Available online at www.sciencedirect.com
SCIENCE DIRECT®
Waste Management 26 (2006) 307–314
wasteWmanagement
www.elsevier.com/locate/wasman

Research on solid waste management system: To improve existing situation in Çorlu Town of Turkey

Esra Tınmaz [a,*], İbrahim Demir [b]

[a] Trakya University, Çorlu Engineering Faculty, Department of Environmental Engineering, 59860 Çorlu/Tekirdağ, Turkey
[b] İstanbul Technical University, Civil Engineering Faculty, Department of Environmental Engineering, Maslak/İstanbul, Turkey

Accepted 20 June 2005
Available online 19 August 2005

Abstract

Over the past decades, uncontrolled population growth and rapid urbanization and industrialization have resulted in environmental problems in Çorlu Town, Turkey. One of the most important problems is solid waste due to inadequate management practices. Nowadays, increasing public awareness of the environment compels local authorities to define and to adopt new solutions for waste management.

This paper presents a general overview of current solid waste management practices in Çorlu Town and principles of the recommended municipal solid waste (MSW) management system. In Çorlu, 170 tonnes of municipal solid waste are generated each day, or 1.150 kg per capita per day. Approximately one-half of the municipal solid waste generated is organic material and 30% of the MSW consists of recyclable materials. The recommended system deals with maximizing recycling and minimizing landfilling of municipal solid waste, and consists of separation at source, collection, sorting, recycling, composting and sanitary landfilling. This study also analyzed the recommended system with respect to feasibility and economics. To evaluate whether the suggested system is cost effective or not, the operating cost of the recommended system and market prices of recyclable materials were compared, and the results show that the recommended system will reduce required landfill volume up to 27% of compared to the present situation. The profit of the recommended system is estimated to be about 80 million US dollars.

1. Introduction

Management of the increasing quantities of solid waste is a global environmental issue. The issue of waste is not only because of the increasing quantities but also largely because of an inadequate management system. In general, there is a lack of organization and planning in waste management due to insufficient information about regulations and due to financial restrictions in many developing countries, like in Turkey.

In Turkey, there are 3215 municipalities, and 16 of them are metropolitan municipalities. A total of 2984 municipalities have solid waste management services. In summer and winter seasons of the year 2002, 12.70 and 12.67 million tonnes of solid wastes were generated by the municipalities that have solid waste management services. In Turkey, the solid waste generation rates in summer and in winter are 1.32 and 1.34 kg per capita per day, respectively. In Turkey, there are 12 sanitary landfills, 4 composting plants and 3 incineration plants. About 45.9% of the wastes are disposed in landfills belonging to municipalities, 15.5% of wastes are disposed in landfills belonging to metropolitan municipalities, 27.8% of wastes are disposed in sanitary landfills, 2.9% of wastes are disposed in landfills belonging to another

* Corresponding author. Tel.: +90 282 652 94 76; fax: +90 282 652 93 72.
E-mail addresses: esratinmaz@gmail.com (E. Tınmaz), idemir@itu.edu.tr (İ. Demir).

0956-053X/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.wasman.2005.06.005

municipality, 1.5% of wastes are composted, 0.9% of wastes are burned, 0.8% of wastes are discharged into rivers, 2.0% of the wastes are buried and 2.85% of wastes are disposed using other methods. In most municipalities, medical wastes are not collected separately from other wastes. Separate collection of medical wastes is only practiced in 471 municipalities. The number of municipalities in compliance with the regulation due to a lack of information about the regulation is 864, and the number of municipalities due to financial restrictions is 1867. Besides these deficiencies, lack of technical capacity, lack of sufficiently trained personnel and uncontrolled population growth and urbanization have contributed to the solid waste management problems (SIS, 2004).

In Turkey, municipal, medical and industrial wastes are managed according to the Solid Waste Control Regulation (1991), the Medical Waste Control Regulation (1993) and the Hazardous Waste Control Regulation (1995). These regulations address the principles of collection, transportation, recycling, reuse, recovery and disposal of municipal waste and the largely hazardous, medical and industrial wastes. According to Turkish Regulations, management of solid wastes is the responsibility of municipalities. Regulations clearly define that wastes have to be disposed in sanitary landfills. Moreover, it is also clearly defined that hazardous wastes have to be disposed separately from non-hazardous wastes in sanitary landfills. Leachate and gas control practices are also well defined in these regulations. In sanitary landfills, a leachate collection system should be operated and percolation from the landfill should be prevented by a liner system.

Although, according to the regulations, the term "waste management", refers to source minimization, collection, transformation, reuse or/and recycling and disposal, in Çorlu Town, like in many municipalities of Turkey, it only refers to collection and unsanitary landfilling of wastes. In Çorlu, uncontrolled disposal activities have threatened the quality of soil, air and water resources and the health of people relying on these resources. Air pollutants generated as a result of fires at the landfill site have adverse effects on human health. Since there is not a liner system, disposal of solid wastes in unsanitary landfills is often associated with soil and water pollution problems. In such a case, the water that percolates through wastes at landfill sites dissolving various materials is considered the most serious environmental impact of a landfill and causes surface and groundwater pollution. In Çorlu, although significant health problems relating to leachate contamination have not been reported, health hazards associated with groundwater utilization for public water supply should be taken into consideration (Tınmaz and Öngen, 2004).

In Çorlu Town, although the problem of solid waste appeared before the 1990s, the first study on solid wastes in the literature was conducted in 1993. In that study it was reported that the amount of MSW generated was 51 tonnes per day and 17% of the waste was recyclable, 29.5% was organic waste and about 50% was ash (Baştürk and Demir, 1993). The conclusion of the study was that municipal solid wastes should be disposed in a sanitary landfill.

Although the previous study suggested that municipal solid wastes should be disposed in a sanitary landfill, it is clear that disposal of solid waste is not the only option for solid waste management. The quantity and characteristics of municipal solid wastes have changed with population growth, industrialization and urbanization since 1993. In the 1990s, while sanitary landfilling was suggested as the only option for waste management, nowadays, recycling, composting and sanitary landfilling of municipal solid wastes produced at Çorlu Town are suitable management practices because of the change in characteristics of the wastes.

This paper addresses current waste management practices and problems in Çorlu Town and evaluates various management methods for suitable solid waste management practices. In order to decide which management system is the most appropriate one, it is important to know the quality and the quantity of solid wastes. In order to have sufficient data on quality and quantity of wastes, lab-scale and field-scale analyses were conducted. In this study, different methods of solid waste management were also evaluated with respect to environmental and economic conditions and feasibility. The recommended system involves separation at source, collection, sorting, recycling, composting and sanitary landfilling.

2. Description of Çorlu Town

Çorlu, located in the Trakya Region of Northwest of Turkey, lies between the 41°07′30″ eastern longitude and 27°41′00″ northern latitude. Çorlu is the fourth largest town in Tekirdad Province. The area of Çorlu is about 991 km^2, at an altitude is 193 m, and receives a yearly rainfall of 545 mm. Çorlu is the second richest area in groundwater resources in the Trakya Region and is in a region where industrial activities have rapidly increased. Good transportation routes (E-5 Highway, TEM Motorway, Çorlu Airport, Harbor of M. Eredlisi and existence of a railway that can be developed), existence of rich subterranean waters, and large enough areas for the construction of factories are the reasons for rapid development. Çorlu has received significant migration, especially from Bulgaria. In the report of the State Planning Organization entitled "Social–Economical Development of the Town", Çorlu is in 16th place (Çorlu Chamber of Commerce and Industry, 1997).

3. Current waste management practice in Çorlu Town

In Çorlu Town, unsanitary landfilling is the only option that is undertaken for the management of solid wastes. The solid waste collection method used in Çorlu is the curb-side collection method. Solid wastes are stored in containers, in sizes of 0.4 or 0.8 m^3. The dimensions and numbers of containers vary according to the width of the street and the quantity of waste; however, there is no certain data on the number of containers. Solid wastes, stored in containers are collected and transported to the unsanitary landfill area by vehicles belonging to the Municipality of Çorlu.

There are two unsanitary landfills in Çorlu. First, an older unsanitary landfill area, opened in 1996, reached the expected total capacity and was closed at the end of 2004. The area and total landfill storage volume of the older site is 20,000 m^2 and 58,400 m^3, respectively. Studies to rehabilitate this site are going on intensively. A second site was constructed in the beginning of 2004. Although the distance between residential areas and the sanitary landfill has to be more than 1 km, according to the Solid Waste Control Regulation, the distances between the residential area and each of unsanitary landfills are less than 1 km.

In the new landfill area, wastes are disposed, spread and compacted in an uncontrolled manner and cover material is not applied regularly. All types of wastes – municipal, industrial, medical and hazardous – are disposed together. Although it is known that compaction of waste can save landfill space and minimize the voids that attract vermin and can cause fire, and daily cover is necessary to abate odor, rodents and birds and to decrease site litter, compaction and covering operations are limited. There is insufficient landfill gas collection system in the area. Several fires at the landfill site are the results of this situation and intentional burning of wastes. It is known that emissions resulted from uncontrolled burning of wastes have huge risks on human health. There is also no provision for a leachate collection system. Due to the lack of liner and collection systems in the Çorlu unsanitary landfills, leachate can easily infiltrate into soil and migrate to surface water and groundwater environments. The soil structure in Çorlu Town is considered permeable or semi-permeable. It is known that a landfill in a region with a permeable soil layer and without a liner system allows leachate to percolate as rapidly as it is generated. Leachate generated at the Çorlu unsanitary landfill site has a huge possibility for infiltration into the soil and migrate into the groundwater. The data in Table 1 show the characterization of the leachate generated at the old unsanitary landfill (Töre et al., 2001). With its high pollution potential, the Çorlu unsanitary landfills are a potential risk for the contamination of groundwater and also surface water. Because groundwater is the main drinking water resource, it is clear that migration of leachate to groundwater poses a real risk to human health.

Table 1
Characteristics of the leachate generated at the Çorlu unsanitary landfill

Parameter	Value	
	Range	Average
pH	8.31–8.47	
COD (mg/l)	13957–15170	14447
BOD (mg/L)	9097–1016	9584
Alkalinity (mg $CaCO_3$/l)	6200–8810	7505
NH_3–N (mg/l)	923–2656	1193
TKN (mg/l)	985–2800	1262
TSS (mg/l)	528–996	688
VSS (mg/l)	184–218	201
SO_4 (mg/l)	1155–1888	1450
VFA (mg Asetikacit/l)	2842.1–5052.6	4071.6
Zn (mg/l)	0.00–0.18	0.11
Cr (mg/l)	0.00–1.02	0.63
Pb (mg/l)	0.00–0.87	0.46
Cd (mg/l)	0.00–0.00	0.00
Ni (mg/l)	0.00–0.145	0.138
Fe (mg/l)	1.08–4.23	2.46
Mn (mg/l)	1.73–3.49	2.64
Co (mg/l)	0.174–1.80	1.241
Cu (mg/l)	0.02–0.36	0.147

Recycling practices are limited to those carried out by the scavengers. There is no data on the number of scavengers or on the amount of materials salvaged by them. Scavengers salvage glass, plastics, metals, papers and cardboard. Scavengers have no facilities or equipment for sorting valuable materials from the solid waste. Unfortunately, they suffer health problems and injuries due to dust, and the presence of broken glass and sharps.

4. Generation and composition of municipal solid waste in Çorlu

According to the records of the Municipality of Çorlu Town (2000), 170 tonnes of waste are collected daily and the waste generation rate is 1.15 kg per capita per day. Approximately 4100 tonnes of industrial wastes, including 31.36% textile and 31.78% plastic wastes, are disposed yearly (Tınmaz, 2002). Wastes from healthcare establishments amount to approximately 1880 kg per day and 33% of the total hospital waste consists of medical waste (pathological and non-pathological, infectious, chemical pharmaceutical and sharps), 48% is municipal waste and the remaining is recyclable waste, consisting of glass and packing materials (Demircan, 2001).

Components of MSW change according to location, season, economic conditions, and many other factors (Tchobanoglous et al., 1993). Because it is known that the distribution of components is a critical factor in a particular management decision process, a special study

Table 2
Percentage of components of municipal solid wastes

Waste component	Low-income level district (%)				High-income level district (%)				Commercial region district (%)			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
Food and yard	61.49	53.66	56.3	58.33	54.29	59.87	59.05	61.15	52.41	54.6	35.09	44.19
Cardboard	0.42	2.68	0.67	1.86	1.50	2.81	1.58	1.93	2.10	2.43	6.65	4.24
Paper	3.34	7.80	5.94	5.75	8.57	11.70	6.11	10.19	6.18	8.32	6.57	6.23
Iron	2.45	–	–	–	6.90	–	–	–	2.31	0.33	–	–
Aluminium	–	0.61	1.10	3.72	0.47	1.17	2.59	1.59	0.42	0.84	1.07	10.17
Nylon	10.45	13.46	11.82	11.83	7.32	6.34	9.48	10.08	11.42	11.70	8.10	6.66
PET	1.31	1.68	1.33	2.79	3.96	1.52	1.94	2.32	7.23	1.35	1.22	0.79
Plactic	3.11	3.56	1.64	1.69	–	1.76	1.15	0.79	0.42	1.05	0.61	2.12
Pacicing	0.96	1.62	5.15	2.03	0.93	1.71	0.86	0.85	8.28	3.06	7.34	0.18
White Glass	5.43	3.72	1.09	1.01	3.72	2.32	1.01	1.02	7.55	2.10	3.98	2.60
Colored Glass	3.70	2.06	4.36	3.21	2.42	2.30	4.17	3.68	1.68	2.43	5.74	4.24
Textile	1.79	1.14	0.30	–	2.00	1.61	2.08	2.38	–	5.26	0.69	5.45
Diaper	3.16	1.50	6.36	4.74	1.77	5.28	3.95	0.85	–	2.50	8.03	–
<10 mm	2.39	4.00	3.51	3.04	6.15	1.61	5.24	3.17	–	3.90	7.80	13.13
Others	–	2.51	0.43	–	–	–	0.79	–	–	0.13	7.11	–

should be carried out to assess the actual distribution. For that reason, to ensure that representative results are obtained, large enough samples taken from four special areas selected according to socio-economic and cultural level and prices of houses were examined in four seasons (Tınmaz, 2002). These special areas were high income residential, middle income residential, low income residential, and commercial districts. The low income district was excluded because of the high moisture content of the waste, which prevented the separation of various components of the waste. To evaluate the quantity and quality of commercial waste, a special area where 98 commercial facilities and 12 houses are located was selected. Five containers were selected in each district.

Waste characterization was determined by field-scale analyses of wastes. For that reason, containers from each of the three districts, mentioned above, were transported and unloaded to an open area at the disposal site. Mixing of samples of waste from one district with those from another district was not permitted. Samples from each of the districts were mixed and raked into quarters and mixed again. Quartering and mixing was continued until a representative sample of about 1 m^3 was obtained. The sample was separated into its components and each component was weighed and compared with the total. The results of the waste characterization of selected districts are given in Table 2.

Lab-scale analyses, followed by field-scale analyses were conducted to determine chemical properties of the waste (Table 3). For that reason, pH, moisture and organic material content of wastes were analyzed. The moisture content of the waste was analyzed by the gravimetric method after drying the representative waste at 105 °C and organic material content was analyzed as a loss of weight between 105 and 550 °C. To evaluate the pH value, the waste sample was diluted with distilled water and after 24 h the pH value of the liquid was measured.

Table 3
Chemical properties of municipal solid wastes

Parameter	Season	Middle-income level	High-income level	Commercial area
pH	Spring	–	–	–
	Summer	5.45	5.60	7.00
	Autumn	4.80	6.85	6.73
	Winter	6.61	6.36	6.78
Moisture content (%)	Spring	–	–	–
	Summer	50.05	67.00	30.57
	Autumn	59.42	51.27	58.43
	Winter	67.78	69.82	49.98
Organic material content (%)	Spring	–	–	–
	Summer	69.74	75.30	32.85
	Autumn	28.37	21.05	23.21
	Winter	27.30	18.06	13.92

5. Recommended solid waste management system for Çorlu Town

In order to plan the most appropriate type of waste management system, it is essential to determine reliable information about quantities, types and how much material can be reused or recycled, as well as to determine valid goals such as complying with regulations, protecting the environment, providing local business with raw materials and job opportunities, and conserving resources. To determine which management technique is appropriate, the costs of the management system and future community trends, such as population growth and waste characterization profile, should be evaluated.

Table 4
General waste characterization and suggested utilization methods

Waste component	Percentage by weight (%)	Percentage of utilization
Cardboard	2.40	85% Composting + 15% SL
Food and yard	54.20	90% Composting + 10% SL
Iron	1.00	100% Recycling
Aluminium	2.00	90% Recycling + 10% SL
Nylon	9.40	90% Recycling + 10% SL
PET	2.30	90% Recycling + 10% SL
White glass	3.00	85% Recycling + 15% SL
Colored glass	3.30	85% Recycling + 15% SL
Paper	7.20	70% Recycling + 30% composting
Plastic	1.50	90% Recycling + 15% SL
Packing	2.70	100% SL
Textile	1.90	100% SL
Diaper	3.20	100% SL
Ash and others	5.90	100% SL

In Çorlu, it is difficult to find an appropriate site, which can be used as a landfill area, meeting the criteria in the Solid Waste Control Regulation. Soil properties in most places of the Trakya Region are suitable for agricultural activities. According to Turkish regulations, it is not possible to use such area as a landfill site. Consequently, it is essential to reduce the amounts of solid wastes requiring landfilling.

Recycling facilities have economic, environmental, social and ecological advantages besides its benefits of reducing the quantities of waste to be landfilled. Recycling of wastes prolongs the life span of the sanitary landfill and reduces environmental pollution. It is also known that there are many manufacturers that use recycled materials as raw materials.

Food and yard wastes, which are the major components of the MSW stream of Çorlu, are suitable substrates for composting. Because economic conditions mainly depend on agricultural facilities in Trakya, it is thought that composting will gain importance due to its potential benefits, such as improving manure handling and enhancing soil fertility.

The recommended system, determined with respect to the issues mentioned above, deals with maximizing recycling and minimizing landfilling of municipal solid waste and involves separation at source, collection, sorting, recycling, composting and sanitary landfilling.

The general waste characterization and recommended utilization methods for each waste component are given in Table 4, and the scheme for the recommended solid waste management system in Çorlu Town is given in Fig. 1 (Tınmaz, 2002). This MSW management system includes the following:

- Separately storing of waste components at source;
- Separate collection of stored wastes;
- Sorting of collected wastes;
- Recovery/reuse of sorted wastes;
- Selling of recovered materials,
- Sanitary landfilling of residues from sorting, recovery and composting.

5.1. Recommended handling system

One of the main components of this management system is recycling. To minimize the cost of recycling and to make it feasible, it is important to plan a better handling system. As such, the following handling system is proposed:

- MSW should be stored in three different containers. The first container should be blue with a lid. The second container should also be blue and the last one should be brown. The first container should be used for storing paper and cardboard, the second should be used for other recyclable materials, and the third one should be used for organic materials.
- Containers in institutions such as schools, shopping centers, and offices, should be designed according to the quality and quantity of waste generated by the institutions.
- Batteries and other hazardous wastes should be stored in different containers separately from non-hazardous wastes.
- Municipal solid wastes include plastic bags because the bags are used to store wastes. In order to minimize the quantity of plastic bags, wastes should be stored directly in containers without the use of plastic bags.
- Ash should be stored in different containers separately from other wastes.

5.2. Recommended collection and transportation system

It is necessary to plan a new collection system that is appropriate for source-segregated waste. It is suggested that recyclable wastes except for paper and cardboard should be collected with compactor vehicles. Paper and cardboard should be collected with non-compactor vehicles, which have two divisions proper for collection of them. Organic wastes should be collected with compactor vehicles. The waste collection schedule should be planned according to the waste quantity, and the collected wastes should be transported to the sorting facility.

5.3. Recommended sorting system

Although it is suggested that waste should be separately stored at the source, a sorting area is necessary to eliminate any mixing of recyclable waste with

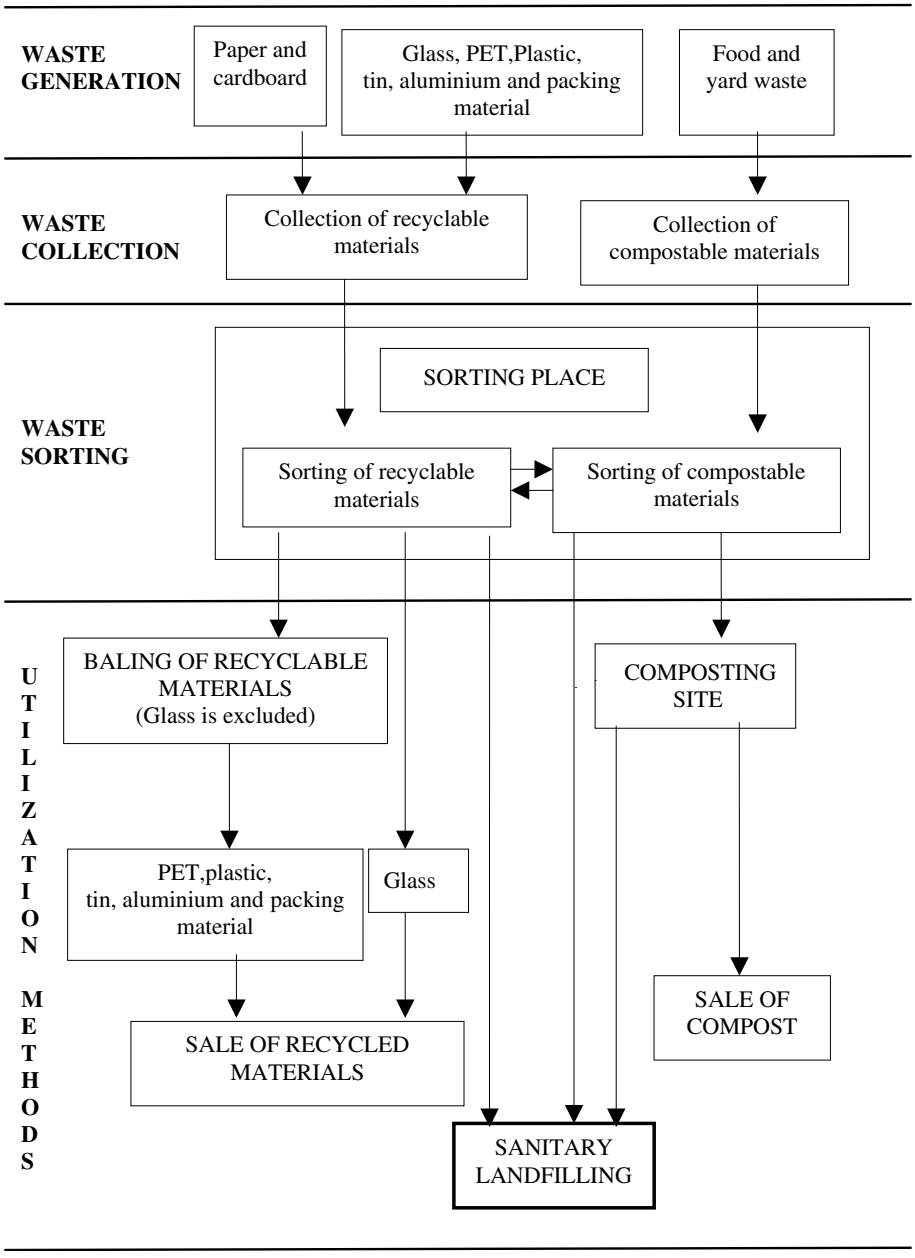

Fig. 1. Recommended solid waste management system.

compostable waste and to reduce contamination. The recommended sorting area should consist of two parts. One part should be used for recyclable wastes and the other part should be used for compostable wastes. Wastes, suitable for neither recycling nor composting should be landfilled at the sanitary landfill area.

Table 5
Required landfill volume and area for current and suggested management systems

Years	Current management system			Recommended management system		
	$V_{Accumulated}$ (m^3)	Height (m)	Area (ha)	$V_{Accumulated}$ (m^3)	Height (m)	Area (ha)
2005	78,135	5	1.56	12,630	5	0.25
2010	517,387	8	6.47	83,636	6	1.39
2015	1,050,788	10	10.51	169,860	8	2.12
2020	1,699,679	15	11.33	274,753	10	2.75
2025	2,490,463	18	13.84	402,583	11	3.66
2030	3,455,851	20	17.28	558,638	13	4.30
2035	4,636,415	25	18.55	749,477	15	5.00

6. Evaluation of recommended management system

Municipal solid wastes generated in Çorlu Town contain up to 30% recyclable materials by weight. Recovery of these materials reduces the required landfill volume and area, in addition to its economic benefits. In Çorlu, there are also many factories which can use recycled wastes as raw material. Separation at source and separate collection protect the quality of the recycled materials and reduce the costs associated with sorting.

Solid wastes generated in Çorlu Town contain up to 55% organic materials by weight and thus are suitable for composting. In deciding whether composting is an appropriate waste management method or not, having marketing opportunities for compost is an important issue. Compost, because of its high concentration of organic matter, is a valuable soil amendment and is used to provide nutrients for plants. When mixed into the soil, compost promotes proper balance between air and water, helps to reduce soil erosion and serves as a fertilizer (EPA, 1995). Although, economic activities in the Trakya Region have been changing towards industrialization and away from agricultural activities since the 1990s, agricultural activities still have a substantial importance in economic activities. In the Trakya

Table 6
Capital and operating costs of different methods (US dollars) (CH2M Hill and Antel, 1992)

Method	Price ($/ton)
Recycling	5.0
Sanitary landfilling	8.5
Composting	10.49

Table 7
Market price of recyclable materials and compost (US dollars)

Method	Price ($/ton)
Paper–cardboard	45
Metals	500
Plastics	46
Glass	25
Compost	
0–5 year	5
5–10 year	10
After 11th year	11

Table 8
Economic evaluation of suggested management system (US dollars)

Year	Cost/price, $			Total	Income, $			Profit, $
	Recycling	Compost	Sanitary landfilling		Recycling	Compost	Sanitary landfilling	
2005	360,482	214,689	99,062	674,234	1,729,562	102,233	1,831,795	1,157,561
2006	374,622	437,799	102,948	915,368	1,797,402	208,476	2,005,877	1,090,509
2007	389,344	669,676	106,994	1,166,014	1,868,037	318,893	2,186,930	1,020,916
2008	404,674	910,684	111,206	1,426,564	1,941,588	433,659	2,375,247	948,683
2009	420,638	1,161,199	115,593	1,697,430	2,018,181	552,952	2,571,133	873,704
2010	437,263	1,421,615	120,162	1,979,040	2,097,947	1,353,919	3,451,866	1,472,827
2011	454,578	1,692,343	124,920	2,271,841	2,181,023	1,611,755	3,792,778	1,520,937
2012	472,612	1,973,812	129,876	2,576,301	2,267,551	1,879,821	4,147,372	1,571,072
2013	491,398	2,266,469	135,039	2,892,905	2,357,682	2,158,542	4,516,224	1,623,318
2014	510,966	2,570,780	140,416	3,222,162	2,451,570	2,448,362	4,899,932	1,677,770
2015	531,352	2,887,232	146,018	3,564,603	2,549,380	3,024,719	5,574,099	2,009,497
2016	552,591	3,216,333	151,855	3,920,779	2,651,281	3,369,492	6,020,773	1,099,994
2017	574,719	3,558,613	157,936	4,291,268	2,757451	3,728,071	6,485,522	2,194,254
2018	597,776	3,914,625	164,272	4,676,673	2,868,077	4,101,035	6,969,112	2,292,440
2019	621,803	4,284,945	170,874	5,077,622	2,983,352	4,488,990	7,472,343	2,394,721
2020	646,840	4,670,177	177,755	5,494,772	3,103,480	4,892,567	7,996,047	2,501,275
2021	672,933	5,070,949	184,925	5,928,808	3,228,673	5,312,423	8,541,096	2,612,288
2022	700,128	5,487,918	192,399	6,380,444	3,359151	5,749,247	9,108,398	2,727,954
2023	728,473	5,921,767	200,188	6,850,428	3,495,148	6,203,756	9,698,903	2,848,476
2024	758,018	6,373,212	208,307	7,339,538	3,636,904	6,676,699	10,313,602	2,974,064
2025	788,817	6,843,000	216,771	7,848,588	3,784,672	7,168,857	10,953,530	3,104,942
2026	820,924	7,331,909	225,594	8,378,427	3,938,718	7,681,048	11,619,766	3,241,339
2027	854,396	7,840,754	234,792	8,929,943	4,099,317	8,214,123	12,313,440	3,383,497
2028	889,295	8,370,382	244,383	9,504,060	4,266,758	8,768,972	13,035,730	3,531,670
2029	925,683	8,921,682	254,382	10,101,747	4,441,342	9,346,524	13,787,866	3,686,119
2030	963,625	9,495,579	264,809	10,724,013	4,623,386	9,947,749	14,571,135	3,847,123
2031	1,003,191	10,093,039	275,682	11,371,911	4,813,219	10,573,660	15,386,879	4,014,967
2032	1,044,452	10,715,073	287,021	12,046,545	5,011186	11,225,314	16,236,500	4,189,955
2033	1,087,483	11,362,734	298,846	12,749,063	5,217,646	11,903,817	17,121,462	4,372,400
2034	1,132,363	12,037,124	311,179	13,480,667	5,432,977	12,610,321	18,043,298	4,562,631
2035	1,179,174	12,739,393	324,043	14,242,611	5,657,572	13,346,031	19,003,603	4,760,993
Total								80,307,894

Region, of which approximately 79% of the total area is agricultural and forest land, it is clear that compost is a marketable product.

The final disposal method for residues from the recycling and composting processes is sanitary landfilling. Recycling and composting processes reduce the quantity of waste that should be landfilled, and also reduce required landfill area. If all types of wastes are landfilled, the estimated landfill volume required over a 30-year period is 4,500,000 m^3 (Table 5); however, if recycling and composting processes are applied, the estimated landfill volume would be reduced to 750,000 m^3 (Table 5) (Tınmaz, 2002).

It is an important issue in deciding whether the suggested system is cost-effective or not, to evaluate the system with respect to economic conditions. Consequently, the recommended management system was assessed from an economic point of view in this study. For that reason, firstly, costs of different alternatives (Table 6) and market prices of recyclable materials and compost (Table 7) were examined, and then costs and revenues of the recommended system were calculated (Table 8) (Tınmaz, 2002). Values given in Table 6 show total capital costs and operating costs. According to the calculation, the profit from the recommended system would be about 80 million US dollars over 30 years. Thus, based on this calculation, it is obvious that the recommended system should be considered a cost-effective system.

7. Conclusions and recommendations

From the previous discussions, problems associated with municipal solid waste management in Çorlu Town were identified. Insufficient and inappropriate disposal of solid wastes, lack of liners and collection systems for leachate and landfill gas, and uncontrolled discharges of leachate are well known solid waste problems in Çorlu. This paper proposed a new municipal solid waste management system to improve the existing situation and to minimize environmental problems that result from inadequate management of solid wastes.

Public participation and awareness are important issues in achieving the goals of the suggested management system. Unfortunately, it is difficult and also takes a long period of time to make people aware of the importance and of the principles of the proposed management system and to effect their participation. In this case, pilot programs, supported with education programs, which make people aware of the importance and of the principles of the suggested system, are of importance. The recommended solid waste management system should be applied as a pilot program for a certain period in small residential areas before being extended to the entire town. If combined with a strong education and publicity program, the pilot program can help people become aware of that system. In Çorlu, Emlak Bank Residence which is the most populous housing estate with 1897 houses, was selected for the pilot program and recently principles of that study have been determined.

The success of the suggested system also is based on marketing opportunities for reusable and recovered materials and compost. To improve the use of reusable and recovered materials, authorized people in establishments which could use recovered materials as raw material have to be informed about the solid waste management system and they have to also be informed about how they can obtain those materials. Farmers have to be encouraged to use compost in agricultural facilities and they have to be informed about how they can use compost.

References

Baştürk, A., Demir, A., 1993. Solid Waste Problems in Tekirdad (Çorlu, Marmara Eredlisi) – First Report (in Turkish).

CH2M Hill International LTD and Antel Treatment Company, 1992. Research on Solid Waste Management, Ystanbul, Turkey (in Turkish).

Çorlu Chamber of Commerce and Industry, 1997. History, Culture, Economy, Uniform Press Company, Çorlu/Tekirdad (in Turkish).

Demircan, D., 2001. Medical Waste Management, Undergraduate Thesis, Trakya University, Çorlu Engineering Faculty, Department of Environmental Engineering, Çorlu/Tekirdad, Turkey (in Turkish).

Environmental Protection Agency (EPA), 1995. Decision-Maker's Guide to Solid Waste Management, Second Edition, Washington, DC, pp. 7–10.

Hazardous Waste Control Regulation, 27 August 1995, Turkey.

Medical Waste Control Regulation, 20 May 1993, Turkey.

Municipality of Çorlu Town (2000) Records of Municipality.

Republic of Turkey, Prime Ministry State Institute of Statistics (SIS), 28.12.2004. Solid Waste Statistics.

Solid Waste Control Regulation, 14 March 1991, Turkey.

Tchobanoglous, G., Theisen, H., Vigil, S.A., 1993. Integrated Solid Waste Management. McGraw-Hill Book Co., Singapore.

Tınmaz, E., 2002. Research on Integrated Solid Waste Management System in Çorlu Town, Graduate Thesis, Ystanbul Technical University, Ystanbul, Turkey (in Turkish).

Tınmaz, E., Öngen, A., 2004. Risk assessment of leachate from unsanitary landfills on groundwater quality in Çorlu Town of Trakya region, NATO ASI Conference, Management And Sustainable Development Of Urban Groundwater Systems (Co-Directors Prof. Dr. John Tellam – UK, Prof. Dr. Rauf Israfilov – Azerbaijan), Baku, Azerbaijan.

Töre, G., Tınmaz, E., Özkan, A., Çelik, S.Ö., 2001. Leachate characterization of Çorlu Town unsanitary solid waste landfill, National Industrial-Environmental Symposium and Exhibition, Mersin, Turkey, p. 29–42 (in Turkish).