

MUNICIPAL WASTE IN URBAN AREAS

UDC 628.46:711.4

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Abstract. *In regards to waste treatment and management, both in the European Union and in the Republic of Serbia, a candidate for EU membership, it is necessary to improve municipal waste management systems, transform them into sustainable management systems and treat waste as a resource in order to preserve the environment and protect human health. In May 2018, an amendment to Directive 2008/98/EC, Directive 2018/851 was adopted, which refers to waste treatment in EU member states and which is in line with all other laws and regulations of the European Union. The total production of municipal waste in the 35 European countries participating in the data collection decreased by 3% in absolute terms and the average amount of waste per person by 7%. The aim of this paper is to compare the amount of municipal waste generated by residents of urban areas in the Republic of Serbia and in the Member States of the European Union.*

Key words: *urban areas, waste management, waste, municipal waste*

1. INTRODUCTION

Directive 2018/851, an amendment to Directive 2008/98/EC that addresses waste treatment in EU member states and is in line with all other legal and statutory provisions of the European Union, was introduced in May 2018. [17]

In order to preserve the environment and human health, when it comes to the treatment and management of waste, it is necessary to improve and transform systems for the manipulation of waste as a resource. Also, it is necessary to rationalize the use of resources, increase the use of renewable energy sources, and thus reduce dependence on imported raw materials. In this way, the principles of the circular economy are also promoted. [17, 18]

Received November 20, 2022 / Accepted December 2, 2022

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The "circular economy" is a perspective on the economy, which was formerly linear. The idea of the circulation of matter in nature inspired economists to develop a model within which production resources, waste and waste-related emissions are significantly reduced by rounding off and extending the energy and material cycles (life cycles) in production, thereby maximally extending the life of the product. [19-21]

In addition to the aforementioned, it is necessary to use natural resources efficiently and rationally, while promoting the principles of the circular economy and enhancing the use of renewable energy sources, to protect, preserve, and improve the quality of the environment and human health. The economy is circular when the entire life cycle of the product is considered in order to preserve resources. Also, it is necessary to take additional measures toward sustainable production and consumption. More efficient use of resources would bring significant net savings while reducing total annual greenhouse gas emissions.

The consumer society is based on the constant need to buy new and discard the old, while the circular economy model advocates returning to nature and reusing the used. First of all, by drawing attention to sustainable development and energy efficiency, as well as reuse through saving resources, this model represents both economic and environmental progress.

2. URBAN SOCIETY AND CITY AREAS

Modern society and the postulates upon which it is based, as well as urbanization, influence the creation of increasingly large amounts of waste, particularly in city centers. If this issue is not adequately addressed, it could be a significant burden for future generations. This is the reason why waste is considered one of the most significant environmental problems of the modern world. Any material or object that its owner discards, intends or must discard is considered waste. [12] Waste is one of today's most pressing issues, from the communal and ecological standpoint, as well as from the technological, sanitary, epidemiological, urban, construction, hydrological and energy aspects. The environmental and human health consequences of insufficient waste storage and treatment can be disastrous.

High demographic growth, industrialization, urbanization, and increasing standards, also mean the generation of an increasing amount of waste that needs to be collected, transported, processed and deposited. Because they are the primary producers of municipal waste, citizens must be made aware of the issue of waste.

2.1. Urban cores in Serbia

When it comes to the division of space into urban and rural areas, as well as attempts to define them, there is a long tradition of researching the same and a multitude of economic-geopolitical factors [10]. The accelerated pace of urbanization was initiated primarily by the industrial revolution, and was followed by a "demographic explosion" on a global scale, through the transformation of space due to the redistribution of the population due to the movement of capital and activities, and the lifestyle of the modern age. Therefore, the division into exclusively urban and rural areas is not sufficient to explain the new changes.

The search for an appropriate definition of rurality/urbanity became relevant at the end of the 20th century [11], especially since the issues of separating cities and villages are considered in normative documents and policies dealing with sustainable spatial and social development, environmental protection, agricultural development, etc. [9]

We consider cities as administrative and economic centers with populations greater than 100,000 people, especially when there are special economic, geographical or historical reasons. However, if a city satisfies all other legal requirements, it may also be considered a territorial unit with a population below 100,000. [9]

According to the Law on Territorial Organization, there are 173 units of local self-government in Serbia - 23 cities and 150 municipalities, of which 83 are in the territory of central Serbia, 39 in Vojvodina and 28 in Kosovo. Of the 23 cities listed in the law, 10 cities have a population of fewer than 100,000 people. [13] According to the previous law, Belgrade, Kragujevac, Niš, Novi Sad and Priština had city status, and the following were added to them: Valjevo, Vranje, Zaječar, Zrenjanin, Jagodina, Kraljevo, Kruševac, Leskovac, Loznica, Novi Pazar, Pančevo, Požarevac, Sombor, Sremska Mitrovica, Subotica, Užice, Čačak and Šabac.

The size of municipalities in Serbia varies considerably (both by territory and by population), but their responsibilities are the same. The differences in competence between cities and municipalities are so small that they are actually in the same position. [13]

Cities also cannot be viewed independently of their regions (administrative or functional). Functional urban areas are the basis for the territorial organization of the state and its balanced development. The hierarchy of cities is no longer formed on the basis of their demographic strength but through their field of influence on the environment. The city is only a part of the economic, social and political entity that makes up the area/region. [7]

The rapid growth of cities, in addition to expanding the territory and increasing the number of people, has a negative impact on the environment, which is particularly reflected in the area of waste management.

3. MUNICIPAL WASTE IN THE EUROPEAN UNION AND THE REPUBLIC OF SERBIA

Municipal waste is waste from households (domestic waste), as well as other waste that is similar to household waste in nature or composition. [12]

When it comes to municipal waste in the countries of the European Union, it accounts for roughly 7 - 10% of total waste generated. However, the waste stream is among the most complex to manage, and the way it is managed generally provides a good indicator of the quality of a country's overall waste management system. The challenges of municipal waste management are the result of its very complex and mixed composition, direct proximity to landfills, residents' awareness and impact on the environment and human health. As a result, municipal waste management requires a very complex system, including an efficient collection scheme, a sorting system and proper monitoring of waste flows, the active engagement of citizens and businesses, infrastructure adapted to the specific composition of waste and an elaborate financing system. Waste management is the implementation of prescribed measures for dealing with waste within the framework of collection, transport, storage, and treatment, i.e. reuse and disposal of waste. Also, waste management includes the supervision of these activities, the maintenance of waste management facilities after they have closed, and activities taken by traders and intermediaries [12]. Countries with developed municipal waste management systems generally perform better in overall waste management, including achieving recycling targets. For this reason, the municipal waste management system must be economically viable.

Data show that over 3.5 million m³ of municipal waste is disposed of annually in the Republic of Serbia. According to data obtained from the Republic Institute of Statistics, it is estimated (based on data from 90% of Public communal companies - PUCs) that approximately 6,000 tons of waste are disposed of in Serbia per day, or 2,200,000 tons per year. Based on this data, it can be estimated that the daily mass of waste per person is about 1 kg. [16]

In Figure 1, there is a graphical representation of the amount of municipal waste generated by an individual in each of the 35 European countries that participated in data collection. The report is for 2004 and 2014. Between 2004 and 2014, the countries' total municipal waste production fell by 3% in absolute terms, and the average amount of waste per person fell by 7%. The diagram shows that in about 45% (16 out of 35) of European countries, an increase in the amount of municipal waste is observed. Of course, there was no unique trend among countries, but an increase in municipal waste per person was observed in 16 countries and a decrease in 19 countries. The most municipal waste per capita is generated in Denmark, where an increase of 22.26% was observed in 2014 compared to 2004, while the largest decrease was observed in Romania at 28.65% for the same period. In Spain, the reduction is less when looking at the percentage share and amounts to 27.5%, but when we see that this reduction is 165 kg per person per year (from 600 kg per person per year in 2004 to 435 kg per person per year in 2014).

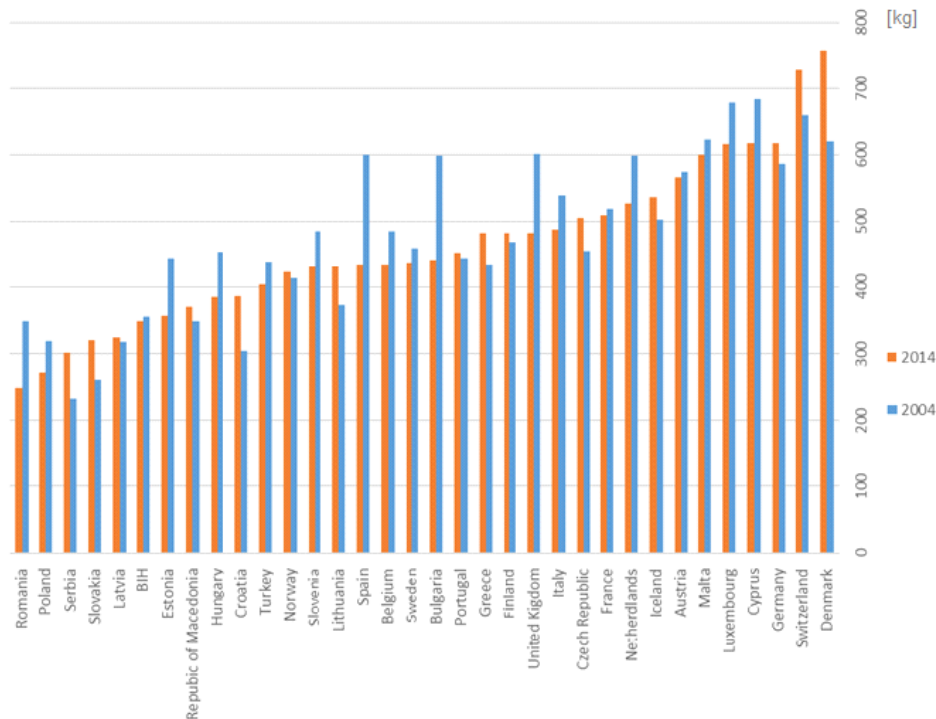


Fig. 1 Municipal waste per person in 35 European countries in 2004 and 2014, annually [18-20]

When we talk about our region and the countries of the former Yugoslavia, Serbia, Croatia and Macedonia recorded an increase in generated municipal waste in the period from 2004 to 2014, while Slovenia and Bosnia and Hercegovina recorded a decrease in municipal waste per person in the said period. In 2004, each person in Serbia generated 233 kg of municipal waste per year, while in 2014 the amount increased to 302 kg per person during the year, which is an increase of 29.6%.

In 2014, the production of municipal waste per person was the highest in Denmark and Switzerland, and the lowest in Romania, Poland and Serbia. This reflects the fact that wealthier countries tend to generate more municipal waste per person, while tourism contributes to the high rate of municipal waste generated in Cyprus and Malta. However, caution is necessary when interpreting the data, due to different definitions of municipal waste and different data collection methods.

Figure 2 shows a graphic representation of the amount of municipal waste generated in 2016, 2018, and 2020. The total amount of municipal waste in 2016 was 2538 million tons. Based on the diagram, we can see that the total amount of municipal waste is largely related to the number of inhabitants as well as the size of the country, whereby the smallest countries generated the smallest amount of waste and the largest countries generated the largest amount of waste. We can see that Cyprus, Malta and United Kingdom had the largest amount of total municipal waste generated in 2016, while Slovenia and Norway had the smallest amount of total municipal waste generated.

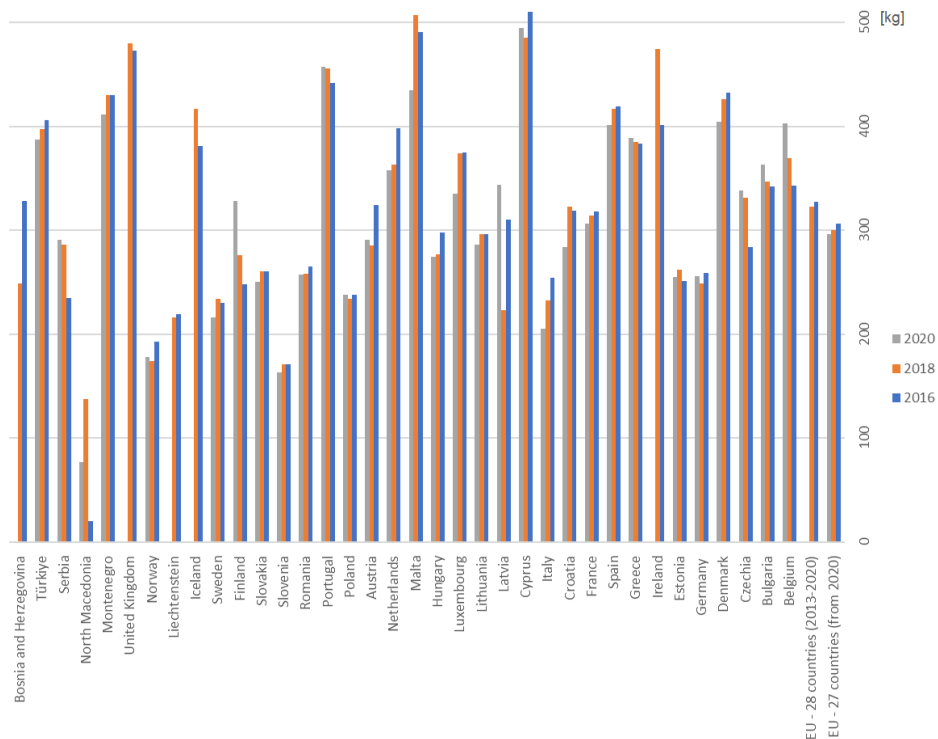


Fig. 2 Total municipal waste in 33 European countries in 2016, 2018 and 2020 [18]

When it comes to 2018, a downward trend can be observed in countries with the highest amounts of municipal waste generated, such as Denmark, where 1.4% less municipal waste was generated in 2018 than in 2016, while in 2020 this downward trend is greater and amounts to 5.1643% less municipal waste than in 2018. In tourist areas such as Malta, Cyprus and neighboring Montenegro, we see that the amount of municipal waste varies, especially in 2020, and shows a decreasing trend, which, if we take into account the Covid-19 virus pandemic, can be justified by restrictive policies related to tourist trips in 2020. The growth trend occurs in Portugal, where in 2018 there was an increase of 3.167% compared to 2016, while in 2020 the increase is only 0.21%. It should also be taken into account that Portugal is an attractive tourist destination and let's talk about the year when the pandemic was declared.

When it comes to Serbia, Table 1 shows the total amount of waste produced in the period from 2011 to 2020. [16]

Table 1 Total amount of produced waste in the Republic of Serbia annually in the period 2011 - 2020 [16]

Year	Amount of waste (t)	Number of people
2011	7.337.333	7186862
2012	10.601.454	7219069
2013	9.881.313	7183925
2014	7.451.105	7149180
2015	9.354.680	7114393
2016	9.197.100	7076372
2017	11.476.550	7040272
2018	11.613.787	7001444
2019	11.976.125	6963764
2020	12.495.392	6926705

Based on Table 1, we can see the tendency of the total amount of waste generated in Serbia to increase from 2016 to 2020, and this increase amounts to 24.78% in 2017 compared to the previous year, 1.2% in 2018, 3.12% in 2019, and 4.36% in 2020. According to the 2016 census, Serbia had 7,076,372 inhabitants, so the municipal waste generated in 2016 was 1,299 t per person per year, while in 2018, the total number of people was 7,001,444 and the amount of waste was 1,699 t per person per year. We observe that the increase in waste generation from 2016 to 2018 was 27.36%.

In 2018, the countries of the European Union generated an average of 5.1 t of waste per person. There is a big difference in the amount of waste generated per person in selected countries in the region. Figure 3 shows a graphic representation of generated waste in 2016 and 2018 for the countries that had the largest growth in the amount of generated waste compared to EU countries, as well as those that had a smaller increase compared to them.

With 7.2 t generated per inhabitant, Serbia was above the European average (5.1 t per person), but also below the averages of Bulgaria (18.5 t per person) and Romania (10.4 t per person). The other three countries from the region generate smaller amounts of waste per person than the European average: Slovenia 4.0; Hungary 1.9; and Croatia 1.4 t per person.

The largest increase in the amount of generated waste in 2018 compared to 2016 was in Slovenia at about 49%, followed by Romania and Hungary with an increase of 15.7%, Bulgaria with 9.2%, and finally, with the smallest increase, Serbia with 5.5% and Croatia with 5.4%.

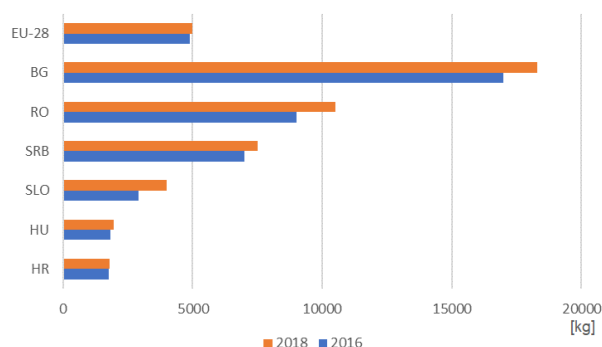


Fig. 3 Total waste per person in 2016 and 2018, annually [16]

When we talk about municipal waste in Serbia, which makes up a part of the total waste, we observe a trend of growth of this type of waste per inhabitant. In 2018, 21.7% more municipal waste was generated than in 2016, while in 2020, this increase is much smaller, especially compared to 2018, and amounts to 1.75%. Figure 4 shows the total amount of municipal waste per inhabitant for the reference years 2016, 2018, and 2020.

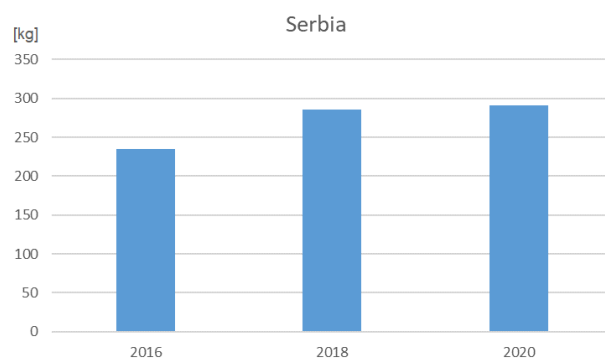


Fig. 4 Municipal waste in reference years for the Republic of Serbia

When we talk about the municipal waste of the countries in the region, Serbia has less generated municipal waste than Bulgaria, Croatia and Greece by 31.28%, 26.3% and 38.64 % respectively for 2016. In 2018 and 2020, Serbia generates less municipal waste compared to the mentioned countries, by 17.57% in 2018 and 19.83% in 2020 compared to Bulgaria, 25.7% and 25.19% less compared to Greece and in 2018, 11.45% less compared to Croatia, while in 2020, 2.464% less communal waste was generated in Croatia than in the same year in the Republic of Serbia.

Figure 5 shows the total amount of municipal waste for the Republic of Serbia and countries in the region. We observe that Serbia generates a larger amount of municipal waste compared to North Macedonia, Slovenia, Bosnia and Herzegovina, and Hungary in 2018 and 2020, while in 2016, both Bosnia and Herzegovina and Hungary generated a larger amount of municipal waste compared to the Republic of Serbia (marked in blue in

the picture), and North Macedonia and Slovenia also generated less municipal waste than Serbia in 2016.

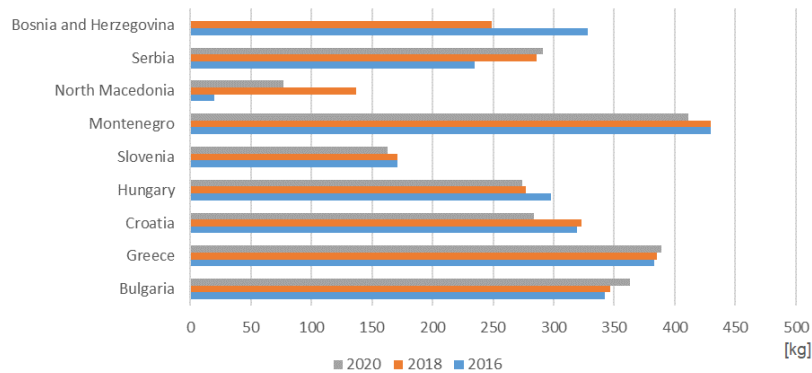


Fig. 5 Municipal waste production expressed in kg/per person, for the reference years 2016, 2018 and 2020 for Serbia and countries in the region, annually

4. CONCLUSION

Modern society and the postulates upon which it is based, as well as the process of urbanization, all influence the generation of increasing amounts of waste, particularly in city centers. In order to preserve the environment and human health when it comes to the treatment and management of waste, it is necessary to improve and transform systems that use waste as a resource. High demographic growth, industrialization, urbanization and increasing standards also mean the generation of an increasing amount of waste that needs to be collected, transported, processed and deposited. Citizens must be educated on the waste problem because they are the largest generators of municipal waste. This is also the reason why waste is considered one of the most important environmental problems of the modern world.

Municipal waste accounts for approximately 7–10% of the total waste generated in the European Union. However, the waste stream is among the most complex to manage, and the way it is managed generally provides a good indicator of the quality of a country's overall waste management system.

Data show that over 3.5 million m³ of municipal waste is disposed of annually in the Republic of Serbia. In 2014, Serbia generated 225 kg/capita of municipal waste, and this type of waste is increasing in our country, with 4.44% in 2016, 21.7% in 2018, and 1.75% in 2020. The minimal increase in 2020 can also be justified by the beginning of the pandemic caused by the Covid-19 virus, and for the purposes of further analysis of the trend of increase or decrease in the amount of municipal waste, we should wait for the reference year 2022.

Based on the comparative analysis that was carried out between the countries of the European Union and Serbia, and the amount of waste generated, the following can be observed:

1. Larger countries generate significantly more waste than smaller ones.
2. Richer countries have higher levels of waste.
3. The tourist season also affects the increased amount of waste.
4. The pandemic caused by the Covid-19 virus also affected the amount of municipal waste generated.

Acknowledgement: *This research was financially supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia, according to contract No. 451-03-9/2021-14/200148.*

REFERENCES

1. Staletović, N., Đurđević, V., Mitić, D., Tašić, D., Tucović, N., (2021), Environmental risk assessment for the unregulated waste disposal sites of municipal waste in the city area of Bor, Mining and Metallurgy Engineering Bor, br. 1-2, str. 25-34
2. Tošić, N., Vasović, D., (2020), Analiza prakse upravljanja komunalnim otpadom u Republici Srbiji, Safety Engineering, vol. 10, br. 2, str. 89-96
3. Đurić S., Stošić-Mihajlović L., Trajković S., (2017), Circular economy and create new values: Recycling, renewable energy, ecology, Journal of Process Management and New Technologies, vol. 5, br. 3, str. 50-68
4. Tomić, M., Rover, S., Pejović, B., Uremović, N., (2020), „Funkcionalne veze između ruralnih i urbanih područja na teritoriji grada Banja Luke i perspektiva njihovog razvoja“, Economics of Sustainable Development, vol. 4, br. 2, str. 49-62.
5. Ermakov V., Jovanović, L., Čajka Z., (2015), Grad kao urbana klasifikacija biosfere i problem otpada, Zaštita materijala, vol. 56, br. 3, str. 251-260
6. Stepanov J., Ubavin D., Prokić D., Stevanović-Čarapina H., Stanisavljević N., (2015), Analiza sistema upravljanja otpadom primenom LCI i LCIA metoda - studija slučaja Južno-bačkog regiona za upravljanje otpadom – Srbija Recycling and Sustainable Development, vol. 8, br. 1, str. 18-26
7. K.H. Halfacree, P.J. Boyle, (1993), „The challenge facing migration research: the case for a biographical approach“ Prog Hum Geogr. Sep;17 (3):333-48. doi: 10.1177/030913259301700303.
8. Gajić, A. (2015), „Različiti metodološki pristupi u definisanju ruralnih i urbanih područja“, - Zbornik radova, Beograd, APPS, Univerzitet u Beogradu Geografski fakultet, str. 129-135
9. Radić Milosavljević, I., (2012), „Tipične nadležnosti regiona: Evropska iskustva, AGENDA, Časopis za javnu upravu i lokalnu samoupravu, broj 5
10. Tomić M., Rover S., Pejović B., Uremović N. (2020), Funkcionalne veze između ruralnih i urbanih područja na teritoriji grada Banja Luke i perspektiva njihovog razvoja, Economics of Sustainable Development, vol. 4, br. 2, str. 49-62
11. Spasenović V., (2020), Spoznavanje urbanih mesta - prevodenje kroz dijagrame, SAJ - Serbian Architectural Journal, vol. 12, br. 2, str. 120-137
12. Law on Waste Management. Official Gazette RS, Nos. 36/09 and 88/10, 14/16 (2009-2016), (in Serbian)
13. Law on Territorial Organization of the Republic of Serbia ("Official Gazette of RS" no. 129/2007, 18/2016, 47/2018, 9/2020)
14. <https://www.stat.gov.rs/vesti/20210702-stvoreni-i-tretirani-otpad-2020/?s=2502>
15. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Statisti%C4%8Dki_podaci_o_otpadu&oldid=462336#Ukupne_koli.C4.8Dine_stvorenog_otpada
16. <http://www.sepa.gov.rs/index.php?menu=207&id=202&akcija=showXlinked>
17. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0851&from=EN>
18. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics
19. <https://ec.europa.eu/eurostat/web/population-demography/demography-population-stock-balance/database>
20. <http://www.mzp.cz>. Waste Management Information System
21. <https://ust.is/english/>

KOMUNALNI OTPAD U URBANIM SREDINAMA

Kada je u pitanju tretiranje i upravljanje otpadom kako u Evropskoj uniji, tako i u Republici Srbiji koja je kandidat za člana EU, u cilju očuvanja životne sredine i zdravlja ljudi, potrebno je unaprediti sisteme za upravljanje komunalnim otpadom i transformisati ih u sisteme za održivo upravljanje otpadom kao resursom. Maja 2018. godine, usvojena je dopuna Direktive 2008/98/EC, Direktivom 2018/851 koja se odnosi na tretiranje otpada u zemljama koje su članice EU, i koji je u skladu sa svim ostalim zakonskim i podzakonskim aktima Evropske unije. Ukupna proizvodnja komunalnog otpada je u 35 evropskih država koje su učestvovala u prikupljanju podataka, opala je za 3% u apsolutnom iznosu i prosečna količina otpada po osobi za 7%. Cilj rada je sagledavanje količina komunalnog otpada koju generišu stanovnici urbanih sredina u Republici Srbiji i u državama članicama Evropske unije, kako bi se izvršilo njihove poređenje.

Ključne reči: urbana gradska jezgra, upravljanje otpadom, generisanje otpada, komunalni otpad