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Analysis of Municipal Waste Management in Municipality of Krakow

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Abstract. Rational waste management is an essential element in the process of transitioning the linear economy into a circular model. Those actions that are taken to achieve better results in this area are important for regional and local development as well as for the implementation of sustainable development goals. This article presents the requirements and rules for the functioning of waste management in Poland. Taking the structure of the system into account, the functioning of waste management in the municipality of Krakow was analyzed. Particular attention was paid to the problem of municipal waste segregation by the inhabitants of Krakow. As part of our own research, surveys were conducted among the employees of the Municipal Cleaning Company LLC (Miejskie Przedsiębiorstwo Oczyszczania w Krakowie – MPO Sp. z o.o.), which showed the scale of the deficiencies. The results of the research were helpful in proposing actions to increase the effectiveness of the waste-segregation system in Krakow.

Keywords: waste management, circular economy, sustainable development

JEL Classification: Q01

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1. INTRODUCTION

When people consume products, they generate waste; a significant part of this is packaging waste that is generated by eating food and using cleaning products and cosmetics (Guinness & Walpole, 2015). Until the late 1980s and early 1990s, food products in Poland were usually packaged in glass or paper. Glass packaging was intended for liquid and semi-liquid products. Glass bottles were returnable and deposits were imposed on them, which effectively reduced the amounts of waste and lowered packaging production costs (Borkowicz, 2022; Królczyk et al., 2015).

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Currently, the deposit-refund system is only used for some bottled beers. Paper packaging is also commonly used, in which loose products, meat, and dairy products are packed. Currently, products are most often packed in packaging made of plastic due to their widespread availability and low price. This leads to a large amount of plastic waste (Ajwani-Ramchandani et al., 2021; Minelgaitė & Liobikienė, 2019; Sadowski et al., 2021). Economic development caused the migrations of people to large cities and the rapid development of housing (single and multi-family) in them, which has affected the expansion of urban agglomerations. High population density makes municipal waste a serious problem, and waste management is one of the key challenges for local authorities (Jakubiak & Śliwka, 2013; Knickmeyer, 2020; Shah et al., 2021). European Union and national regulations impose the obligation to subordinate waste management to the principles of sustainable development on local governments. As part of the common policy of the European Union regarding waste management, a "waste-management hierarchy" has been established. Its stages are waste prevention, reuse, recycling (including composting), disposal (e.g., waste incineration with energy recovery), and finally landfill disposal (*Zarządzanie odpadami...* 2023; Pires and Martinho 2019). Polish regulations on waste management are adapted to EU requirements. *Ustawa z dn. 14 grudnia 2012 r. o odpadach* [the Act of December 14, 2012, on waste] (2012) stipulates that municipal waste is "waste generated in households, excluding end-of-life vehicles, as well as waste that does not contain hazardous waste from other waste producers, which due to its nature or composition are similar to household waste". According to the data from Główny Urząd Statystyczny (Statistics Poland) for 2021, the amount of waste that was collected in households in Poland was about 310 kg per capita. On the other hand, this was about 309 kg/person in the Małopolskie Voivodeship. In Krakow (the largest city in Małopolskie Voivodeship), 443 kg of this waste was collected per person (Bank Danych Lokalnych GUS, 2023). In large cities, the amount of waste that is produced per inhabitant is systematically increasing along with the increase in the standard of living of the residents. This is a major challenge for waste-management planners (Kalisiak-Mędelska, 2017; *Ustawa...*, 2012).

The purpose of this article is to identify problems that are related to waste collection in the municipality of Krakow and to find solutions that would improve the waste-management system in the municipality. Therefore, it was first necessary to assess the effectiveness of waste segregation by waste producers from the point of view of the employees of the waste-collection company.

To achieve this goal, surveys were conducted among the employees of the Miejskie Przedsiębiorstwo Oczyszczania (MPO) in Krakow (Municipal Cleaning Company). Opinions were obtained on problems that are related to waste collection in various types of buildings and mistakes that are made by waste producers during their segregation. Employees of the MPO also presented their opinions on the need to implement measures to improve the efficiency of waste segregation.

A literature study showed that many studies have indicated problems in the functioning of the waste-management system in the commune (Albin, 2018; Irla & Kowalska, 2022; Jakubiak & Śliwka, 2013). However, many works are devoted to this topic from the waste producers' perspective (Kalisiak-Mędelska, 2017; Kowalska et al.,

2020). Studies have been conducted on the behavior and decisions of waste producers and consumers who decide to deal with specific waste groups (Borkowicz, 2022; Królczyk et al., 2015). The literature on the subject also includes analyses, assessments of the satisfaction, and awareness of the inhabitants of Krakow regarding the waste-collection system. Citizens' preferences and expectations that were connected to the waste-management system were also examined (Kołcz & Ziółko, 2021). The research gap covers the area of waste management from the perspective of waste recipients; therefore, the authors of this article decided to conduct a survey among MPO employees who had direct contact with waste collection in the municipality of Krakow. Thanks to this, it was possible to list the emerging opinions and specify the most common problems that helped us formulate our conclusions and recommendations. The Krakow commune has its own specificity, but other municipal communes can also use the results of the research to improve their individual waste-management systems.

2. WASTE MANAGEMENT IN POLAND

Waste management in Poland has been going through changes; this is mainly due to the need to implement the new guidelines that were introduced by the European Union. When using the components of the natural environment, it is required that all entities follow the principles of sustainable development and strive to achieve the objectives of the circular economy, which is a modern model of management. Therefore, those entities that operate on the waste-management market are obligated to respect the guidelines and requirements that have been set at the national level (Dacko et al. 2018).

One of the most important regulations in waste management in Poland is the *Ustawa...* (2012); according to this, waste management should be carried out in such a way that ensures the protection of human life and health as well as the environment. The act also includes guidelines on the handling of individual types of waste and the obligations of the entities that produce and collect waste. In order to achieve the objectives that were set in the environmental protection policy, national and voivodeship waste-management plans are applied and updated accordingly, which are also regulated by the above-mentioned regulations act. Waste-management plans concern the waste that is generated in the area for which the plan is drawn up and imported into this area, including municipal waste, biodegradable waste, packaging waste, and hazardous waste. Waste-management plans also include waste-prevention measures, which are particularly carried out on the basis of the Krajowy Plan Gospodarki Odpadami [National Waste Prevention Program] (Lisowska, 2017; *Ustawa...*, 2012). It was also thought that these plans should create the basis for introducing modern methods for waste management – both in the field of technology and economics – and management – with the perspective of long-term solutions – resulting in a reduction in the amount of waste and limiting the negative effects on the environment (Albin, 2018).

Municipalities are responsible for municipal waste-management in Poland. This was the result from the provisions of the *Ustawa z dn. 13 września 1996 r. o utrzymaniu czystości i porządku w gminach* [Act of September 13, 1996, on maintaining

cleanliness and order in communes (as amended)] (1996). Waste management in municipalities covers the following areas:

1) waste collection and disposal,
2) cleaning up commune,
3) storage and disposal of waste.

Waste producers and property owners are also obligated to handle waste in accordance with the principles that were set out in (*Ustawa...*, 1996). These obligations included the selective collection of municipal waste that is generated by residents and companies in accordance with the requirements that have been set out in the commune's regulations and in the manner that was specified in the regulations that were issued on the basis of Art. 4a Par. 1. In Art. 6 Par. 3b of the act on maintaining cleanliness and order in communes, municipalities are required to achieve a level of preparation for the reuse and recycling of municipal waste. These levels have fixed weights that increase each year (Irla and Kowalska, 2022; *Obwieszczenie Marszałka...*, 2022):

- 35% by weight – for 2023,
- 45% by weight – for 2024,
- 55% by weight – for 2025,
- 56% by weight – for 2026,
- 57% by weight – for 2027.

2.1. Waste management in Krakow

The first mention of the waste-management system in Krakow dates back to 1884, when the "Comprehensive regulations for maintaining cleanliness and order for Krakow" were passed. In 1906, the City Cleaning Department was established, which changed its name to the City Cleaning Department in 1932 and again to the State Municipal Cleaning Company in 1951. On June 12, 1992, the city council adopted a resolution on the transformation of the Municipal Cleaning Company (Miejskie Przedsiębiorstwo Oczyszczania – MPO) in Krakow into a commercial law company that belonged to the municipality of Krakow (*Początki MPO Kraków sięgają 1866 roku*, 2023; *Utrzymanie czystości w sezonie zimowym*, 2023). Currently, MPO conducts analyses of the state of waste management; it performs tasks of maintaining cleanliness and order in the summer and winter seasons on public and internal roads as well as in playgrounds and open areas that are located on real estate that is owned by the municipality of Krakow or the state treasury (*Odbiór odpadów*, 2023; *Odbiór odpadów. Analiza*, 2023).

From April 1, 2022, all municipal waste is collected by a consortium of four companies that were selected through a public procurement procedure under an unlimited tender. The consortium of companies that collects municipal waste includes Małopolskie Przedsiębiorstwo Gospodarki Odpadami Sp. z o.o., PreZero Małopolska Sp. z o.o., REMONDIS Kraków Sp. z o.o., and FCC Polska Sp. z o.o. (*Sektory odbioru odpadów*, 2023). The waste collection by the listed companies in Krakow is determined by waste-collection sectors. Figure 1 shows the division of Krakow into waste-collection sectors.

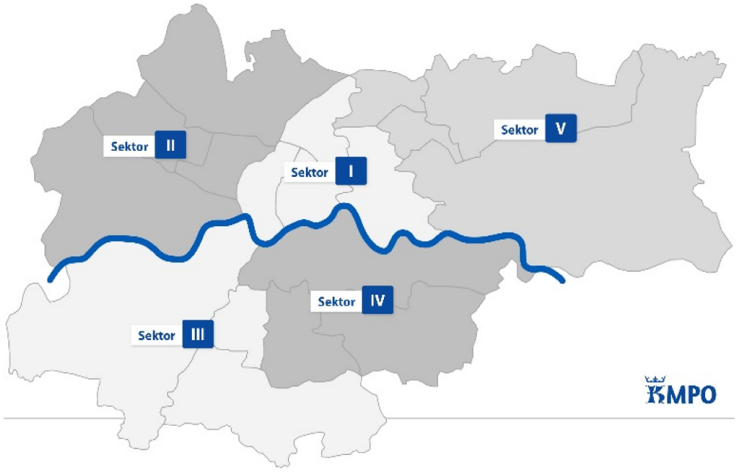

Fig. 1. *Division of Krakow into waste-collection sectors (Sektory odbioru odpadów, 2023)*

The basis for the selective collection of municipal waste in the municipality of Krakow is the collection of waste "at source." Since April 1, 2019, the selective collection of municipal waste have needed to take place according to the new rules. The new regulations introduce the segregation of waste into five fractions, which are assigned the appropriate colors of containers or in single-family houses – bags (Jakubiak & Śliwka, 2013). Detailed guidelines on the segregation of municipal waste in Krakow are presented in Table 1. Since November 1, 2020, all types of real estate in the municipality of Krakow have been required to selectively collect municipal waste. The fee for municipal waste management for residents who do not segregate waste is twice as high as for those who practice waste segregation. The additional fee is a kind of penalty for non-compliance with the requirements of the system (*Analiza stanu...*, 2023; Kołcz and Kołcz, 2021).

Table 1. *Guidelines for segregation of municipal waste in Krakow (Segregacja odpadów, 2023)*

Color of container or bag	Waste fraction	Itemization
Yellow	Metals and plastic	plastic bottles and food packaging, plastic bags, carrier bags, packaging for cleaning products, multi-material packaging (e.g., beverage cartons), metal cans, small iron scrap, polystyrene foam (non-construction)
Blue	Paper	grease-free packaging made of paper, cardboard, paper bags and sacks, newspapers and magazines, catalogs and leaflets, office paper, notebooks and books, wrapping paper

Table 1 cont.

Color of container or bag	Waste fraction	Itemization
Green	Glass	glass bottles and jars of beverages and food, glass packaging of cosmetics (unless they are made of permanently combined several raw materials)
Brown	Biodegradable	vegetable and fruit waste (peelings, etc.), food scraps (without meat and bones), coffee and tea grounds
Black	Mixed waste	greasy paper, soiled foils, used towels and paper tissues, varnished and foil-coated paper, hygiene articles (e.g., diapers), table glass, ceramics, porcelain, crystals, heat-resistant glass, mirrors, meat, bones and fish bones

Figure 2 shows the amounts of the collected municipal waste of the segregated fractions during the years of 2017–2021 in Krakow. The data shows that the greatest number of segregated fractions of municipal waste was generated in 2020. The largest amount of waste that was produced from plastics was collected, and there was about twice as much paper and glass waste. This may have been due to the introduced lockdown, resulting in the closure of catering establishments at the beginning of the COVID-19 pandemic. In 2021, the amount of plastic waste that was collected was the lowest since 2019.

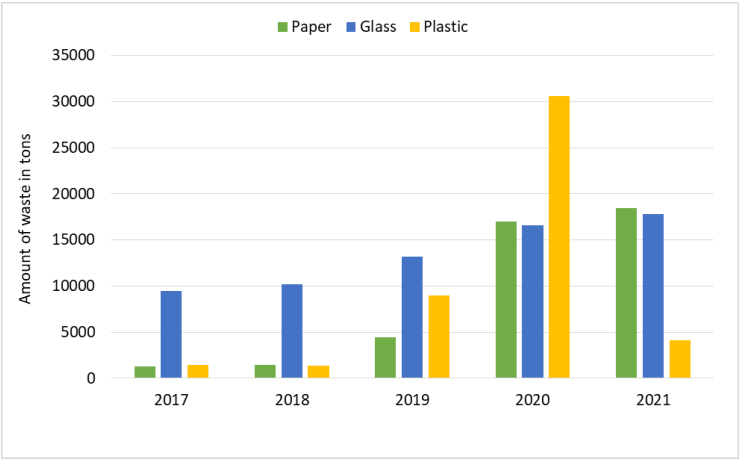

Fig. 2. *The amount of collected fractions of segregated municipal waste in tons in Krakow during period of 2017–2021 (Bank Danych Lokalnych GUS, 2023)*

Several factors contribute to this situation. The municipality of Krakow applies the Integrated Municipal Waste-management System, which covers properties that are

inhabited by residents and properties that are not inhabited by residents, which facilitates the functioning of the system. The use of educational programs and the effective flow of information (e.g., online waste finder) certainly contribute to the increase in the amount of segregated waste (*Analiza stanu...*, 2023; Zarębska and Zarębski, 2018). Another challenge for waste management is the needs for better segregation and increasing the recycling of plastics that have resulted from the EU regulations. Since January 1, 2021, the EU budget has been fed with a fee for the plastic packaging that is produced in a member state that has not been recycled (Directive 94/62/ECC, 2023). Therefore, it is in the interest of all municipalities to increase their amounts of recycled plastic packaging waste.

Waste management in Krakow is planned for a specific period of time (reports on waste-management plans are presented for a period of one year), taking the specific needs and the need to introduce changes in a developing city into account. Waste-management plans are based on the principles of sustainable development, and society should be involved in their development (Wieczorek & Siekierski, 2021). The waste-management plan refers to the provisions of the Environmental Protection Program for Małopolskie Voivodeship, which indicates ordering waste management, among others, among the three main ecological priorities. In the case of Krakow, waste-management directions are defined locally on two levels: in the waste-management plan for the Lesser Poland region, and in the waste-management plan for the city of Krakow (Jakubiak & Śliwka, 2013).

The problems of waste management in Krakow were dealt with by Kołcz and Ziółko, who made an attempt to evaluate it. The study was conducted among the residents and concerned the satisfaction and awareness of the inhabitants of Krakow in relation to the waste-management system in the municipality of Krakow. Based on the answers that were obtained, it was found that the surveyed residents noticed many problems in the waste-collection system. The problems were the technical organization and the information environment (Kołcz & Ziółko, 2021).

3. MATERIALS AND METHODS

In order to achieve the aim of the article (which was to assess the effectiveness of the waste-management system in Krakow), it was decided to conduct a survey among employees who were directly involved in waste collection. They were supposed to show the problems that were faced by the recipients. The municipality of Krakow was selected as the research object, in which 802,583 people lived in 2021 according to the data from Statistics Poland. This population produced 345,720 tons of municipal waste (Bank Danych Lokalnych GUS, 2023) . The waste that was collected selectively accounted for 31% of the municipal waste. Nearly 100% of the residents and businesses were covered by the waste collection.

In order to obtain materials for the analysis of the municipal waste-collection system of recycled fractions, individual surveys were conducted in May 2021 with the employees of MPO Sp. z o.o. in Krakow. The study involved 41 employees who dealt directly with the collection of municipal waste. These were only men with primary and vocational educations.

The surveys that were conducted among the employees of MPO Krakow Sp. z o.o. allowed for the identification of problems that were related to waste collection and the formulation of conclusions that could be used by the municipality of Krakow to improve the functioning of the waste-management system. The results were developed in the Microsoft Excel program.

The questions that were asked in the survey concerned the segregation of the waste fractions: plastic and metal, paper, glass, biowaste, and mixed municipal waste. The following questions that were asked in the survey are presented in Table 2.

Table 2. *Questions asked in survey to employees of MPO in Krakow*

Question	Evaluation
1. How do you assess the waste segregation carried out in single-family buildings? (Please rate from 1 to 5, where 1 means the worst and 5 means the best).	Likert scale 1–5
2. How do you assess the waste segregation carried out in multi-family buildings? (Please rate from 1 to 5, where 1 means the worst and 5 means the best).	Likert scale 1–5
3. In which types of buildings or estates is the correctness of the segregation the best? (Please rate from 1 to 5, where 1 is the worst and 5 is the best).	Likert scale 1–5
4. What are the irregularities in the segregation of waste in the municipality of Krakow? (Please rate from 1 to 5, where 1 means the worst and 5 means the best).	Likert scale 1–5
5. Are the bins for different waste fractions color-coded correctly? (Please rate from 1 to 5, where 1 is the worst and 5 is the best).	Likert scale 1–5
6. Which of the listed waste fractions are most often segregated in the wrong way? (Please rate from 1 to 5, where 1 is the worst and 5 is the best).	Likert scale 1–5
7. Should there be inspections of the correctness of the municipal waste segregation by residents and companies?	Answers: Yes, No, I do not know

The surveyed employees of MPO Sp. z o.o. in Krakow answered all of the questions that were posed in the survey. The questions in the survey were consulted with one of the employees of MPO in Krakow. The results of the surveys were presented in the form of bar graphs in relation to the individual survey questions. In the Results chapter, Figures 3–9 present the respondents' answers to the questions in Table 2. Note that the charts presented in Figures 3–9 express individual levels of the Likert scale with different colors and the numbers above the individual columns express the number of people choosing a given level of the Likert scale. The lowest level of the Likert scale corresponds to the worst rating, and the highest level corresponds to the best rating.

4. RESULTS

Below are the numbers of the responses to the questions in Table 2.

1. How do you assess the waste segregation carried out in single-family buildings?

Figure 3 shows that the vast majority of the respondents assessed that the segregation of waste of all fractions in single-family houses is carried out in a very good or good way (5 and 4 ratings). This may be due to the fact that the inhabitants of single-family houses have individual rubbish bins located on the premises to which only the inhabitants of the house have access, and the waste producers can be easily identified.

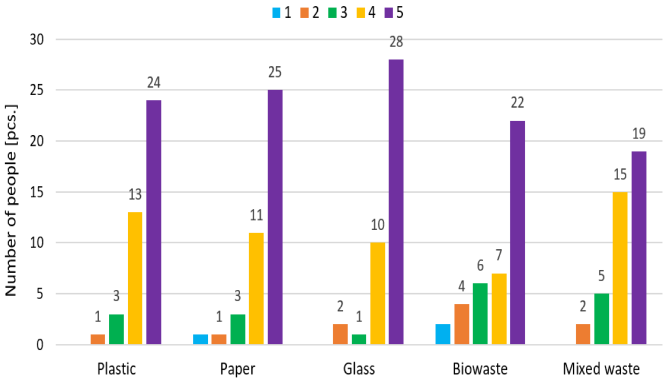

Fig. 3. *Evaluation of effectiveness of waste segregation in single-family buildings – Question No. 1*

2. How do you assess the waste segregation carried out in multi-family buildings?

As shown in Figure 4, the answers of the respondents to this question differed significantly from the answers to Question 1.

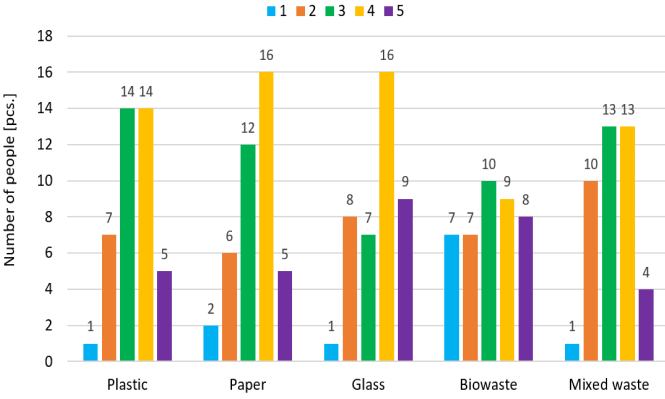

Fig. 4. *Evaluation of effectiveness of waste segregation in multi-family buildings – Question No. 2*

Most of the respondents assessed that there were mistakes in the segregation of fractions of plastic, paper, glass and mixed waste (scores 3 and 4). The segregation of biodegradable waste was rated the worst (scores 1, 2, and 3). In multi-family houses, residents throw waste into containers that are located in common rubbish bins, where there is no possibility to control the correctness of the segregation. Other problems are the insufficient number of containers for individual waste fractions, the poor lighting of rubbish bin shelters, dirt, insects, and odors. These factors may make residents reluctant to segregate waste and want to throw waste into containers as soon as possible in order to have the briefest-possible contact with the inconvenience.

3. In which types of buildings or estates is the correctness of the segregation the best?

As shown on Figure 5, three-quarters of the respondents assessed that the most correct waste segregation (score 5) was in single-family houses. This rating was due to the fact that homeowners personally declare whether they will segregate waste or not as well as the number of residents. On this occasion, they received materials informing them about proper segregation. In the case of single-family houses, it is also possible to determine the responsibility for poor segregation. The correctness of waste segregation in closed housing estates was assessed by ¾ of the respondents as medium (3 and 4 ratings). In such housing estates, containers for segregated waste are located in closed garbage shelters, and only residents have access to them. Segregation was rated the worst in non-gated housing estates, where the rubbish shelters are open and the containers for segregated waste (e.g., bell-type) are placed next to the rubbish sheds. For these reasons, various types of waste can be thrown into them by random people.

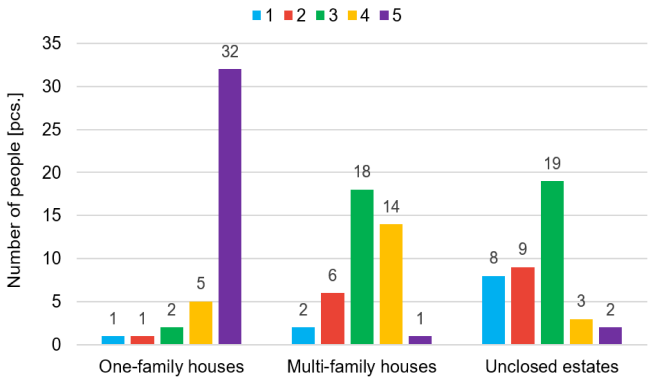

Fig. 5. *Evaluation of effectiveness of waste segregation in multi-family buildings – Question No. 3*

4. What are the irregularities in the segregation of waste in the municipality of Krakow?

Figure 6 shows that the respondents assessed that the biggest problem was throwing away biodegradable waste together with bags for this waste, throwing waste into

bags for other waste fractions, and throwing dirty non-segregated packaging into the wrong containers. Contamination of the waste fraction results in additional costs that are related to the preparation for their management. The smallest irregularities concerned poorly tied bags for segregated waste and damaged bags for segregated waste.

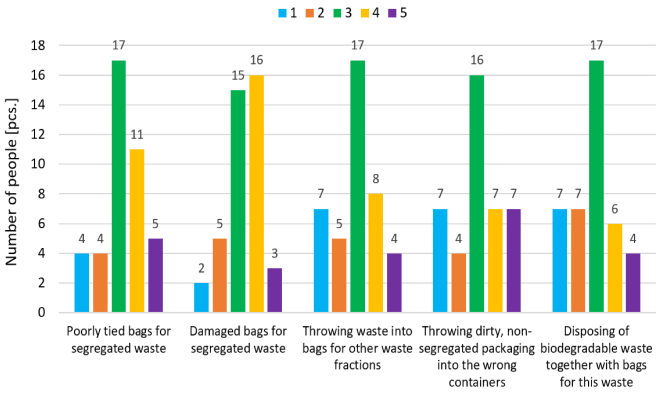

Fig. 6. *Evaluation of effectiveness of waste segregation in multi-family buildings – Question No. 4*

5. Are the bins for different waste fractions color-coded correctly?

Figure 7 shows that almost three-quarters of the respondents believed that the containers for plastic and metal, paper, glass, and mixed waste were properly labeled.

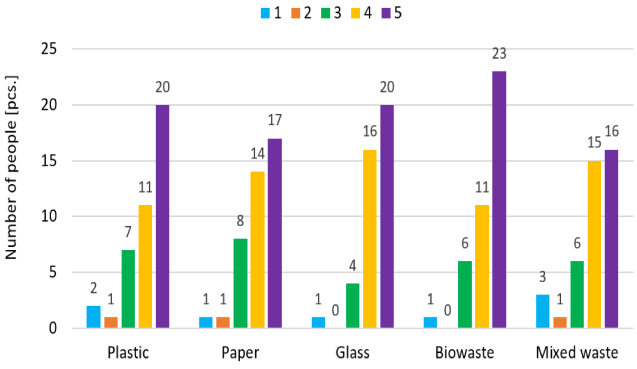

Fig. 7. *Evaluation of effectiveness of waste segregation in multi-family buildings – Question No. 5*

The labeling of containers for biodegradable waste was rated even better (grades 4 and 5), as is shown in Figure 7. Since July 1, 2017, the Uniform Waste-segregation System (*Obwieszczenie Marszałka...*, 2022) has been implemented throughout the

country; according to this, waste fractions have been collected in bags that are marked with the appropriate colors.

6. Which of the listed waste fractions are most often segregated in the wrong way?

Figure 8 shows that the sorting of biodegradable waste received the worst scores (scores 1 and 2). This may be due to the fact that, although the containers for biodegradable and mixed waste have the correct colors (brown and black), they are difficult to distinguish in poorly lit rubbish sheds. This was confirmed by the assessment the of mixed-waste segregation. It was assessed that the least irregularities were among the plastic and metal, paper, and glass fractions, which have distinctive colors (yellow, blue, and green, respectively). These colors have been assigned to these waste fractions since the introduction of the new regulations (i.e., since 2013), and the obligation to segregate biodegradable waste came into effect only on July 1, 2017 (*Obwieszczenie Marszałka...*, 2022)

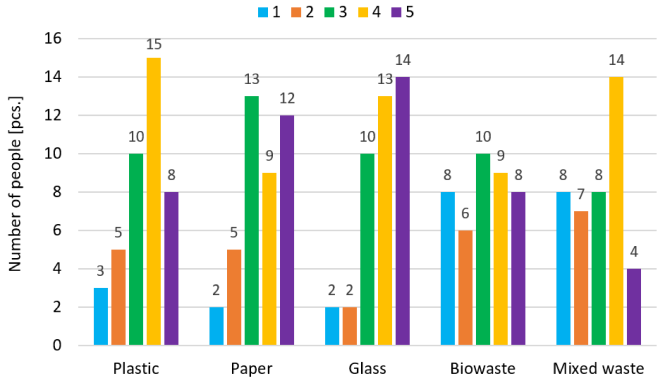

Fig. 8. *Evaluation of effectiveness of waste segregation in multi-family buildings – Question No. 6*

7. Should there be inspections of the correctness of municipal waste segregation by residents and companies?

Figure 9 shows that the majority of the respondents (68%) considered it necessary, while only 10% were against it. This might be a tool that could improve the level of preparation for the reuse and recycling of municipal waste (*Calculation of the level of preparation and recycling of municipal waste*, 2023). The greatest effectiveness of such activities would be among those people who live in single-family houses and have individual dumpster sheds, as penalties for incorrect sorting would be imposed on specific households. Inspections that are carried out in common waste containers that are located in housing estates could result in penalties being imposed on all of the waste producers from a given building. There would have to be an awareness of collective responsibility; unfortunately, this is a problem.

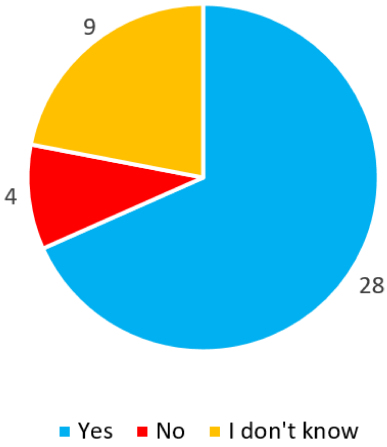

Fig. 9. *Evaluation of effectiveness of waste segregation in multi-family buildings – Question No. 7*

5. DISCUSSION

The European Union undertakes a number of initiatives in the field of changes in the area of waste management, obliging member states to improve their waste-management systems. These concern fulfilling the objectives of the circular economy, which will result in lower gas and dust emissions as well as climate neutrality (Kulczycka, 2018); this will help meet the EU's environmental objectives. Based on the principles of sustainable development, the adopted policies and objectives of the EU require the implementation of regulations on a macro scale (i.e., at the institutional level) as well as at the regional and local levels (i.e., in EU countries [https://sdgs.un.org/goals]). Therefore, it is important to organize, administer, and implement municipal waste-management plans and create integrated waste-management systems while respecting local development strategies.

The development strategy for Krakow through 2030 that was developed in accordance with the smart city concept takes the concept of a smart environment into account regarding the modernization and expansion of municipal infrastructure, including the development of the infrastructure of a comprehensive municipal waste-management system (Gorzelany and Lorek, 2018; *Kraków przyszłości*, 2023). Despite the adopted system assumptions, there are still problems being reported by waste producers and their recipients; these have been presented in this analysis and in the survey that was conducted among the employees of MPO in Krakow. Solving the problems that are related to segregation is a complex issue that should be addressed to all of the participants in the waste-management system. Therefore, informing about the functioning of the waste-management system should be an important part of the activities of those departments that are responsible for waste management (Kowalska et al., 2020). Also, educating society in the field of waste reduction, the selective collection

of recyclable materials, or creating a "fashion" for more durable and environmentally friendly products can significantly contribute to changing such consumer behavior and activating the society to participate in activities that are aimed at improving waste management. A necessary condition is to provide appropriate a "participant-friendly" technical infrastructure; i.e., one that is properly located and facilitates waste segregation (*Poradnik...*, 2002). This applies not only to waste-collection sites but also to the entire spatial order, which takes the needs of waste management into account. Creating such an order is a task for architects who design new roads, housing estates, and buildings (Szewczyk & Chrobak, 2021).

6. CONCLUSIONS

Waste management in Krakow is carried out in accordance with the guidelines that have been set for EU member states and in accordance with the principle of sustainable development. This is aimed at reducing the amount of unsorted waste in favor of sorted waste that is subject to recycling. The actions that have been taken include covering all of the residents of Krakow with the waste-collection system at the point of waste generation and enabling the segregation of municipal waste in single-family and multi-family houses. As part of the actions that are taken, municipal waste-recycling levels are reached every year, and the Municipal Cleaning Company LLC helped to achieve it.

A survey was carried out among MPO employees, which made it possible to evaluate the system from the point of view of the waste-collection company. The conducted analysis showed the scale of the problem of waste management in Krakow. The most difficult situation is in the housing estates of multi-family houses, where, there is often no space to set up the number of containers that are required by law due to too-small rubbish sheds. The consequence of this is throwing waste into the wrong containers, which promotes the development of pathogens and attracts rodents. According to the employees of Krakow MPO who collect the waste in these housing estates, the worst situation concerns the segregation of biodegradable waste. One of the reasons may be the similar colors of the mixed waste (black) and biodegradable (brown) containers. A change of colors should be considered, which would improve their recognition in poorly lit rubbish sheds. Designers of new housing estates should take waste-management regulations into account and design garbage sheds or other waste-collection sites so that residents can segregate their waste products properly.

The basis for the operation of each system is control; therefore, those employees that collect waste should have the right to control the correctness of the waste segregation and report any irregularities to the municipal services. This possibility should be considered and combined with a system of possible financial penalties.

The topic of improving waste management is current and important; this is why the authors will develop it in further research. Improving waste separation is key to achieving the better recycling levels that have been imposed by the European Union. The continuation of the research will cover issues that are related to the fraction of biodegradable waste and an analysis of the possibility of increasing their recycling levels in communes.

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