance the efficiency of the country's waste management system.

Adapting successful elements of international models to local conditions may contribute to improved ecological, economic, and social outcomes in waste management. In this regard, it is considered appropriate to take into account the following recommendations:

➢ Revising the waste tariff formation mechanism – It is recommended to transition to a multi-tiered payment system based on the "polluter pays" principle, which has been successfully implemented in many countries. This includes applying the "Pay-As-You-Throw" (PAYT) model, initially for non-residential tariffs. At the same time, a multi-component payment system should also be introduced for residential consumers in a phased manner. As a pilot phase, the PAYT model can be tested in one district of Baku city within multi-apartment buildings. In other administrative regions and cities of the country, payments for waste collection and transportation should be provided based on the current tariffs, using individual subscriber codes similar to other utility services, and monthly or annual bills should be issued. These payments should be facilitated both via physical payment terminals and online platforms. This approach would encourage waste collection, transportation, and recycling, while also enhancing a sense of individual responsibility among citizens. Additionally, such a system would contribute to greater transparency and ease of payment.

➢ Integrating the Extended Producer Responsibility (EPR) approach – Azerbaijan should gradually plan the introduction of Extended Producer Responsibility (EPR) regulations in its waste management system. The purpose of EPR is to make producers responsible for at least part of the life cycle of their products and/or the management of the waste resulting from them. Implementing EPR can encourage producers to design products that are easier to recycle or dispose of, and can help create a sustainable financing mechanism for waste management.

➢ Improving separate household waste collection systems – Although partial source separation of household waste is already implemented to some extent in Azerbaijan, the system can be significantly improved based on the experience of countries with advanced waste management frameworks such as Germany. The following proposals may be considered to enhance Azerbaijan's system of separate household waste collection:

✓ Expansion of the container system for separate waste collection

Based on Germany's experience, it is advisable to introduce a broader variety of waste-specific containers (Umweltbundesamt, 2024), including:

- Blue container – for paper and cardboard
- Yellow container – for plastic, aluminum, and other packaging waste
- Green container – for colored glass waste

- White container – for clear (colorless) glass waste
- Brown container – for biodegradable waste (e.g., food scraps)
- Gray container – for mixed waste that is not recyclable
- Special containers for household appliances and electronic waste – Collection points and containers should be created for the disposal of unusable electronics, batteries, light bulbs, and other waste types requiring specialized processing.

✓ Development of a packaging waste return system in supermarkets
- Installation of automated return stations in supermarkets for glass bottles, plastic bottles, and aluminum cans.
- Introduction of a deposit-return system for packaging, similar to the Pfand system used in

  Germany. This would encourage the population to return packaging waste and reduce the overall volume of waste. *(DPG Deutsche Pfandsystem GmbH, 2024)*

✓ Public awareness campaigns
- Informing citizens about the importance of separate waste collection and recycling.

  (Interzero, 2024)
- Explaining the color codes of waste containers and how to properly sort waste. *(Interzero, 2024)*

✓ Infrastructure development for waste collection and processing
- Establishing collection points for hazardous waste such as mercury-containing lamps, batteries, and chemical substances.
- Ensuring regular collection of sorted waste and developing mechanisms to prevent contamination between waste types. *(All About Berlin, 2024)*

These measures will make the waste management system more efficient, reduce the volume of waste sent to landfills, and increase the level of recycling.

Although certain progress has been achieved in the field of household waste management in Azerbaijan in recent years, issues such as institutional fragmentation, limited recycling infrastructure, regional disparities, and weak digital monitoring capabilities highlight the urgent need for comprehensive reforms. As is well known, in 2024, only a small portion of the 3,025.4 thousand tons of municipal solid waste generated in the country—just 0.6 thousand tons annually—was processed or reused. This indicator clearly demonstrates the need for systemic improvement.

To address these existing challenges, it is essential to implement a set of comprehensive and phased measures in the following directions:

1. Legal and institutional framework update
   - It is advisable to adopt a unified national waste management strategy, supported by a concrete action plan tailored for each region.

- Clear distribution of management responsibilities among different levels of local executive

  authorities, municipalities, and specialized institutions is required, along with the

  strengthening of coordination mechanisms.

- The applicability of the "Tamiz Shahar" OJSC model to other major cities and industrial
  zones should be explored.

2. Revision of tariff policy and financial mechanisms
   - Existing tariff models (e.g., "per capita payment") do not take into account actual waste

     volumes or production habits. Therefore, a volume-based fee system should be implemented

     gradually.

   - Investment incentives should be increased for the establishment of recycling facilities and

     logistics networks through public-private partnership (PPP) mechanisms.

   - Waste management projects should be supported through green finance instruments,

     including green bonds, tax incentives, and environmental funds.

3. Establishment of digital monitoring and data systems
   - A centralized digital registration system should be developed to record the types and volumes of waste generated by public, commercial, and industrial sources, with strengthened monitoring and reporting.
   - Real-time tracking of waste flows should be ensured through geographic information systems (GIS) and smart waste management technologies.
   - Citizen awareness and participation mechanisms should be enhanced via digital portals and

     mobile applications.

4. Expansion of recycling and waste-to-energy potential
   - The establishment of Material Recovery Facilities (MRFs) across regions should ensure local-level organization of sorting and initial processing stages.
   - The application of waste-to-energy (WtE) technologies, especially in major cities, is of great

     importance for improving energy security and reducing waste loads.

   - The development of composting systems (for organic waste) could enable the formation of an integrated model linked to the agricultural sector.

5. Increasing public awareness and participation
   - Wide-scale public awareness campaigns should be conducted on proper waste sorting and

reduction, and special educational programs should be developed in schools and universities.

- Local-level public engagement should be promoted through citizen monitoring groups and

  eco-volunteer networks.

- Pilot projects on waste collection and reuse should be developed at the municipal level, and

  successful practices should be scaled and replicated.

As a result, improving household waste management in Azerbaijan requires not only technical and infrastructure-focused changes but also systemic reforms at the institutional, legal, and societal levels.

CONCLUSION

This study has provided a comprehensive and multidisciplinary examination of the municipal solid waste (MSW) management system in Azerbaijan, highlighting its structural limitations, regulatory fragmentation, and underdeveloped recycling infrastructure. By situating Azerbaijan's experience within the broader international landscape—particularly the best practices of Germany and the Baltic states—the research identifies both gaps and opportunities in aligning the national waste management framework with sustainable development imperatives.

The analysis reveals that Azerbaijan's current MSW system is characterized by centralized administration, institutional fragmentation, and limited financial capacity. While some progress has been made, the system continues to face significant constraints, including a low recycling rate, limited source separation, and underdeveloped enforcement mechanisms. The prevailing flat-rate tariff structure does not offer sufficient behavioral incentives and falls short of effectively implementing the "polluter pays" principle. These challenges are compounded by the lack of advanced digital monitoring tools, fragmented coordination between national and local authorities, and relatively low levels of public engagement. Addressing these issues through targeted reforms could substantially improve the system's efficiency, transparency, and long-term sustainability.

From a theoretical standpoint, this paper situates MSW management within the broader paradigm of the circular economy, emphasizing the shift from linear "take-make-dispose" models to regenerative systems in which waste is minimized and resources are continuously reused. Solid waste is not merely an environmental externality but a potential input into new value chains—particularly when supported by green technologies, sustainable procurement, and eco-innovation. The integration of digital tools (e.g., GIS-based tracking, smart bins, mobile payment systems) is also indispensable for fostering transparent, accountable, and adaptive governance structures.

For Azerbaijan, the path forward requires a phased and coordinated reform agenda rooted in institutional modernization, legal harmonization, and infrastructure investment. Priority

should be given to revising tariff methodologies, expanding material recovery and waste-to-energy (WtE) infrastructure, enhancing digital monitoring systems, strengthening public engagement, and mobilizing international financial and technical assistance. The modernization of Azerbaijan’s MSW sector is not only a technical necessity but also a governance and behavioral transformation. By adopting a holistic, systems-thinking approach, Azerbaijan can make meaningful progress toward its environmental goals, align with global sustainability agendas, and build a more resilient and resource-efficient future.

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38.

BƏRK MƏİŞƏT TULLANTILARININ İDARƏ OLUNMASI: ÇAĞIRIŞLAR VƏ PERSPEKTİVLƏR

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XÜLASƏ

Azərbaycanda bərk məişət tullantılarının həcmi urbanizasiyanın və çoxmənzilli yaşayış binalarının sayının çoxalması nəticəsində hər il artır. Hazırda maliyyə resurslarının məhdudluğu və əhali arasında tullantıların çeşidlənməsi ilə bağlı maarifləndirmənin zəif olması sektorun dayanıqlı inkişafının üzləşdiyi əsas çağırışlardandır. Bununla yanaşı tullantıların idarə olunması sistemi mərkəzləşmə və koordinasiya problemləri ilə üzləşir.

Bu məqalədə göstərilir ki, Azərbaycanda yalnız təkrar emala fokuslanmaq əvəzinə, tullantıların mənbəyində çeşidlənməsi, müasir poliqon texnologiyalarının tətbiqi, termal emal üsulları və tullantıların enerji və iqtisadi resursa çevrilməsi kimi inteqrasiya olunmuş və real həllər təklif olunur.

Göstərilir ki, modernizasiyanın əsas şərtlərinə sosial davranış modellərinin dəyişdirilməsi, rəqəmsal həllərin tətbiqi, “nə qədər tullantı, o qədər ödəniş” kimi tarif modellərinə keçid və vətəndaş iştirakçılığı daxildir. Bundan əlavə, dairəvi iqtisadiyyat prinsiplərinə əsaslanan idarəetmə modeli və beynəlxalq maliyyə institutlarının dəstəyi tullantı sektorunun dayanıqlı inkişafı üçün strateji əhəmiyyət daşıyır.

Açar sözlər: Bərk məişət tullantıları, tullantı siyasəti, tullantıların emalı, təkrar emal, Azərbaycan, Baltikyanı ölkələr, Almaniya, Qazaxıstan.

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