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THE SHARE OF IMPURITIES IN SELECTIVELY COLLECTED WASTE IN ONE- AND MULTI-SACK SYSTEMS

UDZIAŁ ZANIECZYSZCZEŃ W ODPADACH ZBIERANYCH SELEKTYWNIE W JEDNO- I WIELOWORKOWYM SYSTEMIE

Abstract: According to the legal requirements of the European Union in the field of waste management, as much as possible of municipal waste should be sent for recycling. In order to meet the EU requirements, it is necessary to segregate the waste by the inhabitants in households. The share of waste (such as paper, glass, metal and plastics) prepared for re-use and / or recycling should be at least 50 % by 2020 and 70 % by 2030 in relation to the mass of collected waste in those years. The main objective of the work is to analyse the share of impurities and to the evaluation of cleanliness of selectively collected waste. In many Polish municipalities a compulsory 5-bags (container) waste collection system has been implemented, divided into 5 different factions. The research problem of this work is to compare the one- and multi-sack systems of collecting paper, metal and glass. The research was carried out at MIKI Recykling company in Krakow. The waste for analysis came from the following community: Skawina and Liszki, where the waste was collected selectively in to 3 sacks for 3 different fractions and from the Zabierzow commune, in which selective wastes were collected into one sack. The analysis of the test results allowed to state that the share of impurities present in selectively collected wastes in the multi-sacks system is from 6.4 ± 1.4 % to 7.7 ± 1.1 %, while in the one-sack system 17.0 ± 5.2 %. In the municipalities of Skawina and Liszki, sacks with paper and sacks with glass and metals were characterized by high purity of segregation. The most common contaminants were organic waste, non-recyclable plastics and hazardous waste. In waste from the Zabierzow commune, mainly organic waste was the pollution. The achieved share of pollutants differentiates the analysed systems in a statistically significant manner, which allows to state that the purity of the collected fractions in a multi-sacks system is definitely higher than in a one-sack system.

Keywords: selective collection, municipal waste, impurities

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Introduction

The existence and activities of the human are related to generation of waste; this, under the directive, consists of substances and materials which the owner disposes of, intends to dispose of or is obliged to dispose of [1]. A special type of waste is the municipal one, in other words waste generated by households, except for decommissioned vehicles, and waste without hazardous waste, from other sources, which due to its character or composition is similar to waste generated by households [2]. Waste is one of the threats to the natural environment and its hazardous character mainly stems from weight, varied composition and cases of illegal management [3]. The weight and composition of generated waste is affected by many social (e.g. age structure) and economic factors, which include but are not limited to the type of settlement unit, character of the built-up area or living standards of residents [4–6]. The identification of technological properties of waste enables the proper planning and handling of waste management in a specific region [7]. The examination of properties of municipal waste in Poland is conducted mainly in large cities, such as Warsaw and Krakow, small towns and rural areas, such as Mogilany, Liszki and Zabierzow [8–11]. Similar studies have been conducted in many European countries, such as Czech Republic, Denmark, Norway, Spain and Sweden [12–17]. The amount and composition of waste is also performed taking into account the selective collection system [7, 10, 13–18]

Between 2012 and 2016, in Poland, we observed a significant increase in the quantity of municipal waste collected selectively. The increase was reported to have been the greatest in 2014, when as much as 60 % more segregated waste was collected than in 2013. The year 2014 was the first year throughout which the amendment of the act on maintaining cleanliness and order in communes was in force [3]. The Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste stipulates that by 2020 the level of the preparation of raw materials (metal, paper, plastic and glass) separated from the waste stream (all collected waste) for re-use and recycling should reach 50 % by weight [1]. In 2014 the weight of paper, metal, plastic and glass waste subject to recycling and prepared for re-use exceeded 1 million Mg, which gives the recycling level as high as 26 % [19].

From 1 July 2017, new rules are in place for selective waste collection [20]. The regulation specifies new state-wide uniform rules for waste segregation. Pursuant to its provisions [20], waste will be divided into five fractions:

1. Paper, including cardboard, packaging waste of paper and cardboard,
2. Glass, including glass packaging waste,
3. Metals and plastics, including metal packaging waste, plastic waste, including plastic packaging waste and packaging waste made of multiple materials,
4. Biodegradable waste with special emphasis on bio-waste,
5. Other (mixed municipal solid waste).

Aside from the fractions mentioned above, the Ministry of the Environment specifies colors of containers (or sacks) to which waste should be disposed of. Municipalities are to implement the new rules by the end of the June 2021.

To meet the EU requirements, it is necessary that residents segregate waste where it is generated (in their households). It is the most beneficial method for its collection after generation. In this manner, selective collection allows the cleanest fraction suitable for the recycling of raw materials. Although this is the most efficient waste selection method, it is also the most costly and very complicated organizationally, as it requires special means of transport equipped with compacting presses and increased number of sacks (bags) or containers in households [21, 22]. We differentiate the "at-the-source" multi-sack (multi-container) system, where residents have separate sacks for respective fractions or one-sack system, where all segregated waste is collected into one sack.

This article is related to the evaluation of cleanliness (share of impurities) and comparison of the selective waste collection in one- and multi-sack systems in 3 municipalities of Malopolska. The scope of research comprised the analysis of morphological composition of selectively collected waste with special emphasis on the share of impurities.

Material and methods

The research data was acquired from MIKI Recykling company, where municipal solid waste is treatment. During the research in the municipalities of Liszki and Skawina, waste was collected selectively in 3 sacks of various colours (blue for paper, yellow for plastic and green for glass and metal), whereas in the municipality of Zabierzów, selective waste was collected into one-sack (bag) system.

Based on the itineraries filled out by drivers collecting segregated waste from residents of the municipalities, the amount of collected sacks was tallied from each

Fig. 1. Location of research area

fraction for the period of one year. Every quarter at MIKI Recykling company, containers with segregated waste were unloaded and as many as 50 random sacks were weighed of a specific fraction for the municipalities of Liszki and Skawina each, and 50 sacks for the municipality of Zabierzow. Knowing the number of sacks and mean weight of one sack, information was acquired about the weight of each fraction, which allowed the determination of the share of each fraction in the selectively collected waste stream.

During each quarter, 10 random sacks from each fraction were selected, their morphological composition analysed according the methodology described by Jedrczak and Szpadt [23]. This analysis enabled the determination of the share of impurities, in other words a fraction of non-recyclable waste (for the municipality of Zabierzow) or fractions which were placed in a wrong sack. Sacks with plastics were divided into these fractions: PET, household chemistry, colour foil, white foil, packaging of multiple materials. The sacks and respective fractions were weighed with the platform scales as accurate as 0.05 kg.

Results

Municipality of Liszki – multi-sack system

The mean weight of the sack containing paper was 6.87 kg, glass and metal – 13.7 kg, and plastic – 2.88 kg. Table 1 presents the percentage shares of each fraction in the stream of waste collected selectively by months.

Table 1

Mass share of waste fraction selectively collected in the Liszki municipality

Month	Paper [%]	Glass and metal [%]	Plastics [%]
January	15.2	57.2	27.7
February	11.9	60.9	27.2
March	11.3	62.2	26.5
April	35.3	33.0	31.7
May	40.3	36.8	22.9
June	18.0	59.1	22.9
July	24.3	53.9	21.8
August	18.0	58.0	24.0
September	17.0	59.0	24.0
October	18.4	58.7	22.9
November	18.6	57.8	23.7
December	18.4	57.2	24.5
Mean value	20.5	54.5	25.0
Standard deviation	8.8	9.4	2.8

More than a half of the stream of waste collected selectively in the municipality of Liszki was glass and metal: 54.5 ±9.4 %. In the municipality of Liszki, sacks for paper, glass and metal practically did not contain impurities. Raw materials thus acquired

could be transported directly to a recycling plant. Sacks for plastics were divided into recyclable fractions and impurities, which made 25.6 ±4.9 % of the stream of this fraction. Malinowski et al. [11] state that the share of impurities in the stream of selectively collected plastics is 26.8 % on average, which result is almost identical to the one yielded during the research. Among plastics of commercial value, the most frequent was household chemistry packaging (35.5 %) and PET packaging (23.3 %). The rest was multi-material waste (5.8 %), colour foil (3.5 %) and white foil (2.3 %). Impurities were mainly non-recyclable plastics (PVC, PCB), hazardous waste, styrofoam and metals. The share of these impurities in the entire stream of waste collected selectively in the municipality of Liszki reached 6.4 ±1.4 % (Fig. 2).

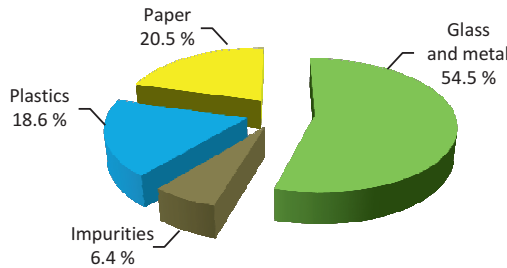

Fig. 2. Morphological composition of waste collected selectively including impurities in the municipality of Liszki

Municipality of Skawina – multi-sack system

The mean weight of sacks from the municipality of Skawina was 5.01 kg for paper, 11.21 kg for glass and metal, and 2.93 kg for plastic.

Table 2

Mass share of waste fraction selectively collected in the Skawina municipality

Month	Paper [%]	Glass and metal [%]	Plastics [%]
January	12.5	58.7	28.7
February	11.8	56.9	31.3
March	13.2	55.4	31.4
April	10.8	56.8	32.4
May	13.4	53.5	33.1
June	12.5	54.7	32.8
July	8.4	61.7	29.9
August	17.3	52.6	30.1
September	14.9	51.6	33.5
October	13.5	57.1	29.4
November	15.2	55.4	29.4
December	13.2	56.6	30.2
Mean value	13.1	55.9	31.0
Standard deviation	2.3	2.7	1.6

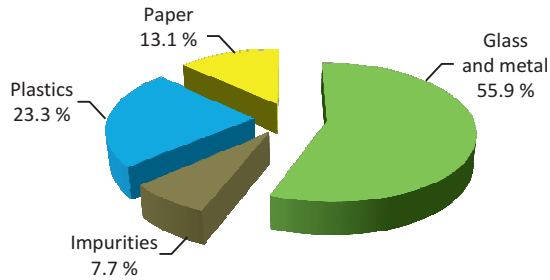

Fig. 3. Morphological composition of waste collected selectively including impurities in the municipality of Skawina

In the municipality of Skawina, the largest stream of segregated waste was glass and metal: 55.9 ± 2.7 % (Fig. 3). Similarly to the municipality of Liszki, sacks with paper, glass and metal were characterised by 100 % purity of segregation. On the other hand, the share of impurities contained in sacks with plastics contained was 24.7 ± 3.1 %; therefore, it was similar as in the municipality of Liszki and research presented by Malinowski et al. [11]. The largest group of recyclable waste was PET packaging (26.5 %). Waste of multiple materials and household chemistry were approx. 18 % each, colour foil 7.1 %, and white foil 4.7 %. Impurities found in sacks containing plastics included but were not limited to: other plastics (PVC, PCB), intimate hygiene products (nappies, etc.), hazardous waste (packaging of medicines, paints, lacquers, fluorescent lights, batteries, etc.), paper and organic waste (Fig. 4). The share of impurities in the entire stream of waste collected selectively reached 7.7 ± 1.1 %.

Fig. 4. Sack with the plastic fraction from the municipality of Skawina (to the left) and sack with the selectively collected fraction from the municipality of Zabierzow

Municipality of Zabierzow – one-sack system

In the municipality of Zabierzow, in the one-sack system, similarly to the multi-sack system, glass and metal have the greatest share in selectively collected waste (60.0 ± 9.4 %). The small share of paper (6.0 ± 4.4 %) is mainly attributable to soiling

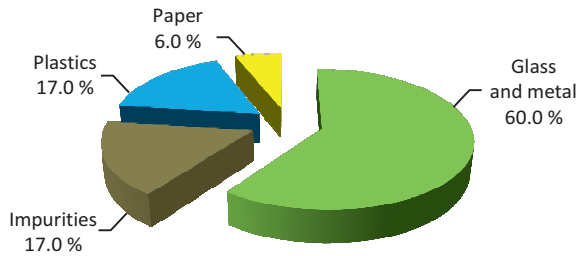

Fig. 5. Morphological composition of waste collected selectively including impurities in the municipality of Zabierzow

of this fraction with organic waste or other substances contained in sacks (Fig. 5). Only clean paper or cardboard which is not greased is recyclable. The selective collection in one sack is characterised by a high share of impurities (17.0 ± 5.2 %). They include organic waste, greased paper, packaging of medicines (Fig. 4).

Impurities found in selectively collected waste cause the further processing to be very complicated, as it requires the use of additional classification methods, for instance manual segregation in the plant collecting such waste or purchase of specialist waste classifiers. At the same time, impurities lower the efficiency of recycling. Without the contribution of society, it is not possible to meet the EU requirements for waste management.

Segregation starts in each household and, if proper, both residents, who pay less for waste disposal, and state economy benefit, as raw materials contained in waste are re-used by industry.

Conclusions

1. The share of impurities in sacks with waste from the municipalities of Liszki and Skawina, where waste was collected in the multi-sack system, was significantly lower (6.4 % and 7.7 %) than in the case of the municipality of Zabierzow, where waste was collected selectively in one sack (17.0 %). The difference between the share of impurities in the respective systems was statistically significant.

2. The most frequent impurities were organic waste, hazardous waste and plastics without any commercial value.

3. The waste collection system affects the cleanliness of segregation. The yielded shares of impurities in fractions collected selectively in the multi-sack system are definitely lower than in the case of the one-sack system.

4. Whether waste was collected selectively in the multi-sack or one-sack system, glass and metal exceeded a half of the segregation stream.

Acknowledgement

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UDZIAŁ ZANIECZYSZCZEŃ W ODPADACH ZBIERANYCH SELEKTYWNIE W JEDNO- I WIELOWORKOWYM SYSTEMIE

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Abstrakt: Zgodnie z wymaganiami Unii Europejskiej w zakresie gospodarki odpadami, jak największy odsetek odpadów komunalnych powinien być kierowany do recyklingu. Aby spełnić unijne wymagania, niezbędne jest segregowanie odpadów przez mieszkańców w miejscu ich powstawania (u źródła), a więc w gospodarstwach domowych. Udział odpadów (takich jak: papier, szkło, metal i tworzywa sztuczne) przygotowanych do ponownego wykorzystania i/lub recyklingu, powinien wynosić minimum 50% do 2020 r. i 70% w 2030 r. w stosunku do masy zebranych odpadów. Podstawowym celem pracy jest analiza udziału zanieczyszczeń znajdujących się w odpadach zbieranych selektywnie. Ponieważ w wielu polskich gminach wdrożono już obowiązkowy 5 workowy (pojemnikowy) system gromadzenia odpadów z podziałem na różne frakcje, problem badawczy tej pracy polega na porównaniu systemu jedno i wieloworkowego gromadzenia papieru, metalu, szkła i tworzyw sztucznych. Badania wykonano w firmie MIKI Recykling Sp. z o.o. w Krakowie. Odpady do analizy pochodziły z podkrakowskich gmin: Skawina i Liszki, w których odpady gromadzono selektywnie do 3 worków na 3 różne frakcje oraz z gminy Zabierzów, w której odpady selektywne zbierano do jednego worka. Analiza wyników badań pozwoliła na stwierdzenie, że udział zanieczyszczeń występujący w selektywnej zbiórce w systemie wieloworkowym wynosi od 6,4 ± 1,4% do 7,7 ± 1,1%, natomiast w systemie jednoworkowym 17,0 ± 5,2%. W gminach Skawina i Liszki worki z papierem oraz worki ze szkłem i metalami charakteryzowały się wysoką czystością segregacji. Najczęściej występującymi zanieczyszczeniami były odpady organiczne, tworzywa sztuczne nienadające się do recyklingu oraz odpady niebezpieczne (np. opakowania po lekach, farbach, lakierach, itp.). W odpadach z gminy Zabierzów zanieczyszczeniami były głównie odpady organiczne. Osiągnięty udział zanieczyszczeń różnicuje analizowane systemy w sposób statystycznie istotny, co pozwala na stwierdzenie, że czystość zbieranych frakcji w systemie wieloworkowym jest zdecydowanie większa niż w systemie jednoworkowym.

Słowa kluczowe: selektywna zbiórka, odpady komunalne, zanieczyszczenia