European Journal of Sustainable Development (2023), **12**, 4, 366-378 ISSN: 2239-5938
Doi: 10.14207/ejsd.2023.v12n4p366

Through Circularity Towards Sustainability: Assessing the Progress and Challenges of the Circular Economy in the EU and Slovakia

By Emília Huttmanová[1], Jana Chovancová[2], Martin J.F. Steiner[2], Peter M. Ramharter[2], Kristína Kočiščáková[2]

ABSTRACT
Sustainable development poses a significant challenge to modern civilization. The current problems and crises underscore the urgent need to establish a sustainable society, marking a crucial milestone in human evolution. The concept of sustainability has gained increasing prominence as a scientific, social, and political concern. The European Union strongly emphasizes the transition to a circular economy as a sustainable approach to economic growth. This circular economy model, one of the transformative policies of the Green Deal, is intended to pave the way for a sustainable future. It is now recognized as one of several approaches to achieving sustainability, as it encompasses and interconnects the economic, social, and environmental aspects of sustainable development. The main objective of this paper is to assess the present state and progress of the circular economy in Slovakia, employing selected indicators within the context of transitioning from a linear to a circular economy.

Keywords: Circular economy. Sustainability. Municipal waste. Recycling rate. European Union countries.

1. Introduction

The circular economy can be seen as an alternative to the linear economy, seeking to extend the longevity of products, materials, and components in circulation to eliminate waste (Machado and Morioka 2021). According to Van Caneghem et al. (2019), it is a novel concept aimed at retaining the value of resources, materials, and products within the economy for as long as possible, with a strong focus on waste reduction. It is also regarded as a new business model that contributes to sustainable development and societal harmony (Ghisellini et al. 2016). The core of this system model is resource efficiency and maximising resource use beyond the traditional supply chain (Jurkovič 2020). Turning from a linear to a circular business model, the concept of circular economy (CE) has gained significance in promoting sustainable development by integrating economic, environmental, and social benefits at various scales (Shevchenko et al. 2021).
One of the major advantages of the circular economy is its ability to minimize waste generation by considering waste as a valuable resource for further use. Guerra, Shahi, Mollaei et al. (2021) assert that the circular economy can be defined as a model centered around effective resource management, involving the rejection, reassessment, and reduction of unnecessary consumption patterns. Its goal is to maintain the circulation of

[1]Department of Economics and Economy, Faculty of Management and Business, University of Prešov Slovakia.
[2]Department of Management, Faculty of Management and Business, University of Prešov, Slovakia.

materials and resources for as long as possible, thereby reducing the need for additional natural resource extraction.
The circular economy is an intentional and deliberate industrial system designed to restore and regenerate. It replaces the concept of end-of-life with restoration, embraces renewable energy sources, eliminates the use of toxic chemicals that hinder reuse and return to the environment, and strives for waste elimination through superior design of materials, products, systems, and business models (World Economic Forum 2020).
The concept of circular economy holds great interest not only for researchers but also for practitioners as it is viewed at the corporate level as an operationalization of sustainable development. While other concepts such as green economy and green growth also aim to operationalize sustainable development for businesses, the circular economy, with its complex economic system and focus on reducing, reusing, recovering, and recycling materials throughout production, distribution, and consumption processes, is currently regarded as the most appealing. It operates at the micro-level (products, consumers, companies), mid-level (eco-industrial parks), and macro-level (cities, regions, states), aiming to achieve sustainable development by promoting environmental quality, economic prosperity, and social justice for current and future generations (Kirchherr et al. 2017).
It is crucial to decouple economic growth from resource consumption. The McKinsey report suggests that increasing revenue from circular activities, coupled with cost savings achieved through functional and easily disassembled products that can be reused, has the potential to boost GDP and drive economic growth (World Economic Forum 2020).
In line with this, the European Union (EU) is currently strongly advocating for the transition to a circular economy, recommending it as an approach to economic growth that aligns with sustainable environmental and economic development (Korhonen et al. 2018). The European Commission has adopted an ambitious "Circular Economy Package," encompassing an EU Action Plan with measures spanning the entire product lifecycle (Enviroportal 2022); European Commision (2015). Embracing circular economy principles could not only yield environmental and social benefits for Europe but also generate a net economic benefit of €1.8 trillion by 2030 (Europe's circular economy opportunity 2015).

2. Material and Methods

The objective of this study is to assess the progress of municipal waste production and municipal waste recycling rates, which are crucial elements in the transition towards a circular economy and sustainable practices in Slovakia and the European Union. Two specific aspects of the circular economy, namely Production and Consumption, and Waste Management, are evaluated using selected indicators. The indicator used for the Production and Consumption theme is Municipal waste production per capita (kg), while the indicator for the Waste Management theme is Municipal waste recycling rate (%).
To evaluate the development of these indicators, regression analysis was conducted using Microsoft Excel. The data utilized for the analysis covers the period from 2000 to 2020 and was sourced from Eurostat.

3. Results and Discussion

Analysis of the Eurostat data for 2020, as presented in Table 1, reveals several noteworthy findings. Among the European Union (EU) countries, Denmark emerges as the largest producer of municipal waste, with a per capita production rate of 845 kg. It is closely followed by Luxembourg (790 kg per capita), Malta (643 kg per capita), Germany (632 kg per capita), and Cyprus (609 kg per capita). Notably, Denmark, Luxembourg, and Malta have experienced an upward trend in waste production since 2010, with further increases observed in 2020. Particularly, Luxembourg witnessed a significant rise in waste production, amounting to 111 kg per capita.

Conversely, some EU countries have exhibited substantial negative changes in municipal waste production between 2010 and 2020. The Czechia, for instance, observed a considerable increase of 59% (equivalent to 189 kg per capita), followed by Latvia with a 48% increase (154 kg per capita), and Finland with a 27% increase (126 kg per capita). In Slovakia, waste production has been steadily rising since 2013, resulting in a 36% increase (114 kg per capita). Although Slovakia is among the 12 EU countries that generate less municipal waste than the EU average of 505 kg per capita, the continuous year-on-year increase in production is concerning.

These findings underscore the importance of addressing waste management practices and transitioning towards a circular economy. While Denmark, Luxembourg, and Malta face challenges in curbing waste production, countries experiencing significant increases, such as the Czechia, Latvia, Finland, and Slovakia, must prioritize sustainable waste management strategies. It is crucial to focus on waste reduction, recycling initiatives, and the adoption of circular economy principles to minimize the environmental impact of waste generation.

The data highlights the need for comprehensive waste management policies and initiatives at both the national and EU levels. Efforts to reduce waste production, increase recycling rates, and promote sustainable consumption patterns are essential for achieving the goals of the circular economy and fostering a more sustainable future.

Table 1 Municipal waste generation per capita (kg) in EU countries for the period 2010-2020

Country	Year											Difference 2020-2010	Index 2020/2010
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020		
EU average	503	499	488	479	478	480	490	496	496	501	505	+2	1,00
Belgium	456	455	445	436	425	412	419	411	409	416	416	-40	0,91
Bulgaria	554	508	460	432	442	419	404	435	407	-	-	147***	0,73***
Czechia	318	320	308	307	310	316	339	489	494	500	507	+189	1,59
Denmark	-	862	806	813	808	822	830	820	814	844	845	-17*	0,98*
Germany	602	626	619	615	631	632	633	627	606	609	632	+30	1,05

Estonia	305	301	280	293	357	359	376	390	405	369	383	+78	1,26
Ireland	624	616	585	-	562	-	581	576	598	625	555	-69	0,89
Greece	532	503	495	482	488	488	498	504	515	524	-	-8**	0,98**
Spain	510	485	468	454	448	456	463	473	475	472	455	-55	0,89
France	534	534	527	520	517	516	530	535	534	555	535	+1	1,00
Croatia	379	384	391	404	387	393	403	416	432	445	418	+39	1,11
Italy	547	529	504	491	488	486	497	488	499	503	-	-44**	0,92**
Cyprus	695	676	664	618	602	620	633	625	646	648	609	-86	0,88
Latvia	324	350	323	350	364	404	410	411	407	439	478	+154	1,48
Lithuania	404	442	445	433	433	448	444	455	464	472	483	+79	1,19
Luxembourg	679	666	652	616	626	607	815	798	803	791	790	+111	1,16
Hungary	403	382	402	378	385	377	379	385	381	387	364	-39	0,90
Malta	623	622	612	602	628	641	642	666	672	697	643	+20	1,03
Netherlands	571	568	549	526	527	523	520	513	511	508	534	-37	0,94
Austria	562	573	579	578	565	560	564	570	579	588	-	+26**	1,05**
Poland	316	319	317	297	272	286	307	315	329	336	346	+30	1,09
Portugal	516	490	453	440	453	460	474	486	507	513	513	-3	0,99
Romania	313	259	251	254	249	247	261	272	272	280	287	-26	0,92
Slovenia	490	415	362	414	432	449	457	471	486	504	487	-3	0,99
Slovakia	319	311	306	304	320	329	348	378	414	421	433	+114	1,36
Finland	470	505	506	493	482	500	504	510	551	566	596	+126	1,27
Sweden	441	453	454	455	443	451	447	452	434	449	431	-10	0,98

Source: own elaboration, data obtained from Eurostat (2022)
*Note: * 2020/2011; **2019/2010; ***2018/2010*

When examining municipal waste production, it can be inferred that there has not been a significant decrease across EU countries during the reviewed decade. Cyprus (12% decrease), Ireland and Spain (11% decrease) appear to have performed the best in terms of reducing waste production. Bulgaria also displayed a positive trend with a decrease of 27%, considering the latest available data for 2018. However, it is worth noting that Cyprus and Ireland still generate substantial amounts of municipal waste, exceeding the EU average. On the other hand, Romania, Poland, Hungary, and Estonia recorded the lowest levels of waste generation. This situation may not only be influenced by the level of economic performance or socio-economic development of these countries but could also be indicative of their specific geographical structure, such as a higher proportion of rural areas and lower population density in such regions. Other factors contributing to waste production variations include population composition and demographic changes, technological advancements, traditional consumption habits, and lifestyles of the population. Additionally, specific influences, such as local policies and waste management

practices, and missing or inadequate waste infrastucture can also play a role. To gain a more comprehensive understanding of the factors influencing waste production, it is necessary to conduct a detailed analysis at the country level, examining the impacts of the aforementioned factors and the composition of municipal waste, including the sorted components.

To analyze the evolution of municipal waste generation in the Slovak Republic and the EU average, trend regression models were developed using a time series dataset spanning from 2000 to 2020.

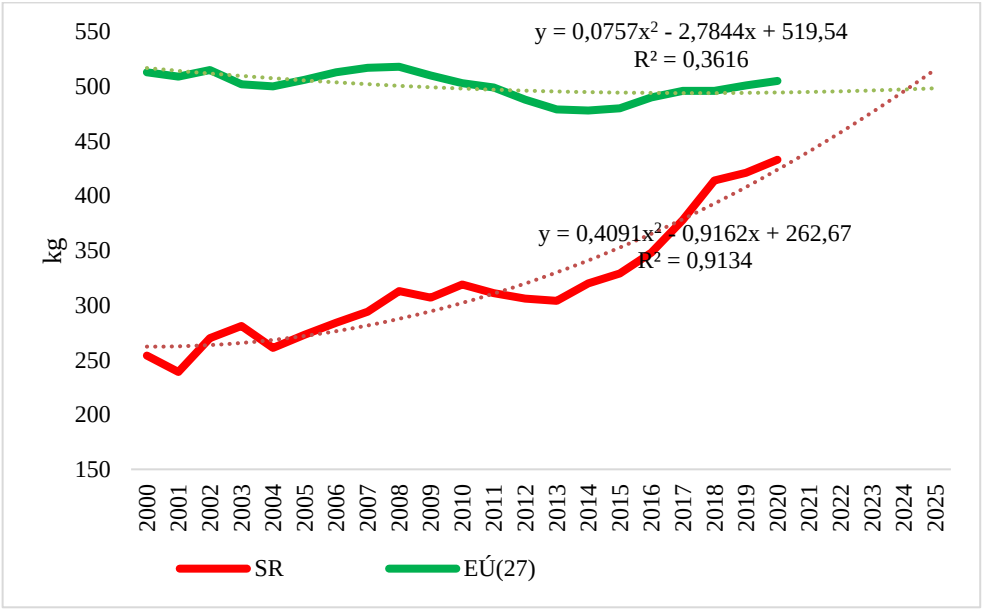

Figure 2 Development of the indicator Municipal waste production per capita (kg) in the Slovak Republic (SR) and the EU
Source: own elaboration

Although the regression model estimated for the EU countries (27) is statistically significant ($F = 5.097$; $df = 2$; $p = 0.02$), the quality of the regression model is deemed insufficient based on the coefficient of determination (36.16%).

On the other hand, in the case of Slovakia, the regression model exhibits a high level of significance ($F = 94.886$; $df = 2$; $p < 0.001$) and explains up to 91.34% of the variability in the data. The resulting regression equation is

$y = 0.4091x^2 - 0.9162x + 262.67$.

Considering the historical trends, municipal waste production is expected to increase in the next period (2025) up to 515 kg per capita.

Moving on to the second waste management indicator, the Municipal Waste Recycling Rate, it represents a crucial aspect of the Waste Management thematic area. Recycling waste and reintroducing it into the economic cycle are vital components of the transition to a circular economy, as it enables the creation of new resources. The European Commission's Circular Economy Action Plan – The ciccle is closing, emphasizes measures

aimed at maximizing the value of materials and transforming the life cycle of products from design to disposal, promoting resource reuse (European Commission 2015). The Municipal Waste Recycling Rate indicator quantifies the proportion of recycled municipal waste in relation to the total municipal waste generated.

Table 2 displays the municipal waste recycling rates in percentage for the period of 2010-2020, along with the difference and index between 2010 and 2020. In 2020, the highest municipal waste recycling rates were observed in Germany, Slovenia, and the Netherlands. However, it is important to consider these results in relation to the overall municipal waste generation. Among these countries, only Slovenia, with a municipal waste generation below the EU average (487 kg per capita), achieved a municipal waste recycling rate (nearly 60%) higher than the EU average.

Lithuania and Croatia demonstrated the most notable improvements in recycling rates, with the recycling rate increasing significantly in 2020 compared to 2010. Slovakia also made substantial progress, with the recycling rate increasing by over 4.6 times since 2010. It is worth noting that both Lithuania and Slovakia have municipal waste production below the EU average, indicating positive developments in recycling. Croatia's progress is also commendable, as the country had the lowest recycling rate among EU countries in 2010 (only 4%), but by 2020, it approached recycling rates seen in countries such as the Czechia, Spain, Latvia, Hungary, Poland, and Sweden, where municipal waste recycling rates ranged from 30% to 40%. Sweden experienced a decrease in recycling rates (20%) during the reviewed period, despite relatively stable trends between 2010 and 2019. Austria (2% decrease) and Belgium (1% decrease) also saw minor declines, although both countries consistently performed above the EU average in recycling rates. On the other hand, Malta, Romania, and Cyprus had minimal improvements in recycling rates over the past decade and overall performed poorly in this indicator.

Table 2 Municipal waste recycling rates (%) in EU countries for the period 2010-2020

Country	Year											Difference 2020-2010	Index 2020/2010
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020		
EU average	38,0	38,9	40,9	41,5	43,4	44,9	46,5	46,9	47,2	48,1	47,8	+9,8	1,26
Belgium	54,8	54,4	53,4	52,8	53,8	53,5	53,5	53,9	54,4	54,7	54,2	-0,6	0,99
Bulgaria	24,5	26,2	25,0	28,5	23,1	29,4	31,8	34,6	31,5	-	-	+7***	1,29***
Czechia	15,8	17,0	23,2	24,2	25,4	29,7	33,6	32,0	32,2	33,3	33,8	+18	2,14
Denmark	-	42,4	42,5	43,3	45,4	47,4	48,3	47,6	49,9	51,5	53,9	+11,5*	1,27*
Germany	62,5	63,0	65,5	63,8	65,6	66,7	67,1	67,2	67,1	66,7	67,0	+4,5	1,07

Estonia	18,2	23,3	19,1	17,9	31,3	28,3	28,1	28,4	28,0	30,8	28,9	+10,7	1,59
Ireland	35,7	36,1	36,6	-	39,8	-	40,7	40,4	37,6	37,4	40,4	+4,7	1,31
Greece	17,1	17,8	17,0	15,8	15,4	15,8	17,2	18,9	20,1	21,0	-	+3,9**	1,23**
Spain	29,2	26,7	29,8	32,5	30,8	30,0	33,9	36,1	34,8	38,0	36,4	+7,2	1,25
France	36,0	36,8	37,7	38,7	39,7	40,7	42,9	44,1	45,1	43,9	42,2	+6,2	1,17
Croatia	4,0	8,3	14,7	14,9	16,5	18,0	21,0	23,6	25,3	30,2	34,3	+30,3	8,56
Italy	31,0	35,5	38,4	39,4	41,6	44,3	45,9	47,8	49,8	51,4	-	+20,4**	1,66**
Cyprus	10,9	11,0	12,5	13,9	14,8	16,6	16,1	16,2	16,5	16,3	16,4	+5,5	1,50
Latvia	9,4	9,7	14,7	25,9	27,0	28,7	25,2	24,8	25,2	41,0	39,6	+30,2	4,21
Lithuania	4,9	19,9	23,5	27,8	30,5	33,1	48,0	48,1	52,5	49,7	45,1	+40,2	9,20
Luxembourg	46,5	46,4	47,4	46,6	47,7	47,4	49,2	48,7	49,0	48,9	52,8	+6,3	1,14
Hungary	19,6	22,0	25,5	26,4	30,5	32,2	34,7	35,0	37,4	35,9	33,0	+13,4	1,68
Malta	8,8	15,4	14,6	12,5	11,7	10,9	12,6	11,5	10,5	9,1	10,5	+1,7	1,19
Netherlands	49,2	49,1	49,4	49,8	50,9	51,8	53,5	54,6	55,9	56,9	56,8	+7,6	1,15
Austria	59,4	56,7	57,7	57,7	56,3	56,9	57,6	57,7	57,7	58,2	-	-1,2**	0,98**
Poland	16,3	11,4	12,0	15,1	26,5	32,5	34,8	33,8	34,3	34,1	38,7	+22,4	2,37
Portugal	18,7	20,1	26,1	25,8	30,4	29,8	30,9	29,1	29,1	28,9	26,5	+7,8	1,42
Romania	12,8	11,7	14,8	13,2	13,1	13,2	13,4	14,0	11,1	11,5	13,7	+0,9	1,07
Slovenia	22,4	35,6	41,9	34,8	36,0	54,1	55,6	57,8	58,9	59,2	59,3	+36,9	2,65
Slovakia	9,1	10,8	13,4	10,8	10,3	14,9	23,0	29,8	36,3	38,5	42,2	+33,1	4,64
Finland	32,8	34,8	33,3	32,5	32,5	40,6	42,0	40,5	42,3	43,5	41,6	+8,8	1,27
Sweden	47,8	47,0	46,9	48,2	49,3	47,5	48,4	46,8	45,8	46,6	38,3	-9,5	0,80

Source: own elaboration, data obtained from Eurostat (2022)
*Note: * 2020/2011; **2019/2010; ***2018/2010*

Considering that only six countries managed to surpass the EU average and achieve the target of reusing or recycling 50% of municipal waste by 2020, it is evident that the EU is facing challenges in transforming waste into a valuable resource. It is clear that a larger number of EU countries must intensify their efforts and explore suitable approaches to reduce waste production and increase recycling rates for already generated waste. Only

through proactive actions and effective measures can these synergies be achieved more swiftly, leading to a successful transition to a circular economy.
Slovakia has set ambitious targets to increase the recycling rate of municipal waste to 55% by 2025, 60% by 2030, and 65% by 2035. Since 2014, there has been a notable upward trend in recycling, indicating that Slovakia is making progress toward meeting its targets. We conducted regression analysis to determine whether Slovakia will achieve its 2025 target of a 55% municipal waste recycling rate. The resulting regression functions are presented in Figure 2.

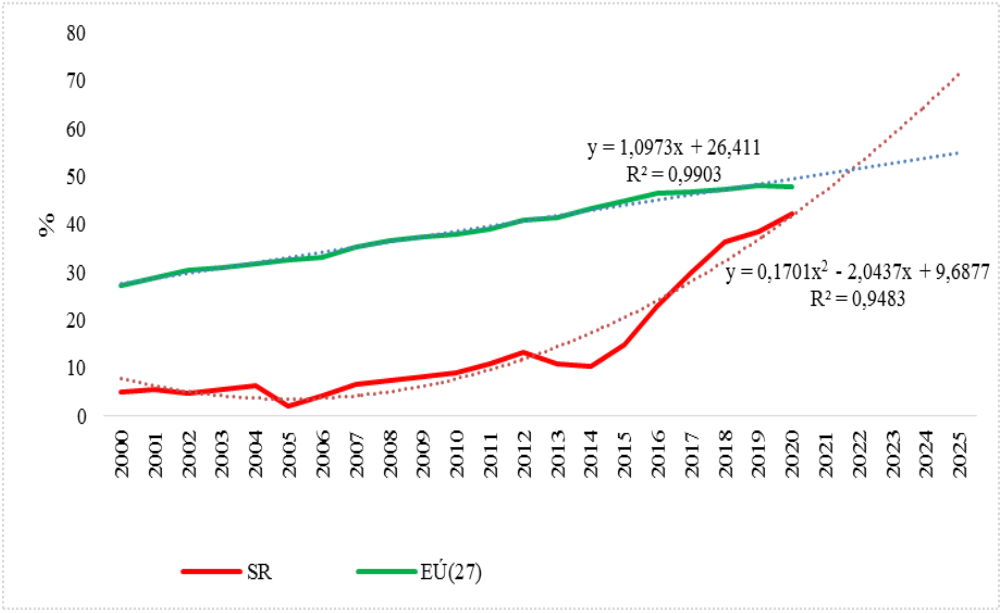

Figure 2 Evolution of the indicator Municipal waste recycling rate (%) in the Slovak Republic (SR) and the EU
Source: Own elaboration

During the assessment of municipal waste recycling rates at the EU level, a simple linear regression model proved to be the most suitable, accounting for up to 99.03% of the variability in the data. This model yielded highly significant results ($F = 1934.259$; $df = 1$; $p < 0.001$), and the resulting regression equation took the form
$y = 1.0973x + 26.411$.
Based on this analysis, it is projected that the municipal waste recycling rate for EU countries will reach 53.3% in 2025.
In the case of analyzing Slovak data, a second-stage polynomial regression was determined to be the optimal method. This regression model explained nearly 95% of the variability in the data, as indicated by the coefficient of determination ($R2 = 0.9483$). Furthermore, the resulting model was highly statistically significant ($F = 165.08$; $df = 2$; $p < 0.001$). The mathematical representation of the relationship takes the form of the equation:
$y = 0.1701x^2 - 2.0437 + 9.6877$.
Based on the regression analysis, holding other factors constant, it can be expected that the municipal waste recycling rate will continue to increase annually, reaching a level of

71.5% by 2025. These findings suggest that the target set for 2025 can be successfully achieved.

4. Discussion and conclusion

The issue of waste generation highlights the challenges associated with high levels of production and consumption of goods and services (Huttmanova, Valentiny and Kalistova 2019). Perspectives on waste have evolved significantly in recent years, primarily driven by resource depletion and the need to address disposal-related problems. Increased waste recovery holds the potential to address these issues. Waste should be viewed as a valuable resource that underpins the circular economy and enables the development of sustainable production and consumption patterns. However, the findings from our evaluations indicate that the reduction of municipal waste production in both EU countries and the Slovak Republic remains insufficient. Only 14 EU countries have managed to decrease their municipal waste production over the past decade, which cannot be considered a positive outcome. Therefore, we also examined the recycling rates of municipal waste.

The results revealed that only six EU countries achieved a recycling rate exceeding 50% in 2020. Slovakia, too, fell short of this target. Similar results, according Smol, Duda, Czaplicka-Kotas and Szołdrowska (2020) were achieved in Poland, there were some small achievements in the circular economy implementation in municipal waste management. The municipal waste generation in Poland was increasing in previous years, to 329 kg per capita in 2018 (346 kg per capita v 2020); however, it is still one of the lowest in the EU. Municipal waste recycling in Poland was also increasing in last years, from 26.5% in 2014 to 34.3% in 2018 (38,7% in 2020); however, this value is unsatisfactory because it is below the European average. Also Giannakitsidou, Giannikos and Chondrou (2020) mention that there are large disparities among European countries, with respect to their waste management performance.

However, we anticipate that newly implemented measures in Slovakia, such as reimbursement mechanisms for PET bottles and aluminium beverage cans (introduced in 2022) and the expansion of separate waste collection to include biodegradable kitchen waste (since 2021) will contribute to an increase in recycling rates. The deposit return system has demonstrated outstanding results in its inaugural year of operation. According to the Ministry of Environment of the Slovak Republic (2023), the return rate of PET bottles and cans exceeded 70%, while optimistic scenarios counted on a maximum of 60% of returned beverage packaging. In Slovakia, more than 820 million deposit packaging will be collected in 2022, with approximately 57% of the collected packaging being plastic bottles and 43% cans. According to the Analysis of Sorted Collection of Biodegradable Kitchen Waste in Slovakia (2022), another way Slovakia is trying to reduce the volume of mixed municipal waste is by introducing sorted collection of biodegradable kitchen waste, as in 2020 up to 62% of bio-waste in Slovakia ended up in a landfill or in an energy recovery facility as part of mixed municipal waste. In this context, a separate collection obligation for biodegradable kitchen waste was introduced in Slovakia in 2021. To assess the impact of the introduction of separate collection of kitchen bio-waste, a survey of a sample of 103 municipalities was carried out. The results of the survey showed that the participating

municipalities collected a total of 11.4 thousand tonnes of municipal solid waste in 2021, which corresponds to approximately 11 kg per inhabitant.

Based on the regression analysis, an increase in municipal waste production is expected, but at the same time, Slovakia is projected to surpass the recycling rate target by 2025. When considering the effects of these newly introduced measures, the outlook for achieving the recycling rate target becomes even more optimistic. Nonetheless, it is important to note that various factors may still pose challenges to this positive scenario. One of the factors that impacted waste generation and management during the reviewed period, albeit not yet fully reflected in the data used (as the last period assessed was 2020), was the COVID-19 pandemic. European countries implemented various containment measures to limit the spread of Covid-19, which affected both municipal waste generation and the operation of waste management services. Changes in work activities, schooling, and daily habits had notable effects on waste production (Axon, Lent and Njoku 2023; Greene, Hansen, Hoolohan, Süßbauer and Domaneschi 2022). Particularly, there was an increase in plastic waste and specific waste items like masks, respirators, gloves, and disinfectant containers, contributing to municipal waste (Ammendolia, Saturno, Brooks, Jacobs and Jambeck 2021; Yousefi, Oskoei, Jonidi Jafari et al. 2021).

ACR+, an organization that promotes a circular economy and sustainable resource use among cities and regions, conducted a survey of waste collection companies and municipalities in several European countries in 2020. The survey revealed that pandemic restrictions initially impacted municipal waste collection. Similar to neighboring Poland, according Urbańska, Janda, Osial and Slowikowski (2023) door-to-door collection saw no significant changes. However, kerbside collection (e.g., bulky waste) and the operation of collection facilities were restricted, resulting in increased illegal waste disposal. Nonetheless, waste sorting and treatment faced minimal disruptions (Odpady-portal.sk 2021). A more comprehensive analysis of the pandemic's impact on waste generation and management will be the subject of our further investigation.

The Slovak Republic has set a goal to significantly reduce municipal waste production by 2030. However, it is evident that substantial efforts will be required to alter the current status and trends in municipal waste production and meet this target, ultimately moving closer to achieving a more circular economy.

Public policies, incentives, and infrastructure are top-down instruments that can align stakeholders' roles and expectations for circular economy transitions, but it is crucial to analyse the possible effects of such instruments before implementation (Guzzo, Rodrigues, Pigosso and Mascarenhas 2022) The Bellagio Delkaration (European Environmental Agency 2022) sets out seven basic principles of a monitoring framework for an effective transition to a circular economy in line with the EU's New Circular Economy Action Plan as well as the European Green Deal. The Declaration states that monitoring the status and development of the circular economy at the macro level can be carried out by tracking in particular material consumption, waste streams and the reuse of secondary raw materials.

Therefore, our efforts should continue to focus on waste elimination, reducing waste production, transforming current production and consumption patterns, and exploring new avenues for utilizing waste as a resource within the economy.

In conclusion, this article presents a comprehensive monitoring of trends in municipal waste production and recycling rates, providing valuable insights into the direction of progress and the need for intensified efforts towards sustainability in waste management. The evaluation findings serve as a crucial foundation for monitoring set targets, enabling the comparison of EU countries, modification of waste management policies, and guiding the design of effective instruments for transitioning to a circular economy. Policymakers can leverage these insights to refine current policies and enhance waste management strategies by understanding the impact of measures like the Deposit return scheme and the sorted collection of biodegradable kitchen waste. By adopting a holistic approach and implementing evidence-based strategies, we can accelerate progress towards achieving a more sustainable and circular economy.

Acknowledgements

This paper was developed as part of the projects: KEGA 010PU-4/2023 Innovation of the Course Entrepreneurship in Small and Medium-Sized Enterprises in the Context of Sustainability and Circularity; KEGA 024PU-4/2023 Preparation of an innovative study programme in Green Economy in the field of economics and management; VEGA 1/0648/21 Creation of a multi-criteria model for evaluating the effectiveness of meeting the objectives of the Agenda 2030 program for the management of sustainable development; VEGA 1/0508/21 Evaluating the energy sustainability of the countries of the European Union in relation to the objectives of the Agenda 2030 for sustainable development.

This article is one of the outputs of the research project BIN 02_2021_024 "Applied research for the improvement of acoustic properties of mobile noise barriers and ecological use of waste generated during their production " benefits from a 1.817.105,- € grant from Iceland, Liechtenstein and Norway through the EEA Grants. The project has been co-financed from the State Budget of the Slovak Republic in the amount of 15%.". The project is focused on applied research of acoustic properties of mobile antinoise barriers and tents and their improvement, subsequently on the use of waste generated during the production of the above-mentioned products. The aim of the project is therefore to improve the prevention of the spread of noise and dust emissions into the environment, especially in the construction industry, but they will also find application in other sectors where it is necessary to reduce the environmental impact of noise emissions for the necessary time. The next step is the upcycling of the material created in the production of acoustic barriers and tents and its reuse in the circular economy.

References

Ammendolia, J., Saturno, J., Brooks, A.L., Jacobs, S. and Jambeck, J.R. (2021). An emerging source of plastic pollution: Environmental presence of plastic personal protective equipment (PPE) debris related to COVID-19 in a metropolitan city, Environmental Pollution, 269, 10. Available at: https://doi.org/10.1016/j.envpol.2020.116160 Accessed 2023-08-05.

Axon, S., Lent, T., & Njoku, A. (2023). Shifting sustainable lifestyle practices and behaviour during times of pandemic disruptive change: Implications for on-going socio-technical transitions, Energy Research & Social Science, 102, 13. Available at: https://doi.org/10.1016/j.erss.2023.103188 Accessed 2023-08-05.

Enviroportal. (2022). Indikátory obehového hospodárstva. Available at: https://www.enviroportal.sk/indicator/321?langversion=sk Accessed 2022-08-21.

European Environmental Agency. (2022) Bellagio Declaration. Available at: https://www.eea.europa.eu/themes/waste/measuring-europes-circular-economy/BellagioDeclaration.pdf/view
Accessed 2022-04-16.

Europe's circular-economy opportunity (2015). Available at: https://www.mckinsey.com/capabilities/sustainability/our-insights/europes-circular-economy-opportunity#/ Accessed 2022-05-04.

European Commission. (2015). Kruh sa uzatvára – Akčný plán EÚ pre obehové hospodárstvo. Available at: https://eur-lex.europa.eu/legal-content/SK/TXT/HTML/?uri=CELEX:52015DC0614&from=NL Accessed 2022-03-25.

Eurostat. (2022). Circular economy database. Available at: https://ec.europa.eu/eurostat/web/circular-economy/database Accessed 2022-05-16.

Ghisellini, P. et al. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic system, Journal of Cleaner Production, 114, 11-32.

Giannakitsidou, O., Giannikos, I. & Chondrou, A. (2020). Ranking European countries on the basis of their environmental and circular economy performance: A DEA application in MSW, Waste Management, 109, 181-191.

Greene, M., Hansen, A., Hoolohan, C., Süßbauer, E. & Domaneschi, L. (2022). Consumption and shifting temporalities of daily life in times of disruption: undoing and reassembling household practices during the COVID-19 pandemic, Sustainability: Science, Practice and Policy, 18(1), 215-230 Available at: https://doi.org/10.1080/15487733.2022.2037903 Accessed 2023-08-05.

Guerraa, B.C., Shahi, S., Mollaei, A. et al. 2021. Circular economy applications in the construction industry: A global scan of trends and opportunities, Journal of Cleaner Production, 324, Available at: https://doi.org/10.1016/j.jclepro.2021.129125 Accessed 2022-12-01.

Guzzo, D., Rodrigues, V.P., Pigosso, D.C.A. & Mascarenhas, J. (2022) Analysis of national policies for Circular Economy transitions: Modelling and simulating the Brazilian industrial agreement for electrical and electronic equipment, Waste Management, 138, 59–74.

Huttmanová, E., Valentiny, T. & Kalistová, A. (2020). Analytický pohľad na udržateľný rozvoj a koncept cirkulárnej ekonomiky, Veda, výskum a vzdelávanie v kontexte udržateľného rozvoja 2020, Prešov : Bookman, 32-39.

Jurkovič, M. (2020). Podnikateľské modely v cirkulárnej ekonomike. Studia commercialia Bratislavensia. 13(46), 292-301.

Kirchherr, J. et al. (2017). Conceptualizing the circular economy: An analysis of 114 definitions, Resources, Conservation and Recycling, 127, 221-232.

Korhonen, J. et al. (2018). Circular Economy: The Concept and its Limitations, Ecological Economics. 143, 37-46.

Machado, N. & Morioka, S. N. (2021). Contributions of modularity to the circular economy: A systematic review of literature, Journal of Building Engineering, 44.

Ministry of Environment of the Slovak Republic (2023). Výsledky zálohovania za prvý rok prekonali všetky očakávania. Návratnosť prekročila 70%. Available at: https://www.minzp.sk/spravy/februar/vysledky-zalohovania-za-prvy-rok-prekonali-vsetky-ocakavania-navratnost-prekrocila-70.html Accessed 2023-08-04

Odpadový hospodár s.r.o. (2022). Analýza triedeného zberu biologicky rozložiteľného kuchynského odpadu na Slovensku. Available at: https://www.odpady-portal.sk/files/Priloha2/ZOP_Anal%C3%BDza%20trieden%C3%A9ho%20zberu%20BRKO%20na%20Slovensku_Odpadov%C3%BD%20hospod%C3%A1r.pdf Accessed 2023-08-04

Odpady-portal.sk (2021). Ako pandémia Covid ovplyvnila nakladanie s komunálnym odpadom. Available at: https://www.odpady-portal.sk/Dokument/106012/ako-pandemia-covid-ovplyvnila-nakladanie-s-komunalnym-odpadom-studia.aspx Accessed 2023-08-04

Shevchenko, T., Kronenberg, J., Danko, Y., & Chovancová, J. (2021). Exploring the circularity potential regarding the multiple use of residual material, Clean Technologies and Environmental Policy, 23(7), 2025-2036.

Smol, M., Duda, J., Czaplicka-Kotas, A. & Szołdrowska, D. (2020). Transformation towards Circular Economy (CE) in Municipal Waste Management System: Model Solutions for Poland, Sustainability, 12(11), 25.

Urbańska, W., Janda, A., Osial, M. and Słowikowski, M. (2023). Sustainable Municipal Waste Management during the COVID-19 Pandemic - A Case Study of Poland, Resources, 12(7), 16.

Van Caneghem, J. et al. (2019). Waste-to-energy is compatible and complementary with recycling in the circular economy, Clean Techn Environ Policy, 21, 925-939.

World Economic Forum (2020) Circular Economy: Definition, Principles, Benefits And Barriers. Available at: https://youmatter.world/en/definition/definitions-circular-economy-meaning-definition-benefits-barriers/ Accessed 2022-04-14.

Yousefi, M., Oskoei, V., Jonidi Jafari, A. et al. (2021). Municipal solid waste management during COVID-19 pandemic: effects and repercussions, Environmental Science and Pollution Research, 28, pages 32200–32209 Available at: https://doi.org/10.1007/s11356-021-14214-9 Accessed 2022-08-05.