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Circularity and Municipal Waste in Romania
An Evaluation between 2011 and 2021

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Abstract. *With the aim of moving to a circular economy, as specified in the European Union amending Directive 2018/851, by the year 2025, member states must reach a level of at least 65% by weight in the preparation for reuse and recycling of municipal waste, with the possibility of a 5-year postponement, under certain conditions. However, the generation of municipal waste has registered an increasing trend, due to the low recycling rates in many member states of the European Union, the low inefficiency of the collection systems and the poor implementation of the legislation in force. Through the research carried out, we want to highlight the trends regarding the generation, treatment, and recycling rates of municipal waste in Romania, in the period 2011-2021, but also the degree of fulfillment of the assumed targets regarding municipal waste. For this, we used the European databases available for the indicators selected in the research, as indicators of a circular economy. The analysis undertaken showed that in the last decade the amount of municipal waste per capita has increased, but it is far below the European Union average. Regarding the treatment of municipal waste, it is noted that the main operation is still landfill disposal and other similar operations, with an increasing trend compared to the base year of the analysis and contrary to the specifications of the European Union Framework Directive on waste, according to which waste disposal should be the last choice, when we consider the hierarchization of waste. The recycling rate of municipal waste was only 11.3% in 2021 and put Romania in last place in the ranking of the member states of the European Union. The bio-waste recycling rate did not have good values either; this was 14 kilograms per capita, decreasing in the analyzed period and well below the European Union average.*

Keywords: municipal waste, municipal waste generation, municipal waste treatment, recycling rate, targets, circularity, sustainability.

Introduction

The circular economy or circularity is the economic model desired by the European Union to replace the traditional linear model, with the aim of achieving a more competitive economy, but with the protection of the environment, the reduction of waste and the encouragement of recycling. In a circular economy, we will deal with a reduction in the materials used in production, because we try to recondition and reuse them as new resources for further manufacturing processes. At the same time, if the traditional linear model assumed a limited lifetime of the products, the circular model implies either the reconditioning of the product, or retaining end-of-life product materials and reusing them as often as possible. Thus, there will be less waste, and the life cycle of the products will be longer.

One of the specific policies of the circular economy is that of waste and recycling. The European Union's waste policy and the European Green Deal support the transition to a competitive, circular economy by extracting good resources from waste and managing it effectively. The legal basis of the European Union for the treatment and management of waste is the Waste Framework Directive, which also includes the concept of waste hierarchy, with 5 levels: waste prevention (as the first option), preparation for reuse, recycling, recovery and disposal (as last option).

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Municipal waste is an important category in the general approach to waste and recycling, especially through the consumption pattern (of each individual state or of the urban-rural demarcation), but also of the complex sources of generation and treatment. Directive 2008/98/EC (consolidated version, amended by Directive (EU) 2018/851) defines municipal waste as "waste collected from households, such as paper, cardboard, glass, metals, plastics, bio-waste, wood, textiles, packaging, waste electrical and electronic equipment, waste batteries and accumulators and bulky waste, mattresses and furniture", but also "waste collected from other sources, which have a similar nature/composition to household waste".

To support the transition to a circular European economy, according to the municipal waste targets specified in Directive 2008/98/EC (consolidated version, amended by Directive (EU) 2018/851) the member countries of the European Union must reach by 2025 a level of at least 55% by weight for preparation for reuse and recycling of municipal waste. Until 2035, the level will increase by another 5% every 5 years, reaching a target of 65%. Member States may request a postponement by up to 5 years, if they show that less than 20% was prepared for re-use and recycled or landfilled more than 60% of its municipal waste generated in 2013, as reported in the OECD-Eurostat questionnaire. In this situation, the targets will be at least 50%-55%-60% for the years 2025-2030-2035. The European Commission will also prepare reuse targets for municipal waste, municipal bio-waste recycling, but also targets for reuse and recycling of new categories of waste.

Municipal waste is part of Romania's National Waste Management Plan (NWMP) established in 2017, which aims to manage waste with minimal negative impact on the environment and includes action plans up to the level of 2025. This type of waste is the only one for which the type and capacities of new facilities are included in the NWMP. The NWMP also includes the National Waste Prevention Programme. Also, the objectives of the NWMP have the role of completing the objectives specified in the National Waste Management Strategy (NWMS), which was revised in 2013 and covers the period 2014-2020 regarding waste management. In the NWMP, on municipal waste, it is specified that the objective regarding preparation for reuse and recycling of municipal waste is set at 50% by weight by the year 2025 according to the proposal to amend the Directive 2008/98/EC on waste. For the objective of disposing of no more than 10% of municipal waste by 2030 contained in the Circular Economy Package, Romania can obtain a 5-year postponement, if it shows that it is taking all measures to reduce municipal waste disposed of by storage to 20% of the total generated. By 2020, the disposed municipal biodegradable waste should reach 35% of the total amount, expressed gravimetrically, produced in 1995, according to the objectives set out in the national legislation part of the NWMP.

The main question of our research is the following: *Does the time horizon of 2025 seem plausible for the fulfillment of the targets assumed by Romania regarding municipal waste, as part of the circular economy?*

Two operational hypotheses will be formulated in our research:

Hypothesis 1: The favorable evolution of the analyzed indicators will show the increased possibility of reaching the assumed targets.

Hypothesis 2: The unfavorable evolution of the analyzed indicators will show the possibility of not reaching the assumed targets.

To highlight the trends regarding municipal waste in Romania and the degree of fulfillment of the assumed targets, we proposed to analyze the dynamics of the evolution of the main indicators specific to the transition to a circular economy, with low carbon consumption for the period 2011-2021. The introduction of the paper is followed by three sections. The first section concerned the review of the scientific literature and the specific methodology, in which we analyzed articles,

materials and documents relevant to the researched topic. The section specific to the methodology followed, in which we presented the four indicators used in the research and the section in which we presented the results and discussions regarding the treated subject. The analysis was completed by conclusions, through a synthetic presentation of the main contributions brought by this research, by mentioning the novelty elements.

Literature review

Literature review regarding municipal waste in the EU states

Studies on the issue of municipal waste and economic circularity are extensive and complex. In the context of our research, we will refer to a series of works on municipal waste in the European Union and its member states, in order to later conclude what is the position of Romania in relation to the performances recorded by the other states, in its capacity as a member of the European Union.

The most recent studies show that at the level of the member states of the European Union there are differences in the efficiency of progress on achieving a European circularity through waste management, having as influencing factors education, living standards and population density, as concluded by Marques and Mendes Teixeira (2022). Also, Ríos and Picazo-Tadeo (2021) noticed differences between member states, but also low performances, in direct relation to the level of development; they concluded that countries in central and northern Europe, such as Germany, Sweden or Finland, have better results in the treatment of municipal solid waste, while countries in eastern Europe and some in southern Europe have poorer results. Banacu et al. (2019) show in the analysis carried out between 2010 and 2017 on the countries of the European Union, that the recycling rates of municipal waste are directly influenced by investments in research and development, both private and those made by the authorities.

Analyzing municipal waste management in Poland in the context of a circular economy, Smol et al. (2020) said that municipal waste generated, and the recycling rate have increased in recent years, but are below the European Union average. That is why the infrastructure needed to treat waste should be improved, and citizens should be encouraged to support the implementation of the adopted measures. Traven et al. (2018) show that in Croatia the production of municipal solid waste has increased, but is lower than in other European Union states, being correlated with economic activity. At the same time, the authors say that the recycling rate is low (about 15%) and over 80% of the waste is landfilled.

Observing the works on Romania are necessary in our analysis, to be able to compare with the results obtained by us and to frame the situation of Romania in the general landscape as best as possible. Stan (2022), according to an analysis between 2000 and 2020, claims that both Romania and Bulgaria face a series of shortcomings in waste management, due to the incomplete transposition of European directives into the country's legislation, as well as existing non-compliant landfills. Petrescu et al. (2022) support the idea of the influence of household consumption on the amount of waste, but also of business environment policies and public education programs offered by local authorities in Romania. In addition, the latter also contribute to increasing recycling rates. Dobre-Baron et al. (2022) note that although the selective collection of waste and recycling are extremely important operations in reducing the impact on the environment, in Romania a small share of municipal waste is recycled. The authors reinforce the importance of implementing the European legislative framework and changing society's attitude towards sustainable development.

Theoretical-methodological approaches regarding the indicators selected for research

The generation of municipal waste per capita is an indicator used by Eurostat in the section dedicated to the analysis of the circular economy, in the part on production and consumption. It measures waste generated by households and similar waste, collected by authorities (directly or on their behalf) and disposed of through the municipal waste management system. The analysis of the evolution of municipal waste generation per capita reflects the degree of waste prevention and the consumption pattern of the population. Thus, a reduction in waste generation will mean an increase in preventive measures, but also a positive change in consumption behavior.

Recycling rate of municipal waste is the second indicator used in our research. Found in Eurostat statistics also in the section dedicated to the analysis of the circular economy, but in the part on waste management. This will measure the percentage of municipal waste recycled in the total municipal waste generated. The analysis of the recycling rate of municipal waste reflects the quality of waste management, being related to the use as a resource in the circular economy of municipal waste, through recycling, composting, anaerobic digestion and preparation for re-use.

Bio-waste recycling is the third indicator used, found in the circular economy section of Eurostat, as part of waste management, alongside the previous indicator. According to the Eurostat methodology, bio-waste recycling is measured indirectly, as a ratio in kilograms per capita between municipal waste, either composted or methanized, and the total population. The analysis of bio-waste recycling is necessary because it shows us the importance of composting or anaerobic digestion.

The fourth indicator used in our research is related to municipal waste treatment as an environmental/sustainable development indicator. In our analysis, this was considered, both the total and according to the main treatment operations, both being expressed in kg/capita. The treatment operations taken into account, according to the definitions in the OECD/Eurostat Joint Questionnaire (European Commission & Eurostat, 2021 - Guidance on municipal waste data collection), Waste Framework Directive (Directive 2008/98/EC) and Directive (EU) 2018/851 amending Directive 2008/98 /EC, were: disposal by landfill and other operations (D1-7, D12), disposal by incineration (D10), energy recovery (R1), recycling of materials, recycling by composting and digestion and preparation for re-use (differentiated category starting from 2019; previously being part of recycling).

Methodology

The qualitative research of our work is carried out by analyzing descriptive data and by observing specialized studies, methodologies in the field, as well as the legislation in force regarding the targets of municipal waste management, which gives us a scientific, theoretical knowledge of the treated subject. As specific research methods, observation, economic analysis, synthesis, and comparison were considered. The quantitative research, through an objective approach and a deductive, measurable reasoning of numerical data, involved a statistical analysis of the issue of municipal waste in Romania in the period 2011-2021, based on the latest data published by Eurostat in January 2023 (Eurostat 2023a, Eurostat 2023b and Eurostat 2023c).

For our research, as mentioned before, four indicators were selected as follows: the amount of municipal waste generated (kg/capita), the amount of municipal waste treated (total and according to the main treatment operations, expressed in kg/capita), recycling rate of municipal waste (percentage) and bio-waste recycling (kg/capita) mentioned in table 1.

Table 1. Indicators selected for research

Nr. crt.	Indicators	Data code	Unit of measure	Average value for the EU -2021
A.	**Circular economy indicators**			
1.	Generation of municipal waste per capita	cei_pc031	Kilograms per capita	530[p]
2.	Recycling rate of municipal waste	cei_wm011	Percentage	49,6[s]
3.	Recycling of biowaste	cei_wm030	Kilograms per capita	100[s]
B.	**Environment/Sustainable Development Indicator**			
4.	Municipal waste by the treatment operations	env_wasmun	Kilograms per capita	524[s] (total-waste treatment)

Note: (p) provisional; (s) Eurostat estimate
Source: Eurostat data processing

Waste indicators in general are necessary to monitor the transition to a circular economy, but also closely related to the sustainable development goals of the United Nations 2030 Agenda. The selected municipal waste indicators show us the trends in their generation, but also the trends in their treatment, through various operations, such as material recycling, composting recycling, energy recovery, disposal by incineration and landfill.

Results and discussions

According to the most recent statistical data provided by Eurostat, the generation of municipal waste reached 5,768 thousand tons in 2021 in Romania, which meant an increase of over 10 and a half percent compared to the level recorded in 2011 (5,216 thousand tons).

To illustrate the trends, municipal waste for the period 2011-2021 was presented in Figure 1. Per capita, data updated in January 2023 (provisional for the years 2020 and 2021) show an increase of 16.6%, from 259 kg per capita in 2011 to 302 kg per capita in 2021, as we can see in figure below.

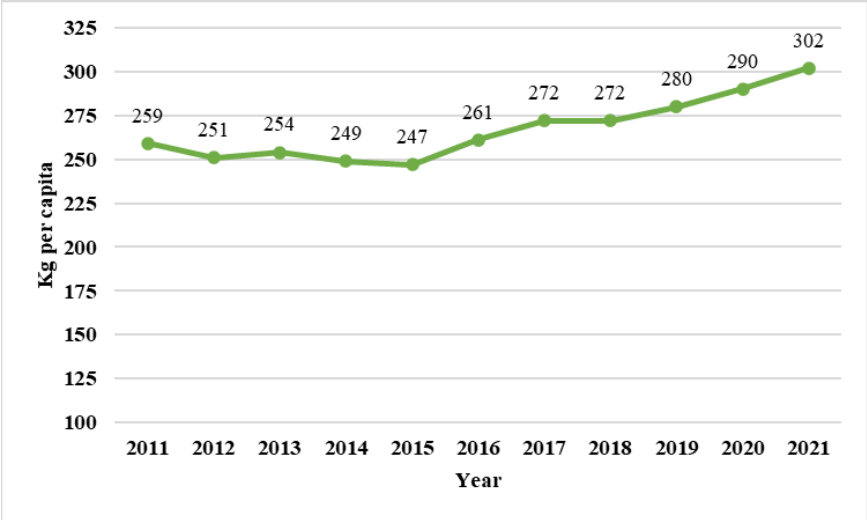


Figure 1. The amount of municipal waste generated in Romania in the period 2011-2021 (Kg per capita)

Note: Provisional dates for 2020 and 2021
Source: Data extracted by the author from Eurostat, available online at https://ec.europa.eu/eurostat/databrowser/view/CEI_PC031__custom_4725905/default/table?lang=en

Although it is noted that after a minimum level recorded in 2015, the trend was an increasing one and the most recent year of statistics represented a maximum level, Romania's values are well below the European Union average (530 kg per capita in 2021). In fact, Romania had the lowest amount of waste generated per capita among the European Union states. This can be explained by the lower purchasing power of Romanians, the existence of many rural population in Romania compared to other states or an underestimation of the values, considering that many deposits were non-compliant.

Considering one of the strategic objectives of the National Waste Prevention Programme, according to which it is aimed to decrease by 10 percent in 2025 the amount of household/similar waste generated per capita compared to 2017 and considering the trend observed above, it becomes unlikely for Romania to meet the targets related to waste generation. Thus, although Romania is making efforts to move from an economic model based on production and consumption to one aimed at reusing materials and preventing waste, the data show that it still has problems with the generation of municipal waste.

For a more complete interpretation of the issue, we believe that along with generation, waste treatment must also be analyzed. Therefore, the amount of municipal waste treated in Romania in the period 2011-2021 is presented in Figure 2. In 2021, an amount of 5,345 thousand tons of municipal waste was treated, that is, an increase of slightly more than 13 percent was recorded compared to the amount of waste treated in the base year of the analysis. Per capita, municipal waste treated had an average of 280 kilograms (below the European Union average of 524 kg/capita), with an increase of almost 20% compared to the base year of the analysis and representing the maximum recorded during 2011 -2021.

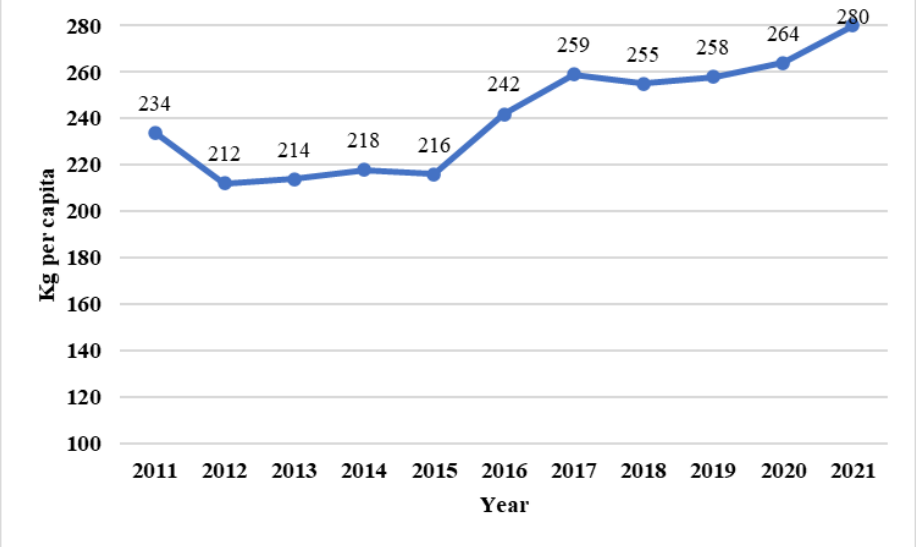


Figure 2. The amount of municipal waste treated in Romania in the period 2011-2021 (Kg per capita)

Note: Provisional dates for 2020 and 2021

Source: Data extracted by the author from Eurostat, available online at https://ec.europa.eu/eurostat/databrowser/view/ENV_WASMUN__custom_4660044/default/table?lang=en

In Table 2 we analyzed the evolution of municipal waste treatment on the main operations in the period 2011-2021 and we calculated the percentage change of the most recent year identified in Eurostat statistics compared to the base year of the analysis. The treatment of municipal waste in Romania involves its disposal through landfill and other similar operations as the main operation,

reaching 228 kg/capita in 2021 and corresponding to a percentage increase of 13.43% compared to 2011. If we consider that the Directive- framework of the European Union on waste claims that landfilling should be the last choice, according to the hierarchy of waste, then we can conclude that Romania must take appropriate measures to fulfill the foundation of waste management. At the same time, the trend is not like the European Union. If at the level of the Union, there is an inverse evolutionary relationship between the generation of waste and the amount of waste stored at the landfill, in Romania both have the same direction of growth. In second place we find recycling. Thus, material recycling was 20 kg/capita, with an increase of 122% compared to 2011, and recycling through composting and digestion was 14 kg/capita, registering a decrease of 33% compared to 2011. Energy recovery reaches 18 kg/capita. Although this is a modest waste treatment operation in Romania compared to the European Union average, the increase is noteworthy, being 800%. Disposal by incineration and preparation for use have zero values.

Table 2. Municipal waste management operations in Romania between 2011-2021 (kg/capita)

Year	Disposal - landfill and other (D1-D7, D12)	Disposal - incineration (D10)	Recovery - energy recovery (R1)	Recycling - material	Recycling - composting and digestion	Preparing for reuse
2011	201	0	2	9	22	:
2012	171	0	4	8	29	:
2013	175	0	5	11	23	:
2014	179	0	7	13	20	:
2015	178	0	6	14	18	:
2016	181	0	11	17	18	:
2017	207	0	12	20	18	:
2018	210	0	12	21	9	:
2019	213	0	13	20	12	:
2020	214	0	15*	16*	18	0
2021	228*	0	18*	20*	14*	0
Change 2021/2011 (%)	13.43%	0%	800%	122%	-33%	0%

Notes: * provisional; (:) not available

Source: Data extracted and processed by the author based on information provided by Eurostat

The recycling rate of municipal waste in Romania in the period 2011-2021 is presented in Figure 3. This fluctuated between a minimum recorded in 2018, of 11.1%, and a maximum recorded in 2012, of 14.8%.

The latest update of Eurostat data from January 2023 shows that the recycling rate for the year 2020 has been reduced from 13.7% (as mentioned in the previous information as provisional data) to 11.9% (provisional data). For 2021, the rate appears to be decreasing compared to the previous year, reaching 11.3% (provisional data). The values of the municipal waste recycling rate in Romania are far below the European Union average. According to the data specified in January 2023, the municipal waste recycling rate of the European Union is estimated for 2021 at 49.6% and Romania is in last place in the ranking of the member states of the European Union.

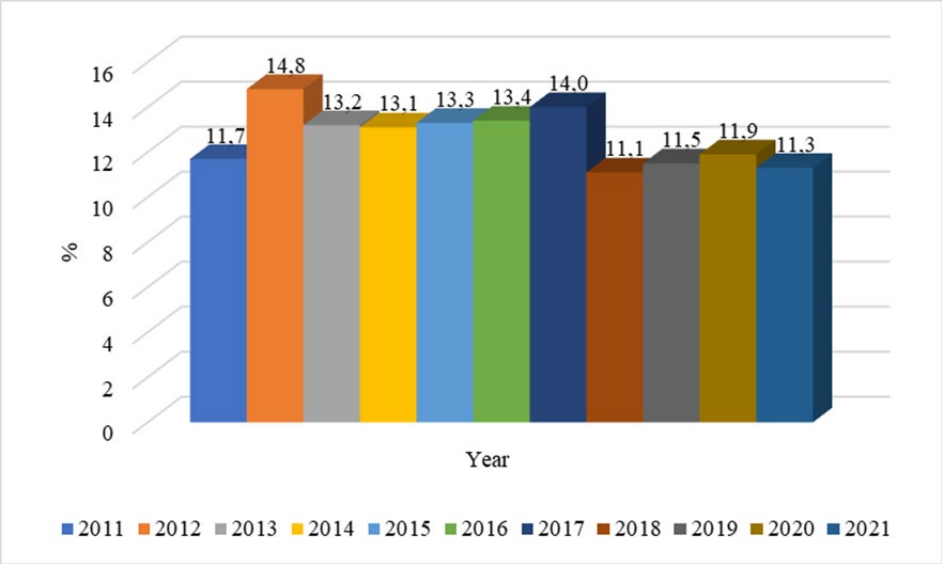


Figure 3. Recycling rate of municipal waste in Romania în perioada 2011-2021 (%)

Note: Provisional dates for 2020 and 2021

Source: Data extracted by the author from Eurostat, available online at https://ec.europa.eu/eurostat/databrowser/view/CEI_WM011__custom_4667322/default/table?lang=en

An important part of municipal waste generation is bio-waste, which is biodegradable waste. Of this, more than half comes from food, and the rest from gardens, parks, and other types of bio-waste. In the context of a circular economy, we must increasingly consider treating bio-waste to obtain nutrients for agriculture, energy (heat, electricity, biofuel), new products and, finally, jobs.

The recycling of bio-waste in Romania in the period 2011-2021 is presented in Figure 4.

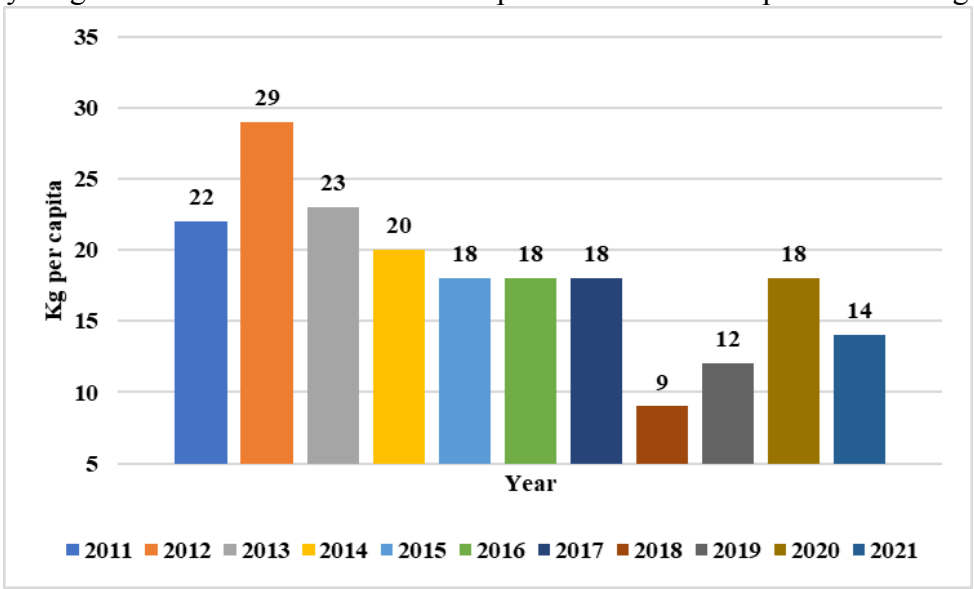


Figure 4. Recycling of bio-waste in Romania in the period 2011-2021 (kg per capita)

Note: Provisional data for 2021

Source: Data extracted by the author from Eurostat, available online at https://ec.europa.eu/eurostat/databrowser/view/CEI_WM030__custom_4689767/default/table?lang=en

As can be seen in the figure above, bio-waste recycling in Romania did not have a favorable, increasing trend. This was more on the decline with little variation. If in 2011, an average of 22 kilograms per inhabitant was recycled, the average decreased in 2021 to 14 kilograms per inhabitant, i.e., a decrease of 36%. The values are low compared to the Community average (100 kg/capita), but also compared to most of the member states of the European Union. At the same time, we remind you that Article 22 of the amending Directive (EU) 2018/851 notes the end of this year as the deadline for bio-waste to be collected separately or recycled at source in all member states.

Conclusion

The sustainable nature of circularity is achieved through the involvement of all interested parties, such as national governments, economic agents, researchers, and academic specialists, but also international bodies and organizations. The advantages are multiple, starting with protecting the environment, innovation, competitiveness, sustainable products, creating new jobs.

The present work was added to the existing literature, through an analysis of the performances recorded by Romania regarding the issue of municipal waste, all in the context of a circular economy, as the indicators used were selected.

Of the two working hypotheses, the second seems to be a reasonable, valid hypothesis. Thus, the evolution of the selected indicators is not a favorable one, which encourages the fulfillment of the assumed targets. This happens because the targeting of rates is not so simple, several influencing factors are involved. At the same time, the degree of waste recycling is influenced by the economic development of each nation, but also by the income of the population. Of course, in the case of Romania, big differences will be observed between the urban and the rural environment, considering the existing socio-economic gaps between the two environments.

Even though in Romania only 302 kg/capita of municipal waste were generated in 2021 compared to the European Union average of 530 kg/capita, the national recycling levels are far below the European ones, more precisely, a recycling rate of municipal waste of 11.3% compared to the European Union average of 49.6%.

The management of municipal waste in Romania still presents shortcomings, due to technical reasons, such as the partial use of the capacity of sorting and composting facilities, the inefficiency of the separate collection of recyclable waste or the inefficient management of certain types of municipal waste; due to legislative causes, such as the lack of technical rules on various issues or inconsistencies between provisions; from institutional causes, such as insufficient involvement of the authorities at all decision-making levels (national, regional, local, etc.) or insufficient institutional capacity of the authorities and, last but not least, financial causes. At the same time, consumer behaviors still require education, as public awareness is not active enough.

In carrying out this study, we faced a series of limitations related, mainly, to the lack of detailed data on the generation and treatment of waste in Romania.

Potential future developments for expanding research may target the geographical proximity effect. Thus, Romania's neighboring countries seem to have similar levels of the analyzed indicators, perhaps also due to the consideration of similar measures regarding municipal waste, similar approaches to the problem by the national authorities, but also the identical behaviors of the population. Another direction of research may involve an analysis according to the degree of urbanization of the population or according to population density.

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