

LOGISTIC ASPECTS OF WASTE MANAGEMENT IN CZĘSTOCHOWA REGION

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Abstract: Last years occurred radical changes in waste management in Poland. The paper presents the legislation in force in this area and challenges facing communities. The changes introduced are designed to tighten the system, prevent waste, remove illegal landfill sites, increase the level of recovery from deposited waste and more. In order to achieve these objectives, it is necessary to introduce an integrated system for waste management using logistics. The paper presents selected elements of waste management logistics using Częstochowa region as an example.

Keywords: *waste management, legal changes, reverse logistics, logistic system for waste management*

1. Introduction

Poland has had a problem with municipal waste for many years. The previous solutions gave rise to numerous problems, such as lack of technical infrastructure, excessive municipal landfilling and others. An answer to the ineffectiveness of the previous system and necessity of meeting EU waste requirements was a reform of the waste management system. An important step in this area was passing the act of 1 July, 2011 on changing the act on maintaining cleanliness and order in communities and some other acts [1], which amended the act of 13 September, 1996 on maintaining cleanliness and order in communities. This act was created based on experiences of other European countries.

It is worth stressing at this point that the amount of waste in Poland is continuously growing. The reason for that, apart from economic development, may be increasing consumerism. For instance, according to the latest statistical data, 10330.4 thousand tons of municipal waste was collected in Poland in 2014, an increase by 8.3% compared with 2013. On average, there was 268 kg of waste per one inhabitant of Poland [2]. Unfortunately, a large part of such waste goes to landfill sites, which has a negative effect on the environment.

Industrial development and increase in the population lead to degradation and contamination of the natural environment. The amount of produced waste is growing, as is society's interest in ecological activities in the area of resources management, environmental protection or waste management. Currently, efforts are taken to minimise waste-related threats through rational waste management based on logistic systems. This issue is addressed in particular by one of logistics branches – reverse logistics [3].

The aim of the paper is to present a waste management system taking into account logistics and to assess this system using Częstochowa region as an example. To achieve the aim, literature studies were used and a case study of the functioning of Regional Facility for Municipal Waste Processing in Sobuczyna was analysed.

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2. Municipal waste management

Municipal waste can be defined as waste produced in households, excluding end-of-life vehicles, as well as waste not containing hazardous waste from other waste producers that, given its character and composition, is similar to waste produced in households. The sources of such waste include: households and infrastructure items (trade, services, education, craft and other) [4].

Waste management should be understood as waste collection, transport and processing, combined with control over these activities, and subsequent activities connected with waste disposal sites and activities of a waste seller or waste broker [5]. The following technologies of municipal waste disposal can be distinguished in waste management.

- composting,
- recycling (waste separation and use of secondary raw materials),
- combustion (thermal treatment),
- landfilling [6].

Of the all above-mentioned technologies, only landfilling has a direct negative impact on the environment. Nowadays, efforts are taken to reach such state where landfilling constitutes the last element of waste management. In the waste management hierarchy, landfilling is the least desirable [6]. The subject of waste management is an important issue, undertaken extensively in the literature [7, 8].

3. Changes in waste management system in Poland

As indicated earlier, the waste management system in Poland has changed. The system that had existed before the Act of 1 July 2011 on changing the act on maintenance of cleanliness and order in communities and some other acts entered into force relied on free market mechanisms, with owners of properties and entities responsible for waste collection deciding how to handle it. The deciding criterion on the market was price, which led to strong competition. Undoubtedly, this situation was financially advantageous to a waste owner, but waste collection enterprises were forced to look for solutions that would allow them to have a competitive offer, i.e. lower price for their service. As result, these enterprises chose the cheapest way of waste management – landfilling. The large fragmentation of entities on the waste collection market made it difficult to control them. In the previous system, a cause of concern was also waste management market – lack of possibility of controlling the stream of waste. Attempts made by communities to organise the market by designating sites for waste delivery met with accusations made by the Office for Competition and Consumer Protection of the use of monopolistic practices. The result of that situation was underdeveloped technical infrastructure [9].

The new solutions adopted in 2011 in the area of waste management place emphasis mainly on waste management. The act of 1 July 2011 on changing the act on maintaining cleanliness and order in communities and some other acts entered into force on January 1, 2012, giving communities 18 months to get prepared for the new solutions. According to the new system, it is local council that should be responsible for waste management. A community will have an influence on each of the elements of the municipal waste management system, which will allow it to shape and organise this system in accordance with the relevant act and local conditions [10].

The aims of the introduction of changes in the waste management system in 2011 are:

- to tighten the municipal waste management system,
- to introduce an effective, selective collection of municipal waste “at point of origin”,
- to increase the number of modern facilities for municipal waste recovery, recycling and disposal, and depart from landfilling,
- to minimise the amount of municipal waste directed to a landfill,
- to completely eliminate illegal landfill sites,
- appropriate monitoring of municipal waste handling conducted by property owners and entities responsible for collection of municipal waste from such owners,
- to reduce additional threats to the environment resulting from municipal waste transport [11, 12].

It should be mentioned that apart from the act of 1 July 2011 on changing the act on maintaining cleanliness and order in communities and some other acts, the main legal acts regulating waste management include: act of 14 December 2012 on waste [5] and act of 13 June 2013 on package and package waste management [13].

One of the reasons for implementing the reform analysed in Poland was the necessity of meeting European Union requirements. For the success of the reform of the municipal waste management system and achievement of its objectives, it is important to carry out an appropriate information campaign. Positive effects of the new system can already be observed. Due to its universal character, the reform affects everybody, and without cooperation with property owners, their willingness to cooperate and develop new habits, it will be difficult to achieve the aims of the reform. It is very important to be aware of selective waste collection “at the point of origin”. Other authors [14] also emphasise the important role of residents in creation of waste management systems.

When developing municipal waste management systems, it is also important to use logistics elements.

4. Basic logistics concepts connected with waste management

In literature, logistics is defined as shaping (through logistic management) material and information flows for the purpose of ensuring access (to material goods or places) under agreed arrangements and priorities of activities [15].

Logistics can be divided into: military, social, economic, international and reverse one [15]. A different division is presented by KORZEŃ, who distinguishes production, urban, hospital, technical system maintenance, military logistics and ecologistics [16]. It should be noticed that one of these divisions distinguishes reverse logistics, while the other – ecologistics. Both of them refer to waste management. In literature, reverse logistics is also referred to as “ecologistics”, “green logistics” and recovery logistics [15]. The issue of waste management is also covered by urban logistics.

Reverse logistics is defined by ROGERS and TIBBEN-LEMDBKE as “the process of planning, implementing and controlling the efficient flow of materials, in-proces inventory finished goods, and related information from the point of origin for the purpose of recapturing or creating value or proper disposal” [17]. SZOŁTYSEK shows the reverse logistics as “all the processes of managing flows of waste (including damaged products) and information (connected with these flows) from the points of origin (appearance) to points of destination for the purpose of value recapture (through repair, recycling or

processing) or proper disposal and long-term storage in such a way that these flows are efficient and cost effective and minimise the negative impact of waste on the natural environment of a human being” [18]. A detailed analysis of the development of the theory and practice in the field of reverse logistics carried out by POKHAREL and MUTHA [19] A review of research on reverse logistics is also presented by a team of researchers: RUBIO, CHAMORRO, MIRANDA [20].

Ecologistics is defined by KORZEŃ as an integrated system which:

- is based on the theory of management of recirculation flows of the streams of waste materials in the economy, as well as linked information flows,
- ensures effective collection, segregation, processing and reuse of waste in accordance with adopted technical and process principles that meet the environmental protection standards,
- enables taking technical and organisational decisions to minimise negative effects of environmental impact that accompany procurement, processing, production, distribution and service processes in logistics supply chains [16].

Waste management includes creation of systems. This is however not an easy task. Such system should be integrated. The concept of integration appears in literature dedicated to logistic aspects of waste management and in non-scientific materials. “Integration” is widely interpreted by many authors and institutions, from internal coherence through compliance with legal regulations, effectiveness and efficiency of a system, to harmonisation of activities as part of the system with the natural environment [21].

SMYK indicates the necessity of noticing relationships between flows in supply chains and waste chains, which should lead to formulation of principles of logistically integrated waste management that takes into account challenges of the idea of sustainable development of the economy [22].

“A logistically integrated system of waste management can be identified and constructed from the perspective of functional areas (according to tasks of activity connected with production of waste, transport to waste management facilities, storage, economic use and utilisation – real sphere – and activity connected with regulation and control in the system – sphere of regulation).” [23] The basic components of a logistically integrated system include the following sub-systems:

- waste gathering,
- waste transport,
- economic use and processing or disposal of waste with recapture of value from waste, including reuse, remanufacturing, recycling and landfilling [23].

The functioning of an integrated system of waste management depends, among other things, on:

- properties, amount and location of waste in a specific area,
- special and urban factors,
- adopted principles of environmental protection,
- general and local norms and requirements connected with permissible impacts on environmental elements [24].

The above-presented elements constitute system input data, representing at the same time its barriers and conditions. The second group refers to internal conditions related to the technology level of the process of storage, processing and transport [24].

Summing up, municipal waste management systems, in which we can distinguish subsystems of gathering, transport and economic use and disposal or processing of waste, should be based on integration of material and information flows with minimal impact on the natural environment.

5. Logistic aspects of the functioning of regional facility for municipal waste processing in Sobuczyna

Article 3, paragraph 3 of the act on waste [5] defines the concept of a municipal waste management region and regional facility for municipal waste processing. A municipal waste management region is an area of at least 150,000 inhabitants defined in the voivodship plan for waste management. A municipal waste management region can be a territory with over 500,000 inhabitants. A regional facility for municipal waste processing is a waste management plant with a capacity that is sufficient for reception and processing of waste from an area inhabited by at least 120,000 residents, that meets the requirements of the best available technology (referred to in article 143 of the Environmental Protection Act) and ensures thermal processing of waste. Moreover, the mechanical and biological processing of municipal waste has to take place in a single installation [25].

Following the proximity principle that demands management of produced waste at the place of its creation or nearest such place, it is entirely appropriate and desirable that the regional storage is the storage located nearest the facility for mechanical and biological processing of mixed municipal waste. The obligation to deliver mixed municipal waste collected from property owners to a regional facility for municipal waste processing arising from art. 9 of the act on changing the act on maintenance of cleanliness and order in communities and some other acts [1] requires that such facilities have a capacity at the level ensuring processing of the whole stream of collected mixed municipal waste. In accordance with the amendment of the act on maintenance of cleanliness and order in communities, communities ensure cleanliness and order in their territory and create conditions necessary for their maintenance, and in particular they ensure construction, maintenance and operation of regional facilities for municipal waste, own or shared with other communities, and cover all the owners of inhabited properties in the territory of the community with the system of municipal waste management [25].

The subject of the activity of Częstochowa Municipal Company (CzPK: Częstochowskie Przedsiębiorstwo Komunalne Sp. z o. o.) based in Sobuczyna is:

1. waste management in the area of:
 - 1.1. gathering, collection, storage and transportation,
 - 1.2. disposal through landfilling,
 - 1.3. recovery and recycling,
 - 1.4. recovery and use,
 - 1.5. administration of waste management system,
2. maintenance and use of the properties including:
 - 2.1. maintenance of order in urban areas as part of commissioned own tasks of Częstochowa community,
 - 2.2. use of the properties owned by the Częstochowa Municipal Company,

3. investment measures, covering:
 - 3.1. investments necessary to meet legal requirements connected with waste management,
 - 3.2. investments as part of commissioned own tasks of Częstochowa community,
 - 3.3. other activities compliant with the Company's statutes.

The area covered by the Company's activities of municipal waste management is the Northern Region of Silesian Voivodeship [26]. The Northern Region of Silesian Voivodeship is a territorial unit defined in the first Strategy for the Development of Silesian Voivodeship, adopted on 25 September 2000, as one of four so-called areas of the development policy (of sub-regions) of Silesian Voivodeship [27].

This division corresponds with the statistical classification introduced by regulation of the Council of Ministers of 14 November 2007, in which Silesian Voivodeship was divided for statistical purposes into eight sub-regions:

- Bielsko sub-region – equivalent to the southern area of the development policy (Southern Sub-region),
- Częstochowa sub-region – equivalent to the northern area of the development policy (Northern Sub-region),
- Rybnik sub-region – equivalent to the western area of the development policy (Western Sub-region),
- Gliwice, Katowice, Bytom, Sosnowiec and Tychy sub-regions, which constitute the central area of the development policy, equivalent to Central Sub-region.

The Northern Sub-region encompasses three counties (poviats): Częstochowa, Kłobuck and Myszków as well as a city holding poviat rights – Częstochowa. Its area – 3050 km² – accounts for one fourth of the area of Silesian Voivodeship (24.7%). In terms of a territory, Częstochowa poviat (1522.49 km², 12.3% of the Voivodeship's area) dominates in this sub-region, followed by Kłobuck poviat (respectively: 889.15 km², 7.2%), Myszków poviat (478.62 km², 3.9%) and the city of Częstochowa with the area of 159.61 km².

The region analysed was inhabited in 2015 by 525,494 people, i.e. nearly one eighth of the total number of inhabitants of Silesian Voivodeship. Its population density (173 people/km²) was half that of the average for Silesian Voivodeship (375 people/km²), but much higher than the national average (123 people/km²). The administrative structure of the subregion consists of 31 communities, including: 2 urban, 6 urban-rural and 23 rural communities. The settlement pattern of this region comprises 586 populated places, including 8 cities inhabited by 58.3% of the total number of residents. The relation of population inhabiting cities to rural population (58.37) classifies this region to relatively poorly urbanised areas. The biggest city of the region – Częstochowa – had 232,318 residents at the end of 2015. The fact that the second most populated urban centre – Myszków – has 32,619 residents, and the number of the inhabitants of the other urban-rural communities fluctuates around a dozen thousand, indicates a strongly monocentric position of this region's capital city [28].

The facilities for municipal waste processing managed by CzPK Sp. z o.o. have a status of regional facilities (regional facility for municipal waste processing, RFMWP). i.e.:

- 1) RFMWP ensuring mechanical and biological processing of mixed municipal waste and sorting fractions fully or partially suitable for recovery from the mixed municipal waste, with a capacity of 95,000 Mg/year, consisting of:
 - a) A waste sorting facility – as a mechanical part that enables processing, among other things, of: mixed municipal waste, waste from packaging group, waste from gardens and parks, waste from renovation group, selectively gathered municipal waste.
 - b) A Compost facility in a closed system using a modern technology for biodegradable municipal waste disposal through aerobic composting in 18 closed reinforced concrete bioreactors.
 - c) A prism composting plant - as a biological part enabling processing, among other things, of: biodegradable waste in the form of plant-tissue, organic fraction (0–80 mm) from a stream of municipal waste, and biodegradable municipal waste.
- 2) RFMWP for storage of waste produced in the process of mechanical and biological processing of mixed waste.

Moreover, RFMWP in Sobuczyn also possesses:

 - A facility for large waste fragmentation enabling processing of large-size waste from municipal and packaging groups (e.g. old furniture, divan beds, pallets).
 - A facility for fragmentation of renovation and construction waste enabling processing of waste generated during renovations.
 - A stationary point for selective collection of municipal waste enabling collection and temporary storage of municipal hazardous, post-renovation and large-size waste, delivered by residents of the City of Częstochowa.
 - A Hazardous Waste Warehouse enabling temporary storage of hazardous waste.

Apart from managing the system, the Company runs the stationary point for selective collection of municipal waste (located in Sobuczyn), where residents of the City of Częstochowa and Poczesna community can deliver by their own transport and leave free of charge selectively collected municipal waste.

For the last 10 years the Company has been conducting an intense investment activity, preceded by active and successful obtaining of non-repayable funds from the European funds. In total, it obtained: PLN 35 768 280.14, including: ZPORR – PLN 14 243 925.00, POIiŚ – PLN 17 840 788.26, RPO – PLN 3 683 566.88.

Currently these funds are spent on building a Composting Plant in the technology of closed, reinforced concrete bioreactors. This investment will finally close an investment process lasting many years that allows facilities in Sobuczyn to meet the criteria of the best available technology [26].

The administration of the City of Częstochowa has 100% share in the Company, i.e. Częstochowskie Przedsiębiorstwo Komunalne Spółka z o.o. in Młynek–Sobuczyn near Częstochowy (CzPK). This Waste Management Plant has a huge municipal landfill site and fulfills the role, in accordance with the plan of waste management of the Silesian Voivodeship, of a regional facility. That's why the City of Częstochowa, as part of its own task, entrusted the Company with organisation of the system of waste management in the territory of the City of Częstochowa.

The regional facility in Sobuczyn is a facility for mechanical and biological waste processing consisting of: a sorting line with a capacity of 90,000 Mg/year and a composting

plant with a capacity of 40,000 Mg/year. The Regional Facility for Municipal Waste Processing in Sobuczyn also has additional technological capabilities for waste processing on a separate sorting line that can process 77,000 Mg/year of municipal waste, including 30,000 Mg/year of waste from selective collection and at a plant for large-size waste processing with a capacity of 25,000 Mg/year and a plant for renovation and construction waste processing with a capacity of 15,000 Mg/year. In total, 207,000 Mg of waste can be processed in plants in Sobuczyn [29].

The municipal waste management provides the achievement of appropriate levels of recycling, preparation for re-use and recovery using other methods and reduce the weight of biodegradable municipal waste transferred to storage (*Table 1*).

Table 1
Levels for the management of municipal waste achieved by Częstochowa in 2012–2015

Type of waste management	2012		2013		2014		2015	
	Level required [%]	Level achieved [%]	Level required [%]	Level achieved [%]	Level required [%]	Level achieved [%]	Level required [%]	Level achieved [%]
recycling and preparation for re-use and recovery using other methods fractions: paper, metal, plastic, glass	10	20,13	12	20,69	14	18,73	16	24,63
recycling, preparation for re-use and recovery using other methods of non-hazardous construction and demolition waste	30	16,05	36	37,85	38	63,32	40	69,91
reduction of biodegradable municipal waste sent to storage in landfill	Acceptable level [%]	Level achieved [%]	Acceptable level [%]	Level achieved [%]	Acceptable level [%]	Level achieved [%]	Acceptable level [%]	Level achieved [%]
	75	0,11	50	0,18	50	0,06	50	0,04

(Source: Own work based on [30])

Częstochowa Municipal Company is responsible for the collection and transport of waste generated on all property from the territory of Częstochowa. In the area of Częstochowa there are:

- 20 entities receiving municipal waste,
- 40 points of collection of waste electrical and electronic equipment (from households),
- 34 landmarks selective collection of green waste,
- 218 nests and 258 points of selective collection of municipal waste,
- mobile collection point for problematic waste,
- mobile collection point for large waste.

The municipal waste management includes all residents the Northern Sub-region. The regional facility, which get mixed municipal waste, biodegradable and remnants from sorting is obligatory The Regional Facility for Municipal Waste Processing in Sobuczyna.

This facility provides processing of all municipal waste generated by the residents of the Northern Sub-region. A newly built Compost Plant is capable of processing of green waste.

6. Conclusion

The relevant act makes communities fully responsible for waste management in their territory. The introduced changes were designed to bring numerous positive changes in this area, such as: tightening of the waste management system, effective selective waste collection, reduction of the number of illegal landfill sites, construction of facilities for waste processing and reduction of threats to the environment as a result of waste transport. When developing municipal waste management systems, it is important to use logistics.

Municipal waste management in the Northern Sub-region is realized through the collection, accumulation, receiving and transport, utilization and disposal of municipal waste. The analysis of the Northern Sub-region confirms that new legal regulations are systematically implemented in communities, which enables management of a stream of produced municipal waste, and creates a system for municipal waste management based on its selective collection, in which the energy potential of waste is used and processed waste is stored. The facility in Sobuczyna, which has the status of a regional facility, meets both ecological and economic requirements. The facility for waste processing will ultimately have appropriate capacity, which should contribute to achievement of required targets in municipal waste management, including achievement of required recycling levels, preparation for re-use, recovery and reduction of the mass of biodegradable municipal waste directed for storage.

In this study some aspects of logistics management of municipal waste are described. Lack of comprehensive empirical data for the Northern Sub-region is an important limitation of the study. Future directions of research should focus on investments in the field of municipal waste management in the Northern Sub-region.

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