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ORIGINAL ARTICLE

Solid waste management practices in Turkey

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Abstract As an economically developing country, Turkey has very well operated integrated solid waste management applications structured on modern facilities, besides over 2,000 scattered open dump areas in the country. Integrated waste management applications seem eligible for the metropolitan cities like Istanbul and Izmit (Kocaeli). Attempts have not been encouraging for the scattered regional settlements using central storage sites due to financial shortages and received rejections from nearby settlements. Small-scale compact solid waste management systems with materials recycling and composting can be more suitable alternatives in the small-scale regional settlements. The major constituents of municipal solid waste are organic in nature and approximately a quarter of municipal solid waste is recyclable. Although paper, including cardboard, is the main constituent, the composition of recyclable waste varies strongly by the source or the type of collection point. Solid wastes need primary treatment in order to be suitable for incineration and composting. Turkey needs to give more emphasis on the usage of modern solid waste removal technologies to overcome the overgrowing solid waste disposal problems.

Keywords Black Sea · Solid wastes · Landfill · Leachate · Coastal pollution

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Introduction

Since the handling and disposal of solid waste is an expensive process, trying to minimize the generation of solid waste, encouraging the recycling/recovery of its valuable components, and their conversion into useful products are important. This, consequently, lessens the amount of solid waste to be dumped and reduces the waste management costs. The application of an integrated solid waste management program is a valuable tool in order to minimize the usage of natural resources and to handle the solid wastes efficiently.

In Turkey, increased population, industrialization, and standards of living have contributed to an increasing amount of solid waste and its consequent disposal problems. Though developed countries have established regulatory programs, developing countries have generally continued to use unsophisticated methods, such as open dumps. Turkey, as an economically developing country, has over 2,000 of these open dumps.

Methods of disposal of solid waste, according to the Turkish State Statistical Institute's (SIS) database, were as follows: 25,014,000 tonnes of municipal solid waste were collected, whereas 7,002,000, 351,000, and 8,000 tonnes were disposed of in sanitary landfills, composted, and incinerated, respectively. A total of 17,653,000 tonnes of waste was disposed of without any control [19].

The amount of solid waste collected from municipalities receiving waste collection services were given with yearly averages (Table 1) [20].

According to the results of the municipal solid waste statistics (Table 2) [20]:

– A total number of 25 facilities, of which 18 were controlled landfill sites, three were waste incineration plants, and four were composting plants, were covered.

Table 1 Number and population of municipalities served by municipal waste services and amount of waste collected seasonally [20]

Year	Turkey's total population	Population of municipalities	Number of municipalities questioned	Population of municipalities questioned	Waste collected							
					Total amount (tonnes/year)	Per capita (kg/capita-day)	Amount of waste in summer (tonnes/summer)	Amount (tonnes/day)	Per capita (kg/capita-day)	Amount of waste in winter (tonnes/winter)	Amount (tonnes/day)	Per capita (kg/capita-day)
2001	67,803,927	53,407,613	3,215	53,377,431	25,133,696	1.35	12,534,609	67,301	1.32	12,599,087	69,341	1.36
2002	67,803,927	53,421,379	3,215	53,391,197	25,373,134	1.34	12,700,895	68,425	1.32	12,672,239	69,387	1.34
2003	67,803,927	53,430,733	3,215	53,400,551	26,117,539	1.38	12,858,960	70,800	1.37	13,258,579	71,312	1.38
2004	67,803,927	53,935,050	3,213	53,903,955	25,013,520	1.31	12,783,745	68,153	1.30	12,229,775	67,455	1.29
2006	70,586,256	58,581,515	3,225	58,581,515	25,279,971	1.21	12,749,850	69,349	1.21	12,530,121	68,363	1.19
2008	70,586,256	58,581,515	3,225	58,581,515	24,360,863	1.15	13,306,071	66,775	1.16	11,054,792	65,271	1.13

- A total amount of 7,136,000 tonnes of waste, of which 39,130 tonnes were hazardous and 7,096,932 tonnes were nonhazardous, were brought to 18 controlled landfill sites. The total capacity of these sites was 309.5 million tonnes. The amount of waste disposed of in controlled landfill sites were 7,078,179 tonnes.
- 30,911 tonnes of hazardous waste were brought to three incineration plants having a total capacity of 44 thousand tonnes per year. 29,807 tonnes of this waste were incinerated and 1,104 tonnes were transferred to controlled landfill sites. In addition to that, 5,586 tonnes of ash and slag remaining from incineration were disposed of in controlled landfill sites. Two incineration plants with energy recovery produced 11,212 MW of electricity.
- 339,114 tonnes of waste were brought to four composting plants having a total capacity of 606 thousand tonnes per year. After the sorting processes, 165,351 tonnes of waste were sent to composting units and 29,256 tonnes of compost were produced. 160,000 tonnes of mixed and undifferentiated waste were transferred to controlled landfill sites.
- 85% of 1,583,519 m^3 of leachate collected in 13 disposal and recovery facilities was discharged into the sewerage systems of municipalities after being treated in the leachate treatment plants within the facilities, and the remaining 15% was discharged without treatment. Collected leachate was sprayed onto wastes in eight facilities and evaporated in two facilities.

Since incineration and sanitary landfill are expensive both in initial investment and throughout their operation, their use is mostly confined to developed countries, while open dumping, at lower cost, is the method used in economically developing countries. Turkey's traditional means of disposing of solid waste has been to dump it at the open sites or at sea, which means that solid wastes are just dumped without any precautions being taken. Serious accidents, such as the methane explosion at the Umraniye open dump, Istanbul, in April 1995, which killed 39 people, or the slippage of a huge mass of solid waste from the Istanbul Kemerburgaz open dump onto the neighboring road in May 1996, demonstrate the significant threat posed by this method of disposal [10].

Turkey's municipal solid waste generally consists of wastes generated from residential and commercial areas, industries, parks, and streets, and is not sorted at the source, but collected in the same waste bins. Data are available about the amount of solid waste in each of these groups. The only data available have been obtained by investigations conducted at the source residential areas. Municipal solid waste per capita is determined from the

Table 2 Main waste indicators of municipalities [20]

Year	1994	1995	1996	1997	1998	2001	2002	2003	2004	2006	2008
Number of municipalities served by municipal waste services	1,985	2,126	2,172	2,275	2,579	2,921	2,984	3,018	3,028	3,115	3,129
Amount of municipal waste collected (1,000 tonnes/year)	17,757	20,910	22,483	24,180	24,945	25,134	25,373	26,118	25,014	25,280	24,361
Amount of municipal waste per capita (kg/capita-day)	1.10	1.27	1.37	1.46	1.51	1.35	1.34	1.38	1.31	1.21	1.15
Amount of municipal waste per capita in summer season (kg/capita-day)	1.04	1.19	1.29	1.41	1.46	1.32	1.32	1.37	1.30	1.21	1.16
Amount of municipal waste per capita in winter season (kg/capita-day)	1.15	1.31	1.42	1.50	1.54	1.36	1.34	1.38	1.29	1.19	1.13
Controlled landfill number	2	6	6	8	8	12	12	15	16	22	37
Capacity (1,000 tonnes)	76,750	202,527	202,527	216,690	216,690	261,282	277,195	278,015	278,060	376,974	390,478
Amount of waste disposed of (1,000 tonnes/year)	809	1,444	2,847	4,364	5,258	8,304	7,047	7,432	7,002	9,942	10,037
Composting plant number	2	2	2	2	2	3	4	5	5	4	4
Capacity (1,000 tonnes/year)	245	245	245	245	245	299	664	667	667	605	551
Amount of waste brought to composting plant (1,000 tonnes/year)	192	159	179	180	166	218	383	326	351	268	276
Incineration plant number	0	1	1	2	2	3	3	3	3	3	2
Capacity (1,000 tonnes/year)	0	9	9	44	44	44	44	44	44	44	44
Amount of medical waste incinerated (1,000 tonnes/year)	0	0.3	3	9	15	7	7	9	8	6	8
Rate of population served by waste disposal and recovery facilities in total population (%)	5	6	10	15	16	26	25	25	26	34	39

amount of solid waste transported to the disposal areas. The data obtained in this way are not dependable, because the amount of solid waste taken to the final disposal areas does not reflect the actual amount of solid waste generated.

The first gas burning power plant in Istanbul with 6 MW capacity, a steam engine turbine generator with 5.2 MW inbuilt capacity in Izmit, and sanitary landfilling applications in some major cities with recovery and recycling have been encouraging alternatives for the future applications.

In this paper, a general overview of solid waste data and management practices including waste recovery and recycling initiatives with some employed case studies in Turkey were given.

Collection, transport, and disposal

The collection and transport of solid waste is the responsibility of the municipalities by law. Household solid wastes are transported by municipality-owned trucks (6–20 m^3 capacity) equipped with a hydraulic press. Metallic bins and containers are used to collect the municipal solid waste from the households. Typical bin sizes are 400 and 800 l. The local municipalities supply containers and bins, and the residents are required to bring their solid waste into these bins within plastic waste bag supplied by the market.

The solid waste disposal methods have lately become a major public concern in Turkey. Open dumps are the majority of the municipal solid waste disposal sites. Although the numbers of sanitary landfills seem very small, it corresponds to almost 20% of municipal solid waste being land filled (Tables 2 and 3). It is also known that several other municipal landfills are in the project or bidding phases. Therefore, within the next 10 years, more than 50% of municipal solid waste in Turkey is expected to be land filled.

Recycling and materials recovery

Solid waste recovery and recycling has been a long-standing commercial activity in Turkey. Glass and paper recycling have been conducted at industrial scales since the 1950s [12]. With the recent investments in the recycling industry, almost all types of the plastic materials, glass, paper, and metals can be recycled at industrial levels. Turkey, as one of the biggest steel scrap importers of the world, recycles more than 2 million tonnes of steel scrap annually. The recycling of nonferrous metals is also widespread and conducted at an industrial scale, including aluminum, copper, lead, and silver. The scrap metal recycling industry is essentially built on small- and medium-

Table 3 Amount of disposed/recovered waste brought to controlled landfill sites by type of waste and disposal/recovery methods [20]

Type of waste	Controlled land filled (tonnes/year)		Sold or donated (tonnes/year)	
	Hazardous	Nonhazardous	Hazardous	Nonhazardous
Total	57,338	9,979,785	5	1,619,699
Chemical wastes	1,537	211,222	–	–
Waste oils	–	–	2	–
Sludges from the treatment of industrial wastewater and purification of process water	3,044	168,435	–	–
Medical wastes	37,195	2,688	–	–
Metallic wastes	–	–	–	113,385
Glass wastes	–	307	–	199,892
Paper and cardboard wastes	–	1,528	–	800,734
Rubber wastes	–	–	–	161,236
Plastic wastes	–	1,254	–	316,673
Wood wastes	–	914	–	12,173
Textile wastes	–	278,938	–	8,958
Discarded equipment and vehicles	77	761	–	127
Waste batteries and accumulators	173	–	3	–
Vegetable wastes	–	293,224	–	351
Animal wastes from food processing	–	90,924	–	–
Manure	–	42,275	–	–
Household and similar wastes	–	7,851,580	–	–
Mixed and undifferentiated wastes	15	249,646	–	6,170
Sorting residues	–	104,586	–	–
Sludges from urban wastewater treatment	–	34,660	–	–
Mineral wastes	15,297	646,843	–	–

scale scrap dealers spread around the country. This type of operation is also valid for most of the collection and recovery of recyclable municipal solid waste.

The scrap dealers and individual collectors mostly conduct the recovery of plastics, paper, glass, and metal from municipal solid waste. These individual collectors and scrap dealers purchase the used packaging (mostly paper and cardboard) from commercial units, markets, and business centers and reprocess (sort and bale) these materials to sell directly to the industrial recycling facilities. In addition, scavenging and collection from the waste bins is a widespread activity. Since this type of collection and recovery process is a part of "unregistered" economic activity, it is difficult to specify figures reflecting the actual collection and recovery. However, estimates made by experienced individuals working in this field indicates that the total amount of municipal solid waste recovered in Turkey is probably over 1.0 million tonnes/year. Separate/curbside collection of the recyclable materials has started within the last 10 years in Turkey. Currently, more than 60 municipal recovery programs (glass, paper, metal, and plastics) are operational nationwide. These pilot programs have been a useful tool to develop relevant statistical basis for solid waste recovery activities.

The Secretariat General for EU Affairs reported that the recycling and recovery of packaging waste rate was well above 40% in Turkey [8]. However, most of these activities operate within the hands of private entrepreneurs and waste collectors working on streets and in waste yards. This is obviously driven by the fact that a strong used material market operates in Turkey, as well as by the limited economic conditions in the country that provide an employment opportunity for this sector. Paper and cardboard are collected through the scrap/waste dealers and delivered to recycling facilities nationwide. There exists approximately 30 medium- to large-scale paper recyclers, operating with capacities exceeding 50 tonnes/day. The output of these facilities is mostly the packaging cardboard made out of recycled paper. Glass recycling also works on the free market principles, which is mostly operated by the Glassworks Co. of Turkey, consuming more than 90% of the collected used glass bottles. The collection and recovery scheme is essentially the same as paper and cardboard recovery. In addition to

glass bottle banks spread around large cities, private entrepreneurs and scrap dealers collect, sort, and prepare used glass bottles for recycling.

Significant efforts have been made, in recent years, to increase the number of glass bottle banks and separate collection systems. The plastics and metal packaging collection system is essentially the same. PET recycling has been an industrial activity since the establishment of a major PET recycling plant in 1992. Currently, three industrial-scale PET recycling plants exist in Turkey, with a total operating capacity exceeding 25,000 tonnes per year. HDPE, LDPE, and PVC post-consumer bottle recycling has also been a long-standing operation and has been evolving since the oil crises in the 1970s. Several small-scale plastics recyclers (like PVC recycling operations) exist, since these facilities can be established with fairly low initial investments. In summary, a strong market demand exists for almost all types of packaging waste, regardless of its nature. Current scrap material prices are indicative of the world market influences. However, glass, paper, and PET recycling are being conducted at fairly high industrial capacities, which is another important recyclable item in household solid waste. Used beverage and tin cans are being recycled together with steel scrap by the steel smelters. Several small-scale aluminum recyclers are spread around the country and a major aluminum can recycler recently started operation in the western part of Turkey, with a capacity of 12,000 tonnes/year. Due to the high intrinsic economic value of aluminum cans, the aluminum collection and recycling rate is fairly high, exceeding 60% recovery rate.

The district municipality of Bakirkoy established the only recycling center in Istanbul, though it is, in reality, a sorting center rather than a recycling center. It has been operated as a pilot project covering the nearby districts of Bakirkoy. In chosen districts, residents collect packaging wastes such as glass, plastic bottles, cartons, and metal containers in the plastic bags/containers distributed to them by the municipality. These wastes are collected and transferred to the Bakirkoy waste separation center on certain assigned days of the week by the municipality's vehicles. The laborers sort them manually and compact them to reduce their size, and then they are sent to different factories to be reused and converted into useful products. Recently, Kadikoy has become another district municipality which has started a waste-recycling program. The solid wastes will be sorted at source and then collected and transferred to the recovery center located in the same district. After the final separation of the solid wastes manually in the center, they will be crushed, pressed, and converted to granules, bailed, and sold to the industry for further processing and recycling.

Materials recovery facilities can be self-sufficient if operated at capacities exceeding 70% of the established capacity, whereas the initial investment to set up large-scale collection and recovery schemes is the major barrier that the municipalities have to overcome. Participation rate measurements indicated that, although 80–85% of citizens are willing to participate in municipal recovery programs, the actual participation varies between 35–45%.

Costs and financing

Cost data on solid waste management in Turkey is usually highly controversial and complicated, due to the nature of the subject. The cost data is further complicated by the specifics of the municipal region and the cost-accounting methodology employed. Revenues are sufficient to cover the general operational costs of material recovery facilities if operated at full capacities. Depending on the source composition or depending on the collection method employed, a relatively acceptable commercial profit can be retained. Costs of items are categorized with different types of collection methodology. Collections through bring-centers yield relatively high investment costs and low operational costs, whereas the door-to-door collection of recyclable materials by plastic bags has the lowest investment cost. However, the continuing consumption of plastic bags yields relatively higher operational costs [11, 22]. Material recovery facilities are usually self-sufficient if operated at their established capacities, whereas the initial investment to set up large-scale collection and recovery schemes still remains to be the major barrier for the municipalities.

Landfill leachate

Although solid waste leachate disposal into the sea directly without treatment is a generally used practice in coastal settlements, recently built sanitary landfills have treatment facilities. Leachate characteristics and treatability have been investigated by Ozkaya et al. [13], Inanc et al. [9], Pala and Erden [14], and Timur and Özturk [21]. Leachate compositions of some major Turkish cities show that the organic and heavy metal concentrations are higher than the Turkish wastewater discharge limits (Table 4). Leachate treatment for organic and heavy metal removal before discharge is compulsory according to the Turkish wastewater discharge regulations. Although existing landfill leachate treatment have inadequacies in most of the deposition sites, recently built modern integrated solid waste treatment systems have leachate treatment using second- (aerobic–anaerobic) and third-stage (metal removal–filtering) treatment facilities.

Table 4 Landfill leachate characteristics of Turkish cities [3, 6, 7, 15]

	City					TRWC
	Istanbul (Kemerburgaz landfill site)	Bursa	Trabzon	Gaziantep	Izmir (Harmandalı landfill site)	
BOD_5 (mg/l)	–	35,000	8,084	500–15,625	10,750–11,000	250
COD (mg/l)	15,490	51,400	14,865	2,431–37,024	16,200–20,000	400
TKN (mg/l)	1,985	35,000	1,793	1,602–2,730	1,350–2,650	40
NH_3-N (mg/l)	1,880	–	1,615	–	–	–
NH_4-N (mg/l)	–	1,012	–	1,379–2,430	1,120–2,500	–
NO_x-N (mg/l)	87	–	–	60.7–285	–	–
Total P (mg/l)	1.72	26.17	1.85	7.7–14.4	–	10
TSS (mg/l)	4,430	2,561	4,487	–	–	350
Volatile acids (mg/l)	–	–	–	–	7,700–9,500	–
Cl^- (mg/l)	4,120	–	3,961	5,725–9,702	–	–
pH	7.86	6.42	7.73	7.90–7.30	7.3–7.8	6–10
Alkalinity (mg $CaCO_3$ l^{-1})	12,130	8,509	11,855	12,897–18,150	7,050–12,100	–
Iron (mg/l)	73	248	–	2.66–25.2	–	–
Copper (mg/l)	0.2	6.83	–	0.26–1.45	–	2
Manganese (mg/l)	3.36		–	0.20–0.85	–	–
Zinc (mg/l)	1.82	56.58	–	0.47–2.20	–	10
Nickel (mg/l)	0.7	–	–	1.23–5.80	–	5
Lead (mg/l)	–	23.8	–	0.67–1.91	–	3
Chromium (mg/l)	–	9.62	–	0.00–2.24	–	5
Cadmium (mg/l)	–	–	–	0.12–0.25	–	2

TRWC Turkey's receiving water criteria

Table 5 Amount of medical waste collected separately by destination [18]

Disposal methods	Number of municipalities[a]	Amount of medical waste (tonnes/year)
Turkey	495	69,628
Metropolitan municipality's dumping site	34	10,542
Municipality's dumping site	223	19,233
Another municipality's dumping site	20	341
Controlled landfill	22	15,732
Incineration plant	35	13,846
Burial	112	6,733
Burning in an open area	49	3,201

[a] Includes district and subdistrict municipalities served by metropolitan municipalities

Medical waste

The number of private and government hospitals in Turkey is constantly increasing. This increases the quantity of medical wastes. The amount of medical waste collected separately by destination is given in Table 5 [18].

Although the Ministry of Environment and Forestry has developed regulations aimed to ensure the appropriate handling and processing of medical waste, there are shortcomings and difficulties to uphold the regulations in practice. This can be achieved by the integrated study of local administrations. Istanbul is a model city to all other cities in Turkey related to medical waste management. The findings of the case study carried out showed that medical wastes collected from hospitals constituted 41% of the total solid wastes collected, with the remainder (59%) being municipal waste. The estimated quantity of medical waste from the hospitals was about 22 tonnes/day, representing an average generation rate of 0.63 kg/bed-day, which is below the average range of 1.5–3.9 kg/bed-day of medical waste in other countries [5].

Results and discussion

According to the results of Municipal Waste Statistics Survey 2008, which was applied to all municipalities, waste services were given in 3,129 municipalities out of 3,225 (Table 1). The amount of waste collected from municipalities receiving waste collection services was 13.31 million

tonnes in summer and 11.05 million tonnes in winter, adding up to an annual total of 24.36 million tonnes. According to the survey results, the daily amount of municipal waste per capita was calculated as 1.16 kg in summer, 1.13 kg in winter, and 1.15 kg for the yearly average. Of the 24.36 million tonnes of waste collected in municipalities in 2008, 41.3% was disposed of in a municipality's dump, 9.3% in a metropolitan municipality's dump, 1.4% in another municipality's dump, 1% by burning in an open area, 0.4% by burial, 0.2% by dumping into lakes and rivers, 44.9% was transferred to controlled landfills, and 1.1% was brought to composting plants. In 2008, the total capacity of 37 controlled landfill sites was 390 million tonnes and a total amount of 11,656,827 tonnes of waste were brought to these sites. 93.9% of the incoming waste was municipal waste and 6.1% was waste brought by other economic sectors and wastes transferred from incineration and composting facilities. 10,037,123 tonnes of waste was disposed of in controlled landfill sites and 1,619,704 tonnes of waste was sold or donated. In addition to that, in three sterilization facilities, which came into operation in 2008 with an overall capacity of 13 thousand tonnes/year, 3,153 tonnes of medical waste was sterilized. 2,688 tonnes of the sterilized waste was transferred to controlled landfill sites and 465 tonnes was transferred to municipal dumping sites. In 2008, 29,117 tonnes of hazardous waste was incinerated in two incineration plants having a total capacity of 44 thousand tonnes per year, and 6,806 tonnes of hazardous waste was transferred to controlled landfills. In 2008, 275,752 tonnes of waste was brought to four composting plants having a total capacity of 551 thousand tonnes per year. After the sorting processes, 143,000 tonnes of waste was composted and 46,827 tonnes of compost were produced. 120,906 tonnes of waste which cannot be composted was transferred to controlled landfill sites. 11,808 tonnes of waste was sold.

The composition of municipal solid waste varies by the source of waste; however, in all cases, organic constituents account for more than 50% of municipal solid waste. However, regardless of the source of collection, whether it is commercial, residential, or a tourist site, the majority of the material collected is composed of paper and cardboard. Glass packaging ranks second, with an average of 20–25% (by weight) and plastics constitute 15–20% of the outputs of the material recovery facilities.

Organic components can be assumed to be 50–55%, whereas recyclable and others (ash and slag, dust, etc.) can be assumed to be 20–25%. Significant alterations may be presented due to the condensed population, type of consumption and specific nature of waste sources, seasonal changes, and demographic factors. Generated waste quantities in some big cities show substantial changes compared to others. This can be caused by the percentage differences of the low income level population densities in these cities. Higher waste generation in winter can be caused by the ash and slag disposal. Differences in the municipal solid waste quantities in some big cities can be caused by the population density variations and by the types of the industrial establishments. The presence of high percentages of ash and slag in the wastes is caused by the used coal for winter heating (Tables 6 and 7).

Integrated waste management applications seem eligible for the metropolitan cities like Istanbul and Izmit in the western Black Sea region. Attempts have not been encouraging for the scattered regional settlements region using central storage sites due to financial shortages and received rejections from nearby settlements (e.g., south-eastern Black Sea region). So, the application of small-scale compact solid waste management systems with materials recycling and composting can be more suitable alternatives in the small-scale regional settlements. Solid wastes of Turkey are deficient in nitrogen but rich in organic carbon, causing an inappropriate C/N ratio for composting with high water contents (Table 8). Low calorific values of the wastes indicate unsuitability for

Table 6 Household solid waste (HSW) composition in Turkey [16]

Season	HSW (kg/capita-day)	Organic and wet (%)	Ash and slag (%)	Recyclable (%)
Summer	0.6	80.21	2.61	17.18
Winter	0.5	46.2	45.89	7.9
Average	0.57	68.87	17.04	14.09

Table 7 Municipal solid waste in Turkey [17]

	Municipal solid waste (kg/capita-day)	Treatment of solid waste		
		Year:	1994	2001
Summer	0.9			
Winter	1.0	Landfill (%)	4.7	15
Average	0.97	Composting (%)	1.1	2.0

Table 8 Solid waste characteristics of the major cities in Turkey [1–3]

City	pH	C (%)	N (%)	C/N ratio	Water content (%)	L. cal. value (kJ/kg)
Trabzon	6.32	35.12	0.51	68.50	76.25	1,703
Istanbul	7.99	21.32	0.84	34.00	47.60	3,773
Ankara	4.94	24.42	1.61	15.28	76.42	460
Izmir	6.94	25.50	1.20	27.50	50.25	1,042

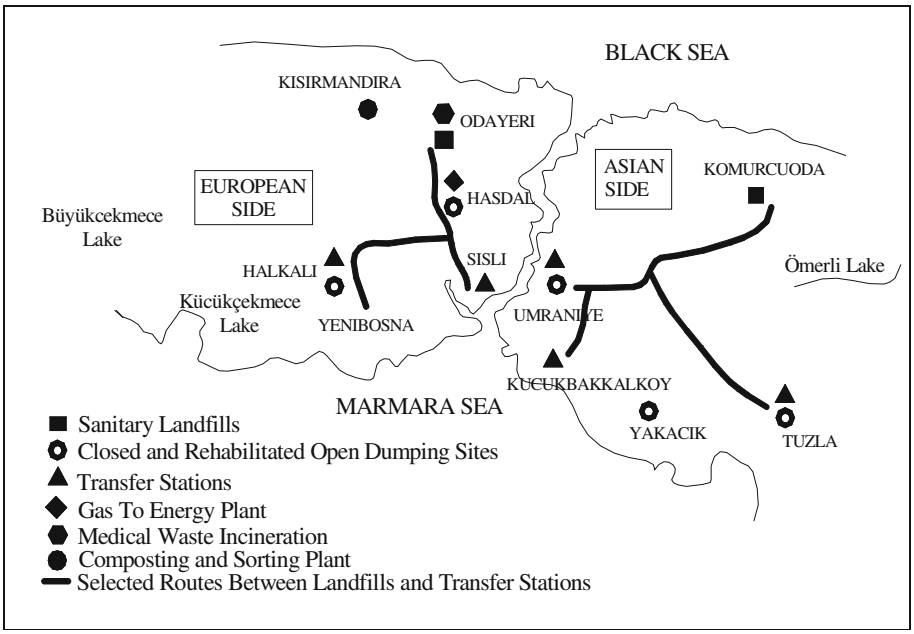

Fig. 1 The integrated solid waste management scheme of Istanbul metropolitan city [4]

incineration. Sanitary landfills and associated power plants (e.g., Istanbul 6 MW plant) seem to be appropriate disposal methods, while composting seems to be potentially applicable. Although gas burners cause considerable gas emissions in the landfill sites, greenhouse emissions from landfills are also an emulous matter of concern, both of which have not been extensively studied countrywide. According to 2004 SIS reports, 59.4% of the CH_4 emission is originated from solid waste disposal in Turkey.

Some solid disposal methods, as a part of integrated solid waste management systems, have been successfully applied in Istanbul and Izmit. But, due to the massive solid wastes of Istanbul metropolitan city, these measures are still far from adequate (Fig. 1). Besides recycling/recovery, applications of composting and appropriate incineration (for medical wastes) methods should be encouraged in order to minimize the generation of solid wastes. Although land filling is the cheapest method for the disposal of solid wastes, it is getting harder to find appropriate landfill sites each year by the ever increasing rates of solid wastes.

Appropriate composting technology can be applied alternatively if solid waste characteristics are suitably adjusted for composting. The removal of medical wastes using modern technologies (e.g., pyrolysis) is urgently needed.

Especially for the integrated solid waste management applications in the solid-waste-rich metropolitan cites, methane recovery from organic substances, gas engine generation, and heat recovery by combustion are also important considerations for the future management policies of Turkey.

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