IMPROVEMENTS IN THE MUNICIPAL WASTE MANAGEMENT PROCESS: THE CASE OF WODZISŁAW ŚLĄSKI

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Introduction/background: The problem of municipal waste management is an increasingly popular topic. The overproduction of waste is dangerous for human health, but also for the whole environment. For this reason, the coordination of the municipal waste management process is important for the general public, but at the same time it is not an easy process and involves many organisational and social challenges.
Aim of the paper: The aim of the paper is to identify problems occurring in the process of municipal waste management together with a proposal for improvement measures.
Materials and methods: The paper was prepared on the basis of a critical review of the literature and an interview conducted with 9 employees of the Town Office in Wodzisław Śląski. The article was created on the basis of the diploma thesis.
Results and conclusions: As a result, the issues of municipal waste management were described, the process of municipal waste management in the municipality of Wodzisław Śląski was characterised, disturbances in the process were detected and improvements correcting the occurring errors were proposed.

Keywords: city logistics, municipal waste, municipal waste management, waste management system, Ishikawa diagram.

1. Introduction

Waste management is a major challenge in the modern world (Elsaid and Aghezzaf, 2015; Sukholthaman and Shirahada, 2015). The increasing amount of waste generated is a nuisance and sometimes dangerous to the environment as well as human health and life. Indeed, poorly managed wastes have a significant impact on the environment, directly threatening the soil, surface and groundwater, and air (Matczak, 2000; Sienkiewicz-Małyjurek and Niczyporuk, 2010). They constitute a socio-ecological problem. Moreover, despite the development of technologies related to the management and use of waste, which has been noticeable in recent

years, or the increase in social awareness, problems in this area still arise (Bautista and Pereira, 2006). Every human activity is associated with the generation of waste (Zdonek, 2021; Jonek-Kowalska and Kaźmierczak, 2020).

According to the Waste Act, the main entity responsible for the waste management process is the municipal government. Therefore, it is recommended that initiatives in this area be context-specific and implemented first at the local level. Furthermore, the socio-ecological importance of the waste management process and the problems involved make it a research area that requires deep and intensive exploration (Chodyński, 2021; Ryszko, 2020; Baran et al., 2017). These premises were the reason for undertaking research on waste management, which was carried out in one of the municipalities of the Silesian Voivodeship – Wodzisław Śląski. The main objective was to identify problems in the process of municipal waste management and to propose actions to improve it. The article was created on the basis of the diploma thesis.

2. Theoretical basis of municipal waste management

Municipal waste management is defined as "the collection, transport and treatment of waste, including the supervision of such activities, as well as the subsequent handling of waste disposal sites and activities performed as a waste dealer or broker". It is an organisationally complex process due to the participation of the municipality, residents and the company responsible for waste management (Bautista and Pereira, 2006; Elsaid and Aghezzaf, 2015). The tasks related to the waste management process are regulated, among others, in the European Union Treaties (Rosik-Dulewska, 2016), the Law of 14 December 2012 on waste and the Law of 13 September 1996 on maintaining cleanliness and order in municipalities.

The bodies responsible for waste management in the territory of each commune are communal offices. It is the responsibility of each commune council to set the principles of maintaining cleanliness and order in the territory of the commune by way of a resolution, while the tasks of the commune office include signing contracts with the company responsible for waste management, selected pursuant to the Public Procurement Act, collecting fees for waste management, which may vary with respect to the method of their calculation for each commune and organisation of the entire process of municipal waste management. The principles of operation of the system in the territory of a given commune are described in the regulations created by the commune council. The company, on the other hand, collects, transports and manages municipal waste under the contract signed with the commune office.

The phases of the waste management process can be divided as follows: prevention of new waste generation, collection, preparation for reuse, recycling, other recovery processes, and neutralisation (Law of 14 December 2012 on waste). The waste collection takes place before its transport to treatment sites. It includes pre-sorting that does not substantially change

the nature and composition of the waste and does not reclassify it and its temporary storage (Law of 14 December 2012 on waste – 3.34). Collection and preparation of waste for transport is the property owner's responsibility. The task is usually fully or partially taken over by the commune as part of the municipal waste collection service. In the next phase, there are two ways of collecting waste from the place where it is generated: collection "at the curb" (mainly used in dispersed multi-family housing), collection directly from the collecting place (e.g. from the property or dumpster). The selected company responsible for waste management in the commune is responsible for the transport of waste from the place of its collection to the place of its processing. The frequency of transport depends, among others, on the population density of the area and the activities carried out there. Recycling and other forms of recovery are forms of waste management that should be considered first. As a result of the recovery, wastes replace other materials. Primary and secondary segregation are processes that help obtain secondary raw materials for recovery. If wastes cannot be recovered for technological or organisational reasons, they are stored. Recycling is a recovery in which waste is reprocessed into products, materials or substances used for their original purpose or other purposes. Recycling waste means reusing it as a raw material to create new items or energy. On the other hand, neutralisation means reducing or eliminating the harmfulness of wastes to the environment through its transformation into biological, physical or chemical processes. The methods of management and neutralisation are divided into mechanical and biological processing applicable to organic waste (e.g. composting of waste, anaerobic digestion) and thermal processing (e.g. incineration, gasification, pyrolysis, fuel production) (Czyżyk, 2012). Generally, in the process of waste management, priority is given to the prevention of waste generation, followed by reuse, recycling, or other methods of recovery and disposal. The last and least desirable way to deal with waste is to landfill it (Rosik-Dulewska, 2016).

The basis for organising municipal waste management is selective collection, which is mainly the task of waste generators. Segregated waste is subjected, among others, to recycling, neutralisation and storage (Wota and Woźniak, 2006; Merkisz-Guranowska, 2010). The aim is to manage as much waste as possible, in line with the concept of a circular economy (Baran et al., 2017; Czaplicka-Kolarz and Kruczek, 2018).

3. Research methodology

In order to identify the problems occurring in the process of waste management in Wodzisław Śląski and possible improvements, all employees of the Municipal Waste Management Department of the Municipal Office in Wodzisław Śląski were interviewed in July 2021. The respondents were persons occupying the positions of inspector, sub-inspector or manager of the desk. The age range of employees is from 20 to 60 years. Their average work

experience in the field of waste management is 8.35 years – the lowest was 5 months and the highest 30 years. In addition, two persons holding inspector positions in the Tax Department, who are directly responsible for finances related to municipal waste management, were interviewed. Finally, nine interviews were conducted focusing on the following issues:

- level of waste management in the city of Wodzisław Śląski,
- problems in the waste management process by source,
- potential and planned improvements of the waste management process in the city of Wodzisław Śląski,
- barriers to the implementation of improvement actions.

The interview took the form of a conversation from which appropriate notes were taken. In order to be better prepared, the respondents were given the questions that were asked during the survey in advance.

4. Results of research carried out

4.1. Analysis of municipal waste management in Wodzisław Śląski

The process of waste management in Wodzisław Śląski begins at the Town Hall, where the list of properties covered by the municipal waste management system is updated on an ongoing basis. The list is subject to change in two cases. First of them is a situation when a property owner reports that there is no inhabitant on the property or municipal waste is not produced there (only in case of entrepreneurs). The second case concerns new properties. The staff of the office will pass this data on to the company responsible for waste collection.

The Department of Municipal Waste Management, which is part of the Department of Municipal Economy of the Town Hall of Wodzisław Śląski, controls the whole process of waste management in the town. It is responsible for signing contracts with companies responsible for collection, transport and storage of waste. The appropriate company is selected on the basis of a tender. The City Council collects a waste management fee from households and property owners where waste is produced and transfers part of the collected funds to the company responsible for waste management. The amount of the fee depends on the number of inhabitants (residential properties) or on the volume of waste produced (non-residential properties).

In Wodzisław Śląski waste is divided into mixed waste and selectively collected waste, which are divided into: packaging waste and secondary raw materials, biodegradable waste, bulky waste and dangerous waste. Waste is collected from properties according to the schedule, and additionally each resident of Wodzisław Śląski can deliver waste collected selectively directly to the Unit of Selective Collecting of Municipal Waste (USCMW). In the city, only USCMW has appropriate permits and infrastructure to manage hazardous waste.

Before starting the waste collection process, the company logs into the Database of Products and Packaging and Waste Management (DPP). This is an IT system as well as a waste database. DPP makes it possible, first of all, to verify the path of waste from its production to its final management and to collect current information about it – for example, about its transport. After logging in the Municipal Waste Transfer Card is generated together with its individual number assigned by the system. This card is, among other things, an authorisation for the driver to start transporting municipal waste and will accompany the entire process. Once all the formal aspects have been completed, the vehicle sets off from the company to the designated locations. At each of the properties, the company's employees check whether the waste has been properly collected. If they notice any irregularities, their task is to document the irregularities with a photo and to record the reason for not collecting the waste in the system using a tablet. The most common reason for irregularities is improper waste collection – mixing fractions or the presence of plastic bags in the bio waste bin. When no irregularities are found, waste is loaded into the vehicle. However, before this can happen, the employee must manually count the number of bags and containers collected, together with their capacity. The data collected is written down in a protocol.

Additionally, in the case of selectively collected waste, households receive waste bags, the number of which equals the number of bags collected. After the waste is loaded, the vehicle is driven to the municipal installation located in one of the five cities – Zabrze, Racibórz, Rybnik, Jastrzębie-Zdrój and Żory.

In a municipal installation, the vehicle must first be driven onto the overrun scales to be weighed. A computer system records the gross weight of the vehicle, which is then unloaded at a designated location. The next step is to weigh the vehicle again in order to calculate the net weight of the collected waste. After this process, a weighing slip is automatically generated and sent to the Municipal Office at the end of the month. The number of collected waste recorded on the receipt must match the number of collected waste on the Municipal Waste Transfer Card.

Next, mixed waste is sent to a landfill. In the case of waste collected from Wodzisław Śląski municipality, waste goes to one of six landfills located in Rybnik, Jastrzębie-Zdrój, Racibórz, Bytom, Lipie Śląskie and Kielcza. On the other hand, selectively collected waste goes to a sorting plant, where it is transferred to a conveyor belt. It separates sieve and subscreen fractions. The next stage is the baling of waste and delivering appropriate fractions to a recycler for reuse. In the final stage of the process, as in the case of mixed waste, the Waste Circulation Card together with weight receipts are handed over to the Municipal Office (Wodzisław Śląski Municipal Office, 2021). The framework process of municipal waste management in Wodzisław Śląski is illustrated in Figure 1.

The presented framework course of the waste management process has been designed for Wodzisław Śląski, however, due to the fact that it is based on legal acts in force throughout Poland, it may be an exemplary picture presenting the waste management system in every municipality and district in the country.

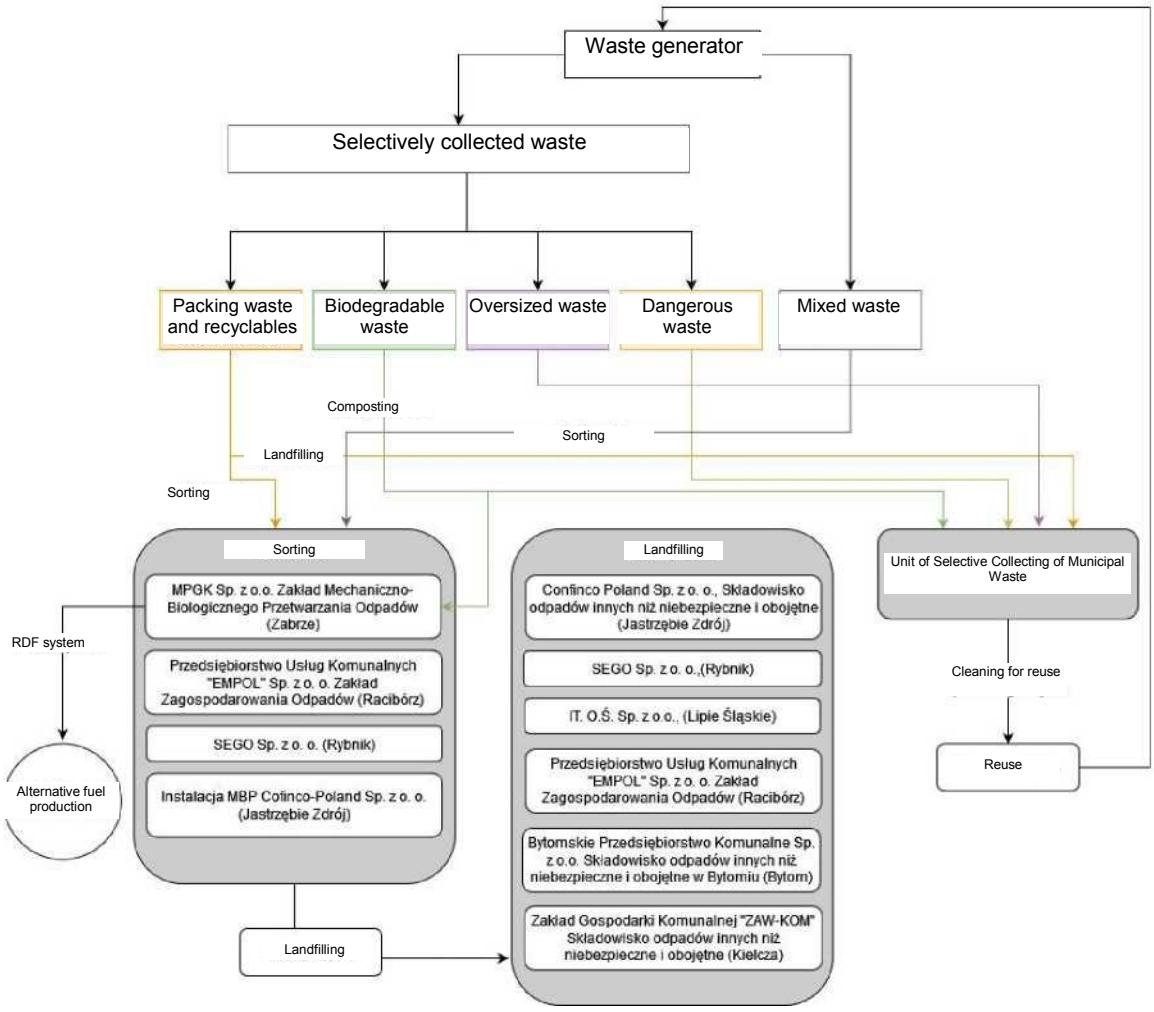

Figure 1. Framework of the waste management process in Wodzisław Śląski. Own work based on Szołtysek, J., Twarog, S. (2017) *Logistyka zwrotna. Teoria I praktyka.* Polskie Wydawnictwo Ekonomiczne, Warsaw;15. Wodzisław Śląski South Gate of Poland. Available online https://Wodzislaw-slaski.pl/miejsce-zagospodarowania-odpadow

4.2. Identification of problems in the municipal waste management process in Wodzisław Śląski

Interviews conducted with persons directly supervising the correctness of the municipal waste management process allowed to identify problems and bottlenecks in this area. Most of those respondents (88%) believe that the level of the municipal waste management process in Wodzisław Śląski is good and one person even considers it very good. Only one person is of an opposite opinion and claims that the level is insufficient. Respondents indicated also positive actions (e.g. introduction of biodegradable bags, special containers for caps from pet bottles) and mistakes (e.g. poor flow of information between the Office and the inhabitants, lack of control over wild dumps and public bins) in the process of municipal waste management. The Head of the Municipal Waste Management Department also added that any changes in the process are difficult to implement due to the legislative process. All municipal management issues must comply with the provisions of the Act of 13 September 1996 on Maintaining Cleanliness and Order in Municipalities.

Problems that originate from residents

The main problem directly attributable to city residents is poor waste segregation. It is stressed that this is mainly due to their ignorance about selective collection of municipal waste and laziness. Additionally, it has been pointed out that the inhabitants of the municipality do not observe the Rules for keeping cleanliness and order. Most of the deficiencies in the case of single-family housing concern such problems as:

- overloading of municipal waste containers,
- throwing waste into inappropriate separation bins,
- failure to close the lid of the container protecting the waste against rainwater,
- disposal of bio-waste in bags,
- lack of the required descriptions on containers and bags to identify the property from which they came.

On the other hand, in multi-apartment properties, where communal waste is collected in hubs, many irregularities are also observed. Due to the lack of possibility to identify the exact dwelling from which the waste comes, the principles of proper segregation are commonly ignored. Residents do not take care of tidiness in the hubs, leave waste in front of the hubs (e.g. when they forget the key to the shed) or leave it on the ground instead of throwing it into the container.

In addition, property owners very often fail to meet the obligation to resubmit the declaration when the number of people living on the property changes. Another negative aspect related to the declarations is the concealment of the number of people actually living on the property – underdeclaration in order to reduce the waste management fee. There are also many problems with payments, which are often made late or not made at all.

In the case of unoccupied properties where waste is generated, more bags/containers are continually put out for collection than previously declared. This is mainly due to the fact that it is impossible for entrepreneurs to estimate how much waste they actually produce.

Additionally, this number may change every month and declarations would have to be changed every month for this reason. The owners of such properties most frequently specify in the declaration the minimum number which is one 110 l container (PLN 17.46) for mixed waste and one 120 l bag (PLN 54.56) for fractions collected selectively. Moreover, entrepreneurs, as part of the fee for municipal waste management, collect non-commune waste (e.g. cardboard boxes belonging to packaging waste), which they should hand over to completely different entities on the basis of a previously signed agreement.

Problems caused by the municipal waste collection company

Another important entity involved in the waste management process is the company directly responsible for the collection, transport and management of municipal waste. The most frequent problems in the process of waste management, which are directly caused by this entity, include first of all: frequent failure to inform the Municipal Office about the inhabitants' failure

to comply with the segregation obligation or about the bad condition of waste storage containers and related problems. This constitutes a breach of the contract signed with the municipality. It is more profitable for the company to collect non-segregated waste, as the repeated arrival at the premises to collect the same (already segregated waste) is connected with repeated costs of transport, administration and depreciation charges.

In addition, the persons directly responsible for waste collection also do not comply with the rules laid down in the contract. Often there are situations when, in order to facilitate the company's employees, they enter the property from which waste is collected and because of that there are cases of damaging the property of the property owner, e.g. denting the fence or damaging the gate. Complaints are then made to the City Council in this regard. In addition, frequent complaints are received about damage to waste collection containers and employees leaving the collection area untidy.

There are also cases of incorrectly attributing the quantity of waste collected to a given property. There are also mistakes in the location of collection points due to a lack of knowledge of the area, which often results in a failure to collect waste from a given property.

Problems with the City Hall of Wodzisław Śląski

The problem in the process of municipal waste management is, above all, the frequency of mixed waste collection in the months from October to March, for which the Municipal Office is responsible for scheduling. In this period, waste for single-family properties is collected only once a month, i.e. half less frequently than in the rest of the year. This is too infrequent, especially in comparison to the collection from hubs for multi-family properties, for which collection is carried out twice a week. In addition, the weight limit for construction waste is an obstacle for residents. The owner of each property can only hand over 800kg of such waste to the USCMW for a period of three years. For new properties, the problem may arise at the very beginning. After filing a declaration with the Municipal Office, they do not receive bags for waste collected in a selective manner. These bags will be given to them only at the next collection, which may take place even a month after submitting the declaration. This is problematic as the waste is already produced and this forces the owners to provide them themselves.

It should also be noted that not enough time and resources are devoted to educational activities concerning proper waste segregation. Moreover, the respondents believe that the opinions and tasks of rank-and-file employees are not taken into consideration while making decisions related to the waste management system in Wodzisław Śląski. As an example they mention, among others, creating a model declaration, which for an average resident is impossible to fill in without the help of an employee of the office. There is also a prolonged flow of information concerning submitted complaints. When an irregularity occurs, residents must report it to the City Hall, which then contacts the company responsible for collecting municipal waste and forwards the information about the error. Once the complaint has been resolved, the information is returned through the same channels.

The results of the research also indicate that the problems in the process of municipal waste management are due to a deficit in human resources. In addition, there is a lack of a database combining the data of people making declarations, those registered and those receiving benefits, which also gives the number of people living in the property.

Holistic approach to municipal waste management in Wodzisław Śląski

In order to have a holistic view of the waste management process in Wodzisław Śląski, on the basis of conducted interviews, an Ishikawa diagram was developed. It is presented in the figure 2.

The diagram presented in Figure 2 shows that the greatest number of problems in the process of municipal waste management in Wodzisław Śląski municipality occurs in the areas of Material and Method. These problems are mainly organisational but also of social character. Therefore, they indicate the need for an integrated approach to waste management, affecting the problems related to the organisation of this process, ensuring the best available technologies, and building social responsibility. It is a difficult task because the municipal waste management process is dynamic. Its functionality is influenced by many internal and external factors, such as costs, technical requirements and constraints, and the dynamics of waste generation (Bautista and Pereira, 2006; Karbownik et al., 2012). One of such factors is the inclusion of residents in the municipal waste management process. Inhabitants are both producers of waste and the first link in this process. Their conscious and responsible approach to municipal waste management can reduce the amount of waste, resulting in better segregation and increasing the level of adaptability of the entire system thanks to bottom-up initiatives.

It is also worth noting that in many cases, sub-causes are interlinked in different spheres. This means, for example, that ignorance on the part of residents has an impact on inadequately sorted waste, but also on incorrect declarations or overproduction of waste. Deceitful declarations have an impact on the inappropriate method of calculating the fee, entrepreneurs issuing too much waste and overproduction of waste. In addition, they overburden the Municipal Office staff as the consequences of irregularities are evident in the lack of proper supervision, incorrect registers and the delay in sending information by the Municipal Office. The existence of dependencies between causes in the categories, as well as in the whole system, means that when the common sub-causes are minimised or completely eliminated the effects will be visible in the different categories and the solutions that make this possible will be much simpler. This will make it possible to reduce the number of mistakes made throughout the waste management process.

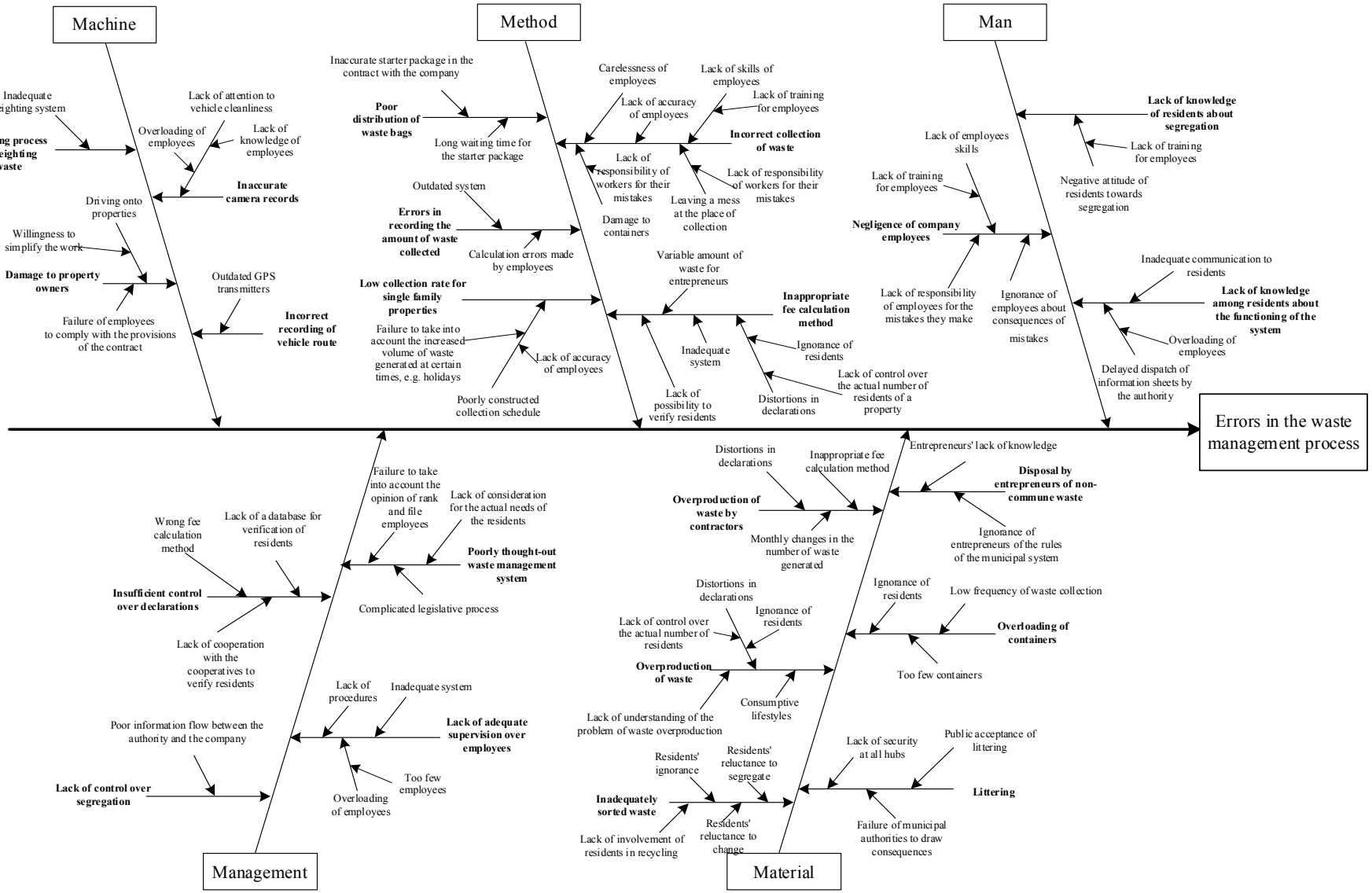

Figure 2. Ishikawa diagram for the municipal waste management process in the commune of Wodzisław Śl. Own work.

5. Suggestions for improvements in the process of municipal waste management in Wodzisław Śląski

Getting to know the waste management process through the people who are at the centre of its supervision has facilitated the knowledge of the problems occurring in it. Despite the fact that the process has been operating for years and all sub-processes included in it have been implemented in accordance with legal regulations, various problems occur. According to the interviews, the problems are mainly due to ignorance of the participants in the process and failure to comply with the rules in force. This particularly concerns property owners – the producers of municipal waste. The system requires continuous improvement and assumption of actual responsibility for municipal waste by all participants of the municipal waste management system in the city of Wodzisław Śląski. There are many possibilities in this respect. During the interviews, the respondents suggested many actions to improve the functioning of the municipal waste management process in Wodzisław Śląski. The most frequently indicated are:

- waste identification – waste attributed individually to the producer by creating a system of "chip" containers/bags,
- increased monitoring of illegal dumping sites and control of the dumping of household waste in municipal bins,
- monitoring of hubs where municipal waste is deposited in multi-apartment buildings,
- introducing reductions in payments for municipal waste management, e.g. for those who do not return ash,
- a change in the method of calculating the municipal waste management fee due to numerous misrepresentations in the declarations,
- the use of hubs for single-family properties, where possible,
- more frequent collection of waste from single-family dwellings,
- blocking of waste collection for properties which are in arrears for many years,
- blocking the possibility of depositing municipal waste at the USCMW in the case of properties that are in arrears with their waste management fees,
- the possibility to choose the frequency of waste collection for non-residential properties,
- creation of a uniform database to facilitate the control of properties in terms of the actual number of inhabitants,
- introducing more educational activities for city residents,
- introduction of higher charges for non-segregation,
- more frequent inspections of the process of waste collection and delivery to recycling by entrepreneurs (currently verification is done once a year),

- control of contracts concluded between waste collection companies and traders who have left the municipal waste management system (currently there is no control and a trader who leaves the system only makes a declaration about it),
- equipping public places such as parks, sidewals, etc. with bins for selective waste separation.

The research carried out allowed to identify areas which first require improvements to improve the functioning of the entire municipal waste management system in Wodzisław Śląski. Suggested improvements concern:

- switching from a bag to a container system,
- automatic identification of real estate,
- changes to the calculation of the municipal waste management fee,
- expand educational activities for city residents.

Switching from a bag to a container system would involve equipping all single-family residential properties with three 240 l containers, one per colour:

- blue – for paper,
- green – for glass,
- yellow – for metals, plastics and multi-material packaging waste.

Each container could have a sticker stating what waste should be kept in it, what waste should not be put in it, and a special barcode to identify it on collection. This solution would reduce the use of disposable bags in favour of reusable containers. It is a more environmentally friendly way of collecting waste, which additionally increases the protection of waste from rainwater, facilitates the collection of selectively collected waste and enables automatic identification of waste. Thanks to information placed on containers, residents would have no doubts as to what waste should go in particular containers, which would eliminate errors resulting from inappropriate sorting of municipal waste.

It is proposed to introduce an optical system for the automatic identification of properties by means of codes and scanners in order to eliminate errors caused by incorrectly assigned amounts of waste collected per property. It is recommended to use Code-39, which would encode information on the area, property address, type of waste contained in the container and its capacity. Each single-family property could be equipped with a unique barcode signed with the property address and type of waste. However, the code below would contain encrypted information:

- R – district number (I-XII) to which the property belongs,
- U – street marking according to predetermined numbering,
- NR – a specific property number,
- 1-6 – type of waste (1 – mixed, 2 – ash, 3 – plastic, 4 – glass, 5 – paper, 6 – BIO),
- P – container capacity.

This implies the need to equip waste pick-up staff with wireless scanners to scan the code and tablets to record the data.

Another proposed improvement is a change in the method of calculating the municipal waste management fee. The current method is based on declarations, in which there are often misrepresentations. Due to the impossibility of checking all properties, it is an inappropriate method of calculating the waste management fee. In order to eliminate this problem it is proposed to consider changing the method to a fee based on the amount of water consumed at a given property.

In the new method, the rate would be calculated on the basis of reports containing monthly water consumption in each property. The fee would depend on the number of cubic metres. For this purpose, the appropriate rate per one cubic metre of water used would be calculated on the basis of the average monthly water consumption in Wodzisław Śląski. Additionally, the calculations should take into account the cost incurred by the Town Hall for waste management in the previous year.

The proposed method of calculating charges for municipal waste management would make it possible to abandon declarations, the updating of which is the responsibility of residents. In addition, this method would take into account seasonal fluctuations in waste generation.

The last proposed improvement is to extend educational activities with basic information on the functioning of the city's waste management system and the correct segregation of municipal waste. It is proposed to organise a series of meetings with environmental education experts in all schools in the city. The classes should be tailored to the age group of the students and their aim would be to familiarise school students with the topics of proper recycling, circular economy, the problem of overproduction of waste and the functioning of the waste management system. Inculcating values at an early age will help avoid mistakes made in the future.

6. Summary

The research carried out allowed to identify many problems in the process of municipal waste management in Wodzisław Śląski. It was found that the main ones are of organisational and social nature. These problems have a negative impact on the environment and the health of residents, and limit the municipality's efforts to manage waste in a closed cycle. For this reason, on the basis of the interviews conducted, four improvements have been proposed to improve the functioning of the municipal waste management process in the municipality of Wodzisław Śląski, which include: changing the system from a bag-based to a container-based one, automatic identification of properties, changing the way of calculating the fee and expanding educational activities. These are basic undertakings whose implementation will enable the

introduction of advanced actions aimed at managing the greatest amount of waste. Although those measures have been identified in the context of the study carried out in Wodzisław Śląski, they seem to be universal and the premises for their application indicate that their introduction may also be beneficial in other cities.

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