

Principles of municipal waste management in Poland and selected regions of Europe

Joanna Kulczycka, Zygmunt Kowalski

Polish Academy of Sciences, Mineral and Energy Economy Research Institute, ul. Wybickiego 7, 31-261 Kraków, Poland, e-mail: kulczycka@min-pan.krakow.pl

Cracow University of Technology, Institute of Inorganic Chemistry and Technology, ul. Warszawska 24, 31-155 Kraków, Poland, e-mail: zkow@chemia.pk.edu.pl

High level of production and consumption in member-countries of the European Union is connected with generating a considerable amount of waste. In individual EU member-countries various methods aiming at decreasing the amount of generated waste are implemented. The current situation in Poland, and the best practical solutions introduced in some European regions have been presented in the paper. These solutions were put in place, mainly to fulfill the EU or country's regulations. The priority of municipal waste management measures is to prevent and minimize its generation. Decisions on preventing waste generation should be made as early as at the stage of product designing and manufacturing. The basic principle of proper municipal waste management is to create a system of regional solutions, which includes all the elements of waste management and relates them to the local conditions.

Keywords: municipal waste management, recycling, landfilling.

INTRODUCTION

High level of production and consumption in member-countries of the European Union is connected with generating a considerable amount of waste. In most countries waste is deposited mainly in landfills, which results in taking over more and more area, loss of valuable natural resources, as well as the increased potential hazard to the environment. In individual EU member-countries various methods aiming at decreasing the amount of generated waste are implemented.

At present waste management is one of the important priorities regarding environmental protection, both in Europe and in the world. The economic and social development has changed people's lifestyle. A large increase in production and consumption is observed, beginning with West European countries and the US. Each year in the European Union more than 1.8 billion tons of waste are generated, which means 3.5 tons per inhabitant. Only 1/3 of it is processed, and the amount of waste subjected to recycling differs among the countries. In certain countries 90% of waste is processed, in other ones only 10%. Considering municipal waste only, each year every inhabitant in European Union generates over 500 kg of it. This is an average amount as in the EU-10 in 2005 a statistical inhabitant generated yearly 300 – 350 kg of this type of waste, while in the EU-15 the yearly amount is already 570 kg per inhabitant. About 49% of municipal waste was deposited in landfills, 18% was incinerated, and 27% was recycled or composted¹.

In consequence of mass production and the increasing consumption people must cope with the effects of these phenomena, mainly with the problems connected with pollution and loss of natural resources. Until the late 20th century in most European countries waste was managed mainly by depositing it in landfills. However, waste landfilling was connected with taking over large areas of usable land, thus increasing the impact on the environment. Thus, measures were taken to implement innovative waste management methods, the aim of which was to decrease the amount of landfilled waste in favour of the recycled waste. On the EU level a lot of legal acts were introduced, whereas on the regional and local levels waste management strategies were developed and implemented. However, the

approach to the planning processes was different in various countries. As a result, waste management and economic development in this sphere differed among the European countries. For example, Denmark and Netherlands deposit in landfills about 4% of municipal waste, and in Poland 95% of this type of waste is managed in this way. Waste recovery ranges from 5% to 63%. Considering the amount of incinerated waste, Denmark and Sweden are the leaders. In these countries the waste managed in this way amounts to 53% and 47%, respectively.

In recent years a positive tendency has been the introduction in the European countries of *Landfill Ban* (ban on landfilling the unprocessed waste) and the implementation of European legislation concerning waste management². The European Commission is considering the introduction of a new target for the reuse and recycling of waste, i.e. 50% of all paper, metal and glass by 2020¹.

EUROPEAN WASTE MANAGEMENT

In Europe still 49% of municipal waste, on average, is directed to landfills. Waste management consisting in its landfilling is connected with various problems:

- Social conflicts (most people do not want to have a waste landfill in their neighbourhood – the NIMBY effect – „not in my own backyard”, which makes the location of such objects difficult),
- Emission of greenhouse gases (landfills can be a source of undesired emission of landfill gases containing methane),
- Taking over large areas that could have been used for other economic purposes.

WASTE SEGREGATION

Considering the waste recovery process, segregation of waste generated by a commercial operation and households „at its source” is of great significance. Each country develops its own system for selective waste collection, taking into consideration the local conditions. The effectiveness of these systems is much differentiated and depends on many factors (legal, social, ecological), which were the objects of interest of individual project

Table 1. Municipal waste management in the chosen cities and regions as provided by partners of the EWM project as of the end of 2005

	Dundee (SCO)	Fryslan (NL)	Gyula (HU)	Kraków (PL)	Sachsen (GER)	SouthEast England	Świętokrzyskie (PL)
Population (cap)	142 170	642 977	53 010	758 500	2 456 687	8 000 550	1 319 611
MSW generated (Mg)	92 342	339 802	17 297	256 200	552 800	4 300 000	244 500
MSW generated (kg/cap)	650	528	326	338	225	537	185
sent for recycling (%)	24,4%	27,0%	1,6%	16,0%	74,0%	30,0%	8,0%
sent for composting (%)	6,6%	23,0%	24,4%	6,0%	11,0%	11,0%	10,5%
sent for incineration (%)	40,6%	35,0%	0,0%	0,0%	0,0%	0,0%	0,0%
sent for landfilling (%)	28,4%	15,0%	74,0%	78,0%	15,0%	59,0%	81,5%
MSW landfilled (Mg)	26 230	50 924	12 800	200 016	82 790	2 536 174	199 261
MSW landfilled (kg/cap)	184	79	241	264	34	317	151

Source [2]

partners. In the European Waste Management project³ the existing waste segregation systems, both those characterized by high effectiveness and those showing low effectiveness, have been analyzed. Differences and the problems resulting from them have been shown, and the optimal solutions have been suggested. Interesting studies were carried out in South East England, which covered the analysis of the structure of recyclable waste and the methods for its collection. The main issues also included the transport of such materials, processing technology, and market research. The objective of the study was also to determine whether the life cycle assessment (LCA) methodology can be used for the assessment of recycling strategies and operations. The information gathered has been put into the database and described in⁴. An interesting conclusion was the statement that the boundaries of separate regions do not determine the boundaries of the „waste market” as the flow of waste is fairly independent of the distance and transport costs. Moreover, the best practices and the most frequent mistakes occurring in collecting waste has been drawn up. It is estimated that in South East England the recycling and composting levels can be increased up to at least 50% if the pointed out mistakes are eliminated. The causes and effects of the informative-educational campaign promoting waste segregation have also been presented, taking the Liguria region (Italy) as an example. In spite of intensive promotional actions (leaflets, films etc.) in favour of waste segregation, six month later few people remembered about it. This situation forced the local authorities to verify their actions and to involve more organizations, including schools, in the next campaign. Besides, in Genoa a local waste collection firm joined the actions in favour of waste segregation and opened the so-called „recycling center” where the inhabitants could leave their waste.

Another important issue that has been discussed concerns waste management statistics. At the Mineral and Energy Economy Research Institute, Polish Academy of Sciences in Cracow, in cooperation with the Marshal Office of the Świętokrzyskie Province, the best data collecting and processing methods were searched for. Having analyzed the existing data collecting and processing systems used in Poland it has been stated that the provincial bases of the data on the generated waste and the waste management methods are currently the best available tools for waste management.

The analysis of the data presented in Table 1 shows that even in old Europe depositing waste in landfills is the dominant waste management method. Only in Frisia a small amount of waste is landfilled, which results from the existing in the province organizational solutions – there is a thriving firm Omrin engaged in waste segregation in a plant called Ecopark De

Wierde in Oudehaske – as well as legal and fiscal regulations, for example, the landfilling tax is 81.6 Euro per 1 Mg of waste (2003). A positive phenomenon in most of the regions is an increase in the amount of waste segregated at its source, which results from increased outlays on education and pressure put on the „ethical” and pro-environmental behaviour of the inhabitants².

PRINCIPLES OF MUNICIPAL WASTE MANAGEMENT IN POLAND

The legal basis for waste management in Poland is the Act on Waste⁵ as well as a number of executive decrees. The principles of waste management concern:

- prevention and minimization of waste generation,
- recovery of the waste the generation, which could not be prevented under the existing technical and economic conditions, by using the recycling method,
- waste management (besides landfilling),
- landfilling of the waste which under the existing technical and economic conditions cannot be recovered or processed, using a method that is safe for human health and the environment.

The principal aim of the National Waste Management Plan (KPGO) is to determine the range of tasks necessary for the functioning in the country of the integrated waste management system. The system should ensure environmental protection, taking into account the current and future technical, organizational and economic possibilities, as well as the level of the existing infrastructure. The waste management system is affected and shaped by waste management plans worked out at the national, provincial, county and district levels.

Having joined the European Union, Poland assumed obligations as to the adjustment of waste management to the EU requirements. As regards the issue „environment – waste”, the following terms have been negotiated:

- five-year transitory period (till December 31, 2007) as regards packaging and packaging waste⁷,
- ten-year transitory period (till July 1, 2012) as regards waste landfilling⁸,
- five-year transitory period (till December 31, 2007 with the possibility of prolonging it till 2012) as regards the inspection and control of transport, within and outside the EU, of certain groups of waste products intended for recovery, being on the so-called „green list”, and the selected waste products intended for recovery, being on the so-called „orange list”⁹.

In order to fulfill the assumed obligations it is necessary to introduce certain modifications into the current waste management system in which landfills predominate. The landfills should

be equipped with installations for the recovery of usable waste components and energy, and there should also be waste processing plants, in accordance with the Act on Waste.

CHARACTERIZATION OF MUNICIPAL WASTE

Municipal waste is defined as the waste generated in households and that coming from other producers, not containing hazardous waste and because of its character or composition being similar to household waste. Municipal waste is characterized by great differentiation in chemical composition and physical properties, depending on the standard of living of the inhabitants and the place of living. Usually it contains 40 – 50% of organic matter, 0.53 – 0.87% of nitrogen, 0.45 – 0.88% of phosphorus, 0.14 – 0.48% of potassium, and 50 – 60% of mineral matter and various trace elements (Mo, Cu, Zn, Co, Ni, Cd, Cr, Hg, Pb). These components can undergo biochemical changes (especially organic components) and affect individual components of the environment polluting them and becoming a feeding ground for insects, birds and rodents, and hence a source of various infectious diseases¹⁰.

The sources of municipal waste products are households and infrastructure objects (trade, services, craft, education, the social part of industry, etc.) As regards the amount of waste collected from households, the data show a pronounced falling tendency. The share of selected waste is still too small, although a rising tendency is observed. However, this is mainly glass waste, waste paper and cardboard. Metal and plastic waste is scarce. On the whole, households generate about 70% of municipal waste and infrastructure objects – 30%¹¹.

In Poland almost 95% of waste is deposited in landfills, which is a very unfavourable phenomenon. Although, on the whole, waste management in the public sector and in towns is improving, showing a falling tendency (from 95% to 91% and from 97% to 95% respectively), but in the private sector and in rural areas an increase is observed (in spite of an apparent decrease from 97% to 95%). An alarming fact is that only from 0.42% (in 2003) to 0.46% (in 2006) of the generated waste is thermally processed. The situation is somewhat better as regards the composting of waste (from 1.3% to 3%). This results

in part from increased ecological consciousness and increased charges for waste removal, and in part from rising fuel prices.

Municipal waste structure and its prognosis are presented in Table 2. In 2006 the amount of the generated biodegradable waste was 10% higher compared with the year 2000, whereas paper and cardboard – 41%.

In Poland the decrease in the amount of the generated municipal waste recorded for the years 2003 – 2005 (Tab. 3). This is connected, among other things²³, with:

- inaccurate recording of the amount of the waste directed to recovery and processing plants, resulting from lack of scales (in 2004 only 32% of landfills was equipped with scales),
- lack of agreements between real estate owners and firms removing municipal waste, which often leads to depositing waste in unauthorized dumps. Moreover, some amount of the waste from the private sector and rural households has been burned or deposited in unauthorized dumps, which is an undesirable phenomenon because of possible environmental pollution (especially groundwater pollution but also air pollution),
- lack of control, on the part of appropriate local authorities, regarding the fulfillment of the requirements to obtain permission to collect municipal waste from real estate owners,
- decreased bulk density of waste resulting from an increase in its volume².

EXISTING INSTALLATIONS FOR WASTE MANAGEMENT AND RECYCLING

In Poland landfills are still the basic type of installations for municipal waste management. As on December 31, 2006 in Poland there were: 1008 legal landfills for municipal waste other than hazardous and inert waste, 69 sorting plants for selectively collected municipal waste, 26 sorting plants for mixed waste and 38 sorting plants for both selectively collected waste and mixed waste. Besides, in Poland there were: 64 composting plants for green waste and selectively collected organic waste, 6 fermenting plants for municipal waste and 21 plants for mechanical and biological modification of mixed municipal waste, and 1 incineration plant for mixed municipal waste⁶. The number of operating legal municipal waste landfills – closing

Table 2. Municipal waste structure in Poland – the amount recorded and the forecast in 2000 – 2014

No.	Stream name	Amount of municipal waste in Poland [thousand tons/year]			
		2000	2006	2010	2014
	Biodegradable kitchen waste	2 493,84	2 741,98	2 857,95	2 887,67
	Green waste	302,00	338,80	368,82	391,26
	Paper and cardboard (non-packaging)	845,25	939,18	983,16	992,71
	Paper and cardboard packaging	1 226,47	1 729,91	2 199,91	2 989,55
	Multimaterial packaging	137,74	194,28	247,06	335,74
	Plastics (non-packaging)	1 472,05	1 571,40	1 580,32	1 441,72
	Plastic packaging	473,54	656,89	828,78	1 114,14
	Glass (non-packaging)	62,91	73,79	82,80	87,81
	Glass packaging	956,59	1 205,57	1 422,92	1 743,10
	Metals	374,77	392,52	394,90	398,79
	Steel sheet packaging	134,01	162,26	185,56	220,92
	Aluminium packaging	39,11	46,89	53,26	62,84
	Textiles	359,70	399,64	418,32	443,88
	Mineral waste	540,91	564,12	604,66	661,19
	Fine ash fraction	1 721,84	1 500,54	1 333,30	1 152,18
	Large-sized waste	703,77	1 013,02	1 017,55	1 025,18
	Building waste	1 556,89	2 457,30	3 103,05	4 290,55
	Hazardous waste classified as municipal waste	101,83	116,00	116,36	117,02
	Total	13 503,22	16 104,09	17 798,68	20 356,25

Source: Based on the data obtained from Institute for Ecology of Industrial Areas (IETU)

Table 3. Municipal waste balance – the waste generated in individual provinces of Poland in the years 2003 – 2006

Provinces	2003		2004		2005		2006	
	[thousand tons]	[kg per capita]	[thousand tons]	[kg per capita]	[thousand tons]	[kg per capita]	[thousand tons]	[kg per capita]
dolnośląskie	935	322	926	320	893	309	918	318
kujawsko-pomorskie	452	218	447	216	448	217	482	233
lubelskie	359	164	313	143	338	155	365	168
lubuskie	307	305	284	281	280	277	289	287
łódzkie	670	258	661	256	639	248	769	299
małopolskie	607	187	611	188	630	193	684	209
mazowieckie	1542	300	1610	313	1500	291	1543	299
opolskie	272	258	271	257	255	243	251	240
podkarpackie	420	200	379	181	346	165	359	171
podlaskie	323	268	293	244	268	223	278	232
pomorskie	556	254	612	279	587	267	619	281
śląskie	1353	287	1304	277	1307	278	1380	295
świętokrzyskie	182	141	179	139	185	144	200	156
warmińsko-mazurskie	331	232	339	237	313	219	335	235
wielkopolskie	1052	313	1003	298	862	256	897	266
zachodnio-pomorskie	564	332	528	312	502	297	507	299
POLAND	9925	260	9759	256	9354	245	9877	259

Source: Annals of Environmental Protection, Central Statistical Office of Poland.

Table 4. Municipal waste landfills in the years 2003 – 2006

	Number	Area [ha] as on December 31	Area reclaimed in the year [ha]
Operating legal landfills:			
2003	In towns	265	1167.3
	In villages	728	2144.3
	Total	993	3311.6
2004	In towns	220	964.1
	In villages	829	2421.0
	Total	1049	3385.1
2005	In towns	219	1006.1
	In villages	806	2353.4
	Total	1025	3359.5
2006	In towns	202	944.3
	In villages	806	2365.2
	Total	1008	3309.5
Closed legal landfills:			

Source: Annals of Environmental Protection, Central Statistical Office of Poland

process connected with EU regulation – has been decreased in Poland since the year 2004, even in 2006 the number of landfills is higher compared to 2003. A falling tendency is observed both in towns and in rural areas, but a worrying fact is a relatively small area recovered as a result of landfill reclamation.

TARGETS OF MUNICIPAL WASTE MANAGEMENT IN POLAND

The long-term target of waste management in Poland is to adjust it to the principles of sustainable development⁶. Then the principles of waste management will be fully realized, and the hierarchy of importance of waste management options will be maintained, especially as regards prevention and minimization of the amount of generated waste together with the elimination of these properties that are hazardous to human health and the environment. Besides, the material and energy potential of waste should be utilized, and as a last resort it should be rendered harmless using various processes. This way the amount of the landfilled waste can be eliminated or minimized. Such actions will also improve the state of the environment as, among other things, the emission of greenhouse gases resulting from the

applied waste management technologies will be limited; besides, the share of energy from renewable sources (burnt waste of plant and animal origin) in the energetic balance of the country will be increased.

Referring to the state ecological policy, the waste management should be based on:

- maintaining the tendency to separate an increase in the amount of generated waste from the economic growth expressed as GDP,
- increasing waste recovery, especially energy recovery, in accordance with environmental protection requirements,
- decreasing the amount of waste sent to landfills,
- closing, by 2009, all the landfills that do not comply with the current legal regulations,
- eliminating the unauthorized dumping,
- creating an extensive database on the products introduced into the market and waste management.

In connection with the necessity to realize the provisions of the Stockholm Convention and to adjust Polish regulations to those being in force in the EU, it is also necessary to:

- develop the waste collection system so as to cover 100% of the population of Poland by the end of 2007 (which in fact, is unreal),

- enable all the inhabitants to participate in selective waste collection, in accordance with the requirements specified in the National Waste Management Plan 2010, by the end of 2007 (which in fact, is unreal),

- decrease the amount of landfilled biodegradable municipal waste, according to the following plan:

- more than 75% in 2010 (this would require the incineration of about 3 million tons of municipal waste. i.e. the construction of 7 – 8 large incineration plants. This is unreal for the year 2010 and rather unreal for the year 2013),

- more than 50% in 2013

- more than 35% in 2020.

in relation to the amount of waste generated in 1995,

- reduce the number of landfills, for the waste other than hazardous and inert waste, in which municipal waste is deposited, to 200 such objects (maximum).

BASIC DIRECTIONS OF ACTIONS AIMING AT A DECREASE IN THE AMOUNT OF GENERATED WASTE AND DEVELOPMENT OF A SYSTEM FOR MANAGING IT

According to the current EU regulations, the priority in the hierarchy of waste management measures is to prevent and minimize waste generation. The attainment of this aim depends on many factors, not always directly connected with waste management, such as economic growth, implementation by entrepreneurs of the best available technologies (BAT) and the society's standard of living. The decisions on preventing waste generation should be made already at the stage of designing and manufacturing of a product, its use and final management of the waste generated from the product after its life cycle has ended. In this connection, the following actions should be taken:

- continuation of studies on new technologies to prevent and decrease the amount of generated waste, as well to minimize its negative effect on the components of the environment,

- support for wasteless technologies and those enabling maximum utilization of all the components of the raw materials used,

- determination and monitoring of real indices for waste generation and composition so as to diagnose properly the needs regarding waste management,

- support for the implementation of waste recovery and processing technologies, including those enabling energy recovery (during thermal and biochemical processes) but only ecologically and economically effective ones,

- verification of the current locations of landfills and elimination of landfills that cause environmental nuisance by closing them and subjecting the area to extensive reclamation so that it could be used for new purposes,

- elimination of improper landfill operating and reclaiming practices,

- intensive inspection of firms engaged in the collection, transport, recovery or disposal of waste,

- introduction of appropriate financial tools which will enable the realization of tasks regarding waste management and will discipline local authorities to perform their duties according to the regulations.

As regards waste recovery and recycling, selective collection and removal of the following waste types is required:

- green waste from gardens and parks,
- paper and cardboard – newspapers, magazines, packaging,
- glass packaging – separately coloured glass and colourless glass,
- plastics and metals,
- used batteries and accumulators,
- used electronic equipment,
- pharmaceuticals past their sell-by date,
- chemicals – paints, solvents, waste oils etc.,
- furniture and other large-sized waste.

MUNICIPAL WASTE RECOVERY AND RECYCLING

In order to maximize the recovery and processing of municipal waste it is necessary to:

- ensure adequate flow capacity of an installation so that all the selective waste could be processed, by means of monitoring the realized and planned investments,

- stimulate the development of the market for secondary materials and products containing them by supporting cooperation between recovery organizations, industry and local authorities and consistent enforcing the fulfillment of their obligations regarding recovery and recycling,

- promote the products made of waste materials,

- issue building permits only if an installation satisfies the principles of the waste management plan and ecological requirements and if it is economically profitable,

- support studies on new technologies for waste recovery and processing, and to promote their use.

One of the aims of actions taken to decrease the amount of landfilled municipal waste is to increase the use of biological and thermal methods for mixed municipal waste processing.

The basic principle of proper municipal waste management is to create a system of regional solutions, which includes all the elements of waste management but relates them to the local conditions. Another important issue is that the planned waste utilization and processing investments should satisfy the criteria of BAT (BREF), and the technologies which are to be used should be verified by many-years' and repeated experiments.

Recycling is one of the methods used to recover valuable secondary materials, and it is important that the recovery processes be cost-effective. The materials most often recovered from municipal waste are: scrap metals (steel and non-ferrous metals), certain types of waste paper (paper and cardboard), and broken glass (coloured and colourless). The use of the recycling technology for these types of waste is justified considering the difficulties in harvesting natural resources resulting from environmental conditioning or availability of raw materials, and the limited capacity of the existing landfills.

In Polish sorting plants selected waste products are segregated mainly manually or manually and mechanically. In Poland, from 2002, annual recovery and recycling levels for packaging waste and used products have to be observed. It is also planned to implement successively the solutions regarding biodegradable waste and to maintain its production at 1,460 thousand ton. With the current level of biological (composting and fermentation) processing of this type of waste, i.e. 248 thousand ton, installations with yearly capacity of 430 thousand ton are needed¹¹.

LITERATURE CITED

1. Less waste and cleaner water in Europe by 2020? Retrieved October 27, 2008, from <http://www.europarl.europa.eu>, and ec.europa.eu/environment/life/publications/lifepublications/lifefocus/documents/waste_en.pdf

2. Kulczycka, J. (ed.) (2007). The rules of municipal waste management in Poland and selected European regions – best practice (Zasady zarządzania odpadami komunalnymi w Polsce i wybranych obszarach Europy – najlepsze praktyki). Kraków, Polska: Wydawnictwo IGSMiE PAN.

3. European Waste Management, project Interreg 3 C. Retrieved October 27, 2008, from www.waste3c.org.

4. Potter, A. & Gentil E., *Towards sustainable recycling in selected EU regions and member state*. Retrieved October 27, 2008, from www.southeast-ra.gov.uk

5. *Act on waste from 27 April 2001* (with changes). Retrieved October 27, 2008, from <http://isip.sejm.gov.pl>

6. *The 2010 National Waste Management Plan* (Krajowy Plan Gospodarki Odpadami 2010) (2006). Warszawa, Polska, Retrieved October 27, 2008, from <http://www.mos.gov.pl/odpady/pgo/index.html>

7. *Directive 94/62/EC packaging and packaging waste*, (Dyrektywa Parlamentu Europejskiego i Rady 94/62/WE z dnia 20 grudnia 1994 r. w sprawie opakowań i odpadów opakowaniowych). Retrieved October 27, 2008, from <http://eur-lex.europa.eu>

8. *Council Directive 1999/31/EC on the landfill of waste*, (Dyrektywa Rady 1999/31/WE z dnia 26 kwietnia 1999 r. w sprawie składowania odpadów). Retrieved October 27, 2008, from <http://eur-lex.europa.eu>

9. *Council Regulation (EEC) No 259/93 of 1 February 1993 on the supervision and control of shipments of waste within, into and out of the European Community*, (Rozporządzenie Rady (EWG) 259/93 z dnia 1 lutego 1993 r. w sprawie nadzoru i kontroli przesyłania odpadów w obrębie, do Wspólnoty Europejskiej oraz poza jej obszar). Retrieved October 27, 2008, from <http://eur-lex.europa.eu>

10. Rosik-Dulewska, Cz. (2007). Basis for waste management (*Podstawy gospodarki odpadami*). Warszawa, Polska: Wyd. Naukowe PWN.

11. Lipińska, A., Kulczycka, J., Kowalski, Z. (2004). *Ecological and economic analysis of energy production from municipal waste*. New Agrochemicals and Their Safe Use for Health and Environment. Prague, Brussels, Czech Republic, Belgium: Czech-Pol Trade.