

ENVIRONMENTAL IMPACT OF RECYCLING IN REPUBLIC OF SERBIA

Aleksandar Jovanović¹ Milica Mišić² Marija Stojanović³, Milica Miletić⁴, Miroslav Sokić⁵

Abstract: The aim of this paper was to present the importance of knowing the basic elements of waste management. Environmental concerns are increasing nowadays. One of the biggest issues of modern society is dedicated to problems with waste. Generation, collection, separation, transport, and treatment or disposal are the main steps of waste management. Because of the variety of the waste, choosing an appropriate solid waste treatment method is difficult. An inadequate municipal solid waste management system may result in infectious illnesses, contaminated land and water, clogged drains, and a decline in biodiversity. In the Republic of Serbia, in 2023., 7.84 Mt of waste was generated. Waste management is one of the crucial aspects of a proper circular economy which leads to further sustainability of society.

Key words: recycling, circular economy, environmental protection, waste management

1. INTRODUCTION

The growing human population and urbanization have been the main causes of the waste's steady increase [1]. Recycling, which includes to recover or reuse the material, is the broad term used to describe the process of obtaining resources or value from the waste. Waste material may be recycled in a variety of ways, such as by extracting and reprocessing the raw materials or by turning the waste's heat content into power [2]. There is a constant development of new recycling techniques: energy recovery, and biological and physical reprocessing. From a worldwide viewpoint of resource management, education and awareness regarding waste and waste management are becoming more and more crucial. By lowering the amount of waste produced, sustainable waste management aims to lessen the quantity of waste released into the environment. Unsuitable waste management can result in fires, explosions, and air, soil, and water contamination, which are possibly major health risks [3], [4]. Similarly, poor waste management and disposal can lead to expensive cleanups and endanger the residents of surrounding areas.

Long-term integrated solid waste management (ISWM) can lessen the negative consequences of solid waste, but inappropriate waste management also increases greenhouse gas emissions, which fuel climate change [1], [5]. Choosing the best solid waste management strategies involves evaluating local demands and conditions.

This work presented the latest data from Waste Reports in the Republic of Serbia from the last two years (2022, 2023). Resources must be used wisely to promote long-term sustainable development on a global scale. Waste management and the circular economy are two ways to address such circumstances. The policy of waste management is focused on recycling and trash avoidance, as well as minimizing landfill waste. The objective of a circular economy is to consider the long-term worth of materials and products, which means that resources should be reused again to create new value once their life cycle is over.

2. WASTE MANAGEMENT

Waste can be categorized based on several factors, including its origin, structure, hazardousness, biodegradability, and physical condition (solid, liquid, or gaseous).

The methods of collection, the potential for reuse or recycling, and the kind of treatment that may be applied to these resources will all depend on the type of trash and the best management strategy for

¹Ph.D., Institute for Technology of Nuclear and Other Mineral Raw Materials, 86 Franše d'Eperea Blvd., Belgrade, email: a.jovanovic@itnms.ac.rs

²M.Sc., Institute for Technology of Nuclear and Other Mineral Raw Materials, Belgrade, email: m.misic@itnms.ac.rs

³ M.Sc., Institute for Technology of Nuclear and Other Mineral Raw Materials, Belgrade, email: m.stojanovic@itnms.ac.rs

⁴M.Sc., Institute for Technology of Nuclear and Other Mineral Raw Materials, Belgrade, email: m.miletic@itnms.ac.rs

⁵Ph.D., Institute for Technology of Nuclear and Other Mineral Raw Materials, Belgrade, email: m.sokic@itnms.ac.rs

it. Making this distinction is essential to lowering the carbon footprint left by human activities and adhering to environmental standards.

The following objectives are part of a waste management philosophy [6]:

1. Reducing the overall quantity of waste through recycling and waste reduction.
2. Recycling and reintroducing appropriate sets of materials as energy carriers or secondary raw materials into industrial cycles.
3. Reducing the amount of residual waste that must be dumped in "suitable" landfills as much as feasible.
4. A notion that is adaptable to changes in trash amounts and the makeup of household waste. The system has to include recent advancements in the waste management industry.

2.1. Data from SEPA

Data on municipal waste are submitted by public utility companies - PUCs from local governments to the Serbian Environmental Protection Agency (SEPA). In 2023, 95 PUCs submitted reports, while in 2022, 104 PUCs submitted reports [7], [8].

A slight decrease in the value of the amount of generated municipal waste is visible, while the amount of collected and deposited waste is approximately the same as in 2022 (Table 1), which can be attributed to the decrease in the population of the Republic of Serbia.

Table 1 – Indicators related to municipal waste [7], [8]

Indicator	2023*	2022**
Total amount of municipal waste generated (million t)	3,07	3,18
Recycled fractions of municipal waste (million t)	0,484	0,561
Exported municipal waste fractions (million t)	0,115	-
Amount of collected and deposited waste (million t)	2,59	2,59
Average waste collection coverage (%)	88,3	87
Average daily amount of municipal waste per capita (kg)	1.26	1.28
Municipal waste recycling rate %	15.5	17.7

* Estimated based on population number in 2022

** Estimated based on population number in 2021

This is seen from the increase in the average daily amount of waste while simultaneously reducing the total amount of generated municipal waste. The scope of municipal waste collection is slightly increasing compared to the previous period. The recycling rate of municipal waste is insignificantly lower compared to the previous year and is 15.5% [8].

Economic entities report to the SEPA on the waste they produce in the course of their activities and the method of handling the waste produced. Based on the reports received, 7.84 Mt of waste were produced in the Republic of Serbia in 2023, of which 90,000 t was hazardous waste [8]. Thermal power plants are the largest producers of waste. Coal fly ash slag and dust, which are marked 10 01 in the Waste Catalogue, were generated in an amount of 5.87 Mt, or 75% of the total amount of waste produced.

Table 2 shows the quantities of waste generated during the activities of enterprises by origin for 2022 and 2023, based on reports received and submitted through the Agency's information system.

Under the law, the Agency does not collect data on the quantities of waste of group 01 generated in research, excavations from mines or quarries and physical and chemical treatment [9].

Table 2 – Recorded quantities of waste produced by origin, excluding municipal waste from households [7], [8]

Group	Activity during which waste is generated	2023*		2022**	
		Quantity of non-hazardous waste (t)	Quantity of hazardous waste (t)	Quantity of non-hazardous waste (t)	Quantity of hazardous waste (t)
1	Mining	/	/	/	/
2	Agriculture and food processing	232,302	2	162,351	0,16
3	Wood industry, paper, cardboard	55,219	1	51,991	
4	Leather, fur and textile industry	13,062		12,356	
5	Oil, natural gas and coal processing	0,001	4,383	0,001	2,916
6	Inorganic chemical industry	152	224	149	1,660
7	Organic chemical industry	11,590	453	8,184	464
8	Coatings, adhesives, sealants and printing inks	964	1,096	1,483	1,414
9	Photography industry	55	44	92	102
10	Waste from thermal processes	6,447,587	16,940	6,987,570	16,034
11	Protection of metals and other materials	1,180	1,401	1,256	1,751
12	Shaping and surface treatment of metals and plastics	56,051	522	66,517	686
13	Waste oils and liquid fuel residues		6,960		8,981
14	Waste organic solvents, refrigerants		24		14
15	Packaging waste, absorbents, wiping cloths	177,332	3,337	159,694	3,587
16	Waste not otherwise specified in the catalogue	61,894	13,108	44,150	17,485
17	Construction and demolition waste	302,615	10,830	332,692	14,849
18	Health protection of people and animals	354	3,811	1,080	4,691
19	Waste from waste treatment plants	275,591	19,044	284,013	2,680
20	Municipal and similar waste	118,341	7,966	86,788	3,291
	Sum	7,754,291	90,147	8,200,367	80,604

Of the presented amount of waste generated, it can be seen that the quantity of the generated hazardous waste increased by 8%, while the amount of non-hazardous waste decreased by more than 0.4 Mt.

Table 3 – Method of dealing with the waste produced [8]

Indicator	Produced (t)	Delivered for temporary storage to another company (t)	Submitted for disposal (t)	Submitted for reuse (t)	Export (t)
Hazardous	90,147	31,954	9,043	47,976	10,852
Non-hazardous	7,754,291	386,468	437,395	1,251,001	207,290

The amount of waste that dropped in the waste producer's warehouse is shown by the difference between the amount generated and the amount submitted for additional treatment (Table 3). When it comes to hazardous waste, it is evident that more was submitted for disposal than was created. This is because, in 2023, several businesses submitted waste from prior years for additional treatment. Significant amounts of hazardous waste are still present in producer warehouses, even though more hazardous waste was submitted for treatment than was produced during the year. In the reporting year, the facility that produced coal fly ash stored 5.47 Mt of non-hazardous waste in its warehouse. This amount is the largest representation of coal fly ash.

2.2. Circularity in Serbia

The circular economy has been recognized as an important strategic concept for the green transition of the Republic of Serbia, which has been placed high on the list of priorities for the development of our society in recent years. Green transition is a process that involves economic, energy and investment transition, which are based on the sustainable use of resources and energy, reducing the negative impact on the environment, the application of innovations and digital tools, knowledge, added value and greater competitiveness of the economy.

The Ministry of Environmental Protection is the implementing partner of the project "Reducing the carbon footprint of local communities by applying the principles of the circular economy in the Republic of Serbia" which will last until 2027. The project supports innovation and in this regard, a call for innovation was announced, which improves cooperation between scientific and research organizations and the economy. In 2023, through the aforementioned project, which is abbreviated as Circular Communities, the development of four local Roadmaps for the Circular Economy began: Sombor, Pančevo, Medveđa and Bujanovac. As part of the Circular Communities project, and as an activity of the CE Development Program in the Republic of Serbia, in 2023, the development of guidelines for the management of construction and demolition waste began. In 2023, a public call was announced to improve cooperation between science and industry in the field of circular innovations - circular vouchers. This call is intended for accredited scientific research organizations that cooperate, or intend to cooperate, with industry (private and public enterprises) to promote the principles and values of the circular economy in practice. Circular vouchers represent a financial incentive for achieving such cooperation by rewarding specific proposals for initiatives in the field of circular economy. This process improves the commercialization of green innovations and thus directly increases the efficiency of raw material and energy use, and reduces harmful emissions.

The Ministry of Economy, in cooperation with the Circular Economy Center of the Serbian Chamber of Commerce, held a series of activities aimed at promoting the green economy and educating business entities in the application of circular economy solutions during 2023. The guides Circular Economy in Agriculture (production of wine, beer and brandy), Guide for the safe management of chemicals, Guide for agricultural producers and food producers for models of wastewater treatment plants, as well as the roadmap for the reuse, recycling or valorization of construction concrete waste have been created.

The Ministry of Science, Technological Development and Innovation is implementing several Eureka projects related to the circular economy within the framework of international cooperation.

The focus of the Center for Circular Economy of the Serbian Chamber of Commerce in 2023 was to launch industrial symbiosis, i.e. the promotion of by-products and the creation of new/old raw materials. A by-product “stock exchange” has been installed on the Center’s Digital Platform, which allows for greater interaction directly between companies.

3. CONCLUSION

The ecosystem is strained by the ongoing use of resources. Accordingly, waste management has drawn more attention from the perspective of a circular economy. Sustainable development, which is impacted by a variety of factors, including the condition of the living environment, has received a lot of attention lately. Future generations must continue to live in a varied and healthy environment. At the national and international levels, achieving this aim is closely and immediately related to raising environmental consciousness and reducing negative externalities.

4. REFERENCES

- [1] Demirbas A., *Waste management, waste resource facilities and waste conversion processes*, Energy Conversion and Management 52 (2): 1280-1287, 2011, <https://doi.org/10.1016/j.enconman.2010.09.025>.
- [2] Pilapitiya, PGC N. T., Ratnayake A. S., *The world of plastic waste: a review*, Cleaner Materials 11 (100220), 2024, <https://doi.org/10.1016/j.clema.2024.100220>.
- [3] Gutberlet J., Uddin S. M. N., *Household waste and health risks affecting waste pickers and the environment in low-and middle-income countries*, International journal of occupational and environmental health, 23(4): 299-310, 2017, <https://doi.org/10.1080/10773525.2018.1484996>.
- [4] Siddiqua A., Hahladakis J. N., Al-Attia W. A. K., *An overview of the environmental pollution and health effects associated with waste landfilling and open dumping*, Environmental Science and Pollution Research, 29(39): 58514-58536, 2022, <https://doi.org/10.1007/s11356-022-21578-z>.
- [5] Longfor N. R., Istrate I. R., Qian, X., *Mitigating greenhouse gas emissions from municipal solid waste in Sub-Saharan Africa via sustainable waste management: An economic benefit assessment*, Resources, Conservation & Recycling Advances, 20 (200192), 2023, <https://doi.org/10.1016/j.rcradv.2023.200192>.
- [6] Kan A., *General characteristics of waste management: A review*, Energy Education Science and Technology Part a-Energy Science and Research, 23: 55–69 (2009)..
- [7] Agencija za zaštitu životne sredine, *Izveštaj o stanju životne sredine u Republici Srbiji za 2022. godinu*, Ministarstvo zaštite životne sredine, Beograd, 2023.
- [8] Agencija za zaštitu životne sredine, *Izveštaj o stanju životne sredine u Republici Srbiji za 2023. godinu*, Ministarstvo zaštite životne sredine, Beograd, 2024.
- [9] Zakon o rudarstvu i geološkim istraživanjima ("Sl. glasnik RS", br. 101/2015, 95/2018 - dr. zakon i 40/2021).