

ASSESSMENT OF THE WASTE MANAGEMENT SYSTEM IN KRAKOW AS AN ELEMENT OF CIRCULAR ECONOMY

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Abstract

Building a waste management system requires considering many aspects for the assessment of its functioning. The transition from a linear system to a circular economy requires taking into account not only technological but also economic and social factors.

The waste management system in Krakow is a comprehensive solution that considers all factors and aspects, allowing for the assessment of technology, economic justification of costs and social acceptance. The paper presents a comprehensive structure of the system with all the factors enabling the transition from a linear to a circular economy. In Kraków, over 200,000 tonnes of mixed waste are collected annually and almost 150,000 tonnes of selectively collected waste. Such potential allows for a landfill reduction below 10% by weight and the achievement of the required recycling levels.

Keywords: Waste management; Solid waste; Circular economy.

LIST OF ABBREVIATIONS

MPO Sp z o.o. – Municipal Cleaning Company in Krakow (MPO)

GMK – Municipality of Krakow (GMK)

ZSGOK – Integrated Waste Management System

PSZOK, LAMUSOWNIA – Point of Separate Municipal Waste Collection, location Nowohucka street

PSZOK Barycz – Point of Separate Municipal Waste Collection, location Barycz Ecological Centre

MBP – Installation for Mechanical-Biological Waste Management

1. INTRODUCTION

On 2 December 2016, the European Commission adopted an ambitious new circular economy package to help European businesses and consumers transition to a stronger, more circular economy, where resources are used more sustainably. The actions proposed by

the Commission will help to “close the loop” of the life cycle of products by increasing recycling and reuse, and bring benefits to both the environment and the economy. These actions will maximize value and ensure the use of all raw materials, products and waste, while contributing to energy savings and reduction of greenhouse gas emissions. The circular economy idea strengthens the waste hierarchy points on waste prevention and reuse [1–10]. According to the definitions included in the Act on waste, waste prevention should be understood as measures applied to a product, material or substance before they become waste, reducing:

- a) the amount of waste, including by reusing or extending the period of further use of the product,
- b) the negative impact of the generated waste on the environment and human health,
- c) the content of harmful substances in the product and material

Municipal waste management systems are the source of numerous studies, and their assessment is a difficult

and multifaceted task. The implementation of the circular economy to waste management systems is another task that will have to take into account many factors [11–16]. The criteria and assessment factors should be selected so that the proposed solution is safe for human health and the environment, while the assessment should be clear and precise [17–20]. The aim of the paper is to present the quantity and quality of generated and accumulated municipal waste streams towards the introduction of a circular economy [20–25].

2. CIRCULAR ECONOMY AS A CHALLENGE FOR THE KRAKOW WASTE MANAGEMENT SYSTEM

Municipal governments are obliged by law to organize waste management in their municipalities. This is due to the act (Journal of Laws 2020.1439, i.e. of 2020.08.24) and the Act on waste (Journal of Laws.2020.797 i.e. of 2020.05.04) together with executive regulations.

Since the Municipality of Krakow (GMK) has entrusted Municipal Cleaning Company in Krakow (MPO) obligations in this regard, on June 7, 2013 an executive agreement was concluded, the provisions of which oblige MPO [1–2]:

- cover all real estates located in the territory of the Municipality of Krakow by the integrated waste management system (ZSGOK),
- ensure the management of municipal waste in installations that allow the Commune to meet its obligations under the Act (recovery and disposal),
- ensure financing, construction, maintenance and operation of own or jointly with other municipalities regional municipal waste treatment installations,
- supervise municipal waste management in the Municipality of Krakow,
- establish a selective collection of municipal waste,
- create Selective Municipal Waste Collection Points,
- ensure the levels of recycling required by law, preparation for re-use and recovery by other methods are achieved,
- reduce the mass of biodegradable municipal waste sent for disposal.

MPO, as the Waste Management System Manager, the area of the GMK, as well as all groups of waste generated as part of the economic and living activities of the

commune's inhabitant, as well as those generated as a result of high tourist traffic, were taken over by the area of the Waste Management System. The company, using its many years of experience, has organized an efficient system, both formally and technically, which is constantly being improved and is currently one of the best functioning in the country [1–5].

3. WASTE STREAMS AS FLOWS IN THE WASTE MANAGEMENT SYSTEM

As part of the ZSGOK in Krakow, mixed waste was collected 217,607.11 tons, which constitutes 59% of the total waste. On the other hand, waste collected selectively at the source is 149,415.19 tons and it is 41% of all waste collected under the ZSGO (Tab.1).

Table 1.
In 2019, the following were collected as part of the Integrated Waste Management System

No.	Description	The amount of waste [Mg]
I	Unsorted (mixed) municipal waste	217 607,11
II	Separately collected waste, including:	149 415,19
1	Separately collected municipal waste (waste from groups 15, 20)	68 139,38
2	Selectively collected bulky waste	22 048,69
3	Selectively collected green waste	42 341,91
4	Selectively collected biodegradable kitchen waste	13 369,67
5	Rubble	3 515,54
SUM		367 022,30

Source: Data from MPO

Table 1 presents the amounts of waste collected on the premises of the GMK within ZSGOK and it is clear that there is more unsorted waste than that collected selectively. Nevertheless, the trend is favorable towards reducing the share of unsorted waste. In 2018, 222 212.51 tons of non-segregated waste and 129 729.34 tons, of sorted waste was collected i.e. the proportions were 63% to 37%, respectively.

3.1. Unsorted waste as a source of information about potential processing options

All unsorted waste is directed to the installation in order to recover as many raw materials as possible. The fraction not suitable for further processing goes to the Waste Incineration Plant in Kraków. Table 2 shows the amounts of waste sent to respective installations.

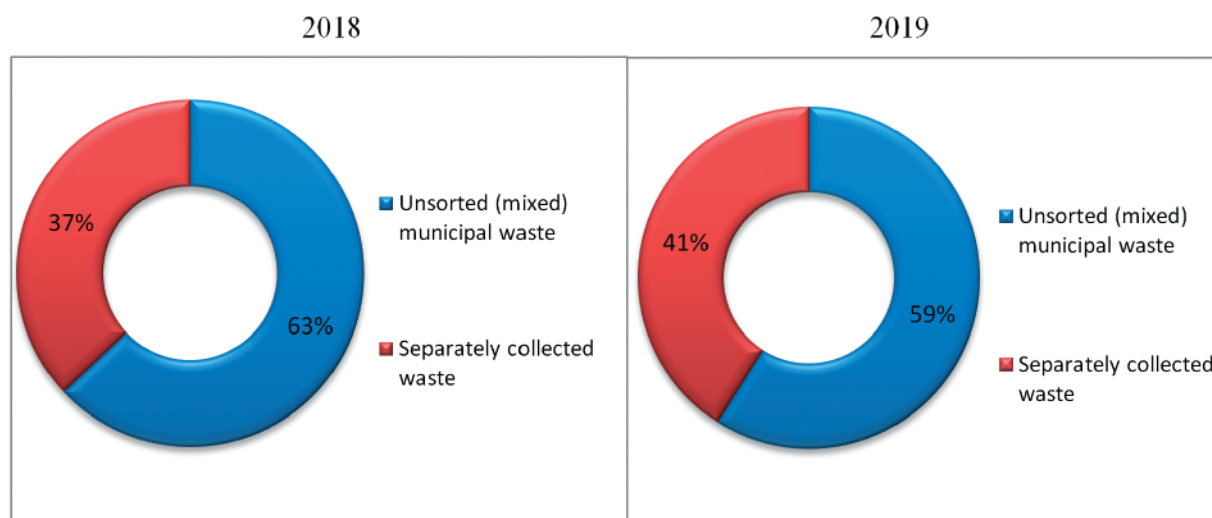


Figure 1. Comparison of the total collected waste in 2018 and 2019 years showing increasing rate of separately collected waste [1–2]

Table 2. Amount of unsorted (mixed) municipal waste transferred for processing in municipal installations in 2019

No.	Installation name	The amount of waste	
		[Mg]	[%]
1	Waste Incineration Plant in Kraków, Cracow	109 816,25	50,47
2	Installation for mechanical and biological treatment of municipal waste “Barycz”, Cracow	99 536,92	45,74
3	Installation of mechanical and biological treatment of municipal waste, MIKI Recycling, Cracow	6 654,00	3,06
4	Installation of mechanical and biological treatment of municipal waste, Remondis Cracow, Cracow	1 317,50	0,60
5	Municipal Waste Landfill Oświęcim	282,44	0,13
SUM		217 607,11	100,00

Source: Data from MPO

3.2. Sorted waste – sources and possibilities of recovery and recycling

From April 1, 2019, in the Municipality of Krakow, changed rules for selective collection of municipal waste were introduced, resulting from the obligation to adapt municipal regulations to the content of the Regulation of the Minister of the Environment of December 29, 2016 on the detailed method of selective collection of selected waste fractions (Journal of Laws of 2016, No. of 2017, item 19), in particular:

- paper; paper waste, including cardboard, paper packaging waste and cardboard packaging waste,

are collected in blue containers (in single-family housing, in bags) marked with the word “Paper”;

- glass; glass waste, including glass packaging waste, is collected in green containers (in bags for detached houses) marked with the word “Glass”;
- metals and plastics; metal waste, including metal packaging waste, plastic waste, including plastic packaging waste, and multi-material packaging waste, are collected in yellow containers (in single-family housing in bags) marked with the words “Metals and plastics”;
- biodegradable waste, with particular emphasis on bio-waste, collected in brown containers (in single-family housing, in bags or containers) marked with the word “Bio”.

In total, in 2019, separately collected waste accounted for almost 41% of all waste collected in the Municipality of Krakow, including: packaging waste (groups 15 and 20) almost 19%, bulky waste – 6%, biodegradable waste over 15% of which almost 4% was kitchen waste.

Sorted waste can be collected on the premises of real estate where residents live and real estate where residents do not live, but municipal waste is generated. In addition, in the Municipality of Krakow in 2019, selectively collected municipal waste was collected at two Selective Collection Points of Municipal Waste (LAMUSOWNIA and PSZOK Barycz).

Separately collected municipal waste (waste from groups 15, 20) in 2019, were transferred for processing to the Selective Collected Waste Sorting Plant and to the Barycz Municipal Waste Treatment Plant.

Selectively collected waste

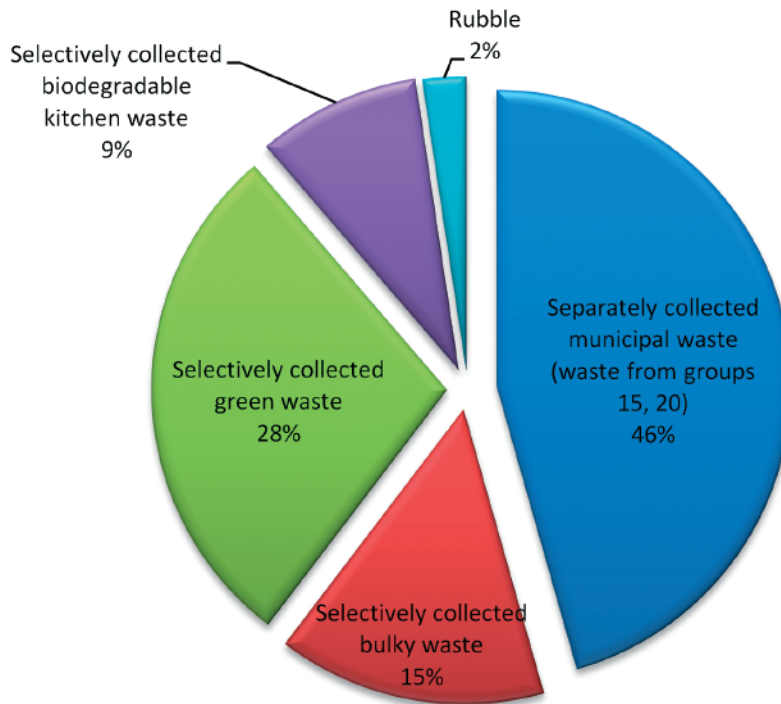


Figure 2.
Share of individual types of waste selectively collected in 2019 as part of the Integrated Municipal Waste Management System [%]

Table 3.
Municipal waste sorting installations in Krakow

No.	Installation	The waste volume	
		[Mg]	[%]
1	Sorting plant of selectively collected waste Barycz	53 989,25	79,23
2	Installation of MBP for municipal waste in Barycz	14 150,13	20,77
Total		68 139,38	100,00

Selectively collected bulky waste, including; waste electrical and electronic equipment in 2019, were subjected to the processing (recovery) process at the Large-size Waste Plant by crushing and processing them into alternative fuel used for energy in cement plants for the production of cement or in the Waste Incineration Plant in Krakow. Electrical and electronic equipment waste, on the other hand, was disassembled in a disassembly plant for used electrical and electronic equipment operated by MPO or in external disassembly facilities with permits required by law.

The total amount of selectively collected large-size waste in 2019 was **22,048.69 Mg**.

Selectively collected green waste in accordance with the provisions of the Regulations for maintaining cleanliness and order in the Krakow City Commune were:

- delivered on their own by property owners to the Municipal Waste Selective Collection Point at the Barycz green waste composting plant,
- collected at strictly defined dates from the property in appropriately labeled bags provided by MPO in 2019, over 4,055,000 bags were issued,
- provided by companies dealing with the maintenance and care of green areas.

Selectively collected green waste was processed into compost at the Barycz Composting Plant.

Table 4.
The amount of selectively collected green waste, transferred to the Barycz Composting Plant in 2019

No.	Green waste	The waste volum	
		[Mg]	[%]
1	collected as part of the green waste collection program	37 708,41	89,06
2	provided by property owners on their own	4 512,26	10,66
3	provided by companies dealing with the maintenance and care of green areas	121,24	0,29
Total		42 341,91	100,00

Selectively collected biodegradable kitchen waste (kitchens with the code 20 01 08) in accordance with the provisions of the Regulations for maintaining cleanliness and order in the Krakow City Commune, the following were collected:

- in households and other municipal waste producers,
- in catering facilities, hotel and commercial facilities, kindergartens, nurseries, schools, care facilities, mass catering facilities (facilities), canteens (in the so-called “barrels”)

and processed in the installations listed in the table below:

Table 5.
The amount of kitchen waste sent for processing in installations in 2019

No.	Installation name	The amount of waste	
		[Mg]	[%]
1	Organic waste composting plant – SUEZ Małopolska, Kosiarzy 5A, 30-731 Cracow	3 784,55	28,31
2	Municipal Waste Landfill, Oświęcim, Nadwiślańska 36, 32-600 Oświęcim	3 722,10	27,84
3	Waste Treatment Plant IB Waste Nowy Targ /FCC Podhale Sp. z o.o., J. Pawła II 115, Nowy Targ	4 648,48	34,77
4	KOMPOSTECH Sp. z o.o., Wiklinowa 4A, Nowy Sącz	303,36	2,27
5	Waste Treatment Plant Myślenice Sp. z o.o. J. Słowackiego 82; 32 – 400 Myślenice	306,70	2,29
6	Regional Waste Processing Plant, Wadowicka 4a; 34-200 Sucha Beskidzka	604,48	4,52
Total		13 369,67	100,00

Construction and demolition waste, selectively collected in 2019 at the Selective Collection of Municipal Waste Points “LAMUSOWNIA” and PSZOK Barycz were subjected to a recovery process at the Barycz municipal waste landfill by using them to build roads and technological sites.

The total amount of selectively collected construction and demolition waste in 2019 as part of the Integrated Municipal Waste Management System was **3,515.54 Mg**.

Other ways of transferring selected groups of waste

- system of containers, the so-called bells for selective collection of waste placed in sets in the city,
- a system of green containers for collecting glass,
- bulky waste collection system,
- medical waste collection system
- dead animals
- medical waste
- rubble
- tires
- waste electrical and electronic equipment collection system called “ELECTRO-WASTE SQUAD ON PHONE”, in which every resident of Krakow, within the time agreed on the phone, may report the need to collect unnecessary electrical or electronic equipment from her apartment,
- a program of selective collection of green waste (grass, small branches, leaves) in plastic bags labeled and delivered by MPO,
- a used clothing collection program called: “100% BENEFITS” implemented jointly with the Polish Red Cross – PCK Regional Branch in Małopolska Region. This program allows every resident of Krakow to report by phone the need to collect unnecessary used clothing from her apartment at the agreed time,
- the program “KRAKOW ECO – BOX”. The program is based on the availability of special devices spread in the city – containers called “KRAKOW EKO – BOX” with separate containers for individual types of waste for collecting small electrical and electronic devices such as; phones, chargers, CDs, light bulbs, batteries etc.
- Additionally, on scheduled days, the residents of Krakow may return waste from the patient's home-made blood sugar test strips, or waste needles or pre-filled syringes, to the container placed in the (electric) car that collects this type of waste.

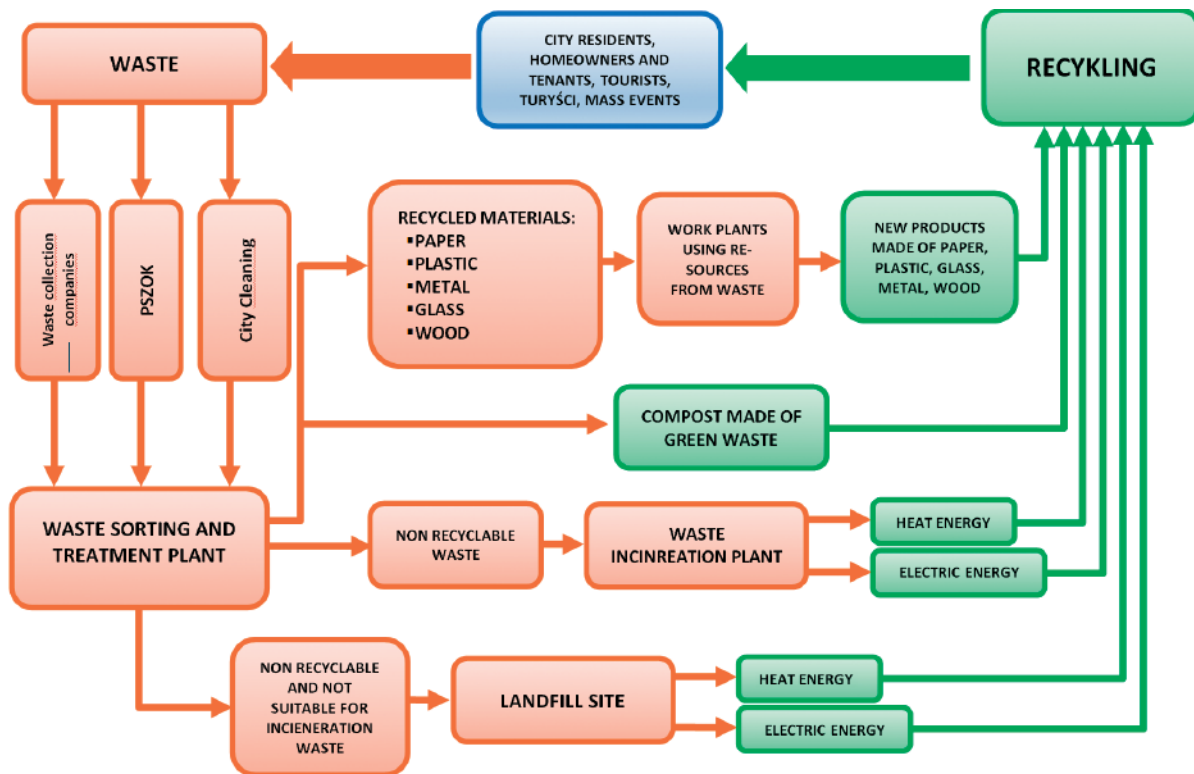


Figure 3.
Circulation of waste in ZSGOK

4. WASTE RECOVERY AND RECYCLING INSTALLATIONS AS THE FIRST ELEMENT OF CIRCULAR ECONOMY

Circular economy – is a model of economic development in which the following basic assumptions meet, while maintaining the condition of efficiency, regarding the maximization of the added value of raw materials/resources, materials and products or minimization of the amount of waste generated while managing them in accordance with hierarchy of waste management methods (waste prevention, preparation for re-use, recycling, other methods of recovery, neutralization). The first element enabling the implementation of a circular economy in the municipal economy is the waste management system, in which properly conducted recovery and recycling processes will be the source and the beginning of the possibility of closing circuits and using all waste fractions. In Krakow, the waste management infrastructure is well-developed and there are installations that allow the processing of all types of waste generated.

4.1. Education

In order to bring the expected results from selective collection at source, it is necessary to educate the residents in the field of waste management, for each age group starting from the youngest. Educational activities implemented as part of the Integrated Municipal Waste Management System in the Municipality of Krakow in 2019 covered all age groups of Krakow residents.

They were intended to the greatest extent for children.

- Art competition for kindergartens – “EKO-CREATORS 2019”
- Educational program for kindergartens – “Krakow preschoolers are ECO-kids”
- Interactive educational workshops – “WE KNOW HOW WE SEGREGATE”
- Educational program for grades I–III of primary schools – “Krakow children know how to throw away rubbish” as part of the “Academy of Young Cracovian” – a project implemented by the City of Krakow
- Educational program for grades IV–VI of primary

FACILITIES RUNNING BY MPO



PSZOK



MBP Barycz



Compost Plant



Sorting Plant

Large-sized
waste Plant

Landfill

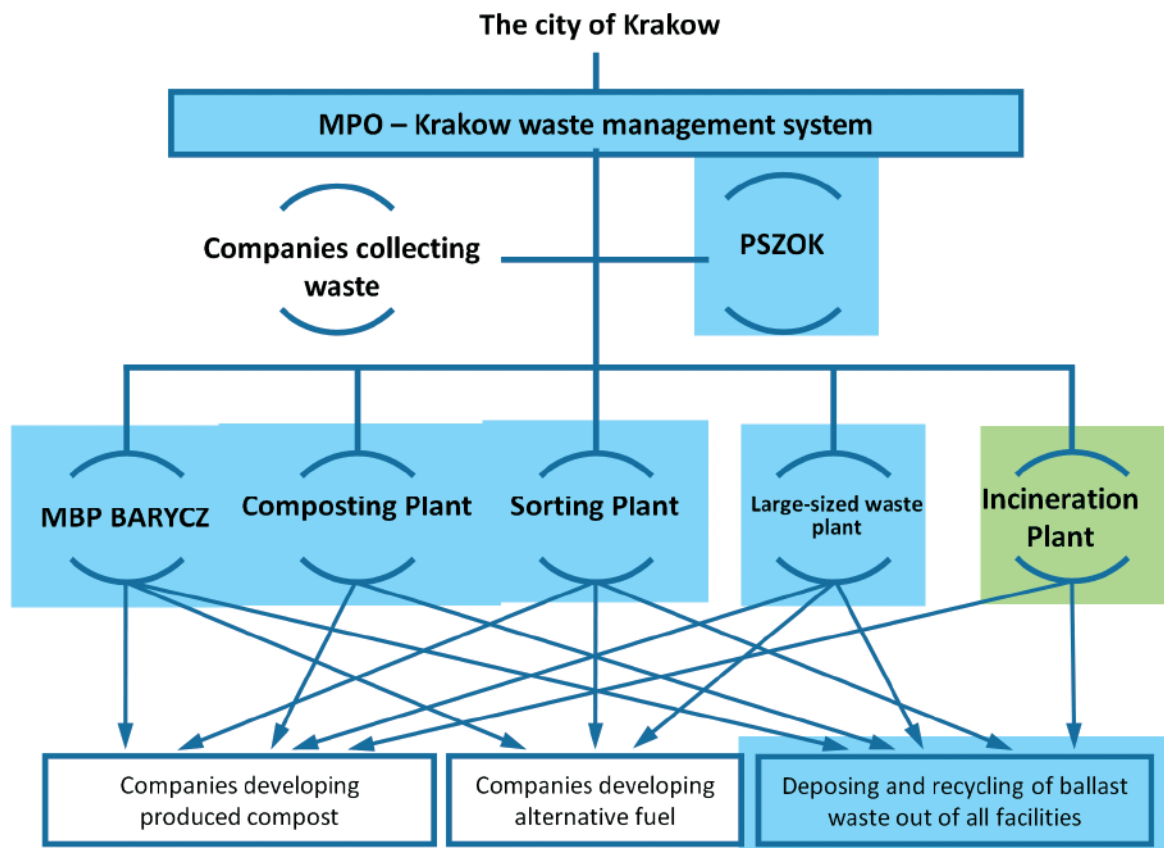


Figure 4.
Krakow waste management system – all facility components. MPO runs all highlight in blue

schools “There is no vacation from segregation”

- Educational program for grades VII–VIII of primary schools and secondary schools – “Electro-waste has rules”
- Educational program “KRAKOW SCHOOLS GRADE WASTE BEST”
- Educational program for educational institutions – “Batteries exchanged for Cinema tickets”
- Educational program for Seniors – “You sort wisely – you gain more”
- Ecological competition – “Re-Creation”
- City game – “KRAKOW GAME FOR CLEAN EARTH”
- Educational Open Days at the MPO
- Educational program – “Simple ways for difficult waste”
- Educational program – “Crush with imPETus!”
- Educational and information materials for residents of Kraków in area of Eco-education and information campaigns organized by the City Hall, District Councils, housing cooperatives, community centers, social welfare centers, educational institutions and others.

5. ACHIEVED EFFECTS

What measures should be taken to make the waste management circulate in a closed loop? There is no such directory containing sufficient actions. Everything, however, is the pursuit of such a synergy of activities that fall within a wide range of waste management system:

- activities required by law (multi-container system),
- inhabitants education (locally),
- cooperation with local support groups,
- organization of the collection system for individual streams in order to segregate them at the source in the largest possible quantities,
- managing (developing) installations that are able to receive and process the collected waste streams,

As a result, we can obtain:

- the required level of recycling,
- a local waste management system moving towards a Circular Economy,
- a well-functioning network of municipal waste treatment installations.

Due to the proper management of the entire system, in 2019 Krakow City Commune achieved a 55.92%

level of recycling and preparation for re-use of waste: paper, metal, plastic, glass, whereas required recovery rate is at least 40% in 2019.

The level of recycling and preparation for reuse and recovery by other methods of waste other than hazardous construction and demolition waste in 2019 should reach at least 60%. The City of Krakow has reached the target level – 100%.

The acceptable level of limitation of the mass of biodegradable municipal waste sent for landfilling in relation to the mass of this waste produced in 1995, in 2019 should be a maximum of 40%. The Municipality of Krakow has reached the target level of – 0%.

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