NICOLAUS COPERNICUS UNIVERSITY IN TORUŃ

Bulletin of Geography. Socio-economic Series, No. 70 (2025): 113-124
http://doi.org/10.12775/bgss-2025-0042

BULLETIN OF GEOGRAPHY. SOCIO–ECONOMIC SERIES

journal homepages:
https://apcz.umk.pl/BGSS/index
https://www.bulletinofgeography.umk.pl/

Fees for municipal waste as an economic tool for reducing the amount of mixed municipal waste

Eva Mihaliková

Pavol Jozef Šafárik University in Košice, Department of Economics and Management of Public Administration, Faculty of Public Administration, Košice, Slovakia, e-mail: eva.mihalikova1@upjs.sk, https://orcid.org/0000-0002-3961-0936

How to cite:
Mihaliková, E. (2025). Fees for municipal waste as an economic tool for reducing the amount of mixed municipal waste. *Bulletin of Geography. Socio-economic Series*, 70(70): 113-124. DOI: http://doi.org/10.12775/bgss-2025-0042

Abstract. One of the key tools of environmental policy is economic instruments. This article focuses on one type of economic instrument applied in waste management – namely, fees for municipal waste. The aim of this work is to ascertain the amount of mixed municipal waste produced, analyze the level of fees for municipal waste, and determine the type of fee applied in Slovakia and its individual regions. This work underscores the need to implement volume-based waste fees and indicates the potential of artificial intelligence which, by employing smart bins and sensors, can assist in determining the quantity and type of waste. This could form the basis for calculating volume-based fees and establishing a more equitable waste-charging system.

Article details:
Received: 29 April 2025
Revised: 14 October 2025
Accepted: 02 December 2025

Key words:
municipal waste,
economic tools,
waste managment,
waste-charging system,
Slovakia

Contents:

1. Introduction

Fees for the collection of municipal waste represent one type of economic instrument employed in environmental policy. Economic instruments have consistently played a significant role in policy because they help internalize externalities, mitigate harm and enhance quality of life (Ščasný et al., 2009). Romančíková (2006) regards them as indirect tools because they stimulate polluters to alter their behavior. Likewise, Tetřevová, Rhys et al. (2024) indicate that economic instruments shape the behavior of businesses and consumers, encouraging them to revise decisions that might adversely affect the environment. The significance of economic incentives in boosting public participation in household waste separation is supported by authors who investigated the effects of economic and social instruments, concluding that economic tools are more effective (Xu et al., 2018). Miller et al. (2008) also contend that individuals' decisions regarding waste separation are predominantly driven by economic considerations, such as costs, rather than societal or ecological values. Economic incentivization was found to be more attractive to participants with lower incomes and make them more active in performing waste separation (Xu et al., 2017).

When assessing the effectiveness of economic instruments, it is critical to evaluate their environmental impact, whether they have prompted behavioral changes among polluters, and whether they have reduced the production of mixed municipal waste. Jurušs and Brizga (2018) argue that environmental taxes and fees must be sufficiently high to effectively motivate individuals and society as a whole to achieve environmental improvements. Watkins et al. (2012) stress that fees serve as an effective economic stimulus – if set at an adequate level, they encourage individuals to rethink their behavior toward reducing mixed waste production and increasing waste sorting. Alongside waste sorting programs, they can be viewed as a mechanism to prevent recyclable materials from entering the waste stream (Han et al., 2018). Concurrently, it is worth noting that economic instruments, such as environmental taxes and fees, ensure reliable funding sources for environmental protection (Bulajic et al., 2020), constitute a revenue stream for public budgets, and facilitate increased revenue for national budgets and local government budgets (Andersen et al., 2011).

Establishing fees is not a straightforward process and differs across countries and their regions. The more developed a country, the more refined its fee schemes tend to be (Alzamora & Barros, 2020). Figure 1 provides an overview of some of the main economic instruments used across the EU.

Fees are linked to mixed municipal waste, which is still predominantly disposed of via landfilling – the least preferable method in the waste management hierarchy. According to Bilitewski (2008), the primary methods for charging mixed municipal waste include:

- a fee system based on the volume of waste produced,
- a fee system based on the mass of waste produced,
- a flat fee system.

Pham (2023) categorizes fee systems into modern payment systems, which account for the actual amount of waste produced, and traditional systems, which do not. Given human tendencies toward self-interest, financial incentives are necessary to promote reduced waste production (Hlavenka & Cvrčková, 2015). Hence, it is vital to design the fee payment system effectively, incorporating greater precision, transparency and equity.

Setting fees requires consideration of multiple factors, including the application of the "polluter pays" principle, ensuring cost-effectiveness in waste management systems, and keeping fees for essential public services socially affordable (OECD, 2019).

A well-structured waste fee system based on the "pay-as-you-throw" principle could incentivize citizens to minimize waste, as their fee would correspond to their actual waste output (Valentovič, 2010).

Pay-As-You-Throw (PAYT) is a system that charges residents based on the amount of waste they generate, providing a financial incentive to reduce waste production and encourage better waste separation. As a policy initiative, PAYT aims to promote waste reduction and support the transition to a circular economy (Matteo & Guadagno, 2024).

Municipalities are primarily responsible for implementing waste management policies and applying PAYT at the local level. PAYT is an economic instrument that encourages more sustainable practices, such as reuse, waste minimization and recycling. The core principles of PAYT are based on three main components: user identification, measurement of waste generated, and the application of a specific (individualized) fee (CandamTECH, 2023).

Many cities and towns around the world have implemented PAYT systems, and evidence shows that when households start paying directly for waste services, they tend to reduce the amount of waste they produce. For example, in the United States, towns in Massachusetts with PAYT systems generated

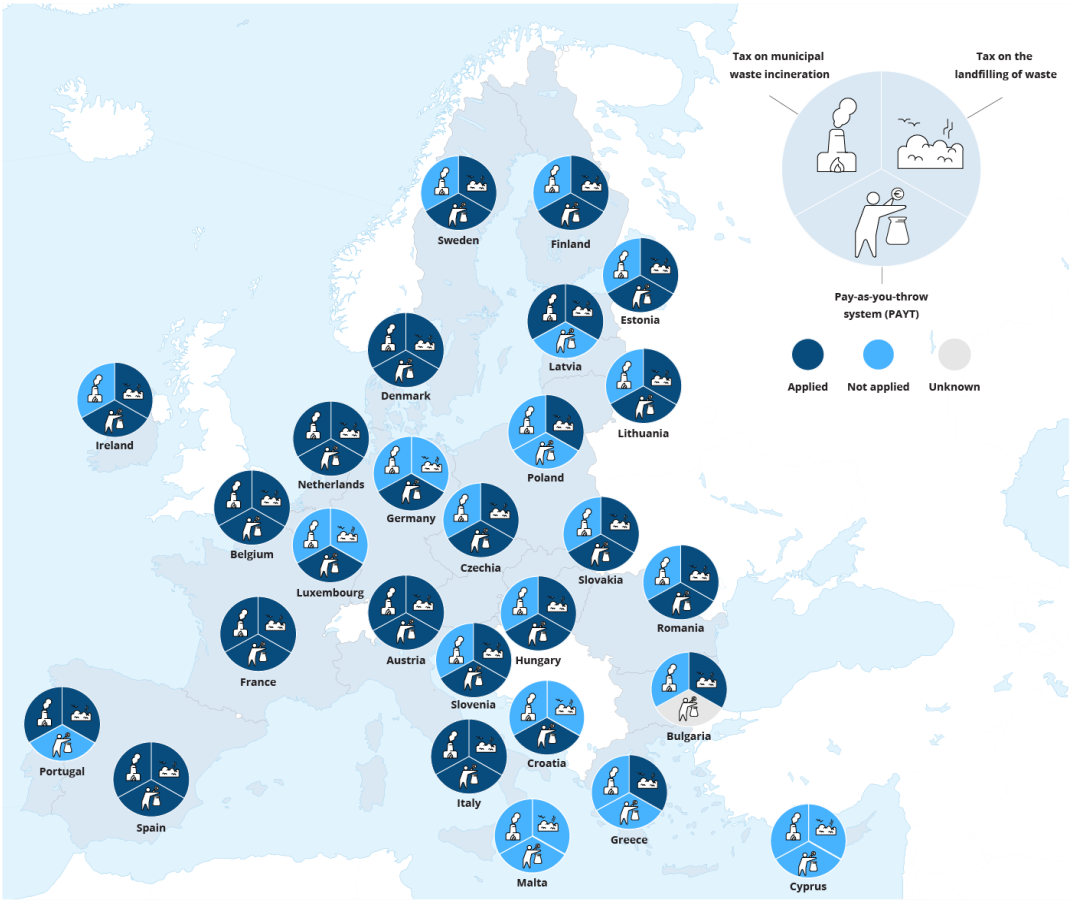

Fig. 1. Key economic instruments for municipal waste management applied by EU Member States
Source: EEA, 2023

an average of 1,239 pounds of trash per household in 2020 – a 30% reduction compared to other towns (WEF, 2022). Similarly, in Sweden, municipalities using pay-by-weight schemes collected, on average, 20% less household waste per capita in bins and bags compared to municipalities without such schemes (Dahlén & Lagerkvist, 2010). The implementation of PAYT in the Italian city of Ferrara not only led to a reduction in total waste generation but also resulted in significant cost savings in waste collection, transport and disposal (Rizzo & Secomandi, 2024).

Across the European Union, PAYT systems are widely used as an economic instrument, with most Member States having implemented some form of the system for at least part of their population.

2. Research materials and methods

This work stems from a content analysis of articles concerning municipal waste fees and the legislation regulating the waste charging system in Slovakia. Its aim is to ascertain the amount of mixed municipal waste produced, analyze the level and evolution of municipal waste fees, and determine the type of fee applied in Slovakia and its individual regions, for the years 2019 to 2023. Much of the data required for the analysis was not publicly accessible, so they were acquired through information requests under the *Act on Free Access to Information*. The data sources were the Statistical Office of the Slovak Republic, the Ministry of Finance of the Slovak Republic and the Environmental fund.

Data from the Statistical Office were derived from annual municipal waste reports, which each municipality must submit yearly for statistical purposes. Data from the Ministry of Finance were sourced from the Financial Statement on Revenues, Expenditures, and Financial Operations of Municipalities; budgetary and contributory organizations under municipal authority; and the Evaluation of Municipal and Regional Budget Management Outcomes. The data from the Environmental Fund concerned fees for landfilling municipal waste.

Table 1. Data sources and accessibility of data

Data	Source		Accessibility		
Municipal waste (MW)	Statistical Office	Statdat	Publicly accessible	Quantity of municipal waste [zp3001rr]	
Mixed municipal waste					
Fee for MW in Slovakia	Ministry of Finance	Evaluation of Municipal and Regional Budget Management Outcomes	Publicly accessible for each year	https://www.mfsr.sk/sk/financie/verejne-financie/uzemna-samosprava/	
Fees for municipal waste produced in Slovakia's regions	Ministry of Finance	Financial Statement on Revenues, Expenditures, and Financial Operations of Municipalities; budgetary and contributory organizations under municipal authority	Not publicly accessible	Information request sent 21.6.2024	Information request processed 2.7.2024
Landfill fees for MW	Environmental fund		Not publicly accessible	Information request sent 21.6.2024	Information request processed 28.6.2024
Percentage of municipalities employing each fee type	Statistical Office	Annual municipal waste reports	Not publicly accessible	Information request sent 21.6.2024	Information request processed 9.7.2024
Amount of MW, in tons per year, subject to flat and volume-based fees			Not publicly accessible	Information request sent 3.2.2025	Information request processed 13.2.2025

Source: Author's own elaboration

The data were gathered and analyzed at the NUTS 2 and NUTS 3 levels, and the results are depicted graphically. An overview of data sources and methods of data collection is shown in Table 1.

3. Research results

3.1. Legislation regulating the waste-charging system in Slovakia

Fees for municipal waste collection are typically set at the municipal level in most countries and form part of their regular revenue. In the Slovak Republic, this fee is designated as a local fee for municipal waste and minor construction waste and is regarded as a municipality's own tax revenue (Koreňová, 2022). Its amount is stipulated in a generally binding municipal ordinance and is derived from the actual costs the municipality incurs in managing municipal waste.

The fee's collection is regulated by *Act No. 582/2004 Coll. on Local Taxes and the Local Fee* for Municipal Waste and Minor Construction Waste, under which the fee covers:

- activities associated with handling mixed municipal waste,
- activities associated with handling biodegradable municipal waste,
- sorted collection of municipal waste components not subject to extended producer responsibility,
- costs arising from insufficient sorting of separately collected municipal waste components subject to extended producer responsibility,
- costs exceeding standard costs as defined by specific regulations,
- activities associated with handling minor construction waste, unless volume-based collection for such waste has been introduced in the municipality.

Municipalities may also incorporate into the fee the costs of a collection container for mixed municipal waste and the costs of supplying collection containers and composting bins for the sorted collection of municipal waste components not

covered by extended producer responsibility. The revenue from this fee constitutes municipal income and must be allocated exclusively to the collection, transport, recovery and disposal of municipal waste and minor construction waste.

Slovak legislation permits municipalities to select their preferred method of fee collection, delineating:

- a flat fee, calculated for individuals as the product of the fee rate and the number of calendar days and, for legal entities and entrepreneurs, as the product of the fee rate, the number of calendar days and an indicator of daily municipal waste production – essentially a fixed annual rate per resident.
- a fee for unweighed volume-based waste collection, calculated as the product of the fee rate, the frequency of collections and the volume of the collection container – often referred to as "token-based collection".
- a fee for weighed volume-based waste collection, where citizens pay based on the waste they actually produce. This calculation is more intricate, requiring municipalities to maintain records of the actual weighed mass of municipal waste in kilograms. At the end of the tax period, the municipality aggregates all costs related to waste management activities and computes the actual costs per collection container as the product of the municipality's unit costs for waste management and the actual weighed mass of municipal waste.

3.2. Analysis of municipal waste and municipal waste fees in Slovakia's Regions

The analysis spans a five-year period, employing percentage share calculations and monitoring changes over time. The initial table outlines the evolution of municipal waste and associated fees across Slovakia (Table 2).

Over the observed period, the amount of municipal waste rose by 8% compared to the baseline year, peaking in 2021. Encouragingly, the amount of mixed municipal waste produced has declined annually (by 15% over the period), and its proportion within total municipal waste has also decreased. The local fee for municipal waste and minor construction waste surged by 42.68% over the observed period. A key contributor to this rise is the increasing fee for mixed municipal waste, partly driven by escalating landfill fees intended to reduce waste disposal in landfills and decrease the number of landfills in Slovakia.

The evolution of mixed municipal waste and the fees for municipal waste across Slovakia are illustrated in Figure 2.

The subsequent section examines the situation across Slovakia's individual regions. Slovakia comprises eight self-governing regions, identified in graphs by abbreviations provided in Table 3.

Figure 3 depicts the amount of mixed municipal waste produced in Slovakia's regions. The highest amounts are generated in the Bratislava and Nitra regions. Though not the most populous, these regions are among the most developed, drawing workers from other parts of Slovakia.

Focus then shifts to analyzing municipal waste fees across Slovakia's regions. The value and structure of these fees in the last of the analyzed years are illustrated in Figure 4.

In the Bratislava region, the municipal waste fee substantially surpasses that of other regions and demonstrates a steady upward trajectory. However, relative to the baseline year, its increase was the smallest, at roughly 15%. The largest percentage increases from the baseline year occurred in the Prešov region (nearly 68%) and the Trnava region (63%).

The municipal waste fee may be applied as a flat fee, a volume-based fee, or a combination thereof, with the choice of charging system left to individual

Table 2. Evolution of municipal waste and associated fees across Slovakia

	2019	2020	2021	2022	2023	Change (%)
Mixed municipal waste (tons)	1,166,419	1,144,886	1,089,588	1,025,071	991,136	-15.03
Municipal waste MW (tons)	2,369,726	2,596,725	2,705,327	2,597,456	2,560,971	+8.07
Proportion (%)	49.22	44.09	40.28	39.46	38.70	
Fee for municipal waste (euro)	157,061,363	175,716,565	187,571,760	190,934,153	224,102,458	+42.68
Landfill Fees for MW (euro)	9,226,517	15,512,550	19,622,206	17,219,758	16,308,955	+76.76

Source: Author's own elaboration based on data from Statistical Office of the Slovak republic, from Environmental fund and from Ministry of Finance of the Slovak Republic

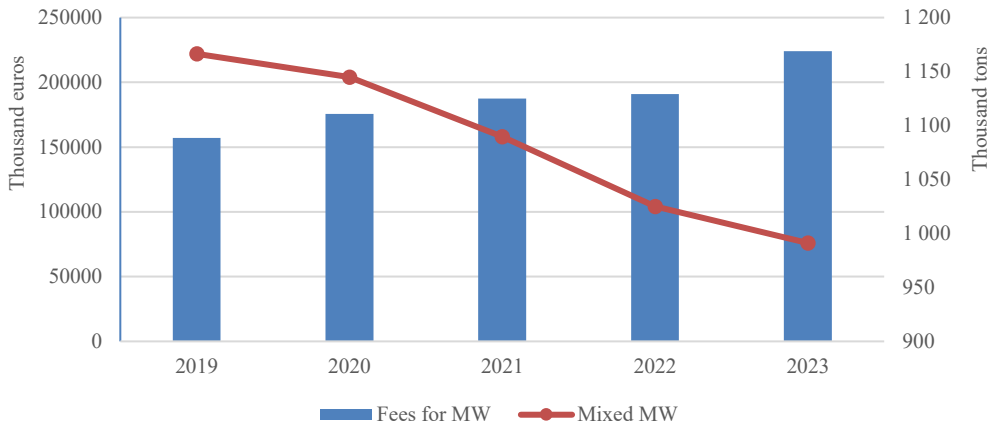

Fig. 2. Evolution of mixed municipal waste and associated fees across Slovakia
Source: Author's own elaboration based on data from Statistical Office of the Slovak Republic and from Ministry of Finance of the Slovak Republic

Table 3. Regions of Slovakia

Regions of Slovakia (NUTS 3)	Acronym	Number of municipalities	NUTS 2
Region of Bratislava	BA	72	Western Slovakia
Region of Trnava	TT	251	
Region of Trenčín	TN	276	
Region of Nitra	NR	354	
Region of Žilina	ZA	315	Central Slovakia
Region of Banská Bystrica	BB	515	
Region of Prešov	PO	664	Eastern Slovakia
Region of Košice	KE	440	

Source: Author's own elaboration based on data from Statistical Office of the Slovak Republic

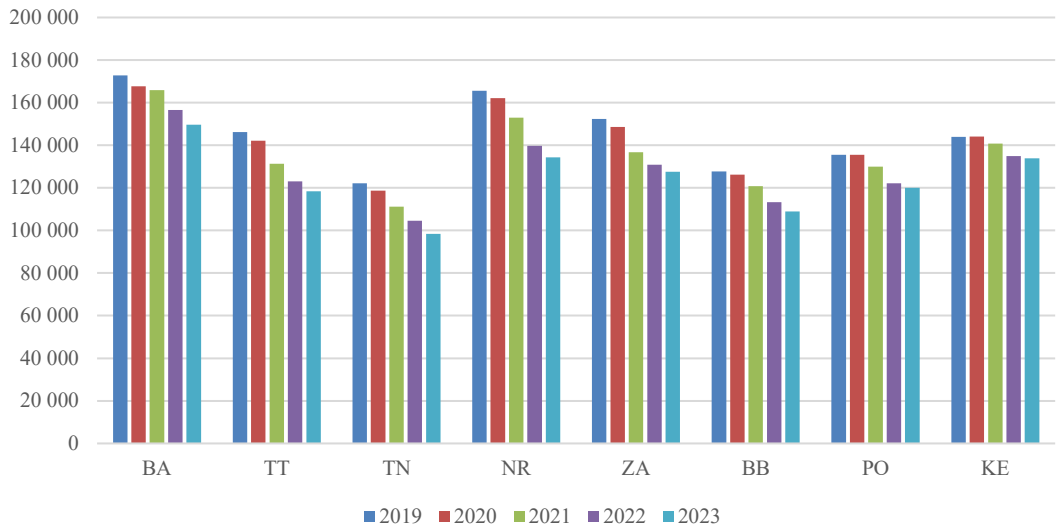

Fig. 3. Mixed municipal waste produced in Slovakia's Regions (in tons)
Source: Author's own elaboration based on data from Statistical Office of the Slovak Republic

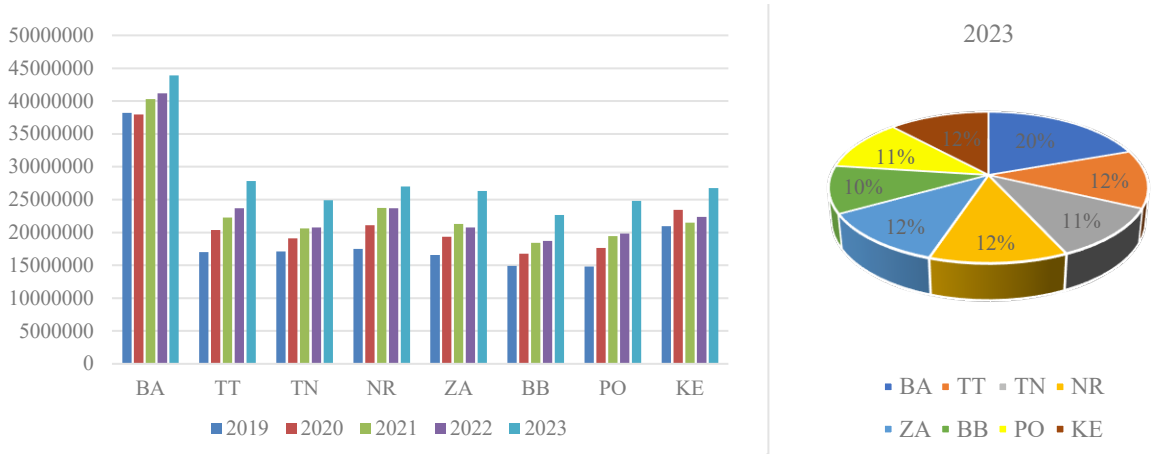

Fig. 4. Fees for municipal waste produced in Slovakia's regions (euro)
Source: Author's own elaboration based on data from Statistical Office of the Slovak Republic

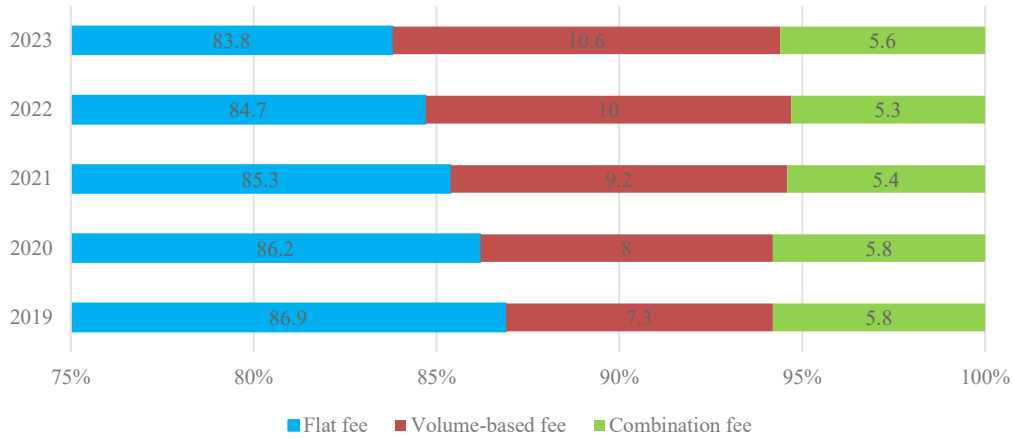

Fig. 5. Percentage of municipalities employing each fee type
Source: Author's own elaboration based on data from Statistical Office of the Slovak Republic

municipalities. Figure 5 indicates the percentage of municipalities employing each fee type.

Slovakia encompasses 2,887 municipalities, over 83% of which still apply a flat fee for mixed municipal waste. This approach is most prevalent in eastern Slovakia, notably the Prešov region. However, a promising trend is the rising number of municipalities adopting volume-based fees, with the highest concentration in western Slovakia, particularly the Nitra region.

The analysis is augmented by data illustrating not only the number of municipalities using specific fee types but also the amount of municipal waste, in tons per year, subject to flat and volume-based fees (Fig. 6).

Over the analyzed period, the amount of mixed municipal waste under a flat fee has decreased annually. The most pronounced declines relative to the baseline year occurred in the Košice region (33.4%) and the Bratislava region (just under 25%). Notably, in the Bratislava region, the amount of municipal waste charged via a volume-based fee rose most significantly, by 160% compared to 2019. The Nitra region follows, with an 80.9% increase in municipal waste charged under a volume-based fee.

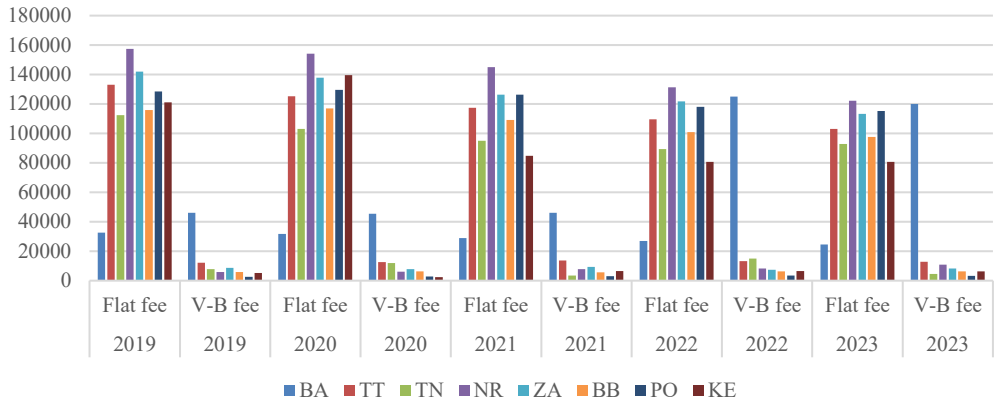

Fig. 6. Amount of municipal waste, in tons per year, subject to flat fees and volume-based fees (V-B fee)
Source: Author's own elaboration based on data from Statistical Office of the Slovak Republic

4. Discussion

An analysis conducted in Slovakia indicates that the local fee for municipal waste and small construction waste increased steadily over the observed period. The fee's amount is determined by individual municipalities through generally binding ordinances and may be set as a flat fee or based on the amount of waste collected. In Slovakia, a substantial proportion of municipalities (over 83%) still employ flat fees for municipal waste. Although volume-based fees are on the rise, they remain limited, being implemented by only about 10% of municipalities, and in Slovakia, these are typically unweighed volume-based fees calculated as the product of the fee rate, collection frequency and container volume. Table 4 presents how the PAYT system is used in countries bordering Slovakia.

Table 4. PAYT system in countries bordering Slovakia

Country	PAYT category	PAYT covering of the population	Robustness of the underlying information
Austria	PAYT scheme fully rolled out (to at least 80% of the population)	PAYT is applied across the whole country.	Information received from the Austrian authorities through the EEA-ETC/WMGE questionnaire.
Hungary	PAYT scheme fully rolled out (to at least 80% of the population)	PAYT is integrated into the waste management services throughout the country.	There are some uncertainties regarding the incentives created by the residual waste fee and if the incentives can be categories as a PAYT system.
Czechia	Less than 50% of the population covered by PAYT	There is a PAYT system in place, covering only about 20% of the population.	Information received from the Czech authorities through the EEAETC/WMGE questionnaire.
Poland	PAYT is mandatory for non-household sources of municipal waste. There are no data on the application of PAYT for households.	According to the Polish legislation, PAYT is mandatory for non-residential properties. There are no data on the application of PAYT for households.	Information received from the Polish authorities through the EEAETC/WMGE questionnaire, complemented with information provided by a consultant.

Source: Author's own elaboration based on data from EEA, 2023 (Country Profile)

International experience with the implementation of PAYT indicates a reduction in mixed municipal waste (MMW), as demonstrated by studies conducted by various authors (e.g., Kinnaman & Fullerton, 2000; Rizzo & Secomandi, 2020; Slučiaková, 2021; Morlok et al., 2017; Slávik 2018; Lewandowska & Szymańska, 2019).

For fees to reflect weighed volume-based collection, modern infrastructure and information technology, such as waste collection vehicles or containers equipped with weighing devices, sensors, QR codes and similar tools, are essential. When waste amounts are assessed for multiple households (e.g., in apartment buildings), a suitable system for allocating waste mass or fees to individual households is required.

In this regard, the potential of artificial intelligence merits attention. Artificial intelligence enhances the efficiency of municipal waste management in urban settings by streamlining both collection and sorting processes. AI leverages various tools to, for example, develop and deploy smart bins, utilize robots for waste sorting, monitor waste conditions via sensors, and optimize waste transport within waste management (Szymańska, 2023: 116-120). During the collection phase, AI enables dynamic route optimization by predicting container fill levels using sensor data combined with machine learning algorithms. A study conducted by Ogbolumani and Adekoya (2025) reported a 35% reduction in collection frequency, a 42% decrease in fuel consumption, and a daily time saving of 2.4 hours on a university campus. Fang et al. (2023) report that AI in waste logistics can reduce transport distances by up to 36.8%, cut costs by 13.35%, and save time by 28.22%. They also note that AI can identify and sort waste with accuracy ranging from 72.8% to 99.95%. Municipalities can benefit significantly from sensors or high-frequency identification chips, which enable the reading and recording of waste data from containers.

Monitored containers facilitate measuring fill levels and actual mass when equipped with weighing devices. Bareková et al. (2011) outline two approaches to waste collection and weighing technology:

1. Weighing waste deposited into a shared container serving multiple producers. This involves containers with integrated weighing devices featuring a contactless identification card reader, a display showing the mass of discarded waste, and a device for recording and transmitting data to a control center. Each household, as a waste producer, possesses an identification card authorizing use of the weighing container and displaying the amount of waste discarded. This approach is particularly feasible for containers in housing estates.
2. Weighing a full waste container during its emptying into a collection vehicle. Here, each mixed waste container is fitted with an electronic chip. The collection vehicle features an automatic reader and weighing device that precisely weighs the waste during unloading and identifies the producer via chip data. This system is primarily applied to private containers at family homes (Eko-Centrum, 2015).

Following weighing, the collected data must be transmitted via wireless communication infrastructure to an advanced system for processing and analysis. Such a system equips municipalities with detailed insights into waste production in their jurisdiction, enabling optimization of collection frequency and container size, as well as fairer fee levels for citizens (Municipal Waste Fees Have Increased, 2023).

The calculation of waste fees can be supported by smart containers. Smart containers are at various stages of technological readiness, and a study by Shan et al. (2024) showed that the highest levels of readiness are found in China, Denmark and France. In Japan as well, smart containers are gaining increasing attention and public preference. This is evidenced by a survey in which respondents identified smart containers as the most suitable method for implementing PAYT systems (Shan et al., 2024).

Literature also indicates that embedded sensors and real-time data collection and analysis encourage sustainable behavior among citizens (Esmaeilian et al., 2018), while municipalities employing AI reduce costs, enhance safety and lessen negative environmental impacts (Fang et al., 2023).

5. Conclusions

In order to comply with European legislation and strategies – such as the European Green Deal, the *Waste Framework Directive*, and the Sustainable Development Goals – municipalities must adopt strategic, targeted approaches to ensure effective waste management.

Fees for municipal waste collection constitute an effective economic tool that motivates the public to reduce the amount of mixed municipal waste. A more equitable system emerges with the application of volume-based fees adhering to the "pay-as-you-throw" model. In Slovakia, this system remains

underdeveloped. The analysis revealed that only about 10% of municipalities implement volume-based fees, which are largely based on container volume rather than weighed waste mass. Positively, the amount of mixed municipal waste is decreasing, even with an annually rising flat fee. The fee value hinges on the municipality's waste management costs, waste sorting levels and the amount of waste disposed of in landfills. Nonetheless, the municipal waste fee remains an inadequate funding source for municipalities to fully cover waste management processes, necessitating co-financing from their own resources.

A limitation of this study is that the analysis of fees related to municipal waste production was conducted solely within Slovakia. Future research could be strengthened by incorporating comparative analyses with other countries. It is important to note that the study was based on data from municipal reports submitted to the Statistical Office, which are not publicly accessible. Research relying on statistical data may face limitations concerning data availability and inconsistent reporting practices across countries. In forthcoming studies, we intend to examine fee systems in countries bordering Slovakia.

In this contribution, we focused on PAYT systems, which are considered an important tool for waste reduction at the municipal level, as highlighted by many authors. The implementation of PAYT schemes aspires towards more responsible environmental behaviors, since they directly and continuously confront users with the amount of waste they generate (Xevgenos et al., 2015). However, the implementation of PAYT systems may also face certain limitations, which:

1. are related to high initial costs and the time-consuming nature of implementing smart waste management devices, as well as the provision of necessary infrastructure, including software systems for data management and monitoring (e.g., in the implementation of Smart Trash Cans [Tenviro, 2024]);
2. stem from concerns about increased waste tourism, illegal dumping, or contamination of sorted waste; based on experiences in some countries, these concerns have not been conclusively confirmed (e.g., in Italy according to Colussi et al. [2022] or in Germany according to Morlok et al. [2017]);
3. may be associated with insufficient public communication; the study by Ghazaryan et al. (2025) shows that communication explaining the transition to the PAYT system increases public acceptance.

Acknowledgements

The article is part of the solution of the project VVGS-2024-3421 Modernization and Rationalization of the Local Governments through AI. VVGS is Internal Scientific Grant System of Pavol Jozef Šafárik University in Košice.

References

Alzamora, B.R. & Barros, R.T. (2020). Review of municipal waste management charging methods in different countries. *Waste Management*, 115: 47-55. DOI: https://DOI:org/10.1016/j.wasman.2020.07.020.

Andersen, M.S., Speck, S., & Mautone, O. (2011). *Environmental fiscal reform-illustrative potential in Italy. In Conference "Environmentally related taxation and fiscal reform"*. December 15th, Ministry of Economy and Finance, Rome.

Bareková, A., Sklenár, Š., & Tátošová, L. (2011). *Metodika nakladania s tuhým komunálnym odpadom v podmienkach vidieckej zástavby* (The methodology for managing solid municipal waste in the context of rural settlement – in Slovak). Nitra: Slovenská poľnohospodárska univerzita. Available at: https://envigeos.sk/wp-content/uploads/2021/08/Monografia1.pdf (Accessed: 03 January 2025).

Bilitewski, B. (2008). From Traditional to Modern Fee Systems. *Waste Management*, 28 (12): 2760–2766. DOI: https://DOI:org/10.1016/j.wasman.2008.03.032.

Bulajic, S., Antanaskovic, D., Ketin, S., Tomic, S., & Lukic, V.(2020). Economic Instruments in the Environmental Protection - Serbian Case. *Fresenius environmental bulletin*, 29(10): 9522-9527. Available at: https://www.researchgate.net/publication/344616606_ECONOMIC_INSTRUMENTS_IN_THE_ENVIRONMENTAL_PROTECTION_-_SERBIAN_CASE (Accessed: 03 January 2025).

Candam TECH. (2023). Pay As You Throw (PAYT): a drive towards a fair and economically sustainable waste fee. Available at: https://candam.eu/pay-as-you-throw-payt-a-drive-towards-a-fair-and-economically-sustainable-waste-fee/ (Accessed: 8 September 2025).

Colussi, T., Romagnoli, M. & Villar, E. (2022). The Intended and Unintended Consequences of Taxing Waste. *CESifo Working Paper No. 9946*. DOI: http://dx.DOI:org/10.2139/ssrn.4226413.

Dahlén, L. & Lagerkvist, A. (2010). Pay as you throw: Strengths and weaknesses of weight-based billing in household waste collection systems in Sweden. *Waste Management,* 30(1): 23-31. DOI: https://DOI:org/10.1016/j.wasman.2009.09.022.

EEA. (2023). Economic instruments and separate collection systems — key strategies to increase recycling. Available at: https://www.eea.europa.eu/en/analysis/publications/economic-instruments-and-separate-collection (Accessed: 3 September 2025).

Eko-Centrum. (2015). Zborník opatrení a príkladov dobrej praxe (Collection of measures and examples of good practice - in Slovak). Available at: http://www.ekocentrum.sk/wordpress/wp-content/uploads/Pr%C3%ADklady-dobrej-praxe.pdf (Accessed: 12 January 2025).

Esmaeilian, B., Wang, B., Lewis, K., Duarte, F., Ratti, C., & Behdad, S.(2018). The future of waste management in smart and sustainable cities: A review and concept paper. *Waste management*, 81: 177-195. DOI: https://DOI:org/10.1016/j.wasman.2018.09.047.

Fang, B., Yu, J., Chen, Z., Osman, A. I., Farghali, M., Ihara, I., Hamza, E.H., Rooney, D.W., & Yap, P.S. (2023). Artificial intelligence for waste management in Smart Cities: A review. *Environmental Chemistry Letters*, 21: 1959-1989. DOI: https://DOI:org/10.1007/s10311-023-01604-3.

Ghazaryan, L., Faure, C., Schleich, J., & Birau, M. M. (2025). Transition from a fixed fee to a pay-as-you-throw waste tariff scheme: Effectiveness of environmental and accountability appeals. *Journal of Environmental Management,* 385. DOI: https://DOI:org/10.1016/j.jenvman.2025.125603.

Han, H., Zhang, Z., Xia, S., & Li, H. (2018). The carrot or the stick: individual adaption against varying institutional arrangements. *Journal of Environmental Planning and Management*, 61(4): 568-596. DOI: https://DOI:org/10.1080/09640568.2017.1326884.

Hlavenka, T., & Cvrčková, R. (2015). Collecting System as a Factor Influencing the Composition of Municipal Waste. *Inżynieria Mineralna – Journal of the Polish Mineral Engineering Society,* 2(36): 63–66. Available at: http://www.potopk.com.pl/an_archiwum.html (Accessed: 08 December 2024).

Jurušs, M., & Brizga, J. (2017). Assessment of the Environmental Tax System in Latvia. *The NISPAcee Journal of Public Administration and Policy*, 10(2): 135. DOI: https://DOI:org/10.1515/nispa-2017-0015.

Kinnaman, T.C., & Fullerton, D. (2000). Garbage and Recycling with Endogenous Local Policy. *Journal of Urban Economics*, 48(3): 419–442. DOI: https://DOI:org/10.1006/juec.2000.2174.

Koreňová, D. (2022). Vybrané kapitoly z verejných financií II. (Selected chapters from public finances II. - in Slovak). Košice: ŠafárikPress.

Lewandowska, A. & Szymańska D. (2019). Municipal waste recycling in big cities in Poland in the context of ecologisation. *Bulletin of Geography. Socio-economic Series*, 43(43): 131-141. DOI: http://doi.org/10.2478/bog-2019-0009.

Local Data Bank. Environmental fund of the Slovak republic. Available at: https://envirofond.sk/.

Local Data Bank. Ministry of Finance of the Slovak Republic. Available at: https://www.mfsr.sk/sk/.

Local Data Bank. Statistical Office of the Slovak republic. Available at: https://slovak.statistics.sk/.

Matteo, D.D., & Guadagno, E. (2024). Tax incentives and environmental performance: The pay-as-you-throw policy in Emilia-Romagna, Italy. *Journal of Cleaner Production,* 475: 143659. DOI: https://DOI:org/10.1016/j.jclepro.2024.143659.

Miller, C., Sarewitz, D., & Light, A. (2008). Science, technology, and sustainability: Building a research agenda. *Science*, 319(5862): 424-434. Available at: https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=51bc3b78c4d882584f24c8e3f7f1d0e9eedc0431 (Accessed: 17 December 2024).

Morlok, J., Schoenberger, H., Styles, D., Galvez-Martos, J.L., & Zeschmar-Lahl, B. (2017). The impact of pay-as-you-throw schemes on municipal solid waste management: The exemplar case of the county of Aschaffenburg, Germany. *Resources*, 6(1): 8. DOI: https://DOI:org/10.3390/resources6010008.

OECD. (2019). Waste Management and the Circular Economy in Selected OECD Countries: Evidence from Environmental Performance Reviews, OECD Environmental Performance Reviews, OECD Publishing, Paris. DOI: https://DOI:org/10.1787/9789264309395-en.

Ogbolumani, O.A., & Adekoya, M. (2025). Intelligent Waste Management Optimization Through Machine Learning Analytics. *Journal of Science Research and Reviews*, 2(1): 7-26.

Poplatky za komunálny odpad sa zvýšili. (2023). (Municipal Waste Fees Have Increased - in Slovak) Available at: https://ekorestart.sk/poplatky-za-komunalny-odpad-sa-zvysili-ako-usetrit-plus-prehlad-vysky-poplatkov/ (Accessed: 10 December 2024).

Pham, H.A. (2023). Způsob poskytování služeb v oblasti odpadového hospodářství a spokojenost s nimi z pohledu uživatelů. (The way services in waste management are provided and user satisfac-

tion with them - in Czech). In: Tetřevová, L. and Rhys, E. et al. (eds.), *Směrem k udržitelnému a regenerativnímu rozvoji a společnosti. Společenská odpovědnost jako potenciální cesta* (Towards sustainable and regenerative development and society. Social responsibility as a potential path – in Czech). Pardubice: Univerzita Pardubice.

Rizzo, L., & Secomandi, R. (2020). Pay as You Throw: Evidence on the Incentive to Recycle. Siep Working Paper 754. Available at: https://www.siepweb.it/siep/wp/wp-content/uploads/repec/1590047673Rizzo_Secomandi_WP_SIEP_754.pdf (Accessed: 4 September 2025).

Rizzo, L., & Secomandi, R. (2024). Pay as You Throw Threshold Tariff: Evidence on the Incentive to Recycle. *The B.E. Journal of Economic Analysis & Policy* 24(2): 361 – 395. DOI: https://DOI:org/10.1515/bejeap-2022-0448.

Romančíková, E. (2006). Vybrané nástroje environmentálnej politiky a ich ekonomická dimenzia. (Selected tools of environmental policy and their economic dimension – in Slovak). *Ekonomický časopis*, 54 (1): 52-68. Available at: https://www.sav.sk/journals/uploads/050710042006_1_Romancikova.pdf (Accessed: 10 December 2024).

Slavík, J. (2018). Účinnost plateb za komunální odpad – změna paradigmatu (Efficiency of municipal waste payments – a paradigm shift – in Czech). Available at: https://www.muni.cz/inet-doc/1057756.

Slučiaková, S. (2021). Effects of the unit-based pricing of waste in Slovakia: Spatial panel data models and matching approach. *Environmental Challenges*, 2: 100022. DOI: https://DOI:org/10.1016/j.envc.2021.100022.

Shan, CH., Pandyaswargo, A.H., Ogawa, A., Tsubouchi, R., & Onoda, H. (2024). Japanese public perceptions on smart bin potential to support PAYT systems. *Waste Management*, 177: 278-288. DOI: https://DOI:org/10.1016/j.wasman.2024.02.003.

Szymańska, D. (2023). *Inteligentne miasta* (Smart Cities – in Polish). Wydawnictwo Naukowe PWN, Warszawa. DOI: https://doi.org/10.53271/2023.090.

Ščasný, M., Píša, V., Pollitt, H., & Chewpreecha, U. (2009). Analyzing Macroeconomic Effects of Environmental Taxation in the Czech Republic with the Econometric E3ME Model. *Finance a Uver. Czech Journal of Economics and Finance,* 59(2): 460-491. Available at: https://journal.fsv.cuni.cz/storage/1170_str_460_491.pdf (Accessed: 12 December 2024).

Tenviro, A.C. (2024). Smart Trash Cans: Simple and High-Tech Waste Management. Available at: https://www.actenviro.com/smart-trash-can/ (Accessed: 8 September 2025).

Tetřevová, L., Rhys, E., Bransk, L., Honková, I., Jelínková, M., Kopřiva, J., Košťálova, J., Kotková, S.M., Kuběnka, M., Kocúriková, A., Munzarová, S., Myslivcová, K., Paták, M., Vávra, J. ,Zemanová, B. (2024). Směrem k udržitelnému a regenerativnímu rozvoji a společnosti. Společenská odpovědnost jako potenciální cesta (Towards sustainable and regenerative development and society. Social responsibility as a potential path - in Czech). Pardubice: Univerzita Pardubice.

Valentovič, M. (2010). Najlepší odpad je ten, čo nevznikne (The best waste is the one that doesn't occur – in Slovak). *Ekolisty*, 4: 4-5. Available at: https://nulaodpadu.sk/files/4-2010-ekolisty.pdf (Accessed: 15 December 2024).

Watkins, E., Hogg, D., Mitsios, A., Mudgal, S., Neubauer, A., Reisinger, H., Troelzsch, J., & van Acoleyen, M. (2012). Use of economic instruments and waste management performances. Final report for the European Commission. Available at: https://op.europa.eu/en/publication-detail/-/publication/566f28fd-3a94-4fe0-b52d-6e40f8961c7e (Accessed: 15 January 2025).

WEF. (2022). What is pay-as-you-throw? A waste expert explains. Available at: https://www.weforum.org/stories/2022/01/pay-as-you-throw-waste-expert-pollution-trash/ (Accessed: 4 September 2025).

Zákon č. 582/2004 Z. z. o miestnych daniach a miestnom poplatku za komunálne odpady a drobné stavebné odpady (Act No. 582/2004 Coll. on Local Taxes and the Local Fee for Municipal Waste and Minor Construction Waste – in Slovak).

Xevgenos, D., Papadaskalopoulou, C., Panaretou, V., Moustakas, K., & Malamis, D. (2015). Success Stories for Recycling of MSW at Municipal Level: A Review. *Waste Biomass Valor,* 6: 657–684. DOI: https://DOI:org/10.1007/s12649-015-9389-9.

Xu, L., Ling, M., Lu, Y., & Shen, M. (2017). External influences on forming residents' waste separation behaviour: Evidence from households in Hangzhou, China. *Habitat International*, 63: 21-33. DOI: https://DOI:org/10.1016/j.habitatint.2017.03.009.

Xu, L., Ling, M., & Wu, Y. (2018). Economic incentive and social influence to overcome household waste separation dilemma: A field intervention study. *Waste Management*, 77: 522-531. DOI: https://DOI:org/10.1016/j.wasman.2018.04.048.