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Selective Bio-Waste Collection System in Gdynia from the Perspective of Residents of Multi-Family Households

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Abstract:

Purpose: *The purpose of the article is to investigate what is the reason for the insufficient amount of bio-waste collected selectively from Gdynia residents in 2020, i.e., in the first year of application of the new rules of separate collection. The research question has been formulated as follows: What problems, if any, for households are caused by the extension of the separate collection model to an additional fraction of bio-waste?*
Design/Methodology/Approach: *Several research methods were applied, literature review, data exploration method, desk research. Moreover, in 2021, a survey was conducted among multifamily households in Gdynia, in which the sample size was 235. Due to the epidemiological situation in Poland, the survey was conducted based on an online questionnaire which contained 11 questions divided into three sections: 1) general knowledge on bio-waste and the current collection model, 2) problems faced by respondents in connection with the introduction of the new model of bio-waste collection, 3) demographic questions.*
Findings: *The research clearly shows that the amount of bio-waste collected selectively in Gdynia is far from the desired. Most of the residents of Gdynia treat their new obligation regarding bio-waste selection as an additional nuisance, and their knowledge about the purpose and methods of collection is highly unsatisfactory.*
Practical Implications: *The survey findings and proposed recommendations can be used by local governments to improve collection system of bio-waste.*
Originality/Value: *So far, no research has been conducted on the problems encountered by residents in the field of separate collection of bio-waste.*

Keywords: *Bio-waste, municipal waste management, selective waste collection.*

JEL classification: *M21, L99, L83, C38.*

Paper Type: *Research article.*

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1. Introduction

Waste management is increasingly recognized as one of the most important environmental challenges around the world. Recently, special attention has been paid to municipal waste, and in particular packaging waste, as an important and growing waste stream. Their formation is favoured by the high population density and dynamic development of modern civilization, becoming a serious threat to the environment and human health (The World Bank, 2018; Gwarda, 2020).

The figures below give us a glimpse into the municipal waste generation in EU countries, with particular focus on bio-waste:

- in 2019, almost 224.5 million tonnes of municipal waste were generated in the European Union (EU-27). This equates to 502 kg per person, that constitutes a slight increase compared with 2018 (495 kg) (Eurostat database online, 2021),
- in 2018, 185,7 million tonnes of waste in the 28-EU countries came from households, being the second largest source of waste generated (excluding major mineral waste) (Eurostat database online, 2021),
- as up to 50 percent of municipal solid waste is organic, the bio-waste fraction has started to play an important role in recycling and the emerging circular economy (ECN, 2019),
- according to EEA report (EEA, 2020) bio-waste accounts for more than 34 percent of the municipal solid waste generated, amounting to 86 million tonnes in 2017 in the EU-28,
- ECN states that it is somewhere between 118 and 138 million tons of bio-waste that arise annually (ECN, 2019).

It is therefore not surprising that the environmentally friendly management of municipal waste and the use of its secondary raw materials has been an important element of the EU's environmental policy for many years. Recently, particular attention has been paid to the bio-waste as equally important fraction for recycling as other waste. Hence a number of EU legal instruments address the issue of treatment of bio-waste.

The EU Waste Framework Directive (WFD) (EU, 2008), define bio-waste as "biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants" (Art. 3 item 4). Revised in 2018 WFD, so called the New WFD (EU, 2018), which is included in the Circular Economy Package 2019 (EC, 2015), mandates the introduction of separate collection of bio-waste on the EU level by the end of December 2023. Updated art. 22 of the New WFD impose an obligation to all Member States to implement collection of bio-waste, which should be either

separated and recycled at source or collected separately without being mixed with other types of waste.

One of the reasons for the introduction of the new regulations (on bio-waste management) was the threat to the environment from bio-waste (and other biodegradable waste) in the form of methane production from such waste decomposed in landfills, which accounted for approx. 3 percent of total GHG emissions in the EU-15 in 1995 (EC, 2008; EU, 2008). Unfortunately, most of the municipal waste generated in Europe is still disposed of through landfilling (24 percent in 2019) or incineration (27 percent in 2019). Only a third of waste was recycled (30 percent) and 17 percent composted (Eurostat database online, 2021).

Efforts to redirect bio-waste from landfilling to other treatment options (composting or anaerobic digestion) as well as collecting bio-waste separately from other municipal waste can bring both environmental and economic benefits. First, it is the avoidance of GHG emissions, especially methane. Secondly, it can prevent cross-contamination of waste streams, that increase the potential of using them as a close-loop secondary resource. Thirdly, which must not be forgotten, separate collection and recycling of bio-waste also contributes to the reduction of food waste, which accounts for almost 60 percent of all bio-waste from households and similar sources (Wojciechowska-Solis *et al.,* 2020).

There are numerous examples of how bio-waste can be reused, ranging from the simples and well-known to the more complex, often under research and development. These include, for example, using bio-waste:

- as a valuable secondary resource for compost production for soil fertilizing purposes,
- for composite materials production; additionally, they can react with other additives and chemicals, which in turn gives materials desired characteristics (Fayomi *et al.,* 2020),
- to provide flexible electricity to a wind and solar powered cities (van Leeuweet *et al.,* 2021),
- to biogas production, which is produce in an anaerobic digestion plants; biogas can be upgraded to biomethane and used for transportation (Pavlas *et al.,* 2019),
- in waste-to-energy process, e.g. converted in anaerobic digestion into energy vectors as bio-oil, syngas, and char via a novel Thermo-Catalytic Reforming process (Neumann *et al.,* 2016; Ouadi *et al.,* 2019).

Recycling bio-waste is therefore crucial for meeting the EU target to recycle 65 percent of municipal waste by 2035, as well as food reduction target of 30 percent by 2025 and 50 percent by 2030.

2. Selective Bio-Waste Collection System in Gdynia

The level of separate collection of bio-waste varies considerably between countries in Europe. Many of them are far from fully exploiting the potential of bio-waste, possibly because implementing a separate bio-waste collection system is usually a long and complex process, and this is also the case of Poland. Since 2014, Poland has started activities related to the circular economy in various areas of economic activity, including the municipal waste management system (Smol, 2018). The latter has undergone a huge transformation in recent years due to the adaptation of Polish regulations to EU law. The legal framework for development of the municipal waste management system in Poland is very complex, however two acts are of particular importance: The Act on waste (Act of 14 December 2012, 2021) and the Act on the maintaining cleanliness and order in municipalities (Act of 13 September 1996, 2021), with many changes and amendments to both, that have taken place over the years. They enable to transform the municipal waste management system into an individual branch of the economy focused on environmental protection (Smol et al., 2020).

As far as selective collection of waste is concerned, the remarkable changes were introduced by the the Regulation of the Minister for the Environment of 29 December 2016 (Ministry of Environment, 2017). It introduced in Poland the so-called a common system of waste segregation, specifying a uniform, nationwide division of municipal waste generated, which was to be implemented throughout Poland by June 30, 2021, at the latest. This meant that individual cities and communes could successively accede to this system, in line with the deadlines for concluding new agreements for collection and management of municipal waste. However, in the meantime, in 2019 the new amendments to 'The act on maintaining cleanliness' (Act of 13 September 1996, 2021) introduced several extremely significant changes affecting the system of municipal waste management. Pursuant to the new regulations, in addition to glass, paper, plastics and metals, from January 1, 2020, property owners have also been obliged to selectively collect biodegradable waste[3].

The selective bio-waste collection system can be a big challenge, especially for large urban agglomerations, such as e.g., the City of Gdynia, which is a part of Tri-city metropolis. Additionally, from 16 July 2020, no more than 35 percent of bio-waste will be allowed to landfill. If the communes do not achieve these indicators, they will face financial penalties, which will be transferred to the inhabitants as a result. Therefore, it is so crucial for both, municipality, and inhabitants, to collect them properly.

[3]*Due to COVID-19 pandemic this regulation entered into force a year later.*

In 2020, the inhabitants of Gdynia generated about 116,845 tonnes of municipal waste, i.e., over 16 percent more than two years earlier. Until 2019, the share of separately collected waste grew year by year, but at an unsatisfactory pace. Only in 2020 there was a breakthrough, which brought a record increase by as much as 46 percent compared to the previous year. Thus, the amount of mixed waste generated also significantly decreased (a decrease by over 29 percent compared to 2019, with almost the same amount of all waste generated in the commune) (City of Gdynia, 2021). Among the separately collected waste, the bio-waste fraction appeared for the first time, from which 6810 tonnes were collected (City of Gdynia, 2021). Together with the waste from gardens, parks, etc. (5189 tons), it accounted for only 10.27 percent of the total collected waste, which is much less than the above-mentioned 34 percent in the result for the EU.

It should be noted that in Poland, depending on the municipality, bio-waste is defined differently, and this depends on whether there is a biogas plant in the commune or not. If a biogas plant is available, residents are allowed to throw leftover meat and bones into bio-waste bins. Otherwise, and this is the case in the City of Gdynia (i.e., only composting is available), it is not allowed, as it would prevent further composting.

Having in mind the above considerations and the presented data, it is worth investigating what is the reason for the insufficient amount of bio-waste collected selectively from Gdynia residents in 2020, i.e., in the first year of application of the new rules of separate collection, and this is the main purpose of the paper. Therefore, the research question has been formulated as follows: What problems, if any, for households are caused by the extension of the separate collection model to an additional fraction of bio-waste?

3. Study Design and Results

3.1 Questionnaire Survey

To achieve the purpose of the article and answer the research questions, a desk research study was conducted to gain a broad understanding of the researched field. The data used in this analysis come from a 2021 questionnaire survey of multi-family households in Gdynia. The study was limited to multi-family housing, which dominates in urban housing. Total number of multi-family buildings (over 4 premises) at the end of 2020 in Gdynia was 107 835 thousand (City of Gdynia, 2021). In this study, the sample size was 235 during the survey process. Due to the epidemiological situation in Poland, the survey was conducted on the basis of an online questionnaire which contained 11 questions divided into three sections.

As social knowledge is one of the most important indicators influencing environmental awareness (Lee *et al.*, 2017), the first section includes questions about

general knowledge on bio-waste and the current collection model. In the second part, particular emphasis is placed on identifying the problems faced by respondents in connection with the introduction of the new model of bio-waste collection. The last part of the questionnaire covered the demographic data of the respondents including age, gender, material status, education level. The survey questionnaire was prepared on the basis of literature analysis, experience from other cities, and conversations with residents and local-government employees as well as with companies responsible for waste management. The results of the study are part of a larger project whose goal is to develop the scope of measures necessary for ensuring the integrated management of municipal waste in Gdynia in a manner consistent with the concept of a zero-waste city.

3.2 General Knowledge on Bio-Waste and the Current Collection Model

The results of the study clearly show that the level of knowledge of respondents about bio-waste is insufficient to properly meet the objectives of the new collection system (Table 1). The respondents themselves (44.7 percent) notice that they do not know what the purpose is of introducing mandatory segregation of the next waste fraction. Moreover, only 15 percent of the answers correctly classified what bio-waste is. A significant group of respondents does not know that bones, dairy products, and flower soil are not included in this faction. Another problem is the way bio-waste is placed in household rubbish bins. According to the regulations of the city of Gdynia, biodegradable waste can be disposed of only in compostable and paper bags. Unfortunately, in as much as 47 percent of answers the method of waste disposal was indicated incorrectly (contrary to the correct 4 percent), and in about 9 percent of answers, the respondents confessed to the lack of knowledge of this matter. This situation may result from the lack of a comprehensive information campaign in Gdynia. The leaflets and stickers on the dumpster shelters that appeared at the beginning of 2020 did not bring the intended results. In addition, the city portal devoted to municipal waste collection lacks, inter alia, information on what to throw away as bio-waste.

Table 1. *The basic information of the surveyed households.*

Questions	**Answer**	**Proportion of respondents/answers (%)**					
		1	2	3	4	5	6
Last year, the obligation to segregate bio-waste in multi-family housing was introduced. Do you know why?	(1) yes (2) partly (3) no	24.2	31.1	44.7			
Indicate from the list which waste, according to Polish regulations, is classified as bio-waste (i.e. which you should throw into a separate container for this waste)*.	(1) dairy (2) animal bones (3) egg shells (4) flower soil	23.3	21.8	15.1	39.8		
According to the regulations of	(1) plastic bags	12	20.6	23.7	27.4	7.4	8.9

the city of Gdynia, bio-waste can be disposed of in...*	(2) compostable bags (3) paper bag (4) biodegradable bag (5) in bulk (6) I do not know
***multiple choice question**	

Source: *Own elaboration.*

3.3 Attitudes and Behaviours of Respondents

The experience of other countries shows that proper segregation of bio-waste at source should be the first step to obtaining better results in its subsequent treatment (Zero Waste Europe, 2019). Therefore, some of the survey questions were aimed at obtaining information on how the respondents deal with this fraction of waste in their households and what difficulties they would encounter while doing it in the right way. The survey data revealed a negative attitude of respondents towards the segregation of bio-waste, as shown in Table 2, and allowed the identification of a number of problems.

Table 2. *Attitudes and behaviours of respondents*

Questions	**Answer**	**Proportion of respondents/answers (%)**						
		1	2	3	4	5	6	7
Do you sort the bio-waste fraction according to the recommendations?	(1) yes (2) partly (3) no	22.1	41.7	36.2				
What do you always do with bio-waste in your household?	(1) I throw waste into a designated, separate container. (2) I put the waste in the mixed waste container. (3) I throw them into the composter.	4.7	94.4	0.9				
What is the reason why you do not separate bio-waste into separate, dedicated bin?*	(1) I do not know what waste should be classified as bio. (2) I have no space in the apartment for an additional waste container. (3) I do not have a separate bio-waste container. (4) I cannot stand the odor nuisance associated with keeping bio-waste. (5) I am not going to buy extra bags, because I still pay a lot to collect them. (6) I do not see the purpose of such actions (I do not	4	23	11.2	23.8	18.4	11	8.6

	believe that this waste will be properly used). (7) other (please specify)

* a multiple choice question for people who answered 2 in the previous question

Source: *Own elaboration.*

When analyzing the above results, it may be worrying, that only 22 percent of respondents believe that they segregate bio-waste in accordance with the regulations. However, the next question shows a certain contradiction, as only about 5 percent of them always put bio-waste into a dedicated container. It means, that the respondents did not quite honestly fill in the questionnaire. Unfortunately, the most frequently method of choice is to put bio-waste in a mixed waste container (94 percent), which is also confirmed by Gdynia statistics according to which the bio fraction collected selectively constitutes only 9.5 percent of all collected waste. Another question was addressed only to people who do not comply with the obligation to segregate bio-waste. They have they been asked to indicate the reason for non-compliance. The most frequently indicated reasons were the lack of space for another container in the apartment (23 percent), an unpleasant smell (23.8 percent) and the need to purchase dedicated bags (biodegradable or paper ones) 18.4 percent.

The respondents also had the opportunity to indicate their personal reasons for not segregating, of which they listed, for example:

- I do not want to segregate additional fraction of waste (2.4 percent),
- I am too far from collective waste containers (bin shelter) (2 percent),
- bio-waste bags are difficult to access (1.8 percent),
- I live according to the principle of zero waste concept and do not generate waste (0.6 percent).

In the last question in this section (open-ended), respondents were asked to indicate what would encourage them to properly collect bio-waste. 9,4 percent did not answer, and the most frequently mentioned ideas include:

- financial penalties for communities, cooperatives, groups of residents (26 percent),
- information on what bio-waste is processed for (23.8 percent),
- educational workshops on how to make a composter on a balcony or apartment (1.3 percent),
- free compostable bio-waste bags or containers (39.6 percent).

The collected data is a valuable hint for decision-makers responsible for municipal waste management in Gdynia.

3.4 The Socioeconomic Characteristics of the Respondents

Table 3 reports the descriptive statistics for the main socioeconomic characteristics of the respondents. Comparing with the Gdynia census data on the characteristics of

the Gdynia population as a whole, the survey data was found to be close to the Gdynia average age (44.4 years). The mean age of the respondents was 40.22 years. 56.22 percent of respondents were female (52.9 percent average in Gdynia) and the average educational level was master or above. The average income level was around 2325.53 zł/month. The surveyed group reflects the current socioeconomic structure of Gdynia inhabitants.

Table 3. *The basic information of the surveyed households.*

Basic information	Group	Population	Proportion of total (%)	Sample average
Age	18-24	63	26.8	
	25-34	42	17.9	
	35-44	41	17.4	40.22
	45-54	25	10.6	
	55-64	34	14.5	
	≥60	30	12.8	
Gender	Female	132	56.2	
	Male	103	43.8	
Income (zł/month)	<1000	44	18.7	
	1001-2000	56	23.8	
	2001-3000	66	28.1	2325.53
	3001-4000	35	14.9	
	≥ 4001	34	14.5	
Education	None or primary school	55	23.4	
	Middle school	73	31.1	
	Master or above	107	45.5	

Source: *Own elaboration.*

4. Conclusions

Recycling of bio-waste makes a valuable contribution to conserving natural resources, improving soil fertility, preventing climate change, and these are the top priorities for the future. Efforts to redirect bio-waste from landfilling to other treatment options can also bring economic benefits (production of bio-gas, electricity, bio-oil or char). Therefore, the effective separate collection of bio-waste should be one of the most important actions governments/local authorities can take to improve the segregation and collection of waste overall. And the role of inhabitants seems to be crucial in that case. That is why it becomes so important to make them aware that the role of selective bio-waste collection is crucial in achieving the goals of the circular economy.

The research clearly shows that the amount of bio-waste collected selectively in Gdynia is far from the desired. Majority of the residents of Gdynia treat their new obligation regarding bio-waste selection as an additional nuisance, and their knowledge about the purpose and methods of collection is highly unsatisfactory. In fact, the city did not inform its inhabitants about the rationale for the need to

separate the new fraction of waste. Such information is also not available on the city's website, except the laconic statement that "The result, with the diligent approach of the residents to the selective collection of bio-waste, will be their proper management".

Therefore, for this system run effectively, some recommendations can be discussed, which include (but are not limited to):

- better and repetitive information campaign (e.g., billboards, leaflets put in mailboxes, article in press etc.),
- comprehensive and consistent information on the governmental/local authorities' websites,
- in multi-family housing, modern solutions can be used, as e.g. equipping containers with user identification technology, which allows for linking citizens with waste generation. Controlled access of users to the container stimulates proper segregation,
- the city could consider whether, following the example of neighbouring municipalities, it should distribute bio-waste bags to the inhabitants.

Perhaps these measures would increase the amount of selectively collected bio-waste and the quality of this fraction, despite the obvious inconvenience indicated by the inhabitants (a lack of adequate space in households, odor nuisance). If not, at a later stage, the city should consider imposing penalties for those who disregard the rules. Another solution may be also the introduction of a fee system based on the principle of 'pay as you throw' (PAYT).

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