ANALYSIS OF SUCCESSFUL WASTE MANAGEMENT IN LARGE CITIES - THE EXAMPLE OF TOKYO

DOI: https://doi.org/10.18485/arh_pt.2024.8.ch2

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ABSTRACT

The impact of global climate change and human activities, in the last 20 years, has been increasingly emphasized in spatial and temporal changes in waste management in large regions. Accurate and reliable information on the spatial distribution, persistence, and quality of municipal and industrial waste is of key importance for regional economic development, urban planning, regional climate, and environmental monitoring. Nevertheless, good governance is one of the key challenges in the 21st century and a key responsibility of every city government. The „nature" of solid waste is changing as society becomes more affluent and urbanized, instead of biodegradable waste, households generate increasing amounts of plastic, metal, and other non-degradable waste. The amount of waste per capita is increasing, as the development of society increases, and this requires the efficiency of service provision and sustainable waste management. The Tokyo metropolitan area with over 37 million inhabitants is the most populated in the world, as well as Japan's economic, financial, political, and cultural center. It generates a significant amount of waste, which would pose a great threat to people and the environment if there were no mechanisms for efficient, sustainable, and conscientious waste management. The city government of Tokyo, 26 cities, 5 towns, and 8 villages, as a solution developed a joint waste management system. In Serbia, inadequate waste management is one of the biggest problems in terms of environmental protection, especially in large cities, such as Belgrade with its 17 municipalities. The specific experiences of Tokyo, in addition to indicating how far behind the best world practices we are, are also very useful guidelines for the further development of mechanisms in Serbia. An open approach to the acceptance of new ideas is of particular importance and would contribute to improving the protection of the environment and the health of the population.

KEYWORDS _ *Waste management, Sustainable development, Pollution, Recycling, Large cities.*

INTRODUCTION

Waste is an inevitable problem when talking about urban space. To understand the urban space of Tokyo, it is important to understand how Tokyo solved the problem of waste. Over time, various systems and mechanisms have been developed that solved the majority of problems, and Tokyo has set an example of how to effectively manage waste. Due to the increase in costs, the principle of district self-sufficiency was abandoned, and that resulted in regionalization in waste management, especially in the processes of pulverization, incineration, and recycling. As the principle was abandoned, to ensure a regional balance different economic instruments are being used to maintainfairness among the wards. Most of the waste is incinerated, which significantly reduces its volume. Because of this and other successfully applied methods, the increasingly valuable space in this metropolis is used rationally and the life of landfills is extended. As for the state institutions in Serbia, as a developing country, and in Belgrade, regardless of the existing problems, it is necessary to understand that the strategic policy in waste management needs to be based on a partnership approach and constructive dialogue. First of all, that is a collaborative partnership of experts, then decision-makers at different levels of administration, with serious consultation and cooperation with the business sector and the civil organizations, which represent the public of a country.

ANALYSIS OF WASTE MANAGEMENT IN TOKYO

Tokyo generates a significant amount of waste, which would pose a great threat to people and the environment if there were no mechanisms for efficient, sustainable, and conscientious waste management. Japan generates over 40 million tons (41,669 million in 2020) of municipal waste annually, in which the Tokyo metropolitan area participates with more than 20%. Statistics from OECD (Organisation for Economic Co-operation and Development) countries show, if we look at countries that generate more than 10 million tons of municipal waste annually, that Japan is second, only behind Germany, in efficient treatment of municipal waste with 94.4% recovery in 2020, which indicates the efficiency of mechanisms used in waste management (Organisation for Economic Co-operation and Development, 2023). The basic principle of waste management in Japan is based on the reduction of waste generation, recycling and reuse if possible, and disposal after volume reduction and detoxification by intermediate treatment, such as incineration (Higuchi, 2021). The city of Tokyo has about 9 million inhabitants, the metropolis over 13 million, while with 37 million inhabitants, the Tokyo metropolitan area is the most populated in the world, as well as the economic, financial, political, and cultural center of Japan (Tokyo Metropolitan Government [TMG], 2015). Many large companies, administrative agencies, and foreign corporations have their headquarters in the metropolitan area, which is well connected by a network of roads and railways. To deal with the issue of waste, the Tokyo city government and 23 surrounding cities have developed a joint waste management system. Under this system, cities are responsible for their waste collection and transfer, while intermediate processing (incineration, pulverization, etc.) is jointly handled by the Clean Authority of Tokyo and the Tokyo Metropolitan Government. This allows cities without incineration plants to access these facilities and optimizes processing efficiency (Kurishima, 2018).

PROXIMITY PRINCIPLE, COLLECTION, AND TRANSPORT OF WASTE

The proximity principle represents the disposal of waste close to the place of its origin. For the past 30 years, this principle has had a central value for the citizens of Japan in municipal waste management, as it represents a solution to the “Not in My Backyard” syndrome. Because of this syndrome, an incident known as the “Tokyo Garbage Wars” occurred in 1971 (Okuda, Thomson, 2007). During the incident, citizens of Tokyo’s Suginami Ward opposed the construction of an incinerator, while their municipal waste was disposed of at a landfill in Tokyo Bay in Koto Ward. This upset the citizens of Koto. The dispute escalated to the point that municipal waste collection in

Suginami was suspended and the governor of the Tokyo Metropolitan Government declared a state of emergency. For the proximity principle to be respected in the future and to prevent such incidents from happening again, the Metropolitan Government decided to build incinerators in every ward of Tokyo (Kurishima, 2018). This principle is very important in Japan and is seen more as a social principle than an environmental policy. However, the rising costs of waste treatment have forced many municipalities to join their forces, although regionalization is contrary to the proximityprinciple. The closing of smaller, less sophisticated, incinerators due to high dioxin emissions contributed to the increase in costs. Municipalities in urban areas find it difficult to find places to build new facilities for waste management, while small rural communities cannot provide the necessary financial resources and technical expertise to maintain sophisticated facilities that meet appropriate environmental standards. Many municipalities have found solutions to these problems through cooperation (Okuda, Thomson, 2007). Waste is collected at the city level, with each city setting days and places for the collection of different types of waste. Collection and processing are free of charge for households that do not produce more than 10 kg per day. Larger amounts of waste and waste from companies are charged. Due to the proximity principle applied in Tokyo, municipal waste is not transported far from the place of origin, which is why transport costs are relatively low. To make waste transportation even more efficient, several methods are used depending on the type of waste. Combustible waste is transported directly from the collection site to the incineration plant using a compact vehicle. Incombustible waste is transported to Chubo Incombustible Waste Processing Center or Keihinjima Island Incombustible Waste Processing Center. Both centers are located on the coast, that's why some cities have established boat transfer stations where incombustible waste from the whole city is loaded onto a boat and taken from there to the centers. Such stations also exist on land, where waste from the entire city is loaded onto larger trucks and taken to the center. Relayed transport of this type increases efficiency, reduces traffic congestion, and reduces air pollution with exhaust gases. Large-sized waste is taken to the Large-sized Waste Pulverization Processing Facility (Clean Authority of Tokyo [CAT], 2023).

PROCESSING OF COMBUSTIBLE, INCOMBUSTIBLE, AND LARGE-SIZED WASTE

Combustible waste is efficiently and safely burned in 22 incineration plants. This prevents the spread of bacteria, pests, and unpleasant odors, thus improving the hygiene and cleanliness of the environment. The volume of waste to be disposed of, after burning, is reduced by 20 times, which significantly extends the life of the landfill (Watanabe and others, 2015). The process begins with weighing the delivered waste and then depositing it in the bunker, where it is momentarily stored. Then waste and air from the bunker are sent to the incinerator, where it is burned at a temperature of over 800°C, to reduce the formation of dioxin. There is a boiler above the incinerator that produces steam which heats water and generates electricity. Exhaust gases are cooled below 200°C to prevent dioxin recomposition. Then, they pass through filters to remove dust, dioxin, mercury, hydrogen chloride, and sulfur oxides and through a catalyst reaction tower that decomposes dioxin and nitrogen oxides. Also, bottom and fly ash are created as combustion products, the fly ash is collected in filters, and the bottom ash is released from the bottom of the incinerator. Solids and heavy metals in wastewater are removed before it is discharged into the sewer (Figure 1) (CAT, 2023).

The bottom ash is disposed of in landfills, tho a certain percentage is recycled to extend the life of the landfills. The recycled ash is used to make slowly cooled slag, burnt sand, and raw materials for cement. They are used for road construction. In 2021, about 70,980 t of bottom ash was recycled. Thanks to the thermal energy produced during combustion, water is heated and electricity is generated. They are both used within the plant, and the surplus is sold. In the period from March 2021 to February 2022 in Tokyo, 1,240.50 MkWh of electricity was generated, and 64,122,217 $ was earned from sales of surplus energy. In the same period, 496,000 GJ of heat was delivered, and the revenue was 1,438,828 $ (CAT, 2023). Processing of incombustible waste can be divided into crushing

and sorting. First, the volume of waste is reduced by crushing, after which iron and aluminum are separated for recycling, and the rest of the waste is disposed of in landfills. Large waste is separated into combustible and incombustible. Separation is done in city transfer stations or upon arrival at the facility. After crushing, metals are separated for recycling, combustible waste is sent to incinerators, and incombustible to landfills (Watanabe and others, 2015).

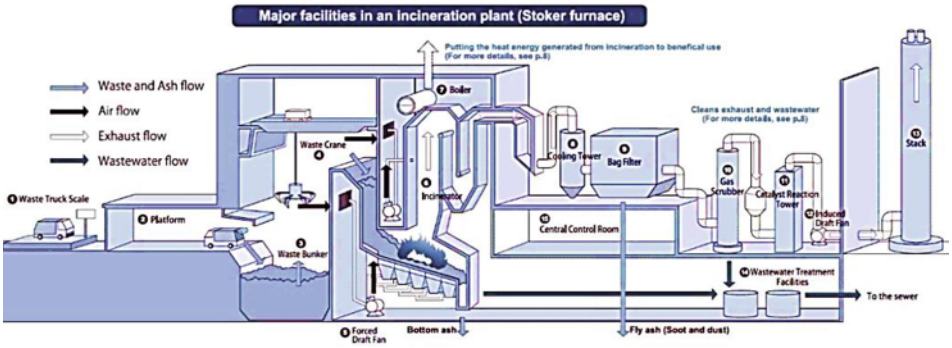


Figure 1: Treatment of combustible waste in incineration plants (CAT, 2023).

MANAGEMENT OF LANDFILL DISPOSAL SITES

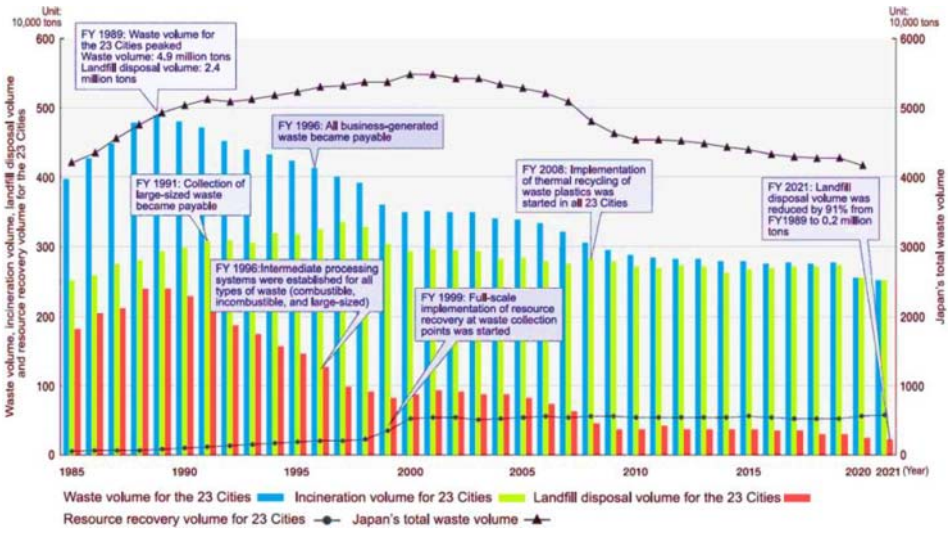
Depending on the impact and hazard of waste, landfills are categorized into 3 types: internal, controlled, and strictly controlled. Depending on the type, different protection measures are used: against the runoff of wastewater, the construction of coastal protection, and increasing the strength of soft soil. The waste of the city of Tokyo is disposed of at two controlled type bay-side landfills (Central Breakwater Outer Landfill Site and New Sea Surface Disposal Site), which according to the plan should be the last landfills in Tokyo Bay. They occupy the last landfill space in the port of Tokyo and should be used as long as possible. That is why various measures have been taken to extend its lifespan. These landfills are equipped with two types of coastal protection structures, caisson structures, and double steel-tubing sheet piles. Utilizing them, leakage of water from landfills and pollution of underground or public water is prevented. Water is collected and processed in treatment plants. To increase the stability of the coastal protection and soil strength, cement reinforcement was placed in the foundation and the ground was replaced with sand (using the sand compaction pile method). Residues after treatment of different types of waste, waste from buildings, such as sewage sludge and industrial waste, are disposed of in landfills. The waste is deposited in a furrow and when it reaches a height of 3 m it is covered with 50 cm of soil. Ridges are formed between the furrows, which are topped with waste and covered with soil. This procedure is repeated until a height of 30 m is reached. The soil prevents waste scattering, and spreading of unpleasant odors and pests, and reduces the risk of fires (TMG, 2021). After the end of a landfill's lifespan, it is processed and adjusted so that it can be used for other purposes. Areas that were once waste disposal sites have been converted into parks, residential areas, campgrounds, a train station, a tropical botanical garden, a baseball stadium, an incinerator, and an airport (CAT, 2018).

3R INITIATIVE (REDUCTION, REUSE, RECYCLING)

To reduce the harmful impact of waste on the environment in Japan, it was decided in 1997 to switch to the principle of sustainable development under the name "Sound Material-Cycle Society" (SMC Society), which is defined as a society where the consumption of natural resources and the burden on the environment is minimized. This definition is closely related to the concept of recyclable resources,

according to which waste can be a resource if properly processed (Yoshida and others, 2007). "The Fundamental Law for Establishing an SMC Society" was passed in 2000, after which various policies based on the 3R initiative were implemented. This law clarifies the priorities for waste management, from which the 3R initiative got its name. According to this law, the sequence in which the waste is managed should be: reduction, reuse, recycling, thermal recycling (heat recovery), and proper disposal (Takiguchi, Takemoto, 2008). Reduce the amount of waste generated by more efficient use of resources and extend the life of products. Reuse the same items as long as they are usable. Recycle waste so it can be used as raw material for making new products.

Graph 1: Tokyo'stransition in waste volume, incineration volume, landfill disposal volume, and resource recovery volume from 1985 to 2021 (CAT, 2023).



At the beginning of the 21st century, Tokyo faced serious problems in waste management due to a lack of landfill capacity and increased illegal dumping. This led to the adoption of "The Fundamental Law for Establishing an SMC Society" and the implementation of various complementary policies. After two decades of work and development, many positive results were achieved. By burning most of the waste, which reduces its volume by up to 20 times, with efficient use of landfill space, and the implementation of the 3R initiative, the amount of waste that is disposed of on an annual basis has been reduced by 85% compared to 1989. Also, as a result of various measures of the 3R initiative, the total amount of generated waste was reduced by over 45% compared to 1989 (Graph 1). The amount of generated waste for the city of Tokyo in 2021 was 2,533,479 t, which means that, on average, each person generates 727 g of waste per day (CAT, 2023).

ANALYSIS OF WASTE MANAGEMENT IN BELGRADE

Waste management in the Republic of Serbia is governed by a system of legal norms, which include laws, regulations, and decrees that are following the regulations of the European Union. In July 2003, the Government of the Republic of Serbia adopted a national waste management strategy as part of the European Union approaching program. This document represents the basis for ensuring the conditions for rational and sustainable waste management at the national level (Đurđević et al., 2011).

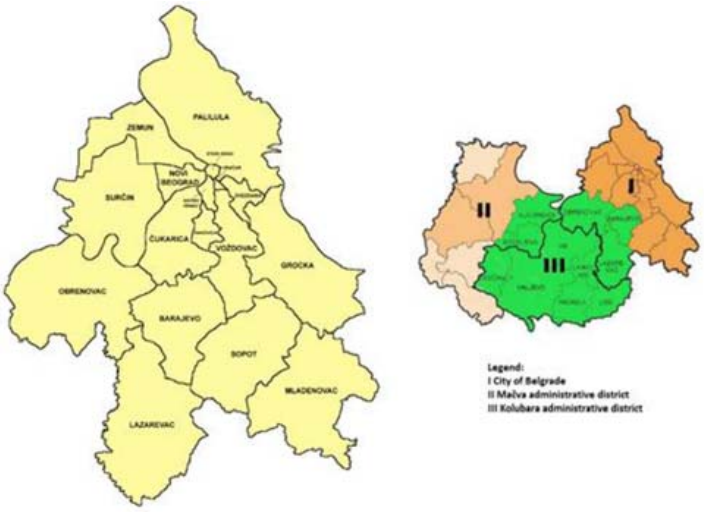


Figure 2: Municipalities of the city of Belgrade with Kolubara and Mačva districts (GUGB, 2021)

Belgrade, as the capital of Serbia, is the economic, cultural, and educational center of the country. From the aspect of development capacity, this is the most dominant region and the most densely populated geospace of Serbia, in which Belgrade forms the outline along which its surroundings are transformed economically and morphologically. The Local Waste Management Plan applies to the Belgrade area, which consists of 14 city municipalities (Voždovac, Vračar, Grocka, Zvezdara, Zemun, Mladenovac, Novi Belgrade, Palilula, Rakovica, Savski Venac, Sopot, Stari Grad, Surčin, and Čukarica). The city municipalities of Grocka, Mladenovac, and Sopot have their own utility companies, while the remaining 11 municipalities are under the jurisdiction of the public communal company "Gradska čistoća" Belgrade. The city municipalities of Barajevo, Lazarevac, and Obrenovac, which signed the agreement on joint waste management with the municipalities of Valjevo, Lajkovac, Ljig, Mionica, Osečina, Ub, Koceljeva, and Vladimirci, were exempted from the Local Waste Management Plan and adopted a joint Regional Waste Management Plan (Figure 2). The Local Waste Management Plan for the territory of the city of Belgrade, for 14 listed city municipalities, for the period from 2021 to 2030 represents a continuation of the strategic approach adopted in the Local Plan from 2011. According to this plan from 2011, a whole series of activities were initiated to solve the issue of handling waste and establishing a waste management system. Local Waste Management Plan for the period 2021-2030 was drafted following the Law on Waste Management ("Službeni glasnik RS", no. 36/09, 88/10, 14/16, and 95/18) (Gradska uprava grada Beograda [GUGB], 2021).

The plan was developed following the strategy for waste management in the Republic of Serbia ("Službeni glasnik RS", number 29/2010). The strategy defines key principles that must be fulfilled by waste management plans: the principle of sustainable development; proximity and regional approach to waste management; hierarchy; application of the most practical option for the environment; responsibility of waste producers; and the "polluter pays" principle. The projected amount of waste for 14 city municipalities, based on the results obtained by modeling, will amount to 730,868 t in 2041, which is 135,549 t more than the base year of 2019. This represents a 20.8% increase, which is about 1% per year. If the obtained results are expressed in the form of kg per inhabitant per year, it is assumed that the amount of municipal waste generated in the observed period will increase from 388 kg to 476.3 kg. The total amount of generated waste per municipal in the city of Belgrade is shown in Figure 3. (GUGB, 2021).

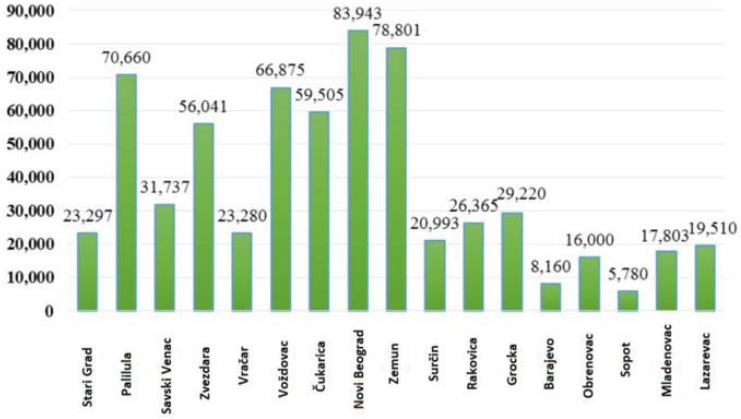


Figure 3: The amount of generated waste in Belgrade city municipalities in tons per year (GUGB, 2021).

According to the Environmental Protection Agency (SEPA) data from 2019, there are approximately 2,305 illegal landfills in Serbia, while the total number of official and regulated landfills for the disposal of non-hazardous waste is only 11. The number was obtained based on the report of 131 local governments from 2019 (Environmental Protection Agency, 2019). Precise data on the amount of recycled waste officially does not exist. The total amount of waste that was primarily or secondary separated for reuse in 2016 amounted to 10,986 t, in 2017 to 8,481 t, in 2018 to 7,253 t, and in 2019 to 7,915 t. During the survey of public opinion in the field of environmental protection, the Agency "Faktor Plus" conducted a survey of citizens on the topic of why they do not recycle. Citizens answered that they don't recycle because: there are no containers nearby (54%), they don't see the purpose of recycling because of other people's actions (28%), they don't have time (10%), it's too complicated for them (7%), they are too lazy (6%) and other reasons (9%). The survey was conducted in October 2019, with the possibility to select multiple answers (Center for Environmental Improvement, 2020).

CONCLUSION

Experiences in waste management in Tokyo can be used as a positive example because the amount of generated waste is successfully reduced on an annual basis. Various methods are used to extend the lifetime of landfills, and after the end of their use, they are turned into useful public facilities. Thermal energy created in the process of burning waste is not wasted but used to generate electricity and heat water. Active efforts are being made to increase recycled and reused waste through the implementation of the 3R initiative. This way of managing waste positively impacts the preservation of the environment. Although it is not perfect, and there is room for improvement, this is a step in the right direction toward a "greener" future. Civil society organizations that primarily deal with waste management policy in Serbia are still underdeveloped, with modest human capacities and limited influence on the creation of waste management policies at all levels. Research on waste projections in Belgrade, i.e. increase in the amount of waste by 2041 for 20.8% compared to the base year 2019, represents a negative phenomenon in waste management and environmental protection. In general, a combination of different environmental policy instruments is needed to effectively divert waste from landfills. Cooperation between municipalities or larger geographical units seems to be necessary for providing sufficient opportunities for the necessary financial and human capacities to build an alternative to waste disposal. At the same time, this cooperation requires considerable planning efforts.

REFERENCES

- Agencija za zaštitu životne sredine. 2019. ”Otpad – Deponije.” Upravnje otpadom. Datum pristupanja 25.05.2023. http://www.sepa.gov.rs/index.php?menu=2072&id=1006&akcija=showExternal
- Centar za unapređenje životne sredine. 2020. “Analiza sistema upravljanja otpadom u gradu Beogradu (2010-2019).” GreenFest. Datum pristupanja 25.05.2023. https://greenfest.rs/upravljanje-otpadom-u-beogradu/
- Clean Authority of Tokyo. 2018. Tokyo Model (Overview): Tokyo’s history and strength that have overcomethe municipal waste problems. Tokyo: Clean Authority of Tokyo.
- Clean Authority of Tokyo. 2023. Waste Report 2023. Tokyo: PattonFive.
- Đurđević, J., Rajković, D.i Đurđević, S. 2011.“Upravljanje otpadom u Srbiji kroz akciju „Očistimo Srbiju“ u Zborniku radova 38. nacionalna konferencija o kvalitetu i 6. nacionalna konferencija o kvalitetu života, Kragujevac, 19-21. Maj. 2011. 315-320.
- Gradska uprava grada Beograda. 2021. Lokalni plan upravljanja otpadom grada Beograda 2021-2030. Beograd: Univerzitet u Beogradu, Geografski fakultet. https://www.beograd.rs/images/data/eaa6cc50b9bcf-38c72ff941f7c7474a0_1691048761.pdf
- Higuchi, S. 2021. „Municipal Solid Waste Landfill Technology in Japan“. Environmental Science and Engineering.
- Kurishima, H. 2018, “Analysis of Current Municipal Solid WasteManagement in Tokyo and Future Prospects.“ In Tokyo as aGlobal City: New Geographical Perspectives, edited byToshioKikuchi and ToshihikoSugai, 287-315. Singapore: Springer Nature.
- Okuda, I. and Thomson, V. E. 2007. “Regionalization of Municipal Solid Waste Management in Japan: Balancing the Proximity Principle with Economic Efficiency.“ Environmental Management 40, 12-19.
- Organisation for Economic Co-operation and Development. 2023. „Municipal waste, Generation and Treatment.“ OECD.Stat. Accessed August 23, 2023. https://stats.oecd.org/index.aspx?DataSetCode=MUNW#
- Takiguchi, H. and Takemoto, K. 2008. “Japanese 3R Policies Based on Material Flow Analysis.“Journal of Industrial Ecology 12, no. 5-6, 792-798.
- Tokyo Metropolitan Government. 2015. “Tokyo’s history, geography, and population.” About Our City. Last modified October 1, 2015. Accessed May20, 2023. https://www.metro.tokyo.lg.jp/ENGLISH/ABOUT/HISTORY/history02.htm
- Tokyo Metropolitan Government. 2021. “Waste Landfill Site.“ Waste and resource recycling publications. Last modified March 29. 2023. Accessed May20, 2023. https://www.kankyo.metro.tokyo.lg.jp/data/publications/resource/pamphlet_list.files/english_pamphlet2021.pdf
- Watanabe, K., Okayama, T., Khadijah, S.,Araki, T.,Lim, C.,Mateo-babiano, I.,Tjiptoherijanto, P. and Licos, A. 2015. “An exploratory study on waste management in SoutheastAsian megacities and Tokyo.“ In Sardinia 2015, Fifteenth International Waste Management and Landfill Symposium, Proceedings, Cagliari, 5-9. October 2015., Padova: CISA.
- Yoshida, H., Shimamura, K. and Aizawa, H. 2007. “3R strategies for the establishment of an international sound material-cycle society.“ J Mater Cycles Waste Manag 9, 101–111.