Integrated waste management of special and municipal waste – a territorial case study

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Abstract

An Integrated Waste Management System must join flows, methods, and techniques of collection, treatment and disposal, in order to achieve environmental benefits, economic optimisation and social acceptability. The aim is to define, by means of the quantification of waste produced, collected, reused and disposed within the studied territory, a practical system of management of these materials. Results obtained in the Province of Mantova (Northern Italy) revealed an overall production of special waste (year 2003) of about 1 million and 137 thousands tons, of which about 74,500 tons of hazardous waste. The most important material flows are represented by the different typologies of wooden rejects, agricultural residues, construction and demolition inert debris, refuses containing asbestos, medical waste, biosolids from sewage sludge. The quantification of municipal solid waste was, on the contrary, performed directly by the local Governments (Municipalities), which must forward these data to the Provincial Waste Observatory. In 2004, the production of urban waste amounted to about 216,000 tons, about 81,000 tons of which were selectively collected. In the second step of the work, plants for waste recovery, treatment, storing and disposal were examined to determine their capacity (according to the authorisations released by the Province); these authorised capacities were compared to the waste quantities to be managed. From this comparison, a good plant capacity resulted, so that the Province can face the problem of waste produced in its territory, in a position to balance supply and demand for the present and future.
Keywords: waste management system, planning, treatment plants, recovery, landfill's useful life.

WIT Transactions on Ecology and the Environment, Vol 92, © 2006 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/WM060531

1 Introduction

The governmental decree currently in force in Italy (Ministry of Environment Decree 22/1997), which implemented three European Community Directives (91/156/EEC on waste, 91/689/EEC on hazardous waste and 94/62/EC on packaging and packaging waste), fixes Regional and Provincial competence, concerning waste management. In particular, each Region must prepare a plan of waste management, in which the guidelines and the direction strategies of the single Provinces are presented. Provinces, according to the specific territorial features (demographic, geographic, productive…), elaborate provincial plans of waste management, which are in force for 10 years and undergo a revision every 5 years. Within these plans, indications concerning the management of both municipal and industrial waste are contained. The following study consists in the revision of the provincial plan of waste management in the Province of Mantova. This province extend over about 2,340 km^2 and is mainly constituted (for about 92% of its surface) of plan areas, typical of Po valley. The territory is divided into 70 Municipalities, generally of low demographic density (165 inhab./km^2). The productive fabric is distinguished by the small sized enterprises (93% of the total), but some large industrial facilities are also present. The main business fields represented are food, textile, clothing, engineering sectors.

2 Urban waste

The governmental decree 22/97 defines urban waste as "any substance or object included in the categories reported in the Annex A, and which the holder get rid of (or has decided to or must get rid of)". This means all waste deriving from household and productive consumers (which are comparable for quantity and typology). In order to know physico-chemical and commodity characteristics of wastes, sorting of waste according to IPLA [1] methodology were performed in 5 Municipalities: waste sample was sorted in 18 categories (fines < 20 mm, glass, other incombustibles, metals, aluminium, batteries, drugs, packaging with toxic and/or flammable substances, other hazardous waste, textiles, leather and hide, plastic films, plastic packaging, other plastics, fermentable organics, paper and cellulosic materials, cardboard, wood). Fines are sorted according to the size (10-20 mm, 5-10 mm, 3-5 mm and < 3 mm). Coarse wastes were separated, weighted and sorted in the different categories.

As can be seen in Figure 1, about one third of the undifferentiated waste is constituted of organic matter, i.e. the waste coming from consumers' kitchens. An integrated management system provides that the organic component is distinguished by a separated collection and afterwards treated in composting plants. In this way, it is possible to obtain a high quality compost (competitive in the market of amendments) and to take away the humid fraction of municipal waste from landfill disposal (significant reduction of leachate and biogas production). Waste from Electrical and Electronic Equipment (WEEE) represents a further critical component in municipal waste management, because they contain some hazardous substances for human and environment, and require

careful precautions in all the steps of disposal, from collection to treatment. Another Italian Decree (n. 151, 25 July 2005), which implemented three European Community directives (2002/95/EC, 2002/96/EC and 2003/108/EC), introduces in this wide class all the Equipments whose correct operation depends on electric currents or electromagnetic fields and those which operate in generating, transferring and measuring these currents and fields. Within the Decree, the quantitative and financial goals of separated collection (4 kg/inhab.*y) and recovery (about 60-80%, depending on the class) are defined.

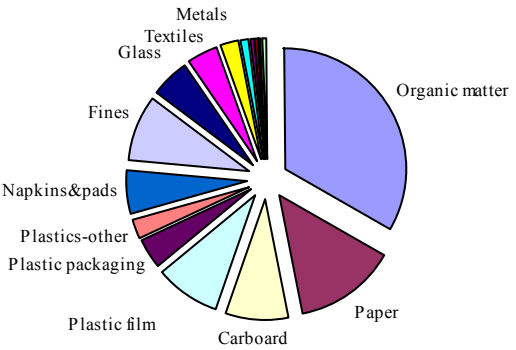

Figure 1: Percentage of waste categories analysed by sorting.

2.1 Production

In 2004 in Province of Mantova about 216,000 thousands of municipal waste were managed; the amount pro capita is of 550 kg/inhab*y, basically in line with the regional and national pro capita production (510 and 533 kg/inhab*y).

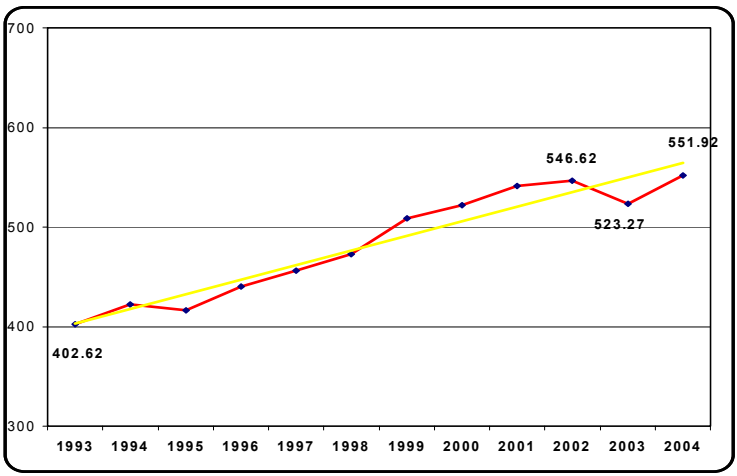

Figure 2: Pro capita production of municipal waste from 1998 to 2004.

Within the study performed on the Province of Mantova, many interventions aimed to counter the linear growth of waste have been proposed. In particular, the practice of domestic composting has been promoted, being easily diffusing in an agricultural territory, like Mantova. Furthermore, in the next years, prevention actions will be proposed, as the development of Last Minute Market: it consists in the building of relationships between supply and demand, and in the appreciation of products in the last step of their life cycle. Finally, financial tools will be adopted to stimulate the reduction of waste production, as the tariff of environmental hygiene. In the case it was possible to calculate that tariff in the single cases, it could be possible to measure the direct production of each consumer.

2.2 Separated collection

The above mentioned Ministerial Decree 22/97 defines separated collection as "the collection suitable to sort municipal waste in homogenous fractions, from a commodity point of view".

Lombardy Region calculates the percentage of separated collection as the ratio between the amount of waste separately collected and the total extent of waste produced; at the numerator the bulky waste reclaimed in the proper selection plants are included. In 2004, the Province of Mantova reached a percentage of separated collection of 37.5%; this value is in line with the result obtained in North-Italian Regions (35.5%). However, Regional average is slightly higher (40.9%), because in many Lombard Provinces more efficient collection systems have been implemented. In the Province of Mantova bring scheme of collection is the most common system. In the next years the introduction of kerbside collection system is going to be introduced, in order to reach higher percentage of separated collection and an improved product quality. Furthermore, it is fundamental to divide organic fraction, which now is separately collected only in 10 Municipalities out of 70. In order to encourage Municipalities to adopt efficient systems of separated collection and reach high qualitative standards, a financial incentive, named Project Tribute, has been proposed: each Municipality is classified depending on the percentage of separated collection, the pro-capita production and other management parameters; Municipalities which show the most efficient results will benefit from the relief of provincial tax, due to the activities of environmental safeguard, protection and hygiene. This incentive has been acknowledged by the European Environmental Agency.

2.3 Recovery-disposal plants

Province of Mantova is served by two mechanical-biological treatment plants, a landfill disposal plant, some composting plants and a recovery plant for bulky waste. The first ones treat the undifferentiated waste which is suitably sieved, deferrized and stabilized. In output, stabilized organic and inert material, metals are recovered and, most of all, a Refuse Derived Fuel (RDF) is produced.

From the analysis of the current flows and of those expected for the next decade, a management overcapacity (160,000 tons per year are permitted) and the necessity of a re-vamping of treatment technologies resulted (comparison with Best Available Techniques), in order to obtain quality RDF (according to UNI 9903 standard).

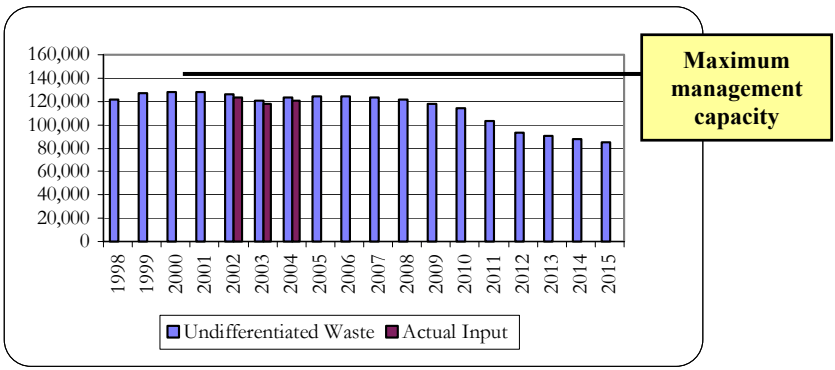

Figure 3: Prevision of undifferentiated waste flows destined to mechanical-biological treatment plants

Existing composting plants are of different type: some of them treat only the "green" waste, coming from the maintenance of public parks and gardens, others treat a mix of green, organic material and sludge. All in all, the expected flows for the Province of Mantova appear fulfilled; in the next decade an intervention on composting process variables will be performed, in order to improve the quality, and thus the marketability of the compost obtained (according to the law n. 748/1984)

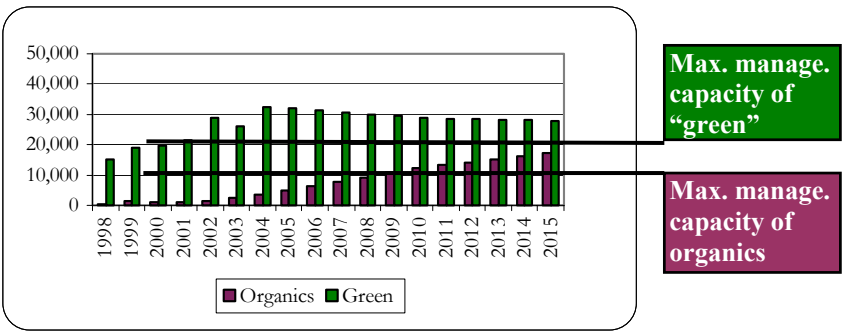

Figure 4: Amount of waste treated in composting plants.

The plant devoted to the recovery of bulky waste is authorized to treat about 6,000 tons/y of waste. From the analysis of historical fluxes of waste flown into

this plant (in 2004 about 6,150 tons were treated) and from the prediction of the future flows a certain plant shortage results; indeed, at present, about 5,000 tons of bulky wastes are conveyed directly into the disposal plant. This practice appears in contrast with Italian law (Decree 36/2003) which, since 2007, allows conveyance of waste not further exploitable in terms of matter and quality, and not further treatable.

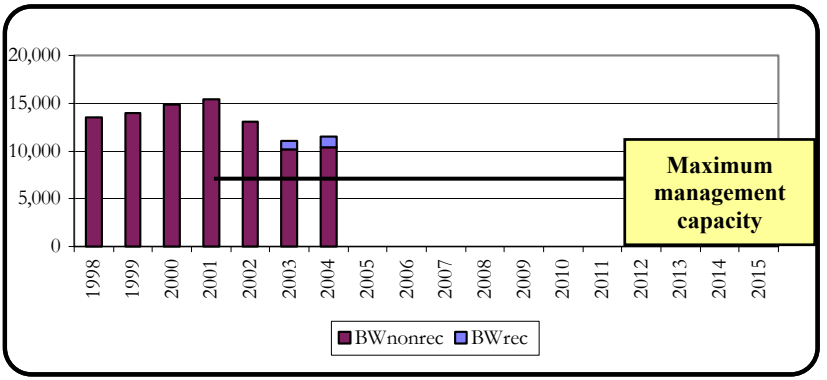

Figure 5: Bulky waste (BW) collection, years 1998-2004.

Table 1: Landfill's life, depending on annual input and degree of compaction.

Capacity of the second lot (m^3)	**950,000**		
Degrees of compaction (t/m^3)	**1.3**	**1.0**	**0.8**
Capacity of the second lot (t)	1,235,000	950,000	760,000
Used capacity (t)	140,478		
Residual Capacity (t)	**1,094,522**	**809,522**	**619,522**
Hypothesis of input quantities (t/y)	**Landfill's useful life**		
30,000	36.5	27.0	20.7
40,000	**27.4**	20.2	**15.5**
60,000	18.2	13.5	10.3
80,000	**13.7**	10.1	**7.7**
100,000	10.9	8.1	6.2
120,000	**9.1**	6.7	**5.2**
150,000	7.3	5.4	4.1

The Province of Mantova is not equipped with waste-to-energy plants, and with landfills for inert and hazardous waste. At present, residual municipal wastes are conveyed into one landfill for non-hazardous waste, made up by two lots, measuring about 464,000 and 950,000 m^3. The estimation of landfill life has been performed considering different hypothesis, according to the coefficient of

compression and to the annual amount accepted by the plant in the next decade. The degree of compaction is an index of "density", calculated as ratio between the total tons input in the plant and the projected volume capacity of it; it depends on material in input's characteristics (e.g., fermentable substance content), and on the compression techniques applied (natural or mechanical volumetric reduction). To this parameter, the used capacity and thus the residual capacity of landfill are strictly linked. In Table 1 it can be seen that residual capacity ranges from 620,000 t, in the hypothesis of coefficient equal to 0.8 t/m^3, and 1,100,00 t, in the best management case (compression of 1.3 t/m^3). The other decisive parameter is the amount of waste annually conveyed to the landfill; this value is highly unpredictable, thus in this study a range between 30,000 and 150,000 t/y is suggested. As can be observed in Table 1, landfill's useful life is strongly related to input quantities: keeping the same amount accepted in the previous years (about 80,000 t/y), landfill would be active until 2012 (compaction of 0.8), or 2018 (optimal situation, compaction of 1.3). The cases of 50% less or more (40,000 or 120,000 t/y) are also highlighted in the table.

3 Special waste

The Decree 22/97 states that, as for Industrial Waste, there is no obligation of planning, because this waste can be transported, swapped and traded as commodities or consumer goods. The Province, in this case, must only monitor waste flows produced, imported, exported and managed within its territory, to check if the treatment and disposal capacity of its plants is adequate.

The same decree defines an inventory system of the different material flows (M.U.D. Data Base, consisting in the compulsory declarations of the producers, managers and carriers of special and hazardous waste) and makes the Province responsible for authorisation of plant construction and working. The decree requires annual declarations by waste producers and managers. These declarations must contain the waste quantities produced and managed in their industries. After a correction of mistakes in declarations at first, we initially calculated the quantities of industrial waste produced in the Province, adding the single quantities declared by every activity; then, we identified the fraction of the hazardous waste. Values are shown in Tab. 2.

Table 2: Total Industrial waste products in the Province at 2002.

Industial waste (t)	Hazardous waste (t)	Total Industrial Waste produced in the Province, 2002 (t)
1,062,902.54	74,580.08	**1,137,505.60**

The most important material flows are waste from wooden applications and panels, furniture, pulp, paper, cardboard production. This category represents the 38% of the whole quantity of industrial waste produced. This trend of production is due to the presence on this territory of wood manufactures with a volume of business prevailing compared to other kinds of territorial activities. The second

category, as for production, is “19” (from waste treatment plants, sewage sludge, water purification and its preparation for industrial use): wastes deriving from treatment plants are considered in their turn as industrial wastes that must be properly disposed. The third category considered is construction and demolition waste (11% of the total product). As for hazardous waste, the most important categories are “07” (waste from organic chemical experiments) and “16” (e.g., discarded cars, oil filters, lead batteries, electric and electronics equipments).

The second step was aimed to determine different kinds of waste management, practised in Mantova Province; divided into recovery and disposal activities. The processed data have been inferred from the declarations of treatment plants managers, in 2002. The total quantity of industrial waste, managed in the Province of Mantova, was 3,171,996.57 tons (recovery and disposal). The difference between the produced and managed quantity is due to a great amount of waste imported inside the territory. Province is the institution responsible for authorization release and for specific plant capacities. The total plant capacity of recovery and disposal is essentially given by the sum of all capacities of the single authorized plants, in tons.

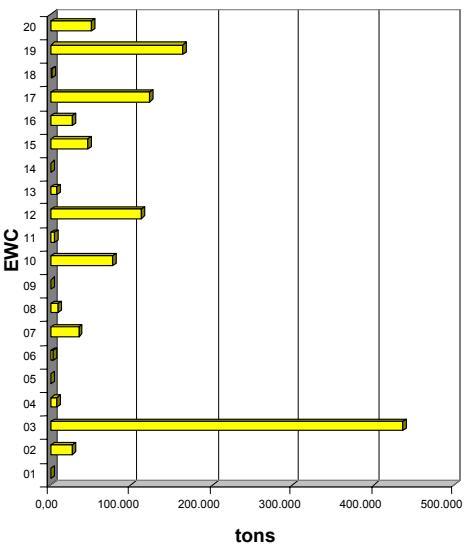

Figure 6: Total quantity of industrial waste products in Mantova Province, classified according to EWC codes (tons).

The authorized quantity, recovery and disposal, in Mantova territory, is 8,832,685.70 tons. Authorized plants for hazardous waste treatment are few and their treatment capacity is not so high; thus, the greatest part of hazardous waste produced in the Province is exported out of the territory. In this way, Mantova Province is not self-sufficient for recovery and disposal of this kind of waste; even if the small produced quantities, often, do not justify construction and starting of specific plants.

Table 3: Total capacity of all the different kinds of plants authorized to waste management, in Mantova Province (tons)

Authorized operations	Total capacity, in tons
Recovery/treatment/disposal	1,418,540.88*
Own disposal	131,234.87
Simplified recovery	7,282,352.50
TOTAL (t)	**8,832,685.70**

A first comparison between produced and managed quantities (produced + imported), on the territory, is showed in Tab. 4.

Finally, the study's results have demonstrated a good total potentiality of waste management on the whole provincial territory and a clear prevalence of plants capacities in comparison to the quantities conferred at 2002.

Table 4: Comparison between capacities of recovery/disposal and waste quantities, in 2002.

Total Authorized Recovery Plant Capacity (t)	Total waste recovered in 2002 (t)	Total Authorized Disposal Plant Capacity (t)	Total waste disposed at 2002 (t)
8,023,416.50	2,884,863.74	307,513.48	173,309.56

4 Conclusion

This study was aimed to the implementation of an integrated waste management system in a local territory. A detailed survey of the current management system in the Province of Mantova was performed: waste analysis, technical-economical solutions adopted, separated collection systems. Furthermore, a comparison between the present treatment and disposal capacity authorized and the requirements expected for the decade 2005-2015 was performed. Waste Management system resulted sufficiently integrated; however, some critical points emerged for particular kinds of waste (bulky, biodegradable, WEEE, etc.). The current status appear adequate to meet the needs expected for the next decade. However, it is necessary to improve technological processes to increase the percentage of recovered matter and secondary raw material of quality (RDF and compost). Finally, a prediction of the useful life of the only landfill present in the territory was performed; this shortage could represent a critical point for the next decade.

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