

Ewa Dziawgo

Kazimierz Wielki University

e-mail: edziawgo@ukw.edu.pl

ORCID: 0000-0001-9764-8855

ANALYSIS OF CHANGES IN WASTE GENERATION AND MANAGEMENT IN POLAND AGAINST THE BACKGROUND OF EU WASTE MANAGEMENT OBJECTIVES

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Abstract: One of the environmental problems of the current generation is the increase in volume of waste generated, which has a negative impact on the environment and human health. Therefore, it is important to reduce the amount of waste generated and to manage it rationally. Waste management is one of the areas of environmental protection. The article examines the changes in the amount and structure of waste generated in Poland in the period 2017-2020. An analysis of the size and structure of funding sources of the main forms of waste management was also carried out. The aim of the article was to present, compare and evaluate the changes occurring in waste management and its sources of financing. The research considered the impact of the Covid-19 pandemic on the volume of waste generated and on waste management. The analysis shows that the crisis caused by the Covid-19 pandemic affected the decrease in the volume of total waste generated and the increase in the volume of municipal waste. There was also some variation in the area of generated waste and its management in individual provinces.

Keywords: waste, waste management, municipal waste, industrial waste.

1. Introduction

As a result of the dynamic development of the economy and increased levels of consumption, there has been an increase in the amount of waste generated, threatens both the environment and human health (Górka, Poskrobko, and Radecki, 2001, p. 103). The scale of generated waste is a problem of contemporary society, posing a challenge in the field of seeking and implementing solutions for the neutralisation and ecological management of waste (Dmowska and Warechowska, 2009, p. 95). In Poland, 122.6 million tonnes of waste were generated in 2020, of which approximately 10% was municipal waste. Thus, municipal waste amounted to 346 kg *per capita*. The volume of generated municipal waste per one inhabitant in the European Union in 2020 was 505 kg.

Waste management is one of the areas of environmental protection, which includes the collection, transport, recovery, and disposal of waste, as well as the supervision of the activities undertaken in this respect and the places where waste is disposed of. The implementation of the main principles of waste management also includes proceedings in the area of waste prevention and measures for the thermal processing of waste with energy and heat generation.

In the global effort to protect the environment, the EU plays a significant role. The European Commission's European Green Deal development strategy has as its central goal the achievement of climate neutrality by 2050. It is an ambitious plan to transform Europe into a society with a modern, economical and sustainable economy, and to move away from an economy that consumes non-renewable resources. This area assumes a transition to a closed-circuit economy, in which the consumption of raw materials and waste is minimised, as well as emissions and loss of energy by creating a closed loop of processes (Broniewicz, Godlewska, Lulewicz-Sas, and Miłasewski, 2019, pp. 23-24; Pikoń, 2018, p. 28). Poland's membership in the European Union obliges it to follow its priorities and intentions in the field of environmental protection. However, the implementation of the concept of transition to a circular economy, with a minimum amount of waste generated, requires both time and considerable financial resources.

The article presents issues related to waste management in Poland. It examines, among others, the dynamics of changes in the amount of generated waste, analyses both the structure of the generated waste and the structure of financing individual forms of waste management. The aim of the article was to present, compare and evaluate the changes in the generation of waste as well as the financing of individual forms of waste management. The analysis covers the period 2017-2020, hence it also takes into account the impact of the Covid-19 pandemic on the volume of waste generated.

The data source for the calculations, the results presented and analysis is the Central Statistical Office (GUS).

2. The problem of waste overproduction and EU waste management policy

The amount of waste generated and its inappropriate management adversely affect the state of the environment and thus lead to the deterioration of human life and health (Manczarski and Juda-Rezler, 2010, p. 97; Sonesson, Björklund, Carlsson, and Dalemo, 2000, p. 29).

The type and volume of waste generated depends also on the quality and availability of raw materials, production technology and technical progress, the standard of living of the population and the consumption of material goods, the existing level of awareness and environmental ethics of the population, and the value of financial resources allocated to research and development for pro-environmental innovations and modern technologies (Ciechelska, 2009, p. 142; Czaja and Becla, 2007, p. 317; Directive EU, 2018/851; Dobrzańska, Dobrzański, and Kiełczewski, 2009, p. 277).

One of the priorities of the European Union's pro-environmental policy in the field of waste management is the implementation of solutions contributing to the development of a closed-circuit economy model, in which the starting point for waste management is the reduction of its generation, followed by re-use, other recovery (e.g. energy) and, as a last resort, disposal (landfilling and incineration without energy recovery). It is important to extract the highest quality resources from waste.

The transformation to a circular economy is to be assisted by the implementation of the tasks set by the European Union to which the EU Member States have committed, including:

- to make every effort to ensure that, from 2030, all recyclable or otherwise recoverable waste, in particular municipal waste, is kept out of landfills. The only exception is for waste for which landfilling provides the best environmental performance,
- to reduce the volume of municipal waste landfilled to no more than 10% of the total municipal waste generated by 2035,
- to increase the proportion of municipal waste recycled to no less than 55% (by 2025), 60% (by 2030), 65% (by 2035).

In 2020, more than 225 million tonnes of municipal waste was generated in the European Union, of which 48% by weight was composted and recycled (Eurostat, 2022). There is variation in the volume of waste generated and its management across the EU. Wealthier countries tend to generate more waste *per capita*, with tourism contributing to a higher value of this indicator, for example in Malta (643 kg *per capita*).

In 2020, Austria had the highest share of municipal waste *per capita* (834 kg), followed by Denmark (814 kg) and Luxembourg (790 kg). For Germany, the indicator stood at 628 kg. Romania had the lowest recycling rate (287 kg). In contrast, recycling

of municipal waste in the countries concerned reached the following levels: Romania 13.7%, Malta 10.5%, Luxembourg 52.8%, Denmark 45%, Austria 61.8%. Germany had the highest municipal waste recycling rate – its value was 68.3%.

3. Analysis of the volume of waste generated

The dynamic increase in the production of waste is having a negative impact both on the environment and on human health. There is a danger of unfavourable and irreversible changes to the ecosystem (Grabowska, 2001, p. 21; Pezzey and Toman, 2002, pp. 5-12; Poskobko and Poskrobko, 2012, pp. 123-126). Therefore, in relation to the generation of waste, it is very important to implement strategies for its rational management.

In Poland, compared to 2019, a decrease of 3.4% in total waste generated to 122.6 million tonnes was noted in 2020. On the other hand, in the case of municipal waste, an increase of 4.1% in the amount of waste generated was recorded at 13.1 million tonnes. The rate of generated municipal waste *per capita* in Poland was 346 kg and increased by 10 kg compared to 2019. As in previous years, it was one of the lowest in the European Union.

Table 1 shows an evaluation of the total amount of the generated waste in Poland in 2017-2020.

Table 1. Evaluation of the total amount of the generated waste in Poland in 2017-2020

| Specification | Years | | | |
|--|-------|-------|-------|-------|
| | 2017 | 2018 | 2019 | 2020 |
| Waste total (mln t) | 125.7 | 127.8 | 126.9 | 122.6 |
| a) excluding municipal waste | 113.8 | 115.3 | 114.1 | 109.5 |
| b) municipal waste | 11.9 | 12.5 | 12.8 | 13.1 |
| Structure (%) | | | | |
| a) excluding municipal waste | 90.5 | 90.2 | 89.9 | 89.3 |
| b) municipal waste | 9.5 | 9.8 | 10.1 | 10.7 |
| Dynamics of changes in the volume waste generated (previous year = 100%) | | | | |
| a) total waste | | 101.6 | 99.3 | 99.6 |
| b) excluding municipal waste | | 101.4 | 98.9 | 95.9 |
| c) municipal waste | | 104.3 | 102.1 | 102.9 |

Source: authors' own calculations based on GUS (GUS, 2018, 2019, 2020, 2021).

As regards total waste, 2019 and 2020 saw a decrease in waste generation of 0.7 p.p. and 0.4 p.p. respectively compared to the previous year. In 2019 and 2020, the amount of industrial waste generated also decreased by 1.1 p.p. and 4.1 p.p. respectively. Only in the case of municipal waste, did the generation of municipal waste increase every year. In the period under study, the average annual rate of change in the volume of waste generated was as follows:

- total waste: -0.9%,
- industrial waste: -1.3%,
- municipal waste: 3.1%.

Industrial waste accounts for about 90%, and municipal waste 10% of the total amount of waste generated. In the structure analysed, the share of industrial waste was decreasing year by year. In 2017, it accounted for 90.5% of total waste generated, and in 2020 by 1.2 p.p. less (89.3%). The opposite was the case with the share of municipal waste in the total structure of generated waste. In 2017, it accounted for 9.5%, and in 2020 it was 10.7% of total waste.

In total, most waste was generated in *Dolnośląskie* province (Table 2). In 2020, 34.5 million tonnes of waste were generated there, which accounted for 28.1% of waste generated in Poland. This is followed by *Śląskie* province, where 29.4 million tonnes of waste was produced (24% of waste in Poland). *Lubuskie*, *Podkarpackie*, *Podlaskie* and *Opolskie* provinces had the lowest amounts of the generated waste.

Table 2. Evolution of the total amount of generated waste in individual provinces (in millions of tonnes) and their share (%) in the total amount of generated waste in Poland in the period 2017-2020

| Provinces Specification | Years | | | | | | | |
|----------------------------|-------|------|-------|------|-------|------|-------|------|
| | 2017 | | 2018 | | 2019 | | 2020 | |
| | mln t | % | mln t | % | mln t | % | mln t | % |
| Dolnośląskie | 36.3 | 28.9 | 35.1 | 27,5 | 35.3 | 27.9 | 34.5 | 28.1 |
| Kujawsko-Pomorskie | 2.5 | 1.9 | 2.5 | 1.9 | 2.3 | 1.8 | 2.3 | 1.8 |
| Lubelskie | 6.8 | 5.4 | 7.9 | 6.2 | 7.5 | 5.9 | 6.3 | 5.1 |
| Lubuskie | 1.0 | 0.8 | 0.9 | 0.8 | 1.0 | 0.8 | 1.1 | 0.9 |
| Łódzkie | 7.7 | 6.1 | 10.8 | 8.4 | 9.1 | 7.1 | 8.0 | 6.6 |
| Małopolskie | 6.7 | 5.3 | 7.4 | 5.8 | 7.6 | 5.9 | 6.4 | 5.2 |
| Mazowieckie | 7.4 | 5.9 | 7.8 | 6.1 | 7.6 | 6.0 | 7.9 | 6.5 |
| Opolskie | 1.9 | 1.6 | 2.1 | 1.7 | 2.3 | 1.8 | 1.8 | 1.4 |
| Podkarpackie | 1.3 | 1.0 | 1.3 | 1.0 | 1.3 | 1.1 | 1.6 | 1.3 |
| Podlaskie | 1.4 | 1.1 | 1.2 | 0.9 | 1.3 | 0.7 | 1.6 | 2.2 |
| Pomorskie | 2.5 | 1.9 | 2.9 | 2.3 | 1.9 | 1.5 | 2.7 | 2.2 |
| Śląskie | 33.2 | 26.4 | 30.3 | 23.7 | 32.2 | 25.4 | 29.4 | 24.0 |
| Świętokrzyskie | 4.6 | 3.6 | 5.3 | 4.1 | 5.3 | 4.2 | 4.9 | 4.0 |
| Warmińsko-Mazurskie | 1.4 | 1.1 | 1.1 | 0.9 | 1.4 | 1.1 | 2.9 | 2.4 |
| Wielkopolskie | 5.3 | 4.2 | 4.9 | 3.8 | 4.8 | 3.8 | 4.6 | 3.7 |
| Zachodniopomorskie | 5.7 | 4.6 | 6.2 | 4.8 | 6.4 | 5.0 | 5.6 | 4.5 |

Source: authors' own calculations based on GUS (GUS, 2018, 2019, 2020, 2021).

In the period under analysis, the average annual growth rate of the total waste generated was characteristic of the *Podlaskie*, *Świętokrzyskie* and *Warmińsko-Mazurskie* provinces. In the remaining provinces, the average annual rate of the decrease of the total waste generated was observed, with the greatest rate of decrease in *Wielkopolskie* (-5.2%) province, followed by *Śląskie* (-4.05%) province.

In the period analysed, Poland noted an increase in the share of municipal waste in the total waste generated (Table 3). In comparison with 2018, this share increased by 0.3 p.p. and already in the following year by 0.6 p.p. A significant share of industrial waste can be seen in the *Dolnośląskie* (96.6%), *Śląskie* (93.9%), *Świętokrzyskie* (93.7%) and *Łódzkie* (89.4%) provinces. On the other hand, the largest share of generated municipal waste was found for the *Lubuskie* (36.1%), *Kujawsko-Pomorskie* (31.7%) and *Podkarpackie* (31.6%) provinces.

Table 3. Structure of municipal and industrial waste generated in selected provinces in the period 2017-2020

| Specification | Years | | | | | | | |
|---------------------|-------|------|------|------|------|------|------|------|
| | 2017 | | 2018 | | 2019 | | 2020 | |
| | I | M | I | M | I | M | I | M |
| | % | | % | | % | | % | |
| Poland | 90.5 | 9.5 | 90.2 | 9.8 | 89.9 | 10.1 | 89.3 | 10.7 |
| Dolnośląskie | 97.0 | 3.0 | 96.8 | 3.2 | 96.7 | 3.3 | 96.6 | 3.4 |
| Kujawsko-Pomorskie | 74.2 | 25.8 | 73.2 | 26.8 | 70.4 | 29.6 | 68.3 | 31.7 |
| Lubelskie | 93.6 | 6.4 | 94.0 | 6.0 | 93.4 | 6.6 | 91.7 | 8.3 |
| Lubuskie | 63.9 | 36.1 | 62.2 | 37.8 | 63.0 | 37.0 | 63.9 | 36.1 |
| Łódzkie | 90.8 | 9.2 | 92.7 | 7.3 | 91.0 | 9.0 | 89.4 | 10.6 |
| Małopolskie | 84.9 | 15.1 | 85.5 | 14.5 | 85.8 | 14.2 | 82.4 | 17.6 |
| Mazowieckie | 75.9 | 24.1 | 76.9 | 23.1 | 77.3 | 22.7 | 76.3 | 23.7 |
| Opolskie | 84.0 | 16.0 | 84.7 | 15.3 | 85.4 | 14.6 | 78.9 | 21.1 |
| Podkarpackie | 63.5 | 36.5 | 62.1 | 37.9 | 61.6 | 38.4 | 68.4 | 31.6 |
| Podlaskie | 79.4 | 20.6 | 74.7 | 25.3 | 59.6 | 40.4 | 87.5 | 12.5 |
| Pomorskie | 67.8 | 32.2 | 71.8 | 28.2 | 54.1 | 45.9 | 68.9 | 31.1 |
| Śląskie | 95.2 | 4.8 | 94.5 | 5.5 | 94.7 | 5.3 | 93.9 | 6.1 |
| Świętokrzyskie | 94.9 | 5.1 | 95.3 | 4.7 | 94.6 | 5.4 | 93.7 | 6.4 |
| Warmińsko-Mazurskie | 69.4 | 30.6 | 61.1 | 38.9 | 69.7 | 30.3 | 85.3 | 14.7 |
| Wielkopolskie | 77.7 | 22.3 | 75.1 | 24.9 | 74.1 | 25.9 | 72.4 | 27.6 |
| Zachodniopomorskie | 88.9 | 11.1 | 89.7 | 10.3 | 89.6 | 10.4 | 88.4 | 11.6 |

I – industrial waste, M – municipal waste.

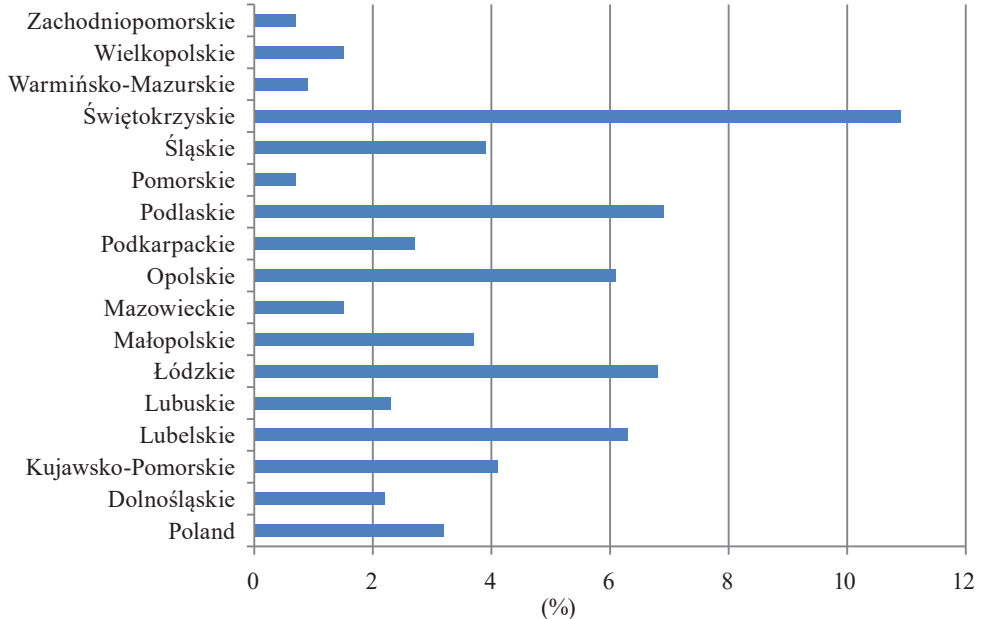
Source: authors' own calculations based on GUS (GUS, 2018, 2019, 2020, 2021).

Compared to 2017, in 2018 all the provinces showed an increase in waste generated *per capita* (Table 4). The largest increase was noted in the *Łódzkie* (11.2%) province. In the following year, in two provinces (the *Mazowieckie* and *Warmińsko-Mazurskie* provinces) there was a decrease in the value of the municipal waste per capita indicator, whereas in 2020, five provinces (*Dolnośląskie*, *Podkarpackie*, *Pomorskie*, *Warmińsko-Mazurskie*, *Zachodniopomorskie*) recorded a lower value of the analysed indicator in relation to the previous year. Unfortunately, these provinces did not include the *Mazowieckie* province, where the amount of waste generated *per capita* increased by 7.8%.

Table 4. Dynamics of changes in the volume of municipal waste generated *per capita* in individual provinces in the period 2017-2020 (previous year = 100%)

| Specification | Years | | |
|---------------------|-------|-------|-------|
| | 2018 | 2019 | 2020 |
| Poland | 104.3 | 102.2 | 103.0 |
| Dolnośląskie | 105.2 | 102.9 | 98.8 |
| Kujawsko-Pomorskie | 104.6 | 103.7 | 103.9 |
| Lubelskie | 107.3 | 105.6 | 105.9 |
| Lubuskie | 100.2 | 105.3 | 101.6 |
| Łódzkie | 111.2 | 104.3 | 104.2 |
| Małopolskie | 106.5 | 100.3 | 104.4 |
| Mazowieckie | 101.6 | 95.5 | 107.8 |
| Opolskie | 103.1 | 103.8 | 111.8 |
| Podkarpackie | 107.3 | 103.6 | 97.5 |
| Podlaskie | 107.5 | 111.9 | 101.8 |
| Pomorskie | 102.5 | 104.8 | 95.2 |
| Śląskie | 104.2 | 102.6 | 105.1 |
| Świętokrzyskie | 107.1 | 115.4 | 110.3 |
| Warmińsko-Mazurskie | 104.4 | 99.2 | 99.3 |
| Wielkopolskie | 102.3 | 101.3 | 100.8 |
| Zachodniopomorskie | 100.7 | 103.7 | 97.7 |

Source: authors' own calculations based on GUS (GUS, 2018, 2019, 2020, 2021).

**Fig. 1.** Rates of change in the generation of municipal waste per on inhabitant in individual provinces in the period 2017-2020

Source: own elaboration.

In Poland, in the period 2017-2020, municipal waste *per capita* increased on average annually by 3.2% (Figure 1). In all the provinces there was a positive rate of change of this indicator. However, significant variation can be observed in the average annual growth of generated waste per one inhabitant in individual provinces. The highest growth rate of municipal waste per one inhabitant was recorded in the *Świętokrzyskie* (10.9%) province followed by the *Podlaskie* (6.9%) and *Łódzkie* (6.8%) provinces. The lowest average annual growth rate of municipal waste per one inhabitant was observed in the *Zachodniopomorskie* (0.7%), *Pomorskie* (0.7%) and *Warmińsko-Mazurskie* (0.9%) provinces.

4. Changes in waste management

The rational use of resources and minimising the amount of waste generated is intended to limit the negative environmental impact of the resulting products. In terms of environmental protection, it is important to strive for waste management, including abandoned and hazardous waste. The priority in the area of implementing the concept of a closed-circuit economy (CFC) is to strive for a state of the economy in which materials and raw materials could function for as long as possible by originating from the full recovery of waste.

Table 5 shows the structure of management of generated industrial waste.

Table 5. Structure of management of generated industrial waste in the period 2017-2020

| Specification | Years | | | |
|---|---------------|-------|-------|-------|
| | 2017 | 2018 | 2019 | 2020 |
| Total: industrial waste generated (mln t) | 113.8 | 115.3 | 114.1 | 109.5 |
| | Structure (%) | | | |
| Recovered | 49.1 | 50.6 | 48.9 | 48.4 |
| Disposed, of which | 46.9 | 47.4 | 48.1 | 47.9 |
| a) thermal | 90.1 | 89.8 | 89.2 | 88.4 |
| b) landfilled | 0.77 | 0.78 | 0.52 | 0.76 |
| Transferred to other recipients | 2.9 | 0.9 | 1.8 | 1.4 |
| Temporarily stored | 1.1 | 1.1 | 1.2 | 2.3 |

Source: authors' own calculations based on GUS (GUS, 2018, 2019, 2020, 2021).

In the studied structure, the largest part of industrial waste was recycled. However, 2019 and 2020 showed a slight decrease in this form of waste management compared to the previous year (by 1.7 p.p. and 0.5 p.p., respectively). Disposal of industrial waste was in second place in terms of its share of the analysed structure. From 2017 to 2019, this share increased, but there was a slight decrease in 2020 (by 0.2 p.p.).

Thermally disposed waste in 2017 accounted for more than 90% of disposed waste. However, from year to year the share of this form of waste disposal decreased, which in 2020 was at the level of 88.4%.

Landfilling, in turn, accounted for about 0.8% of the waste disposal volume. The exception was 2019, when it was at the level of 0.52%.

In the structure analysed, the share of transfer of industrial waste to other recipients fluctuated. In 2017 it was 2.9%, in 2018 it decreased by 2.1 p.p., while in 2019 it increased by 0.9 p.p. and in 2020 it decreased again and reached 1.4%.

Compared to the previous year, the share of industrial waste temporarily stored increased in 2019 and 2020 (by 0.1 p.p. and 1.1 p.p. respectively).

In 2019 and 2020 the amount of industrial waste recovered decreased by 4.5% and 5.1%, respectively (Table 6).

Table 6. Dynamics of the management of produced industrial waste in Poland in the period 2017-2020 (previous year = 100%)

| Specification | Years | | | Rate of changes (%) |
|------------------------------------|-------|-------|-------|---------------------|
| | 2018 | 2019 | 2020 | |
| Industrial waste generated (total) | 101.4 | 98.9 | 95.9 | -1.3 |
| Recovered | 104.6 | 95.5 | 94.9 | -1.8 |
| Disposed, of which | 102.3 | 100.4 | 95.5 | -0.6 |
| a) thermal | 104.1 | 67.0 | 138.6 | -1.1 |
| b) landfilled | 101.3 | 99.8 | 94.7 | -1.5 |
| Transferred to other recipients | 30.4 | 205.6 | 76.4 | -21.8 |
| Temporarily stored | 103.3 | 110.9 | 179.3 | 27.1 |

Source: authors' own calculations based on GUS (GUS, 2018, 2019, 2020, 2021).

In 2020, the amount of industrial waste disposed of decreased by 4.5%. In the case of thermal disposal of waste, a decrease of 33% was recorded in 2019 and an increase of 38.6% the following year compared to the previous one.

As for the amount of industrial waste landfilled, 2019 and 2020 showed a decrease of 0.2% and 5.3% respectively compared to the previous year.

In the period under consideration, significant fluctuations occurred in the amount of waste sent to other recipients. Compared to the previous year, a decrease of 69.6% was observed in 2018, an increase of 105.6% in 2019 and a renewed decrease of 24.6% in 2020.

Industrial waste temporarily stored was characterised by an annual increase (by 79.3%), with a particular increase noted in 2020.

Table 7 shows the structure of management of generated municipal waste.

Table 7. Structure of management of generated municipal waste in Poland in the period 2017-2020

| Specification | Years | | | |
|--|---------------|------|------|------|
| | 2017 | 2018 | 2019 | 2020 |
| Total: municipal waste generated (mln t) | 11.9 | 12.5 | 12.8 | 13.1 |
| | Structure (%) | | | |
| Recycling | 26.7 | 26.2 | 25.0 | 26.7 |
| Composting | 7.1 | 8.1 | 9.0 | 12.0 |
| Incineration | 24.4 | 24.1 | 22.9 | 21.5 |
| Landfilling | 41.8 | 41.6 | 43.1 | 39.8 |

Source: authors' own calculations based on GUS (GUS, 2018, 2019, 2020, 2021).

The largest share in the management of municipal waste occurred in the case of its storage (39.8%-43.1%). This was followed by recycling (25%-26.7%), incineration (21.5%-24.4%) and composting (7.1%-12.9%). Waste composting showed an annual increase in their share in the analysed structure (from 7.1% in 2017 to 12% in 2020). The opposite occurred in the case of thermal processing of municipal waste, as its share in the analysed structure decreased year by year (from 24.4% in 2017 to 21.5% in 2020).

Fluctuations in the structure analysed occurred in the case of the share of waste subject to recycling and landfilling. In 2019, the share of recycling in the municipal waste management structure was 25% (by 1.2 p.p. less than in 2018), and in 2020 it increased by 1.7 p.p. However, landfilling of waste in 2019 showed an increase by 1.5 p.p. of its share in the analysed structure compared to the previous year, and in 2020 a decrease by 2.3 p.p. compared to the previous year.

Table 8. Dynamics of the management of produced municipal waste in Poland in the period 2017-2020 (previous year = 100%)

| Specification | Years | | | Rate of changes (%) |
|---|-------|-------|-------|---------------------|
| | 2018 | 2019 | 2020 | |
| Municipal waste generated (total) | 104.3 | 102.1 | 102.9 | 3.1 |
| Municipal waste <i>per capita</i> in kg | 104.3 | 102.2 | 103.0 | 3.2 |
| Recycling | 102.2 | 97.6 | 109.6 | 3.0 |
| Composting | 119.3 | 113.9 | 136.9 | 23.0 |
| Incineration | 103.1 | 96.9 | 96.7 | -1.1 |
| Landfilling | 103.8 | 105.7 | 95.1 | 1.4 |

Source: authors' own calculations based on GUS (GUS, 2018, 2019, 2020, 2021).

In 2018, an increase in the amount of processed waste was noticeable in all forms of municipal waste management (Table 8). However, in 2019, the volume of waste recycled and incinerated decreased (by 2.4% and 3.1% respectively). In turn,

in 2020, compared to the previous year, the amount of municipal waste stored and thermally transformed decreased (by 4.9% and 3.3% respectively).

Every year there was an increase in the amount of waste subject to composting. In particular, an increase occurred in 2020, as the amount of waste managed in this form increased by 36.9% compared to the previous year.

In the period analysed, the highest average annual growth rate was characteristic of waste subjected to composting (23%), and then recycling (3%) and landfilling (1.4%). In the case of incineration, there was an average annual decrease in the amount of municipal waste processed in this form (-1.1%).

5. Financing of expenditure related to waste management

The implementation of the concept of a transition to a circular economy, involving the reduction of waste generation, requires time and financial resources.

In 2020, expenditure on fixed assets serving environmental protection decreased by 8.1%, and amounted to PLN 11.4 billion (Table 9).

Table 9. Expenditure on fixed assets for environmental protection and the structure of this expenditure by directions of destination for environmental protection

| Specification | Years | | | |
|---|---------------|------|------|------|
| | 2017 | 2018 | 2019 | 2020 |
| Total: expenditure on fixed assets for environmental protection (bln PLN) | 6.8 | 10.4 | 12.4 | 11.4 |
| | Structure (%) | | | |
| Protection of air and climate | 33.9 | 28.3 | 32.9 | 32.7 |
| Wastewater management and protection of water | 39.8 | 52.3 | 48.7 | 48.3 |
| Waste management | 12.7 | 6.9 | 6.7 | 6.5 |
| Protection of soil, groundwater and surface water | 0.7 | 0.5 | 0.8 | 1.8 |
| Noise and vibration reduction | 0.98 | 0.96 | 1.19 | 1.2 |
| Protection of biodiversity and landscape | 2.0 | 1.4 | 1.1 | 1.5 |
| Research and development activity | 0.02 | 0.07 | 0.03 | 0.05 |
| Other environmental protection activities | 9.9 | 9.57 | 8.58 | 7.85 |

Source: authors' own calculations based on GUS (GUS, 2018, 2019, 2020, 2021).

As regards the structure of expenditure on fixed assets for environmental protection, expenditure for waste water management and water protection dominated, followed by air and climate protection and waste management. In the considered structure, the share of expenditure on environmental protection fixed assets in waste management decreased from year to year. In 2017 this share was 12.7% and in 2020 it was 6.2 p.p. lower and thus dropped to 6.5%.

Compared to the previous year, in 2020, expenditure on environmental protection fixed assets for waste management decreased by 10.4% and stood at PLN 744.7 million (Table 10).

Table 10. Expenditure on fixed assets for environmental protection and their structure according to the main directions of investment in waste management

| Specification | Years | | | |
|---|-----------------------|-------|-------|-------|
| | 2017 | 2018 | 2019 | 2020 |
| | Expenditure (mln PLN) | | | |
| Waste management (total) | 867.7 | 713.9 | 831.6 | 744.7 |
| Preventing pollution | 2.1 | 4.5 | 3.6 | 34.0 |
| Waste collection and transport | 164.8 | 255.8 | 369.2 | 353.2 |
| Treatment and disposal of hazardous waste | 5.8 | 5.6 | 10.7 | 36.3 |
| Treatment and disposal of waste, other than hazardous waste | 591.8 | 271.8 | 298.1 | 231.1 |
| Other types of activity | 104.1 | 176.2 | 149.9 | 108.1 |
| | Structure (%) | | | |
| Preventing pollution | 0.2 | 0.6 | 0.4 | 4.6 |
| Waste collection and transport | 18.9 | 35.8 | 44.4 | 47.4 |
| Treatment and disposal of hazardous waste | 0.7 | 0.8 | 1.3 | 4.9 |
| Treatment and disposal of waste, other than hazardous waste | 68.2 | 38.1 | 35.9 | 28.6 |
| Other types of activity | 12.0 | 24.7 | 18.0 | 14.5 |

Source: authors' own calculations based on GUS (GUS, 2018, 2019, 2020, 2021).

In the period under review, an average annual 5% decrease in total expenditure on environmental fixed assets for waste management was noted. Compared to 2019, expenditure on fixed assets for pollution prevention (by PLN 30.4 million) and hazardous waste disposal and neutralisation (by PLN 25.6 million) increased significantly in 2020. In contrast, expenditure on neutralisation and the disposal of non-hazardous waste decreased by PLN 67 million.

In the case of the structure of expenditure on fixed assets for environmental protection, since 2019 expenditure on waste collection and transport has been dominant, followed by the neutralisation and disposal of non-hazardous waste. In the analysed structure, expenditure for disposal and disposal of non-hazardous waste are characterised by an annual decline.

In the examined period, the average annual rate of change in the volume of individual expenditure on environmental protection fixed assets for particular forms of waste management was:

- prevention of pollution: 151.8%,
- waste collection and transport: 28.9%,
- neutralisation and disposal of hazardous waste: 84.6%,
- neutralisation and disposal of non-hazardous waste: -28.6%.

In the analysed structure (Table 11), the share of enterprises in each of the main directions of financing of fixed asset expenditure in the field of waste management

was the largest. Compared to 2017, in 2020, within the considered structure, an increase in the share of municipalities in pollution prevention (5 p.p.) and waste collection and transport (10.9 p.p.) was recorded, while the share of budgetary units in financing the analysed expenditure incurred in pollution prevention increased (from 0.5% in 2017 to 3.2% in 2020).

Compared to 2018, in 2019 there was a decrease in the share of municipalities in financing the expenditure in the area of waste collection and transport (9.5 p.p.) and pollution prevention (6.1 p.p.).

In the case of enterprises, there was a negative rate of change in the financing of expenditure on environmental protection fixed assets in the field of waste management.

In the period under consideration, the average annual rate of change in the volume of outlays incurred by individual groups of investors on environmental fixed assets for waste management was:

- enterprises: -7.7%,
- municipalities: 15.3%,
- budgetary units: 80.9%.

Table 11. Expenditure on fixed assets for environmental protection in the field of waste management incurred by individual groups of investors and the structure of this expenditure by main investment directions in the field of waste management and by investor groups

| Specification | Years | | | |
|---|---------------|-------|-------|-------|
| | 2017 | 2018 | 2019 | 2020 |
| Total: waste management (mln PLN) | 867.7 | 713.9 | 831.6 | 744.7 |
| a) enterprises | 809.6 | 581.6 | 733.3 | 636.8 |
| b) municipalities | 55.1 | 112.2 | 79.8 | 84.4 |
| c) budgetary units | 3.9 | 20.1 | 18.4 | 23.5 |
| | Structure (%) | | | |
| Preventing pollution | | | | |
| a) enterprises | 93.2 | 81.5 | 88.2 | 85.5 |
| b) municipalities | 6.3 | 15.7 | 9.6 | 11.3 |
| c) budgetary units | 0.5 | 2.8 | 2.2 | 3.2 |
| Waste collection and transport | | | | |
| a) enterprises | 88.9 | 65.8 | 81.6 | 78.8 |
| b) municipalities | 9.5 | 26.4 | 16.9 | 20.4 |
| c) budgetary units | 1.6 | 7.8 | 1.5 | 0.9 |
| Treatment and disposal of hazardous waste | | | | |
| a) enterprises | 100 | 100 | 99.3 | 99.6 |
| b) municipalities | – | – | 0.7 | 0.4 |
| c) budgetary units | – | – | – | – |
| Treatment and disposal of waste, other than hazardous waste | | | | |
| a) enterprises | 95.6 | 98.2 | 94.6 | 95.3 |
| b) municipalities | 4.2 | 1.7 | 1.7 | 3.9 |
| c) budgetary units | 0.2 | 0.1 | 3.7 | 0.8 |

Source: authors' own calculations based on GUS (GUS, 2018, 2019, 2020, 2021).

6. Conclusion

Implementing more rational waste management can contribute to the more efficient use of natural resources. It is one of the priorities in the field of environmental protection. The key objectives pursued in the field of environmental protection in the area of waste management include reducing the amount of waste deposited, increasing the mass of waste recycled and other recovery processes, reducing the amount of waste generated, and limiting the negative environmental impact of manufactured products. The implementation of such very important assumptions requires both time and significant financial resources. In Poland, in 2020, expenditure on environmental protection in the field of waste management was 10.5% lower compared to the previous year.

During 2017-2020, disparities in waste generation were noted across the provinces. While the pandemic period, total waste generation (by 0.8% and 3.4% respectively) and industrial waste generation (by 1% and 4.1% respectively) decreased between 2019 and 2020. In the studied period, eight provinces showed an average annual decrease in the amount of total waste and industrial waste generated, namely the *Dolnośląskie*, *Kujawsko-Pomorskie*, *Lubelskie*, *Małopolskie*, *Opolskie*, *Śląskie*, *Wielkopolskie* and *Zachodniopomorskie* provinces.

The amount of municipal waste generated increased annually between 2017 and 2020. In each province there was a positive rate of change in the given scope, however some variation between provinces was also observed. The lowest average annual growth of municipal waste generation was noted in the *Pomorskie*, *Zachodniopomorskie* and *Warmińsko-Mazurskie* provinces.

The main principle of the EU's waste management strategy is to implement closed-cycle economy methods and approaches, to dispose of waste and to reduce the mass of waste sent to landfills.

In the period 2017-2020, in the case of industrial waste, an average annual decrease was noted in terms of recovery and disposal, while the mass of temporarily stored waste increased significantly.

In turn, municipal waste management in certain areas, was characterised by more favourable indicators as there was an average annual increase in recycling and composting. However, unfavourable changes were recorded in thermal processing (negative rate of change) and landfilling (positive rate of change).

The implementation of the EU's policy intentions to move towards a circular economy and the implementation of waste management reforms requires significant financial resources.

In the years in question, the average annual rate of decrease in the volume of expenditure on fixed assets for environmental protection in the area of waste management was 5%. In 2020, in the structure of expenditure on fixed assets for environmental protection, expenditure on waste management accounted for 6.5%. The largest part of this expenditure is allocated to fixed assets for environmental

protection in the field of waste collection and transport as well as disposal and disposal of non-hazardous waste. In the period under analysis, the expenditure incurred for pollution prevention had the highest growth rate, followed by expenditure for hazardous waste neutralisation and disposal and waste collection and transport. However, expenditure on non-hazardous waste neutralisation and disposal showed a mid-term decline.

The possibility of achieving priorities in the field of reduced waste generation, waste disposal and moving towards a closed-circuit economy depends on the financial potential earmarked for action in the areas concerned. It is also important to allocate available funds to the implementation of tasks which bring the greatest and most beneficial effects for the environment. The general objective is to improve the condition of the environment and to manage its resources in a sustainable way through stable, effective and efficient support for undertakings and initiatives serving the environment. It should be stressed that the increase of the ecological awareness of society considerably facilitates the introduction of the concept of rational waste management, yet the implementation of the established priorities also requires time.

References

- Broniewicz, E., Godlewska, J., Lulewic-Sas, A., and Miłasewski, R. (2019). *Ekonomia i zarządzanie w inżynierii środowiska*. Białystok: Oficyna Wydawnicza Politechniki Białostockiej.
- Ciechelska, A. (2009). *Ocena oddziaływania jako narzędzie realizacji zrównoważonego rozwoju*. Białystok: Wydawnictwo Ekonomia i Środowisko.
- Czaja, St., and Becla, A. (2007). *Podstawy procesów gospodarowania*. Wrocław: Wydawnictwo Akademii Ekonomicznej.
- Directive EU 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste, of 30 May 2018, Official Journal of the European Union
- Dmowska, D., and Warechowska, M. (2009). The effect of the municipal waste landfill on the heavy metals content in soils. *Contemporary Problems of Management and Environmental Protection*, (4), 95-105.
- Dobrzańska, B., Dobrzański, G., and Kielczewski, D. (2009). *Ochrona środowiska przyrodniczego* (pp. 277-279). Warszawa: Wydawnictwo Naukowe PWN.
- Eurostat. (2021). *Waste*. Retrieved from <http://www.ec.europa.eu/eurostat>
- GUS (2018, 2019, 2020, 2021). *Ochrona środowiska*. Warszawa: GUS.
- Górka, K., Poskrobko, B., and Radecki, W. (2001). *Ochrona środowiska. Problemy społeczne, ekonomiczne i prawne*. Warszawa: Polskie Wydawnictwo Ekonomiczne.
- Grabowska, G. (2001). *Europejskie prawo środowiska*. Warszawa: Wydawnictwo Prawnicze PWN.
- Manczarski, P., and Juda-Rezler, K. (2010). Zagrożenia związane z zanieczyszczeniem powietrza atmosferycznego i gospodarką odpadami komunalnymi. *Nauka*, (4), 97-106.
- Pezzey, J. C. V., and Toman, M. A. (2002). The economics of sustainability: A review of journal articles. *Resources for the Future*, (02-03), 5-12.
- Poskrobko, B., and Poskrobko, T. (2012). *Zarządzanie środowiskiem w Polsce*. Warszawa: Polskie Wydawnictwo Ekonomiczne.

- Pikoń, K. (2018). *Gospodarka obiegu zamkniętego w ujęciu holistycznym*. Gliwice: Wydawnictwo Politechniki Śląskiej.
- Sonesson, U., Björklund, A., Carlsson, M., and Dalemo, M. (2000). Environmental and economic analysis of management systems for biodegradable waste. *Resources, Conservation and Recycling*, (28), 29-53.

ANALIZA ZMIAN ILOŚCI WYTWARZANYCH I ZAGOSPODAROWYWANYCH ODPADÓW W POLSCE NA TLE ZAŁOŻEŃ UE W ZAKRESIE GOSPODARKI ODPADAMI

Streszczenie: Jednym z problemów ekologicznych obecnego pokolenia jest wzrost ilości wytwarzanych odpadów. Wywierają one niekorzystny wpływ na środowisko i zdrowie człowieka. Stąd tak ważne jest zmniejszanie ich ilości i racjonalne ich zagospodarowywanie. Gospodarka odpadami jest jednym z obszarów ochrony środowiska. W artykule zbadano zmiany ilości i struktury wytwarzanych odpadów w Polsce w latach 2017-2020. Przeprowadzono także analizę wielkości i struktury źródeł finansowania głównych form zagospodarowania odpadów. Celem artykułu jest przedstawienie, porównanie i ocena zmian zachodzących w gospodarce odpadami oraz w źródłach jej finansowania. W badaniach uwzględniono wpływ pandemii COVID-19 na ilość wytworzonych odpadów i na zarządzanie gospodarką nimi. Z przeprowadzonej analizy wynika, że kryzys wywołany pandemią COVID-19 wpłynął na zmniejszenie ilości wytworzonych odpadów ogółem i na wzrost wielkości odpadów komunalnych. Odnotowano również pewne zróżnicowanie w obszarze wytwarzanych odpadów i ich zagospodarowywaniu w poszczególnych województwach.

Słowa kluczowe: odpady, gospodarka odpadami, odpady komunalne, odpady przemysłowe.