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Analysis of Municipal Waste Development and Management in Self-Governing Regions of Slovakia

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Abstract: In the European Union, basic strategy results from the need to provide intelligent, sustainable, and inclusive growth, along with respect to social and economic impacts of waste treatment. The paper focuses on municipal waste and its separation. Generally, within global waste management initiatives, the main goal is to minimize the negative effects of waste on the environment, as well as to increase and optimize the sources' efficiency in the waste economy. Research on municipal waste development and its separation was done in individual regions of Slovakia to find if socially weaker regions have worse waste treatment. The results were compared according to the waste development per inhabitant and per household, as well as through rate indexes, which are connected to relationships between waste, social, and economic indexes. The results confirmed research results from other countries that show that the volume of municipal waste is increasing due to increased living standards of inhabitants. However, on the other hand, waste separation rates also increased—mainly based on the legislative support.

Keywords: environment; sustainable development of regions; municipal waste; separated waste; Slovakia

1. Introduction

Nowadays, issues surrounding the living environment, and its protection, present often-discussed topics. Experts on this global theme most often refer to sustainability, considering all elements of the environment. Environmental aspects present a base for sustainable development on the Earth for current and future generations. This theme is incorporated into strategic documents and action plans at national and international levels. In the European Union (EU), the basic strategy in this field results from the need to provide intelligent, sustainable, and inclusive growth. One of these strategic priority demands is sustainable development—connected to the Seventh Environment Action Programme (EAP)—as a part of the long-term vision, strategy, and orientation of the EU in the areas of living environments and climate protection, until 2050. The EU's goal is to achieve a balance between the living and ecological conditions of the planet in 2050 [1,2].

The paper focuses on municipal waste, which can be considered as one of the most problematic elements of the environment in many regions of our planet, as mentioned in the EAP, stating that

waste should be treated as a source, and demanding the reduction of waste creation per inhabitant. Energetic evaluation of waste will be limited to non-recyclable materials. Storage of waste that can be recycled or composted should be eliminated. To achieve this, it is necessary to promote and comply with environmental protection and the hierarchy of waste economy, which is considered the basis of European policy in the field of waste management. This basis is orientated towards minimizing the negative effects of waste on the living environment, and increasing and optimizing sources in the waste economy. Waste economy hierarchy allows storage—only in case that there is no chance to avoid waste rising. This should be the priority of the waste economy. Moreover, repeated use and recycling of materials should be preferred within energetic waste evaluation from (possible and proper) environmental, technical, and economic perspectives. In the field of waste economy, Slovakia is significantly behind many EU countries due to the low level of recycling and a high level of municipal waste storage. According to the European Commission, the problem is in the system of collection and separation of waste.

Based on the above-mentioned, the paper is focused on (1) the evaluation of waste creation and treatment at the level of individual counties in the Slovak Republic and (2) the identification of factors affecting the situation. This goal was determined due to the backsliding of Slovakia behind a number of EU countries in the area of waste economy, mainly due to the low level of recycling and a high level of waste storage. Given the present state of the situation, we hypothesized that Slovakia would probably not meet goals determined by the EU in the waste economy area. In this regard, it is necessary to determine the situation, not only at the national level, but also at the level of individual self-governing regions and municipalities. At these "lower" levels, it is more likely to positively influence the responsible attitude of society towards effective waste treatment.

2. Literature Review

Increased production of waste, as well as the ineffective use of Earth's resources, is still affecting and changing the environment. Recently, municipal waste has absorbed vast spaces of territory of the Earth; therefore, it presents a threat to the whole ecosystem, economy, and societies around the world. Humanity must realize such environmental risks and try to minimize negative impacts as much as possible to preserve the Earth for future generations' wealth and health. Meena et al. [3] pointed to the environmental problem, warning that waste storage does not solve the problem, since polluting elements from municipal waste could contaminate underground water or plants. In this way, municipal waste can cause serious health problems for people and animals. In addition, Iacoboaea et al. [4] pointed to the negative impacts of improper treatment of municipal waste on health. Such negative impacts mainly result in soil, air, and water pollution [5,6]. Therefore, the task of managing solid municipal waste has become a very important issue all over the world, from not only the perspective of human health, but also from the perspectives of environmental protection, and social and economic interests.

Waste treatment is very unevenly distributed, just like population growth, and is affected by the depletion of natural resources. They are threatened by social unrest and wars. This requires being focused on the 3P (people, planet, profit) criteria or the Triple Bottom Line approach, measuring the impacts of business on people, planet, and profit [7]. The impact on people can be considered from various perspectives. Esmaeilian et al. [8] studied the contribution of waste management to smart and sustainable cities. In one of the studies from a social impact perspective, Xu et al. [9] tested economic incentive and social influence in terms of household waste source separation. The social influence approach promotes waste separation directly or by increasing self-efficacy. Meanwhile, information dissemination and social modeling could increase the knowledge and self-capacity of performing separation activities.

Several authors devoted their research to preventive behavior from the view of waste avoidance [10] and energy saving [11]. Others discussed the support of circular economy through sustainable consumption, purchase of renovated and used objects, etc. [12]. According to Turcott et al. [13], there is

a need to accept and promptly realize measurements, orientated towards the limitation of waste increase. In case waste decreasing is not possible, there is a need to use waste as a source, leading to the minimizing of using other natural resources. Everyone must perceive the need to save sources and to strengthen a sustainable economy. Waste treatment should therefore be solved at international as well as national levels of public administration. Solid waste must be treated in every village, in every city, since waste could have dangerous impacts on living environment conditions of inhabitants in individual communities.

Households present a rather dominant subject that create municipal waste. Waste volume is influenced by the decisions of individuals, connected with their lifestyles. Therefore, it is necessary to increase public awareness of waste economy principles and to increase the ecological behavior of the general public. Ecological behavior is based on recycling, as well as the preventive behavior of individuals. Some authors deal in their research with awareness and motivation of the recycling behavior of the public. Such research mainly focuses on the identification and analysis of factors affecting ecological behavior, such as monetary stimulus [14], social influence [15], regulations [16], and comfort in recycling [17]. Various authors, e.g., [18–21], studied economic and social factors from the view of their influences to increasing public participation in municipal waste separation. The results of these studies indicate that economic and social factors can support behavior during the separation of municipal waste, while economic factors are considered as more effective, mainly in the initial stadium of waste separation support [9].

Modern technologies play a very important role in the system of waste collection and recycling. At the same time, innovative technologies present a very important factor supporting the economic function and effectiveness of waste treatment. The relation between inhabitants and technology is duplex. While the decisions of inhabitants affect the system of waste treatment, the infrastructure of the waste economy surrounding individual inhabitant influence, also, the behavior of the inhabitants [22]. Individual communities need to implement innovative solutions for more simple solid waste collection and liquidation [23]. Communities must find solutions on how to use technologies, supporting the improvement of human behavior with waste to ecologic behavior. In this area, Zhang et al. [24] illustrated possible waste treatment using various technologies. Technologies for use of waste treatment support are divided into four groups, mainly: territory and place technologies (Geographical Information System (GIS), Global Positioning System (GPS), etc.), technologies for identification (Radio Frequency Identification (RFID), barcodes, display, etc.), and technologies for data communication (Global System for Mobile Communication (GSM), Wi-Fi, Bluetooth, etc.). Generally speaking, there is a vast development of waste processing technologies. However, the use of such technologies is often limited due to the relatively high investments required [25]. In addition, the system for treatment with solid municipal waste must be optimized and integrated, orientated to waste minimizing [26]. On the other hand, attention must be given to the increase of the effectiveness of provided services in municipal waste treatment. This presents competence mainly of local or regional communities [27–29]. Research presented by Bel, Fagenda, and Warner [30], and Bel and Warner [31], show that the better the municipal waste service, the better the whole system of waste economy is optimized. Mentioned authors discussed the full use of technology capacity during using and removal of municipal waste. Dollery and Akimov [32] consider the next factor, influencing better cost and administrative effectiveness of the waste system. Such a factor presents ownership of waste treatment companies. Mentioned factors contribute to the creation of intelligent towns, as mentioned by Caragliu et al. [33], which are necessary for sustainable development. This is supported by Čepelová and Douša [34], which state that the concept of the intelligent city requires the use of modern technologies in individual areas, including the waste economy. In this regard, the synergic effect can be developed, increasing life quality and more effective administration of communities.

The existence of different classifications of municipal solid waste (MSW) can cause problems with interpretation and comparing the analysis results. Therefore, Buenrostro et al. [35] illustrated MSW as waste, originated in the frame of municipality territory. Storino et al. [36] have brought a

new system for municipal waste management that integrates composting intending to motivate the public to increased participation in waste treatment. Beede and Bloom [37] examined the economic development of treatment with municipal solid waste through global development. The research shows that the industrially developed countries record a higher share of the worldwide waste related to the share of the world's population. On the other hand, developing countries registered a high rate of the world's waste related to their rate on the world's income. Research by Joseph [38] shows that, to provide sustainable waste treatment, stakeholders must be involved. Studies have been carried out on private sector provision of municipal solid waste services [39], indicating that increased private sector involvement in different regions requires more attention. Waste container provided by the local authority and the socio-economic position of inhabitants also influence a municipal waste generation. On the other hand, some studies failed to find this connection [40]. Adhikari et al. [41] classified waste according to urban organic waste composting strategies. According to their results, management costs can be decreased by house and community composting. Moreover, composting decreases greenhouse gas emissions. Further examination is given to the relation between the food residues rate and paper and board, metal, glass, and plastics residues rate in MSW [42]. In the USA, the relation is examined for just packaging waste. In the UK, the relation is not statistically significant. In Slovakia, the situation is the same. The management of municipal solid waste (MSW) is based on the understanding of MSW categories and their characteristics. Guermoud et al. [43] characterized and determined MSW categories model for conditions of Western Algeria. The categorization considers the inhabitants' lifestyle and consumption behavior. Abu-Qudais et al. [44] evaluated the energy content of municipal solid waste (MSW), indicating that the food waste component is normally distributed. The other components did not record a normal distribution. Magrinho et al. [45] evaluated municipal solid waste management in Portugal, pointing out that the majority of MSW was collected as a mixture.

Wastewater also presents the city service problem. Vialková et al. [46] found an effective method for the treatment with liquid waste. The research confirmed the energy-efficient economy of microwave irradiation using municipal wastewater sediments. Laramee et al. [47] evaluated the efficiency of approaches to wastewater treatment. The study shows the necessity to attract investment in wastewater treatments. A review of relevant agricultural studies is presented in the area of municipal solid waste using [48]. Its safe use in agriculture can be ensured with increased waste separation.

Practices for municipal solid waste treatment differ in various countries. The least efficient practices can be observed in developing countries. Considerable evidence indicates that waste management is sensitive to income and prices [37]. Mistakes in solid waste treatment cause a bad environment in most developing cities since municipal corporations of the developing countries are not able to handle increasing quantities of waste. Individual countries search the state of national system creation for effective use of sources via waste treatment with the material and energetic flow, based on principles of zero waste and circular economy. Such a study was presented by Brauweiler, Shkola, and Markova [49], focusing on the conditions in the territory of Ukraine.

Research in individual countries, in time development, reveal that the generation of municipal waste is positively related to differences in household income and that the generation of municipal waste per inhabitant is not different according to the population size among countries with comparable household income. Burnley [40] examined municipal solid waste (MSW) in the United Kingdom, illustrating a good state of the composition of household waste, but a worse state of civic waste composition. Koufodimos and Samaras [50] applied the concept in southern Europe. The research results show that recycling will present an important part of present waste treatment strategies. On the other hand, composting can play an important role. Incineration can be a conditionally useful solution. Rathi [51] estimates the cost of waste treatment in Mumbai, India, finding community participation in waste management is the least cost option. On the other hand, there is a strong case for comprehensively involving the community in waste treatment. Lusugga and Yhdego [52] studied solid waste management in urban areas in Tanzania from a governance point of view, finding major obstacles to waste management, such as corruption, political apathy, etc., in urban Tanzania;

Alamgri and Ahsan [53] did research focusing on different sources of waste generation in Bangladesh. The findings of the research are similar to the findings in Tanzania [52]. Metin et al. [54] evaluated waste treatment in Turkey. The major elements of municipal solid waste are organic while a quarter of municipal solid waste is recyclable. Due to the problems with waste management, Messineo and Panno [55] studied waste treatment in one of the Italian large regions. The use of landfills can no longer be a satisfactory solution [56]. New methods have to be found when we consider waste-to-energy plants. Dunne et al. [57] evaluated the waste system in Ireland from the perspective of economic and environmental efficiency. The situation shows a growing waste crisis. The present state of waste treatment is studied in India, producing every day more than 3000 tons of solid waste. Moreover, in China, one of the most important tasks is to support waste separation due to the growth of municipal waste [58].

However, in the available literature, there is a lack of waste treatment evaluation in Slovakia as a post-communist country from the view of individual regions approach, especially in the area of municipal waste management.

3. Methods

Evaluation of waste creation and treatment and identification of factors affecting the situation has been achieved by a single analysis in individual self-governing regions (SGRs) in Slovakia. By the analysis, the goal is to find and evaluate the level of waste economy and to show relations between individual social and economic indexes, consequently, to determine if and to what measure chosen indexes in individual counties affect the level of waste indicators. In any SGR of Slovakia, this evaluation allows identifying areas that need increased attention to implement appropriate measures and fill recycling goals.

Concerning the number of inhabitants or the number of households, indicators of municipal waste management recorded in each Slovak SGR from 2002 to 2017, were analyzed. Studied data were analyzed in detail using correlation analysis, analyzing the influence of individual region development to the achieved level of waste management in the counties. The following indexes were analyzed in the structure:

1. Indicators of waste:

    - volume of municipal waste (kg/inhabitant or household);
    - volume of separated waste (kg/inhabitant or household);
    - measure of waste recycling (%);
    - measure of storage (%).

2. Indicators of regions development:

    - regional gross domestic product per inhabitant (Euro);
    - net incomes of households (Euro);
    - average liquidation of equivalent incomes of households (Euro/month);
    - measure of registered unemployment (%);
    - poverty risk rate—60% of the median (%).

Using time series, a trend of individual indicators was determined. After removing the trend element, the relationship between indicators was determined, as well as the relationship between individual counties from the view of indicators development.

Using box plots, the differences between individual SGRs, within the framework of enviro indicators, were compared to find significant differences. To consider the need for further analysis of unit indicators (per capita), the impact of the population on the production of municipal waste was visually examined via cartographers.

The regression analysis revealed a linear relationship between the volume of separation and the recycling rate of municipal waste as well as the exponential development of waste separation per capita in years. Bubble charts were used to summarize the results of four indicators in graphical analysis, providing a comprehensive view of recycling and landfilling. Through cluster analysis, common features at the regional level were summarized, characterizing the level of environmental behavior depending on the SGR development.

4. Materials

Research is done in individual SGRs of Slovakia defined the administrative structure of Slovakia, given by Act No. 302/2001 Coll. on the government of higher territorial units. From the Slovakian law perspective, the regional government is responsible for regional development and regional international cooperation, executes delegated powers, has its own revenue and property, and can conduct referendums. In Slovakia, there are eight SGRs, namely: Bratislava SGR, Trnava SGR, Trenčín SGR, Nitra SGR, Žilina SGR, Banská Bystrica SGR, Prešov SGR, and Košice SGR.

The single research is connected to the results from the municipal waste analysis [59] and focuses on the issue of municipal waste and its treatment in the area of Slovakia.

For research purposes, various data inputs have been used. Basic data input is based on the statistical data on municipal waste provided by the Statistical Office of the Slovak Republic [60]. Analysis of the waste storage growth and treatment in Slovakia is based on the national regional information system about waste (RISO). The data are entered by "Waste Disposal and Disposal Notices" online through district offices [61]. The database under the Act of Waste [62] is provided exclusively by SGRs. According to Decree No 366/2015 [63], SGRs provide Reports of Waste Rising and Treatment together with the Annual Statistic Report of Municipal Waste.

5. Results and Discussion

Many countries, including Slovakia, face the issue of municipal waste volume growth [59]. Results of the analysis indicate that applying for all analyzed SRGs of Slovakia is a growing trend in the production of municipal waste, mainly in the last years (Figure 1). From the long-term perspective, the highest volume of municipal waste is in Bratislava SGR and Nitra SGR. Long-term lowest values are observed in Trenčín, Prešov, and Košice SGRs (Figure 2). The most rapid waste volume increase is in Banská Bystrica SGR. This region also had a significant fluctuance in 2003. In this year, this region produced the highest volume of municipal waste among all self-governing regions of Slovakia. Due to the difference in density of inhabitants in individual SGRs, it is necessary to evaluate the production of municipal waste regarding the number of inhabitants or households. From this perspective, the higher objectiveness is recorded when comparing SGRs. This principle is also used for other analyzed indicators mentioned in the 'Methodology' section of this paper.

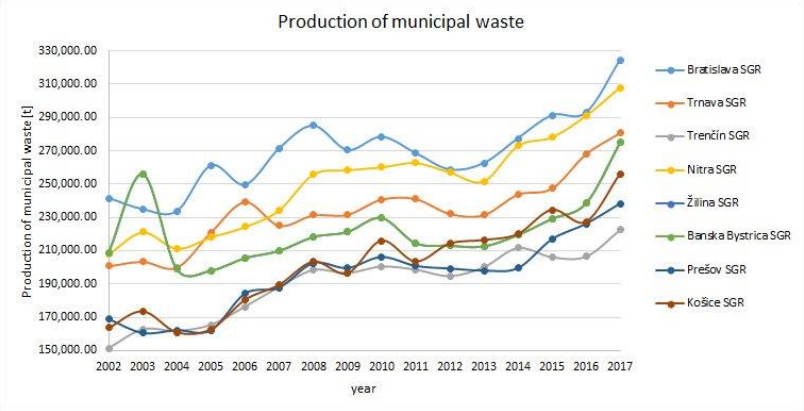

Figure 1. Production of municipal waste in self-governing regions (SGRs) of Slovakia from 2002 to 2017.

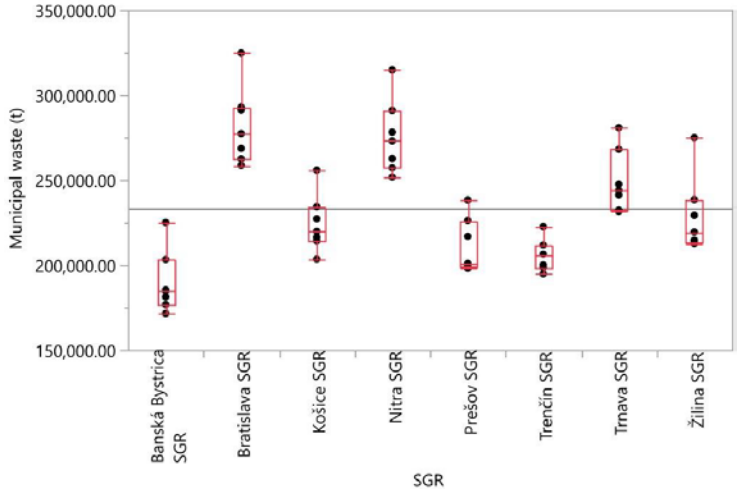

Figure 2. One-way analysis of municipal waste production in SGRs of Slovakia.

Analysis of data per inhabitant shows a significant influence of the indicator on the ranking of SGR in the production of municipal waste. This relationship is obvious in the case of SGRs, defined as leading waste producers, as well as in the case of SGRs with the lowest waste production. The leading producers include Bratislava SGR, Nitra SGR, and Trnava SGR. The lowest production of municipal waste per inhabitant is present in the eastern part of Slovakia, in the Prešov and Košice SGRs (Figure 3).

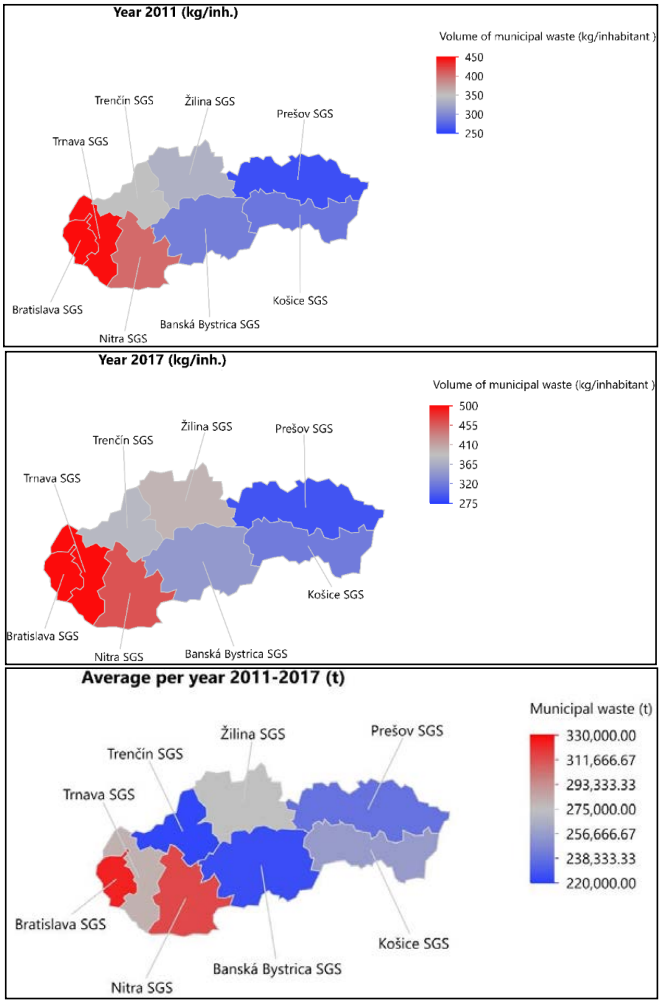

Figure 3. Production of municipal waste per inhabitant in SGRs of Slovakia.

Slovakia, together with other EU countries, has committed to increasing the rate of municipal waste recycling to 50% until 2020, which is heavily realized without waste separation. The measure of recycling is closely connected to the volume of separated municipal waste. This was confirmed by regression analysis (Figure 4). Recently, there has been an established system of municipal waste separation according to commodities: paper, plastics, multilevel materials (beverage cartons), metals, glass, electro waste, and biowaste in Slovakia. One year after the establishment of a separated system of municipal waste (2009), 48% of the waste was separated. Individual elements of waste have been separated in different measures as stated in the Evaluation of the Waste Management Plan of the Slovak Republic for 2016–2020 published by the Ministry of Environment of the Slovak Republic [64]. In recent years (from 2015), the volume of separated waste has significantly increased in all regions of Slovakia. The most rapid growth of waste separation has been recorded in Košice SGR (Figure 5). However, the overall increase in the volume of municipal waste in this region (Figure 1) can be considered as negative.

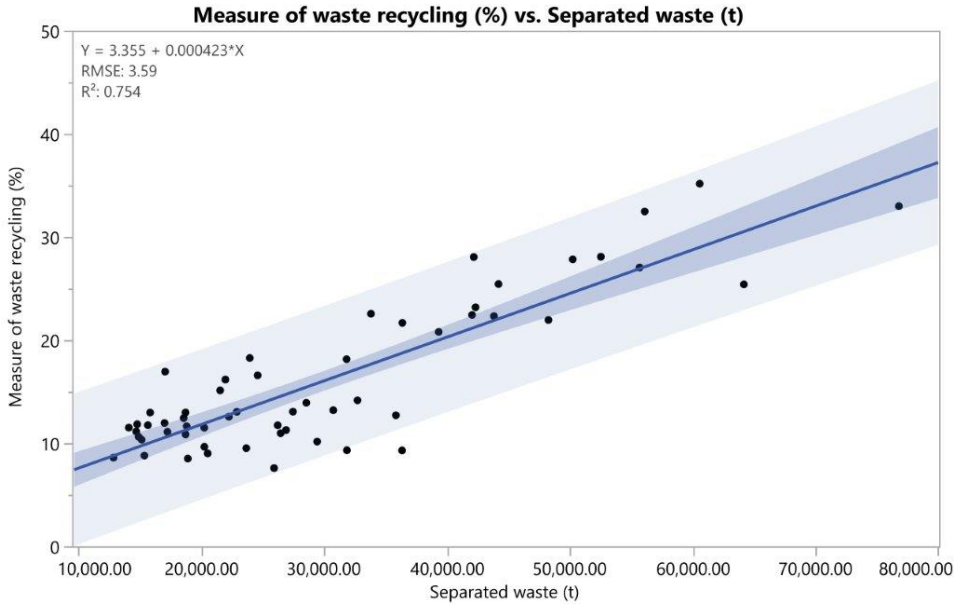

Figure 4. Relationship between the volume of separated waste and the measure of waste recycling in Slovakia.

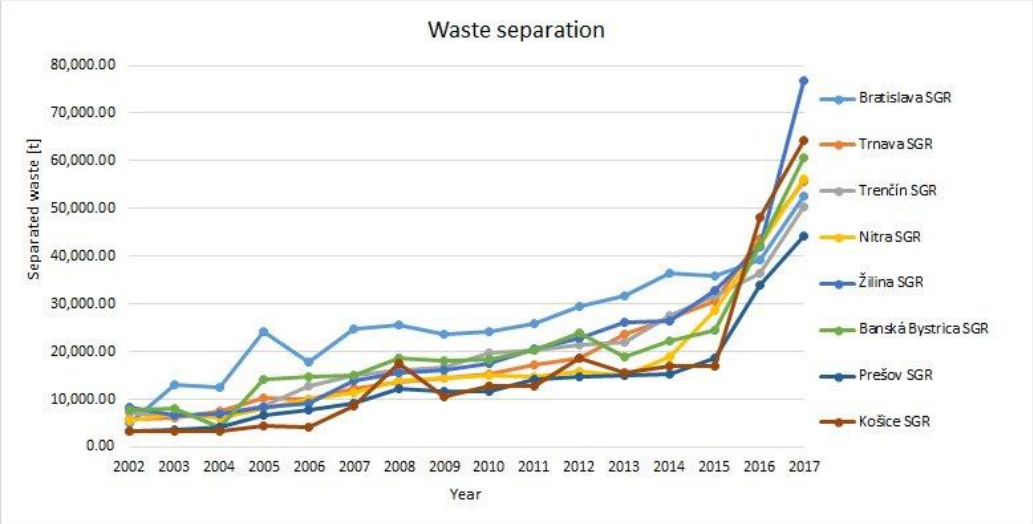

Figure 5. The volume of separated waste (in tons) in SGRs of Slovakia from 2002 to 2017.

By comparing these two indicators per inhabitant, we can see positive development. During the last seven years, the production of municipal waste per inhabitant is, stabilized to a certain level but separation is growing exponentially (Figure 6). Despite the mentioned result, there is an obvious disproportion between individual SGRs of Slovakia. Each SGR also focuses on the need to deal with these indicators individually (Figure 7).

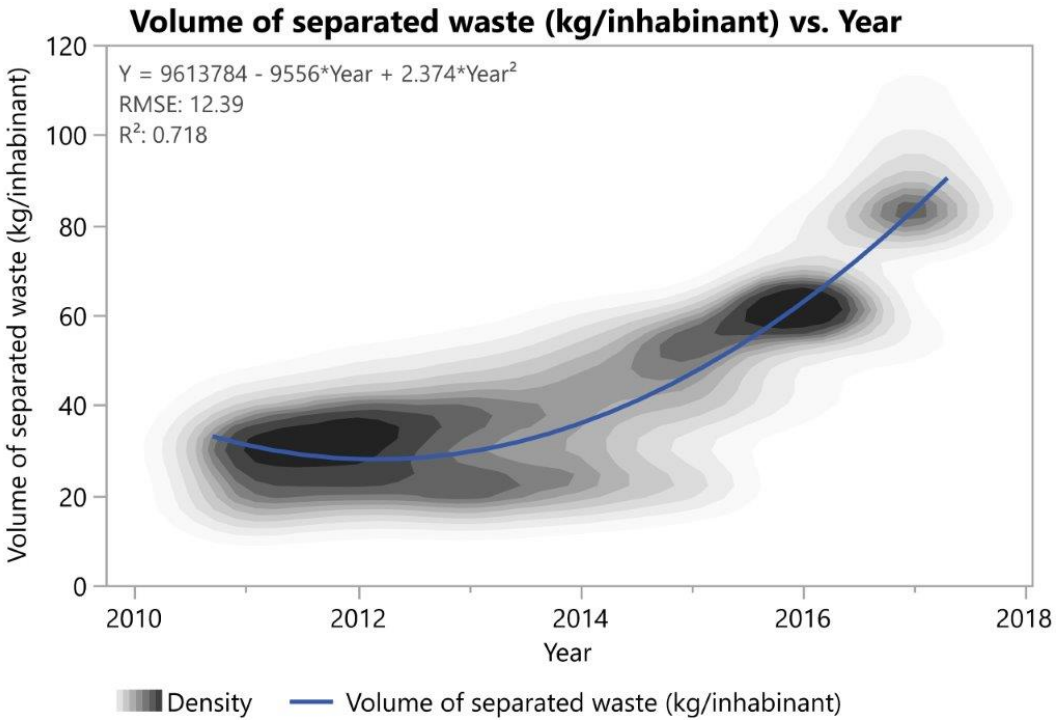

Figure 6. The volume of separated waste in Slovakia from 2011 to 2017.

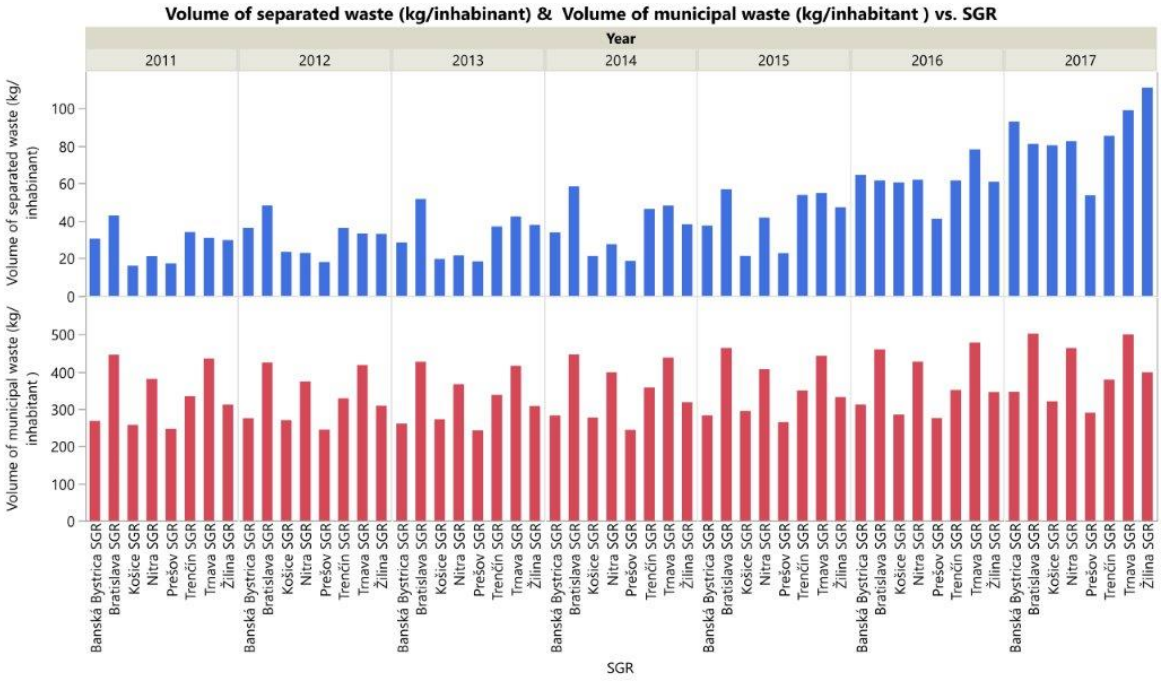

Figure 7. The volume of municipal waste and the volume of separated waste in SGRs of Slovakia from 2011 to 2017.

A gradual increase in the volume of separated waste is recorded in every SGR of Slovakia from 2011 (Figure 7). Figure 8 shows the growing recycling rate in all regions of Slovakia. The highest recycling rate has been recorded in the Banská Bystrica SGR for a long time; we can see the latest start in this trend in the Bratislava and Trnava SGR.

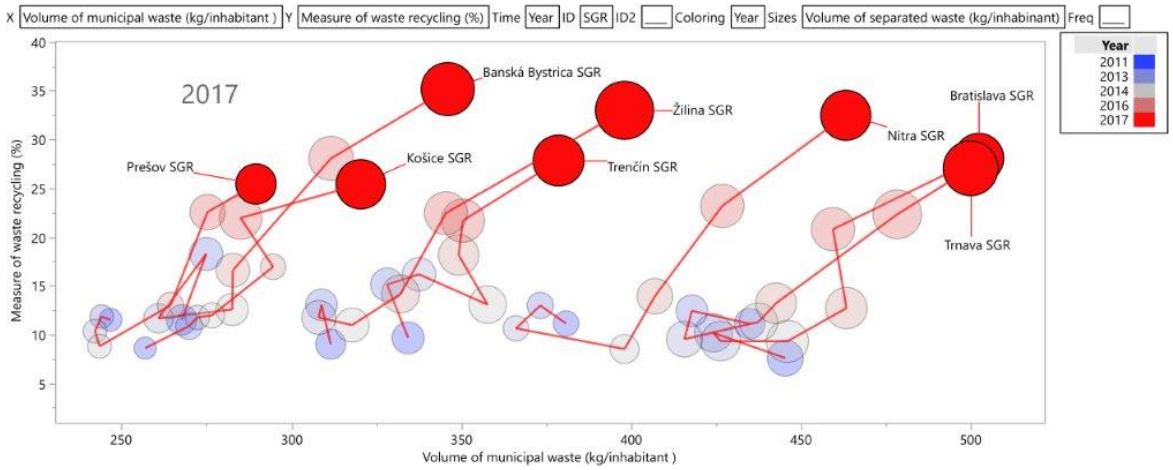

Figure 8. Relationship between the measure of waste recycling, the volume of municipal waste, and the volume of separated waste in SGRs of Slovakia.

The opposite of recycling is the negatively assessed rate of landfilling, which has a decreasing trend in almost each SGR of Slovakia. The exception is the Bratislava SGR, which is stabilized at values around 35% (Figure 9).

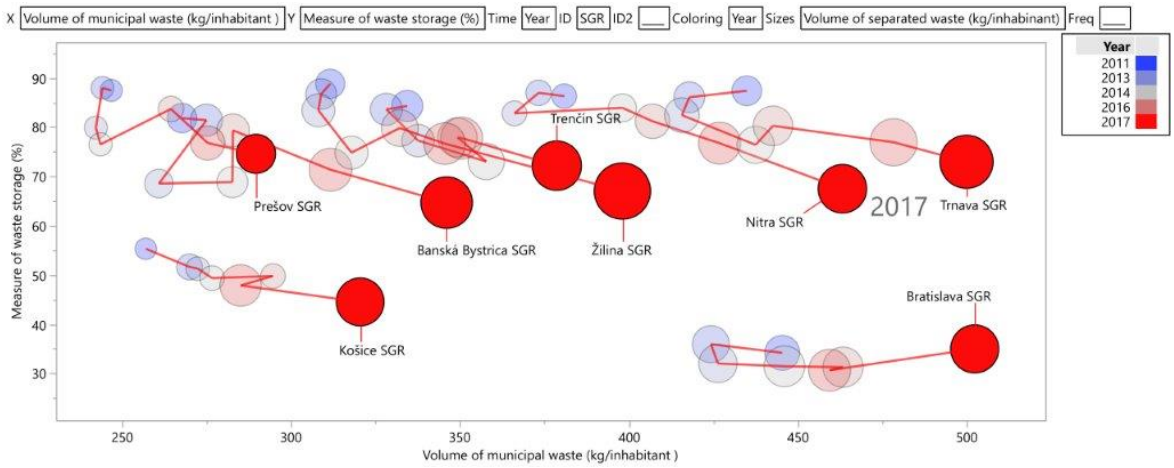

Figure 9. Relationship between the measure of waste storage, the volume of municipal waste, and the volume of separated waste in SGRs of Slovakia.

The environmental indicators analyzed in the area of waste are part of the indicators used to assess the sustainable development of regions. In the Slovak Republic, according to Act no. 17/1992 Col. [65], it is a development that maintains the present and future generations the ability to satisfy their basic living needs without reducing the diversity of nature and preserving the natural functions of ecosystems. Results of cluster analysis, based on production, separation, and recycling of municipal waste, SGRs of Slovakia were divided into three groups (Figure 10) defining their environmental behavior.

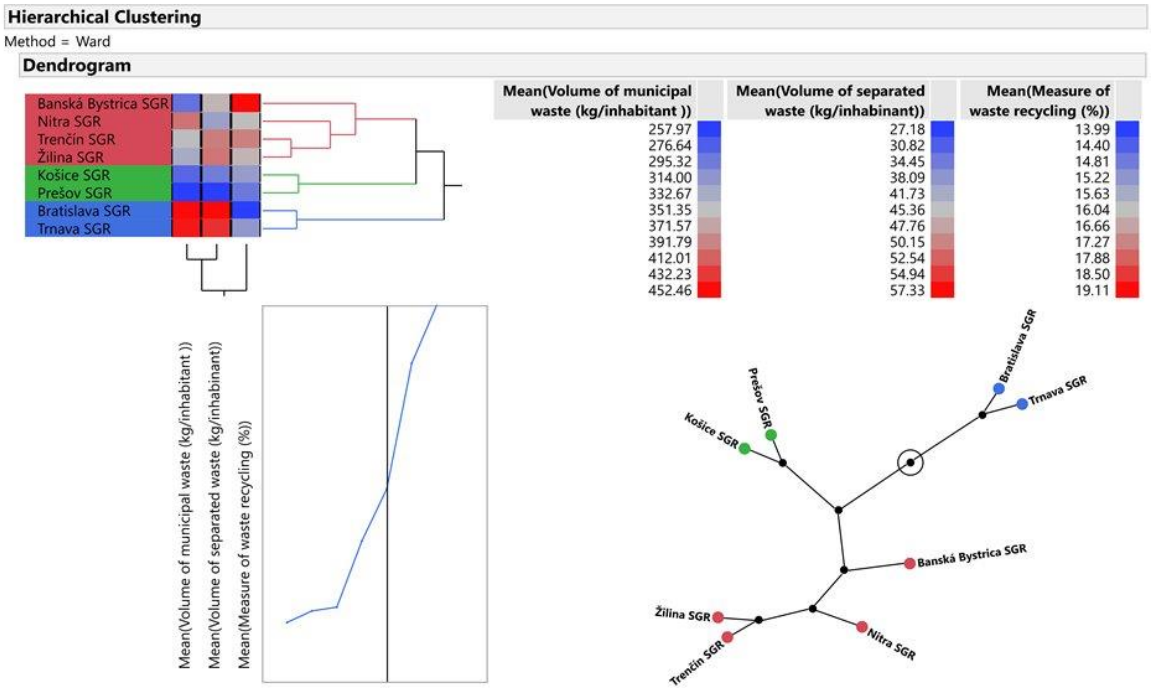

Figure 10. Results of the cluster analysis of the SGRs of Slovakia based on production, separation, and recycling of municipal waste.

1. Group (blue)—Bratislava, Trnava SGR.
2. Group (green)—Kosice and Presov SGR.
3. Group (red)—Banská Bystrica, Nitra, Trenčín and Žilina SGR.

Clusters differ from each other in the intensity of the analyzed indicators. Blue cluster associates regions with the highest production and separation of municipal waste—but at the same time, with a very low recycling rate. The green cluster represents regions with the lowest municipal waste production and separation and, at the same time, a relatively low recycling rate. The red cluster represents regions with the highest recycling rates, but from the production and separation of municipal waste perspective, these regions stand in the middle between the blue and green clusters. We were interested in what influences the behavior of the subjects. In this regard, a relationship between the level of SGR development and the enviro-behavior of individual SGRs was studied.

The relationship between economic, social, and environmental indicators was analyzed via repeated cluster analysis and the addition of economic and social indicators. The analysis resulted in identical groupings of the counties as in Figure 11. This confirms the link between the development level of the region and its environmental behavior.

Following economic indicators, as one of the most commonly used indicators of the SGR development, were used in the study: average net nominal wage, regional gross domestic product per capita, average disposable equivalent household income, and net monetary expenditure in euro. From social indicators, the unemployment rate and poverty risk rate were used.

The blue cluster groups economically and socially more developed regions with the highest municipal waste production. It is represented by the Bratislava and Trnava SGRs, which are the most economically developed, with the lowest unemployment rate and poverty, but the production of municipal waste per capita is the highest in the long term. According to Hrabovska [66], the economically stronger regions utilize waste more intensively, so the environment is ultimately less burdened in these parts of the country. Although, a higher volume of waste is generated. This contradicts findings presented in this paper indicating that more developed regions in Slovakia have the lowest recycling rates.

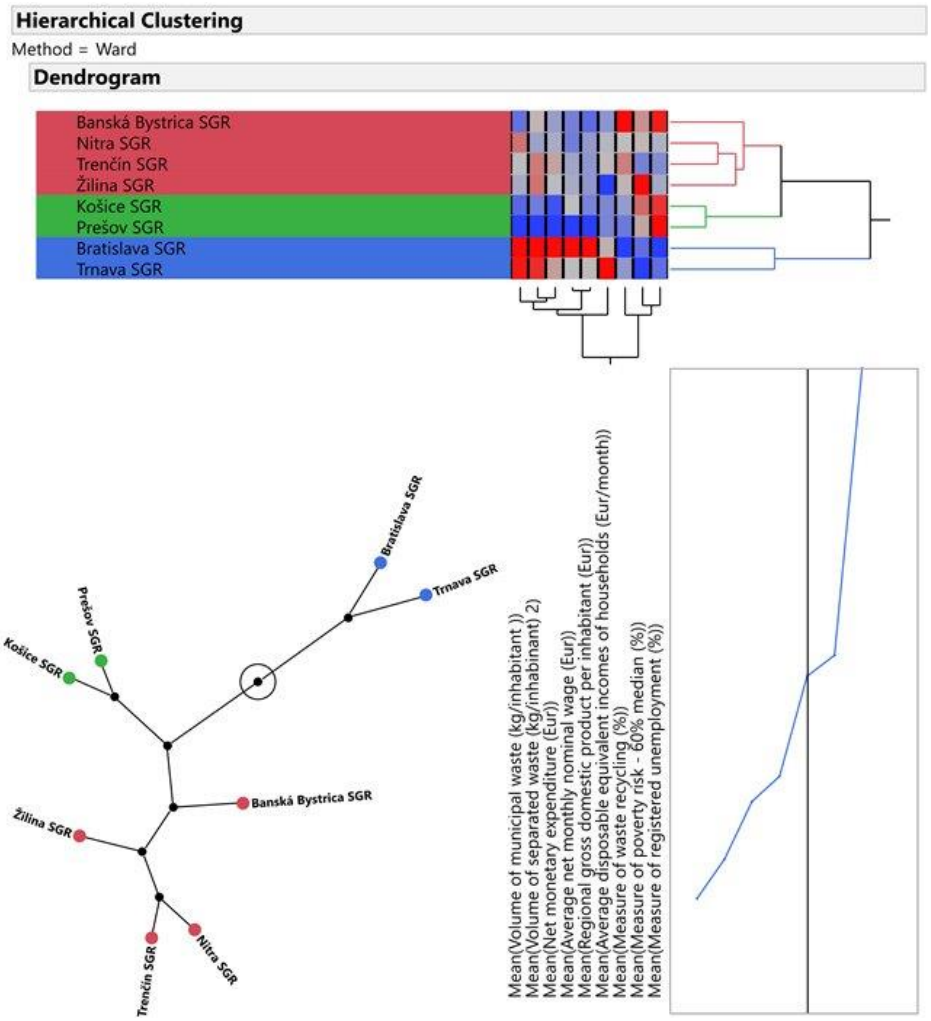

Figure 11. Results of repeated cluster analysis of the SGRs of Slovakia based results of the cluster analysis of the SGRs of Slovakia based economic, social, and environmental indicators.

The green cluster groups the less developed regions with the lowest population income, high risk of poverty, and the highest wastes in terms of waste are those with the lowest municipal waste production and separation, as well as low recycling rates.

The red cluster groups the average developed regions with significantly positive environmental behavior.

The majority of municipal waste (68.4%) in Slovakia is disposed by landfilling, with the highest rate in Prešov SGR, followed by Trnava and Trenčín SGRs. It is the process of depositing waste into the ground or on the ground, e.g., in landfills. In Slovakia, there are 85 landfills for non-hazardous waste, of which 15 are landfills in Prešov SGR and 12 landfills in Trnava SGR.

Due to the need to reduce landfilling, landfill conditions are tightened and waste landfill charges increase. The effort is to disadvantage the deposition of waste at landfills as opposed to its recovery. However, one of the main goals should be to motivate people to behave more pro-environmentally [67]. In this regard, people in Slovakia should, e.g., to sort waste and thus make recycling easier.

The recovery of municipal waste predominates in Bratislava and Košice SGR. In these two regions, municipal waste is largely recovered for energetic purposes. It is related to the existence of municipal waste incineration plants in Bratislava and Kosice. In recent years, energy recovery has begun to take on a downward trend. Material recovery and waste composting are at the forefront, as they seem to be a more efficient way of waste treatment in terms of environmental impact [68]. Recently, most of the material recovers from municipal waste are in the Žilina SGR, which has developed industrial

production. Composting prevails in the territory of the Nitra SGR, which is the strongest agricultural region in Slovakia.

Waste management is one of the important areas that need to be addressed while maintaining the sustainable development of society. The submitted paper pointed to indicators of municipal waste management in individual regions of Slovakia. The upward trend in waste separation, material recovery, waste composting, and the decline of landfill can be viewed positively. Nevertheless, Slovakia is not able to meet its 2020 target of recycling 50 percent of municipal waste. The new objectives set out by the EU are even stricter. By 2035, the Member States should recycle 65 percent of municipal waste and land less than 10 percent of waste [69]. As reported by Ferenčák for the journal "Odpady" (English: "Wastes") [70], Slovakia can benefit from the exemptions to the five-year grace period referred to by the recent approval by the European waste legislation. However, the application of exemptions is conditioned by the elaboration and submission of a detailed implementation plan to the European Commission.

The waste generation rate is influenced by individual decisions, based mainly on technical criteria (costs) rather than societal and ecological criteria [71]. It means that waste management presents a complex problem of the municipality when considering that people educated in environmental issues would probably have higher pro-environmental attitudes [67]. This consideration, similar to considerations of governments and environmental NGOs, considering the improvement of sustainable development of municipalities. Moreover, waste management approaches should be compatible with citizen lifestyles, such that they do not reduce the flexibility in social life while reducing the waste generation rate and increasing citizens' life customizations. In this regard, people should be positively motivated to actively contribute to the reduction of waste generation and an increase in the waste recycling rate [72,73]. At the regional and national levels, as discussed by Taušová et al. [59], probably the most effective tools how to reduce landfilling and support waste recycling are landfill taxes and/or the export of waste to developing countries as discussed by, e.g., Horvath et al. [74]. An increase in taxes in countries with low recycling rates (and relatively low levels of landfill taxes) may effectively lead to an increase in the recycling rate [59].

Municipal wastes also present a major environmental and public health problem in many (especially developing) countries of the world. By introducing waste reduction, reused and separation at source, effective waste collection and transportation, waste to energy facilities, and the polluter pay principle, a sustainable economy, and a healthy environment are guaranteed. However, they present a small part of selected waste (only 1%) and, therefore, they are not included in the Table 1.

Table 1. illustrates in detail obligatory elements of communal wastes in SGRs of Slovakia in 2017. From 2016, also, the number of combined materials has been added to elements of municipal waste.

Individual Elements of Separated Waste in SGRs of SLOVAKIA in 2017 (%)					
SGR	**Glass**	**Paper**	**Plastics**	**Metals**	**Biowaste**
Bratislava SGR	15.40	18.15	16.08	7.16	17.37
Trnava SGR	10.12	10.73	10.58	14.66	12.31
Trenčín SGR	13.16	13.74	11.71	9.12	7.19
Nitra SGR	9.42	11.74	12.58	14.82	24.07
Žilina SGR	19.85	13.46	16.60	18.62	8.27
Banská Bystrica SGR	10.72	12.84	9.45	14.84	11.28
Prešov SGR	11.08	10.76	11.34	8.67	8.95
Košice SGR	10.27	8.58	11.66	12.12	10.56

Grey color highlights the highest value in each category.

Slovakia, together with other EU countries, has committed to increasing the rate of communal waste recycling, which is heavily realized without waste separation. The measure of recycling is closely connected to the volume of separated communal waste, which was confirmed by regression analysis

(see Figure 4). Recently, there is an established system of communal waste separation according to commodities: paper, plastics, multilevel materials (beverage cartons), metals, glass, and bio waste in Slovakia.

Results of the presented data show structure of obligatory separated elements of municipality waste. Among Slovak SGRs, Žilina, and Bratislava SGR have the best position in the separation of municipality waste, Glass and metals are mostly separated in Žilina SGR. Mentioned types of waste are considered as mostly recycled with multiple repeating. Paper and plastics separation dominate in Bratislava SGR. Paper recycling is possible to repeat approximately 6 to 8 times. Plastic recycling is more difficult; however, it is very important due to the considerable impact of plastics on the environment. Biowaste is mostly separated in Nitra SGR. Biowaste has great importance since it presents the biggest part of municipality waste. Through improper treatment, it can negatively influence the environment.

One year after the establishment of a separated system of communal waste (2009), 48% of the waste was separated. Individual elements of waste have been separated in different measures. It results from the Evaluation of the Waste Management Plan of the Slovak Republic for 2016–2020, published by the Ministry of Environment of the Slovak Republic [59]. In recent years (from 2015), the volume of separated waste has significantly increased in all regions of Slovakia. The most rapid growth of waste separation has been recorded in Košice SGR (Figure 5). However, the overall increase in the volume of communal waste (Figure 1) can be considered as negative.

An increased volume of waste presents a worldwide issue. Many countries try to find sustainable ways how to improve environment via increasing waste recycling, decreasing waste volume, and suggesting measurements on how to avoid waste rising [55–58]. Slovakia is under the EU average in the creation and recycling of communal waste. While EU production per inhabitant has not considerably changed in the last years, in Slovakia there is a considerable increase. In 2013, Slovakia has 64% of the EU average in waste creation, while in 2018 it increased to 81%.

This trend is shown in the analysis presented in this paper at the level of SGRs of Slovakia. In every SGR, there is a growing volume of production of municipal waste, separated waste, and measure of waste recycling. However, this development differs from region to region. Analysis results indicate that measures of recycling need not depend on the level of regional development. Moreover, the high recycling of all waste was confirmed with considerable dominance of metals and bio waste. A proper system of waste separation, which is in Slovakia in the hands of individual autonomies, is the base for recycling. Therefore, when considering fulfilling goals set by the EU [69], authorities—not only on the national but also on the regional level in Slovakia—should adopt legislation and mechanisms that effectively affect waste management in the whole country.

6. Conclusions

Despite the growing volume of municipal waste, a positive development was recorded in waste recycling, analyzing the development of local analytical indexes of municipal waste treatment in the context of social and economic indexes in individual regions of Slovakia. According to the analysis of waste recycling at the EU level, Slovakia is a country with a waste recycling rate below the average measure of municipal waste recycling.

Waste management is a complex municipal problem, as shown on the example of Slovakia in this paper. Results presented in this study indicate that, despite a relatively small territorial extent of Slovakia compared to other EU countries, SGRs in Slovakia significantly differ in the production of waste and its management. Moreover, most developed regions do not have the highest recycling rate. It may indicate that the legislation on waste in Slovakia should be stricter to move from landfilling to recycling and waste reduction across the whole country.

The vision of Slovakia is to achieve a better quality of the environment and sustainable circular economy using the minimum of non-renewable resources and dangerous elements—what could lead to the improvement of inhabitants' health. The aim is to increase the measure of waste evaluation with an orientation to prepare the waste for repeated use and recycling, as well as the support of avoiding waste

rising. According to the mentioned goals, the Slovakian government accepted concrete measurements on the municipal waste decreasing, storage decreasing, and recycling increasing. The measurements are connected to the law of waste, law of bottles backup, and economic tools, such as increasing fees for waste storage at dumps and waste ponds.

Except for social and economic factors, which have been evaluated in this paper, waste treatment is also influenced by other factors, e.g., the awareness of inhabitants on the importance to sort waste and to create a proper system for selected collections that would be convenient for the inhabitants. This could be the subject of further research in the field of waste management in Slovakia.

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