

MOHAMED ALWAEI<sup>1</sup>

## AN OVERVIEW OF MUNICIPAL SOLID WASTE MANAGEMENT IN POLAND. THE CURRENT SITUATION, PROBLEMS AND CHALLENGES

An overview of municipal solid waste management (MSWM) in Poland has been presented. The processes of waste generation and composition have been described and a comprehensive review of MSWM in Poland has been provided, covering some of the important aspects of waste management, such as the current status of waste collection, transport and disposal in Poland. An additional aim of the present work was to identify the potential barriers and the factors affecting waste management as well as provide recommendations for system improvement in Poland and other similar developing countries. An analysis shows that the state of municipal solid waste (MSW) management in Poland is not yet as developed as in many other EU countries. Landfilling is still the predominant method used for the disposal of MSW. Composting and incineration are also used but refer only to a small percentage of the total. According to the latest data (31st December 2014), around 84% of MSW was collected and transported and that ca. 53% was disposed of in landfill, ca. 7% was incinerated at waste-to-energy plants, ca. 11% was treated at organic waste recovery plants and 23% was delivered to sorting. The average generation rate of MSW was 293 kg/capita/year. Generally, recycling in Poland is on the increase, especially concerning easily collectable and recyclable materials such as paper, plastics, glass and metals. Around 37% of MSW collected selectively is recycled.

### 1. INTRODUCTION

Waste management and disposal represents a major economic and environmental issue throughout the world. Trends in waste generation show an increase in the volumes of waste produced in most countries and it is clear that the trend will continue. This is especially true in developing countries as a result of the rapid increase in waste generation caused by rapid urbanization, industrialization and economic development [1]. The

---

<sup>1</sup>Silesian University of Technology, Faculty of Energy and Environmental Engineering, Department of Technologies and Installations for Waste Management, ul. Konarskiego 18, 44-100 Gliwice, Poland, e-mail: mohamed.alwaeli@polsl.pl

increasing production of municipal solid waste has reached the point at which changes must be made, including the implementation of waste minimization programs [2].

Many management systems of solid waste are based on the waste-generation hierarchy. The hierarchy of priorities for solving waste generation problems is as follows: waste minimization, recycling/reuse, treatment and disposal. Unfortunately, these principles are not reflected in the current waste management system in Poland. When analyzing the state of municipal solid waste management in Poland, it is clear that MSWM is not yet as developed as in many old EU countries. By reviewing waste treatment methods, one can observe that Poland still maintains very high rates of landfilling. Other methods such as composting, recycling, and incineration are also used, but on a negligible scale.

In the paper, a comprehensive review of municipal solid waste management (MSWM) in Poland has been provided. Some of important aspects of waste management such as the current status of waste collection, transport and disposal in Poland, have also been discussed in Sections 1 and 2. The future challenges for waste management have briefly been discussed, which could provide the basis for further development in sustainable solid waste management. The third section gives an overview of the current situation of MSWM system in Poland, while Section 4 briefly presents the MSWM barriers affecting MSW management. Section 4 contains a discussion. Finally a number of challenges are made in section 5, aimed at improving the MSW management system in Poland.

## 2. POLAND. A BRIEF INTRODUCTION

Poland is a Baltic state located in central Europe. It is bordered on the north by the Russian Federation (the Kaliningrad province), on the east by Lithuania, Belarus, and Ukraine, on the south by the Czech Republic and Slovakia, and on the west by Germany. The area of Poland extends from latitudes the 49°00' and 54°50' N to longitudes 14°08' and 24°09' E. The total area of Poland is 312 685 km<sup>2</sup>, which includes 311 904 km<sup>2</sup> of the land area (inland waters included), and 781 km<sup>2</sup> of the offshore waters. The arable land covers an area of 186 000 km<sup>2</sup>, forests and coppices cover 91 000 km<sup>2</sup>, settlement areas constitute 10 300 km<sup>2</sup>, mining land covers the area of 400 km<sup>2</sup>, and idle land covers 5000 km<sup>2</sup>. Poland has a three-tier administration system. There are 16 voivodeships and 380 counties. The main industries are: fuel and power industry, iron and steel, machine and electrical engineering, electrical, electronic, metal, chemical, mineral, food, timber and paper-making, as well as light industry.

### 2.1. THE POLICY FRAMEWORK FOR MUNICIPAL SOLID WASTE MANAGEMENT

Waste management is one of the key priorities of EU environmental policy and the framework in this area has been progressively put in place since the 1970s. The fundamental *Framework Directive on Waste Disposal 75/442/EEC* was issued in 1975. It

gives general advises how to prevent and reduce waste arising at source; to increase recycling and re-use of materials and products; and to safely dispose of unavoidable waste. Under the umbrella of this framework directive a number of directives have been decided upon which regulate the disposal and/or recovery and recycling of specific waste streams, among others packaging, waste electrical and electronic equipment and end-of-life vehicles [3]. Each of these sectors is covered by EU directive which sets for recover and recycling of these waste stream. These targets aim to make the best use of resources contained in waste and to minimise the environmental and human health impacts associated with waste management.

Among binding resolutions being introduced by adequate organs of the European Union, are ordinances, directives and decisions regarding the recovery and recycling of packaging waste. Introducing their precept is obligatory for all countries which are members of the European Union. Increasing packaging waste quantity has forced countries of the European Union to face this problem. The issue is reflected in EU legislation. *The European Parliament and Council Directive 2005/20/EC*, passed into European Law in October 2000. To reduce electronic waste going to landfills and incinerators, the European Union in 2003 adopted the *Waste Electrical and Electronic Equipment (WEEE) Directive* requiring producers, starting in 2005, to take responsibility for recovering and recycling electronic waste without charge to consumers. This is intended not only to promote recycling and reduce landfill disposal and incineration, but also as an incentive to producers to design products so as to reduce waste and facilitate recycling. Regarding to batteries and accumulators and waste batteries and accumulators, the proposed Directive 2006/66/EC aims to promote recycling and other forms of recovery in order to reduce the quantity of waste discarded. This directive apply to all types of batteries and accumulators, regardless of their shape, volume, weight, material composition or use (European Commission, 2006). To reduce hazardous and non hazardous waste directed to landfills, the European Union in 2000 adopted the 2000/76/EC Directive on the incineration of waste. The aim waste incineration (WI) directive is to prevent or to limit as far as practicable negative effects on the environment caused by the incineration and co-incineration of waste.

Another directive of fundamental importance for the disposal of MSW is the *Landfill Directive 1999/31/EC* (European Commission, 1999). The directive's overall aim is *to prevent or reduce as far as possible negative effects on the environment, in particular the pollution of surface water, groundwater, soil and air, and on the global environment, including the greenhouse effect, as well as any resulting risk to human health, from the landfilling of waste, during the whole life-cycle of the landfill*. This legislation also has important implications for waste handling and waste disposal. The most important part is Article 5 on waste and treatment not acceptable in landfills, which requires a reduction of biodegradable municipal solid waste going to landfills.

Since 1 May 2004, Poland has been a member of the European Union. This fact has forced the adjustment of Polish legislation to European Union requirements. A number

of legal regulations and norms aligned with international standards has been introduced in Poland.

The new *Waste Act* [4] finally adopted in December 2012, is an important step towards further coordinating efforts in this area. It introduces major changes in the waste management system in Poland. The act implements the provisions of *Directive 2008/98/EC* of the European Parliament and of the Council on waste and a number of other specific directives on the waste management.

In the *New Act* on waste, parts of specific issues concerning waste management, including above all the regulations implementing not only the *Council Directive 2008/98/EC* but also the *Council Directive 2005/20/EC*, *Waste Electrical and Electronic Equipment (WEEE) Directive*, *2000/76/EC Directive*, *1999/31/EC Directive*, *2000/76/EC Directive*, *2000/53/ EC Directive* and *94/62 EC Directive*. However, the legislator did not make an effort to include, in the new main act of 2012 on waste, such issues as packaging waste, batteries and accumulators. The lack of consolidation of regulations on waste in one coherent act shall be assessed critically.

Major changes in the fundamental terminology of waste management law were introduced in the *Act of 1 July 2011 Amending the Act on Maintenance of Cleanliness and Order in Communes and Certain Other Acts*, which otherwise made revolutionary changes in the system for management of communal waste, changing the model for communal waste management and establishing new rules for financing, collection and administration of communal waste from property owners. Definitions were introduced at that time for such concepts as bio-waste, re-use, and treatment. The new *Waste Act* adds or modifies such key definitions as waste, waste management, waste administration, waste storage, waste broker, waste dealer, and waste collection.

## 2.2. INSTITUTIONS RESPONSIBLE FOR WASTE MANAGEMENT AND ECOLOGICAL SUPERVISION

In Poland, three institutions are involved in the organization of waste management: the Ministry of the Environment is responsible for the national waste management strategy, including major assumptions of environment policy which focuses on reducing waste production, recycling, etc; the Ministry of Economy defines the technical standards of waste disposal and deals with both waste utilization and waste processing, treating waste as one of the sources of potential renewable resources and energy. The Ministry of Health focuses on preparing environmental regulations connected with waste processing and reduction under sanitary conditions. Environmental protection is monitored by inspection authorities including the Chief Environmental Inspector, the National Environment Protection Inspection and the Environmental Protection Department. The above authorities perform the tasks of establishing environmental quality standards and defining regulations for environmental supervision; they supervise activities closely related to the functioning of the national system which, in turn, is responsible

for environmental impact assessment; they verify whether or not environmental protection rules are obeyed; organize and coordinate national environmental monitoring, conduct research on environmental quality, and observe and estimate both its state and changes; and develop both analytical and research methods as well as measurement and control methods.

### 3. OVERVIEW OF THE CURRENT SITUATION

#### 3.1. WASTE GENERATION

Poland currently generates and disposes 11 295 million tons per year of municipal waste. This waste is primarily generated by residential, institutional and commercial sources. When municipal generation data are calculated on a per capita basis, each individual in Poland is said to generate about 0.80 kg/capita/day [5]. However, there is considerable variation in waste generation across regions in Poland. A considerable amount of MSW i.e. 46% was generated in four regions, namely: Śląskie, Dolnośląskie, Mazowieckie, and Wielkopolska [5].

Considering that the development of the market economy in Poland and the ensuing economic and social changes occurred relatively recently, the amount of municipal waste generated is still lower than in other developed European countries. The MSW generation per capita in 2013 has been reported in many other European countries. Denmark, with 747 kg per capita, had the highest amount of waste generated in 2013, followed by Luxembourg, with 653 kg per capita.

Cyprus, Germany and Ireland with values between 600 and 700 kg per person. Malta and the Netherlands, Austria, Spain, Italy, France, Portugal and the United Kingdom all generated between 500 and 600 kg per person, while Belgium, Sweden, Finland, Greece, Bulgaria, Slovenia, and Hungary were between 400 and 500 kg. Values of below 400 kg per person were found in the Czech Republic, Poland, Latvia, Slovakia, Estonia, Lithuania and Romania [6].

#### 3.2. WASTE COMPOSITION

Information on waste composition is an essential part of the selection of the most appropriate system for storage and transport, evaluating equipment needs, determination of the potential for resource recovery, choice of a suitable method for disposal, sustainable management programs and proper planning. This information is necessary in order to determine the possible environmental impact on nature as well as on society; identify waste components to target for source reduction and recycling programs; and to allow technical professionals to design any waste facility such as material recovery facilities, composting facilities, projects sanitary landfills, etc. [7].

Nowadays one can observe a changeable municipal waste structure consisting of a mixture of materials which are found in various proportions. The proportion of particular components changes depending on the climate and living conditions as well as on the infrastructure of waste removal areas. In recent years in Poland, the morphologic composition of waste did not differ significantly from the average composition of municipal waste in other countries. Polish waste, when compared to that from OECD countries, is composed of organic waste, small particles of 0–10 mm, and packaging waste.

Table 1

MSW composition [%]

Component	Big city <sup>a</sup>	Small city <sup>b</sup>	Rural area	Average
Organic waste	34.20	42	35.60	37.27
Paper and cardboard	19.10	9.7	5	11.27
Wood	0.20	0.3	0.70	0.40
Multilayer packages	2.5	2.6	1.3	2.13
Plastics	15.10	11	10.30	12.13
Glass	10	10.20	10	10.07
Metals	2.6	1.5	2.40	2.17
Textiles	2.3	4	2.1	2.80
Hazardous	0.8	0.6	0.8	0.73
Minerals	3.2	2.8	6	4.00
Bulky	2.5	4	4.10	3.53
<10 mm fraction	4.2	6.8	16.90	9.30
Other <sup>c</sup>	3.20	4.5	4.9	4.20

<sup>a</sup>More than 50 thousand citizens.

<sup>b</sup>Less than 50 thousand citizens.

<sup>c</sup>Refers to any unknown or hardly classified material in solid waste.

Source: National Waste Management Plan 2014 (2010).

The typical composition of MSW in large cities, rural areas and small cities in Poland is shown in Table 1. As can be seen, the main components are organic waste, plastics, paper and glass. 8.47% of the material is denoted as other, which mainly includes construction and demolition debris, coal ash, and hazardous waste. The waste has a heterogeneous composition comprising of both degradable and non-degradable materials. The bulk of the non-degradable waste is potentially recyclable materials, while the degradable materials could be composted.

### 3.3. COLLECTION AND TRANSPORTATION

According to the Chief Statistical Office data, the system of organized waste collection and transport in 2013 covers around 84% of population [5]. Waste collection

does not differ in its technical aspect (containers, cars) from the EU standards. In Poland, municipal waste collection and transport are operated by private companies which sign contracts with both institutional clients (housing co-operatives, housing communities and economic entities) and individual ones. The frequency of waste collection is fixed in agreement with clients and the by-law according to which the emptying of selective collection containers should take place. This agreement also covers the frequency of collection, which prevents containers from being overfilled.

Plastic containers marked both with a legend and colors ascribed to a particular waste group are used for the selective collection of waste. Green ones are usually designed for color waste glass, white for white glass, yellow for plastics, blue for paper, black for mixed municipal waste, and red for hazardous waste. Waste paper, glass and plastics are collected selectively among municipal waste. They are collected in two ways:

- waste bag system – covering single-family houses, which obtain waste bags for collecting specified waste and informational and educational leaflets pertaining to the method and the time of waste collection every month,
- waste container system – covering multi-family housing (blocks of flats, tenement houses, public utility establishments and trading institutions), where special containers are arranged (yellow ones for plastics, blue for waste-paper, green for color glass and white for white glass).

Mixed waste is stocked in metal containers whose capacity ranges from 2 to 7 m<sup>3</sup>. They are used for waste storage in large housing estates. Oversized waste, hazardous waste and other forms of waste are collected regularly depending on the need and in the form agreed upon between a property owner and a waste removal company using specialized containers and vehicles. In Poland, used electrical and electronic equipment from the municipal sector is collected by trading entities free of charge on an exchange basis with the purchase of new equipment, and by entrepreneurs running a business in the sphere of municipal waste collection and used-equipment treatment [8]. Very recently, out-of-date medicines, batteries, electrical and electronic waste, spent light bulbs and fluorescent lamps have been collected monthly by specialist companies.

At present, a few regional waste management systems exist in Poland. The municipalities cooperate and form joint organizational structures, for both technical and economic reasons. According to the data, about 11 295 million tons of the MSW was generated in Poland in 2013, which amounts to 293 kg/year per capita [5]. In accordance with the data provided by the companies involved in municipal waste collection and transport, the Chief Statistical Office states that 9474 million tons of municipal waste was collected and transported in Poland this year. It has been concluded, from a comparison of the amount of municipal waste generated in Poland to the quantity of waste collected and transported by the specialized companies, that around 16% of the municipal waste generated nationwide is reintroduced into the environment without any control over it [5].

### 3.4. WASTE LANDFILLING

Landfilling is the simplest, cheapest and most common way of waste treatment; however it is also the least environmentally friendly. When MSW is disposed of in a landfill, naturally occurring microorganisms (bacteria) degrade the waste. The amount of water in, and the temperature of the MSW control the rate of degradation. This process turns the organic portion of the waste into methane (a primary constituent of natural gas) and carbon dioxide in roughly equal proportions. If generated, gas from this process permeates into the atmosphere and, if it is not properly captured, affects environment and human health [9]. It is now generally accepted that MSW landfilling is not an efficient approach for the management of MSW [1]. Disposal of waste through landfilling is becoming more difficult because existing landfill sites are filling up at a very fast rate. At the same time, constructing new landfill sites is becoming more difficult because of an increase in land prices [10].

Poland still maintains very high rates of landfilling. As much as 53% of waste is landfilled [5]. About 84% of operating municipal waste landfills are located and run according to binding technical requirements. The remaining facilities do not fulfil any norms which could classify them as landfills [5]. They were located without having hydro-geological conditions examined; furthermore, they have not been sealed and may adversely impact the quality of ground water and surrounding grounds. The system of municipal waste management in Poland can only be compared to that of Czech Republic, Greece, Hungary and Estonia. In Czech Republic, 83% of the municipal solid waste is landfilled, while in Greece, the amount of MSW landfilled in 2009 was 82%. In Hungary and Estonia the corresponding figure was 75% [6].

In 2013, there were 431 working landfills with a combined area of around 1944 ha [5]. In all, about 318 landfills were located in rural areas, while 113 landfills were located in urban areas. Of 431 working landfills, 363 are equipped with outgassing installation systems, including 199 landfills with gas released to the atmosphere, 139 landfills treated through combustion without energy recovery, and 65 landfills treated through combustion with energy recovery [5].

### 3.5. WASTE COMPOSTING

The main component of municipal solid waste generated is of biodegradable origin (Table 1). Unfortunately, only a small percentage (11%) of waste is composted [5]. This proportion of solid waste managed by composting is insignificant compared to the huge amount of waste generated. Composting of municipal waste has been reported in many other European countries. 30% was composted in Austria, 33% in the Netherlands, 36% in Belgium, and 24% in Sweden [6].



### 3.6. WASTE INCINERATION

Waste incineration is very controversial for Polish society due to its impact on the environment. Hence, requirements pertaining to the location, construction, and commissioning of plants and equipment for thermal treatment of waste are specified in detail. The calorific value of MSW is about 6.3 kJ/kg [11], which makes it suitable for combustion. Unfortunately, as of this moment, throughout Poland only one incineration plant is active – in the capital city of Warsaw. In 2000, 29 thousand tons of waste was incinerated there, while in 2013, the amount of waste incinerated was about 766 thousand tons [5].

Waste incineration has been given top priority and may continue to play a major role in the reduction of solid waste in the foreseeable future. According to the Polish Ministry of Environment, by 2020 around 25% of waste will be thermally treated at incinerators. There is a plan to construct 11 thermal waste treatment plants in the upcoming years, whose total processing capacity is expected to reach 2.4 million tons. However, it should not be overlooked that the processing capacity of the planned installations will not suffice the needs of an economy that generates more than 12 million tone of municipal waste annually.

### 3.7. WASTE RECYCLING

Nowadays the amount of produced packaging waste, especially that of paper, cardboard, glass and plastics, has increased by around 49% since 2000 [5], [12–22]. An increase in the quantity of packaging has forced the Polish government to face this problem; subsequently, the issue of packaging waste has been reflected in Polish legislation. A number of legal regulations and norms aligned with EU standards have been introduced in Poland in the domain of packaging, especially in recent years [23]. The annual recycling levels shown in percentage terms in particular years were defined in the Ordinance of the Council of Ministers of 30 June 2001. The required and achieved recycling targets of packaging waste in the years 2002–2013 are given in Table 2.

The data shows that the required levels of recovery and waste packaging recycling were met and even exceeded in some cases. This result was influenced by the fact that Poland has been a member of the EU since 1 May 2004. Hence, actions were enforced in Poland pertaining to waste packaging management as well as an obligation with respect to the recycling levels dictated by European directives. An additional stimulus was provided in the form of a product charge for failing to comply with the recycling target levels.

Table 2

Required levels of packaging waste recycling [%] in the years 2002–2013

Package	2002		2003		2004		2005	
	Required	Achieved	Required	Achieved	Required	Achieved	Required	Achieved
Plastic	7	11.4	10	16.8	14	24.4	18	30.3
Aluminium	15	22.8	20	27.1	25	33.3	30	86.7
Paper	37	44.4	38	52.9	39	57	42	65.4
Glass	13	15	16	20.4	22	31.2	29	38.4
Package	2006		2007		2008		2009	
	Required	Achieved	Required	Achieved	Required	Achieved	Required	Achieved
Plastic	22	36.9	25	27	16		17	21.5
Aluminum	35	84.6	40	82	41		43	64.2
Paper	45	85.6	48	69.1	49		50	50.9
Glass	35	48	40	39.7			41	41.9
Package	2010		2011		2012		2013	
	Required	Achieved	Required	Achieved	Required	Achieved	Required	Achieved
Plastic	18	20.2	19	22.6	20	22.2	21.5	20
Aluminium	45	60.5	47	54.2	48	46.7	49	34
Paper	54	57.2	54	58.7	56	53.2	58	49.7
Glass	49	45.6	46	45.1	49	51.3	55	43.4

Source: own data handling based on [5], 12–22].

#### 4. BARRIERS AFFECTING MSW MANAGEMENT

The main factors responsible for the poor performance of MSW management in Poland are summarized below:

- Rapid development of economic growth will have an impact on the quantity of solid waste.
- At present, municipalities are trying to encourage the use of a new classification pattern. Four containers, each of a different color, have been placed in some residential areas of a large cities for selective collection. Nevertheless, the organized system of waste collection does not involve the entire population. The data shows that only around 27% of generated MSW was collected selectively [5]. The absence of selective waste collection will be a huge obstacle to reduce the amount of MSW directed into landfills.
- Landfilling is still the predominant method for municipal solid waste management. Poland's municipal waste landfills receive about 78% unprocessed waste mass. Moreover, about 30% of operating municipal waste landfills do not fulfil any norms which could classify them as landfills and has polluted natural streams and created high health risks for human beings and livestock.

- Although the waste composition has a high biodegradable content, the data shows that only a small percentage (5%) of waste is composting. According to the [24], Poland has to reduce the amount of biodegradable waste directed to landfill by 50% by 2015. The lack of progress in the scope of achieving particular levels of reduction in the amount of landfilled biodegradable waste, which are described in this directive, will result in substantial financial penalties.

- Although the required levels of recycling of packaging waste were fulfilled, Poland still faces many problems in catching up to European Union requirements. According to the *Directive 94/62/WE* of 20 December 1994, further amended by *Directives 2004/12/WE* and *2005/20/WE*, before 2014, Poland must achieve higher levels of packaging recovery and recycling, that is, recovering up to 60% and recycling from 55% minimally to 80% maximally.

## 5. CHALLENGES

When analyzing the state of MSWM, it is clear that that source separation and collection, composting of biodegradable waste and recycling (except packaging waste recycling) and resources recovery have not yet been implemented entirely effectively. For an effective and efficient solid waste management in Poland, future challenges are anticipated to include the following phases:

- Strengthen the implementation of MSW reduction and sorting at the generation sources.

- Establishing an effective waste selective collection system should be a fundamental strategy of solid waste management in Poland. An increase in the efficiency of MSW collection to 100% in municipalities and outside municipalities is required.

- Reduction of organic municipal waste landfilling according to required level. The lack of progress in the scope of achieving particular levels of reduction in the amount of landfilled biodegradable waste, which is described in this directive, will result in substantial financial penalties. Organic waste separation, composting and using the compost as an organic fertilizer is a sustainable way of managing biodegradable waste.

- Sorting would be required to exclude hazardous and non-degradable components from the waste. The removal of subsidies on fertilizers in Poland has created a demand for alternatives, and a market for compost exists.

- Reinforcement of the waste recycling and reuse. To achieve higher levels of packaging recovery and recycling, that is recovering up to 60% and recycling from 55% minimally to 80% maximally, it is advisable:

- place emphasis on the increased efficiency of selective waste collection at the location of waste generation,

- increase the number, and treatment capacity, of packaging waste recycling plants,

– create a registry of entrepreneurs engaged in waste recycling and recovery, including packaging waste recycling and disposal.

- A properly sited engineered landfill should be constructed as recommended in the 2010 National Waste Management Plan. They should only receive the remains of processed waste and will cease to be both self-contained and the sole facilities of municipal waste neutralization, which is currently the prevailing state of affairs in Poland.

- Finally, as is shown in the paper, it is critical to reduce the amount of MSW directed into landfills. That goal can be achieved through aggressive actions to increase the number of facilities of municipal solid waste recovery and treatment using other methods than landfilling.

## 6. CONCLUSIONS

MSW generation and characteristics, management, collection and transportation, as well as treatment and disposal of MSW were studied.

The results show that the average generation rate of municipal solid waste was around 0.9 kg/capita/day, the composition of municipal solid waste varies by the source of waste; however, in all cases organic waste is the main component of the municipal solid waste. Other than organic waste, a considerable part of Poland's MSW consists of recyclable materials such as paper and cardboard, plastic, metal, and glass.

An analysis shows that landfilling is the predominant method for MSW management. Of the total amount of municipal solid waste, approximately 71% is landfilled without prior treatment. Other methods such as composting, recycling, and incineration are also used, but on a negligible scale, which can be attributed mainly to a lack of waste separation at the source.

Thus, it seems there is a need to increase the source separation and collection, composting of biodegradable waste, recycling and recovery of resources. One of the most effective solutions to such a problem is to implement a sustainable and effective municipal solid waste management system. The system should enhance the planning and decision making process and take a holistic view of the entire system, including waste collection, transfer, resource recycling and disposal. To meet this challenge, the current solid waste management systems must undergo significant changes. The development of an efficient MSW management approach will help explore new opportunities for urban environmental protection.

## REFERENCES

- [1] DAMGHANI A.M., SAVARYPOUR G., ZAND E., DEIHIMFARD R., *Municipal solid waste management in Teheran. Current practices, opportunities and challenges*, Waste Manage., 2008, 28 (5), 929.
- [2] AGAPITIDIS I., FRANTZIS I., *A possible strategy for municipal solid waste management in Greece*, Waste Manage. Res., 1998, 16 (3), 244.

- 
- [3] VEHLow J., *Biogenic Waste to Energy. An Overview*, [http://www.icabioenergytask36.org/Publications/2004-2006/Report%209\\_Biogenic%20Waste.pdf](http://www.icabioenergytask36.org/Publications/2004-2006/Report%209_Biogenic%20Waste.pdf)
- [4] Official Journal, *On waste 2013*, 2012 December 14, item 21.
- [5] CSO, *Environment Protection*, Central Statistical Office, Warsaw 2014.
- [6] Eurostat. Data on municipal waste: [http://ec.europa.eu/eurostat/statistics-explained/images/d/d2/Municipal\\_waste\\_generated\\_by\\_country\\_in\\_selected\\_years\\_%28kg\\_per\\_capita%29\\_new1.png](http://ec.europa.eu/eurostat/statistics-explained/images/d/d2/Municipal_waste_generated_by_country_in_selected_years_%28kg_per_capita%29_new1.png) [Accessed March 27, 2012 ].
- [7] TCHOBANOGLOUS G., THEISEN H., VIGIL S.A., *Integrated Solid Waste Management-Engineering Principles and Management Issues*, McGraw-Hill, New York 1993.
- [8] *Directive of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE)*, European Union, Brussels 2002.
- [9] MICEVSKA O., TASESKA K., *Scenario for decreased greenhouse gases emission in Macedonia by successful municipal solid waste management*, Analytical Journal, 2008, 1, 7. <http://www.logincee.org/file/19614/library> [Accessed February 2, 2008].
- [10] JIN J., WANG Z., RAN S., *Solid waste management in Macao: Practices and challenges*. Waste Management, 2006, 26 (9), 1045.
- [11] PAJAŁ T., *Thermal waste utilization into municipal solid waste management*, [in:] Proc. 4th Int. Conf. FORUM Waste Management, *Systems of Waste Management*, Futura Publisher, Poznań 2001, 479 (in Polish).
- [12] CSO, *Environment Protection*, Central Statistical Office, Warsaw 2001.
- [13] CSO, *Environment Protection*, Central Statistical Office, Warsaw 2002.
- [14] CSO, *Environment Protection*, Central Statistical Office, Warsaw 2003.
- [15] CSO, *Environment Protection*, Central Statistical Office, Warsaw 2004.
- [16] CSO, *Environment Protection*, Central Statistical Office, Warsaw 2005.
- [17] CSO, *Environment Protection*, Central Statistical Office, Warsaw 2006.
- [18] CSO, *Environment Protection*, Central Statistical Office, Warsaw 2007.
- [19] CSO, *Environment Protection*, Central Statistical Office, Warsaw 2008.
- [20] CSO, *Environment Protection*, Central Statistical Office, Warsaw 2009.
- [21] CSO, *Environment Protection*, Central Statistical Office, Warsaw 2010.
- [22] CSO, *Environment Protection*, Central Statistical Office, Warsaw 2012.
- [23] ALWAEI M., *The impact of product charges and EU directives on the level of packaging waste recycling in Poland*, Res. Cons. Rec., 2010, 54 (10), 609.
- [24] Official Journal, *Ordinance of the Ministers of environment on the levels of mass limits of biodegradable municipal waste directed to landfilling and the method of the levels calculating*, 18 June 2012.