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Transport and storage of selected industrial waste

Abstract

According to Statistics Poland (GUS), the amount of waste from industrial activities in Poland in 2021 exceeded 107 million tons. Waste poses a threat to the environment and human life and health, which is why it is so important to properly manage processes such as waste transportation and storage. The handling of industrial waste is covered by a number of regulations, which must be followed in order to protect the environment. Industrial companies are obliged to register and record a significant portion of their waste, and they must also submit reports regularly. Entrepreneurs acting in accordance with strict rules contribute to improving the quality of life of present and future generations.

Keywords: industrial waste, waste transport, food processing.

Transport i składowanie wybranych odpadów przemysłowych

Streszczenie

Według danych Głównego Urzędu Statystycznego (GUS) ilość odpadów pochodzących z działalności przemysłowej w Polsce w 2021 r. przekroczyła 107 mln ton. Odpady stanowią zagrożenie dla środowiska oraz życia i zdrowia ludzi, dlatego tak ważne jest właściwe zarządzanie procesami takimi jak transport i składowanie odpadów. Postępowanie z odpadami przemysłowymi reguluje szereg przepisów, których należy przestrzegać w celu ochrony środowiska. Przedsiębiorstwa przemysłowe są zobowiązane do rejestrowania i ewidencjonowania znacznej części swoich odpadów, a także do regularnego składania raportów. Przedsiębiorcy działający zgodnie z surowymi przepisami przyczyniają się do poprawy jakości życia obecnych i przyszłych pokoleń.

Słowa kluczowe: odpady przemysłowe, transport odpadów, przetwórstwo spożywcze.

1. Introduction

The primary piece of legislation dealing with waste is the Waste Act of December 14, 2012. It implements, within the scope of its regulations, European Union directives (Wieczorek, 2021). The act defines waste as "any substance or object which the owner disposes of, intends to dispose of, or is obligated to dispose of" (Act of Waste, 2013). The term "industrial waste" has not received a statutory definition.

The term is most often used to describe "waste generated as a result of various production processes" (Jakubowski, 2006). According to (Maciak, 2003), "Every economic activity of man is now inextricably linked with the production of waste. The ideal solution, impossible to apply on a larger scale neither now nor in the near future, is the use of waste-free technologies". Waste-free technology is based on full utilization of the raw material, thereby which waste is not generated. The development and implementation of such technology is generally difficult. It requires the involvement of, for example, many specialized scientific institutions and a significant financial contribution, which often goes beyond the capabilities of a single company (Rosik-Dulewska, 2015).

Industrial waste, generated in millions of tons per year, differs in composition and physicochemical properties, among other parameters. This depends on the branch of industry from which they originate. Waste can occur as relatively pure substances or as complex mixtures of varying composition, so industrial waste includes natural materials or such natural materials which were only anthropogenically transformed, as well as products hitherto unknown. They are generated in both liquid and solid form (Kozak, 2001; Maciak, 2003).

In the study, an attempt was made to analyze the regulations on the transport of pomace, two transport routes were selected from the Fruit Processing Plant in Nowy Sacz to the Mládežnícka waste disposal site in Slovakia The transport cost estimate was determined and the optimal transport route was selected, both in terms of regulations on the transport of hazardous materials, traffic regulations, relief, operation of motor vehicles and ecology. These issues are not addressed by the authors of the works (Ciuła, 2023; Kądziołka, 2021; Kowalski, 2021) no less, they can complement the present study especially in terms of the durability of motor vehicle assemblies and their impact on road safety.

2. Waste classification

The basis of any classification is provided by appropriately selected criteria. In the case of waste, a division reflecting the source of waste generation, waste properties, environmental harmfulness, usefulness and mass production is necessary (Rosik-Dulewska, 2015). There are many classifications of waste and one of them is the division according to the share of the organic fraction in the composition of waste.

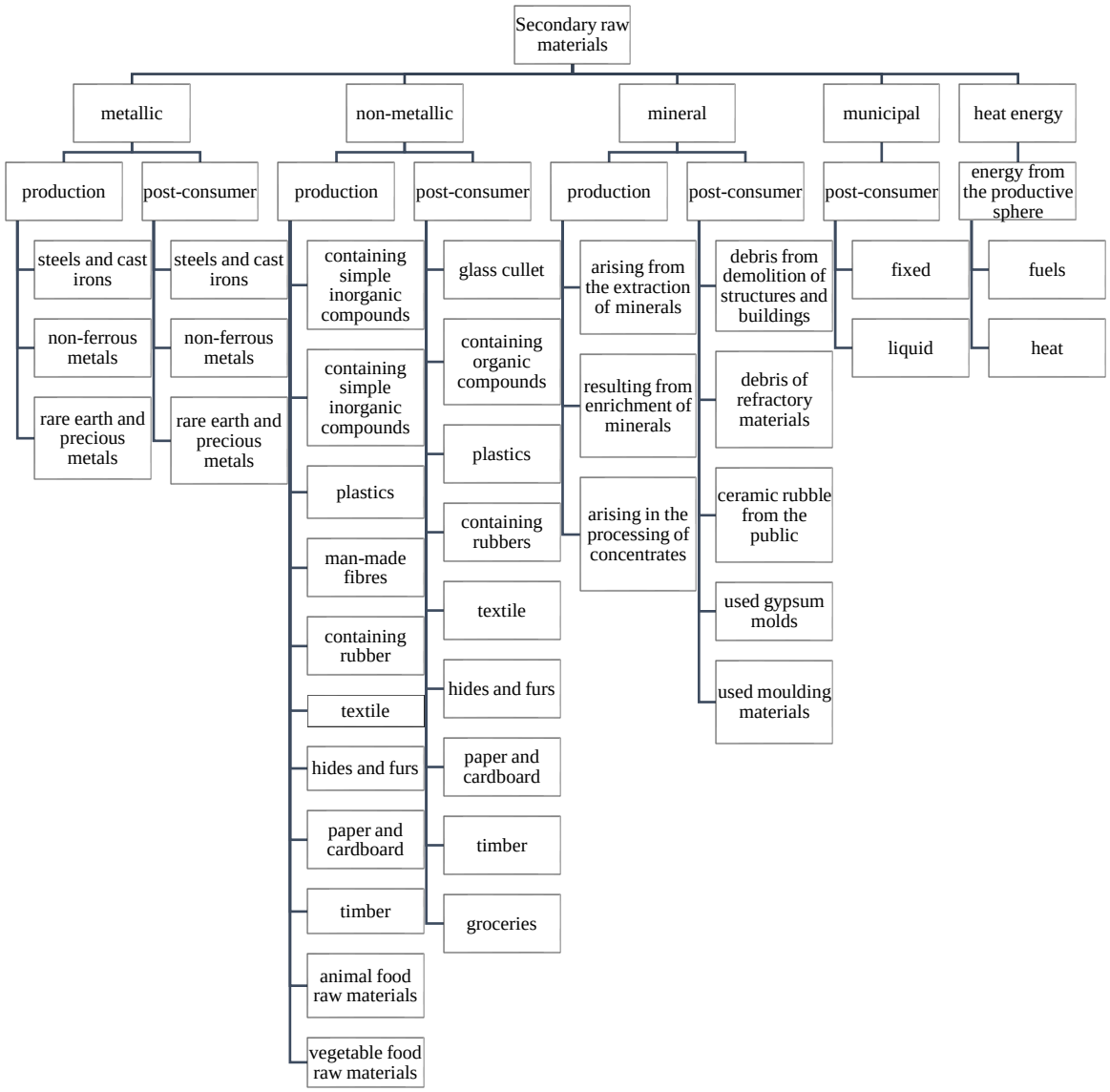

Figure 1. Division of secondary raw materials

(source: own study based on Rosik-Dulewska, 2015)

This division distinguishes the following waste (Figure 1):

– mineral (up to 1% of organic matter);
– organic – mineral (5-50% of organic matter);
– organic (the share of organic matter is more than 50%).

The sources of organic waste, containing more than 50% of organic matter (on a dry weight basis), include the agro-food and timber industries. Figure one shows the classification which has been in use since 1976.

It treats waste as secondary raw materials. This classification, based on a multilevel structure, using different criteria for the division of waste, distinguished 5 basic groups of waste:

– metallic;
– non-metallic;
– mineral;
– municipal;
– thermal energy.

The basis for the further division of waste is the place where waste comes into being. In the next stage, non-uniform criteria were adopted, for example the state of aggregation for municipal waste. This classification can be used as an overview in economic practice (Peng, 2023; Rosik-Dulewska, 2015).

3. Industrial waste in Poland

The largest share, that being 59%, in the amount of waste generated in 2020, was waste generated in the exploration, extraction and processing of ores and other minerals, which is called mining waste. In second place came waste from thermal processes with a share of 17%. Taking these data into account, the regions where the largest amount of industrial waste is generated are the Śląskie (Silesia) and Dolnośląskie (Lower Silesia) regions, since the mining industry is located there. The smallest amount is generated in Lubuskie and Podkarpackie regions. The share of each of these regions in the total amount of industrial waste generated is only 1% (Figure 2).

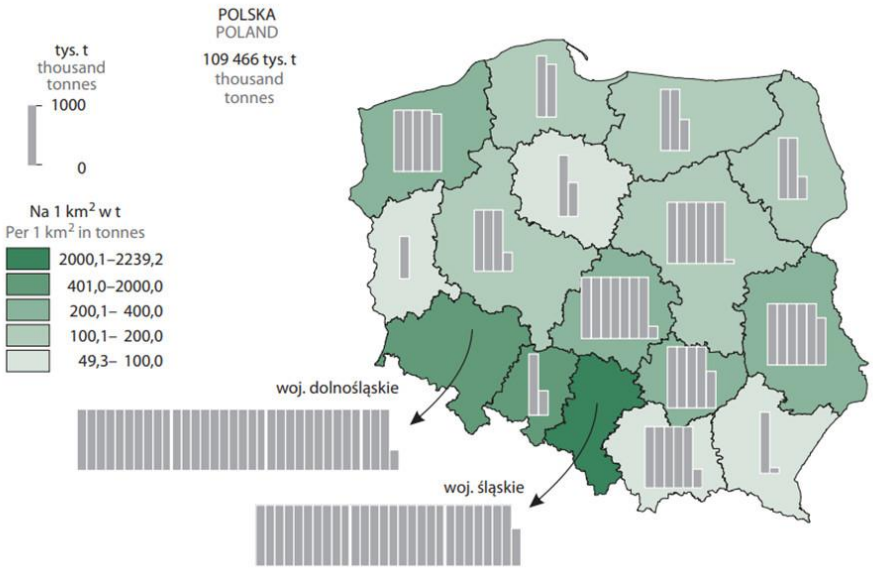

Figure 2. Waste generated (excluding municipal waste) by region in 2020

4. Waste treatment methods

Waste should be treated as a potential raw material after first being subjected to various recovery methods. Recovery is any process that aims to bring waste to such a state that it can replace a specific raw material for use in a particular production process. The disposal process can be treated as a manifestation of economic inefficiency, since it is a process that does not lead to the recovery of the waste (Ciuła, 2023). Disposal processes, in addition to landfilling, include treatment in soil and ground or post-landfill retention (accumulation of waste in lagoons or sediment plots) (Central Statistical Office Environmental Protection, 2022). A breakdown of recovery and disposal processes is shown in Figure 3.

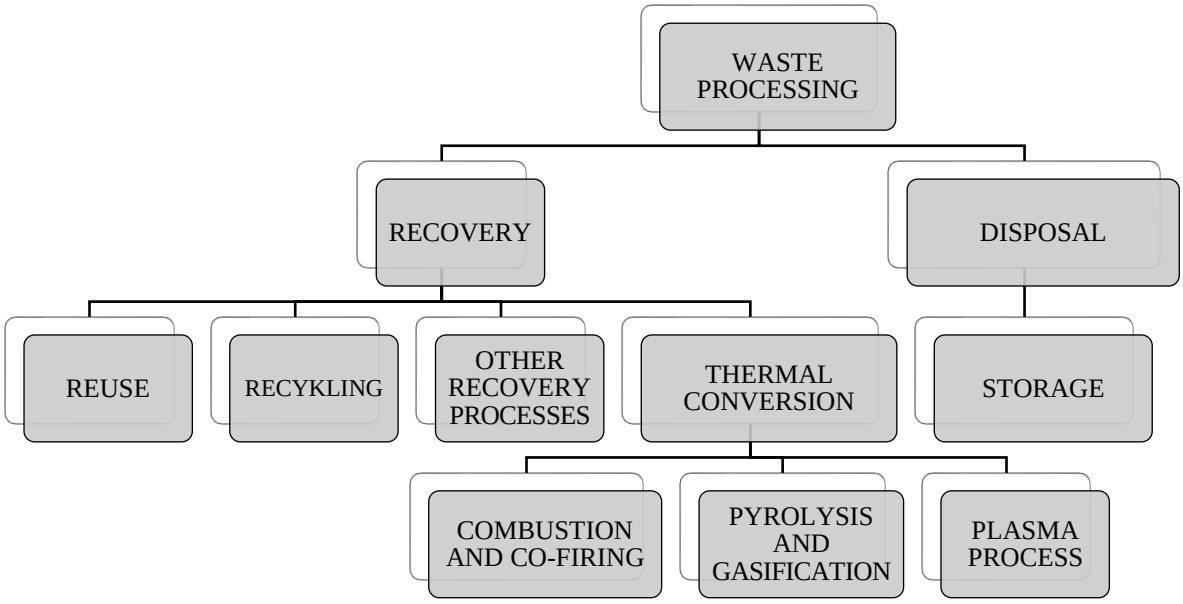

Figure 3. Waste management – the breakdown of waste processing

(source: own study based on Wieczorek, 2022)

In 2020, industrial processing contributed approximately 23 thousand Mg of waste. More than one half of that volume, some 16.5 thousand Mg, was recycled (one of the recovery processes). Almost 6 thousand Mg of waste generated in this industry sector was disposed of. The exact figures are shown in Table 1.

Table 1

Waste generated by industrial processing and its handling

Waste generated during the year [Mg]						
			inactivated			
	total	recycled	total	of which the amount stored	temporarily stored	waste previously stored
Industrial processing	**23 123**	**16 418**	**5 909**	**3 332**	**517**	**282 500**

(source: own study based on Central Statistical Office Environmental Protection, 2022)

According to the principle of proximity of waste treatment, "...Waste, taking into account the hierarchy of waste treatment methods, shall first be treated at the place of its origin. Waste that cannot be processed at its place of origin shall be transferred, taking into account the hierarchy of the ways of handling waste and the best available technology referred to in Article 207 of the Environmental Protection Law Act of April 27, 2001, or the technology referred to in Article 143 of that Act, to the closest places where such waste can be processed..." (Act of Waste, 2013).

5. Waste storage

Waste storage refers to the temporary storage of waste. This storage includes:

- pre-storage by the waste generator;
- temporary storage by the waste collector;
- storage by the waste processor.

Under Article 25(1) of the Waste Act, "Storage of waste shall be carried out in accordance with the requirements for protection of the environment and safety of human life and health, in particular, in a manner that takes into account the chemical and physical properties of the waste, including its state of aggregation, and the hazards that the waste may cause, including in accordance with the requirements set forth in the regulations issued pursuant to paragraph 7" (Act of Waste, 2013). The basic principles of storage include:

1. The waste holder has legal title to the land where the waste is stored.
2. The storage of waste is carried out as part of waste generation, collection or processing – only in connection with these processes.
3. The storage of waste is allowed if the need for storage arises from organizational or technological processes, but may not exceed 3 years, and may not apply to waste intended for storage, which may be stored for a maximum of 1 year in order to collect a sufficient amount for transport to a landfill. The aforementioned storage periods are counted together, for each subsequent holder of such waste.
4. In some cases, a visual system of inspection of the waste storage or disposal site must be carried out (Act of Waste, 2013).

The requirements set forth in the regulations issued under paragraph 7 of Article 25 of the Waste Act are contained in the Regulation of the Minister of Climate, dated September 11, 2020. This regulation "specifies detailed requirements for waste storage, covering initial storage of waste by a waste generator, the temporary storage of waste by a waste collector, and the storage of waste by a waste processor" (Regulation on specific requirements for waste storage, 2020).

5.1. Specific requirements for the place and manner of waste storage

The place and method of storage depend primarily on the chemical and physical properties of waste, including the state of aggregation. The place where waste is kept should have a surface area adapted to the amount of waste generated in a certain period of time and the frequency at which the waste is received, while the method of storage is selected in such a way as to prevent the spread of waste beyond the designated storage area. In the storage process, special consideration should be given to the use of:

– packaging;
– bins;
– bags;
– tanks;
– containers.

Storage in piles and prisms is permitted, provided that it does not cause the pollution of surface and groundwater, soil and the ground (this applies, in particular, to waste generated from weather-resistant products).

More stringent regulations require that waste be stored on a surface paved with construction products, and that protection against unauthorized entry and the adverse effects of the weather should be used.

In the case of waste that may cause leaks or leachate escape from storage areas, protection in the form of sealed packaging, containers, tanks, etc., impermeable substrate with a drainage system for leaks and seals is used. Spills and wastewater generated at the storage site should be treated, for example, in oil separators (Regulation on specific requirements for waste storage, 2020).

5.2. Storage of hazardous waste

Hazardous waste shall be stored in a separate zone, where the storage of non--hazardous waste is also allowed. In the case of hazardous waste, the rules cited above shall apply, along with additional regulations concerning, for example, the marking of the storage zone for such waste. A sign with the words "HAZARDOUS WASTE" should be displayed at a conspicuous place. This sign should be weatherproof, durable and legible (Naeem, 2024; Regulation on specific requirements for waste storage, 2020).

Hazardous waste shall be placed in packages, containers, bins, tanks or bags. If their capacity exceeds 5 liters, each shall be marked with a label (Regulation on specific requirements for waste storage, 2020).

6. Pomace as industrial waste

The generation of pomace is related to the increase in the consumption of fruits and vegetables, and in particular the processed products extracted from them, i.e. purees, juices or jams. The food sector is the fifth largest generator of waste in Europe. After the processed fruit or vegetable production process based on the raw material, approximately 20% of the fruit and vegetable mass remains, which receives the status of waste and is called pomace. Fruit and vegetable processing begins at the time of delivery. Upon receipt, the raw material should be pre-washed and separated from rotten and defective fruits and vegetables and from other contaminants. This is followed by crushing, pressing, pasteurization, depectinization and filtration. The final stage is packaging of the finished product and pasteurization. During these processes, waste such as the following is generated:

– post-production wastewater;
– rotten and defective fruits;
– pomace (Jakubowski, 2006; Kozak, 2001, Magiera, 2006).

According to statistics kept by the Statistics Poland, more than 3 thousand tons of apples were allocated to the production of concentrated juice in Poland in the 2018/2019 season. Assuming that 20% of the raw material consumed was pomace, about 630 thousand Mg of it was generated. Depending on the processing method and variety of raw material, pomace may include fruit and vegetable peels, seeds or pulp residues. This is a material characterized primarily by low durability and stability. In addition, pomace is distinguished by high water content, which exposes the material to rapid growth of contamination (Pietrzyk-Sokulska, 2018; Tran, 2024).

Pomace belongs to perishable wastes, which can lead to the microbiological contamination of the enterprise and hinder the production process. Pomace should be utilized as soon as it is obtained and as long as it is fresh because its quality deteriorates over time and this leads to a change in the physical and chemical composition and to the reduction of pomace value and usefulness (Jakubowski, 2006; Zhang, 2023).

6.1. Example of pomace utilization

Pomace is waste because it is not used in a technological process. However, pomace can be properly utilized elsewhere (Jakubowski, 2006). Waste generated in fruit processing contains many valuable components, so it should be treated as a secondary raw material (Ciuła, 2023). Pomace as a secondary raw material is used in the food industry as an ingredient of confectionery products or as an additive to fruit infusions. Pomace can also be used to obtain dyes, oils and aromatic substances (Pietrzyk-Sokulska, 2018), which are used in many other industries, e.g. in the cosmetics industry various extracts obtained from pomace are used as cosmetic ingredients. In the textile industry, pomace is an alternative to animal skin (Wieczorek, 2022). In addition, pomace is among the types of waste that individuals or non-business entities can recover for their own use. The recovery process R1 or R3 is involved – pomace used as a fuel (Ciuła, 2023) or soil fertilizer. The acceptable maximum quantity to be received is the amount that can be utilized (Regulation on waste recovery by non-entrepreneurs, 2015; Tran, 2024).

6.2. Assigning the correct waste code to pomace

The waste code is an important part of the waste handling process. In order to assign the code correctly, it is first necessary to select the appropriate group from among 20 possible ones, taking into account the source of waste being classified (Dobroselskyi, 2019). Pomace is a waste generated during food processing, so it belongs to group 02 of the waste catalog – waste from agriculture, horticulture, hydroponics, fishing, forestry, hunting and food processing. In group 02 of the waste catalog, there are 7 subgroups including: waste from agriculture, horticulture, hydroponics, forestry, hunting and fishing (the subgroup code: 02 01); waste from preparation and processing of food products of animal origin (the subgroup code: 02 02); waste from the preparation, processing of food products and stimulants and waste of vegetable origin, including waste from fruit, vegetables, grain products, edible oils, cocoa, coffee, tea and tobacco preparation and processing, yeast and yeast extract production, molasses preparation and fermentation (the subgroup code: 02 03); wastes from the sugar industry (subgroup code: 02 04); waste from the dairy industry (the subgroup code: 02 05); waste from the baking and confectionery industry (the subgroup code: 02 06); waste from the production of alcoholic and non-alcoholic beverages (the subgroup code: 02 07). The subgroup to which pomace belongs is subgroup

02 03 – waste from preparation, processing of food products and stimulants, and waste of vegetable origin, including waste from fruit, vegetables, cereal products, edible oils, cocoa, coffee, tea, and preparation and processing of tobacco, yeast and production of yeast extracts, preparation and fermentation of molasses. The relevant group and subgroup enables the designation of final six-digit code 02 03 80 to pomace. The group comprises pomace, sludge and other waste from the processing of plant products (excluding waste from the production of plant feed).

7. Pomace storage

7.1. Characteristics of a food processing enterprise

The food processing company from which pomace will be transported is engaged in the production of jams, juices, purees, etc. from more than 30 kinds of fruits and vegetables. The company operates in Nowy Sącz in the Małopolska region, Poland. The company supplies products to local stores and confectionery plants located both throughout Poland and in other countries. Unfortunately, the production process generates a significant amount of waste in the form of pomace, and its utilization is no less important (Dobroselskyi, 2019).

The estimated amount of raw materials received daily on the production line is approximately 10 tons. For the purpose of the analysis, it was assumed that pomace accounts for 30% of the weight of the raw material, so approximately 3 Mg of pomace is generated daily. The waste transporter collects the waste once a week (Friday).

7.2. Pre-storage of pomace by its generator

Waste storage is regulated by the Waste Act of December 14, 2012 and the Regulation of the Minister of Climate of September 11, 2020 on detailed requirements for waste storage. A person who conducts waste storage must have the relevant permit. However, an exception is made for the initial storage of waste by the waste generator (Act of Waste, 2013). The company under analysis only stores pomace on a preliminary basis. Pomace is a biologically unstable plant matter. It is characterized by a high content of water and, for example, sugars, which promotes decay processes. The prolonged storage of fresh pomace is dangerous, as it poses the risk of biological contamination. The methods of preserving pomace include pickling and drying. These processes inhibit disadvantageous changes that reduce pomace quality. The food processing company presented in the article has a specially designated area where pomace is pre-stored until it is collected by a collection service provider. The area is a cold store, where low temperature is maintained to keep pomace in good condition until it is transported so that it does not rot or become moldy. Pomace is pre-stored in plastic bins with a capacity of 1 ton of the raw material.

8. General principles of waste transportation

Pursuant to Article 24 of the Waste Act of December 14, 2012, "The transportation of waste shall be carried out in accordance with the requirements for the protection of the environment and the safety of human life and health, in particular, in a manner that takes into account the chemical and physical properties of waste, including the state of aggregation, and the hazards that waste may cause, including in accordance with the requirements set forth in the regulations issued pursuant to paragraph 7" (Act of Waste, 2013). The requirements specified in the regulations issued pursuant

to paragraph 7 of Article 24 of the Waste Act are contained in the Regulation of the Minister of the Environment of October 7, 2016 (Regulation on specific requirements for waste transport, 2016). The Regulation contains basic information on the means of transportation, including their correct marking and the method of waste transport. First of all, attention should be paid to:

1. Preventing the mixing of different types of waste;
   a. Care should be taken to ensure that the means of transport does not contain residues of previously transported waste.
   b. The exception is a situation where the mixed types of waste are dispatched in their entirety to be processed in the same process.
2. Preventing the spread of waste beyond the means of transportation;
   a. Reducing odor nuisance and waste spillage, dusting and leaks.
3. Preventing atmospheric factors from affecting the waste which, under the influence of those factors, can cause a hazard;
4. Preventing waste bins or bags from tipping over, by stacking or securing them properly in the means of transport, unless waste is transported in tanks or in bulk.

9. Transport of pomace

Transport of pomace will be described on the example of a local transport company based in Podrzecze, the commune of Podegrodzie. The company provides services in the field of truck transport by specialized vehicles. The company has been in business for almost 30 years. It is a partnership founded by two brothers. It also holds a permit for the collection of certain types of waste (Appendix 1) including waste with code 02 03 80 – pomace, sludge and other waste from the processing of plant products (excluding waste from the production of plant feed). The permit allows for the collection of waste from a given enterprise and allows for temporary waste storage (according to the guidelines specified in the permit) and subsequent waste transport to the place of processing. As of 2018, the company has operated the mandatory BDO (Waste Database) system, in which every activity of the company in relation to waste management is electronically documented. Currently, any entrepreneur transporting waste or carrying out waste transportation on behalf of another company is only registered in section VII of BDO – "VII Waste Transporters". It is not necessary to have a "paper permit" as is the case with the waste collection permit.

Waste transport is regulated by the Waste Act of December 14, 2012 and the Regulation of the Minister of the Environment of October 7, 2016 on detailed requirements for waste transport. If waste is dangerous, it is additionally subject to the Transportation of Dangerous Goods Act of August 19, 2011. However, it should be noted that not all hazardous waste will be a dangerous cargo.

The place for the processing of pomace collected from the food processing company is a biogas plant located in Slovakia (Kądziołka, 2021; Kowalski, 2021). Transportation will be carried out by the following means of transport Figure 4:

- MAN truck tractor (year of manufacture 2010, the EURO 5 standard),
- Semi-trailer – the ZASŁAW D-653 tipper truck (year of manufacture 2011, the open load-carrying body made of aluminum, sealed with continuous welding, and equipped with a tarpaulin. The permissible load capacity is 28,260 kg).

Figure 4. The pomace transport vehicle

The next step in preparing the means of transport is proper marking. The article outlines the cross-border shipment of waste, so a plate with the capital "A" in a prominent place is attached to the vehicle. The plate must be durable and weatherproof (Kądziołka, 2021; Kowalski, 2022, Wojnarowski, 2019).

The waste transfer process is presented in Table 2. The stages of the procedure in the BDO system are shown in Figure 5. The waste transfer card, or KPO for short, can be prepared in the system in advance, but not yet approved. The card will not be visible to other entities then. It should be kept in mind that before issuing the KPO by the holder/generator, the latter should communicate with the transporter/collector beforehand, since the information needed for issuing the KPO includes the registration number of the means of transport or the date and time of the start of the transport. At the time of approval, the-entities mentioned in the card, as well as state institutions such as the Department of Environmental Protection Inspection, have access to the card.

The approved waste transfer card permits the generation of the confirmation of the issuance of the waste transfer card, a document needed during transportation. The confirmation does not have to be printed, and holding an electronic version only is possible. Both the transferee (processor) of waste and the transporter must confirm the completion of processes in the BDO system. In this article, the recipient is a foreign company, so actions based on the waste transfer card will be taken only during the transfer of waste to the collector or during the transfer to the transferee using the services of a transport company (Jakubowski, 2009).

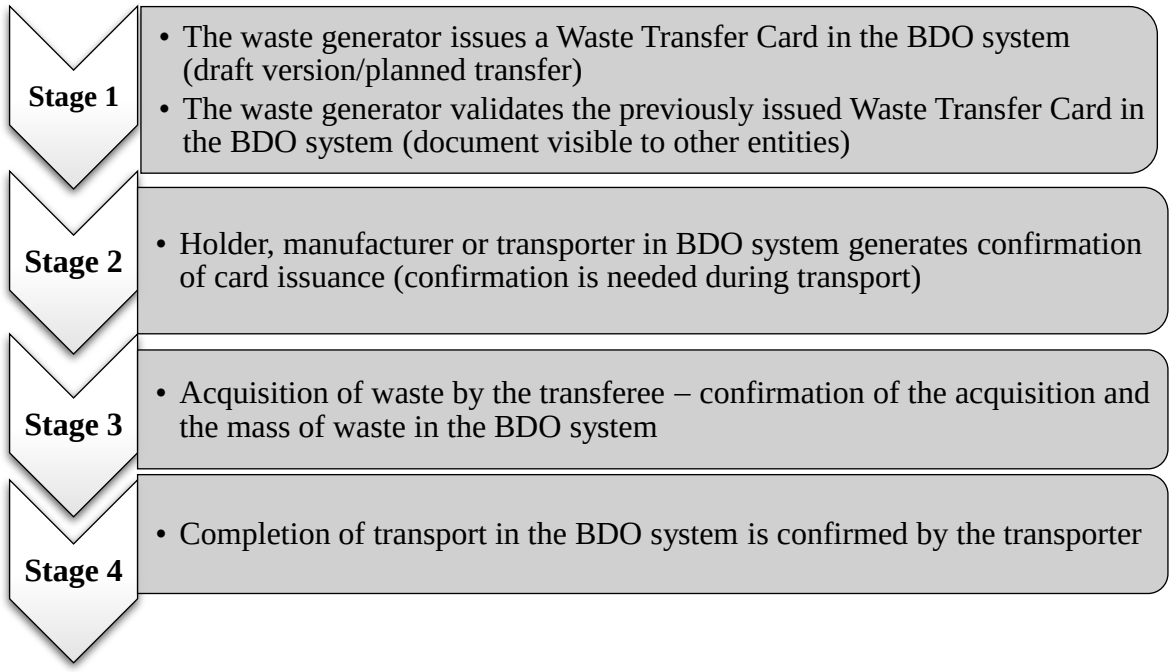

Figure 5. Steps in the waste transfer process

Table 2
Methods and conditions of waste transfer

	Method I **Transfer of waste by the transporter** **Company "Y"**	**Method II** **Transfer of waste by collector** **Company "X"**
Waste generator	Company "X" (POLAND)	
Quantity of waste	approx. 20 Mg of pomace	
Waste processor	Company "Z" (SLOVAKIA)	
Type of transport	**ROAD TRANSPORT – INTERNATIONAL**	
Responsibilities of the parties	**The party ordering the transportation** service is obliged to indicate the destination of the waste and the holder to whom waste is to be delivered. That party ceases to be the holder of the waste only at the moment of handing it over to the processor. **The transporter** is obliged to deliver the waste to its destination, but never becomes the holder of the waste. The transporter only keeps simplified records.	**The waste generator** transfers waste on the basis of the waste transfer card to the waste collector. The waste generator keeps records on the basis of the waste transfer card. **The collector of waste** becomes the waste holder and bears full responsibility and records waste. Based on the international bill of lading and Annex VII, the collector transfers waste to the processor
Waste transfer documentation prepared in the BDO system	NONE	**(Generator – Collector)** Waste Transfer Card
Waste transfer documentation prepared outside the BDO system	**(Generator – Processor)** International bill of lading Annex VII	**(Collector – Processor)** International bill of lading (Annex 2) Annex VII
Records	The generator keeps records only on the basis of the waste record card – general rules apply.	The generator keeps full records. The collector only on the basis of the waste record card.

10. Alternative pomace transport routes

10.1. Alternative 1 – Transport from Nowy Sacz to the waste processing site in Slovakia

When analyzing the route determined with the help of Google Maps, it should be concluded that the fastest transport route will be the shortest route of approximately 275 km (Figure 6). The transport time, depending on the traffic volume, will be approximately 4 to 5 hours. Assuming that the average fuel consumption of a MAN truck tractor is 45 l/100 km and the price of 1 liter of diesel fuel is PLN 6.50, the cost of the fuel consumed by the pomace transport vehicle was determined, which in the analyzed alternative amounted to PLN 805 (Kowalski, 2022; Zhang, 2023).

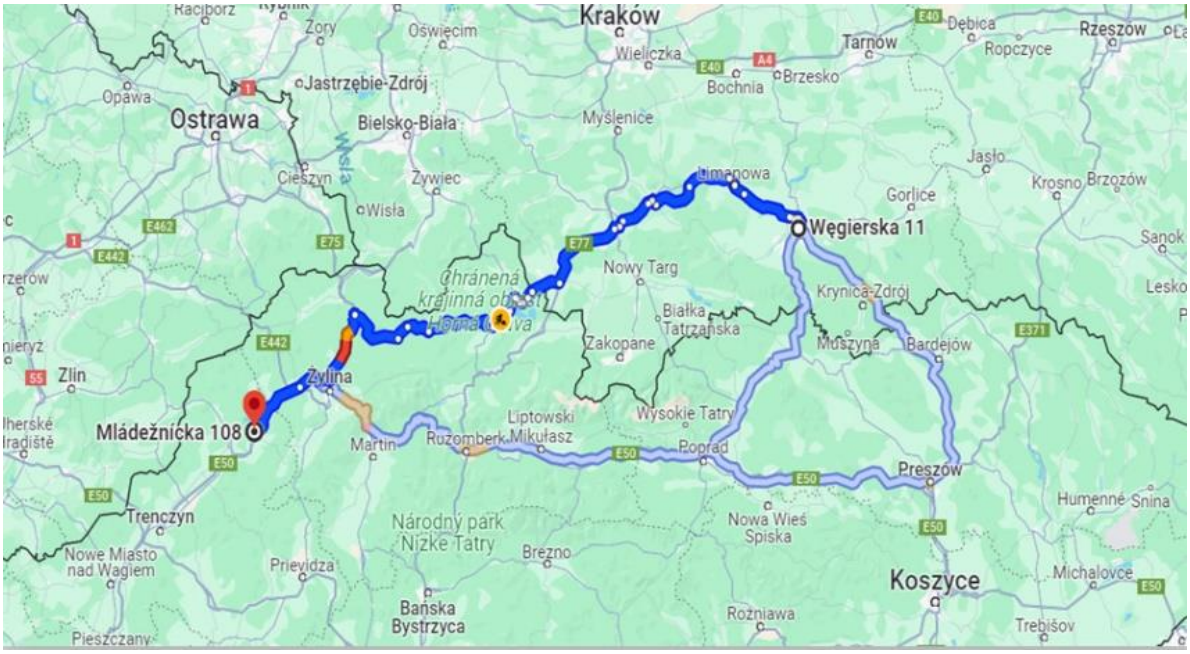

Figure 6. The waste transport route from the food processing company in Nowy Sącz to the waste processing site in Slovakia

10.2. Alternative 2 – Transport from Nowy Sącz to Podrzecze (waste receipt at the collector's warehouse), then transport from Podrzecze to the waste processing site in Slovakia

In alternative 2, pomace will be transported from the Fruit and Vegetable Production Company of Nowy Sącz to Podrzecze by smaller vehicles (in smaller transport batches), where pomace will be received into the carrier's warehouse. Once pomace has been collected in an amount that ensures the optimal use of the cargo space, pomace will be transported from Podrzecze to Slovakia for processing (Figure 7).

In this alternative, the distance is approximately 300 km, while the transport time will depend on traffic and will be, as in alternative 1, from 4 to 5 hours. The cost of fuel for alternative 2 was also determined, which amounted to PLN 880. An important aspect for the transportation of dangerous goods is the effect of road surface condition on the wear and tear of vehicle components. This problem, the aspect of protecting vehicle components from damage, and ways to increase the durability of automotive vehicle assemblies are discussed in detail in the articles (Kądziołka, 2021; Kowalski, 2021; Kowalski, 2022; Wojnarowski, 2019).

The disadvantage of this solution is the need for the carrier to have a warehouse in which waste can be stored. There will also be the cost of fuel and the salary of the driver, who, with a smaller vehicle, will collect pomace from the producer and transport that waste to the transport company's warehouse (WANG, 2023).

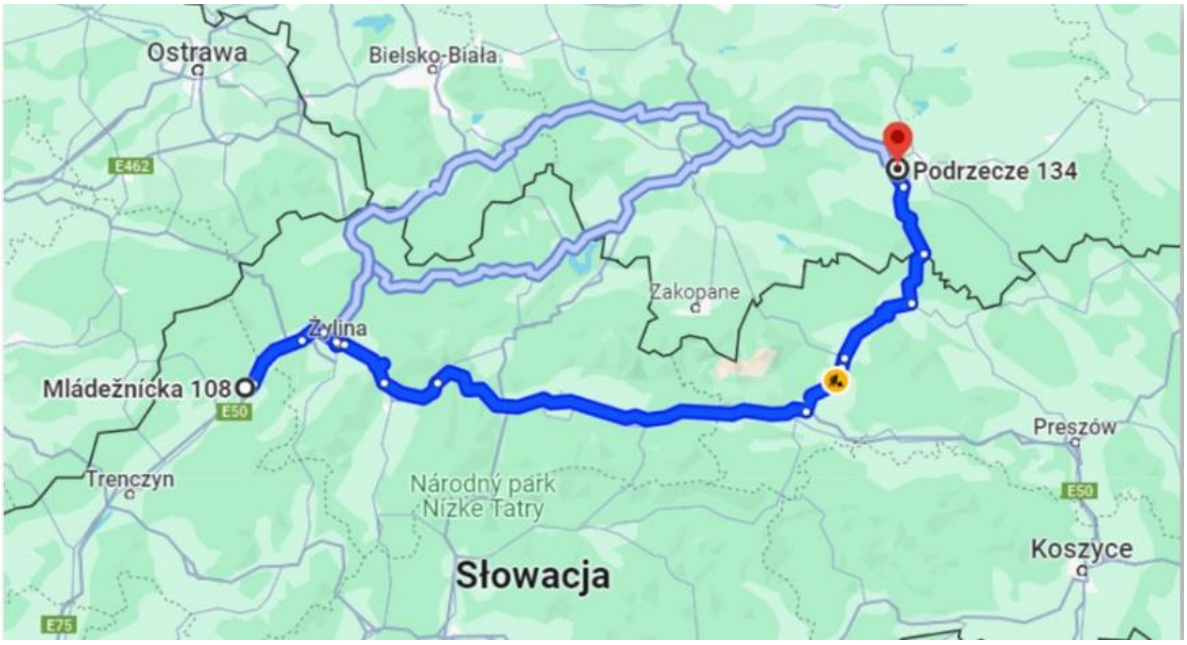

Figure 7. The waste transport route from the waste collection company in Podrzecze to the waste processing site in Slovakia

11. Conclusions

In the present study, the waste transporter carries waste from the place of its generation to the place of processing, i.e. from Nowy Sącz (Poland) to Mládežnicka (Slovakia). As the place of pomace processing is the biogas plant located in Slovakia, international transport is involved. The transport company must be registered in Section VII of the Waste Database (BDO) in order to transport non-hazardous waste. The entity responsible for the waste during transport is the waste holder, in this case the waste generator.

The documents required for transport are the confirmation of the generation of the waste transfer card (the paper version of the document is not necessary), Annex VII and the international waybill. In order for a company to be a waste collector i.e. also to receive waste into the company's warehouse, the company must hold a decision on waste collection. If pomace is received by the waste collector, the responsibility for waste management passes to the collector and rests on it until waste is transferred to the processor.

The waste transfer process in the BDO system is fast and efficient. Documentation prepared in the system can have a working version, which is needed at a later stage and can be approved, which means that the physical transfer of waste, the start or end of waste transport also takes place. The records are visible to the relevant services, including the Environmental Inspection Department. The waste records maintained in the system make it possible to compile the relevant static data of the enterprise, both for the entity itself and the state. As the obligations of the waste generator, collector, transporter and processor, are specified in the laws and regulations on waste management, these entities

perform those obligations taking into account the safety of the environment as well as human health and life. Waste has more or less harmful properties, and its proper identification and classification are key elements in waste management. If any doubts arise as to whether the activities pose a hazard, documentation made at each stage of waste management, allows the relevant services to react (Tran, 2024; Wang, 2023; Zhang, 2023).

Analyzing the route variants in question, it should be noted that the choice of their variant depends on the driver. Although route 2 is longer than route 1 by about 25 kilometers, nevertheless, this does not represent a drastic increase in fuel costs – PLN 75. It is worthwhile before setting out on the road for the driver to assess traffic congestion using Google Maps and choose an appropriate route. This can save time and fuel.

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