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ANALYSIS OF CONTEMPORARY MUNICIPAL WASTE MANAGEMENT PRACTICE IN THE REPUBLIC OF SERBIA

Abstract: *This paper presents an analysis of the current practice in the field of municipal waste management in the Republic of Serbia. Data on generated, reused and disposed waste, collected by the Serbian Environmental Protection Agency, have been analyzed. The analysis showed that part of the generated waste is still not properly disposed of in sanitary landfills. Also, the paper presents municipal waste management methods that are most commonly used in the Republic of Serbia. From the data analyzed, it was concluded that the most commonly used method of waste management is landfill disposal. The aim of the paper is to present the improvements made so far in the field of municipal waste management practice through the Waste Management Strategy 2011 to 2019 with reference to the betterments and changes expected in the new Strategy in the coming period.*

Keywords: municipal waste, quantity, composition, treatment methods, Republic of Serbia

INTRODUCTION

Waste generation has been recorded ever since the emergence of the human population. Waste management had not been given adequate attention until the period of intensive economic growth after the Second World War. The awareness of sustainable waste management appeared during the first global initiatives in the field of environmental protection, in the 1970s. Sustainable waste management has become indispensable in the last few years at all stages (collection, transport, treatment and disposal) that potentially have an environmental impact. As a result, a range of new and existing waste treatment technologies and management strategies are brought together to maintain environmental quality today and to meet the sustainable development goals in the future [1]. Waste generation depends on the degree of industrial development, quantity, level and type of industrial and economic activities, the standard of living, lifestyle, social environment, consumption, and other parameters such as population size and waste management efficiency [12] [3]. The basic information needed for the planning, operation and optimization of waste management systems is the amount and composition of generated waste [4]. Poor management of solid waste may result in serious urban, sanitary and environmental problems such as unpleasant odors and risk of explosion in landfill areas, as well as groundwater contamination due to leachate percolation [5]. The legislative framework in the field of environmental protection and management provides the conditions for establishing and developing an integrated waste management system. Solid waste management in developing countries around the world has been reported by several researchers in 2005, 2006, 2008 and 2009. [6] [7] [8] [9]. Waste management in the Republic of Serbia can generally be characterized as underdeveloped [10]. Waste management methods usually consist only of collection, transport and disposal, while advanced waste treatment methods are less common [11]. Research to date has shown that a small portion of treated municipal waste in the Republic of Serbia is mainly treated with mechanical treatment methods (it is important to keep in mind that, so far, thermal methods have only been used to treat medical waste). The collection of waste management data is based on the existing legislation of the Republic of Serbia, EU directives, as well as obligations arising from various international treaties [12]. Reporting and data collection began in 2007 with the establishment of the Integrated Pollutant Cadaster. Data on waste management in the Republic of Serbia are collected under the Law on Waste Management. This paper analyzes waste reuse, recycling and disposal, as the most commonly used methods of municipal waste management in the Republic of Serbia.

THE IMPORTANCE OF SUSTAINABLE MUNICIPAL WASTE MANAGEMENT

Municipal waste includes the waste left from households, non-hazardous solid waste from industrial, commercial and institutional establishments (including hospitals), market waste, yard waste, and street sweepings [13]. In the 21st century, the perception of sustainable municipal waste management has become necessary at all phases, starting from planning to construction of specific technological units, transport, treatment, disposal and final activities related to site remediation. In terms of environmental impact, the most important thing is to reduce the amount of waste that is disposed of in landfills, through a combination of different approaches. For example, instead of being disposed of, mixed municipal waste can be used as a source of secondary material or as a source of energy [14]. Reliable data about waste quantities and morphological composition are the basis for the successful planning of waste management programs [15]. The waste manager needs information about

quantities and waste composition generated within the municipality which may be included in the waste management system under the control of the municipality [16]. According to the World Bank report *What a Waste: A Global Review of Solid Waste Management*, from 2012, it was 2.9 billion residents who lived in urban areas and generated about 0.64 kg of solid municipal waste per person per day (0.68 trillion tons per year) [17]. These values are estimated to have increased today. About 3 billion people today generate 1.2 kilograms per person per day (1.3 billion tons of waste per year). Forecasts for 2025 indicate that the population will increase to 4.3 billion that will generate about 1.42 kg per capita per day of municipal solid waste (2.2 billion tons per year) [18]. For this reason, the growth of solid waste is inextricably connected to the urbanization process and economic development of particular countries. Waste volume in the Republic of Serbia is hard to estimate. The main reason is the lack of information on waste qualitative and quantitative analysis, i.e., a database of quantities, characteristics, especially content, and classification of waste [19]. According to data from the National Waste Management Strategy 2010-2019 in the Republic of Serbia currently generates 2,448,566 tons of municipal waste, or 340.7 kg/capita per year i.e., 0,8 to 1kg per capita per day [20]. Despite the high content of organic components, there are no facilities for the biological treatment of municipal waste. In the Republic of Serbia, the waste management infrastructure is underdeveloped. Currently, the most common way to manage waste is to dispose of it in landfills. Many municipalities/cities have their own landfill - dump. The capacity of existing landfills in most municipalities is already full, while most landfills do not meet the minimum technical standards. The most polluting materials emitted from landfills are nitrogen and sulfur oxides, dust and heavy metals, landfill gas that has about 50% methane and leachate resulting from precipitation and other sources, like groundwater breach, which are filtered through the mass of waste deposited and dissolve pollutants thereby polluting soil and groundwater. In order to reduce the negative impact of municipal waste on the environment, it is necessary to analyze waste management such as collection, transport and disposal, which is currently one of the major environmental problems [21].

CURRENT PRACTICE OF MUNICIPAL WASTE MANAGEMENT IN THE REPUBLIC OF SERBIA

The basic prerequisite for the analysis and more complete insight into the state of municipal waste management is the data on the amount of waste generated per capita on an annual basis, as well as information on the methods of its treatment. Data on waste management in the Republic of Serbia are collected following the Law on Waste Management. Waste data are collected in accordance with [22]:

- Regulation on the Methodology for Creating a National and Local Register of Pollution Sources, and Methodology for Types, Ways and Terms for Data Collection [23].
- Rule on the Form of the Document on Waste Movement and the Instruction for its Completion [24].
- Regulation on Forms for the Report on Packaging and Packaging Waste Management [25].
- Regulation on the form of the Document on the movement of hazardous waste, the template for the previous notification, the manner of its submission and the instructions its completion [26].

The number of reports submitted has been kept since 2013 when the existing information system was established. Table 1 shows the number of submitted reports by year for the period 2013 - 2018.

Table 1. Number of submitted annual reports in the period 2013 – 2018 in the Republic of Serbia [27]

Year	*Waste generation*	*Waste disposal*	*Reuse*	*Municipal waste*
2013	6602	24	253	106
2014	8014	29	274	96
2015	9266	28	291	96
2016	11204	33	311	99
2017	12924	33	306	104
2018	15421	32	331	101

The number of reports in 2018 increased by 56% compared to the number of reports submitted in 2013. The number of reports by waste producers is increasing, while the number of reports submitted by waste management operators remains constant. The categories of waste generated in the Republic of Serbia in 2018 are shown in Figure 1.

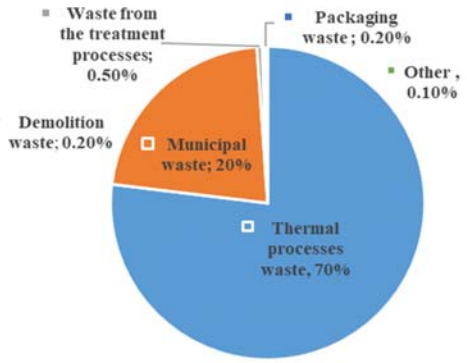

Figure 1. Categories of waste in the Republic of Serbia in 2018 [28]

The total amount of municipal waste in 2018 in the Republic of Serbia was 2.3 million tons or 20% of the total amount of waste in all waste categories. The annual amount of municipal waste in the Republic of Serbia is 2.448.566 tons or approximately 0,90 kg per capita per day. The largest share in municipal waste is organic waste, with a share of 43%, followed by cardboard and paper ≈15%, plastics ≈15%, and fractions such as glass and textiles represent ≈5%.

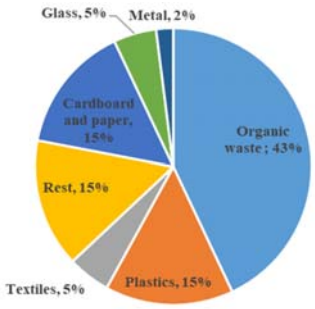

Figure 2. Composition of municipal waste in the Republic of Serbia [29]

Determining the morphological composition of waste is an important stage in waste management. The value of the representation of each type of waste contributes to the overall analysis of data on the success of waste management in an area.

Table 2. Average values of municipal waste composition by type of waste [30]

Type of waste	*Examples*	*Composition (%)*
Garden waste	Mowed grass, weeds, flowers, twigs, branches, leaves	14,58
Other biodegradable waste	Food waste - all types (bread, meat, vegetables, fruits ...)	31,1
Paper	Envelopes, old mail, posters, books, bus tickets, bills, letters	5,9
Glass	Bottles, glass jars, flat glass, light bulbs, mirrors	4.7
Cardboard	Boxes of food packaging, cardboard beer boxes, biscuit boxes	6,28
Cardboard with wax	Tetra Pak for yogurt, milk, juices	0,85
Cardboard with aluminum	Tetra Pak for yogurt, milk, juices	0,77
Metal- packaging and others	Food cans, tools	1,43
Metal - aluminum cans	Beverage cans	0,3
Plastic packaging waste	Plastic bottles for water, juices, beer …	3,6
Plastic bags	Bags from stores, garbage bags	6,42
Solid plastic	Rulers, pens, toilet lids, toothbrushes, plastic boxes, buckets, basins, sunglasses	4,19
Textile	Natural fibers (cotton, wool, linen), and synthetic fibers (trousers, socks, cloth bags, linen)	5,3
Leather	Wallets, belts, leather shoes, bags	0,67
Diapers	Diapers for babies, sanitary diapers	4,17
Fine elements	Dust, ashes, sand, fragments of glass	9,54

In the Republic of Serbia, municipal solid waste is sorted by categories. Table 2 shows a catalogue with types of municipal waste, accompanying examples, and average values of waste composition in ten local municipalities (Inđija, Sombor, Novi Kneževac, Šabac, Topola, Kragujevac, Bor, Niš, Novi Sad, Beograd) in the Republic of Serbia [30].

The data were obtained as a result of the project "Determining the composition of waste and estimating the amount in order to define a strategy for the management of secondary raw materials within the sustainable development management of RS". Research has shown that the largest percentage of municipal waste is biodegradable waste- food waste - all types (bread, meat, vegetables, fruits, etc.), domestic animal carcasses, etc. Of the total municipal waste generated in the territory of the Republic of Serbia, only 60% is collected in an organized manner, mainly in urban areas. Reducing municipal waste generation is a strategic goal of the Republic of Serbia. The monitoring of this objective was established by indicators of the Environmental Protection Agency based on annual data on the amount of waste reported by municipal companies in local self-governments in accordance with the Rule on Daily Records and Annual Reports of Waste Containing Instruction for its Completion [24].

Table 3. Total amount of waste generated in the Republic of Serbia [22]

Year	*Total amount of waste generated (mil t)*
2011	2,71
2012	2,62
2013	2,41
2014	2,13
2015	1,840
2016	1,89
2017	2,15
2018	2,23

Year	*Amount of waste collected and deposited by municipal PUCs (mil t)*
2011	2,09
2012	1,83
2013	1,92
2014	1,67
2015	1,36
2016	1,49
2017	1,80
2018	1,95

Year	*Average volume of waste collection (%)*
2011	77
2012	70
2013	80
2014	80
2015	82
2016	82
2017	83,7
2018	87,2

Year	*Average daily amount of municipal waste per capita (kg)*
2011	1,01
2012	0,99
2013	0,92
2014	0,81
2015	0,71
2016	0,73
2017	0,84
2018	0,85

Year	*Average annual quantity per capita (t)*
2011	0,37
2012	0,36
2013	0,34
2014	0,30
2015	0,26
2016	0,27
2017	0,30
2018	0,31

The indicators show the quantities of municipal waste produced.

Table 3 presents indicators of the total amount of municipal waste generated in the Republic of Serbia.

In the Republic of Serbia the value of quantities of generated and collected municipal waste continued to increase. This shows, first of all, the success of the system of collecting individual fractions of municipal waste in local communities, such as the waste paper and cardboard, packaging waste, as well as other types of waste that usually end up in containers, but also reflects the disposable personal income (DPI) of the population.

SOLID MUNICIPAL WASTE MANAGEMENT PROCEDURES

The municipal waste management system is based on the analysis, consideration and definition of solid waste treatment methods and procedures, starting with the possibility of reducing waste, selecting the optimal solid waste treatment routes from the place of their generation to the final disposal, with the overall aim to minimize the negative impact on the environment and the human health. In addition to a large number of available and developed waste treatment methods (mechanical, physico-chemical, biological and thermal), unfortunately, waste disposal at landfills remains the most common type of waste treatment in the Republic of Serbia [18]. Waste prevention includes measures to avoid waste generation by changing practices in production and consumption, reusing products and materials, and preventing waste disposal. Measures that affect the general conditions of waste generation include economic instruments that encourage efficient use of resources, promote research and development in the area of cleaner technologies. Unlike other options in the waste management hierarchy, waste reduction is not an option that can be selected in the absence of others. The reduction must be considered every time a decision is made to use resources. The reduction must be designed throughout the life cycle of the product, at the design stage, through the manufacturing, packaging, until the transport and placement of the product. According to the National Strategy, the objectives of waste prevention are stated through the following long-term and short-term planning activities [31]:

- Reduction of municipal waste for disposal in conditions of the expected increase in population consumption,
- Stabilization of industrial and hazardous waste in accordance with the expected increase in production,
- Encouraging the establishment of licensing regimes relating to waste generation in large industrial companies.

Based on data submitted by August 2019 by 331 operators licensed for waste reuse, 2.03 million tonnes of waste have been reused in the Republic of Serbia in 2018 [27]. Of the total amount of reused waste, the most represented are waste metals followed by waste from processed and unprocessed slag from the iron and steel industry, and finally paper and cardboard packaging. Table 4 gives an overview of the amount of reused waste, according to the technique used. The procedures of R1 - R10 are different types of treatment procedures, while the procedures of R11 - R13 represent ancillary activities related to the treatment procedures - waste preparation, storage [32].

Table 4. The amount of reused waste in the Republic of Serbia in the period 2011-2018 [27]

Year	Treated with R1-R10 (t)	Treated with R11-R13 (t)	Total treated (t)
2011	1.422.017	31.755	1.453.722
2012	940. 662	178.820	1.119.482
2013	1.493.388	294.275	1.787.664
2014	1.660.068	345.319	2.005.387
2015	1.279.231	360.255	1.639.486
2016	1.418.226	261.122	1.679.340
2017	1.479.522	260.609	1.740.131
2018	1.700.470	332.679	2.033.149

Also, 1,6 million tons of non-hazardous waste and 94 thousand tons of hazardous waste are processed according to procedure R1 - R10, while 313 thousand tons of non-hazardous waste and 19 thousand tons of hazardous waste are processed according to procedure R1 - R10. The National Register of Pollution Sources, within the Environmental Protection Agency, through the online platform of the Geographic Information System (GIS), provides insight into the generation, collection, treatment, disposal, import and export of waste in the Republic of Serbia [33]. Municipal waste treatment in the Republic of Serbia is performed by 32 companies and their spatial distribution is presented in Figure 3. The locations of companies are mainly concentrated in the surroundings of larger cities, while two-thirds of the total is located in the northern part of the Republic of Serbia.

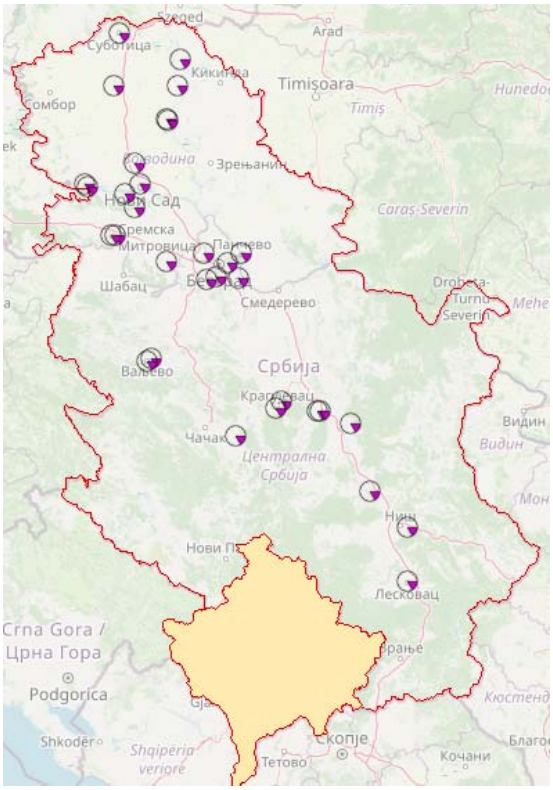

Figure 3. Waste treatment companies [33]

Table 5 gives an insight into the defacto data on the amount of municipal waste treated according to the procedures applied in 2018.

Table 5. Amount of municipal waste treated depending on the procedure applied in 2018 [33]

Procedure	Number of companies	Amount of treated municipal waste (t)
R1	2	85,348
R3	5	413,999
R4	7	29.521,098
R5	2	3.931,683
R7	1	1,54
R11	1	15,401
R12	11	19.514,123
R13	3	491,16
Total	32	53.974,412

Table 5 provides data showing that municipal waste is mainly treated by the reuse method and the waste recycling by the procedures R1, R3, R4, R5, R7, R11, with ancillary operations R12 and R13. Recycling is the waste treatment to obtain the raw material for the production of the same or another product. The difference between reuse and recycling is that reuse does not change the material structure, as in recycling. Procedure R1, which uses waste as fuel or other means of energy production, most often treats edible oils and fats as well as mixed municipal waste. R3 represents a process of recycling/reclamation of organic substances that are not used as solvents (including composting and other biological transformation processes) and the waste treated by this process is mainly biodegradable kitchen waste, oils, fats, etc. R4 is a process of recycling/reclamation of metals and metal compounds and it is most commonly used as a municipal waste treatment method and treats metals, electrical and electronic equipment containing hazardous substances. Textiles and clothing are treated by procedure R5, which is recycling/reclamation of other inorganic materials. R7 is a procedure for recovering components used for pollution abatement. R11 is the procedure for using wastes obtained from any of the operations numbered R1 to R10. R12 and R13 are ancillary operations related to waste preparation and storage and they are most commonly used for wood, plastic, paper, cardboard and mixed municipal waste [32]. Waste disposal is currently one of the most widely used methods of waste management in the Republic of Serbia. The report on quantities of landfilled waste in 2018 was submitted by 32 operators. Table 6 gives an overview of the amount of disposed of non-hazardous and hazardous waste in the Republic of Serbia in the period 2011 - 2018.

Table 6. Amount of disposed non-hazardous and hazardous waste in the period 2011 – 2018 [27]

Year	Amount of disposed non-hazardous waste (t)	Amount of disposed hazardous waste (t)
2011	347.367,00	-
2012	1.172.413,17	7.684,87
2013	985.005,36	7.390,48
2014	1.117.831,71	5.995,01
2015	1.267.632,45	13.900,25
2016	1.291.323,57	30.417,12
2017	1.518.138,00	27.915,00
2018	1.716.092,00	29.404,00

Table 6 provides data showing that in 2018, 1.7 million tons of waste were disposed of, of which 1 716 092 tonnes of non-hazardous waste, and 29.4 thousand tonnes of hazardous waste. A significant amount of landfilled non-hazardous waste is municipal waste, followed by the presence of thermal process slag wastes, solidified sludge from treatment plants, mixed construction and demolition wastes, soil and stone, as well as mixtures or individual fractions of concrete, bricks, tiles and ceramics. For the disposal of non-hazardous waste, sanitary landfills are used, where waste is disposed from public places, households, production processes, and which does not have hazardous substances and cannot be processed or rationally used as industrial raw material or fuel. Since 2002, 11 sanitary landfills have been built in the Republic of Serbia. Two more are currently in the process of being built. Ten landfills have been used for municipal waste for years, while the eleventh one (in Subotica) is still under trial.

Table 7 provides data showing the total amount of landfilled waste in sanitary landfills in the period 2010-2018 in the Republic of Serbia.

When an analysis is made on the generation of municipal waste and data on the quantities of waste disposed of in sanitary landfills, it is estimated that municipal waste is likely to continue to be disposed of in municipal non-sanitary landfills.

Table 7. Total amount of disposed waste in sanitary landfills in the Republic of Serbia in the period 2011-2018 [27]

Year	Total amount of landfilled waste in sanitary landfills (t)
2011	90.384
2012	165.558
2013	302.187
2014	333.227
2015	385.228
2016	463.497
2017	437.878
2018	439.642

Table 8. Amount of disposed municipal waste in the Republic of Serbia in 2018 [33]

Amount	(t)
Total amount of municipal waste disposed of in the Republic of Serbia	822.000
Total amount of municipal waste disposed of in sanitary landfills in the Republic of Serbia	380.000

According to data from the National Register of Pollution Sources, the total amount of landfilled municipal waste is approximately 822.000 tons, of which about 380.000 tons are located in sanitary landfills, representing only 46%. Based on the comparative analysis of the data in Tables 6 and Table 8, the total amount of municipal waste disposed represents 47% of the total disposed waste in 2018 in the Republic of Serbia. According to the data in Table 7 and Table 8, the total municipal waste disposed of in sanitary landfills represents 86% compared to the total amount of municipal waste disposed of on sanitary landfills in the Republic of Serbia in 2018.

IMPROVEMENTS IN MUNICIPAL WASTE MANAGEMENT

In order to comply with increasing international requirements for comparable regional data on quantities and morphological composition of waste, a study in the municipal waste management field was conducted for the first time in Serbia, in 2009 [30]. Based on socio-economic conditions and geographical location, ten municipalities in Serbia were included in this study. The study analysed the morphological composition of municipal waste in summer, winter and spring, and thus contributed to a better insight into the types of waste that can be found in various municipalities as well as a better way of reporting on the situation in the field of waste management. The data obtained in this study on the composition of municipal waste are shown in Table 2. A study conducted in 2015 contributed to a comparative analysis of a system in which municipal waste is properly managed (Scenario 1) and in which municipal waste is not managed (Scenario 2) in the south Bačka waste management region.

Table 9. Comparison of waste management systems for scenarios 1 and 2 in the Republic of Serbia in 2015 [11]

Waste manag. process	Scenario 1	Scenario 2
Total amount of waste at the entrance (t)	195.850	195.850
Recycling (%)	0,05	22
Disposal (%)	99,95	64

To date, different studies have been conducted on different aspects. In 2018, the amount of municipal waste collected in the Republic of Serbia has increased significantly. Also, there is a noticeable better coverage of the territory with waste collection equipment. This shows, first of all, the success of the system of collecting individual fractions of municipal waste in local communities, but also successful collections by operators. The overall and specific national targets for the Republic of Serbia in 2018 are fulfilled for the reuse of 57.1% of waste and the recycling of waste 55.3% [31]. So far, 11 sanitary landfills have been built in the Republic of Serbia. Compared to the previous year, the amount of hazardous waste disposed of in regional sanitary landfills have been reduced. The Waste Management Strategy was adopted for the period 2010 to 2019 at a time when certain EU directives were in force. But, over the past ten years, both EU directives and the system have changed, and as a result, a new Strategy has now been prepared for a five-year period. The major change that has been implemented over the past year is that the Ministry of the Environment is not only in charge of the preparation of a strategic and legal framework, but it begins to assist municipalities in the implementation of it. In addition to expert assistance, donators provided vehicles, bins, containers and two composting facilities.

New Waste Management of the Republic of Serbia Strategy for 2019-2024 represents the transition from the concept of regional sanitary landfills to the model of regional waste management centres, which include:

- separate collection of waste,
- waste separation and recycling and
- treatment of non-recyclable waste.

The Ministry will change the territorial distribution of regional sanitary landfills, and reduce the number of them, as it became clear that there were many problems in coordination between the municipalities. More attention was paid to the construction of these landfills, instead of turning waste into a resource and raw material immediately. This means that there will be more regional waste management centres, than regional sanitary landfills where will take place recycling of all recyclable wastes and recuperation of energy from non-recyclable wastes, while the rest will be used in the

construction industry. The goals of the waste management system over the last few years were [20]:

- to reduce the amount of waste generated,
- to reduce the amount of waste disposed at landfills by a primary selection of useful waste,
- to reduce the share of biodegradable waste in landfilled municipal waste,
- to reduce the negative impact of landfilled waste on the environment, climate and human health, and
- to develop a system of waste management according to the principles of sustainable development.

The principle of circular economy and waste prevention will be introduced, according to new EU directives. When it comes to percentages, the Republic of Serbia will follow EU trends so that, for example, 90% of biodegradable waste will not be landfilled and 60% of waste must be recycled.

CONCLUSION

According to the presented comparative analysis of the goals of the 2011-2019 Strategy and the previous research and data collected, it could be noticed that the waste management system has not yet fully met the goals set. The amount of treated waste is still not at an adequate level, while the waste that is suitable for recycling is not recycled in a sufficient amount. As waste disposal is still the most commonly used method of waste management, the waste must be disposed of in accordance with strict regulations and in an environmentally friendly manner.

REFERENCES

1. M. Nikolić, "Uporedna analiza izabranih pokretača integrisanog sistema upravljanja otpadom na bazi pokazatelja u opštinama u Srbiji," Fakultet za ekologiju i zaštitu životne sredine, Beograd, 2016.
2. A. Batrićević, "Napropisno odlaganje otpada u Srbiji- aktuelno stanje i kaznenopravna reakcija," Zbornik instituta za kriminološka i sociološka ispitivanja, vol. XXXVI, no. 1, pp. 107-122, 2017.
3. J. Bijeljić, N. Petrović, N. Tošić and N. Ristić, "Građevinski otpad iz javnih objekata kao posledica koncepta linearnog upravljanja otpadom," Četvrti naučno-stručni skup Politehnika 2017, Beograd, 2017.
4. P. Beigl, S. Lebersorger and S. Salhofer, "Modelling municipal solid waste generation: a review," Waste Manage, no. 28, pp. 200-214, 2008.
5. D. Anatanasijević, V. Pocajt, I. Popović, N. Redžić and M. Ristić, "The forecasting of municipal waste generation using artificial neural networks and sustainability indicators," Sustain Sci, no. 8, p. 3746, 2013.
6. M. Berkun, E. Aras and S. Nemlioglu, "Disposal of solid waste in Istanbul and along the Black sea coast of Turkey," Waste Manage, no. 25, p. 847–855, 2005.
7. Henry, Z. Yongsheng and D. Jun, "Municipal solid waste management challenges in developing countries-Kenyan case study," Waste Manage, no. 26, pp. 92-100, 2006.
8. S. Chung and C. Lo, "Local waste management constraints and waste administrators in China," Waste Manage, no. 28, pp. 272-281, 2008.
9. U. Ngoc and H. Schnitzer, "Sustainable solutions for solid waste management in Southeast Asian countries," Waste Manage, no. 29, pp. 1982-1995, 2009.
10. A. Dedijer, "Environment in Serbia: an indicator-based review," Serbian Environmental Protection Agency, Belgrade, 2007.
11. J. Stepanov, D. Ubavin, K. Prokić, H. Stevanović and N. Stanisavljević, "Analiza sistema upravljanja otpadom primenom LCI i LCIA metoda: studija slučaja južno-bačkog regiona za upravljanje otpadom (Srbija)," Reciklaža i održivi razvoj, no. 8, pp. 18-26, 2015.
12. L. Đorđević, "Izveštavanje o otpadu," Agencija za zaštitu životne sredine, Nacionalni registar izvora zagađivanja, Beograd, 2020.
13. A. Shumeli, A. Kopali and E. Jojiç, "Hazards related to collection, transportation and disposal of urban waste in Tirana municipality," Safety Engineering, vol. II, no. 1, pp. 33-36, 2012.
14. D. Nešković Markić, Modelovanje i optimizacija upravljanja komunalnim otpadom primjenom analize tokova materijala ocjenom životnog ciklusa, Sremska Kamenica: Univerzitet Educons, Fakultet zaštite životne sredine, 2016.
15. M. Sharma and E. McBean, "A methodology for solid waste characterization based on diminishing marginal returns," Waste Management, no. 27, pp. 337-344, 2007.
16. G. Vujić, N. Jovičić, N. Redžić, G. Jovičić, B. Batinić, N. Stanisavljević and O. Altabt Abuhress, "A fast method for the analysis of municipal solid waste in developing countries - case study of Serbia," Environmental Engineering and Management Journal, no. 8, pp. 1021-1029, 2010.
17. D. Hoornweg and P. Bhada-Tata, "What a waste: A Global Review of Solid Waste Management," Urban development & Local Government Unit, World Bank, Washington, DC, USA, 2012.
18. V. Mihajlović, Model upravljanja otpadom zasnovan na principima smanjenja negativnog uticaja na životnu sredinu i ekonomske održivosti, Novi Sad: Univerzitet u Novom Sadu, Fakultet tehničkih nauka, Departman za inženjerstvo zaštite životne sredine i zaštitu na radu, 2015.
19. D. Prokić and A. Mihajlov, "Contaminated sites. Practice of solid waste management in a developing country (Serbia)," Environment Protection Engineering, vol. 38, no. 1, pp. 81-90, 2012.
20. R. Srbija, "Strategija upravljanja otpadom 2010-2019. godine," Sl. Glasnik RS, br. 29/10, Beograd, 2010.

21. O. Kalamada, "Ekološki prihvatljivo odlaganje komunalnog otpada na području Republike Srpske," Poslovne studije, vol. XV, no. 16, pp. 163-179, 2016.
22. N. Redžić, "Upravljanje otpadom u Republici Srbiji," Agencija za zaštitu životne sredine, Nacionalni registar izvora zagađivanja, Beograd, 2019.
23. R. Srbija, Pravilnik o metodologiji za izradu nacionalnog i lokalnog registra izvora zagađivanja, kao i metodologiji za vrste, načine i rokove prikupljanja podataka ("Sl. glasnik RS", br. 91/2010, 10/2013, 98/2016).
24. R. Srbija, Pravilnik o obrascu dnevne evidencije i godišnjeg izveštaja o otpadu sa uputstvom za njegovo popunjavanje ("Sl. glasnik RS", br. 7/2020).
25. R. Srbija, Pravilnik o obrascima izveštaja o upravljanju ambalažom i ambalažnim otpadom ("Sl. glasnik RS", br. 21/2010, 10/2013 i 44/2018 - dr. zakon).
26. R. Srbija, Pravilnik o obrascu dokumenta o kretanju opasnog otpada, obrascu prethodnog obaveštenja, načinu njegogovg dostavljanja i uputstvu za njihovo popunjavanje ("Sl. glasnik RS", br. 17/2017).
27. L. Đorđević, N. Radovanović, N. Redžić and G. Jovanović, "Upravljanje otpadom u Republici Srbiji u periodu 2011-2018. godina," Republika Srbija, MInistarstvo zaštite životne sredine, Agencija za zaštitu životne sredine, Beograd, 2019.
28. N. Veljković and D. Lekić, "Životna sredina u Srbiji: 2004-2019," Republika Srbija, Ministarstvo zaštite životne sredine, Agencija za zaštitu životne sredine, Beograd, 2019.
29. J. Stepanov, "Model za evaluaciju sistema upravljanja komunalnim otpadom primenom metode ocenjivanja životnog ciklusa," Univerzitet u Novom, Fakultet tehničkih nauka u Novom Sadu, Novi Sad, 2018.
30. G. Vujić, D. Ubavin, B. Batinić and e. al, "Utvrđivanje sastava otpada i procene količine u cilju definisanja strategije upravljanja sekundarnim sirovinama u sklopu održivog razvoja Republike Srbije", Univerzitet u Novom Sadu, Fakultet tehničkih nauka, Departman za inženjerstvo zaštite životne sredine, Novi Sad, 2009.
31. R. Šerović, "Nacionalna strategija upravljanja otpadom (strateški ciljevi RS)", Ministarstvo poljoprivrede i zaštite životne sredine, Odeljenje za upravljanje otpadom, Beograd, 2015.
32. N. Redžić, L. Đorđević, I. Dukić, N. Misajlovski and L. Mihailović, "Uputstvo za određivanje oznaka postupaka ponovnog korišćemja (R) i deponovanja otpada (D)", Republika Srbija, Ministarstvo životne sredine i prostornog planiranja, Agencija za zaštitu životne sredine, Beograd, 2010.
33. Agencija za zaštitu životne sredine, "Nacionalni registar izvora zagađivanja", GIS solution, 2016. [Online]. Available: http://www.nrizgis.sepa.gov.rs/NRIZGIS/index.html. [Accessed: 14 April, 2020].

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ANALIZA PRAKSE UPRAVLJANJA KOMUNALNIM OTPADOM U REPUBLICI SRBIJI

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Rezime: *U ovom radu predstavljena je analiza trenutnog stanja u oblasti upravljanja komunalnim otpadom u Republici Srbiji. Analizirani su podaci o količini generisanog otpada, otpadu koji se ponovo koristi i odlaže, a koji je prikupila Agencija za zaštitu životne sredine Republike Srbije. Analizom je utvrđeno da se deo otpada još uvek ne odlaže na odgovarajući način na sanitarne deponije. Takođe, u radu su predstavljene metode upravljanja komunalnim otpadom koje se najčešće koriste u Republici Srbiji. Na osnovu analize podataka je zaključeno da je najčešće korišćena metoda upravljanja komunalnim otpadom deponovanje. Cilj rada je da predstavi poboljšanja u primeni metoda upravljanja komunalnim otpadom proisteklih primenom Strategije upravljanja otpadom za period 2010 - 2019. godine kao i promene koje se očekuju primenom nove Strategije upravljanja otpadom u narednom periodu.*

Ključne reči: komunalni otpad, količine, sastav, metode tretmana, Republika Srbija