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MUNICIPAL WASTE MANAGEMENT IN MUNICIPALITIES IN POLAND – TOWARDS A CIRCULAR ECONOMY MODEL

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ABSTRACT: The aim of the study was to answer the question of to what extent it is possible in Poland to reach the target recycling rates and landfill of municipal waste by 2035 and build a circular economy model (CEM) by 2050. The authors will continue research in this area. In the article, the authors: 1) diagnose EU and Polish legislation in the given area, 2) review the literature with regard to the circular economy, 3) analyse municipal waste streams in Poland and present their forecasts for the period of Poland's approach to the CEM. The data were taken from the public statistics and refer mainly to the period 2013-2021. The study used the method of literature analysis and legal regulations, as well as methods of descriptive analysis and linear extrapolation. The results obtained, albeit aggregated, suggest that it is possible to reach the EU-targeted recycling and landfill level for municipal waste in Poland by 2035 and the CEM by 2050.

KEYWORDS: circular economy, municipal waste, municipality, recycling, landfill

Municipal waste management in a circular economy – literature review

The concept of a circular economy has been present in the specialist literature since the end of the 1960s, yet its modern assumptions were formulated only in the late 1990s by Lyle (1996), indicating the need to reconstruct the natural environment. Other works expounding the concept of a circular economy (CE) include: 1) the theory described as *cradle-to-cradle* or *eco-effectiveness* (Braughart et al., 2007), referring to a circular metabolism, according to which all materials move in an endless biological and technological circulation, where every piece of waste becomes a material for a new product (McDonough & Braungart, 2002), 2) the concept of ecological production (*industrial ecology*) (Stahel, 2016) and of *biomimicry*, in which Nature is seen as a measure for evaluating ethical correctness of technological innovations (Blok & Gremmen, 2016), 3) the concept of functional and service, or an effective economy (Stahel, 2006), 4) the concept of industrial ecology (Lifset & Graedel, 2002), and 5) the system of blue economy (Pauli, 2010).

The implementation and improvement of the CE concept on a wider scale commenced only in the early 21st century, first in Asia (i.e. China, Japan), next in the EU legislation (European Commission, 2014; European Commission, 2015), which was then followed by numerous EU member states (Kulczycka, 2019), including Poland.

Within the EU, the breakthrough in the approach to waste management took place in 2014, with the preparation of the communique entitled "Towards a circular economy: A zero waste programme for Europe" (European Commission, 2014). This meant moving away from the model of a linear economy, "produce, use and throw away" (*cradle to grave*), towards the model of a circular economy (*cradle to cradle)*. This document was further elaborated in 2015 (European Commission, 2015). According to the EU, a circular economy (CE) constitutes "a strategy of development which enables economic growth together with the optimisation of the use of resources, deeply transforming production chains and models of consumption, and redesigns industrial systems at the level of a system". In this way, the European Commission states that it is vital to maintain the value of products, materials and resources in the economy for as long as it is possible and to minimise the production of waste. A circular economy will increase the competitiveness of the EU, protecting enterprises from a shortage of resources and instability of prices, bringing new business and innovation opportunities and more efficient ways of production and consumption. At the same time, this economy will contribute to energy saving and allow us to avoid the irreversible damage caused by the use of resources exceeding the capability of

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the Earth for their renewal. Communication regarding the matter of monitoring a circular economy, indicated the areas which, due to the transformation towards the CE model, should be observed (European Commission, 2018); these areas and indicators for their monitoring are shown in Table 1.

Table 1. Areas and indicators of monitoring the EU countries regarding transformation towards CE

Areas of monitoring	Indicators
Production and consumption	self-sufficiency of the EU in raw materials, green public orders, production of waste, food waste.
Waste management	total level of recycling, levels of recycling regarding individual streams of waste.
Recyclable materials	impact of recycled materials on the demand for raw materials, trade in recyclable materials.
Competitiveness and innovation	private sector investment in CE (work places and gross value added), patents.

Source: authors' work based on Kirchherr et al. (2017); Kulczycka (2018).

The active work of non-governmental organisations, such as the Ellen MacArthur Foundation, and introducing the concept of CE into the strategies and policies of many countries, also in the EU, contributed to the promotion and implementation of the principles of this economic model. This may be why some suggest that it is the practitioners (politicians, business people, consulting companies, associations and foundations) and not the scientists, who had a greater impact on its creation, as was confirmed by the 2021 survey prepared by a group of Indian academics on the basis of publications listed in SCOPUS up to June 2020 (Mhatre et al., 2021). This does not mean that the scientific literature does not provide definitions of CE – in fact, there are several of them highlighting its various aspects, and most of them have been made more precise in recent years.

The most frequently quoted definition of a circular economy came from the Ellen MacArthur Foundation, according to which it is an industrial system, planned and designed as self-reproducing and regenerating, aimed at the use of renewable energy, elimination of toxic chemical substances and waste through a better design of materials, systems and products in business models (Ellen MacArthur Foundation, 2012). Other authors define CE in a similar spirit, stating that it has its roots in industrial ecology, which predicts a form of industrial symbiosis between different entities and production processes, and stresses the benefits from recycling waste materials and

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side products, promoting the minimisation of resources and implementation of cleaner technologies (Andersen, 2007). Along with the concept of the circular system, the economy of circular materials and sustainable management of resources, CE is a paradigm based on the conviction that what was previously seen as waste should now be viewed as potential resources until it is decided otherwise (Park & Chertow, 2014). Production companies collaborate in order to exchange resources, waste, energy and water in such a way that new products can be designed using waste (Thomas & Birat, 2013). Thus it is an industrial system concentrated on closing the loopholes in the flows of resources and energy and contributing to long-term stability, which includes principles and strategies for the more effective exploitation of resources, and at the same time, makes minimum emissions of waste into the environment (Geng et al., 2013). Its purpose is to extend the period of exploitation of resources to maximise their use, with a simultaneous reduction of the environmental impact according to the 3R principle of reducing, reusing and recycling (Tisserant et al., 2017). Hence CE requires integrated management of the supply chain and the use of instruments aimed at stimulating technological changes, and results in the internalisation of the costs of waste management in prices of consumer goods and waste management services, higher profitability and full participation of society in its design. This is a circular economy whose aim is to reduce both the amounts of final waste (after its use) as well as decreased demand for primary resources at the beginning of the circle (production of basic material) (Stahel, 2016).

CE stands for an economy which requires organised economic activities in order to create a backflow of "resources-products-recycled resources" with low exploitation, high use and low emissions. In this economy, all that matter and energy should be used in a sensible and sustainable way, minimising the impact of economic activity on the natural environment (Pin & Hutao, 2007; Heshmati, 2015). It is a strategy of economic development based on appropriate legal and economic instruments and monitoring indicators, both in the progress of its implementation and application of the latest IT solutions. Therefore, it is a global model of economic development promoting eco-innovative solutions, meeting the following assumptions: a) the added value of raw materials/resources, materials and products is maximised in the value chain, i.e. from designer to consumer; b) the amount of produced waste is minimised, and the waste is utilised according to the hierarchy of waste-treatment methods (preventing production of waste, preparation for re-use, recycling, other ways of recuperation, waste disposal) (Kulczycka, 2019).

A circular economy redefines again the models of production and consumption because it is inspired by the rules of ecosystems and reproductive design, which increases resilience, reduces waste and creates common value

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thanks to the increased circulation of both material and non-material flows (Circular Academy, 2022). It is, in principle, a reproducing and regenerating economy, which aims at maintaining products, components and materials at the highest level of usefulness and value all the time. The future of CE is a reality in which waste does not exist, loopholes of resources are closed, and products are subjected to indefinite recycling. This is the economy which is constantly evolving without the input of non-sustainable resources (Cullen, 2017). The economic and ecological value of resources is maintained as long as possible by 1) retaining them in the economic system, or 2) extending the life of products made from them, or 3) putting them back into the system to re-use them. The concept of waste does not exist in CE anymore because products and resources are re-used and endlessly processed (Den Hollander et al., 2017), hence its other description as the *cradle to cradle* model (Hryb & Ceglarz, 2021). The CE model is implemented on three levels (macro, meso and micro), stressing the achievement of goals both in terms of ecology and economic efficiency (Zhu et al., 2010). To sum up, it can be said that today CE is no longer a concept but a global business model. It stands for effective management of resources and, above all, a new model of the economy, seeking *win-win* solutions – effective economically and ecologically (Kulczycka, 2019).

Municipal waste and its management in the Polish and EU legislation

Economic activity and functioning of society at this stage of growth bring with them the creation of 'rubbish' (things used-up and damaged) as well as waste (unused post-production remainder of raw materials and post-consumption remains). Polish legislation (Act, 2012) recognises 'waste' as a substance or object which the owner wants to be rid of gets rid of or is obliged to do so. Annually there are around 135 mln tonnes of waste produced in Poland, classified into 20 groups. However, in line with the main classification (according to the place of origin), waste can be industrial (resulting from a production activity) or municipal. The former, industrial, amounts on average to 91.5% of all the waste, out of which over half results from mining and excavation activities, while the latter, municipal, constitutes from 8.5% to 10% of the waste produced in general (Hryb & Ceglarz, 2021).

Municipal waste (Act, 2012) comprises waste generated by households and other producers of waste, which due to its nature and composition, is similar to household waste. Municipal waste does not include the following types of waste from 1) industrial production, agriculture, forestry, and fisheries, 2) septic tanks, 3) sewage system and sewage processing plants, includ-

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ing sewage sludge, 4) vehicles withdrawn from use, and 5) construction and demolition. Bearing in mind the ways of waste collection, it can be divided into: collecting selectively (paper and cardboard, glass, metals, plastics, organic waste, wood, textiles, packaging, discarded electric and electronic equipment, used-up batteries, and large-size waste (including mattresses and furniture), and unsorted waste (mixed). In the literature, one can also find the classification according to the place of generating waste (sorted – from residential housing, waste from gardens, parks and cemeteries, other municipal waste – i.e. mixed, large-size waste, as well as waste from open-air markets, street cleaning and drains) (Hryb & Ceglarz, 2021).

There are three terms strictly linked with municipal waste: waste management, municipal waste management and a system of municipal waste management. Despite their apparent similarity, they are not identical. Waste management comprises producing waste and managing it (Act, 2012). Municipal waste management comprises a series of processes related to: a) collection – gathering waste, including preliminary sorting and preliminary storing waste prior to its transport to the waste-processing plant (Directive, 2008), b) transport – involves processes of recuperation and disposal, including the preparation preceding the recuperation or disposal (Directive, 2008), c) processing, d) procedures in places of waste disposal, and e) municipal waste trading. Waste management should be conducted in a way ensuring the protection of life and health of people and the environment. In particular, it must not: pose a threat to water, air, soil, flora and fauna; cause nuisance by noise and odour; or bring undesirable effects for rural areas and places of special importance, such as cultural and environmental. Therefore, one should first prevent generating waste and then undertake actions aimed at its re-use, next subject it to recycling, and when that cannot be carried out, initiate other processes of reclaiming. Finally, after applying the previously mentioned methods, the remainder should be disposed of.

In Poland, management of municipal waste is the responsibility of the unit of local government closest to residents, namely 'gmina' (a municipality or a commune) (Act, 1996). These units were obliged to organise the collection of household waste from local residents (Act, 1996), while collecting waste from the non-residential property is optional (Act, 1996). Hence the duty of a municipality is to: define the rules of maintaining cleanliness and order, the way of collecting and gathering waste by its residents, collecting charges for the management of municipal waste, outsourcing to companies – by means of public tender – the collection of waste from residents and transporting it to the regional plant for processing municipal waste, maintenance and exploitation of municipal facilities, as well as storing and utilisation of waste.

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In Poland, there is no legal definition of the system of management of municipal waste, therefore only attempts at defining this concept can be found in the literature, which suggests that it is an organisational and technical system which offers the possibility of the correct management of municipal waste, not generating excessive (unjustified) costs (Jerzmański, 2011). This concept is strictly linked to financial flows from the management of municipal waste, namely collecting charges and incurring costs.

The management of municipal waste is of crucial importance for the European Union. Its main directions were already set in 1975 in the directive of the European Economic Community (Directive, 1975), which since then has been already updated a few times (Directive, 1975; Directive, 1991; Directive, 2006; Directive, 2008). The directive set out the fundamental directions in respect of waste management, which include: 1) establishing general principles of control of waste disposal on the national scale, 2) assuming that the main purpose is the minimisation of waste generation, the introduction of 'clean technologies', wide implementation of recycling and the use of waste as a source of energy, 3) launching products such that their usage and/or final disposal would not have any or merely minimum impact on the increase of amounts and harmfulness of waste. In its resolution (Council Resolution, 1997), the Council confirmed that the top priority in the management of waste should be preventing its generation, and that re-use and recycling should come before the production of energy from waste, and if so then only to the extent in which these are the most ecological among the available methods. In turn, in the preamble to the directive currently in force by the European Parliament and the EU Council (Directive, 2008), it is stated that the main objective of any policy regarding waste should be a reduction of the negative effects of its production and management for human health and the natural environment (in Germany, Japan and China, the legislation in this respect arrived much earlier – Mathews & Tan (2016)). The policies regarding waste should also aim at restricting the use of resources and favour a practical implementation of the hierarchy of waste processing. The recommendations of the directive should aid the EU in approaching the state of a "recycling society", striving for the elimination of waste production and using waste as one of the resources. In particular, the 6th EU programme of action regarding the environment requires the introduction of means to ensure the segregation of waste at source and the collection and recycling of the priority streams of waste. In line with this objective, and at the same time as a means of facilitating and improving the potential of its recovery, waste should be collected selectively if this is carried out technically, economically and ecologically correctly, and then subjected to the appropriate procedures.

The issue of the compatibility of the terminology used in Poland in terms of waste management with that accepted in the EU is of vital importance for

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the harmonisation of Polish legislative regulation. The already obsolete Act on waste dated 27 April 2001, together with other regulations addressing the subject of waste, was based on the amended, in relation to the earlier regulations, conceptual apparatus already adapted to the EU legislature. This is in line with the current law (Act, 2012), containing regulations concerning the prevention of waste production and reducing its amounts in order to reach the state of a circular economy. In terms of municipal waste, the regulations regarding the transformation into a circular economy had appeared earlier in the Polish legislation, in the amended law on the maintenance of cleanliness and order in municipalities (Act, 2011). According to that law, by 16 July 2020 communes were obliged to reduce the mass of biodegradable municipal waste transferred for storage, in relation to the amounts produced in 1995 (Act, 2020). The detailed regulations in this aspect were issued in 2012 (Regulation, 2012; Regulation, 2017), in which the indicated level was to be reached over a period of some years (Table 2).

Table 2. Levels of reduction in the mass of biodegradable municipal waste for storage

Year	Reference levels (minimum)
2012	75% weight-wise
2013	50% weight-wise
2014	50% weight-wise
2015	50% weight-wise
2016	45% weight-wise
2017	45% weight-wise
2018	40% weight-wise
2019	40% weight-wise
2020	35% weight-wise

Source: authors' work based on Regulation (2012); Regulation (2017).

The law on the maintenance of cleanliness and order in municipalities (Act, 2020) introduced new levels for recycling and preparation for re-use of municipal waste. Thus in 2020, communes were obliged to reach the level of: 1) preparation for re-use and recycling of the following shares of waste: paper, metals, plastics and glass at minimum 50% weight-wise; 2) recycling, preparation to re-use and recovery with other methods of other than dangerous construction and demolition waste constituting municipal waste at a minimum of 70% weight-wise. The levels of preparation for re-use and recycling, and of storing municipal waste including biodegradable mass, applicable after 2021 are shown in Table 3.

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Table 3. Obligatory levels of recycling and storing municipal waste in Poland since 2021

Year	Levels of preparing for re-use and recycling of municipal waste (the minimum of)	Levels of storing municipal waste (no more than)
2021	20% weight-wise	No directives
2022	25% weight-wise	
2023	35% weight-wise	
2024	45% weight-wise	
2025	55% weight-wise	30% weight-wise
2026	56% weight-wise	
2027	57% weight-wise	
2028	58% weight-wise	
2029	59% weight-wise	
2030	60% weight-wise	20% weight-wise
2031	61% weight-wise	
2032	62% weight-wise	
2033	63% weight-wise	
2034	64% weight-wise	
2035 and after	65% weight-wise	10% weight-wise

Source: authors' work based on Act (1996).

The level of preparation of municipal waste for re-use and recycling (P) is calculated as the ratio of the mass of municipal waste prepared for its reuse and subjected to recycling (Mr) to the mass of the generated municipal waste (Mw). When calculating such a level, not included are other than dangerous construction and demolition waste constituting municipal waste (Regulation, 2021). The level of storage (S) is calculated in accordance with the regulations stipulated in the executive decision of the EU Commission (Commission Implementing Decision, 2019), as the ratio of the mass of municipal waste and waste originating from the stored municipal waste (Mw) – from 2023 onwards the amounts of Mr and Mw will be given in Mg. To calculate the levels of the storage of waste after 2023, the mass of waste will not include waste generated during recycling or other recovery processes, which is then stored.

Methodology and research results

Starting out from the viewpoint of the need to reduce the amounts of the generated, and in particular of the stored waste, the authors of this study

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focused on the empirical verification of data representing the volume of the waste collected and processed in Poland over recent years, compared to other EU countries. The research covered the period from 2013 to 2021; however, some data apply to shorter periods of time. In order to demonstrate the changes related to the mass of generated and processed waste, including the sorted waste, according to the main shares of waste stored, recycled and re-used, the study used the processed and aggregated series of data, based on the official statistics of the Statistics Poland (GUS), from its database on waste, and from EUROSTAT. The calculations were carried out jointly for all the communes in Poland, including the spatial aspect (divided into regions [voivodeships]). The authors are aware that the presented values constitute averaged data and may significantly differ in individual communes. The statistical error and the model-fitting error are also present in the projections regarding the mass of municipal waste, which will be collected, recycled and stored over the period 2022-2035 and then up to 2050. The methods used in the study included the methods of descriptive analysis of selected elements (analyses of structure, dynamics, and trend), as well as linear extrapolation.

According to EUROSTAT, the level of municipal waste generated per capita in the EU countries over recent years is clearly varied, and the span of differences is very large (Table 4). In 1995 it spanned from 220 kg (Croatia) to 694 kg (Bulgaria) per person, and in 2020 from 287 kg (Romania) up to 834 kg (Austria). The largest increase in the mass of municipal waste occurred in this period in Croatia (90.4%), and the largest decrease was in Bulgaria (36.0%).

Table 4. Annual mass of generated municipal waste per capita in the EU in 1995-2020, and their changes [in kg]

Countries	1995	2000	2005	2010	2015	2020	Change 2019/1995 [%]
EU	467	513	506	503	480	505	8.2
Austria	437	580	575	562	560	834	33.9
Belgium	455	471	482	456	412	746	-8.6
Bulgaria	694	612	588	554	419	444	-36.0
Croatia	220	262	336	379	393	418	90.4
Cyprus	595	628	688	695	620	609	2.3
Czechia	302	335	289	318	316	543	67.7
Denmark	521	664	736	758	822	814	62.2
Germany	623	642	565	602	632	628	1.4
Estonia	371	453	433	305	359	383	-0.7
Finland	413	502	478	470	500	596	44.4

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Countries	1995	2000	2005	2010	2015	2020	Change 2019/1995 [%]
France	475	514	529	534	516	538	12.8
Greece	303	412	442	532	488	525	73.1
Hungary	460	446	461	403	377	403	-21.0
Ireland	512	599	731	624	557	555	8.4
Italy	454	509	546	547	486	487	11.4
Latvia	264	271	320	324	404	478	80.8
Lithuania	426	365	387	404	448	483	13.4
Luxembourg	587	654	672	679	607	790	34.4
Malta	387	533	625	623	641	643	66.1
Netherlands	539	598	599	571	523	533	-0.8
Poland	285	320	319	316	286	346	21.6
Portugal	352	457	452	516	460	513	45.7
Romania	342	355	383	313	247	287	-16.1
Slovenia	596	513	494	490	449	487	-18.3
Slovakia	295	254	273	319	329	433	47.0
Spain	505	653	588	510	456	455	-10.1
Sweden	386	425	479	441	451	431	11.7

Source: authors' work based on Eurostat (2022).

The mass of municipal waste collected in communes in Poland since 2013 is clearly on the increase (Figure 1), but importantly since 2019, a growing amount of it has been subject to sorting, which means that less of it is stored. Over the analysed period (taking 2013 as the point of reference), the combined mass of collected municipal waste increased by 50%, while the sorted waste by as much as nearly 330%.

The mass of municipal waste collected in communes clearly differs among voivodeships (Figure 2). The largest amounts, both in the first and the final year under study, were collected in four voivodeships in Poland (namely: mazowieckie, śląskie, wielkopolskie and dolnośląskie), which is strictly linked to the population number, its density and financial status of residents. The smallest amounts of municipal waste are collected in voivodeships located in the east of Poland (podlaskie, podkarpackie and warmińsko-mazurskie), which is connected with their agricultural production and tourism. Over the studied period, one can observe significant changes in the amounts of municipal waste per capita collected in the communes (Figure 3).

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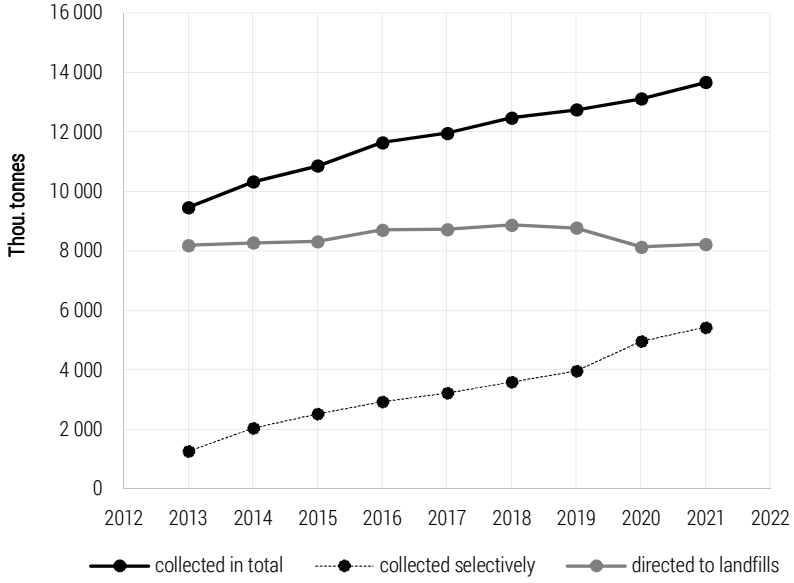

Figure 1. Municipal waste in Poland in 2013-2021 [in thou. Tonnes]
Source: authors' work based on GUS (2022).

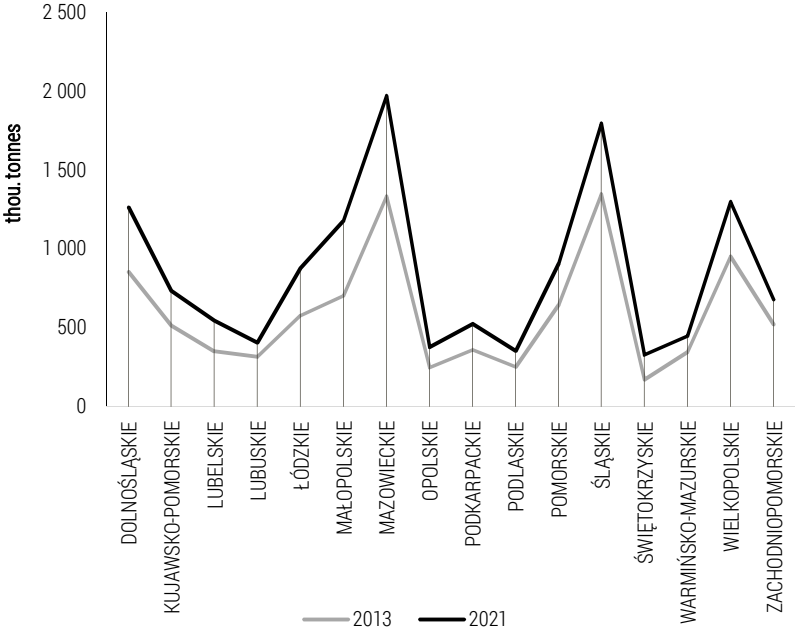

Figure 2. Municipal waste collected in 2013 and 2021 [by voivodeship in thou. Tonnes]
Source: authors' work based on GUS (2022).

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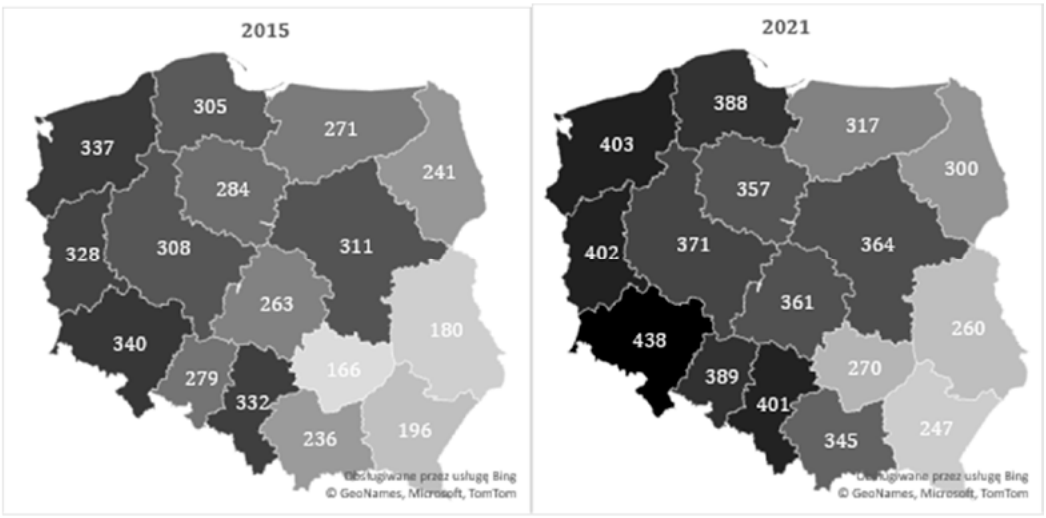

Figure 3. Mass of municipal waste produced in Poland in 2015 and 2021 [per capita in kg]
Source: authors' work based on GUS (2022).

In 2015 and 2021, the largest amounts of municipal waste were collected by residents of the following voivodeships: dolnośląskie, zachodniopomorskie, śląskie and lubuskie (in 2015 more than 320 kg, and in 2021 400 kg), whereas in the same period, the mass of municipal waste produced per person in three voivodeships (podkarpackie, lubelskie and świętokrzyskie) did not exceed 200 kg in 2015, and 300 kg in 2021.

Despite the annual increase in the amounts of produced municipal waste (by over 40% in 2021 compared to 2013), similar amounts were stored in landfills (Figure 4), while there was a significant increase in the mass of waste collected selectively. During these years, the relation between the amounts collected without sorting and those collected selectively was very strong, indicating that there is a growing amount of collected municipal waste suitable for recycling.

The projection up to 2035 of data regarding the mass of collected municipal waste according to its designation (Figure 5) demonstrates the great speed of growth in Poland of the mass of municipal waste designated for fermentation and composting (the goodness-of-fit of the function of linear regression is R^2=0.9618). There will also be a relatively quick increase in the mass of municipal waste designated for recycling (goodness-of-fit of the regression function is R^2=0.7732). Time is not entirely a determinant of the mass of municipal waste stored in landfills (it should be a slower increase).

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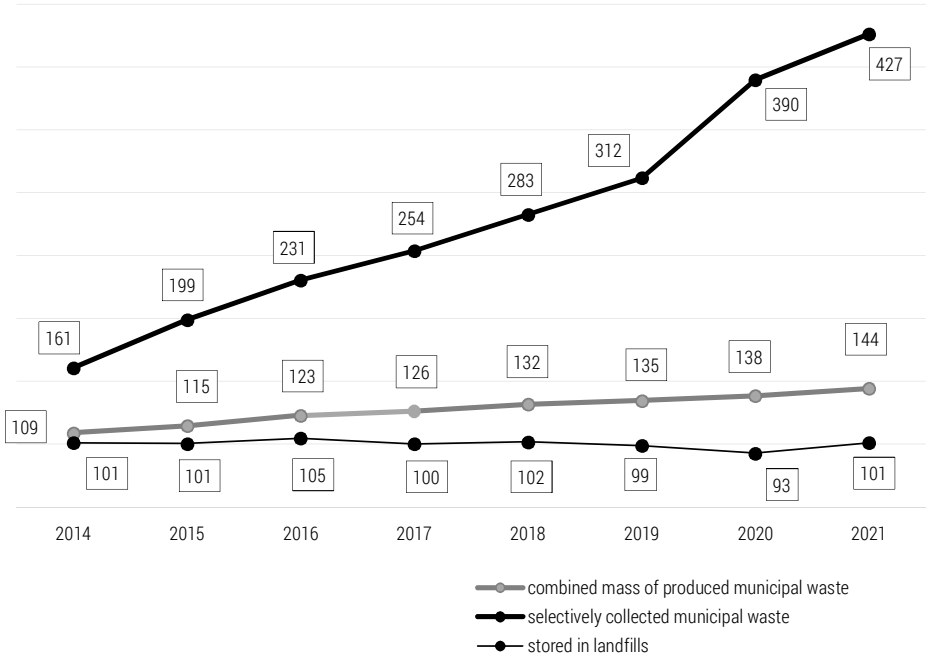

Figure 4. Changes in the amounts of waste produced, selectively collected and stored in municipal landfills in Poland in 2014-2021 [2013=100, in %]

Source: authors' work based on GUS (2022).

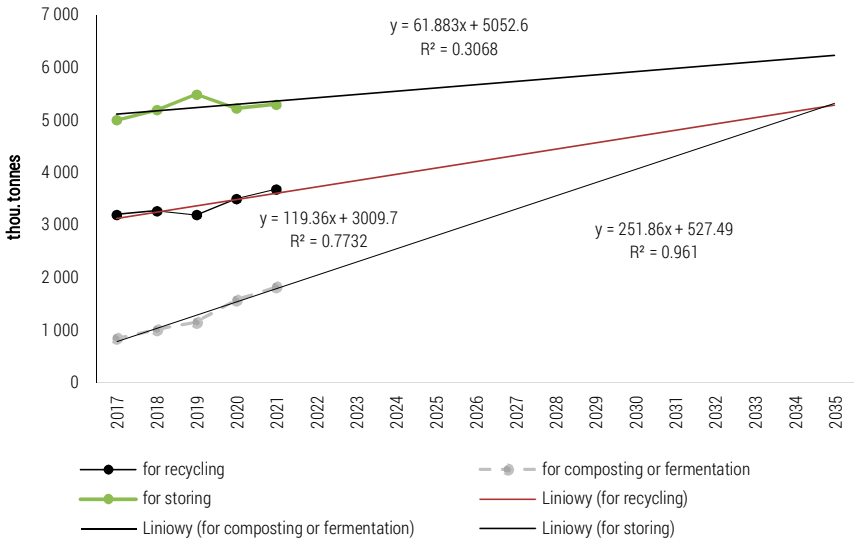

Figure 5. Mass of collected municipal waste according to designation in 2017-2021 and the projection up to 2035 [in thou. tonnes]

Source: authors' work based on GUS (2022).

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These data suggest that residents of communes in Poland are becoming increasingly experts at the segregation of municipal waste. In the period 2013-2021, there was a growing trend in the level of four distinguished categories of waste collected selectively (Figure 6). This applies to the greatest extent to biodegradable (an increase from 312 thousand tonnes in 2013 to 1.843 thousand tonnes in 2021) and glass (from 316 thousand tonnes in 2013 to 784 thousand tonnes in 2021).

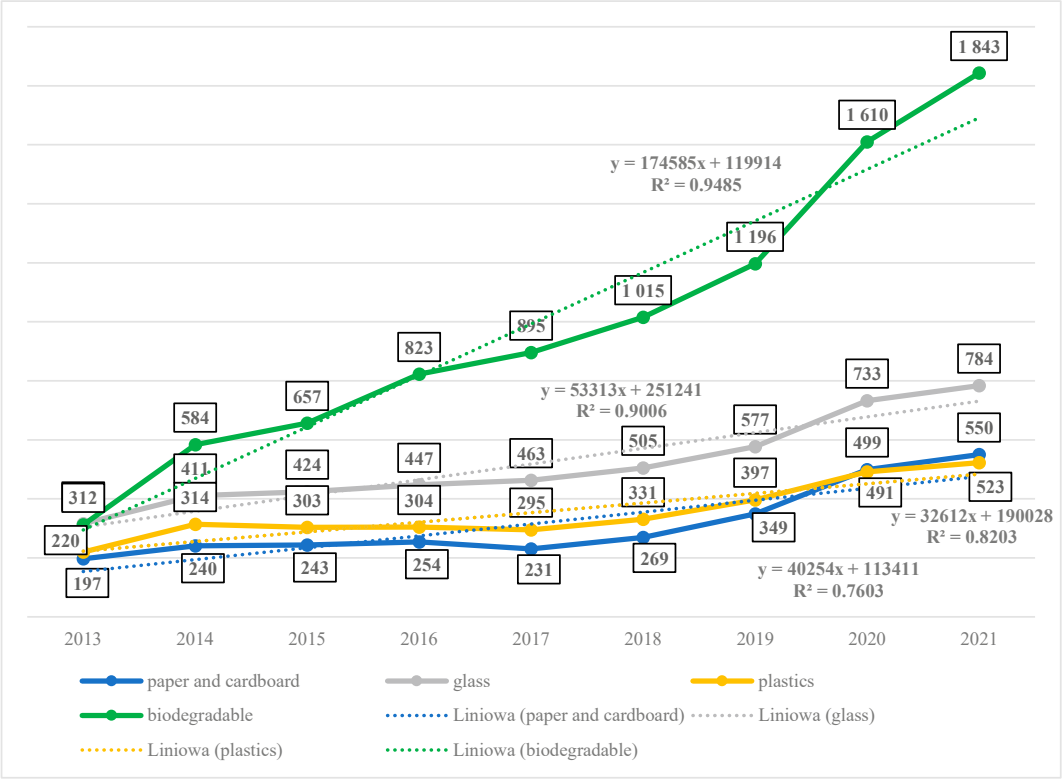

Figure 6. Municipal waste selectively collected in Poland in 2013-2021 [by segment, in thou. tonnes]

Source: authors' work based on GUS (2022).

The level of sorting municipal waste differs in individual voivodeships in Poland (Figure 7). In 2013, sorted waste constituted from 7.3% (podlaskie) to 16.4% (świętokrzyskie) of the combined pool of collected municipal waste, while in 2021, this was already from 32.3% (świętokrzyskie) to 50.0% (lubelskie). Municipal waste designated for recycling (Figure 8) from the four seg-

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ments (paper and cardboard, metals, glass, plastics) in 2013 amounted from 4.3% (podlaskie) to 13.9% (świętokrzyskie) of the combined mass of collected municipal waste, and in 2021 from 10.4% (opolskie) to 18.0% (lubelskie). The projection regarding the mass of municipal waste designated for recycling from the four segments in the combined pool of collected municipal waste up to 2035 (based on data from 2003-2021) indicates that it will exceed the level of 20% (Figure 9).

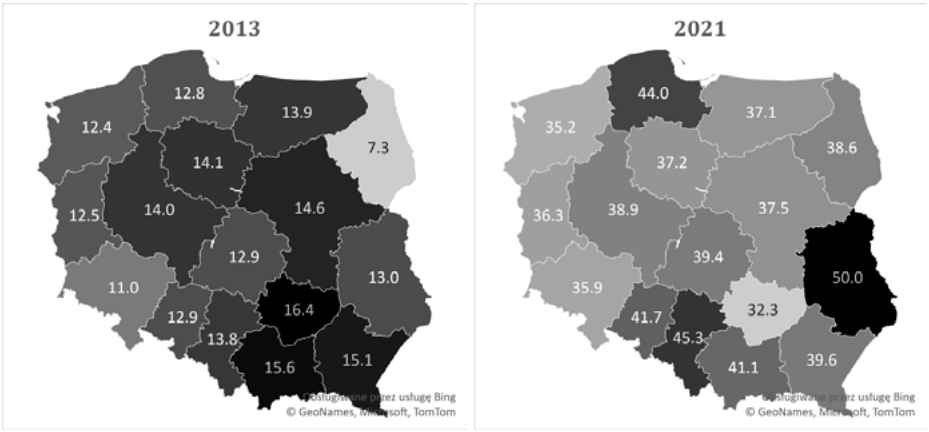

Figure 7. Municipal waste collected selectively in Poland in 2013 and 2021 [% of general municipal waste]

Source: authors' work based on GUS (2022).

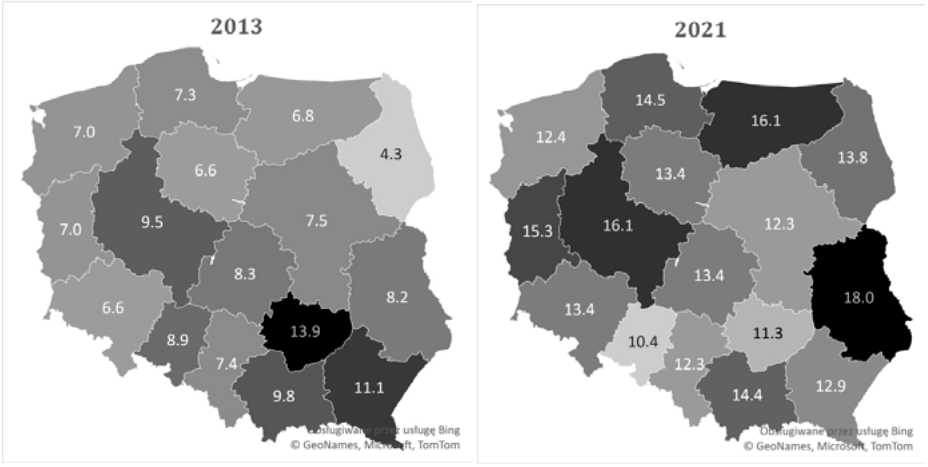

Figure 8. Share of paper and cardboard, metals, glass and plastics in a combined pool of municipal waste collected in Poland in 2013 and 2021 [by voivodeship, in %]

Source: authors' work based on GUS (2022).

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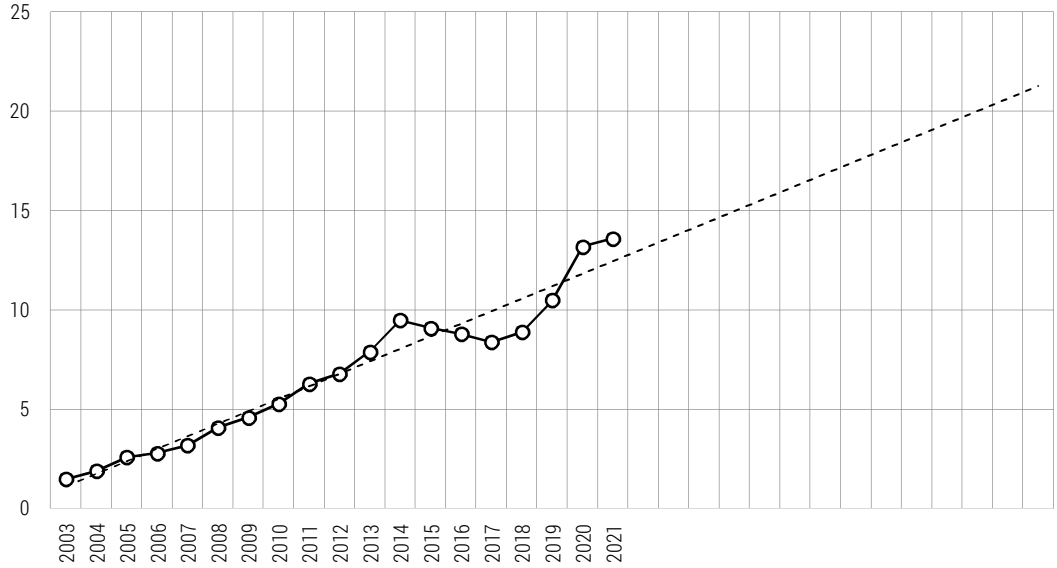

Figure 9. Share of paper and cardboard, metals, glass and plastics in a combined pool of collected municipal waste in Poland in 2003-2021 and the projection up to 2035 [in %]

Source: authors' work based on GUS (2022).

The projection – based on historical data – for all municipalities in Poland as to (1) the level of preparation of municipal waste for re-use and recycling, and (2) the amounts of stored municipal waste (Figure 10) allow to hope that they will reach in 2035 the amounts required by the EU regulations. In individual municipalities, the situation may greatly differ, and this may result in incurring fines imposed due to not respecting these duties, which were already given by regional inspectorates for environmental protection in 2022. For example, the Pomorski Wojewódzki Inspektor Ochrony Środowiska (in the pomorskie voivodeship) already imposed this year fines amounting to PLN 3.4 mln on communes which did not fulfil their duty of achieving the required indicators for the year of 2020. In that region, out of 123 municipalities, 79 did not meet the requirements of preparation for re-use and recycling of municipal waste in the following segments: paper, metals, plastics, and glass. At the same time, 37 did not achieve the requested levels regarding other than dangerous construction and demolition waste constituting municipal waste, while 13 municipalities did not meet the requirements regarding the reduction of biodegradable municipal waste designated for storage. This resulted in the regional inspectorate imposing the fines of nearly PLN 3.4 mln.

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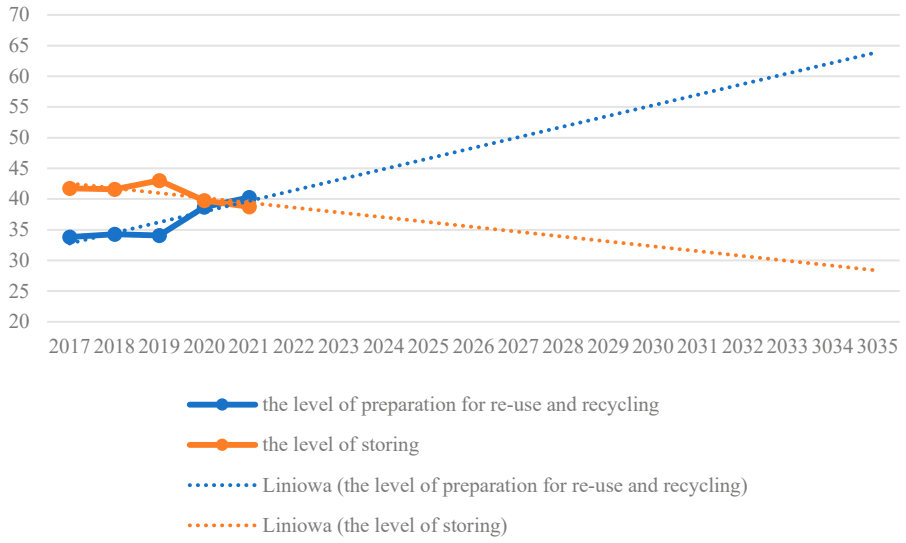

Figure 10. Preparation of municipal waste for its re-use, recycling and storage in Poland in 2017-2021, and the projection up to 2035 [in %]

Source: authors' work based on GUS (2022).

Conclusion and recommendations

The considerations presented in this paper lean towards the following conclusions:

- waste, including municipal waste, constitutes an integral part of the functioning of modern economies and societies, which as a result of implementing diverse solutions and technologies, produce increasing amounts of waste while the limited resources and storage space enforce carrying out actions aimed at not merely limiting the amounts of the produced and stored waste, but also increasing the pool of those which are suitable for re-use as well as the implementation of the model of a circular economy,
- the mass of municipal waste produced per capita in the EU oscillated in 2020 between 287 kg (Romania) to 834 kg (Austria), while in the period 1995-2019, the amount of produced municipal waste per capita increased in the majority of the countries (mostly Croatia – by 90.4%), even though some countries managed to reduce it during that time (mostly Bulgaria, Hungary and Slovenia),
- the EU obliged its member states to limit the level of stored municipal waste and to increase its re-use and recycling by 2035 and by 2050 to

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enter the stage of a circular economy, as reflected in the existing and already executed legal regulations,

- in Poland in the period 2013-2021, one could observe an increase in produced and collected amounts of municipal waste (per capita in 2015 from 166 kg to 340 kg, and in 2021 from 247 kg to 438 kg), including sorted waste globally, even though this was spatially differentiated (in 2013 from 7.3% to 16.4%, in 2021 from 32.3% to 50.0%), while during that time a comparable mass of municipal waste was placed annually in landfills,
- communes in Poland are accumulating a growing mass of biodegradable municipal waste which is not placed in landfills, as well as recovered glass, paper and cardboard, plastics and metals, but these amounts vary in individual voivodeships (from 4.3% to 13.9% of the combined pool of the collected municipal waste in 2013, and from 10.4% to 18.0% in 2021),
- the projection of data regarding the share of paper and cardboard, metals, glass and plastics in the combined pool of the collected municipal waste in Poland by 2035, and also the assumed levels of preparation for its re-use and recycling, as well as storage, allows to hope that the amounts of stored and re-used municipal waste assumed in the EU regulations will be met in Poland, but it is difficult to foresee whether this will be possible in every commune, due to various considerations.

Bearing in mind the above, one can formulate the following recommendations:

- there are numerous determinants which may decide about the fact whether the levels of recycling and storage of municipal waste required by EU regulations will be met in Poland, yet not all of them are of a systemic character which means that local authorities of every commune will have to decide, appropriately and individually, how to organise the management of municipal waste to meet the set objectives,
- the management of municipal waste comes at a cost, and only a few municipalities manage to balance their revenues and costs of the system of managing their municipal waste; nevertheless, they should not skimp on means for ecological education,
- the key to success in reaching the assumed levels of recycling and re-use, and the storage of waste, is the education of citizens in this respect, as well as clear directives regarding the conditions in which the waste can be considered municipal waste suitable for re-use, and how to proceed in order that landfills (and no other places) could receive diminishing amounts of municipal waste; it is necessary to build the ecological awareness of society (consumers and producers of goods),

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- young people provide a chance to create a circular economy in terms of the management of municipal waste, as their concern for the environment, segregation of waste, and pro-ecological attitude in life are something which is both natural and desirable.

The contribution of the authors

Conceptualization, J.K. and H.Ż.; literature review, J.K. and H.Ż.; methodology, J.K. and H.Ż.; formal analysis, J.K. and H.Ż.; writing, J.K. and H.Ż.; conclusions and discussion, J.K. and H.Ż.

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