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MUNICIPAL SOLID WASTE MANAGEMENT SYSTEMS IN POLAND AND THE CZECH REPUBLIC. A COMPARATIVE STUDY

The work provides an overview of methods of waste collection and treatment in Poland and the Czech Republic. Differences (in contrast to Poland, MBT technology is not used in the Czech Republic and only one incineration plant works) and similarities (similar share of waste management methods, the comparable mass of generated municipal solid waste per capita and similarly low sorting rate) between both countries have been indicated focusing on various fractions of municipal solid wastes as well as the dominant system of their management. SWOT analysis focused on the municipal solid waste management of both countries has been created. In Poland, the proportion between small amounts of waste collected selectively and the mass of waste sent to landfills is not satisfactory. In the Czech Republic, lots of municipal solid waste is deposited in landfills.

1. INTRODUCTION

Regardless of the disproportions in their citizens' wealth or economic position of individual countries, the amount of waste is increasing year by year. Therefore, waste generation should be considered as a global phenomenon for every country and society. In the European Union, unified legislative provisions are gradually being introduced to implement systemic and joint solutions in the field of waste generation and waste management. The EU member states are obliged to adapt their economies to such guidelines; however, according to the review of waste management systems in European countries conducted by Pires et al. [1], there are differences in the approach to the problem and the implementation of tasks.

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Municipal solid waste management (MSWM) is a result of several factors, the national economy and market, the population size, and predominant consumption behavior being the most important. Taking this under consideration, municipal solid waste must be seen as a multi-faceted problem, as a development instrument for other economic sectors related to energy generation, as well as recovery, recycling, and marketing of secondary raw materials.

Additionally, waste management has to be consistent with the principles of sustainable development, to prevent waste generation and reduce its volume, to increase resource efficiency, reduce the quantity of waste intended for landfills as well as encourage its reuse and raw material recovery. In response to these goals, many legal acts have been developed in the EU. The most relevant targets for municipal solid waste management include landfill diversion targets for biodegradable municipal waste [2], recycling targets [3], and the target of recycling and preparing for reuse [4, 5]. The main concepts of these documents focus on the hierarchy of waste management, the polluter pays principle, the principle of nearby (waste treatment as close as possible to the manufacturing place), the extended producer responsibility as well as reduction of biodegradable municipal solid waste storage.

To intensify the activities within the preferred levels of the hierarchy, the ideas of the circular economy were developed. Such an approach was strengthened and supported by the Communication Towards a Circular Economy [6]. This document promotes a fundamental transition from a linear to a circular economy. The above-mentioned document is a part of a comprehensive legislative package on waste, including, e.g., a new *Waste Framework Directive*, the *Directive on Packaging and Packaging Waste*, and the *Landfill Directive*. These documents set targets for waste management for reduction, recycling, and landfilling by 2030. To fulfill the main aims of the circular economy and the zero waste program for Europe [6] the following limits have been established:

- increasing the level of all packaging waste reuse and recycling up to 75% by 2030,
- increasing recycling and preparing for reuse of municipal solid waste up to a minimum of 55% by 2025, 60% by 2030 and 65% by 2035,
- landfilling of waste makes no sense in a circular economy and can pollute water, soil and air, so by 2035 the amount of municipal solid waste landfilled must be reduced to 10% or less of the total amount of MSW generated. By 2025 (2030 – total elimination of storage) – prohibition of storage of plastic materials, metals, glass, paper, and cardboard subject to recycling and biodegradable waste.

The assumptions set out above are especially important and require discipline and changes in waste management systems in the individual countries. While over the past two decades many EU member states have gradually improved their waste management, in line with the EU waste hierarchy, in 2016 ten member states still landfilled over 50% of their household waste and six of them incinerated 40% or more [7]. Analysis of Eurostat data indicates that sustainable MSWM is particularly inadequately solved in the

countries of the former communist bloc, countries with less developed economies. Nevertheless, even in this group, some differences may be noticed. The literature source quoted above primarily focuses on the presentation of waste management systems in Western European countries, completely ignoring the issues of Eastern European countries. Also, Eurostat data [8] present both old information in this context (despite of the last update on Eurostat website is from 24.02.2020 presents data from 2016) and incomplete because most statistics are based on estimated data (for example, for Hungary and Romania) or no such a data (for example, for Albania or Bosnia and Herzegovina) and thus presenting a false picture of the current situation in individual countries. Therefore, the presented study shows the actual status of municipal solid waste management systems in Poland and the Czech Republic in the aspect of current requirements in waste management, which are obligatory for all EU member states. Additionally, the current data on solid waste generation is given with SWOT analysis for both countries individually. As previously indicated in the current literature on the subject, there are no such studies, and therefore the present ones, presenting in a broad sense the current issues of municipal solid waste management should be considered innovative and important.

2. GENERAL DESCRIPTION OF COUNTRIES AND THEIR FRAMEWORK POLICIES ON MUNICIPAL SOLID WASTE MANAGEMENT

2.1. GEOGRAPHIC AND ECONOMIC CONTEXT OF POLAND

Poland is a Baltic state located in Central Europe. Its total area is 312 696 km², inhabited by 38 411 thousand of citizens. The administrative division of Poland comprises 16 provinces and 380 counties. Poland is a developed market economy, ranking sixth in the European Union. Since 1 May 2004, Poland has been a member of the European Union and this fact has forced the adjustment of the Polish legislation to EU requirements.

Presently the most important documents defining municipal solid waste management (MSWM) are:

- the Act on maintaining cleanliness and order in communes and certain other acts of 2011, amended in 2019 (Journal of Laws of 2019, item 1579) [9],
- the Act on the waste of 2012, updated in 2019 as the Act on the waste and certain other acts (Journal of Laws of 2019, item 1403) [10],
- the Ordinance of the Ministry of the Climate on the waste catalog (Journal of Laws of 2020, item 10) [11],
- the Act on packaging management and packaging waste of 2013, amended in 2019 (Journal of Laws of 2019, item 542) [12],

- the Regulation of the Ministry of Economy and Labour on the criteria and procedures for admission of waste to respective landfill types (Journal of Laws 2015, item 1277) [13],
- the National Waste Management Plan 2022 (Monitor Polski, 11 August 2016) [14].

In brief, these documents give basic definitions of individual waste types, indicate issues related to waste management, waste storage, waste carriers, brokers and dealers, waste collection, and disposal. In summary, these acts include all regulations stipulated in the following Directives: 1994/62/EC [3], 1999/31/EC [2], 2000/76/EC [4], 2008/98/EC [15] as well as the Communications from the Commission [6, 16].

2.2. GEOGRAPHIC AND ECONOMIC CONTEXT OF CZECHIA (THE CZECH REPUBLIC)

The Czech Republic is a landlocked country in Central Europe and borders Poland, Slovakia, Austria, and Germany. The total area of the Czech Republic is 78 866 km² and there live 10 650 thousand citizens. The Czech Republic is administratively divided into 14 regions. The Czech Republic joined the EU on May 1st, 2004. Like other EU members, the Czech Republic must implement EU requirements into its legislation documents (and into operational practice, too). The relevant EU documents have been mentioned above.

3. CURRENT SITUATION IN MUNICIPAL SOLID WASTE MANAGEMENT

3.1. WASTE MANAGEMENT IN POLAND

3.1.1. WASTE GENERATION

The definition of municipal solid waste is given in the Act on Waste of 2012 [10] according to which MSW is waste generated in households, excluding end-of-life vehicles, as well as waste not containing hazardous waste from other waste producers, which due to its nature or composition is similar to waste generated in households. According to the list of waste given in the Ordinance of the Ministry of the Climate on the waste catalog [11], there are 20 different types described by codes from 01 to 20. Generally, municipal solid waste is generated within the following groups:

- 15 – waste packaging, including separately collected municipal packaging waste,
- 20 – municipal waste (household waste and similar commercial, industrial and institutional waste), including separately collected fractions.

In 2018 in Poland 127 824 thousand tons of waste were generated, of which about 10% (12 485 million tons) were MSW. It should be underlined here that the percentage share of MSW in the total generated a mass of waste has remained practically constant since 2000, amounting to ca. 10%. Unfortunately, the waste volume has been systematically increasing and in 2018 it was by 4.3% higher than in 2017. Analysis of the data

calculated per capita showed an evident increase in generated waste from 245 kg in 2005 to 325 kg in 2018 (Fig. 1) [17]. At this point, it should be noted that this value is one of the lowest among European countries. On average, a resident of Europe generated 486 kg of waste in 2017, with the highest values recorded for the richest countries, such as Denmark (781 kg), Germany (633 kg), Luxembourg (607 kg) as well as countries with high tourist traffic such as Cyprus (637 kg) or Malta (604 kg) [8]. However, there is a considerable variation in waste generation across Poland, which is related not only with the number of inhabitants but also differences in economic development, the wealth of residents and their consumption attitudes in individual provinces. Regardless of the year, from 2005 to 2017 the highest amount of MSW was collected per capita in the following provinces: dolnośląskie (309–394 kg), zachodniopomorskie (297–377 kg), mazowieckie (291–336 kg), lubuskie (277–361 kg) and wielkopolskie (256–351 kg). On the other side, the lowest amounts of MSW were recorded for the provinces located in the eastern part of Poland, such as świętokrzyskie (144–201 kg), podkarpackie (223–234 kg) and lubelskie (155–222 kg) [17].

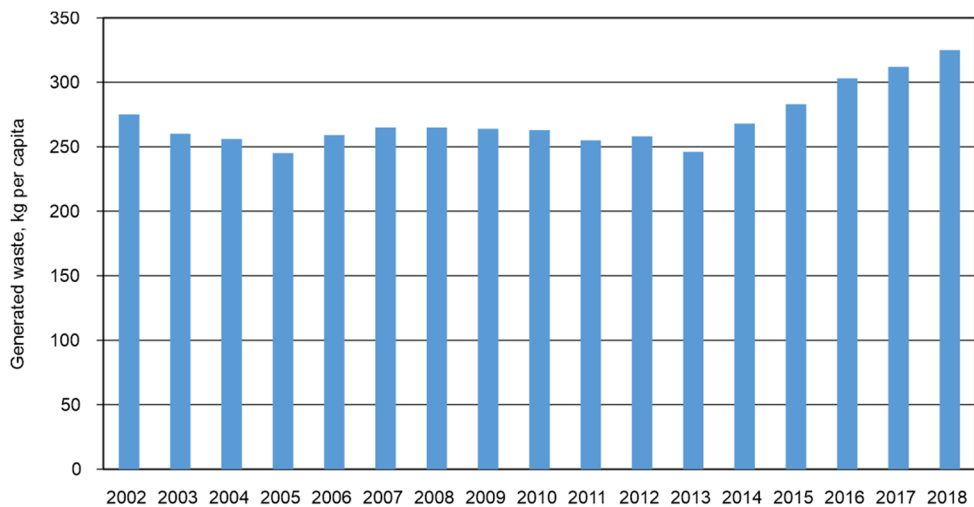


Fig. 1. Generated waste per capita in individual years of the study in Poland [17]

The most municipal solid waste generated in 2018 in Poland (84%) was collected from households [17]. Despite a selective waste collection system intensively implemented in Poland, the amount of mixed waste is considerable, amounting to 71% of the total stored mass. The mass of waste selectively collected by residents has been steadily increasing since 2012, reaching 29% in 2018. Of course, the amount of selectively collected waste varies and strictly depends on the inhabitants of individual cities and municipalities. A crucial role in any waste separation system is typically played by the local population because they directly perform primary selection and in this way reduce the cost of the entire waste management process. As was confirmed by Jakubus et al. [18, 19], in

this context the standard of ecological education and social participation is essential. Although the fractional composition of waste collected separately is stable, the mass of individual waste types has changed over the years. The waste fractions dominant in 2005, such as paper and cardboard, glass, and plastics (total 80% selectively collected waste), currently represent slightly over 30% of the total, while the shares of metals also decreased (from 2.5% in 2005 to 0.3% in 2018). The selective collection of bulky waste remains comparable within 10–15%. In recent years, the mass of biodegradable waste significantly increased, in 2018 amounting to 28.4% of the total mass. A high share (26% in 2018) of other fractions, including mixed packaging waste, multi-material packaging, waste electrical and electronic equipment, should be underlined (Fig. 2).

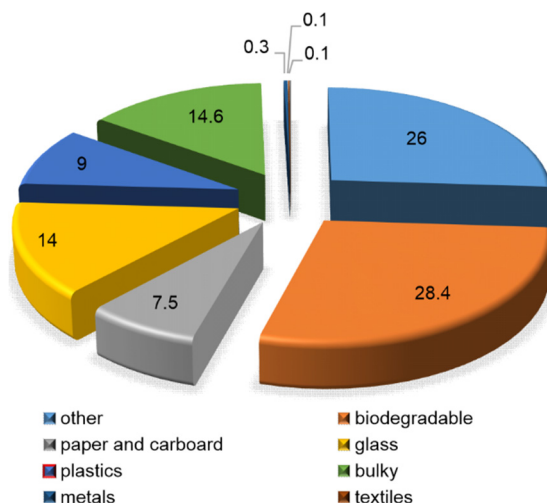


Fig. 2. The percentage share of waste fractions collected separately in the total mass of municipal solid waste in Poland in 2018 [17]

3.1.2. WASTE COLLECTION

From the technical point of view, waste collection in Poland does not differ from the UE standards. There are three possible methods of waste collection in Poland. The first system is based on the drop off of waste at the Municipal Solid Waste Collection Points (MSWCPs), which are mainly dedicated to deposition of various waste types other than waste separately collected in residential areas such as glass, metals, plastics or paper and cardboard. The MSWCPs are usually located in the suburbs of municipalities, cover a considerable area, and consists of multiple containers for individual waste fractions. This system offers quality separation service; however, it is costly and least convenient for inhabitants, because it waste has to be delivered by them to those points within the point opening hours. A more convenient solution is provided by waste collection based on the drop off waste to large bins located in readily accessible public places. This type of collection system in Poland is called “nearby” and is dedicated only

to recyclable waste such as glass, metals, plastics or paper and cardboard. This system is used by residents of multi-family housing. The third type of waste collection is kerbside collection (door-to-door) dedicated to recyclable waste at the household source. This is the most convenient method and is popular in many countries [20]. This collection system involves plastic bins or bags positioned at the edge of the property and it is used for collecting glass, metals, plastics, paper and cardboard, and biodegradable waste. This system is predominant in small communities and detached houses. In Poland, municipal solid waste collection is provided by private companies selected in the tender issued by municipal firms responsible for waste management. Selected companies collect and transport mixed waste and waste selectively collected from both individual owners and businesses. The current system in Poland emphasizes collecting recyclables to reduce the amount of material intended for the landfill. This is important because in Poland the landfilling of wastes is predominated (42%) and their recycling accounts only 26% (Fig. 3) [17].

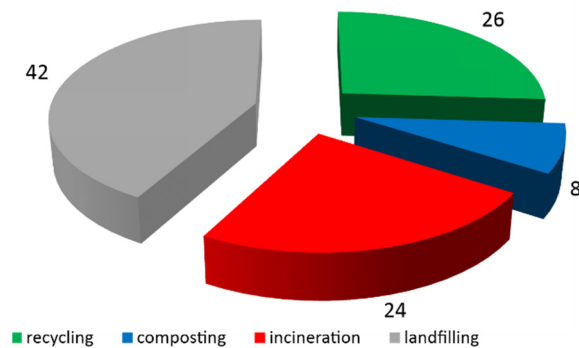


Fig. 3. The percentage share of the municipal solid waste management methods in Poland in 2018 [17]

Thus at the household level, the following waste fractions are stored selectively: biodegradable deposited in brown containers, paper, and cardboard in blue containers or single-use blue bag, plastic and metals in yellow containers or single-use yellow bag, glass in green containers or single-use green bag and mixed waste in black containers. The frequency of collection of individual fractions depends on the type of waste and often the biodegradable fraction is collected weekly, mixed waste every 2 weeks, while recyclable materials such as paper and cardboard, plastic and metals as well as glass – once a month. The system of fees for waste management is individualized and depends on the local authorities, which charge a monthly fee paid per household. The fees are calculated based either on the number of inhabitants living in a given household or per square meter, while the fee for separately collected waste is lower than for non-separately collected. Generally, in most counties, residents can return to waste collection

centers for free other waste generated at the household level, such as medical, veterinary, hazardous waste, electrical and electronic equipment waste, car tires, textiles, or bulky wastes.

Of course, the waste types listed above some of a large mass of municipal solid waste generated by residents. This only indicates the great diversity and heterogeneity of waste. These features constitute a major obstacle and impediment to their proper management, so they need to be correctly sorted at the source, i.e., at the waste producer (resident). This facilitates and improves the system of their processing in municipal facilities. The main tasks of MSW management facilities are to ensure:

- mechanical and biological treatment (MBT) of mixed municipal solid waste and separation fractions suitable for recovery either whole or in part from mixed municipal solid waste or
- storage of waste generated by mechanical and biological treatment of mixed municipal solid waste and residues from municipal solid waste sorting.

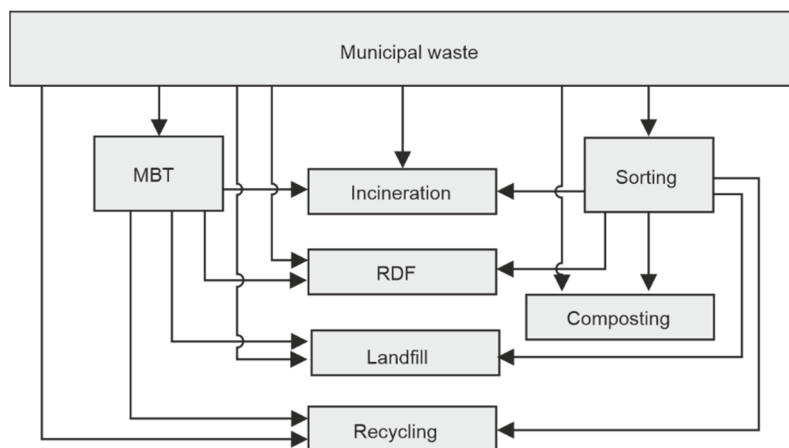


Fig. 4. The municipal solid waste management system in Poland

Currently, in Poland there are 157 MBT installations with a total capacity of about 10.8 million tons per year, operating following the principles of the best available techniques (BAT) [14]. As it was shown in Fig. 4, MBT plays an important role not only in the waste management system. Installations of this type are intended not only to sort out valuable material and energy fractions but also to biologically stabilize those fractions that cannot be managed otherwise than by landfilling. Generally, MSW may be subject to direct incineration with energy recovery, a source of RDF (refuse derived fuel), destined for composting (biodegradable waste), or forwarded to landfills. Annually, 3–3.5 million tons of the combustible (oversize) fraction, referred to as RDF or pre-RDF, are produced in MBT installations. Except for the incineration plant in Poznań, all the other

such facilities (in number 7) in Poland burn both mixed municipal waste and RDF. According to estimates, 0.5–0.8 million tons of RDF are used annually to produce alternative fuel for cement plants. It is calculated that alternative fuel is 70% made from municipal solid waste. In 2017 in Poland, 849 thousand tons of waste were incinerated and of that mass, 68% were mixed MSW and 32% were residual waste after sorting and alternative fuel [21]. Simultaneously in 2017, the cement facilities utilized 1866 thousand tons of waste, of which 95.2% were alternative fuel and 4.8% were residues from mechanical treatment of municipal waste. According to Wielgosiński and Czerwińska [22] at the moment, 8 municipal waste incineration plants in Poland burn slightly over 1 million tons of municipal solid wastes (Table 1). This represents only 10% of the potential capacity. There is no doubt that the processing capacity is needed for the disposal (thermal transformation, preferably combustion) of 2.0–2.5 million tons of RDF generated annually from operating MBP installations. Therefore at least several new facilities need to be built for the thermal transformation of waste, such as incineration plants, which generate the calorific fraction (oversize) formed in MBP installations or RDF. Currently, work is underway on projects for an additional seven facilities with a total capacity of approximately 935 000 tons per year [22]. Unfortunately, these projects are stalling for many reasons related to the financing of such installations and protests of ecological organizations.

As was mentioned above, nowadays, most of the RDF produced in Poland are incinerated in cement plants. However, the capacity of RDF production installations is big enough to provide the waste substrates also to the power industry. It should be taken into account that the production of RDF is one of the waste-to-energy strategies whose goal is to solve both waste and energy problems. Thus RDF can be utilized for energy recovery in direct combustion or co-combustion systems in cement plants, paper, and pulp mills, heat and power plants as well as incineration plants [23].

Table 1

Summary of Polish waste incineration plants parameters [after 22]

No.	Localization	Capacity [t/year]	Mass of burned waste [t/year]		Share of RDF [%]	
			2017	2018	2017	2018
1	Kraków	220 000	219 994	218 351	48.2	44.0
2	Poznań	210 000	210 000	209 972	–	–
3	Bydgoszcz	180 000	138 875	154 464	32.0	36.5
4	Szczecin	150 000	–	113 537	–	88.8
5	Białystok	120 000	114 703	114 121	53.1	64.8
6	Rzeszów	100 000	–	–	–	–
7	Konin	94 000	93 454	89 081	40.1	31.0
8	Warszawa	40 000	37 147	46 021	17.8	19.6
Total		1 114 000	814 173	945 547		

3.1.3. SWOT ANALYSIS FOR POLAND

The strengths, weaknesses, opportunities, and threats (SWOT) analysis is a tool commonly applied to strategic business planning, environmental management, and waste management assessment [24]. SWOT analysis is recognized as a very convenient diagnostic method facilitating the development of long-term plans for the effective management of external opportunities and threats asking into consideration internal strengths and weaknesses. This section briefly describes significant strategic factors, identified by SWOT analysis and presented in Table 2, that have an influence on municipal solid wastes management in Poland. The strengths and opportunities represent positive factors, while the weaknesses and threats indicate negative ones. This analysis is based on the materials developed for the needs of environmental analyses of strengths, weaknesses, opportunities and threats (SWOT) for individual provinces [25].

Table 2

The SWOT matrix on strategic factors affecting municipal solid waste management in Poland

	Positive	Negative
	Strengths	Weaknesses
Internal factors	<ol style="list-style-type: none"> 1. Regulated system of collecting municipal solid waste from residents 2. Selective waste collection system, including most of MSW fractions, particularly bulky waste, waste electronic equipment, medical and veterinary waste, hazardous waste 3. Implementation of waste segregation and recovery system 4. An increase in the number of communes (or a high number of communes) in which MSWCPs have been established 5. An increase in the share of waste selectively collected in the general waste stream 6. Modernization, extension and construction of MBT facilities 7. Considerable reduction of the volume of biodegradable municipal waste sent to landfills 8. Closing (or gradual closing) of municipal waste landfills that do not meet EU requirements 9. Plans to build new and expand existing MSWCPs equipped with repair and replacement points 10. Plans to build additional incineration plants 	<ol style="list-style-type: none"> 1. Insufficient ecological awareness of the inhabitants and insufficient level of environmental education 2. Uncontrolled rubbish dumps 3. Lack of funds for eco-investments and environmental education for the general public 4. Waste storage as the dominant form of waste management 5. A small number of MSWCPs in each commune 6. A small number of MBT installations which leads to a lack of competitiveness (price monopoly) and the need to transport municipal solid waste over considerable distances (high costs) 7. Insufficient quality of selective MSW collection/excessive share of mixed MSW in the entire stream of municipal waste collected 8. Insufficient scope of actions taken to prevent waste generation 9. Excessive residue after MBT processing of mixed municipal solid waste directed to landfills

Table 2

The SWOT matrix on strategic factors affecting municipal solid waste management in Poland

		Positive	Negative
		Opportunities	Threats
External factors	1. Dynamic development of technologies for management and treatment of various waste types	1. Insufficient domestic financial resources for environmental protection	
	2. Global actions to raise environmental awareness of the public	2. Complicated procedures in obtaining financial aid for environmental protection	
	3. Establishment of a waste management system in accordance with the principle of sustainable development and based on the hierarchy of waste management methods	3. Legislative chaos resulting from unclear policy changes	
	4. Development of municipal, post-consumer, hazardous and other waste management system	4. Failure to comply with legal requirements related to reduction of waste landfilling	
	5. Introduction of EU programs supporting the development of environmental protection infrastructure	5. Danger of environmental contamination with inappropriately managed waste	
	6. Increasing numbers of waste recovery installations	6. Increasing consumer consumption	
	7. Implementation of new technologies (using the best available techniques), including environmental protection, which will reduce the material, water, and energy consumption of production systems	7. Lack of state support for municipalities in the field of education on proper waste management	
	8. Implementation of a circular economy model at the regional level	8. High costs of installations used for waste recovery or disposal	
	9. Promoting backyard composting and the construction and expansion of biodegradable waste processing plants	9. Increased illegal import of waste into individual provinces from neighboring countries and other provinces	
	10. Increasing environmental awareness of the public	10. A slow investment process for the establishment of new MSWCPs and MBT installations	
	11. Increased control of proper compliance with waste management regulations		

3.2. WASTE MANAGEMENT IN THE CZECH REPUBLIC

3.2.1. WASTE GENERATION

The definition of municipal solid waste is given in the *Act of Waste* [26]. By this definition, MSW is all waste generated in the municipality by the activities of citizens and which is listed as municipal solid waste in the *Waste Catalog* [27], except for waste generated by legal entities or individuals authorized to do business. Act on Waste also

defines “waste similar to municipal waste”. It is all waste listed as MSW in the *Waste Catalog* (Group 20) and generated on the territory of the municipality by mentioned above legal entities’ or individuals’ activities. Due to these differences, it is difficult to determine the amount of municipal solid waste comparable to foreign data.

Two information systems for waste management are operated in the Czech Republic. One is operated by the Czech Statistical Office (CZSO), the other one (Integrated Waste Management System) is operated by the Czech Environmental Information Agency (CENIA), established by the Ministry of the Environment [28, 29]. Because of the comparison with data of Poland (from the Central Statistical Office), just CZSO data have been evaluated.

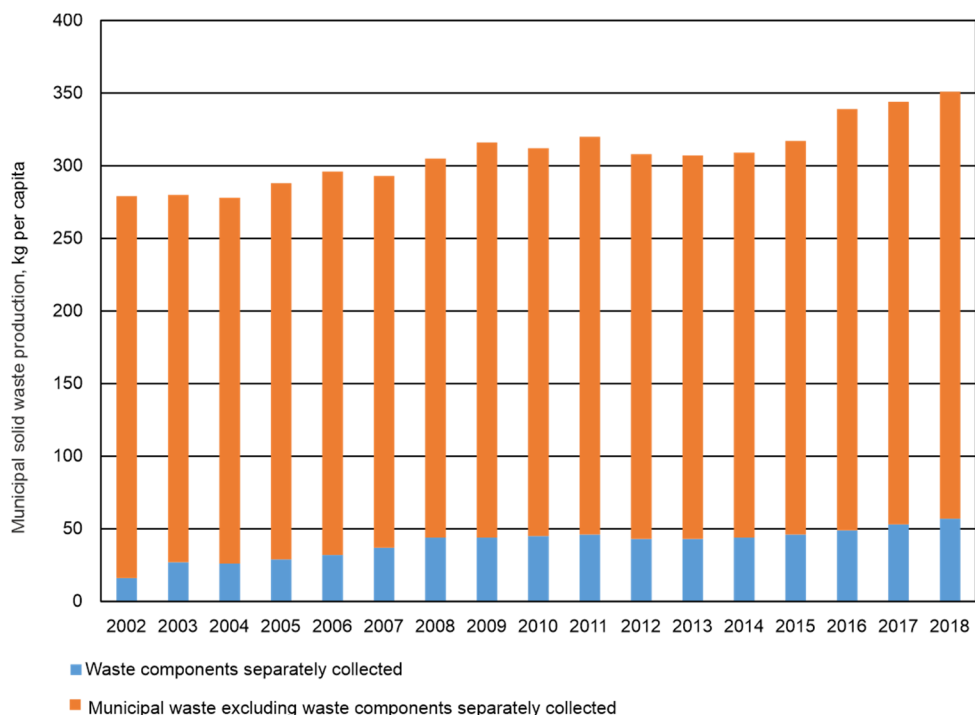


Fig. 5. Municipal solid waste production (per capita) in 2002–2018 [28]

The amount of municipal solid waste (per capita) fluctuates over time but increases slightly with longer monitoring (Fig. 5). By comparing the data from CZSO it can be seen that the amount of residual municipal solid waste increased from 263 kg in 2002 to 294 kg in 2018 per capita (11.8%); at the same time, the amount of separately collected waste components increased from 16 kg in 2002 to 57 kg in 2018 per capita (256.3%). Total amount of municipal solid waste (residual + separately collected) increased from 279 kg in 2002 to 351 kg in 2018 per capita (25.8%). Despite the obliga-

tion of municipalities (as MSW generators) to ensure the collection of separately collected waste components and a dense network of collection containers, just about 16% of municipal wastes are collected separately.

3.2.2. WASTE COLLECTION

The most (83%) of municipal wastes generated in 2018 in the Czech Republic were collected from households [30]. In the Czech Republic there are three main and several complementary possible methods of MSW collection. The first method means door-to-door collecting system, the second method means waste collecting into containers on the streets and the third method means waste collecting at collecting yards. Complementary methods include, for example, collecting of batteries in shopping malls and government institutions, collecting of medicines in pharmacies, collecting of waste electrical and electronic equipment (WEEE) in electrical and electronic equipment stores, etc.

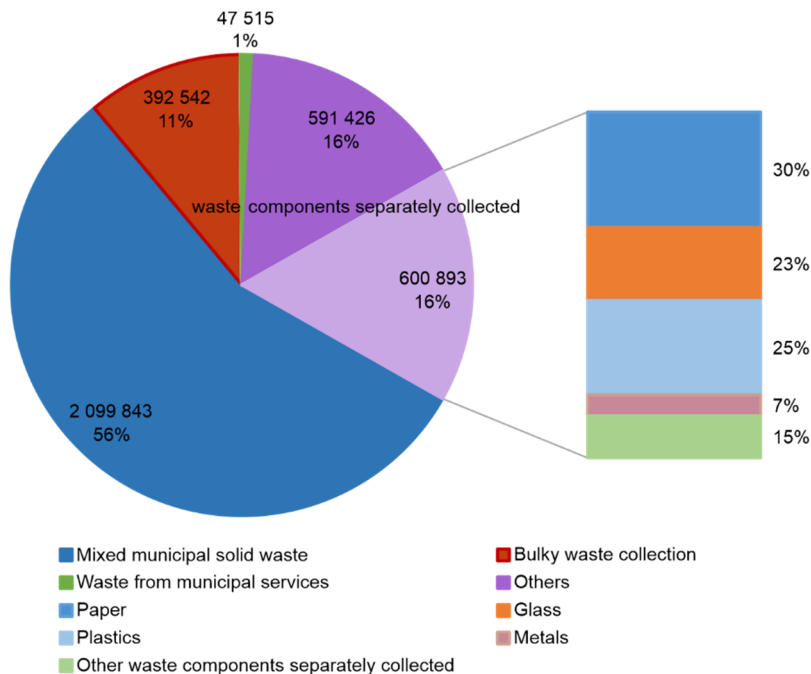


Fig. 6. Municipal solid waste management in 2018 [28]

The amount of mixed municipal solid waste was 2 099 843 tons (56%) in 2018 (Fig. 6). Without any treatment, this waste is deposited on landfills or it is used in facilities for energy recovery of waste (WtE plants). 1 828 236 tons (49%) of municipal solid waste was landfilled in 2018 [26] (Fig. 7). Four WtE plants in the Czech Republic offer a total capacity of 769 000 tons of waste. The total amount of MSW used for energy recovery was 611 192 tons and 5047 tons were incinerated without energy recovery. The ratio

of incinerated municipal wastes is 17% (Fig. 7). In municipalities, paper, plastic, glass, metals, biodegradable and hazardous wastes, and from 01.01.2020 also edible oils and fats (at least), must be collected separately [31]. Separately collected waste components are collected at collection yards into bulk containers, into color plastic bins or containers placed on the streets or into plastic bags in door-to-door systems. The most common method of collection is collection through street containers. More and more municipalities are collecting bio-waste in brown containers (the remaining municipalities fulfill their legal obligations through collection yards), in some municipalities metals are collected in containers. WEEE collection containers are rarely used.

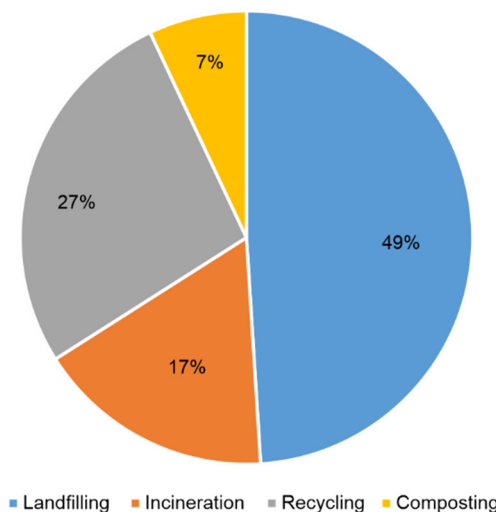


Fig. 7. Municipal solid waste by type of collection in 2018 [28]

Sorted fractions of municipal solid waste and packaging waste are collected in street containers together. Ensuring the obligation to take back consumer package waste is usually taken over by an Authorized packaging company.

Authorized packaging company EKO-KOM is an almost monopolistic company in this market. EKO-KOM offers its services to 6131 municipalities (of 6258 in the Czech Republic) where live 10 589 729 (99%) inhabitants of the Czech Republic. Municipalities involved in the EKO-KOM system are rewarded for sorted MSW components [32]. Bulky waste collection is realized through collecting yards, together with hazardous wastes, biodegradable wastes, WEEE and other wastes. The amount of bulky waste was 392 542 tons (11% of municipal wastes) (Fig. 6). Of course, not every waste that are collected through street containers or collecting yards are possible to recycle (Figs. 6, 7).

3.2.3. SWOT ANALYSIS

Significant strategic factors, identified by SWOT analysis, that have an influence on municipal solid wastes management in the Czech Republic, and presented in Table 3.

Table 3

SWOT matrix on the strategic factors impacting on the municipal solid waste management in the Czech Republic

	Positive	Negative
	Strengths	Weaknesses
Internal factors	1. Legal regulations for (all) waste collection, sorting, treatment, and utilization	1. Low discipline of the inhabitants in waste separation
	2. System of municipal solid waste components collecting is offered to 99% (at least) of the inhabitants	2. Low number of waste-to-energy plants
	3. High (and still increasing) number of collection yards and collection points in municipalities	3. Still high ratio of residual municipal solid waste
	4. All operated landfills comply with EU standards	4. Still high ratio of landfilled municipal waste
	5. Reducing the amount of MSW landfilled, increasing recycling and composting municipal solid waste components	5. Minimal awareness of the possibilities of waste prevention
	6. Increasing the number of collection yards that serve as reuse centres	6. High prices for repair and renovation of goods
		Opportunities
External factors	1. Development of goods producers using recycled materials	1. Unclear legislation
	2. Development of technologies waste-to-fuel for engines	2. Not supporting the construction of new waste-to-energy plants and their rejection by the public
	3. Encouraging the production and use of composts as a way of waste recovery, increasing soil microbial biodiversity and water retention capacity in the landscape	3. Minimum interest in sorted plastics from MSW on the market
	4. Transformation of waste management into circular economy	4. Missing facilities for material recovery of waste
	5. Extension of reuse centres	5. High price of secondary raw materials
	6. Linking environmental education with education to personal responsibility	6. Unrealistic recycling targets set by EU institutions
	7. Establishing a uniform definition of municipal waste for EU member states	
	8. Establishing a uniform methodology for data collection in the field of waste management for EU member states	
	9. Establishing a uniform and mathematically correct methodology for the evaluation of waste management data for EU Member States	

4. CONCLUSIONS

Based on the collected data related to broadly understood municipal solid waste management in Poland and the Czech Republic it may be stated that there are relatively few common features in both systems. Although the history of both states was similar after World War II and the change of the socialist regime to the democratic political system took place at the same time, the development of the respective waste management systems proceeded at a different rate and direction. Poland has been implementing the principles of sustainable and proper waste management for less than 10 years, while these efforts have been ongoing in the Czech Republic for ca. 25 years. Within a very short time in Poland, significant progress in waste management has been observed, while similar progress may hardly be reported in the Czech Republic. New municipal solid waste management facilities such as MBT or waste-to-energy plants have been built, are being planned or under construction in Poland. Moreover, the *Packaging Waste Directive* promoting extended producer responsibility (EPR) and the deposit-refund system is also being implemented in the Polish waste management system to ensure the maximum reuse and recycling of packaging waste. In contrast, in the Czech Republic, only one waste-to-energy plant has been completed since the 1990s because of objections of various activists and interest groups. The MBT technology for processing mixed MSW is not used in the Czech Republic at all; waste management experts are of an opinion that MBT is not feasible in the Czech Republic.

It is a promising finding that in both countries the production of municipal solid waste per capita is lower than the EU average. It is also mandatory in both countries to separate similar MSW fractions. In addition to plastic, paper, glass, beverage cartons, and metals, biowaste is increasingly being sorted in municipalities. It should be emphasized that the selective collection of biowaste has not been implemented in some EU member states. Unfortunately, in both countries, the sorting rate is not high enough and much municipal solid waste is still being landfilled. When adapting to EU regulations, both Poland and the Czech Republic must increase recycling levels; Poland is more active in this area, although not sufficiently yet. The main reason is insufficient funding for waste management, legislative chaos, insufficient environmental education for the local communities as well as objections of residents to the construction of new installations required to complete the MSWM cycle.

The lack of facilities for material recovery of sorted municipal solid waste components may be considered both the biggest problem and challenge for the future. However, this problem is common to most EU countries, as was shown when China refused to continue to accept most of the sorted plastic. Because of the transition to a circular economy, it is essential to address this problem not only at national but also at international levels. It needs to be acknowledged that waste will continue to be generated and some of it may no longer be materially recovered. For such waste, it is necessary to develop a technology enabling conversion of combustible waste into engine fuels, not

just incinerators. It should be noted that the need for a sustainable solution to this problem applies not only to the Polish and Czech economies but to all EU countries. The main idea should include global and systemic solutions, enabling their easy implementation in the system of each country to increase waste management efficiency.

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