

Municipal Waste Management Systems in the Terms of Logistics

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Abstract— The paper demonstrates the need of use logistic solutions to develop municipal waste management systems. It was shown that waste management logistical systems ensure efficient management of the whole process, are useful for the overcoming of various implementation difficulties, and facilitate planning long-term investments. As an example, the new established waste management system in the Warsaw, the capital of Poland, was rated in terms of fulfilling the conditions of the logistics system. The effects of the three years implementation of the reform on municipal waste management were summed up. The necessary changes in waste management in Poland related to the transformation of the European Union economy into a closed-loop model have been discussed.

Index Terms— Municipal waste, waste management, waste logistics systems, circular economy

I. INTRODUCTION

According to the amended regulations on waste management, the municipal authorities in Poland are obliged to manage the waste because the municipalities became their owners [17]. New waste management policy required by the EU directives was introduced by the Waste Act in late 2012, which began to apply in 2013 [16]. Waste management regulations specified in the law are aimed at protect human life and health and protect the environment in accordance with the principles of sustainable development. In detail, the regulations include sections such as prevention of waste generation, reduction of waste production, elimination of negative impact of landfills and processing plants on the environment, and preparation of waste for reuse or utilization [5], [6].

According to the latest EU directives related to functioning of the whole economy in close circulation, Poland must achieve 50% of waste recovery by 2020. In addition, the EU rules stipulate that waste should be processed on its area, so e.g. composting should be done in waste collection areas. Taking into account currently required in waste management the priority of recycling, municipalities should accomplish two goals: organizing a well-functioning waste reception system and ensuring an adequate level of waste recovery [7], [10]. New tasks as results of UE regulations are the challenge for these municipalities that invested in waste incineration plants.

II. WASTE LOGISTICS

Waste management, in order to achieve efficiency and effectiveness, should be supported by logistical solutions [1]. For this purpose, a new branch of logistics has been developed called reverse logistics. In the literature of the subject, the reverse logistics is known as waste logistics, recycling logistics, recovery logistics as well as eco-logistics [11], [12], [22]. The purpose of waste logistics is to find the

most convenient organizational and cost solutions for transport, storage, processing and waste disposal. Waste logistics supports all waste management processes (including full and damaged products recognized by their disposers as a waste) and information related to waste flows from places of origin (appearance in the logistics system) to the place of destination where the waste is treated for reuse, recovery (repair or recycling) or proper disposal and long-term storage [23]. The proper organization of waste flows should ensure their economic efficiency and minimize the negative impact on the human environment.

III. WASTE MANAGEMENT LOGISTICS SYSTEMS

The amended Waste Act requires every municipality to develop a waste management system [16]. According to experts in the field of waste logistics, in order to ensure efficiency and effectiveness, waste management systems should have the character of logistics systems [1]. The logistic waste management system should take into account functional areas including waste generation, transport to processing facilities where waste is stored, recycled or neutralized, as well as current general and local regulations [1], [2], [23]. External conditions constituting restrictions on the functioning of the logistic waste management system include:

- quantity, composition, and location of waste,
- degree of regularity and dynamics of waste generation,
- principles of environmental protection,
- spatial and urban factors such as the structure and configuration of the settlement network of the region, the location of processing facilities, transport routes, spatial structure of economic activity,
- general standards, as well as local and regional requirements for acceptable environmental pollutants.

Internal conditions are closely related to the technological aspect of transport, storage and processing of waste and include:

- way of collecting waste,
- location and size of objects,
- functioning of objects,
- waste transport routes and appropriate means of transport.

The scheme of the system may correspond to a static or dynamic model. In a static model, the description of the system operation concerns a specific time point. The dynamic model takes into account changes in input parameters over time, so it should take into account:

- frequency of waste generation,
- possibility of stepwise localization of objects,

- restrictions on the capacity of objects,
- possibility of launching new waste recycling processes,
- location of places available to build new objects.

Developing a logistical waste management system should take into account the location of towns and villages in the region and the location of industrial plants. Waste processing facilities can be sorted out in terms of how to recycle or dispose of waste. Evaluation of processing objects includes:

- Existing objects.

If there is no need to build new facilities then it should make an evaluation already existing facilities, with particular regard to their technical condition, the ability to modernize and expand. It is necessary to assess obstacles related to location and access to the storage site and establish environmental conditions.

- Planned objects.

When creating a new facility is necessary, the primary task is to provide access to it. In the absence of a suitable route, it is necessary to determine what financial contribution should be required to the construction of a new road.

Detailed assessment of the new facility includes:

- Geotechnical conditions.

Type of soil and its degree of permeability, groundwater level, land drainage conditions in a given area.

- Environmental conditions.

Sanitation hazards, soil, air and water pollution.

- Urban conditions.

Geographical location, height of the object, nuisances of the object for the environment, possibility of further expansion, and external appearance.

- Operating conditions of cooperating objects.

Amount of waste that will be stored in the facility, lifetime of the landfill.

- Disruptions of the system.

Identification of emergency actions such as the organization of substitute landfills and the assurance additional means of transport.

- Development intentions.

Modernization of objects, replacement of equipment and vehicles.

As an example of the functioning the municipal waste management system, the authors of this paper took into account a system implemented in Warsaw, city capital of Poland. Warsaw is the largest city of Poland, located in the central-eastern part of the country, on the Vistula River.

An evaluation of Warsaw waste management system was made taking into account the requirements of the logistics system.

IV. WARSAW WASTE MANAGEMENT SYSTEM

The municipal waste management system in Warsaw was developed in a document entitled 'Waste Management Plan for the Capital City of Warsaw for 2008-2011 with a perspective for 2012-2015' [9]. This plan covers the tasks of the province and the town community due to the fact that the capital city of Warsaw is a municipality with province rights.

This plan was accepted by the resolution of Council of Warsaw on December 8, 2015.

The scope of the Waste Management Plan includes:

- analysis and evaluation of the current state of waste management with identification of problems,
- predicted changes in the functioning of the system,
- specification of waste management objectives,
- actions aimed at improving the situation,
- instruments and financial resources for the implementation of planned investments,
- estimating the operating costs of the waste management system,
- monitoring system and evaluation approach to assess of achieving the intended goals.

Morphological analysis showed that municipal waste mainly includes:

- organic components (vegetable, kitchen remnants, animals),
- paper and cardboard,
- plastics,
- glass,
- metals,
- minerals,
- ash fraction,
- hazardous waste.

In the stream of municipal waste there are also components requiring separate treatment, i.e. large-scale waste and waste from the renovation of houses and flats.

Waste management plan emphasizes that the waste management system being developed should be characterized by such features as 'regional' and 'perspectives'. The idea is that in the future the system would allow the management of municipal waste not only from the area of capital city of Warsaw, but also from neighboring municipalities forming urban agglomeration. Comparison with the EU legislation and with municipal waste management methods applied in European agglomerations similar to Warsaw, e.g. Vienna, indicates the need to reorganize the existing system and invest in modern waste recycling and utilization facilities.

Warsaw occupies a total area of 617 km², inhabited by 1.7 million people. There are also 500,000 people not registered in Warsaw. In the structure of Warsaw residential areas (habitable, industrial and other built-up areas, also undeveloped and recreational areas) are predominant. Their area in 2001 was over 17 thousand hectares and is constantly growing. A significant part of the city area also occupies farmland, over 15,000 hectares, but their surface is decreasing. The remaining part includes grassland (over 3,000 hectares).

Administratively, the capital city of Warsaw is divided into 18 districts (from 2002) having the status of auxiliary self-government units (Fig. 1). The largest district constituting 15.4% of the city's total area is Wawer District, then Bialoleka (14.1%), Ursynow (8.5%), Wilanow (7.1%), Mokotow (6.9%), Bielany (6.3%), Wlochy (5.5%), Bemowo (4.8%), Targowek (4.7%), Wesola (4.4%), Praga Poludnie (4.3%), Wola (3.7%), Rembertow (3.7%), Srodmiescie, i.e. Central District (3.0%), Praga Polnoc (2.2%), Ochota (1.9%),

Ursus (1.8%) and Zoliborz (1.6%). Individual districts are characterized by different conditions and directions of development.



Fig.1. Administrative division of Warsaw

Source: Press materials

To realize waste management in Warsaw the following types of activities are listed:

1. Organization the system of selective waste collection through:

- a) intensification of collection by the way 'at source' and 'containers set in the neighborhood',
- b) district points of voluntary waste collection,
- c) mobile points of waste collection.

2 Investments:

- a) material recovery facilities for selective waste collection:
 - construction of 8 district points of voluntary waste collection,
 - construction of 2 systems for the sorting of selective waste materials with a capacity of 20,000 Mg/year with the possibility of expansion to 30,000 Mg/year; In addition, there will be existing sorts of raw material waste belonging to private entrepreneurs,
 - construction of green waste composting plant with a capacity of 20000 Mg/year,
 - construction of an anaerobic treatment of biodegradable waste with a capacity of 10,000 Mg/year,
 - construction of an installation for the dismantling of large-scale waste, including partially used electrical equipment with a target capacity of about 10,000 Mg/year,
 - construction of a plant to process the waste generated in home renovations with a capacity of 8,000 Mg/year.

b) installations for the disposal of waste mixed with the recovery of heat and electricity:

- modernization and extension of the existing municipal waste utilization and incineration plant for operation of the right bank of Warsaw (Municipal Solid Waste Disposal Plant) and the agglomeration with the target capacity of 312,000 Mg/year,

- undertaking activities aimed at the construction of a second waste disposal facility for operation of the left bank of Warsaw and the agglomeration of 390,000 Mg/year (taking into account the forecasts of the amount of generated waste by 2025 and the possibility of servicing the surrounding municipalities).

c) storage facilities:

- construction of a non-hazardous and inert waste landfill with a capacity of 400,000 Mg in 2009, 300,000 Mg in 2011 and then around 190,000 Mg in 2013. The amount of landfill waste will be reduced due to the requirement to reduce the amount of biodegradable waste directed to the landfill and from 8 January 2013 to meet the criteria for the acceptance of waste for disposal at the landfill of that type.

2. Education:

The program of learning: how to properly handle waste.

Functioning of the planned system (Fig.2):

1. The mixed municipal waste will be directed to the thermal treatment of waste with the recovery of heat and electricity.

2. The system of selective collection and recovery of waste will be expanded:

- a) selective collection will cover the following types of waste: packaging waste, paper and cardboard waste, plastics waste, metals, hazardous waste, large-scale waste, construction waste, green waste, biodegradable kitchen waste (restaurants, hotels, canteens) and waste electrical and electronic equipment,
- b) selected raw material waste will be collected 'at source' from single family housing, and from multi-family housing by means of 'neighboring containers' and in district points of voluntary waste collection and then directed to the waste sorting plant,
- c) household waste and other biodegradable waste will be collected selectively 'at source' in single family and low multi-family housing,
- d) green waste from green areas will be selectively collected 'a source' and through district points of voluntary waste collection.
- e) selectively collected biodegradable waste will be composted in green waste composters and fermented in methanization plants,
- f) hazardous waste will be collected at district points of selective waste collection and in specially designated areas (e.g. pharmacies, schools, shopping centers, etc.); in addition, companies authorized to receive municipal waste, according to the regulations are obliged to receive, among others. Selectively collected hazardous waste by landlords,
- g) hazardous waste will be disposed of in specialized facilities dealing with the disposal of hazardous waste outside the capital city of Warsaw,
- h) large-scale waste will be collected as part of a temporary collection and in selective waste collection districts; in addition, companies authorized to receive municipal waste pursuant to the regulations are obliged to collect selectively collected large-scale waste by landlords,
- i) large-scale waste will be recycled in special dismantling installations,
- j) waste from repairs and demolition shall be taken in the

district points of selective waste accumulation and recovered in the debris processing plant; In addition, companies authorized to receive municipal waste pursuant to the regulations are obliged to collect separately collected waste from demolition by property owners,

k) ballast waste from the sorting plant for packaging and raw material waste will be disposed of in the waste thermal treatment plant and to the landfill depending on the type of waste.

This system was called the new system because it successively covered other districts due to difficulties in conducting tenders (the decisions were appealed to the court by some participants in the tender). It is only from 1 August 2014 that a uniform system of municipal waste is applied throughout Warsaw.

V. RATING WARSAW MANAGEMENT SYSTEM

Waste Management Plan in Capital City of Warsaw was evaluated by the authors of this paper as a report for the

International Conference on Logistics, Transport Systems, and Transport Safety in Szczyrk, Poland in 2015 [2]. Rating was repeated after the term of obligation (to the end of 2015), taking into account the functioning of the system and its effects [3].

The waste management plan of the system covered the period up to 2015. The city authorities have decided to update the waste management system as part of the creation of the new 'Environmental Protection Program for the Capital City of Warsaw for 2017-2020 with a view to 2023'. In this purpose a cycle of debates under the name 'EcoWarsaw' was organized as meetings of inhabitants with experts and officials.

Useful information for residents Municipal Department of Environmental Protection publishes on the municipal portal (<http://www.czysta.um.warszawa.pl>) includes up-to-date communications, legal documents specifying the system framework, form templates for making declarations, answers to frequently asked questions, useful tips, for example how to properly segregate Waste, or how to set up a composter.

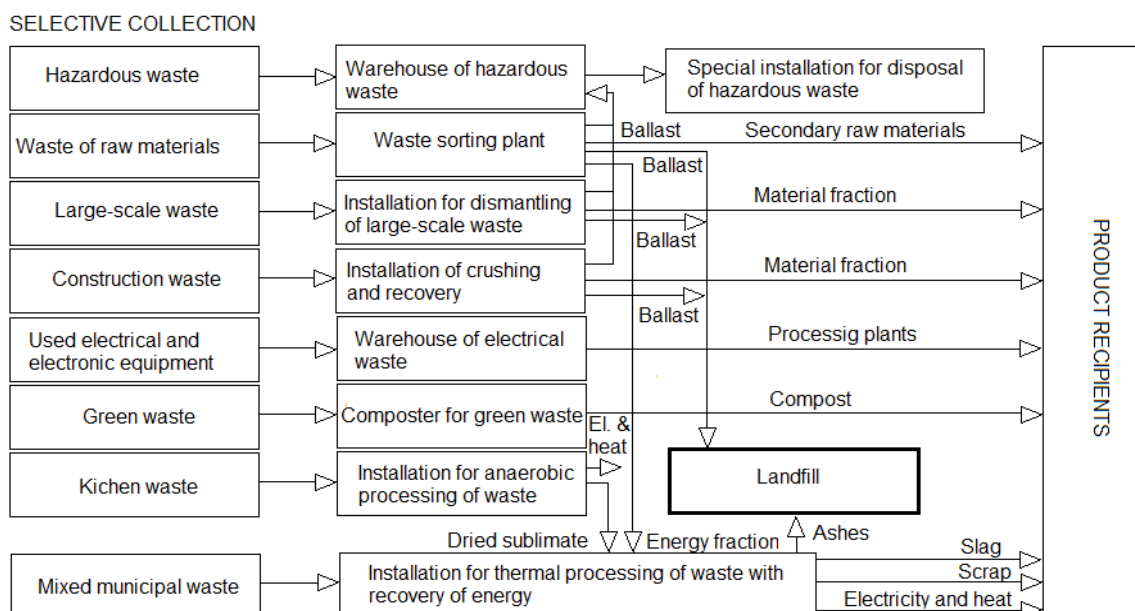


Fig.2. Scheme of waste management system in Warsaw

Source: Own material on the basis of [9]

Further rating was made based on the observations of the effects of the functioning of the system, as well as the residents' complaints and opinions of journalists [4]. In this paper the rating of functioning system was made on the basis of ongoing implementation, comments of self-government activists, guidelines of the Ministry of Environmental Protection and opinions of residents and journalists as well as of the changes enforced by the new legislation in response to EU Circular Economy Directives. Regarding the planned system described in the Waste Management Plan in Warsaw, authors of this paper find that it contains logistic-oriented system features, as the specification of external determinants and internal conditions, the forecast of waste generation, and the directions of development grouped in legislative, organizational, investment and educational activities. Unfortunately, the implementation of the system from the beginning was not correct. The main defects in the functioning of the system are:

- **Wild dumps**
Despite the obligation to export and segregate waste to municipalities, rubbish in the initial phase of the system's implementation was still being dumped in the forest and into illegal landfills. The reason for littering the surrounding woods was that many people successfully avoided fees, such as keeping the number of homeowners and not reporting their homes. Waste collection periods were too long, which was not enough for some residents.
- **Inadequate selective waste collection infrastructure.**
The city has long failed to fulfill its obligation to create voluntary waste segregation points. Access to information on hazardous waste collection sites or large-scale disposals was difficult. Only the monitoring of the Warsaw City Hall office by the local press contributed to the discipline of the clerical apparatus and organized two permanent points of selective waste collection in October 2015, one on the left bank (on the

border of Mokotow and Wilanow districts, on Zawodzie Street no. 16), second in the right bank of the city (in the district of Bialoleka, Plytowa Street no. 1). Before, there was only one waste collection point [13]. These points accept environmental pollutants such as paints, varnishes, adhesives, aerosols, detergents and chemicals and their packaging, fluorescent lamps and batteries, as well as green waste. But they do not take debris (except debris from self-repair) and furniture. In addition, mobile collection points were organized. It consists in the fact that from mid-October 2015 on Wednesdays and Saturdays special cars are on the streets of Warsaw and they stand after 1, 5 hours in a designated place in each district (list of places and hours can be found on the portal: <https://www.czysta.um.warszawa.com>). Mobile points do not accept debris, large-scale waste, green waste, electrical and electronic equipment, or furniture. The collection of this waste takes place in every district of Warsaw on Saturdays.

- Education of inhabitants

Educational actions have contributed to a better understanding by residents of the importance of segregation of waste, but the very way of providing useful information was poorly organized. Long working of the principles of waste segregation delayed the placement of properly labeled waste containers in the streets, which was only done in mid-2014 (Fig. 3).



Fig. 3. Containers for waste segregation

Source: press materials

With the setting of the containers, an information campaign was carried out covering the streets and the distribution of leaflets describing the types of waste segregated (Fig. 4).



Fig. 4. Information leaflet

Source: District Portal, <http://www.targowek.pl>

Waste are divided into three groups: dry waste (in red containers), glass (in green containers) and mixed waste (in black containers). Residents, however, still find it difficult to properly segregate waste as they have become accustomed to the old classification, where waste was divided into paper, plastics, glass and metals. Varied educational actions are carried out by non-governmental organizations. The Musical Wizards' Foundation organizes the 'Christmas Eco-Help' campaign in December. The entire income from the waste management is allocated to support the charges of foundations, which are people with intellectual disabilities from the Warsaw Self-Help Center. The organizers encourage residents to bring their waste electrical and electronic equipment, batteries, plastic, metal, paper and packaging glass with them. Anyone who brings waste will receive a Christmas tree in pots. Waste is collected at voluntary points of selective collection of municipal waste. The city provides two special bus lines on the day of the action to bringing residents to the waste collection points. The cyclical educational action is Warsaw Recycling Day under the slogan 'ECO arranged'. Warsaw Recycling Days are organized in the spring and fall by NGOs and waste collection companies. Residents are encouraged to bring recyclable materials and waste electrical and electronic equipment. The main message of the Warsaw Recycling Day is the promotion of efficient waste segregation, pro-ecological behavior, conscious shopping, proper waste management and sharing with other products that are no longer needed. During the last action in September 2016, in each district in exchange for the recycled materials, plantings (perennials, herbs, trees and shrubs) could be obtained. In addition, 'Clean up the World' action was conducted in each district. All the people taking part in it received vouchers for the seedlings. On Sunday, at the Parades Square at the center of the city took place a picnic with various attractions, contests, quizzes, workshops, time stamps, ecological rebirths, nature-related funs, paper-making workshops, presentations of modern gas-powered garbage trucks, gifts and educational materials awaited all participants.

- Investment delay

The construction of new waste treatment plants is necessary because existing plants use outdated technology requiring long storage of waste before they can be re-used. Wastes received from generators by specialized traders are supplied to the recovery or disposal facility. The municipal waste recovery and disposal system is based on the following main facilities: Radiowo Composting Plant (Fig. 5).



Fig. 5. Landfill in Radiowo

Source: Press materials

The second composting plant at Marywilska Street in Bialoleka District was not approved for waste treatment in 2006. Municipal Solid Waste Disposal Plant and Municipal Waste Landfill located in Lubna in the municipality of Gora Kalwaria. There is no municipal waste disposal facility in Warsaw, and a significant amount of waste is generated in various landfill sites, both within and outside the Mazovia Voivodeship. In total, the waste is exported to 19 landfills (public and private), up to 44 waste recovery plants and to the Municipal Waste Disposal Plant (incineration plant). Long-term waste discharges the odor nuisance for local residents. Before the local government elections in Warsaw in November 2014, the city authorities had promised to transfer the waste disposal plant from the Radiowo in Bielany district to the nearby town of Zielonka. The plant in Zielonka was to be located far from the building. The new plant was planned to build a modern incinerator for waste collected from Warsaw and its surroundings. After the election, the new authorities of Warsaw changed the location of the plant and decided to expand the municipal waste treatment facility on the right side of the Vistula River at the confluence of Zabraniecka Street and Gwarkow Street on the border of Targowek and Rembertow districts (Fig. 6). The plant at Targowek handles around 40,000 tons of rubbish a year, and after the extension it is expected to convert over 300,000 tons.

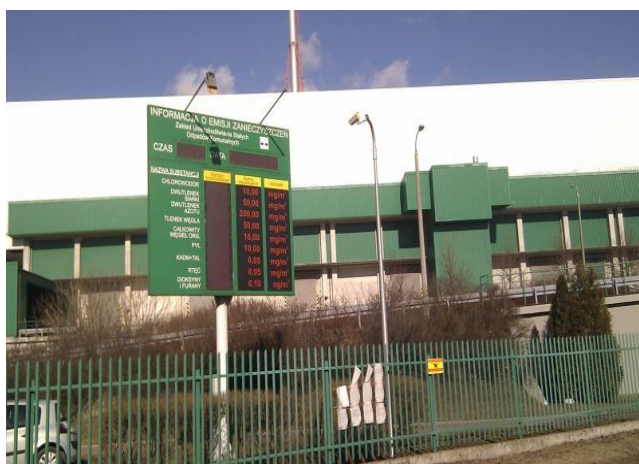


Fig. 6. Incinerator at Targowek district
Source: Press materials

The factory has been operating since 2000 as a waste incineration plant. This incinerator was obsolete at the time of launch, because the city government had opted for a cheaper 80s technology. From the beginning it was planned to modernize the plant, which today uses about 10% of municipal waste, which is about 70 thousand tons per year. The construction of the new incinerator is delayed mainly because of the lack of agreed position on its funding. The installation was originally to be financed from municipal funds, then from EU funds, and finally from a private investor. When it turned out that the installation would generate big profits, the city authorities once again changed their minds. In December 2015, the Warsaw Council decided that the expansion of the incinerator, which would remove up to 320,000 tons of rubbish a year, would be financed by the town hall. Municipal City Cleaning Company is able to finance the investment financially as the European Investment Bank has already awarded over PLN 560 million. Negotiations have been concluded with consortiums of banks

to provide commercial credit for the investment budget. In addition, the Cleaning Company is seeking around PLN 600 million from EU funds to refinance loans. The new incinerator will not be a nuisance for residents. Only about one third of the plant is a grate furnace to burning waste. The rest of the place will occupy the most advanced system of flue gas cleaning in Poland. The object will generate about as much gas as one truck with the engine turned on, and the garbage trucks will dump the waste in a vacuum chamber from which air will not get out (Fig. 7).



Fig. 7. New incinerator at Targowek – Project
Source: Press materials

In December 2016 announces a tender for expansion and combustion equipment acknowledging that the tenders through reverse for appeal, Municipal City Cleaning Company plans to sign a contract with the contractor in September 2017. The remarks that the construction of six plants recently formed lasted approximately 24 months on average, so that in the autumn of 2019 a new incinerator could be commissioned [18].

- Inconvenience of landfills for local residents.

Despite the declaration of the city authorities, the landfill in Radiowo has not been liquidated and is still a source of odor, a nuisance for the local residents. City authorities would like to extend the landfill until 2018. At the initiative of the 'Clean Radiowo' Association, at the request of the public prosecutor's office, the Environmental Protection inspectorates initiated administrative proceedings but decided that there was no reason to suspend the landfill operation because no degradation of the environment was observed. The Association 'Clean Radiowo', which appealed the decision to the Province Administrative Court in Warsaw, disagreed with the decision of the Inspectorate (concerning one part of the landfill the so-called mechanical and biological waste treatment facility). The Ombudsman also joined the case in support of the complaint of the Association. Ombudsman pointed to the major shortcomings of the conducted procedure, which incorrectly assessed the impact of the landfill on the health of the surrounding population, including their mental health. On January 24, 2017 the Province Administrative Court in Warsaw upheld the complaint and overturned the decision. The court pointed to numerous defects, in particular the lack of reference to the

functioning of the storage site to the binding emission standards and failure to adequately assess the threat that this activity has to the life and health of the surrounding population. The Ombudsman expects a written justification for the judgment. It is not valid and has a cassation appeal from the Supreme Administrative Court. The Ombudsman's complaint against the decision regarding another part of the landfill (composting plant) at the Radiowo is also expected. On a smaller scale, similar inconveniences for local residents due to the spread of fetuses by waste treatment plants took place in 2016 in the Bialoleka district. In the area of Zarzecze Street, three companies engaged in waste disposal were operating 20 m from the multi-family building at Zarzecze Street and in the vicinity of streets with single-family buildings and blocks. Due to ignoring the matter by the city authorities, the intervention was taken by journalists of the local newspaper 'New Gazette of Praga' [14]. Journalists' intervention has shown mechanisms of irregularities in the issuance of clerical decisions for the operation of waste disposal companies. Journalists have shown that the material benefits a city derives from business are more important to decision-makers than to the quality of life of its residents. Journalists have found legislation that could lead to the cessation of garbage businesses in the area [15]. According to the Athens Treaty of 16.04.2003, Poland has committed itself to designating within its territory a network of 'Nature 2000' areas (including areas on the Vistula River in the Zarzecze region), i.e. it must comply with EU legislation prohibiting investments in these areas threatening the environment. These regulations were introduced into the Polish law of the day 16.04.2004 by Act on nature conservation.

It should be emphasized that waste management operates on a free market basis. The city is only a supportive and enforcing unit of local law. To this law belongs to the rules of maintaining cleanliness and order in the Capital City of Warsaw, adopted by the resolution of the Warsaw Council on June 22, 2006.

VI. SUMMARY OF THE WASTE MANAGEMENT REFORM

The implementation of the reform of waste management in Poland, commonly referred to as the 'garbage, reform, has already passed three years. According to Andrzej Kraszewski, a former minister of the environment and co-author of the laws amending the rules of waste management in Poland, the system is civilized [19]. The greatest scourge in the early stages of reform was wild landfills in the forests where waste was dumped by small businesses that did not recycle their waste. The Voivodeship Inspectorates for Environmental Protection eliminated these illegal practices.

At present, after the regulation has been amended, the requirement to conduct a competition for the selection of companies receiving waste is eliminated. Withdrawal from tenders has made it possible to select subordinate municipality companies in the 'in-house' procedure. Municipal companies can be better controlled by municipalities than outside companies. The former minister Kraszewski admitted that there was too little control in the whole system. The waste management reform was planned by the Ministry of Environmental Protection with the establishment of the Environmental Protection Agency. Unfortunately, the eminent prime minister did not agree to its

establishment. Over time, the situation has improved as the provincial inspectorates have been re-equipped and have learned to fight abuses. Local authorities, on the other hand, had ceased to rely solely on the low cost of rented companies and have begun to pay attention to their infrastructure.

Currently the Chief Environmental Inspectorate announces that it will significantly strengthen control. However, with the police's reluctance to fight abuses in waste management, the government should create a kind of State Environmental Protection Agency. On the other hand, when it comes to controlling the population, with the choice of parenting or coercion and the imposition of penalties, the Ministry has chosen ecological education. However, ecological awareness of society is improving slowly and therefore control activities are still needed.

Ecological behavior is, in current conditions, an excessive financial burden for society. The state should reduce the cost of using alternative energy sources, which is the responsibility of the government. Then the demand for alternative energy sources would be increased.

Pro-ecological education is expensive in the current situation, because the leaflets and posters do not produce nearly any effects, the Internet is much more effective, but it is far from television. 70% of the respondents admitted that they learned from television about the so-called garbage reform [19]. Media is subject to economic pressure, which assumes that only profit is counted and no one gives a discount for promoting ecological attitudes.

It is commendable to the attitude of artists who have engaged in promoting recycling by designing furniture or clothing from recycled materials and even by creating works of art from waste. In the scrap metal warehouse in Pruszkow, the city near Warsaw, the workers themselves created steel-cast sculptures showing various vehicles and characters from science-fiction films with the help of burners. The local authorities opened the special pavilion for these sculptures as the Museum of Steel Figures. There are school trips for educational purposes. On the other hand, in Warsaw there is an open-air art installation composed of a old 'Syrenka' (in English 'little mermaid') brand car with welded motors shaped as a symbolic Mermaid (hybrid half woman and half fish) which in the historical symbol of Warsaw placed in a official crest of City Warsaw. This work initially stood on the Vistula River as one of the exhibits of the exhibition 'Warsaw Mermaids' at the new pavilion of the Museum of Modern Art, then it was moved in front of the Building of Targowek District Office (Fig. 8).

When assessing the reform, it is also legitimate to ask whether it was really needed. Under Polish conditions, the reform of the waste management system has even been called a revolution [8]. Although the reform by imposing a number of new tasks on municipalities was not popular among local government officials, the lasting advantage of its implementation is the inclusion of Poland in the waste management system required in EU countries.

Implementation of the new waste management rules, introduced three years ago, still requires a lot of government efforts, mainly to allocate financial resources for pro-ecological education, reduce the cost of using alternative energy sources, and promote cooperation between local governments and scientists [6]. The next changes in regulations of waste management are related to the introduction of circular economy in EU.



Fig. 8. Mermaid created from scrap (above: Warsaw crest and monument to Mermaid)

Source: Private material

VII. WASTE MANAGEMENT IN CIRCULAR ECONOMY

The reform of waste management in Poland is continued, and the Ministry of Environmental Protection plans to amend the legislation. The current amendments refer to alignment with the EU Directives on the development of circular economy (also called a closed-loop economy). In 2020, according to EU regulations, Poland needs to achieve a 50% recycling rate. It is almost certain, however, that in the coming years this percentage will increase. In the EU countries the level of recycling of municipal waste up to 2030 may increase to 65%. However, the level of waste disposal would be limited to 10% [20].

Currently in Poland, the recycling level of four basic municipal waste fractions (paper, metal, plastics and glass), mainly those from home, is significantly different from the European average of around 26%. Between 2014 and 2015, the recycling level of the four fractions in Poland increased by only 0.7%. That is why the Ministry of Environmental Protection has introduced a unified waste selection rule, which has been in effect since 1 July 2017 [21]. Waste must to be collected in four containers of different colors (Fig. 9): glass (green container), paper, including cardboard (blue), biodegradable waste with special consideration of bio-waste such as kitchen waste (brown) and metals and plastics

(yellow). Local governments will have five years to customize the coloring of containers. The old rules may also apply until the expiry of the tenders. Whereas the designation of containers without their replacement, for example by means of appropriate leaflets, the municipal authorities must do so by the end of December, 2017.

The Ministry of Environmental Protection is also working on an amendment to the so-called junk act, i.e. the Law on the maintenance of cleanliness and order in municipalities. The changes relate to the reduction of garbage removal fees for those residents who are well segregated. The introduction of new rules for waste segregation is an argument for the allocation of PLN 1.3 billion from EU funds for waste management.



Fig. 9. Containers for uniform waste segregation
Source: Press materials

These funds can be used for the construction of more points of selective collection of waste in the area of municipality. The ministry also wants to delete from the Act the records of the main role of the installation for the mechanical and biological processing of mixed municipal waste. Using only these installations will not ensure the level of waste circulation required by EU directives. It is difficult to invest in incinerators. For some time the leading role of lobbyists has been played by the incineration companies and the large installations of mechanical and bio-processing waste, which are actually taking the lead in developing smaller, more ambitious initiatives. These companies have a tremendous amount of money to help them reach the media and authorities. Municipalities, in line with national and provincial plans, have invested money in large incineration plants, but meanwhile, it appears that there will be no contribution at the start.

It seems that next to the ministerial regulations and amendments to the law, a wider educational action is needed at the governmental level. Many experts and local government activists determine the adaptation of domestic waste management to the EU circular economy as a revolution of garbage. Up to now, incineration of waste in modern incineration plants has been an important way of disposing of waste. Meanwhile, waste incineration is a technology that destroys resources, consumes other resources. Waste incineration is an element of linear economy, where the element supporting the operation of the system is the continuous increase of waste. Incineration plants are

expensive investments that are contracted for many years with the respective territorial units obliged to deliver a certain amount of waste for incineration. Generally, waste incineration does not serve ecology, as future generation burn ash from incinerators and alternative green and ambitious waste disposal initiatives are shifted 25-30 years further. At the same time, job creation in the repair and recycling sectors is being lost.

A major obstacle to the recycling of waste is the use of toxic substances and components in products. It should not recycle materials that contaminate another product with substances listed on the list of hazardous substances. An example is PVC material that is recyclable but should not be re-introduced because it contains dangerous substances from DEHP group that have been found to be carcinogenic. Hazardous waste should be disposed of and stored in special landfills that ensure the penetration of harmful substances into the soil and air. However, there are municipalities that allow hazardous waste incinerators to operate in their area.

With the amendments to the Waste Act, legislative changes in the laws governing the manufacture of packaging are also needed, which is in line with the trend towards reducing the generation of waste at source. Already, the Waste Act already foresees the creation of a Database of Products and Packaging. According to the provisions of the law, the obligation to operate the database entered into force on January 23, 2016. The paper annual reports submitted by entrepreneurs were replaced by one to which the data will be made available online through the registered number.

This provision is the implementation of the 'polluter pays' principle is one of the fundamental principles of the EU policy on the environment. According to this principle, waste is treated as pollutant emissions. Waste generation is unavoidable, but for some groups of waste the so-called 'extended producer liability' is considered. This applies to packaging waste and waste products such as tires, batteries and accumulators, end-of life vehicles and electrical and electronic equipment. When placing goods on the market, producers and importers are obliged to participate in the cost of their future disposal as waste. Processing of this waste must be of adequate recyclability. This obligation can be implemented directly or through a recovery organization. This system is supposed to help finance the emergence and functioning of the modern waste-based recycling industry and mobilize payers to create products that produce as little waste as possible, especially those destined for neutralization.

The waste producer who is required to keep records may be entity acting under pain of a waste decision (permit for waste generation or an integrated permit) or a producer of waste from which a waste decision is not required. This is due to lack of installation or not to exceed the annual limits (1 Mg for hazardous waste and 5,000 Mg for non-hazardous waste). This is true for small and medium-sized companies that do not have to officially agree on waste generation at the time of decommissioning waste and waste management programs. Similarly, companies that perform waste generation activities (cleaning, repairs, upgrades, etc.) at the installation of foreign recovery organizations, exporters and intra-community delivery of waste from products for recycling.

VIII. CONCLUSION

Implementing the Waste Act obliges municipalities to develop waste management systems. Since waste management contains a broad spectrum of issues of various characters: legislative, organizational, economic, technical and technological, specialists of logistics demonstrate that efficient municipal waste management requires developing logistical systems.

In practice developed systems encounter unforeseen difficulties because waste management is not only technical and legislative issues, but an area that includes the activities of various socio-economic actors, such as municipalities, the environment ministry, waste management organizations and various experts [6]. Government has amended the Public Procurement Law by introducing provisions that allow in-house orders, along with appropriate amendments to the law on cleanliness in municipalities. Solutions are more restrictive than EU regulations, because a municipal company will have to carry out 90% of its activity (80% allowed in UE) to obtain a contract without a tender.

Low ecological awareness of society is also a source of difficulties in implementing established systems.

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