

Position of Slovak in EU from the View of Material Recovery of Waste in Circular Economy

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Abstract

The constant growth in resource consumption is putting pressure on the environment. Most resources are non-renewable and, therefore, need to be managed sustainably. For this reason, increased attention is also being paid to their efficient use within the European Union. The European Union is addressing these aspects to maintain long-term competitiveness and ensure sustainable development in line with all the associated environmental impacts. One of the paths currently on offer is a gradual transition from a linear to a circular economy. A CE monitoring system based on a group of indicators has been introduced within the EU. In this paper, we analyse one of the key areas of the circular economy, material recovery of waste, focusing on municipal waste and its position in the EU and Slovak economy. Measure of circular waste reuse, Measure of municipal waste recycling, CW production per inhabitant, Measure of waste landfilling. By analysing the development of the indicators over the last 10 years, we have tried to realistically assess the achievability of the EU recycling and landfilling targets. The situation in Europe in this area is not optimistic since some EU countries will have a problem fulfilling the EU goals in waste management.

Keywords

Circular Economy, Waste, European Union, recycling, landfilling



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Introduction

Over the years, the topic of waste management has been an increasingly topical issue, monitored and evaluated by the European Union (EU) and member states. Waste thus gradually becomes the so-called "raw material of the future" (Medici, 2022). Today's model associated with waste generation depends on production and subsequent consumption using the "extract - produce - throw away" cycle. In order to use the potential of this raw material (focusing on material efficiency, reuse, repair or change of purpose), it is necessary to adopt the already existing problem. At the same time, it needs to monitor the indicators closely related to the transition to a circular type of economy, pay attention to the efficient management of waste, and use the principle of circularity as much as possible (Jandova et al., 2012). The concept of the circular economy dates back several decades. The concept of circular economy was developed at the theoretical level as part of environmental economics by several authors (Hogg and Ballinger, 2015). The main task of using the circular economy (circular economy) is to reduce natural resources for production while prioritising recycled and sustainable resources, minimisation of waste, and maximum use of the product in terms of lifespan while creating the so-called loop (Bilitewski, 2012).

In current practice, this means almost anything previously considered waste is turned into a valuable, sustainable resource. It also means achieving the permanent goal of reducing waste to a minimum. If a given product reaches the end of its useful life, i.e. passes through all phases of the product's life cycle (introduction, growth, maturity, decline), all the material components that made up the product are used wherever possible. These partial parts are thus reused, which forms the basis of the circular economy. Measures leading to a circular economy are mainly reuse, repair, renovation and recycling (Kadárová and Petričová, 2010).

The paper focuses on the role of material recovery of waste in the circular economy in an attempt to define the meaning and emphasise the current situation from the point of view of the European Union and the Slovak Republic by using individual indicators for monitoring the current state of the transition to a circular economy.

Literature review

In the last few years, the Circular Economy (CE) has received increasing attention worldwide (Chen et al., 2023). The circular economy aims to increase resource use efficiency, with a special focus on urban and industrial waste, to achieve a better balance between economy, environment and society. European and national waste directives prioritise recycling of waste and material and energy recovery from waste (Laurmaa, 2011; Huber, 2020). However, in bio-waste fractions, there are not many methods investigated (Ingrando et al., 2022).

Ghisellini et al. (2016) provided an extensive literature review from the view of individual countries. Their study found that China promotes CE as a top-down national political objective, while in other areas and countries, such as the EU, Japan, and the USA, it presents a bottom-up environmental and waste management policy. The next finding is that the implementation of CE worldwide still seems to focus on recycling rather than reuse. Martinho and Mourao (2020) also studied the literature and found the increased importance of the CE concept within the EU. A literature review was also done by Ruiz-Real et al. (2018) that analysed the worldwide situation in CE from the literature and found the most productive countries are China, the UK, Italy, the Netherlands and Germany. Also, in the Netherlands, waste is an important point for discussion on the circular economy agenda. In this area, Golsteijn and Martinez (2017) showed the Dutch example of waste turned into a resource, resulting in material recycling appearing particularly beneficial for households.

Acelandu et al. (2019) focused on the topic of CE in the context of sustainable development since the concept of the circular economy has brought relevant contributions to the area of sustainable economic development. The authors wanted to identify the major actions of the EU in order to promote CE vision, especially in Romania. The study showed that the Romanian decision-makers understand the CE; however, the situation still demands improvement. Recently, the role of public procurement has started to be important, yet it is not fully exploited. This area was studied by Alhola et al. (2019), who concluded that public procurement can promote CE, especially from the view of green public procurement. The study also suggests criteria concerning the reuse and recycling of materials and waste.

Avdjushchenko and Zajac (2019) studied the CE at the regional level in Poland. They found that existing and traditional tools for CE monitoring are not proper for comparing different European regions because of the data availability limits. Additional indicators should be identified at the regional level to increase the quality of CE monitoring.

Bassi and Dias (2019) explored the CE practices in SMEs in EU countries through typical measures, such as re-planning the way water to minimise or maximise re-usage, RES use, re-planning energy use to minimise consumption, etc. The study shows CE measures in the EU are very heterogeneous due to the firm size and turnover of the firm.

There is a need to study especially industrial recycling of raw materials, which could reduce dependences, conserve resources and reduce emissions. According to Seifert et al. (2021), only a small quantity of refractory materials can be recycled due to insufficient quality.

According to mentioned, there is a gap in the literature to provide the situation in Slovakia. The contribution aims to provide information in the area, which can be used to compare with other post-communist countries.

Methodology

During the research, we resulted from the main characteristics of the circular economy. Based on the linear economic model, a circular economy is seen as a decline from the traditional economy, according to the following process: take, produce, consume, and waste (Figure 1) (Hogg and Ballinger, 2015).

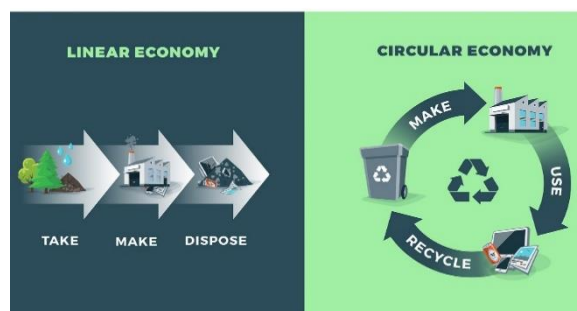


Fig. 1. Model of linear (left) and circular (right) economy
Source: <https://www.instarmac.co.uk>

Next, we considered a new circular economy action plan in the EU (see Figure 2). The plan presents mutually connected initiatives, serving to create strong content for the product policy. Due to the plan, products, services and business models could become the norm and could be transformed without waste. The plan provides the future agenda and is mainly for achieving a net and competitive Europe (COM, 2020).



Fig. 2. Action Plan Logo Source: COM (2020)

CE indicators determination

From the present view of the EU, it is most important to regard "building pillars "on which there is a base of transition to the circular economy. Such pillars present mainly the following two documents:

- New action plan for circular economy in EU (CEAP),
- European Green deal (Palušková et al., 2021).

A number of indicators are used to evaluate or analyse the present state transition to the circular economy (www.ec.europa.eu). According to the OECD, evaluation is extended since the organisation identified 474 CE indicators applied at various levels. The structure of the groups is according to the percentage rate. The study of OECD presents the frame view of indicators, serving as inspiration. EU regularly monitors its goals' process through various indicators together with the chosen methodology. Chosen indicators connected to the CE in the research from various areas are illustrated in Table 1.

Tab. 1. EU indicators to evaluate the state of transition to CE

Production and consumption	Production of communal waste per inhabitant
Waste economy	Measure of communal waste recycling
Secondary raw materials	Measure of circular material reuse

Source: own processing according to Eurostat

Indicator Production of communal waste per inhabitant describes the total produced waste per inhabitant regarding the total population of the country (www.ec.europa.eu). An indicator is in percentage value, waste in tons.

$$CW \text{ production per inhabitant} = \frac{\text{total produced waste in the country}}{\text{average population of the country}} \quad (1)$$

The next indicator used is a measure of communal waste recycling, evaluated according to the following equation:

$$\text{Measure of communal waste recycling} = \frac{CW \text{ recycled}}{\text{total CW production}} \quad (2)$$

The indicators point to the measure of waste recycling, except for the mineral waste sent to the recycling. It expresses the measure to which the waste is recycled from the total waste volume. The indicators are in percentage value.

A measure of circular material reuse measures the rate of recycled material, which is consequently returned to the economy, present third used indicator. Generally, it means how much material is reused and returned to the circular economy. In this way, the exploitation of primary raw materials saves on total material use. The evaluation of the indicator is as follows:

$$\text{Measure of circular waste reuse} = \frac{\text{recycled material}}{\text{returned material to the economy}} \quad (3)$$

The indicators are used for evaluation of present state, which can be described as follows:

Because of the Slovak Republic's membership in the EU, the same principles as in the EU are in the field of waste, as well as the implementation of European legislative regulations. Based on the growing production of waste, emphasis in Slovakia is on waste prevention, collection and recovery of waste, and monitoring of indicators of the transition to CE, while this policy helps the transition of Slovakia as a member of the EU to a circular economy.

Valorisation is the main prerequisite for the creation of circulation within CE. In order to understand the current state of the Slovak Republic in this area, we, therefore, had to pay attention to the analysis of waste production, compare recovery and analyse its rate, and at the same time, compare data from several sources, with not only Eurostat and the Statistical Office of the Slovak Republic.

Slovakia also pays attention to the hierarchy of the waste economy, which presents a cornerstone in the field of waste, considering that the following hierarchy in waste area applies:

- Waste prevention,
- Preparation for the reuse,
- Recycling,
- Another recovery, for example, an energetic one,
- Disposal or landfilling (Hager et al., 2012).

Results

Evaluation of production of communal waste

Within the current state, it is necessary to notice the production. As we have indicated in the figure (Figure 3), within the curve of Slovakia, a growth of KO production in kilograms per inhabitant was recorded from a value of 306 kg/inhabitant to a limit of 496 kg/inhabitant in the 10 analysed years.

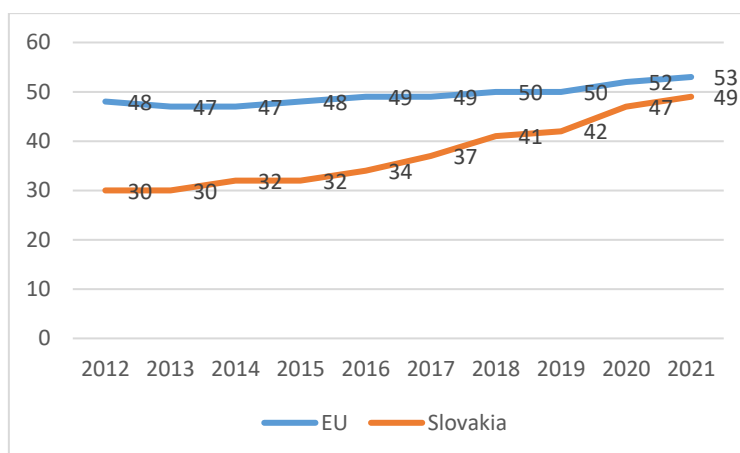


Fig. 3. Comparing the communal waste production in Slovakia and average EU production in kg/inhabitant
 Source: own processing according to Eurostat

When compared to the development in Figure 3, it is obvious Slovakia is under the EU average, but at the same time, Slovakia registered significant growth in the last years. Table 2 compares the situation with chosen EU countries.

Tab. 2. Position of Slovakia in the frame of communal waste production in tons

Average CW production in 2018- 2021 (t)	
15. Finland	3 229 250
16. Ireland	3 069 333
17. Bulgaria	2 923 666
18. Slovakia	2 466 750
19. Croatia	1 760 000
20. Lithuania	1 328 750
21. Slovenia	1 040 500

Source: own processing according to Eurostat

Within the framework of the Slovak Republic's position compared to other EU countries, Slovakia, with its production of municipal waste, is in 18th place out of 27 countries of the European Union. As we can see from the table (Table 2), Slovakia produced an average of more than 2.5 million tons of CW in the period from 2018 to 2021, which is only 5.66% of the total EU production (up to 220,612,000 tons on average in the years 2018 to 2021). As a result of determining the estimated position of Slovakia, we compared Slovakia with Finland; with a similar amount of population (5.4 and 5.5 million inhabitants) (www.ec.europa.eu), Slovakia produces less CW.

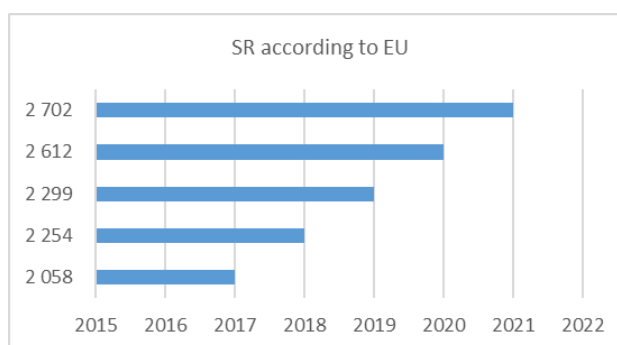


Fig. 4. Development of CW production in Slovakia in mill. tons, according to the EU
 Source: own processing according to Eurostat

From Figure 4, we see that waste production in Slovakia has a growing trend. From the view of the EU, such a trend is expected.

Landfilling

The EU Commission, which also applies to the Slovak Republic in the area of landfilling, has set a clear goal. The goal is in line with the hierarchy of waste management without energy recovery of waste, for the member states to adopt such measures because of which, by 2030, the amount of municipal waste deposited in landfills will reduce to 10% of the total amount of municipal waste. The European Union lists this method of waste management as the last option (Kello and Semančík, 2016).

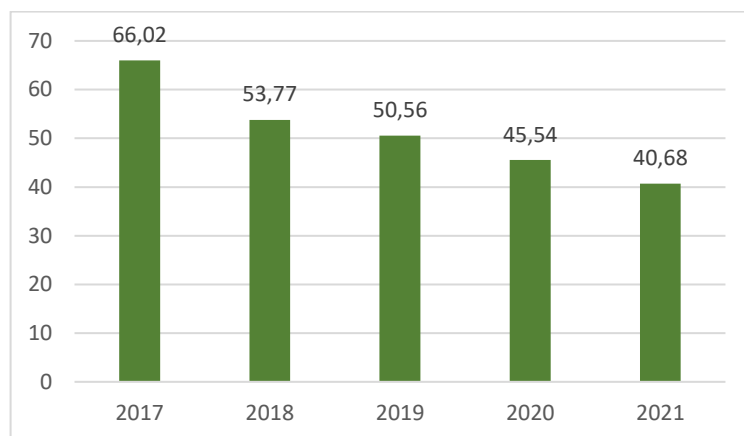


Fig. 5. Measure of waste landfilling in Slovakia in %
Source: own processing according to Statistical Office, SR

In Slovakia's current state of landfilling, we can see (Figure 5) that the trend line of the landfilling rate is decreasing. This fact can have a positive character from the point of view of depositing the amount of CW in landfills. When comparing the Slovak Republic with the EU and its average, we can observe in the figure (Figure 6) that the position of the Slovak Republic from the point of view of landfilling CW is well above the EU average. It also records a decrease within individual periods.

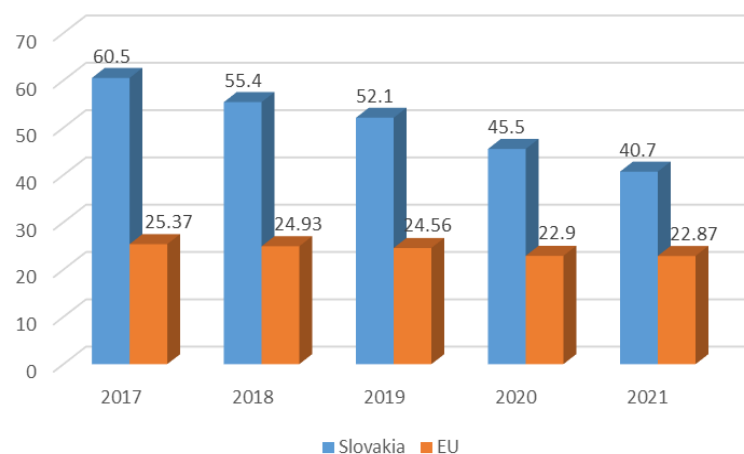


Fig. 6. Comparing of CW landfilling in EU and Slovakia in %
Source: own processing according to Eurostat

Tab. 3. Prediction of CW landfilling measure in Slovakia at the average 5% decrease annually

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SR	40,7	38,64	36,71	34,87	33,13	31,47	29,90	28,40	26,98	25,63

Source: own processing

As part of the analysis and calculation of the average decrease in the rate of landfilling in Slovakia for the period from 2017 to 2021, we found that the decrease was at the level of 5%, which is compared to the decrease in the EU and the same period, where this value was 0.63%. Despite the increased decrease in landfilling and

predictions of a 5% year-on-year reduction, the Slovak Republic is probably not able to meet the EU goal of achieving a landfilling rate of 10% by 2030. As we can see in the table (Table 3), with the current state and prediction decrease from the average for the analysed period of 2017 to 2021, the Slovak Republic will reach a landfill rate of 25.63% in 2030.

When comparing Slovakia from the point of view of neighbouring countries within the V4 countries, we can see in the figure (Figure 7) that for the period from 2017 to 2021, Slovakia had the largest landfilling rate of KO compared to other countries shown in the figure. Slovakia achieved the largest average year-on-year decrease in the mentioned period at over 5%.

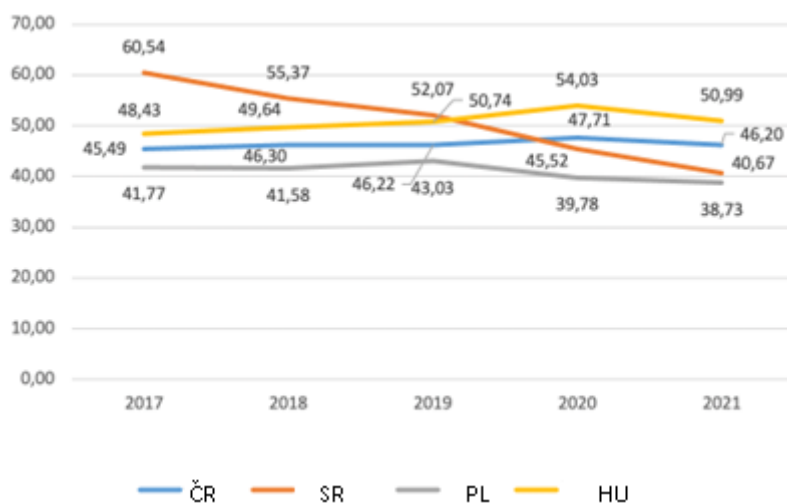


Fig. 7. Comparing of CW landfilling in V4 in %
Source: own processing according to Eurostat

However, when analysing the individual development trends, we found that within the Czech Republic, there is an average growth of 0.16%; in the case of Poland, there is an average year-on-year decrease of 0.76%, and in the case of Hungary, it is an average growth of 0.64%. From Figure 7 and the analyses, we concluded that the municipal waste landfilling rate, despite a smaller growth and decrease, is stagnant except in countries such as Slovakia and Poland. Despite the above, Polish landfills produce the least amount of municipal waste compared to the V4 countries, where the rate of municipal waste landfilling in 2021 was 38.73%. If we consider the target set by the EU and the actual state of landfilling of CW within the V4 countries, it is highly likely that the EU goal in landfilling of CW cannot be met.

Material recovery

From the point of view of the data coming from the Statistical Office of the Slovak Republic on material recovery, we observed in the figure (Figure 8) a clear increase in waste. In 2021, the amount of materially recovered municipal waste in Slovakia reached 583,815.12 tons.

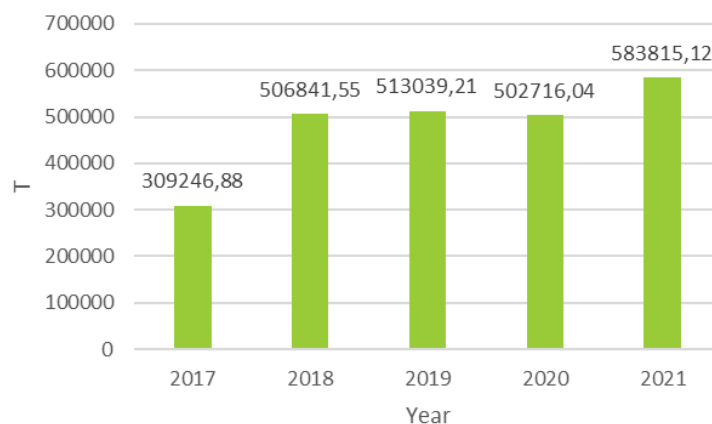


Fig. 8. Volume of CW material recovery in Slovakia in tons
Source: own processing according to Statistical Office, SR

Measure of circular material reuse

In order to assess the current state of the rate of use of circular material in Slovakia, we analysed the development of the Slovak Republic and then compared this development with the development of the EU average in the area of use of circular material. As we can see in the picture (Figure 9), the development of Slovakia in this area was relatively growing from the initial period of 2012, where later in 2016, there was a decrease and subsequent growth, while in 2020, the Slovak Republic achieved the largest rate of use of circular material of all available years for 10.5%. As part of the comparison of the Slovak Republic and the EU average, we could see in the figure (Figure 9) that Slovakia was far below the EU average across all the mentioned periods, where such a difference was up to 2-fold, except for the last two periods.

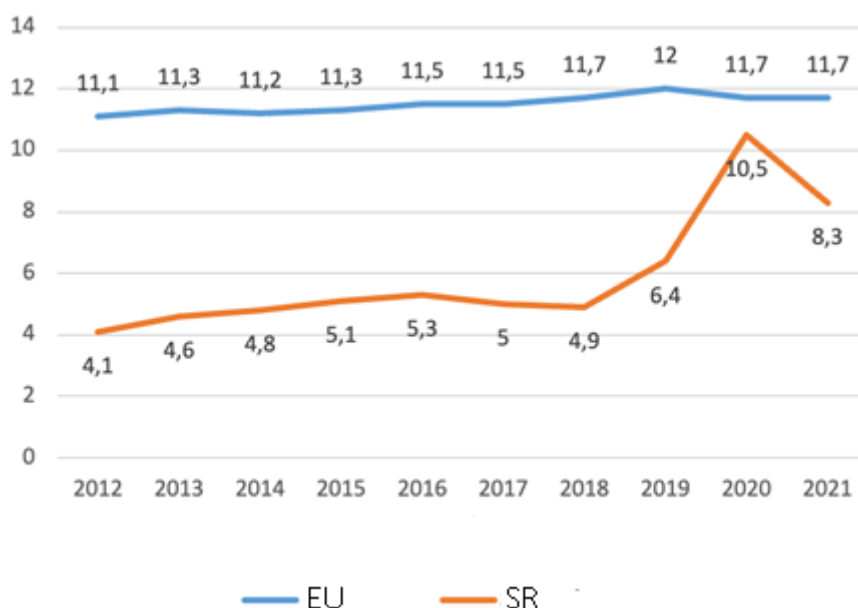


Fig. 9. Comparing the average measure of circular material use in EU and Slovakia in %
Source: own processing according to Eurostat

When comparing the Slovak Republic as a member of the V4 group with the other V4 countries, we can see in the figure (Figure 10) that Slovakia had the lowest rate of use of circular material in the periods of 2012-2019, despite that it overtook Hungary and Poland in growth, eventually finding itself at positions between these countries.

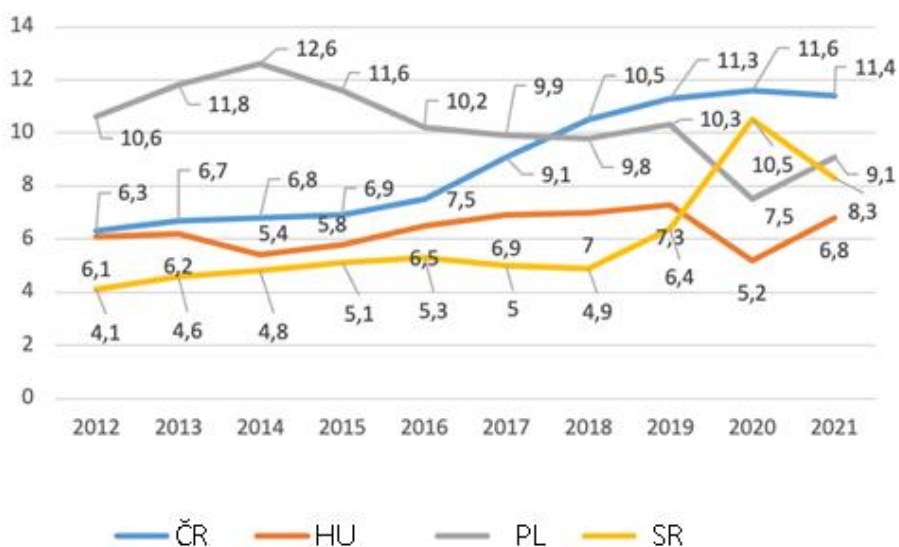


Fig. 10. Development of a measure of circular material use in V4 in %
Source: own processing according to Eurostat

Discussion

In order to assess the current state of the rate of use of circular material in Slovakia, we analysed the development of the Slovak Republic and then compared this development with the development of the EU average in the area of use of circular material. As we can see in the picture (Figure 9), the development of Slovakia in this area was relatively growing from the initial period of 2012, where later in 2016, there was a decrease and subsequent growth, while in 2020, the Slovak Republic achieved the largest rate of use of circular material of all available years for 10.5%. As part of the comparison of the Slovak Republic and the EU average, we could see in the figure (Figure 9) that Slovakia was far below the EU average across all the mentioned periods, where such a difference was up to 2-fold, except for the last two periods. When comparing the Slovak Republic as a member of the V4 group with the other V4 countries, we can see in the figure (Figure 10) that Slovakia had the lowest rate of use of circular material in the periods of 2012-2019, despite that it overtook Hungary and Poland in growth, eventually finding itself at positions between these countries.

The result of our work was the selection and assessment of individual indicators from the point of view of material valorisation in the circular economy and their evaluation using an evaluation scale. At the same time, within the individual findings, we determined and created a group of measures and recommendations in the next chapter. The main findings were as follows:

- the production of municipal waste per inhabitant is increasing. In 2021, the EU average reached a value of 530 kg/inhabitant in the amount of 236,801,000 million tons. Slovakia produces less MSW than the EU average, but in 2021, the growth of municipal waste production reached up to 496 kilograms per inhabitant,
- the municipal waste recycling rate is growing, and the goal is being met. In 2021, the rate was 49.6%, but in the case of countries such as Romania or Cyprus, this goal is not being met.
- the EU largely fulfils the recycling of packaging waste by type of packaging, as the level of the rate is up to 80% in 2020,
- the rate of use of circular material is increasing slightly. Nevertheless, it has recorded a decrease over the last two years, where its level in 2021 is 11.7%, but for the last 2 years, we have registered stagnation and a decrease in some countries, including Slovakia, the rate of use of EU circular material is still at a relatively low level.
- The set EU goal in the field of landfilling is not being met, where the average EU landfilling rate is at the level of 22.87%, SR achieves a linear decrease in the KO landfilling rate, while in the last period up to 40.68% of municipal waste is landfilled. With predictions of a decrease of 5%, while this decrease is greater than the decrease in the EU (0.63%), we concluded that in 2030, the rate of landfilling of solid waste in the Slovak Republic would decrease to 25.63%. It is not possible to fulfil the set goal of reducing the landfill rate to 10% by 2030.

Due to the mentioned, the following suggestions for EU and Slovakia could improve the situation:

- Change the material composition of individual components of KO to those that are more advantageous for material and energy recovery, starting with the minimisation of waste and losses from individual types of recovery.
- Implement fines and penalties for incorrectly classified individual components of KO, which burden the process and efficiency of material recovery of municipal waste, starting with the polluter and ending with the waste processor.
- Develop a case study in the field of energy recovery of municipal waste in the event of a change in the applicable legislation, which affects the use of this method of recovery of municipal waste and its impact on the achievement of various EU strategic plans, and reevaluate individual types of recovery according to the current trend.
- Introduce a system for monitoring the lifetime of individual materials, which would be able to predict the use of a given material after its lifetime to the highest degree of circularity.
- Regulate the type of packaging of fast-moving consumer goods and products to minimise municipal waste generation.
- Modify the current municipal waste disposal system by adding more sorters lines in the landfill waste storage area.
- Increase society's pressure to increase waste recovery in all directions in order to achieve proper awareness and compliance with the waste hierarchy.
- Implement a municipal waste processing system from countries that are the best in individual aspects of waste management and implement them in countries with little potential.
- Ensure the implementation of circular material in all remanufactured products.
- When transitioning to a circular economy, improve all individual areas of the circular economy by replacing primary production sources with waste, while we consider it necessary to substitute as much of the waste as possible, which would otherwise end up as an unused source of raw materials and energy in landfills.

Conclusion

One of the main tasks of the countries is the rational and economical use of raw materials and energy. Rational and economical use of materials applies especially to countries like Slovakia, where a complex situation with raw material and energy resources has developed. Slovakia is a country that has an increased share of waste in landfills, while material recovery is at a quite stable level. The increasing number of inhabitants and their needs relate to a sharp increase in the impact on the environment and other diverse factors, for example, the current waste management issue. The transition to a circular economy model emphasises efficient waste management in the form of material recovery. Thanks to the available data from the European Union and the Slovak Republic, we have analysed individual indicators that have the task of determining the status of the transition to a circular economy and point to the importance of material recovery in the case of municipal waste.

There is room for continuous improvement of all aspects of the transition to a circular economy in all spheres, from legislation to people's awareness, while it would be appropriate to reevaluate the current state and direction of waste management. Despite the advantages of material recovery of waste, we consider it important to reevaluate the use of energy recovery of waste, which can benefit the dynamics of the transition to a circular economy. The paper is limited to the project solving ITMS 3131011T564, "Research on the impact of the implementation of alternative energy sources in the energy management processes of industries", and the research will therefore continue in the future. However, the results of the paper can be presently used for waste management at the level of municipalities and government, as well as for improving the protection of the living environment.

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