

Country report

Municipal solid waste disposal in Portugal

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Abstract

In recent years municipal solid waste (MSW) disposal has been one of the most important environmental problems for all of the Portuguese regions. The basic principles of MSW management in Portugal are: (1) prevention or reduction, (2) reuse, (3) recovery (e.g., recycling, incineration with heat recovery), and (4) polluter-pay principle. A brief history of legislative trends in waste management is provided herein as background for current waste management and recycling activities. The paper also presents and discusses the municipal solid waste management in Portugal and is based primarily on a national inquiry carried out in 2003 and directed to the MSW management entities. Additionally, the MSW responsibility and management structure in Portugal is presented, together with the present situation of production, collection, recycling, treatment and elimination of MSW. Results showed that 96% of MSW was collected mixed (4% was separately collected) and that 68% was disposed of in landfill, 21% was incinerated at waste-to-energy plants, 8% was treated at organic waste recovery plants and 3% was delivered to sorting. The average generation rate of MSW was 1.32 kg/capita/day.

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1. Introduction

In the last two decades, MSW management became a major concern and is presently one of the main public subjects under discussion. This is probably due to the considerable increase of MSW production in both absolute and per capita values. The amount of MSW produced increases with economic growth and the demand for efficient management solutions (McCarthy, 1994). Therefore, the technological solutions to deal with MSW management must satisfy the sanitary and environmental purposes and also those related to the economic and social aspects.

One can find in the open literature several regional and national case-studies about waste management practices in different countries: in Sweden (Hartlén, 1996), in Japan

(Sakai, 1996; Tanaka, 1999), in the Netherlands (van der Sloot, 1996), in Greece (Andreadakis et al., 2000; Koufodimos and Samaras, 2002), in India (Gupta et al., 1998), in France (Defeuille and Lupton, 1998), in Turkey (Metin et al., 2003), in England (Woodart et al., 2001), and in Germany (Vehlow, 1996). These studies analyzed MSW disposal and management in different countries, sharing data and allowing for the evaluation of the state-of-the-art and the waste treatment in terms of management, legislation, production, characterization, treatment technologies and elimination.

To the authors' knowledge, there have been no comprehensive studies at a national level for MSW in Portugal. The existing information that is disclosed by the responsible entities for both direct and non-direct MSW management is limited, restricted and not always reliable. However, the situation is changing, with several factors contributing to this change including:

- the attitude of society concerning the environment;
- the appearance of European and national legislation about waste;

Abbreviations: EP, private enterprise; INR, National Waste Institute; IR, Recycling Industry; MA, Environment Ministry; MSW, municipal solid waste; PERSU, Portuguese Strategic Plan for MSW management; SGRSU, MSW management entities; SPV, Green Dot System; WTE, waste-to-energy.

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- new political measures carried out by the national, regional and municipal authorities that are in charge of waste management;
- the increasing number of actors participating in the waste management process such as private companies or even citizens;
- the increase of the regional cooperation between municipal authorities; and
- the appearance of new technologies for waste treatment.

The existence of a wide variety of processes and technologies for MSW treatment, or even the various possibilities of combining them, have given rise to the appearance of a lot of different structures and solutions for MSW treatment. In the present situation, according to the most recent technologies, the optimal solution for MSW treatment is not fully established. Nevertheless, Directive 94/62/EC (European Commission, 1994) established the basic principles of packaging and packaging waste management and defined their hierarchy under the following priority ranking: production, prevention, reuse, recycling, recovery (e.g., organic recovery, energy recovery), and disposal (e.g., landfilling, incineration without heat recovery). However, in Portugal, these principles and hierarchy are still not specified in the legislation for MSW, except for the packaging waste.

In the present paper is presented a brief history of the legislative trends in Portugal for waste management, which states the background for current waste management and recycling activities. The legally established MSW responsibility and management structure in Portugal is also presented. Finally, and based primarily on a national inquiry carried out in 2003 by the authors directly for the MSW management entities (SGRSU), the present situation of production, collection, recycling, treatment and elimination of MSW in Portugal is presented and discussed. This inquiry was carefully prepared by the authors and sent directly to the 30 existing SGRSU, entities that are responsible for MSW management in the entire continental territory of Portugal. The SGRSU completed the inquiries and sent them back to the authors. The purpose of the inquiry was the acquisition of precise data that was not available elsewhere, such as the total amounts of MSW generated, the amounts of different packaging wastes collected separately and the amounts of waste subjected to the different disposal fates. Standard statistical procedures, as those available in Excel spreadsheets, were used to treat the acquired data.

2. Portuguese framework and responsibilities in MSW management

In 1997, targets for 2000 and 2005 were established through the creation of the Portuguese Strategic Plan for MSW Management (PERSU) (Ministerio do Ambiente, 1997a). The strategy aimed at the total eradication of open

dumps and at the installation of landfills and incinerators, in parallel with a general policy for biodegradable waste recovery through composting and a significant increase in recycling.

Several SGRSU for MSW treatment were created and came legally into force in order to accomplish the above plan. Such entities were created by public financing, joining several municipalities together in order to facilitate the implementation of the major part of the predicted projects. In 2003, 30 SGRSU existed in Portugal (not including Azores and Madeira islands) that covered the entire national continental territory.

Until the end of the 1990s, closing dumps was the first process adopted for MSW management; however, in 2001, more than 340 dumps were still to be closed (Passaro, 2003). Today, there are four organic waste recovery plants, three incineration plants and 37 sanitary landfills in Portugal. MSW management has developed towards partial treatment and disposal options such as recycling, composting, and incineration with energy recovery. However, in Portugal, the sanitary landfills were still the dominant option for MSW disposal in 2002.

With the present MSW management structure, the responsibilities are normally shared by different entities, namely the municipalities, the SGRSU and the Green Dot System (SPV). These entities guide their activities according to the legislation and the policies dictated by the Ministry of the Environment (MA). MSW management activities are controlled and supervised by the National Waste Institute (INR) as showed in Fig. 1.

By legal definition, established by the Portuguese Environment Ministry – *Ministerio do Ambiente* (1997b) – municipal solid wastes (MSW) are “the domestic wastes or some other similar wastes, according to their nature or composition, namely those coming from the tertiary sector or from the commercial, trading or industrial plants and from health care units, providing that, in any case, the daily production do not exceed 1100 L per producer”.

Generally mixed waste collection is under the responsibility of municipalities, whereas the responsibility for separate collection changes from region to region and can be undertaken by the municipalities, the SGRSU and private companies.

The SGRSU are responsible for waste treatment, recovery and disposal. The responsibility of those entities, as far as the recycling process is concerned, consists of sorting of the separately collected packaging waste. After sorting, the packaging waste is guided towards the Green Dot System. The SPV is responsible for receiving the sorted packaging waste and for guiding it towards the recycling industry. It is the responsibility of all of the involved entities in MSW management to organize campaigns to develop awareness and a positive attitude of the citizens as far as the environment, the need for recycling and the active participation are concerned.

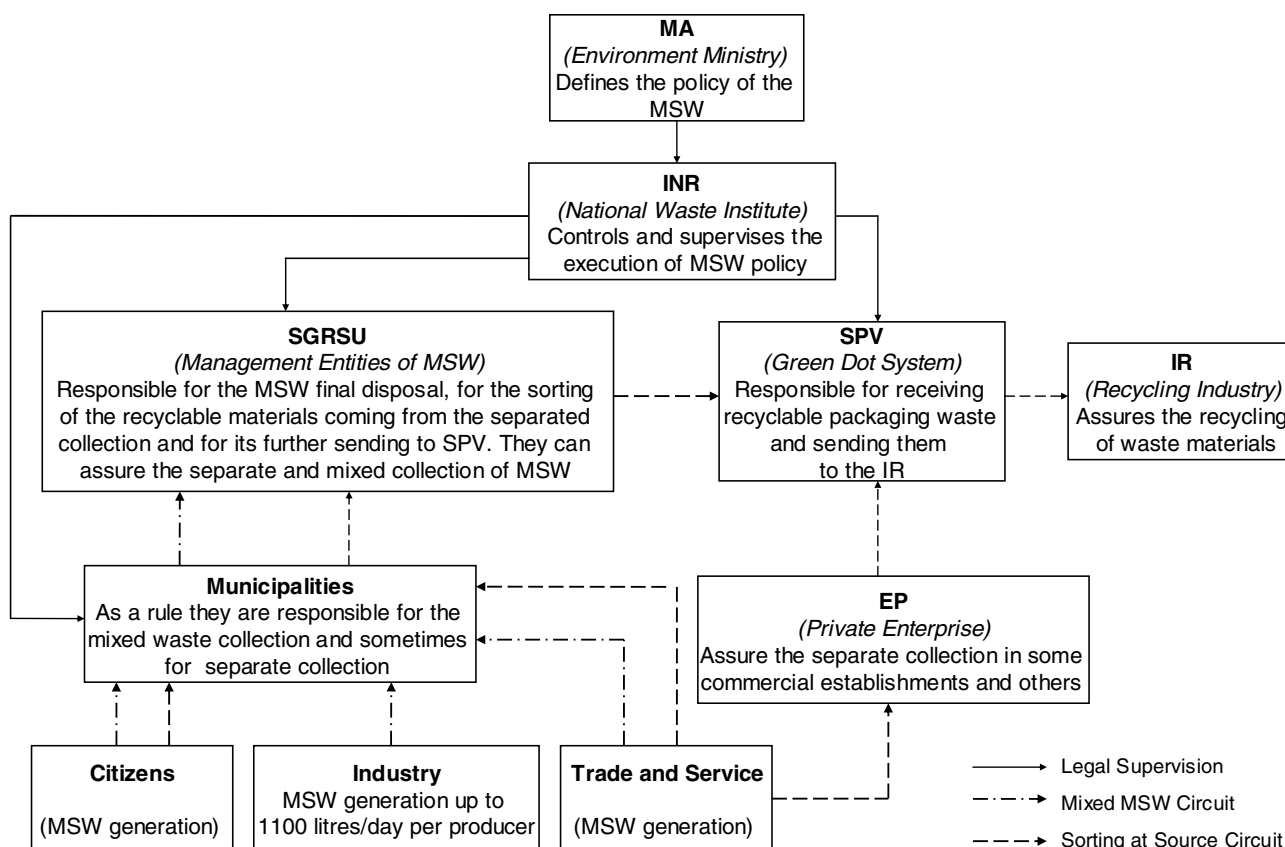


Fig. 1. Framework of responsibility and management of MSW in Portugal.

3. Waste-related legislation and basic principles of waste management in Portugal

The European directives had a determining influence on the development of the MSW management in Portugal, working as a paradigm, an incentive and as guidelines to be included into the Portuguese legislation. In 1975, when the first European Directive about waste (European Commission, 1975) appeared, there was no consensus on the best option for MSW management. Northern Europe was committed to solutions that included incineration or recycling, and it was clear that Southern Europe preferred the economic advantages of controlled landfills. The above quoted Directive defined the conditions for waste disposal. In 1994, Directive 94/62/EC (European Commission, 1994) had as its main purpose the harmonization between the national regulations concerning packaging and packaging waste management in order to reduce the environmental impact of the materials. This directive played a fundamental role in the promotion of recycling through the definition of the hierarchy of packaging and packaging waste management principles, as well as for the definition of the recycling targets for the Member States with the simultaneous creation of national systems that could ensure packaging and packaging waste management according to the defined principles.

In 1999, Directive 99/31/EC (European Commission, 1999) defined the rules for waste landfilling in order to

establish the measures, the processes and the guidelines that could avoid or reduce as much as possible the negative effects of pollution on the environment, either at the local level (namely the surface and underground water, the soil and the atmosphere) or at the global level (including the greenhouse effect and any other risks for human health coming from waste disposal in landfills for their lifetime). On this basis, the above mentioned directive required the Member States to create strategic plans for the reduction of biodegradable MSW previously going to landfills and defined the targets for biodegradable waste landfill disposal.

In 2004, Directive 2004/12/EC (European Commission, 2004) came into force in order to update Directive 94/62/EC and to redefine targets for packaging and packaging waste recovery and recycling for 2011 in Portugal. This directive has not yet been transposed into Portuguese law, but the targets are to recover a minimum of 60% by weight of packaging waste, and to recycle 60% by weight of metals, 22.5% by weight of plastics and 15% by weight of wood.

In Portugal the legislative pattern for waste management was defined for the first time by Decreto-Lei 488/85 (Ministerio do Ambiente, 1985). This decree established a basic action line for waste management based on the collection, storage, transport and disposal or reuse of the wastes by their owner. Some types of waste, such as radioactive wastes, were excluded from that law. The same

law established a set of legal definitions and general responsibilities for several entities (municipalities, companies and health units, among others) namely concerning the removal, the treatment and the final destination for MSW. The existence of a waste inventory and record was also predicted.

The concept of social co-responsibility was established by Lei 11/87 (Ministerio do Ambiente, 1987), the Environmental Basic Law, where the concern for environmental global preservation was considered and the principle of the producers' responsibility for waste self-production was consecrated in conformity with the European Community legislation.

Decreto-Lei 310/95 (Ministerio do Ambiente, 1995) revoked Decreto-Lei 488/85. Ten years later, the new law established the general legislative pattern for waste management, consecrating the principle of the producers' responsibility for appropriated waste management and the principle of the keeping of records of waste management operations. This law also established the principle of licensing for the recovery and disposal operations concerning MSW, industrial waste, dangerous waste and other waste types.

Since 1994, and through a set of laws, several systems for municipal solid waste recovery and treatment (SGRSU) were legally created throughout the country. In 1996, Portaria 15/96 (Ministerio do Ambiente, 1996) was introduced, predicting the types of waste disposal and recovery operations in Portugal, including energy recovery (incineration with heat recovery, waste-to-energy – WTE).

In July 1997 the PERSU was created and defined. It was finally possible to evaluate as maturely as required the problem and its dimension. A diagnosis was made and the priorities were clarified: the option by reduction preventive tools, reuse and recycling, and the creation of treatment and final disposal systems were the priority choices of the Plan's options.

However, it was soon verified that Decreto-Lei 310/95 was still not sufficient. Therefore, it was necessary for the preceding law to be reviewed in order to adapt it to the new political options and in order to introduce the improvements that experience revealed to be convenient, keeping, however, the spirit of the European directives.

The new law, Decreto-Lei 239/97, revoked Decreto-Lei 310/95, and reaffirmed the producers' responsibility principle for waste production introducing an autonomous way for prior permission for waste management operations. This law is presently in force and establishes the following general principles and objectives that govern waste management in Portugal:

1. prevention or reduction;
2. reuse;
3. recovery (e.g., recycling, incineration with heat recovery); and
4. polluter-pay principle, making the producers or the wastes owners responsible for disposal.

This law also consecrates essential rules for waste management. The following are the most important ones:

1. elaboration of waste management plans both at national and regional levels;
2. prior permission for the operations of waste storage, treatment, recovery and disposal;
3. prohibition of wastes abandonment and discharge, as well as wastes incineration at sea and injection in the soil;
4. projects for waste management operations must have the agreement of the competent municipality; and
5. the waste management operations must be compulsorily registered.

On the 20th of September 1997, Decreto-Lei 366-A/97 (Ministerio do Ambiente, 1997c) came into force transposing Directive 94/62/EC to the national legislative system. This directive, concerning packaging and packaging waste, establishes the principles and the regulations that must be applied to their management in order to reduce their production, ensuring the reuse of used packaging, recycling and some other forms of packaging waste recovery and, consequently, reducing the amount requiring final disposal, assuring a high level of environmental protection. In that directive, the targets and objectives to be achieved in Portugal, concerning the recovery and recycling of packaging waste, were also established:

- (a) 25% as a minimum by weight of packaging waste to be recovered by the end of 2001;
- (b) 50% as a minimum by weight of the packaging waste to be recovered by the end of 2005; and
- (c) within this general target, and with the same time limit, 25% as a minimum by weight of the total packaging materials contained in packaging waste to be recycled with a minimum of 15% by weight for each packaging material.

Finally, and more recently, Decreto-Lei 152/2002 (Ministerio do Ambiente, 2002) came into force in May 2002, establishing the legislative pattern for the licensing procedures concerning the installation, exploration, closing and after-care of landfills, transposing to the national legislative system European Directive 1999/31/EC on waste landfilling. The same directive established national targets concerning the reduction of biodegradable waste landfilling:

- (a) by January 2006 biodegradable MSW going to landfills must be reduced to 75% of the total amount (by weight) of biodegradable MSW produced in 1995;
- (b) by January 2009 biodegradable MSW going to landfills must be reduced to 50% of the total amount (by weight) of biodegradable MSW produced in 1995; and

- (c) by January 2016 biodegradable MSW going to landfills must be reduced to 35% of the total amount (by weight) of biodegradable MSW produced in 1995.

In 2004 the national strategy for the reduction of biodegradable waste for landfilling was defined by INR (*Ministerio do Ambiente, 2004a*). This strategy is based on objectives intended to preserve the natural resources and minimize the negative impacts on public health, in order to ensure a clean and healthy environment (*Ministerio do Ambiente, 2004b*) and establishes the following principles: separate collection of organic matter; construction of new recovery plants; optimization of the existing plants and of those to be built; gradual compost production; quality warranty of the compost; and minimization of biodegradable waste landfilling.

A comparative analysis between the Portuguese and the European legislations concerning the present waste management situation allowed the conclusion that Portugal is still taking the first steps in waste treatment and recovery. Portugal began its waste management policy at the lowest step in the hierarchy of the treatment and disposal methods for packaging waste as defined by Directive 94/62/EC – sanitary landfills. Landfills are far from answering completely the hierarchy's priorities as they are defined by the Community Directive, although landfills can be considered an important step forward in comparison with the previously used open dumps.

As sanitary landfill is the main method for MSW treatment, it would be understandable that the Portuguese legislation could consider recovery of landfill biogas, since this gas has a high calorific value, which can be and must be recovered. However, in 2002 landfill biogas energy recovery was not conducted in Portugal. In 2003 equipment for biogas energy recovery was in the installation phase in two sanitary landfills while, in neighboring Spain, the successful installations were numerous (*Villegas, 2003*).

So far the figures are still not known concerning the prevention and reduction of MSW packaging production.

4. Generation and disposal of MSW

Until 2001 there were only estimates of MSW generation in Portugal because of the predominance of open dumping and the difficulty of recording MSW generation. Following the complete closure of those dumps in 2001, the conditions to obtain reliable figures on MSW generation and management at a national level were created.

The absence in Portugal of reliable data and statistics for waste generation, treatment and recovery makes a regional or national evaluation of the evolution in MSW management difficult. There are several international studies and statistics about MSW management, in which Portugal is not represented or the positions concerning Portugal are not completed (e.g., *Koufodimos and Samaras, 2002; Shimura et al., 2001*). The importance of those statistics comes from the need for a comparison of the generation,

treatment and recovery with preceding years, as well as with other countries or regions.

The data and figures presented in this paper result from a study based on a national inquiry carried out in 2003 by the authors directly to the 30 SGRSU. Portugal is a country having a relatively small territory but, in contrast, it also exhibits large differences of development levels between the rural interior and the more developed regions near the coast. For this reason the MSW generation rate per capita varies considerably from one region to another. After the close of open dumps, 2002 was the first year that reliable data on waste disposal could be obtained for Portugal. In 2002 the production of MSW in the different SGRSU ranged from 0.75 to 1.98 kg/capita/day with a national average of 1.32 kg/capita/day (see *Table 1*). The highest value is much higher than the national average, which can be explained by the high level of tourism in the region with the visitors increasing the amount of MSW per capita. In 2002, the amount of MSW generated nationally was 4,746,021 tons, managed by 30 SGRSU (see *Table 1*). As can be seen from the table, the sizes of the 30 SGRSU vary greatly, the smallest system having only 0.27% of the population and the largest 12.13%. It can also be observed that the percentage of inhabitants is different from the percentage (by weight) of MSW produced. This fact can be explained by the differences in the generation per capita, resulting from different standards of living and cultural habits. Analyzing *Fig. 2*, one can see the quantity of waste allocated to the different components of the waste generation and collection system. The total quantity of waste generated is 4,746,021 tons, with 4,553,952 tons (96%) of waste collected mixed and only 192,069 tons of waste separated at source (4%). From this observation, one can also see that only a part (packaging) of the separately collected MSW is sorted. The yard wastes that were separately collected in different regions had different destinations, depending on the type of existing disposal plants in each region. In 2002, from the total of the separately collected yard waste, 14,071 tons were recovered by composting, 8447 tons by waste-to-energy (WTE) and 9930 tons were disposed of in sanitary landfills.

If only the initial destination of the waste is considered, more than 3 million tons are disposed in sanitary landfills, about 992,000 tons are treated in WTE plants, about 400,000 tons are treated in organic waste recovery plants and about 159,000 tons coming from the separated collections are sorted in sorting plants (see also *Fig. 3*). This corresponds, respectively, to 67.3% of the MSW disposed of in sanitary landfills, 20.9% treated by WTE, 8.4% treated in organic waste recovery plants and 3.4% sorted in sorting plants.

Considering now the total amount of wastes that are directed to landfilling, one can see from *Fig. 2* that such deposition has increased considerably, by 8.6% when compared to the case of initial destination, with a total of 3,470,347 tons of MSW disposed of in sanitary landfills (summation of all of the inputs directed to sanitary

Table 1
MSW production for continental Portugal in 2002

SGRSU	MSW (ton/year)	Number of inhabitants	kg/capita/day	Percentage (%)	
				MSW	Inhabitants
1	282,174	391,000	1.98	5.95	3.97
2	34,379	104,695	0.90	0.72	1.06
3	53,539	152,506	0.96	1.13	1.55
4	43,615	101,658	1.18	0.92	1.03
5	461,487	714,589	1.77	9.72	7.25
6	22,331	61,762	0.99	0.47	0.63
7	150,404	471,256	0.87	3.17	4.78
8	58,878	119,550	1.35	1.24	1.21
9	12,967	26,500	1.34	0.27	0.27
10	69,568	221,191	0.86	1.47	2.24
11	97,790	160,000	1.67	2.06	1.62
12	41,315	110,300	1.03	0.87	1.12
13	117,028	275,139	1.17	2.47	2.79
14	183,292	365,000	1.38	3.86	3.70
15	361,842	970,702	1.02	7.62	9.84
16	497,706	969,000	1.41	10.49	9.83
17	49,716	181,297	0.75	1.05	1.84
18	29,978	105,000	0.78	0.63	1.06
19	40,197	114,859	0.96	0.85	1.16
20	177,042	382,077	1.27	3.73	3.87
21	88,255	214,300	1.13	1.86	2.17
22	64,199	118,119	1.49	1.35	1.20
23	114,720	325,680	0.97	2.42	3.30
24	176,714	437,255	1.11	3.72	4.43
25	430,317	746,815	1.58	9.07	7.57
26	56,005	120,000	1.28	1.18	1.22
27	114,911	297,206	1.06	2.42	3.01
28	29,241	79,632	1.01	0.62	0.81
29	770,804	1,196,344	1.77	16.24	12.13
30	115,607	327,768	0.97	2.44	3.32
Total	4,746,021	9,861,200	1.32		

landfills – 3,183,629; 9930; 19,146 and 257,642 tons). This is due to the depositing of the composting rejects and a part of the rejects coming from the sorting of the materials separately collected. Similarly, disposal by WTE is increased by 3%, in this case such increase is due to the combustion of the remaining part of wastes being rejected during the sorting of the materials separated collected – 29,942 tons (Fig. 2).

5. Physical composition of MSW

When municipal solid wastes are discharged into containers without any separation, the result is a mix having a complex physical composition making treatment more difficult. The knowledge of MSW physical composition and evolution is crucial to planning the methods and technologies to be applied as treatment. An understanding of the physical characterization of the wastes is also crucial to determine a typical MSW, in order to evaluate indicators such as the potential and the rates of recovery and recycling of materials such as packaging waste. In Table 2, the MSW physical composition for 2002 is shown for six different Portuguese regions (four urban and two rural). Fig. 4 shows a typical example representing the MSW physical composition in 2002 in Portugal for a par-

ticular urban SGRSU. In both cases (Table 2 and Fig. 4), the figures indicated represent the percentage (dry weight) of mixed collected waste, which excludes the materials collected separately. The comparison between the different physical waste compositions is not always an easy task because different analysis are performed by different sample gathering methods and different procedures to analyze the waste may be adopted. Nevertheless, from Table 2 it can be observed that the approximate ranges are: organic wastes, 33–41.5%; paper and cardboard, 17–27%; textile wastes, 3–5.5%; plastic wastes, 10–14%; metal wastes, around 2%; glass wastes, 3.5–6.5%; and wood wastes, around 0.7%.

6. Separate collection and recycling of packaging waste

Separate collection is a vital process in order to make possible the recycling of several materials that are an intrinsic part of MSW (Sociedade Ponto Verde, 2002). In Portugal, the separate collection of packaging waste materials by the householders has been achieved by the following strategies:

- campaigns to bring about the awareness of citizens of the environmental issues and of the need to recycle;

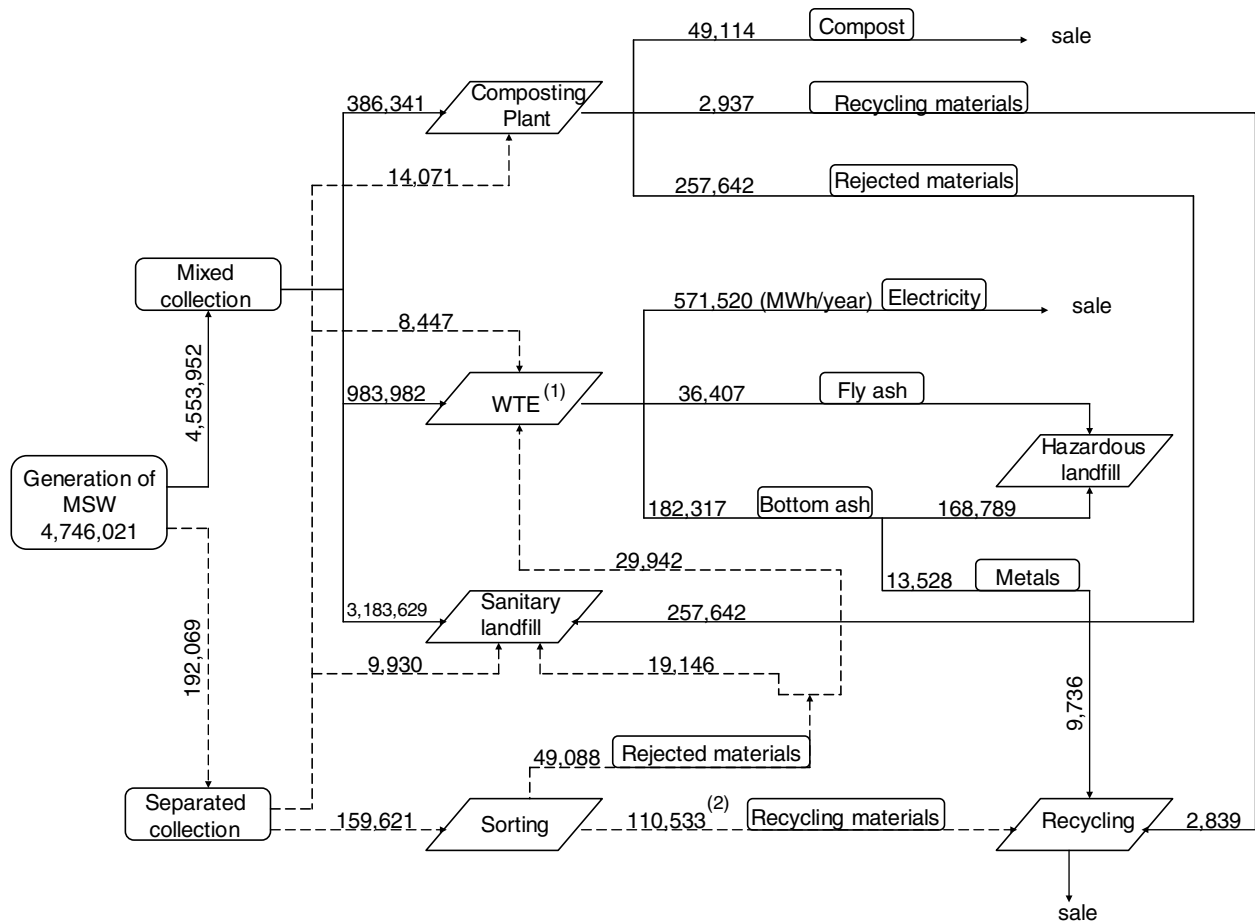


Fig. 2. The distribution of MSW into collection, recycled, treated and landfilled wastes in Portugal, 2002 (tons). (1) WTE – (waste-to-energy). (2) This figure was obtained from *Sociedade Ponto Verde* (2002).

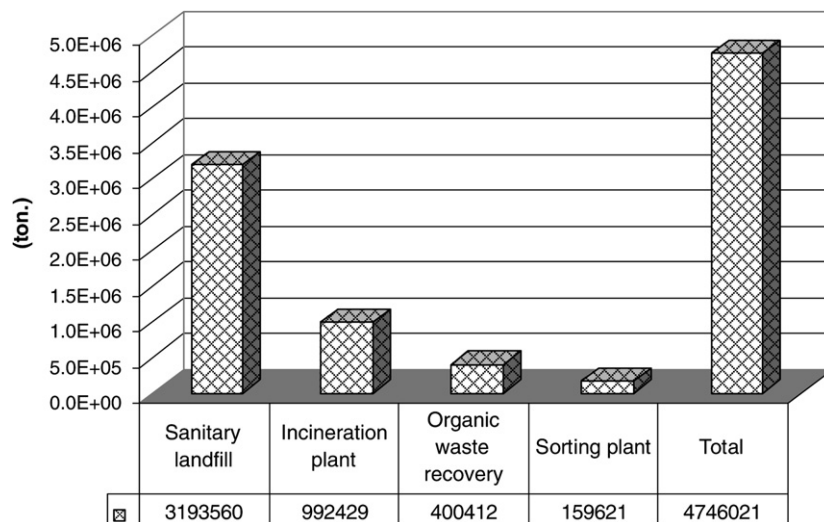


Fig. 3. MSW amounts by methods of disposal in continental Portugal, 2002.

(b) locating appropriated containers (ecopoints) in specific places (group of containers to receive different sorted materials);

(c) separation of several material types at the beginning of the MSW treatment system (e.g., sorting before composting);

Table 2

Physical composition of Portuguese municipal solid waste in 2002 (numerical values indicate weight percentages on a dry basis)

Materials		SGRSU (type)					
		5 (Urban)	8 (Rural)	13 (Rural)	16 (Urban)	25 (Urban)	29 (Urban)
Organics	Kitchen	30.9	23.73	8.7	32.9	29.37	37.5
	Yard	4.6	14.35	32.7	4.2	3.53	1.3
	Sub-total	35.5	38.08	41.4	37.1	32.9	38.8
Paper and board	Packaging	7.6	6.82	5.2	9.1	7.65	7.1
	Others	18.3	10.48	19.7	15.1	19.75	18.2
	Sub-total	25.9	17.3	24.9	24.2	27.4	25.3
Textile		3.4	4.04	5.5	2.9	3.09	3.8
Plastics	Packaging	10.7	13.47	2.7	11.1	11.01	8.8
	Others	0.8	0.74	8.4	0.9	1.01	1.1
	Sub-total	11.5	14.21	11.1	12	12.02	9.9
Metal	Packaging of ferrous	1	0.05	0.7	1	1.27	1
	Packaging of aluminum	0.5	1.24	0.5	0.2	0.45	0.3
	Others	1.1	0.41	1.3	0.3	1.26	0.8
	Sub-total	2.6	1.7	2.5	1.5	2.98	2.1
Glass	Packaging	4.9	3.32	6	6.3	5.29	5.5
	Others	0.5	0.18	0.6	0.3	0.18	0.3
	Sub-total	5.4	3.5	6.6	6.6	5.47	5.8
Wood	Packaging	0.4	0.55	0.4	0.5	0.12	0.4
	Others	0.35	0.25	0.2	0.4	0.5	0.4
	Sub-total	0.75	0.8	0.6	0.9	0.62	0.8
Fines	<20 mm	12.7	15.16	1.9	12.7	10.39	10.1
Others		2.25	5.21	5.5	2.1	5.13	3.4

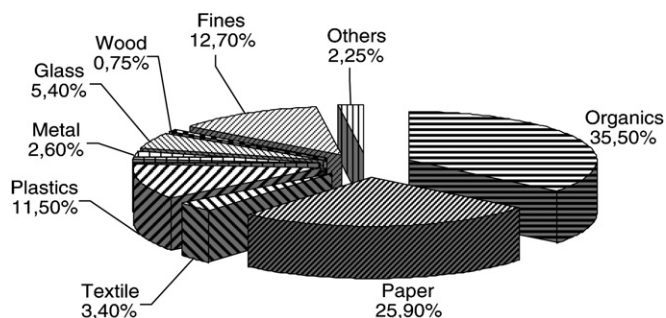


Fig. 4. Representative physical composition of Portuguese MSW in an urban region (weight percentage on dry basis).

- (d) collection of specific materials near trading shops and services;
- (e) collection of specific materials close to schools; and
- (f) door to door collection.

The most common method for separate collection is based on the use of different containers for glass, paper/cardboard, and plastic/metal, placed together at ecopoints preferably located on streets, and at strategic points such as schools, parks, pools, sport complexes, markets, fairs, etc.

So far no quantitative national data concerning separate collection is known. The data obtained from a national inquiry performed by the authors directly to the SGRSU are displayed in Fig. 5 and indicate that in the 5 year period

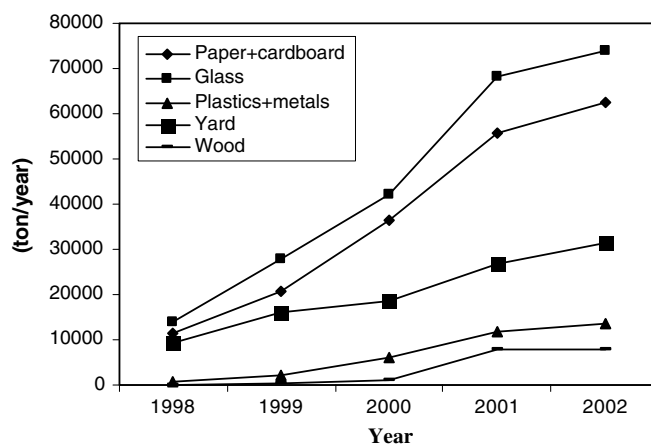


Fig. 5. Separate collection of waste in continental Portugal from 1998 to 2002.

from 1998 to 2002, separate collection had quite an accentuated growth. Separate collection in Portugal exhibited fast growth from 1998 until 2001, and a smaller growth in 2002. The increase in the first years is probably due to the fact that separate collection was initiated in Portugal in the late 1990s. The separate collection of paper/cardboard increased 447% (from 11,418 to 62,485 tons), glass increased 429% (from 13,996 to 74,017 tons), and plastic and metallic packaging increased 1656% (from 781 to 13,717 tons). As already mentioned, from 2001 to 2002 separate collection had a more moderate increase, when

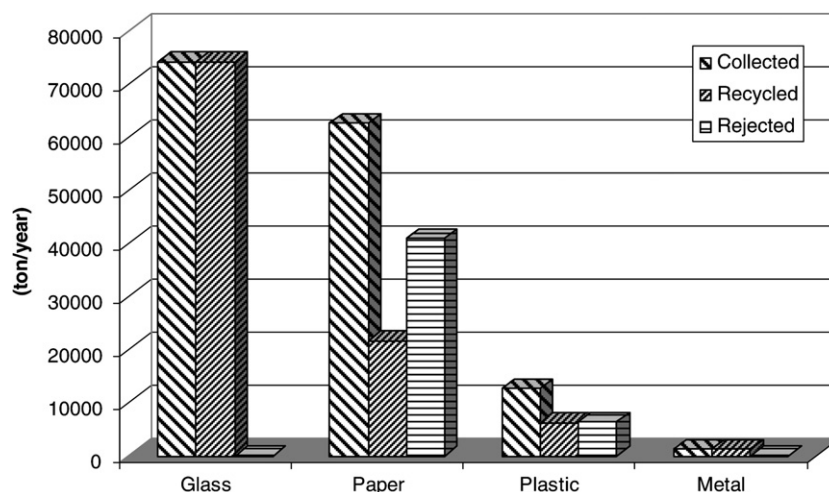


Fig. 6. Separate collection and recycling of packaging materials for continental Portugal in 2002.

compared with the preceding years. During the one-year period, the separate collection of paper/cardboard increased 12% (from 55,665 to 62,485 tons), glass increased 9% (from 68,221 to 74,017 tons), plastic and metallic packaging increased 16% (from 11,807 to 13,717 tons).

The organic waste separate collection from 1998 to 2002 was limited to yard waste and some wood packaging waste having a residual value. As can be seen in Fig. 2, a part of those separately collected yard wastes were then disposed of in sanitary landfills instead of being recovered. This fact is explained by the lack of facilities for organic processing and energy recovery in the regions where such wastes were collected.

As mentioned earlier, the Green Dot System (SPV) is the entity that is in charge of both the receipt of all packaging materials in conditions to be recycled and forwarding them to the recycling industry, thus the packaging recycling data for Portugal presented in this paper was obtained from the SPV official data (Sociedade Ponto Verde, 2002, 2003). From 2002 to 2003 the recycling figures for packaging and packaging materials increased significantly: paper/cardboard from 26,018 to 29,965 tons (15% increase), plastic from 7126 to 8217 tons (15% increase), glass from 75,227 to 91,035 tons (21% increase), and metals from 12,724 to 14,138 tons (11% increase).

Although the amount of separately collected wastes is not the only factor influencing their recycling, separate collection is a determining factor in order to reach the defined targets for recycling of packaging materials. Therefore, it is important to analyze the relationship between the collected and the recycled materials as shown in Fig. 6. In 2002, only 35% of the separately collected paper/cardboard in Portugal was recycled, the remainder being rejected; and only 49% of the separately collected plastics was recycled, the remainder being rejected. From these figures, it can be concluded that both the amount and the quality of the separation performed at source have a crucial influence on the recycling targets. In order to reach the proposed targets for Portugal it is, therefore, necessary to intensify separate

collection at the source. It must be also mentioned that the rejected packaging waste during sorting could contribute significantly to reach the packaging waste recovery targets. The rejected packaging must be recovered as it has a high calorific value that must not be disregarded. However, as can be verified in Fig. 2, a part of the packaging waste (19,146 tons) is disposed of in landfills without any recovery.

It must be noted that a considerable increase in separate collection and in packaging recycling is crucial to achieving the targets imposed by the Portuguese and European legislations; however, the significant increases referred to above seem to be insufficient to achieve such targets for 2005. According to Sociedade Ponto Verde (2003), in 2003 the global recycling rate was 18%, the recycling rates for the different materials being: 12.5% for paper/cardboard, 4.5% for plastics, 30.2% for glass, 24.8% for steel, 6.9% for aluminium and 81.2% for wood. In comparing the targets that were imposed by law for 2005 and the rates in 2003, Portugal had only 2 years to achieve the goals and was still far from achieving them; hence, it seems that, if no special measures were taken, it would be difficult to attain the proposed figures for 2005 and the goals for 2011 may become compromised.

7. Organics waste recovery – composting

In 2002, only four SGRSU had organic waste recovery plants working as main waste treatment processes. All of these plants use aerobic composting for treatment of biodegradable wastes. In Portugal, MSW entering the composting plants are from mixed collection systems. As a consequence they have to be sorted and, by this sorting process, the inorganic materials and those to be recycled are extracted. Nationally in 2002, 8% of MSW entered organic waste recovery plants, a total of 400,412 tons (the summation of 386,341 and 14,071 tons, as displayed in Fig. 2). From those, 49,114 tons of compost were produced, 2937 tons of packaging materials were recycled

and 257,642 tons of MSW were rejected to landfilling (see Fig. 2). Only 13% of the MSW coming into the organic waste recovery plants was recovered. Figs. 7 and 8 show that in the 3 years from 2000 to 2002, the amount of MSW being treated in those plants had a very small increase, the percentage of recovered waste was kept constant and the slight decrease in compost production was balanced by the increase of the recycled materials.

The quality of the compost produced and the viability of its application depends on the heavy metal contamination in the compost, which in turn depends basically on the raw material quality in the composting process. When the organic wastes entering into the organic wastes recovery plants come from separate collection, and providing that they were not in contact with contaminating sources during the collection and transportation processes, it is possible to obtain a final product having a very low concentration of heavy metals. When dealing with mixed collected municipal wastes (as is so far, the case in Portugal), higher percentages of those metals in the organic compost are to be expected.

According to Jardim and Sebastião (2003), in 2003 the compost produced by the organic wastes recovery plant

of Setubal (a southern Portuguese municipality) is far from satisfying the anticipated limits that will be imposed by the European Directive proposal. In fact, comparing the characteristics of the compost produced at the Setubal plant to the limiting values foreseen by both the Portuguese Standard proposal for “class III” and the corresponding European Directive proposal for “class II” (the less demanding class of the European Directive that still allows the product application to agricultural soils) presented in Table 3, one can see that some of the heavy metal concentrations in the compost at the Setubal plant are above both recommended values. The discussion of both legislation proposals is important as EU directives are a result of policies of all of the member-states. Moreover, a member-state, as Portugal, can temporarily have a less restrictive legislation due to the specificities of the country.

The Setubal organic waste recovery plant has a great deal of experience in composting and it is considered as a reference plant. Therefore, it may be concluded that if the above referred Portuguese standard and European directive come into force, the agricultural use of the final product that is generated at the Setubal plant (and throughout Portugal) will be compromised, unless there is a more favorable evolution for the raw material quality delivered to the waste recovery plants, that is, if there is a more favorable evolution of the separate collection.

However, it must be stated that mixed MSW composting helps to solve some important problems. In fact, through organic MSW treatment the methane production is eliminated, which helps to achieve the requirements of European Directive 1999/31/EC concerning sanitary landfills and reduction targets for the generation of those gases contributing to the greenhouse effect. It also allows important recovery of recyclable materials and the life expectancy of landfills is increased. On the other hand, with mixed collection there is a lack of power generation and the compost produced cannot be generally used in agriculture. In conclusion: with the coming into force of the European directive the composting of the presently mixed collected MSW is not viable because the compost cannot be used for agricultural purposes. Nevertheless, composting

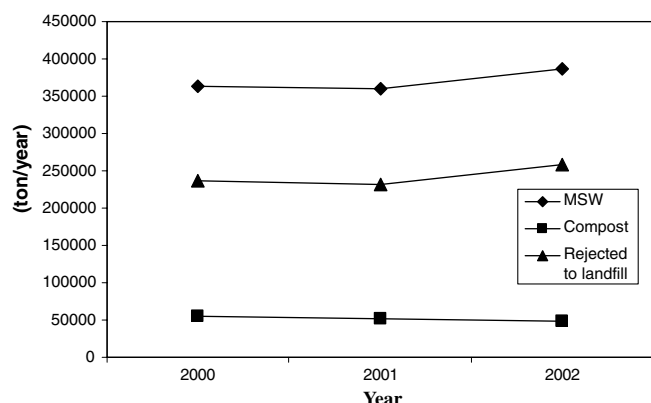


Fig. 7. Handling of MSW at organic waste recovery plants for continental Portugal between 2000 and 2002.

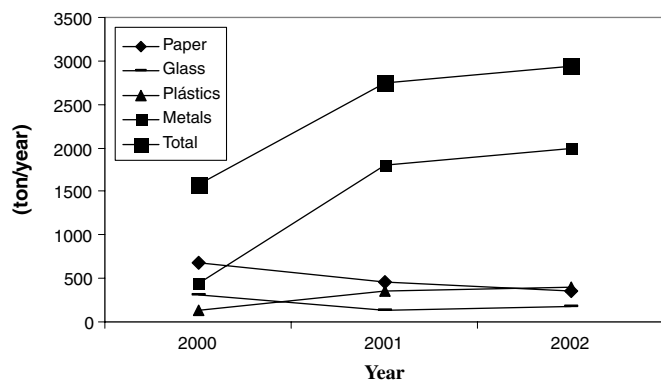


Fig. 8. Recycling of packaging material from sorting of mixed MSW at organic waste recovery plants for continental Portugal between 2000 and 2002.

Table 3

Contents of heavy metals (ppm) in the compost produced in the Setubal organic waste recovery plant and maximum admissible values according to Portuguese Standard proposal for class III (Manuel and Marco, 2001) and to European Directive proposal for class II (European Commission, 2001)

Heavy Metal	Compost at Setubal Plant (measured values)	Portuguese Standard proposal for class III	European Directive proposal for class II
Cadmium	1–4	5	1.5
Lead	165–654	400	150
Copper	134–539	500	150
Chrome	20–172	300	150
Mercury	0.2–1.5	5	1
Nickel	24–113	200	75
Zinc	210–721	1500	400

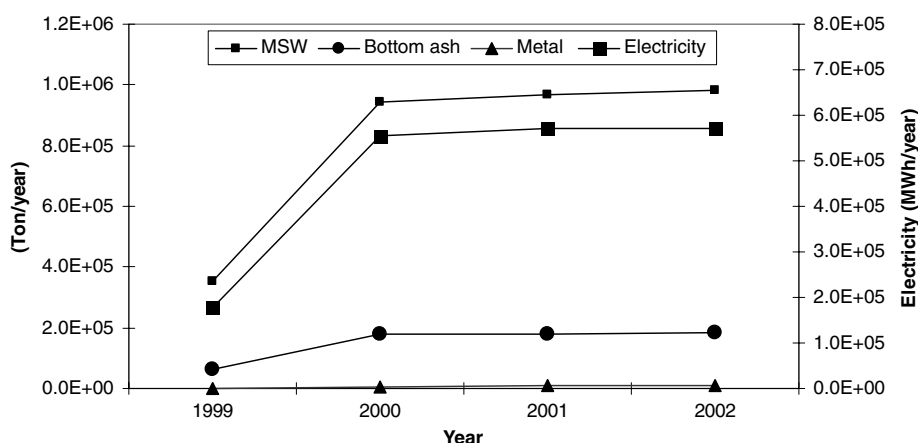


Fig. 9. Disposal of MSW in WTE plants and respective electricity generation for continental Portugal between 1999 and 2002.

can become a valid option provided that sorting and the composting of separately collected organic wastes is performed.

8. Waste-to-energy

The amount of MSW treated by incineration increased significantly from 1999 to 2000 owing to the commissioning of a new plant. Since then there has been a slight increase that can be explained by the increase in the production rate per capita. As a result of this trend, the electric power generation has increased and the amount of the metals collected from the bottom ash for recycling has also increased, from 2317 tons in 1999 to 9888 tons in 2002 (see Fig. 9). However, the amount of bottom ash was kept almost constant during the same period. In 2002, 992,000 tons were incinerated yielding 572 GWh of electrical power generation, 13,528 tons of metal, 182,317 tons of bottom ash (168,788 tons directed to hazardous landfill and 13,528 tons directed to recycling) and 38,407 tons of fly ash.

In 2002, waste-to-energy plants were used as the main MSW disposal process by the two most important SGRSU.

9. Landfilling

Landfilling, the last choice method in the waste management hierarchy, is the method that has been adopted by the majority of the SGRSU for MSW treatment in Portugal. This situation may be explained by three main factors: the small capacity of the SGRSU, the low installation and operating costs of landfills, and the existence of considerable available space to locate the landfills. Following the dump closures and the creation of landfills to replace them, the amount of MSW to be disposed of in sanitary landfills increased significantly in the 5 years from 1998 to 2002: 128% (see Fig. 10). In 2002 3,470,347 tons of MSW were disposed of in sanitary landfills, corresponding to 73% of MSW generation. Note that about 6% of the sanitary landfill input (276,788 tons) is the result of the rejects from the

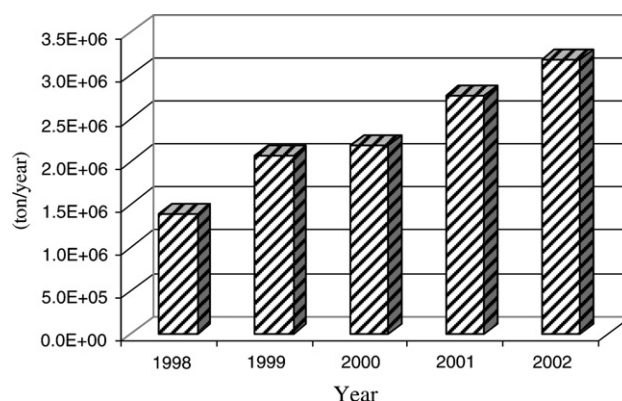


Fig. 10. Deposition of MSW in sanitary landfills for continental Portugal between 1998 and 2002.

composting plan (257,642 tons) and from the sorting process of the materials separately collected (19,146 tons), as shown in Fig. 2.

10. Concluding remarks

In the last decade MSW management in Portugal was changed positively, basically due to the coming into force of the legislation and due to the appearance of regional entities in charge of MSW management.

For the first time, in 2002, it was possible to quantify the MSW being generated in Portugal. In that year 4,746,021 tons of MSW were generated, 67.3% of this amount being disposed of by sanitary landfilling, 20.9% being incinerated at WTE plants, 8.4% being treated at organic waste recovery plants and 3.4% being processed at sorting units. The average per capita generation rate in 2002 was 1.32 kg/capita/day.

As far as the collection method is concerned, 96% of the MSW were collected mixed and 4% were collected separately at the source. Separate collection in Portugal has greatly increased since 1998, and the most common method for separate collection is based on the use of separate containers for glass, paper/cardboard and plastics/metals. The

increase of separate collection at the production source is quite important to attaining the recycling targets defined for packaging waste material; however, the packaging waste recycling rate in 2003 was only 18.2%. Therefore, the actual significant increase in the separate collection does not seem to be enough to accomplish the recycling targets for either 2005 or 2011.

If the anticipated legislation on compost quality is to be applied, the agricultural use of the final product being generated in the mixed waste composting plants in Portugal will be compromised due to the heavy metals content. Keeping this in mind, the present mixed MSW composting is not justified, unless there is a considerably more favorable evolution of the material quality, which can be achieved through sorting and composting of separately collected organic wastes.

Landfilling, the last choice method in the hierarchy of waste management, is the method that has been adopted by the majority of the SGRSU for MSW treatment in Portugal. However, even with sanitary landfilling being the most common method of MSW management, there was no landfill gas energy recovery.

Concerning the hierarchy of the principles and the methods for MSW management defined by the European directives and regulations and by the national legislation, Portugal still has a long way to go and, therefore, there is a considerable amount of effort to be done in order to obtain real and significant positive evolution in MSW prevention, reduction and recovery.

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