WASTE GENERATION AND WASTE MANAGEMENT IN ROMANIA IN THE CONTEXT OF THE EUROPEAN TRANSITION TO A CIRCULAR ECONOMY

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Abstract: *The circular economy is, from 2015, the European Union's answer to today's sustainability issues. This paper highlights some of these issues and summarizes what circular economy means and some of the barriers facing its implementation, based on a classical literature review. Then, the monitoring framework of The European Union is presented, with the most important regulation mentioned. Starting from the famous 3R, the research was narrowed to recycling. An analysis was carried out concerning waste production and waste management based on Eurostat's official European statistics. A descriptive comparison was made between Romania's situation and the European Union average to establish the evolution of indicators like waste generation, municipal waste generation, and recycling rates since this country joined The European Union in 2007. Overall, it can be said that Romania has made steady progress in managing waste more responsibly, but there are still quite large differences from the EU average for the majority of the indicators analyzed. Also noteworthy is the fact that the European Union, as a whole, evolves with small, but steady steps, increasing the waste management indicators towards a circular economy.*

Keywords: *circular economy; waste management; recycling rate; Romania, European Union.*

JEL Classification*: Q01, Q50, Q53.*

1. Introduction and theoretical framework

Environmental problems should be a global priority at this moment for the sake of future generations. According to the World Meteorological Organization (2023), the data collected until October show that the year 2023 was the warmest in the history of climate records i.e. the warmest in the last 174.
This is affected and affects several other aspects related to the environment. Among them, the United Nations University, in their Interconnected Disaster Risks report (2023), highlights some like accelerating extinctions, groundwater depletion, unbearable heat, mountain glacier melting, space debris, and uninsurable future.
The list above can be completed more and more because there are too many environmental problems. Why did it end up here?
The economic model practiced for hundreds of years can be blamed. This is the traditional linear economic model developed based on the principle "take, make, dispose" (Tambovceva and Titko, 2020). Therefore, a new approach is needed on how to carry out economic activities.
Many of these problems also affect Romania, a country in the EU engaged in the implementation of the circular economy (CE) principles and practices. On this basis, in the

following, it is presented a review of the literature on the circular economy concept and the EU Circular Economy monitoring framework with a summary of indicators.

One of the new approaches to carrying out economic activities is the circular economy, which appears as an alternative to the classic linear model that reduces the negative socio-environmental impacts (Terra Dos Santos et al., 2023). This implies considering some important aspects like closing, slowing, and narrowing the loop of materials' flows by returning to production the products that reached the end-of-life and were usually intended for final disposal (Nikolaou and Tsagarakis, 2021). These closed-loop production patterns have the purpose of increasing the level of efficiency in the process of using resources and improving the relationship between the economy, environment, and society (Ghisellini et al., 2016).

The closed loop is based on the three R's: Reduce, Reuse, and Recycle as a central element for the circular Economy. The complexity of the notion led some authors to conceptualize the circular economy starting from over 100 collected definitions. (Kirchherr et al., 2017). With this in mind, Murray et al. (2017) consider the circular economy as an economic model where "planning, resourcing, procurement, production, and reprocessing are designed and managed, as both process and output, to maximize ecosystem functioning and human well-being".

Based on the concepts above the three R's were extended in time to five: recycling, remanufacturing, repairing, refurbishing, and reuse, but the essence remains the same. Both consumers and producers must consider the principles of the circular economy so that instead of a product being used only once, viable alternatives must be found to extend the product's life. For example, an electronic product that someone no longer needs can be refurbished and donated to others who need it, or in the worst case, the product can be recycled and the materials obtained need to be reintroduced into the economic circuit.

The concept can be further extended, as a framework was proposed (Morseletto, 2020; Potting et al., 2017) based on ten common circular economy strategies coded from R0 (high circularity) to R9 (low circularity): R0 - Refuse, R1 - Rethink, R2 - Reduce, R3 - Re-use, R4 - Repair, R5 - Refurbish, R6 - Remanufacture, R7 - Repurpose, R8 - Recycle, R9 - Recovery.

There are many followers, but also critics of the circular economy. Palea et al. (2023) demonstrate that adopting the model of circular economy can bring benefits for firms and new profitability opportunities. CE can contribute to better financial performance, ease of raising capital, and better efficiency.

The critics refer mainly to CE's limits in achieving a real circularity, closed loops in which waste no longer exists are almost impossible to achieve. For this reason, the studies also focus on the barriers encountered in the implementation of the circular economy. Most often, reference is made to cultural barriers (Kirchherr et al., 2018; Grafström and Aasma, 2021), market barriers (Kirchherr et al., 2018), regulatory barriers (Briguglio et al., 2021), and technological barriers (Trevisan et al., 2023). Other researchers (Vermunt et al., 2019) have shown that the types of barriers are not generally valid but that they differ, depending on the circular business model that is implemented.

When it comes to technology, a new concept is more often mentioned "Smart Circular Economy". This is based on the use of the latest generation of digital technologies in the implementation of circular economy principles (Lobo et al., 2021). Consequently, industry 4.0 technologies as well as other technologies such as blockchain or the Internet of Things can play a crucial role in the implementation of this concept (Javeed and Akram, 2024; Trevisan et al., 2023). Along with these, the transformative role of artificial intelligence in the use of the circular economy should not be neglected either, this technological revolution is predicted to be increasingly important (Sánchez-García et al., 2024).

The objective of the paper is to analyze the situation of Romania, in comparison with the EU average, regarding waste generation and waste management, in the context of transitioning to a circular economy. Therefore, the following research questions were stated:

RQ1: What progress has Romania made in reducing waste compared to the average of the European Union?
RQ2: Have the waste recycling rates improved in Romania since joining the European Union?

For this study, statistical data were collected from the official Circular Economy Monitoring Framework available on the Eurostat website. The values of the selected relevant indicators were collected for Romania and compared with the EU average, for the period 2000-2022 (depending on the indicator).

The remainder of the paper is organized as follows: section 2 presents the monitoring framework of The European Union, with the most important regulation, section 3 presents a comparative analysis between Romania and the European Union average considering indicators like waste generation, municipal waste generation, and recycling rates and the discussions related, section 4 presents the conclusions of the study, and section 5 is dedicated to presenting the acknowledgements.

2. The approach of the EU to the circular economy

There is an obvious and growing interest in implementing the circular economy principles and practices, but still, global production has remained mainly based on the linear model. Thus, in the process of implementing a circular economy, further additional support is necessary, and public and government policies have an essential role in it (Hartley et al., 2023).

Since 2005, the European Union has recognized the high degree of resource consumption as being slightly lower than that of the USA, but double that of Japan (European Environment Agency, 2005). In this context, the EU developed in the same year a framework for the sustainable use and management of natural resources, as an important step towards transitioning to a circular economy, but without this concept being mentioned.

The first EU action framework regarding the transition to the circular economy model was developed in 2015 and targets the following areas: production, consumption, waste management (including material reuse), innovations, and investments (European Commission, 2015).

The European Commission has been constantly working to improve the approach to the circular economy. Therefore, in 2020, it was published a new regulatory framework emphasizing the need for sustainable product design, waste management, and secondary raw materials and specific regulations for certain relevant product categories (European Commission, 2020). For monitoring, Eurostat follows 11 indicators divided into 5 areas: production and consumption, waste management, secondary raw materials, competitiveness and innovation, and global sustainability and resilience (Eurostat, 2024).

Table 1: The conceptual framework of Circular Economy indicators in the European Union

Sub-Indicator	**Indicator**
Production and consumption	
Material footprint	Material consumption
Resource productivity	
Green public procurement	
Waste generation per capita	Waste generation
Generation of waste excluding major mineral wastes per GDP unit	
Generation of municipal waste per capita	
Food waste	
Generation of packaging waste per capita	
Generation of plastic packaging waste per capita	
Waste Management	

Recycling rate of municipal waste	Overall recycling rates
Recycling rate of all waste excluding major mineral waste	
Recycling rate of packaging waste by type of packaging	Recycling rates for specific waste streams
Reuse and recycling rate of WEEE separately collected	
Secondary raw materials	
Circular material use rate (circularity rate)	Contribution of recycled materials to raw materials demand
End-of-life recycling input rates	
Trade in recyclable raw materials: • *Imports from non-EU countries* • *Exports to non-EU countries* • *Intra EU trade*	Trade in recyclable raw materials
Competitiveness and innovation	
Private Investments to circular economy sectors	Private investment, jobs and gross value added related to circular economy sectors
Persons employed to circular economy sectors	
Gross value added to circular economy sectors	
Patents related to waste management and recycling	Innovation
Global sustainability and resilience	
Consumption footprint	Global sustainability from circular economy
Greenhouse Gas emissions from processing, manufacturing, and services	
Material import dependency	Resilience from circular economy
EU self-sufficiency for raw materials	

Source: Authors` elaboration based on Eurostat statistics, [Online], Available: https://ec.europa.eu/eurostat/web/circular-economy/database [3 April 2024].

3. Waste generation vs waste management – Romania vs EU: analysis and discussion

As was shown, the EU framework for monitoring the circular economy is quite large. To compare Romania's situation with that of the European Union, we chose some representative indicators regarding waste production and waste management.
The issue of waste was chosen because of the central role that waste management has in the European Union's Circular Economy. Over time, there have been many normative acts specially created for this. If we refer to the time of Romania's accession to the European Union, a year later, in 2008, a precursor act of the current circular economy, a waste management directive that lays the foundations for the principles of producer responsibility and "the polluter pays principle", was introduced (The European Parliament, 2008). Starting from 2015 we refer to the Circular Economy Action Plan updated and modified with the realities encountered in implementing the CE concept.
According to Eurostat (2024), the generation of municipal waste per capita indicator shows "waste collected by or on behalf of municipal authorities and disposed of through the waste management system". This indicator should have a value as small as possible to reduce the environmental impact. As shown, the municipal waste per capita is lower than the EU average in all the years since 2000. It can be highlighted that, in the period 2020-2022, the kilograms per capita were almost half of the EU average, but there is a slightly negative trend of growth for Romania in the last years. Surprisingly, according to the most recent data (Eurostat, 2024), Romania ranks first in the European Union for this indicator, with 301 kilograms of municipal waste per capita, followed by countries like Poland, Estonia, Sweden, and Hungary. At the opposite pole, we find countries like Austria, Denmark, Luxembourg, and Belgium with values over 700 kilograms per capita.

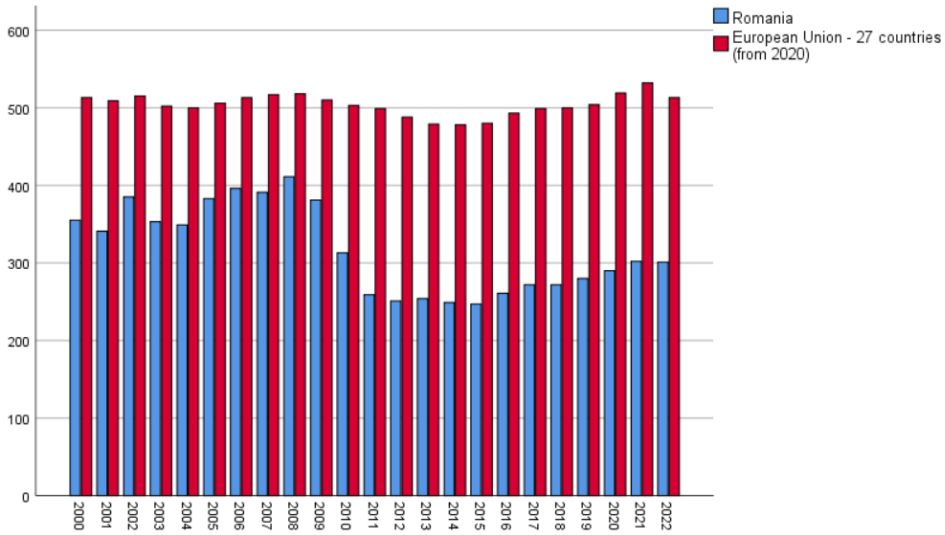

Figure 1: Generation of municipal waste per capita (in kilograms per capita)
Source: Authors` elaboration based on Eurostat statistics, [Online], Available: https://ec.europa.eu/eurostat/databrowser/view/cei_pc031/default/table?lang=en&category=cei.cei_pc [4 April 2024].

The total waste generation per capita (including major mineral wastes) is higher than the EU average in all analyzed years. It should be noted, however, that this has more than halved from 17.215 kg per capita in 2004 to 7.338 kg per capita in 2020, while the European average remains around 5.000 kg per capita.
In 2020 the best-performing countries from this point of view were Croatia, Latvia, Portugal, and Hungary, with values below 2.000 kilograms per capita of total waste generation. In contrast to these, there are also countries with very high values of waste generation, namely Finland (20.993 kg per capita), Bulgaria (16.785 kg per capita), Sweden (14.664 kg per capita) and Luxembourg (14.618 kg per capita).

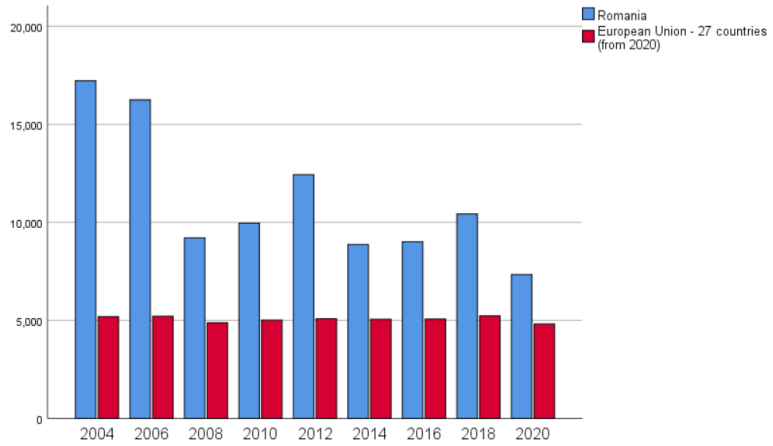

Figure 2: Waste generation per capita (in kilograms per capita)
Source: Authors` elaboration based on Eurostat statistics, [Online], Available: https://ec.europa.eu/eurostat/databrowser/view/cei_pc034/default/table?lang=en&category=cei.cei_pc [4 April 2024].

The indicator presented in Figure 3 is representative of the circular economy because it shows somewhat the efficiency regarding waste generation with which the economy

generates a thousand euros of GDP. The value should be as low as possible. Romania's evolution is good, decreasing from 379 kg per thousand euro in 2004 to 107 kg per thousand euro in 2020, but still above the EU average of 65 in 2020. This may also be due to the major differences between Romanian's GDP (11.430 euro per capita in 2020) and the EU's average GDP (30.050 euro per capita in 2020), based on statistics from Eurostat (2024). Consequently, Romania is at the top of the countries with the worst performances from this point of view, being exceeded, in 2020, only by Bulgaria – 419 kg per thousand euro, Estonia – 412 kg per thousand euro, Poland – 150 kg per thousand euro and Latvia – 110 kg per thousand euro. Also, Eurostat data places Ireland, Luxembourg, and Denmark as the best-performing countries in 2020, with values under 40 kg per thousand euro GDP.

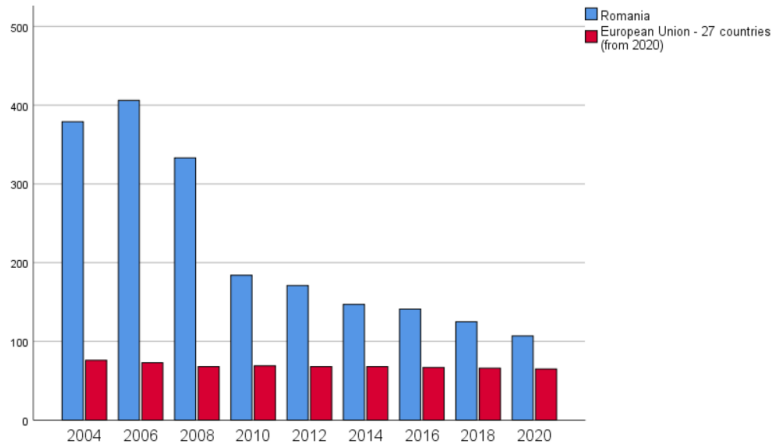

Figure 3: Generation of waste excluding major mineral wastes per GDP unit (in kilograms per thousand euro, chain-linked volumes - 2010)
Source: Authors` elaboration based on Eurostat statistics, [Online], Available: https://ec.europa.eu/eurostat/databrowser/view/cei_pc032/default/table?lang=en&category=cei.cei_pc [4 April 2024].

In the following, two of the most important waste recycling rates are analyzed, recycling being one of the foundations of the circular economy.

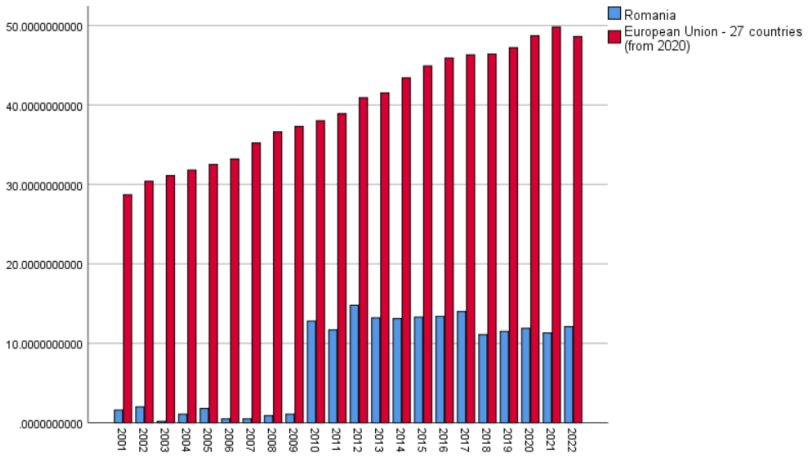

Figure 4: Recycling rate of municipal waste (Percentage)
Source: Authors` elaboration based on Eurostat statistics, [Online], Available: https://ec.europa.eu/eurostat/databrowser/view/cei_wm011/default/table?lang=en&category=cei.cei_wm [4 April 2024].

Romania's municipal waste recycling rate was quite bad, with values under 2% every year from 2001 to 2009. The rate improved since 2010 and in 2022 was 12,1%, but far below the European Union average of 48.6%.
Even with this development, according to the most recent Eurostat data, Romania ranks last, close to countries like Malta, Cyprus, and Greece, also with values below 20%. The best performers are Germany, Austria, and Slovenia with values of municipal recycling rates over 60% in the last years.

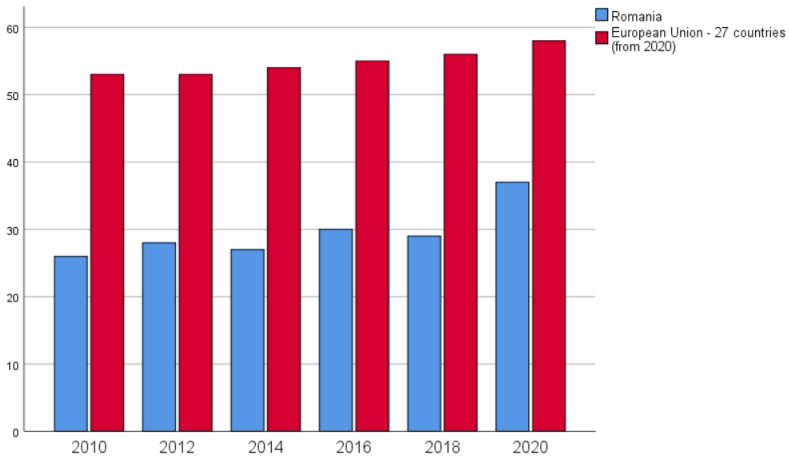

Figure 5: Recycling rate of all waste excluding major mineral waste (Percentage)
Source: Authors` elaboration based on Eurostat statistics, [Online], Available: https://ec.europa.eu/eurostat/databrowser/view/cei_wm010/default/table?lang=en&category=cei.cei_wm [4 April 2024].

A better recycling rate for Romania is in the case of all waste excluding major mineral waste, which has steadily increased since 2010 and reached 37% in 2020. However, this percentage is still below the EU average of 58% in 2020. Eurostat's statistics shows also other countries with small percentages in the last years, under 40%, like Bulgaria, Greece, Malta, Portugal, and Finland. High percentages of this recycling rate can be found in countries such as Belgium, Slovenia, Netherlands, Italy, Lithuania, and Luxembourg, which have exceeded the 70% milestone in recent years.

4. In conclusion

The study focused on analyzing several relevant indicators of waste generation and waste management in Romania, compared with the EU average, in the context of transitioning to a circular economy. For this purpose, we have enunciated two research questions that have guided our analysis.
Answering the question "What progress has Romania made in reducing waste compared to the average of the European Union?" we can say that it was a constant one, but not a very spectacular evolution was registered. The generation of municipal waste per capita is one of the few indicators from the CE monitoring framework that Romania is over than the EU average. This is not the case for the total waste generation per capita, but also here some overall progress is observed on the evolution chart.
To answer the other question "Have the waste recycling rates improved in Romania since joining the European Union?", we can conclude that joining the European Union brought improvements in the way of recycling waste, especially that of municipal waste. For this particular type of waste, the values of recycling rates increased from almost nothing, around and under 1% until 2009, to values above 10%. There is much improvement to be done to

reach the EU average that has a constant upward trend. However, the implementation of European legislation in the field of waste and its recycling has left a positive mark.
For future research, we intend to develop a thorough analysis of all indicators in the framework, and also a comparison with other countries in the European Union, revealing the challenges faced by Romania in implementing circular economy principles.

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