CZASOPISMO TECHNICZNE Ch
WYDAWNICTWO POLITECHNIKI KRAKOWSKIEJ

z. 2-Ch/2008
ISSN 0011-4561
ISSN 1897-6298

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MUNICIPAL WASTE MANAGEMENT IN POLISH NATIONAL AND LOCAL PLANS

GOSPODARKA ODPADAMI KOMUNALNYMI W POLSKICH PLANACH KRAJOWYCH I LOKALNYCH

A b s t r a c t

Physicochemical properties of municipal waste collected in Poland have been characterized quantitatively. The regulations and methods for municipal waste management used in Poland have been discussed. At present the methods most often used for municipal waste are the selective collection (the use of materials which with the present state of technique and technology can be recycled) or segregation of the collected waste. This is the first stage – besides landfilling – on the way to render municipal waste harmless. An insignificant increase in the amount of waste subjected to various treatments outside landfills, which has been observed in recent years, results from the fact that a very small amount of such waste has been obtained from segregated waste products and those selected from mixed waste. The currently available techniques enable effective treatment of waste; however, in Poland we lack such installations. Another barrier to the use of these methods is created by people themselves. It often happens that due to their opposition, plans for building municipal waste incineration plants remain only paper plans – the "NIMBY" effect. The possibility of using thermal treatment for municipal waste, both segregated and not segregated, would enable a considerable decrease in the amount of landfilled waste, the best available techniques having been maintained.

Keywords: type of waste, system of waste management, hazardous waste

S t r e s z c z e n i e

W artykule przedstawiono charakterystyki ilościowe własności fizykochemicznych odpadów komunalnych zbieranych w Polsce. Omówiono aktualne przepisy oraz metody gospodarki tymi odpadami. W Polsce większość odpadów komunalnych jest składowana, ale stosowna jest selektywna zbiórka (z wykorzystaniem materiałów nadających się do recyklingu przy obecnym stanie techniki i technologii) lub też segregacja odpadów po ich zebraniu. Stanowią one pierwszy etap – poza składowaniem – na drodze do unieszkodliwiania odpadów komunalnych. Nieznaczny wzrost w ostatnich latach odpadów unieszkodliwianych poza składowiskiem wynika z bardzo małej ilości odpadów wyselekcjonowanych i wysegregowanych ze zmieszanych. Obecnie dostępne techniki pozwalają w bardzo efektywny sposób na ich unieszkodliwienie, jednakże w Polsce brakuje takich instalacji. Ponadto równie skuteczną barierą przed zastosowaniem tych metod jest społeczeństwo. Najczęstszym tego przykładem są plany budowy spalarń odpadów komunalnych, które na skutek sprzeciwu pozostają jedynie na papierze. Możliwość przeróbki termicznej odpadów komunalnych zarówno segregowanych, jak i niesegregowanych pozwoliłaby na znaczne zmniejszenie składowanych odpadów, przy jednoczesnym zachowaniu najlepszych dostępnych technik.

Słowa kluczowe: rodzaje odpadów, system zarządzania odpadami, odpady niebezpieczne

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1. Introduction

According to the definition, municipal waste is the waste generated by households, as well as the waste that does not contain hazardous waste coming from other waste producers and which, because of its character or composition, is similar to the waste produced in households [1]. Two sources of municipal waste are distinguished:

– households – statistical data show that they produce 2/3 of the total municipal waste,
– infrastructure objects (mainly trade, services and craft, tourism objects, market places and others) produce 1/3 of the total municipal waste.

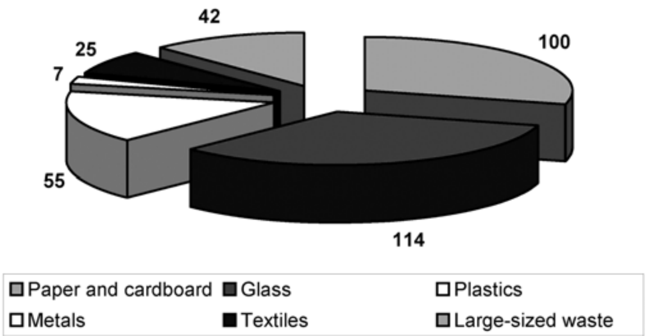

Fig. 1. Disposal of selected waste (thousands of Mg)

Rys. 1. Skład odpadów wyselekcjonowanych (tys. Mg)

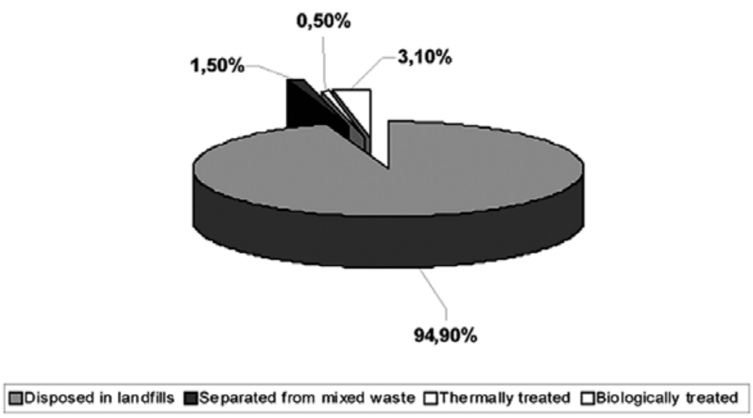

Fig. 2. Methods of solid municipal waste management [%]

Rys. 2. Udział metod unieszkodliwiania stałych odpadów komunalnych [%]

According to the Waste Act [1] "waste treatment is the subjection of waste to processes of biological, physical or chemical modifications", defined in Annex 6 to the Act [1], in order to bring it to the state which is not hazardous to human life and health or the environment". Waste should be first of all recycled or treated at the point of its generation, or it should be brought to the nearest place where it can be recycled or treated. Treatment is applied to the waste from which recyclable waste has been separated.

According to the Central Statistical Office (GUS) data, in 2006 9.877 million Mg of municipal waste was collected in Poland, and only 4.1% of waste had been separated (0.403 million Mg). Figure 1 presents the amount of selected waste [2], and Fig. 2 shows methods used for solid municipal waste management. Only 5.1% of this waste was managed using a method other than disposal, or was separated from mixed waste. Forty-five thousand Mg of waste was treated thermally, 297 thousand Mg biologically, and 144 thousand Mg was separated from mixed waste.

2. Characterization of municipal waste and the methods of managing it

The National Waste Management Plan [3] specifies the admissible amount of municipal waste that *undergoes biodegradation* which can be landfilled in a given year in relation to the base amount of municipal waste undergoing biodegradation generated in 1995, which amounted to about 4.4 million Mg (Fig. 3).

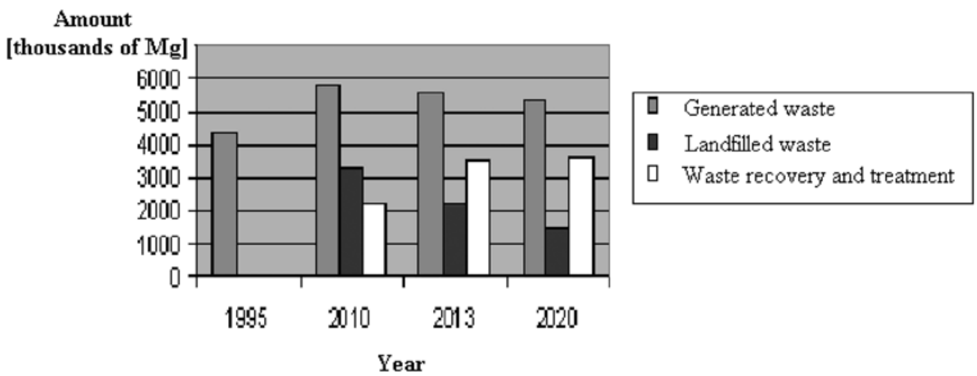

Fig. 3. Decrease in the amount of landfilled municipal waste undergoing biodegradation – plans [4]

Rys. 3. Redukcja ilości składowanych odpadów komunalnych ulegających biodegradacji – założenia [4]

In the case of waste collected separately, the possibilities of using various recovery and treatment methods are considerably greater, beginning with simple composting technologies and ending with thermal processes, such as pyrolysis or gasification (Tab. 1).

Recycling means a repeated use of materials to manufacture new products, in order to reduce the amount of waste and to save natural resources. Three kinds of recycling are distinguished:

– reuse – a repeated use of materials or products for the same purpose (for example retreading of tyres, replacement bottles),

– further use – the use of waste for new applications after a suitable physical, chemical or biological treatment (for example granulation of plastics and tyres, where granulate is used as a filler in building materials),
– reutilization – recovery of chemical waste and its reintroduction into the production process (for example the use of auto hulks in steelworks).

Table 1

Possibilities of managing municipal waste undergoing biodegradation, besides landfilling [3]

Municipal waste undergoing biodegradation	Possible methods for managing municipal waste undergoing biodegradation, besides landfilling							
	Burning	Gasification	Pyrolysis	Mechanical and biological transformation of mixed waste	Composting	Anaerobic fermentation	Recycling	Manual or mechanical sorting
Mixed waste	*			*		*		*
Waste-derived fuel	*	*	*					
Kitchen waste undergoing biodegradation					*	*		
Green waste					*	*		
Kitchen waste undergoing degradation and green waste					*	*		
Paper	*	*	*		*	*	*	
Textile waste	*	*	*				*	
Wood	*	*	*				*	

The state policy supports recycling: appropriate designing (use of materials that are easily recyclable, homogeneous material, simple combination of materials to make their separation as easy as possible, use of components which can be used once more without reprocessing); labelling of waste, products and components to facilitate segregation, development of waste processing technology, and proper preparation of waste for processing [5].

It has been a well-known fact for a number of years that it is useless to *compost* the whole mass of waste, mainly because of poor quality of the compost obtained that way and, in consequence, the limited possibilities of using it. At present, the development of composting methods is connected with the development of the technology for composting municipal waste undergoing biodegradation, such as kitchen waste, sewage sludge, food industry waste, green waste (generated while cleaning parks, gardens, green areas). Depending on the potential amount of organic waste, composting can be a single-stage or a two-stage process. The single-stage process includes composting under natural conditions, which is the simplest method for recovering the organic mass, as well as home composting, for one's own use as a method for minimizing the amount of waste going to the general stream, and also artificially aerated pile composting or pile composting with shovelling. The two-stage process includes initial composting in bioreactors. The initial stage makes it possible to intensify the whole process and obtain the proper quality final product in a much shorter time. It can be assumed that with the single-stage process the time needed to obtain a proper quality product is 5–6 months, while with the two-stage process it is 2–3 months. The potential biomass content of waste does not mean that it can be all obtained by composting. The mass balance for the process of composting the waste organic fraction at the stage of planning can be as follows: from 1 Mg of the input we obtain 40% of mature compost (400 kg), 5% of ballast (50 kg), a 55% mass loss as a result of biochemical processes (550 kg). The market price of 1 Mg of good compost is about 100 zlotys [6].

The purpose of the *anaerobic decomposition (fermentation) of waste* is the production of biogas which can be used for energy production. It is assumed that from 1 Mg of raw waste one can obtain 100 Nm^3 of gas, its energetic value being 6.2 kw/Nm^3, which makes it possible to obtain 200 kWh of electric energy and 300 kWh of thermal energy. In most of waste fermentation installations, municipal waste undergoing biodegradation is separated from the whole stream mechanically (rarely manually). *Energetic piles* constitute one of the anaerobic fermentation methods. This method can be also characterized as transitory waste disposal with intensive biochemical processes taking place in the deposit. The pile life is from 1 to 5 years, which is of significance considering the limited area of the waste disposal site. Once a pile has been processed, it can be replaced by a new one. The calorific value of biogas, after stabilization of the process, is 17.6 to 21 MJ/Nm [7, 8].

Mechanical and biological treatment (initial sorting of mixed waste and composting of the 20–100 mm fraction) is aimed at controlled preparation of municipal waste undergoing biodegradation for disposal in landfills or for the use of the product for applications which do not require a high quality material, for example for rehabilitation of landfills or other degraded areas [8].

Waste burning predominates decidedly in the world as regards the processes of thermal treatment of municipal waste. The merit of this process is the possibility of complete neutralization of waste and its removal from the ecological cycle. Additionally, the obtained energy as well as slag can be used without detriment to the environment. An incinerating plant is especially advisable when, as a result of spatial development of an urban-industrial agglomeration, the areas suitable for landfill sites are necessarily located far from waste generation sites. However, sometimes incinerating plants are located within buildings in city centres. They have been working without reservations for years, emitting waste gases into the atmosphere. The concentration of the components of these gases does not exceed the obligatory limits, which is a vital argument considering the fact that in the case of landfills, even well-ordered ones and with the best possible subsoil insulation, there always exist potential dangers of pollution of, for example, underground waters. The municipal waste incinerating plants presently designed and built in the world are characterized by high operational reliability and they ensure sufficient amounts of steam and energy to make the plant economically justified. The incineration technique has progressively been developed in the world, meeting stricter and stricter environmental protection requirements.

The studies carried out at the Institute for Ecology of Industrial Areas show that fuel properties of municipal waste are different and depend on many factors (for example generation region, season of the year, sanitary system etc). Considering the waste from 20 towns of the Katowice province, only about 50% of it meets fuel requirements. Its calorific value is 1.1–1.3 kcal/kg, i.e. it is within the values accepted as the limits when considering the possibilities of burning the waste.

Pyrolysis is a process of oxygen-free decomposition at an increased temperature (above 600ºC). The purpose of pyrolysis is to decrease the volume and mass of waste with the simultaneous storing of its calorific value in market products (gas, coke). The waste mass subjected to pyrolysis is transformed into the gas phase, the so-called pyrolytic gas, which chiefly contains hydrogen, methane, ethane and their homologues, CO and CO_2 , as well as other compounds such as H_2S, NH_3, HCl, HF; solid phase contains carbon, inert substances, metal; liquid phase consists of a mixture of oils and tars, water and organic components. Pyrolysis is recommended for homogeneous and high-calorific waste as well as for a small amount of waste. That is why it is a solution mainly for counties or several districts when the amount of waste is about 10 thousand Mg/year. Compared with burning, the amount of usable energy produced in this process is smaller as coal is changed to coke. Part of energy can be recovered from gases which, after suitable purification, can be used in the existing power stations and heat and power stations. Pyrolysis, if the process is correctly conducted, can serve for producing highly valuable market products [9].

Production of *fuel from municipal waste* on the basis of combustible fractions separated from the total stream (RDF – *Refuse Derived Fuel*) is one of the directions of thermal treatment modification. The principal reason for using that method is the stability of the calorific value at 16–18 MJ/kg. Installations for thermal transformation of waste which process at least 100 thousand Mg of waste per year, or even more, are considered optimal, while installations with efficiency of 60 thousand Mg are treated, from the point of view of economic profitability, as objects the flow capacity of which is at the lower limit. This means that population must be at least 250 thousand, and optimally 400 thousand in the areas where a thermal transformation installation is to operate. The calorific value of waste should be at least 5.8 thousand kJ/kg (the limit of autothermal combustion on a grate, i.e. the combustion which does not need fuel). In the case of the pyrolytic technology, the calorific value is assumed to be about 6 thousand kJ/kg of waste and the capacity about 10 Mg/h; the values ensure a positive energy balance in the process conducted.

The negative attitude of various social circles towards the thermal transformation of municipal waste results undoubtedly from lack of full information on that issue. This can be changed if the public opinion is given reliable and detailed information and ecological consciousness of people is continuously raised [3].

Large-sized waste from households needs to be treated separately because of its dimensions (they do not fit in standard waste containers). Thus, one can find old furniture, worn out household equipment such as refrigerators, washing machines, ovens and so on, and spatial packages near rubbish bins. Such waste is treated like municipal waste although it often contains substances and materials known as hazardous (mercury, compressor oils) which should be separated first. Large-sized waste is a source of potential secondary materials (Tab. 2) so before it is subjected to any treatment (according to the Act [1]), recoverable waste should be separated from it.

The system of large-sized waste collection includes:

– direct waste collection, organized by the producer, used especially for electronic equipment and household equipment. The equipment collected is disassembled and

secondary materials are recovered. Such a form of collecting large-sized waste facilitates the system of waste collection and removal,
– periodical collection directly from the owners of such things, and conditions created for ordering such a service individually known as the “call service”,
– replacement collection, consisting in giving back good but obsolete equipment and getting a next-generation item,
– individual delivery of the equipment to a waste management plant or a recycling centre using own means of transport.

Table 2

List of materials potentially recoverable from large-sized waste [12]

Sort of equipment	Basic raw material composition [%]					
	Ferrous metals	Non--ferrous metals	Plastics	Glass	Electronic equipment	Other materials
Refrigerators	33.0	5.5	34.5	2.0	17.0	37.0
Freezers; gas and electric cookers	82.0	8.0	2.0	0.2	–	7.8
Washing machines and spin dryers	82.5	7.0	7.0	–	–	3.5
Dishwashers	82.5	7.0	7.0	–	–	3.5
Radio and TV sets, computers	12.5	–	7.0	70.0	7.0	3.5

Regarding the disposal of the collected large-sized waste in a rational way, centres of its temporary storing and preliminary disassembling are organized. The main aim of this disassembling is to reduce the volume of waste before landfilling, to separate hazardous waste, and to recover and reuse waste components.

Recently the amount of *building waste* [8] directed to municipal waste landfills has increased. Building waste contains most often building and road-making materials and elements such as crushed concrete, brick, ceramics and asphalt, wood, glass and plastic waste, asphalt, tar and tar product waste – roofings, scrap metal, excavated soil and ground, stones and gravel, insulation waste. A considerable part of this waste comes from sources outside the municipal economy. Producers of waste are obliged to dispose of it in a proper way, including collection and transport (building and demolition firms, individual persons doing repair works). A producer of waste can appoint other firms to do it on condition they have appropriate permission. It is recommended to deposit preliminarily segregated building waste already on the construction site. It will make it possible to take it selectively away, to a waste recovery plant and waste landfill. Building waste intended for recovery and treatment includes:
– crushed concrete, brick, ceramics and asphalt,
– waste composed of materials used for window, door and wall unit manufacturing,
– waste composed of damp insulation materials and roofings, materials used in sanitary and electrical systems, reinforcing steel and building metalwork,
– excavated soil and ground, stones.

The treatment of building waste consists in its size reduction and separation into fractions in order to get building aggregate. A loader with a grab makes preliminary segregation, separating large parts from other waste products. The rest is directed to a vibrating screen to separate the fractions 0–20, 20–80 and > 80 mm. The fraction > 80 mm is directed to a sorting line where ferromagnetic waste, non-ferrous scrap and homogeneous plastic waste products are separated. The unsorted rest is crushed to make building aggregate. The fraction < 20 mm is used as fine aggregate, sub-crust, while the fraction 20–80 mm is used as building aggregate. Excavated soil and ground (not containing hazardous substances) should be used for shaping the ground surface.

Textile waste [3, 8] is as a rule, according to the Act [1], municipal waste. It includes both used clothes, unsuitable for further use for what they were intended, and clothes removed from better-off households because of lack of some qualities (colour, fashion) or small defects. Throughout the world such clothes are taken over by individual persons, social groups or poorer countries and still used for what they were intended ("second-hand" clothes). However, according to the definition of waste, valid since October 1, 2001, any clothing that households "get rid of" is considered as waste. The needs as regards textile waste management can be grouped as follows:

– organizational needs (to lift import ban on "unsorted" clothing, to remove formal and financial barriers to textile waste collection resulting from the fact that each district has to get a separate permission to organize municipal waste collection),
– investment needs (to develop the container collection system for textile waste, increase the capacity of waste sorting and processing plants according to the increase in the amount of collected textile waste),
– financial (districts should support selective textile waste collection systems, especially in less urbanized regions, for example by buying containers).

The basic management method for treating textile waste is segregation resulting in the separation of a fraction with clothing properties (intended for sale) and a fraction of a secondary raw material character (subjected to processing). It is estimated that yearly about 180 thousand Mg of clothing waste and other used textile products, classified as municipal waste, are generated in Poland. Most textile waste is deposited on landfills. The share of textiles in municipal waste is estimated to be 2.5% (by weight), but it varies considerably depending on the location (in some big cities even up to 10%).

The method used for collecting waste textiles is the container collection system. In 2002 about 14.5 thousand special waste clothing containers were placed all over Poland. Another important source of obtaining clothing waste is the purchase of unsold items from second-hand clothing shops. In 2006 turnover of textile waste in production units came to about 123.2 thousand Mg (receipts – 61.5 thousand Mg, expenditure – 61.8 thousand Mg). The collected textile waste is sorted and recycled in processing plants. Good quality clothes (not worn out) are brought on the home market, or foreign markets (former USSR countries, Africa, Asia – in 2006 the export amounted to 16.2 thousand Mg). Most used clothing is processed to get cleaning cloth. Another important process used for textile waste is the recovery and further processing of textile raw materials. In this case the recovery process consists mainly in cutting and tearing (defibring) the waste. The obtained raw material (shredded fibres) is reused for the production of textiles. A considerably small amount of textile waste is used for paper mass production, mainly for cardboard and pulp production. The production capacity of the existing plants is estimated to be about 140 thousand Mg of clothing per year. The plants process textiles sorted out of mixed waste as well as clothes and textiles obtained through selective municipal waste collection. They are mainly for the production of cleaning cloth or shredded fibres. The economic basis for the functioning of textile waste processing plants is the import of "unsorted" clothing (about

60% of the output). The amount of used clothing is expected to increase systematically; in consequence the amount of textile waste will increase as well. Most of these plants are going to be developed and modernized. The increase in the number of waste containers to the level of one container per 1000 inhabitants is planned.

In 2005 about 500 installations and devices for recovery and neutralization of *hazardous waste classified as municipal waste* were operating in Poland. They included 35 landfills and about 100 installations for thermal waste treatment [8]. The main problems as regards hazardous waste are:
– lack of correlation between the existing hazardous waste collection systems,
– insufficient use of modern technologies and the financial barrier hindering the introduction of modern technological solutions which could help minimize waste production and increase the degree of waste recovery,
– insufficient economic motivation for proecological activities,
– EU regulations limiting the possibilities of public aid given to entrepreneurs,
– insufficient monitoring of hazardous waste management in the sector of small and medium-sized enterprises, especially those that generate small amounts of hazardous waste (for example photographic and polygraphic studios, X-ray laboratories),
– insufficient level of people's education and consciousness.

At present ~95% of hazardous waste generated in households goes to the general waste stream that is directed to municipal landfills. It would be advisable for each district to organize a local system of hazardous waste collection which ultimately would cover 100% of inhabitants. Local authorities, being responsible for waste management in their region, should order the collection of this waste to a specialist transport firm meeting the requirements defined in the procurement agreement. Such a firm, beside specialist equipment for transporting hazardous waste, should provide adequate space for temporary disposal of the collected hazardous waste. Local hazardous waste disposal sites, their number in a given administrative unit and their size depend on the size and character of a town or rural district. Another condition for obtaining good effects as regards the collection of hazardous waste classified as municipal waste is the readiness of inhabitants for selective collection of this waste. This requires suitable actions shaping public consciousness as well as training courses organized in various social circles in each district. The experience that has been gathered hitherto shows that the effects of selective waste collection are difficult to be obtained in Poland. In many towns where the organized system of selective waste collection has already been functioning, the effects are estimated to be 1–5% of the total amount of generated waste.

Considering hazardous waste management, the following waste collection systems are used, on condition that each household is equipped with a special container for the collection of hazardous waste classified as municipal waste:
– collection centres – waste collected in households is brought, as the need arises, by people to waste collection centres which provide containers for secondary raw materials and additional containers or especially separated part of multi-chamber containers for hazardous waste classified as municipal waste,
– trading network – local authorities enter into agreements with various outlets, for example drugstores, photographic studios, paint stores etc as regards taking in and storing various hazardous waste coming from products sold by those firms, products

that are past their sell-by date, packaging, etc. This hazardous waste, classified as municipal waste, is taken away by a special car on demand,

– travelling waste collection points using containers – inhabitants are provided with containers for collecting certain types of waste. The containers are regularly emptied several times during a year by qualified staff. This is the most expensive system but it gives good effects as regards the amount of waste collected.

Hazardous waste, classified as municipal waste, coming from various sources, is directed to central waste treatment and processing plants (burning, neutralization, detoxication, safe disposal) of a regional character. The methods for treating hazardous waste are presented in Tab. 3, where:

Table 3

Methods for treating hazardous waste classified as municipal waste [3]

Type of waste	Treating method
Batteries and lead-acid accumulators	physical, chemical or both physical and chemical transformation: B3 and B4
Detergents containing hazardous substances	physical, chemical or both physical and chemical transformation: B4
Photographic reagents	physical, chemical or both physical and chemical transformation: B2 or B4
Paints, inks, printing paints, adhesives, binders and resins containing hazardous substances	thermal transformation: A1 or A3
Acids Alkalies	physical, chemical or both physical and chemical transformation: B4
Fluorescent lamps and other sorts of waste containing mercury	physical, chemical or both physical and chemical transformation: B3 – D2
Cytotoxic and cytostatic pharmaceuticals	thermal transformation: A3
Oils and fats	thermal transformation: A2 or A3
Plant protection agents (for example pesticides, herbicides, insecticides)	thermal transformation: A2 or A3
Used electric and electronic devices other than those listed in 20 01 21 and 20 01 23, containing hazardous components	physical, chemical or both physical and chemical transformation
Wood containing hazardous substances	thermal transformation: A1 or A2 or A3 or A4
Devices containing freons	thermal transformation: A3
Solvents	thermal transformation: A1 or A3

A – thermal transformation processes:

A1 – burning processes used for hazardous waste products which do not contain organohalogen compounds or zinc, cadmium, copper, nickel, cobalt and mercury compounds at the amount exceeding 0.5% (by weight) of total waste dry matter adjusted to the mass of the elements,

A2 – burning processes used for hazardous waste products which contain organohalogen compounds, including PCB, the content of heavy metals being as for A1, A3 – burning processes used for hazardous waste in rotary furnaces for concrete or lime production,

A4 – pyrolytic decomposition of hazardous waste.

B – physical, chemical or both physical and chemical processes:

B1 – precipitation processes used for sparingly soluble heavy metal compounds contained in waste, aimed at decreasing their water solubility, and immobilization of these compounds by enclosing them with a concrete mass, sintering in ceramic materials or vitrification,

B2 – oxidation and reduction of waste components,

B3 – separation of hazardous waste components from inert components using distillation, steam distillation, gas stripping, extraction, adsorption and other physical processes,

B4 – neutralization of acids and bases.

D – disposing of hazardous waste:

D1 – depositing waste loose in open landfills arranged in a way that does not cause danger to human life and health, and the environment,

D2 – landfilling as in D1 in containers made of corrosion-resistant materials,

D3 – depositing waste in enclosed landfills on the surface of the earth in the form of special buildings or under the ground in mineral workings.

3. Conclusion

At present the methods most often used for municipal waste are the selective collection (the use of materials which with the present state of technique and technology can be recycled) or segregation of the collected waste. This is the first stage – besides landfilling – on the way to render municipal waste harmless. An insignificant increase in the amount of waste subjected to various treatments outside landfills, which has been observed in recent years, results from the fact that a very small amount of such waste has been obtained from segregated waste products and those selected from mixed waste. The currently available techniques enable effective treatment of waste; however, in Poland we lack such installations. Another barrier to the use of these methods is created by people themselves. It often happens that due to their opposition, plans for building municipal waste incineration plants remain only paper plans – the “NIMBY” effect. The possibility of using thermal treatment for municipal waste, both segregated and not segregated, would enable a considerable decrease in the amount of landfilled waste, the best available techniques having been maintained.

The first draft version was prepared during the realization of the European Waste Management project (EWM), Interreg IIIC, and the final one during the realization of the project on Municipal waste management system and methods of its assessment used for decision support process No. 14-0016-04/2008.

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