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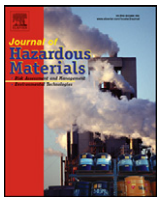

Review

Industrial hazardous waste management in Turkey: Current state of the field and primary challenges

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ABSTRACT

A holistic evaluation of a country's hazardous waste management (HWM) practices is useful in identifying the necessary actions to focus on. Based on an analysis of industrial hazardous waste (HW) generation in Turkey, this paper attempts to critically evaluate and report current Turkish HWM practices and discuss the primary challenges to be addressed. The generation of industrial HW for Turkey reported in 2004 was 1.195 million tons, which accounted for 7% of the total industrial solid waste (ISW) generated by the manufacturing industry, and for nearly 4.9% of the total solid waste generated in the country. The HW generated by the top five manufacturing product categories – basic metals, chemicals and chemical products, food and beverages, coke and refined petroleum, motor vehicles and trailers – accounted for 89.0% of total industrial HW. 21% of the HW generated in 2004 was recycled or reused, and 6% was sold or donated, whereas 73% was sent to ultimate disposal. 67% of the HW sent to ultimate disposal was disposed of at municipal landfills. The total capacity of the existing regional HW facilities is 212,500 tons/year, which accounts for about 24% of the HW to be disposed. Turkey has identified the HW problem in the country and enacted legislation, designated a lead agency, and promulgated rules and regulations. Several new initiatives are planned for improving HW management nationally; however, some HWM problems will be persistent due to previous and existing industrial development plans. These development policies led to the concentration of industry in regions marked by precious agricultural fields and high population density. This occurred because the government previously exhibited a default prioritization towards industrial development, leading to insufficient implementation of regulations on HW generators. Some of the problems may also be rooted in other countries that allow illegal transboundary HW movements despite international regulations.

Contents

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1. Introduction

The increasing use of chemicals in the industrializing world has resulted in many residual hazardous substances. Wastes produced due to increasing trend of consumption have reached to threatening levels in terms of quantity and hazardous content.

The environmental and human health consequences of hazardous waste (HW) generation by our so-called 'developing' global society were misunderstood and failed to garner significant international attention until several crises arose concerning hazardous waste management (HWM); one example of such a landmark event was that of the Love Canal. It was the Love Canal incident that eventually resulted in the passage of the Superfund Act in 1980 by the U.S. Congress [1].

Industrial HWM has become a critical environmental issue in Turkey [2]. Turkey (2007 population: 70,586,256) (Fig. 1) has experienced several negative HW events that occupied the national agenda beginning in the 1980s. In 1988, more than 360 barrels full of various toxic substances were found on the Turkish Black Sea Coast; documents found inside the barrels revealed that the waste had been exported from Italy [3,4]. In 1991, the ship-breaking industry received national attention due to asbestos contamination [5]. There are many ship-breaking/recycling companies all over the world, but only those in Pakistan, India, China, Bangladesh, and Turkey are currently functional [6]. In 2007, 76 ships were scrapped in Turkey and at least half of the ships came from European countries [6]. The Turkish earthquake of 1999 triggered some significant hazardous materials releases from nineteen industrial facilities located in the Marmara Region, including the leakage of 6500 tons of toxic acrylonitrile into the air, soil, and water from ruptured tanks, along with the atmospheric release of 200 tons of hazardous anhydrous ammonia [7]. In 1999, 3488 tons of hazardous fly ash was loaded onto the MVUlla ship in Spain [4]. The HW was to be sent to Algeria but was rejected; following this, the ship mysteriously ended up in Turkey [4,8]. This ship sank in the Turkish port of Iskenderun in 2004, burying tons of HW [4,8]. Although the entry of such HW into Turkey is banned under both national and international legislation (Basel Convention and EU legislation), no country wanted to take responsibility for the ship in the critical timeline before the ship sank, during which it could have potentially have been prevented. In 2002, an abandoned ship called the Sea Beirut was towed from Dunkirk harbor in France to the ship-breaking yards in Turkey, where asbestos was found onboard [4]. Proper notification processes were not followed by the relevant country authorities, under either the EU or the Basel Convention protocols [4]. In 2006, hundreds of toxic waste barrels were found buried under a patch of grassland in the Istanbul suburb of Tuzla; they were later revealed to have been dumped by a pharmaceutical company [9]. The authorities assume there may be many more waste cemeteries all over Turkey, contaminating the water and soil. The repeated nature of the HW events led to questionize the HWM in Turkey and the roles of the authorities involved.

There are several geographical areas in Turkey that may also pose environmental and health risks. The Dilovasi Organized Industrial District in the Marmara Region is one of the most important industrial areas in Turkey, and serious environment and health problems have resulted in this vicinity [10]. According to the result of epidemiological research carried out by the Ministry of Health, cancer has become the primary cause of death among all illnesses in the region, while cardiovascular diseases is the main cause of death in the country [10]. It is reported that between 1995 and 2004, 493 people died in Dilovasi industrial area [10]. 32.3% of the deaths were due to cancer, mostly lung and stomach cancer [10].

Based on an analysis of industrial waste generation in Turkey, this paper attempts to critically evaluate and report Turkey's current HWM state, and discusses the primary challenges faced. The

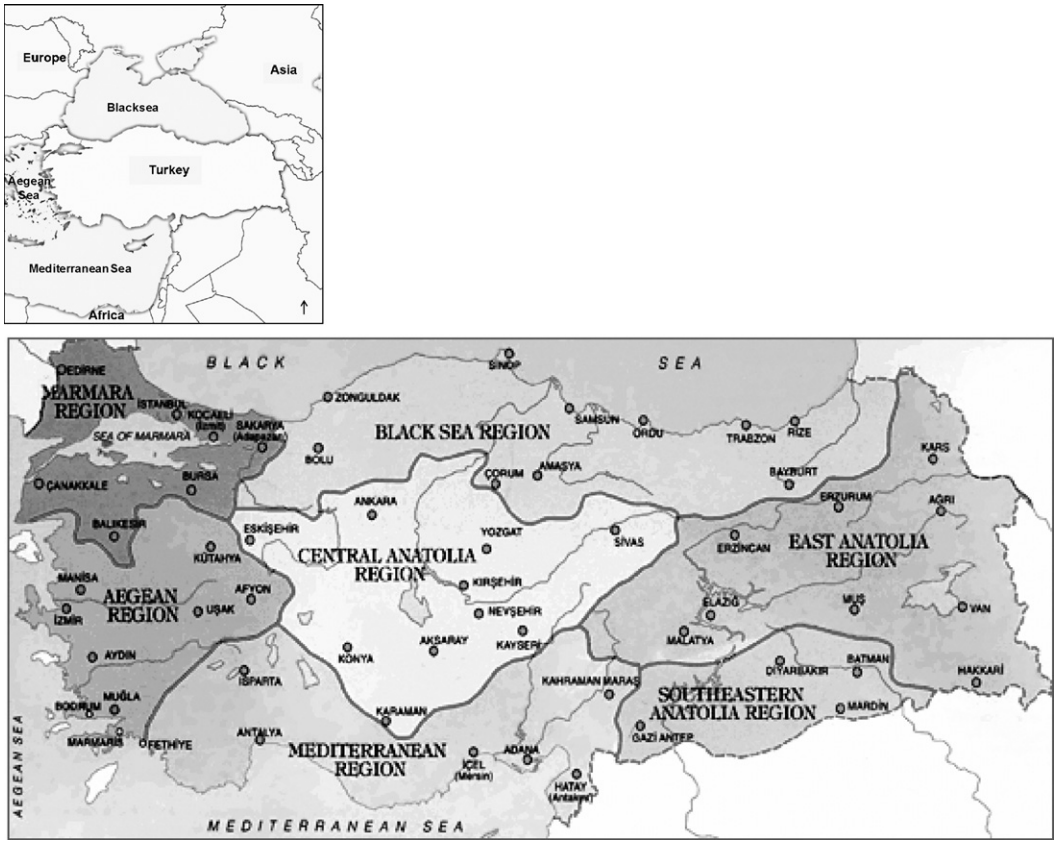

Fig. 1. Map of Turkey.

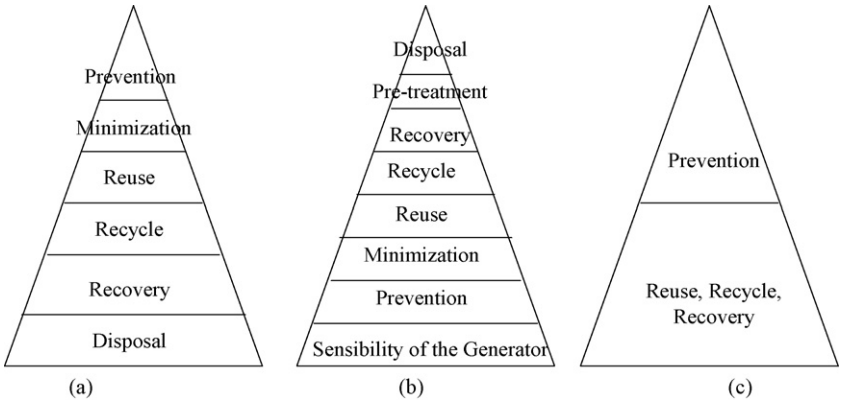

Fig. 2. Hazardous waste management hierarchy in Turkey, (a) existing state, (b) targeted state, (c) targeted after 2020.

paper also evaluates how Turkey handles the key components of a successful HWM program as suggested by Probst and Beierle [11], and makes a SWOT analysis of the system.

2. Industrial hazardous waste management in Turkey

The manufacturing industry is the main source of HW for most countries and regions of Europe [12]. This is particularly the case for Finland, Germany, and Norway, where more than 75% of the HW come from the manufacturing sector [12]. Manufacturing industry refers to those industries, which involve in the manufacturing and processing of items and indulge in either creation of new commodities or in value addition. HW generation data from manufacturing industry of Turkey has been evaluated in this study.

Manufacturing industry has a crucial role in Turkish economy in terms of significant contributions to employment, industrial value added, and export opportunities [13]. About 4.5 million workforce is employed and about 95% of the total export is generated by the manufacturing industry [13]. Turkish economy experienced a marked change in structure, in which agriculture as the primary source of output and employment was displaced by more urban-based manufacturing and services between 1980 and 2004 [14]. In Turkey, the share of manufacturing industry in GDP is about 20% and has grown 9% on average in 2004–2006 term [15,16]. Economical analyses suggest an increase in the share of manufacturing sector in the total economy for another term [17].

Wastes having one or more of the features of "being explosive, flammable, combustible, producing flammable gases, causing oxidation, corrosiveness, causing acute and/or chronic poisoning, leading to infection and forming toxic gas, being ecotoxic and producing liquid extraction are defined as 'hazardous waste' in Turkish Hazardous Waste Control Regulation. HW list of Turkey is in line with the European Waste Catalogue (2000/532) [18]. HW Control Regulation adopts the main HWM hierarchy approach in the order 'prevention at source, reduction, recycling, incineration/energy production, and disposal. However, the pyramid operates inversely in Turkey; both solid and HW are mostly landfilled and although very limited, some are reused through incineration and energy production [19] (Fig. 2a).

One of the primary problems arising along with industrial activities in Turkey is uncontrolled HW that were illegally dumped or discharged to receiving water bodies [2]. Another problem is the general habit of mixing the HW with municipal waste and landilling together [2,20]. According to recent data of Official Institute of Statistics (OIS) [21], nearly 58% of the HW produced is dumped to the landfills together with municipal waste or directly left to the nature in a way that causes threats to environment and human health. Turkey has begun to consider ways of developing and implementing programs to assure proper disposal of HW in 1983 with the Environmental Law [22], and subsequently in 1995 by issuing the first HW regulation [23]. Turkey has been party to the Basel Convention on Control of Transboundary Movement of Waste since 1994. Waste prevention or minimization is regarded as the priority principle in all the arrangements regarding waste management, especially in the Environmental Law. However, up to date the HWM in Turkey has mostly emphasized proper and legal disposal of the HW generated in the implementation-oriented arrangements, rather than the precautionary principle. First regional HW incineration plant and HW landfill were established in 1996. EU Waste Framework Directive makes it obligatory for the member countries to take measures encouraging minimization of the amount and the hazardousness level of wastes. As part of the EU integration process of Turkey, several sections of EU *acquis* in HWM sector have been transposed, and the targeted HWM hierarchy (Fig. 2b) has been attempted to be enforced better. Several strategies, starting with legislation, action planning for 2008–2012, information-raising campaigns, establishment of new disposal facilities, electronic HW inventory system have been employed for a better HWM in the country. Ministry of Environment and Forestry (MoEF), the main institution in charge of HWM, announces in every occasion that their main policy is encouraging waste minimization at source. However, although it is defined as the most prioritized policy, which instruments and methods should be used in the waste management is not clearly established.

2.1. Industrial hazardous waste generation and disposal

There is limited data on the generation of HW in Turkey. The most comprehensive study has been conducted by the OIS in 2004. Since 1991 OIS has been preparing the manufacturing industry waste inventory to identify the amount and distribution of industrial waste in cooperation with MoEF, local administrations, and industrial organizations. The 2004 inventory as compiled by OIS is still the only available databank of HW covering the whole country, despite such shortcomings as a lack of any verification. New projects initiated by the MoEF and OIS, and construction of an electronic database for HW indicate that the shortcomings of this area will possibly be reduced in the next term [24].

According to the existing databank, the manufacturing industry generated over 17.5 million tons of solid waste in 2004 [21]. The volume of the waste generated by manufacturing industry accounted for 72.2% of all the solid waste produced in 2004 [21]. Norwegian manufacturing industries are reported to have generated 3 million tons of waste in 2005, which accounted for 36% of the national total [25]. According to a report by Kloek and Blumenthal [26], Romenia and Bulgaria reported most of their waste from

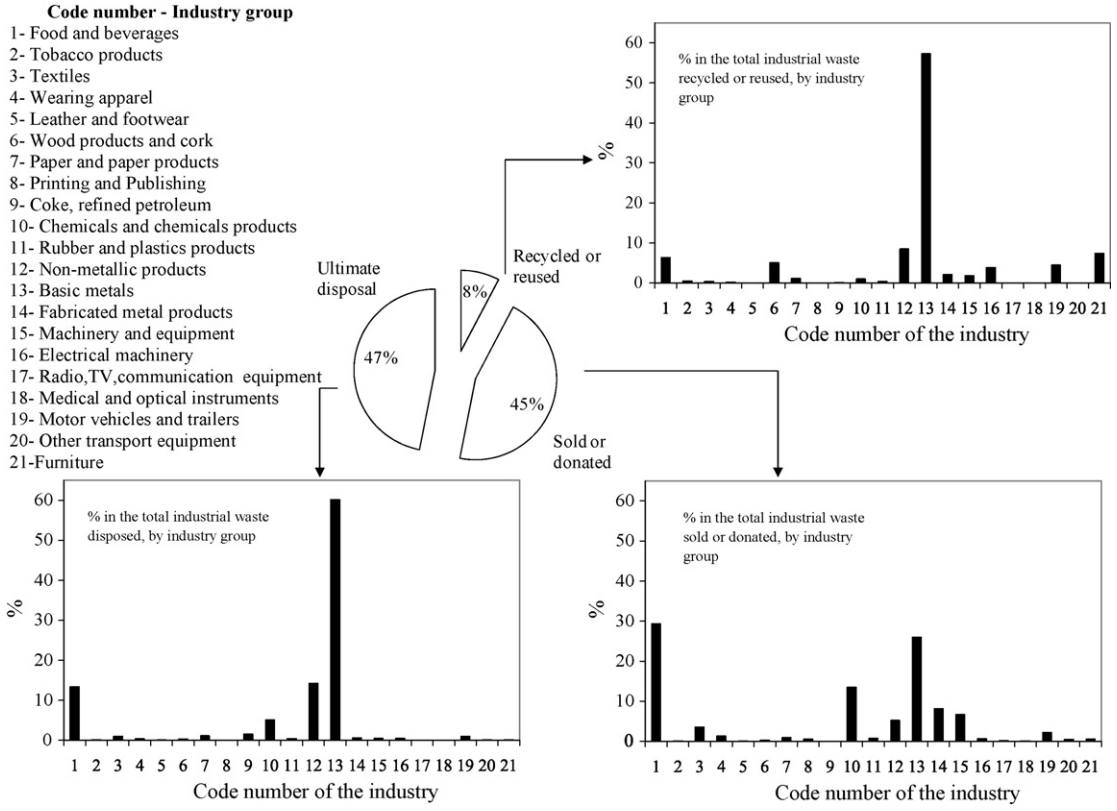

Fig. 3. Amount of the industrial solid waste generated in 2004, by industry group.

the industrial sector (95.6 and 98.7), in 2006. Spanish manufacturing industry generated 25.9 million tons of solid waste in 2006 [27]. 18 million tons of industrial waste are produced every year in Taiwan [28], and 3 million tons/year industrial wastes are produced by Chilean industry [29]. Differences between the amounts of the industrial waste generated by different countries may be partly explained by differences in the structure of their economies [26].

Of all the industrial solid waste (ISW) generated in 2004, 8% was recycled or reused, 45% was sold or donated, and 47% was sent for ultimate disposal (Fig. 3) [21]. The ISW sent to ultimate disposal was 8.2 million tons in 2004. 20% of the ISW sent to ultimate disposal was sent to dumpsites; and 1.1% of this waste was hazardous (Fig. 4). 10% of the ISW sent to ultimate disposal was landfilled as municipal waste; and 65% of this waste was hazardous. 2.7% of the ISW sent to ultimate disposal was incinerated; and 91% of this waste was hazardous. 9.3% of the ISW sent to ultimate disposal was stored in the own storage fields of factories; and 8% of this waste was hazardous. The highest portion of the ISW sent to ultimate disposal was expressed under the disposal method 'other' in Fig. 4. This portion includes 3.9 million tons of ISW discharged to receiving water bodies in 2004. According to the figures, 62% of the ISW sent to ultimate disposal was disposed legally and properly.

Fig. 5a shows the distribution of total ISW amounts generated by different industry groups, in 2004. Wastes from manufacturing of basic metals (ISIC R3 Code: 27) were found to be the largest single contributor (44.4%) to the total ISW generated in Turkey. It is reported that the manufacture of basic metals generated 32% of all manufacturing waste in the European Union (EU27) [26]. Greece reported 72% of its manufacturing sector waste from basic metals sector [26]. Basic metals industries include facilities involved in smelting and refining of metals from ore, pig, or scrap; rolling, extruding, and alloying metals; manufacturing castings, nails, spikes, insulated wire, and cable; and production of coke [30]. Waste from basic metals is followed by the manufacture of food and beverages (ISIC R3 Code: 15) (20.1%), and non-metallic products (9.7%). The manufacture of food accounted for 17% in EU27 and over 40% in Cyprus, the Netherlands, Ireland, and Hungary [26].

As can be seen from Fig. 3, the top four manufacturing industry groups that recycle or reuse the waste are basic metals (57.2%), non-metallic products (ISIC R3 Code: 26) (8.5%), furniture (ISIC R3 Code: 36) (7.4%), and food and beverages (6.3%), in that order. Heavy metal containing electric arc furnace dust from basic metal industries (e.g. steel foundries) is an easily recyclable waste [31]. Especially the recycling of Zn might have contributed to the recycling figure of basic metals manufacture. As for sold/donated waste amounts, the top four list includes the manufacture of food and beverages (29.3%), basic metals (25.9%), chemicals and chemical products (ISIC R3 Code: 24) (13.4%), and fabricated metal products (ISIC R3 Code: 28) (8.12%), in that order. Animal feed stuff, com-

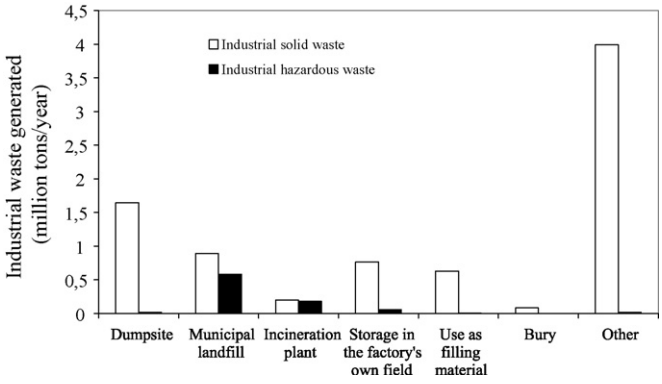

Fig. 4. Ultimate disposal methods for the industrial solid and hazardous waste generated in 2004.

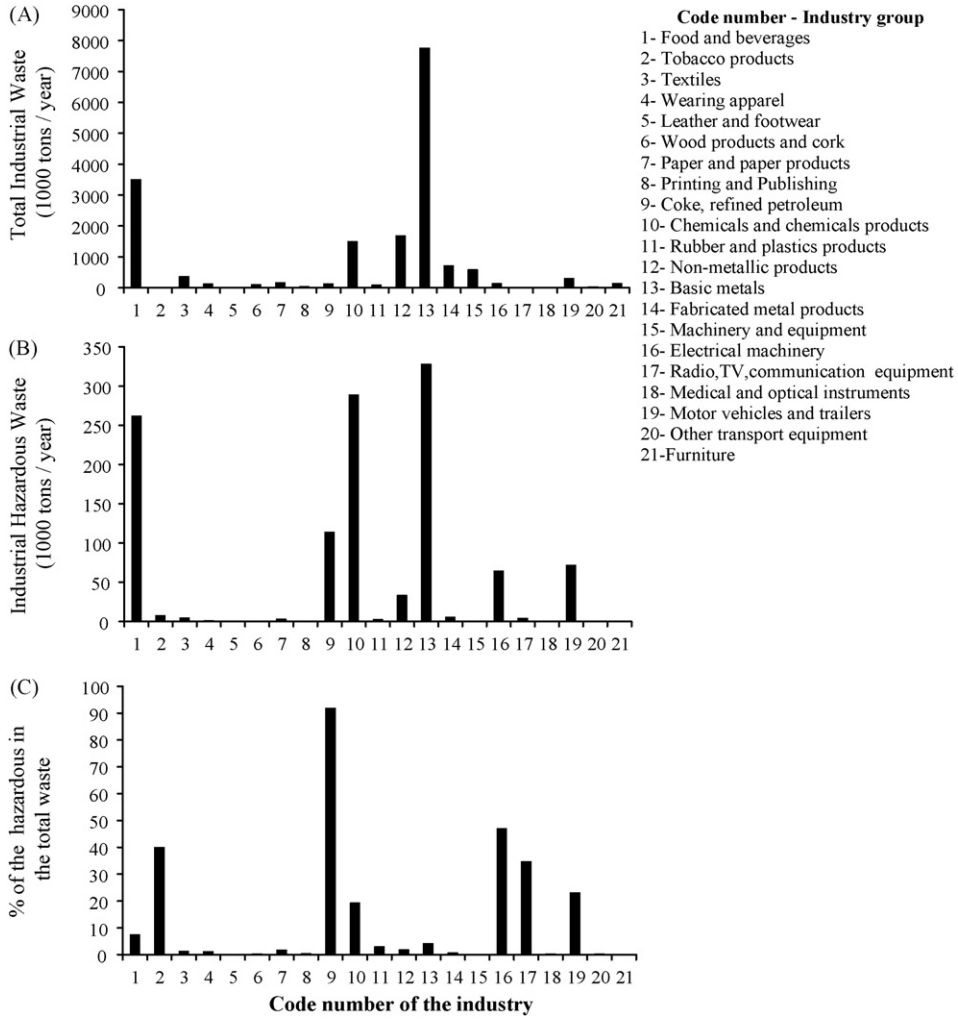

Fig. 5. Distribution of the waste amounts generated in 2004, by industry groups, (a) industrial solid waste generated, (b) industrial hazardous waste generated, (c) percentage of the hazardous waste in the solid waste.

post materials, wood pallets, glass, plastic, and metal bottles are examples to the reused/recycled or sold wastes from food and beverage manufacturing sector. Scrap metals, metal tailings are wastes that could be recycled or sold by basic metals manufacturing sector. Lubricated metals are pre-treated to separate the metal and oil before sell by basic metal industries. The waste oils can also be sold. Chemicals and chemical products manufacture industries sell their outdated products as secondary raw material, they also reuse their contaminated plastic barrels after washing. Paint sludges, metal tailings, solvents, metal sludges, waste oils are examples to the wastes from fabricated metals manufacturing sector that could be reused/recycled or sold [32].

The HW portion of the total ISW amounted to nearly 1.195 million tons/year, or 7% in 2004 [21]. This quantity accounted for nearly 4.9% of total solid waste generated in the country in 2004 [21]. Spanish manufacturing industry produces nearly 2 million tons/year HW, which accounts to nearly 8% of the total solid waste generated by the manufacturing industry [27]. Norwegian industry produced 908,000 tons HW in 2004, and more than 90% of this waste went to approved treatment [25]. More than 6 million tons HW was produced in 2006 in England and Wales [33]. The total amount of HW generated in Finland was 1.3 million tons in 2003, and industrial HW accounted for 98% of the total quantity [34]. Around 3% of waste generated in EU27 in 2006 was hazardous [26]. Bulgaria, Romania, and Greece reported low percentage of HW (0.3%, 0.3%, and 0.5%), while Estonia reported high percentage of HW (35%) [26]. In China the reported generation of HW was 11.62 million tons in 2005, which accounted for 1.1% of ISW [35], and 46,7 million tons of HW was generated in the USA in 2007 [36]. In 2002, industries in Malaysia generated about 363,017 tons of HW [37], and 1,47 million tons of HW which accounts for 8% of the total ISW was produced in Taiwan in 1998 [28].

The amount of HW generated by the top five manufacturing industry categories in Turkey, which are basic metals (27.4%), chemicals and chemical products (24.2%), food and beverages (21.9%), coke and refined petroleum (9.5%), and motor vehicles and trailers (6%), accounted for 89.0% of the HW generated in 2004 (Fig. 5b). The largest contributor to the HW from Spanish manufacturing industry was reported to be basic metals together with non-metallic products manufacture (57%), followed by chemical and plastic industries (27%), in 2006 [27]. 38% of the HW generated by Chinese industry was from raw chemical materials and chemical products industry [35].

The wastes typically generated in basic metals sector are emission control dust [38–40] or sludge containing heavy metals, spent pickle liquor, paint wastes containing heavy metals, strong acids and bases, cyanide wastes, etc. [41]. Typical HW from manufacture of chemicals and chemical products are strong acids and bases, reactive wastes, ignitable wastes, discarded commercial chemical products [42]. Animal wastes, cleaning wastes, CFCs (refrigerants) are examples to the HW resulted from the manufacture of food and beverages [42]. Dissolved air flotation (DAF) float, slop oil emul-

Table 1
Geographical location of the hazardous waste management facilities and transportation vehicles in Turkey [46].

Geographical region in Turkey	Licensed cement plants*	Reuse/recovery plants	Licensed transportation vehicles**	Incineration plants	Hazardous waste landfills	Interim storage plants
Aegean	11	24	130	1		1
Blacksea	2				1	
Central Anatolia	6	29	154			1
Eastern Anatolia	2		8			
Marmara	11	74	359	2	1	2
Mediterranean	3	6	84		1	
Southeast Anatolia	3	1	31			
Total	38	134	766	3	3	4

* Licensed to burn hazardous waste.
** Licensed to carry hazardous wastes.

sion solids, heat exchanger bundle cleaning sludge, tank bottoms, ammonia still lime sludge, decanter tank tar sludge are typical HW from coke and refined petroleum manufacture sector [43]. Paint wastes, ignitable wastes, spent solvents, and acids and bases can be resulted from the manufacture of motor vehicles and trailers [42]. Fig. 5c shows the percentages of the hazardous components in the total ISW generated by different industries in 2004. According to the figure, 91.9% of the ISW from coke and refined petroleum manufacture was hazardous. Waste from electrical machinery manufacture is the second most hazardous component-bearing waste with 47% share, while tobacco products manufacture is the third sector with 40% hazardous share.

HW generated by manufacturing industry in 2004 was disposed as shown in Fig. 6. 21% of the HW was recycled or reused, and 6% of the HW was sold or donated, whereas 73% was sent to ultimate disposal. The proportion of the HW generated by Chinese industry was reported to account for 43.4% of the total HW in 2005 [35], the recycling and recovery ratio for Shanghai is reported to be 54.86% in 2003 [44].

66.7% of the HW sent to ultimate disposal was disposed of at municipal landfills. It is stated in all official documents of MoEF [2,20] that one of the most important problems in HWM is the disposal of HW, ISW, household wastes, special wastes, and construction wastes together at landfills engineered for only municipal waste. Incineration and collection in the factory field are the second and third common disposal methods, respectively. According to Fig. 6, 58% of the HW generated were disposed illegally in 2004.

2.2. Recycling, transportation, and disposal facilities

The unregistered recycling sector, which has grown rapidly in recent years, but operating inappropriately makes it impossible to audit this sector [20]. MoEF gives license to the firms and facilities in order to register the recycling sector. According to its law on establishment, the duties of issuing license, monitoring and auditing the licenses issued is given to the MoEF. The firms and the facilities that are registered through issuing license or interim work permit still constitute the very small part of the firms actively operating in the field of recycling [20].

The 2005 legal notification on the usage of wastes as supplementary fuel gave the legal support for cement factories to burn several types of HW [45]. As of August 2009, 38 cement factories were licensed to burn HW for additional energy recovery [46] (Table 1). The amounts of HW licensed to be used as additional fuel are given in Table 2 [2]. Cement factories can only burn HW such as waste oils, used tires, solid wastes contaminated with oils, waste plastics, petroleum refinery wastes, petroleum bottom sludges, paint sludges, liquid fuel sludges for energy recovery. The number of recovery facilities as of 2009 is 134 [46] (Table 1). Table 3 gives the recovery capacities of all licensed facilities. The total licensed amount far exceed the actual usage of the facilities. 248 tons of HW was reused/recovered in 2004, which accounts for 31% of the recovery capacities of all licensed facilities. Only several types of HW can be recovered by the existing licensed facilities (Table 3). The highest capacity among the recovery activities (527,460 tons/year) is for using the waste principally as a fuel or as other means of generating energy. It is unofficially declared by the MoEF that only 20% of the recovery capacity is being used [2]. This indicates that some part of the recycling activity is made through recycling of some wastes at the source by certain industrial facilities without license.

Table 2
Licensed amounts of hazardous wastes to be used as additional fuel by cement factories [2].

Waste types	Licensed amount (tons/year)
Waste oils (categorized by the notification)	214,226
Used tires	106,458
Contaminated wastes*	61,884
Waste plastics	51,866
Petroleum refinery waste	24,120
Petroleum bottom sludge	18,902
Paint sludge	16,964
Liquid fuel sludge	4,020
Total	498,440

*Solid wastes contaminated with waste oils.

There are also several initiatives in several organized industrial districts to operate waste exchange markets. The Turkish Union of Chambers and Commodity Exchanges and MoEF coordinate these initiatives in order to minimize and reuse the waste produced by the industry [47]. However, these exchange markets are not operating at the desired level [2].

Table 3
Recovery capacities of the facilities licensed [2].

Recovery code*	Licensed amount (tons/year)
R1 Use principally as a fuel or other means to generate energy	527,460
R2 Solvent reclamation/regeneration	9,350
R3 Recycling/reclamation of organic substances which are not used as solvents	17,477
R4 Recycling/reclamation of metals and metal compounds	113,442
R5 Recycling/reclamation of other inorganic materials	1,955
R9 Refinery of waste oils	82,452
R10 Land treatment resulting in benefit to agriculture or ecological improvement	0
R11 Use of waste obtained from any of the operations numbered R1–R10	14,570
R12 Exchange of waste for submission to any of the operations numbered R1–R11	24,415
Total	791,121

* Recovery codes from Directive 2008/98/EC of the European Parliament.

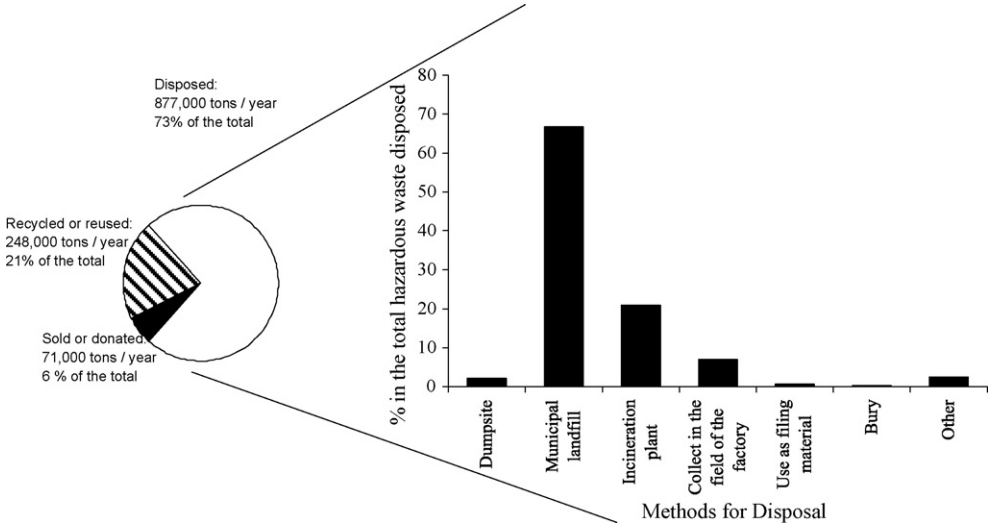

Fig. 6. Amount of the industrial hazardous waste generated in 2004 and disposal methods.

HW must be handled via vehicles that comply with the standards specified by the MoEF and have the relevant license for handling according to relevant legislation [48]. Despite the fact that a significant progress was achieved due to the studies towards giving licenses to the vehicles, it is not possible to measure the success obtained, since the acts that do not comply with the system are not monitored and no sanctions is imposed [20]. There are 766 licensed transportation firms operating in Turkey [46] (Table 1), however the number is insufficient to transport all the liquid and HW generated [2]. It is compulsory to keep waste tracking forms (containing the relevant information) in vehicles to realize the HW transportation process. The procedure is the same as the 259/93/EC requirements [49]. The tracking form has 3 parts to be filled and signed by waste generator, transporter, and disposer. Fig. 7 shows how the HW is tracked between the generator and competent authority, MoEF. HW tracking forms are composed of 5 copies of information pages. Waste generator fills the forms and takes one of the copies to declare to the provincial MoEF directorate that the transportation of the HW started. Other 4 copies of the forms are carried by the driver of the vehicle to the disposal facility. The disposal facility signs these copies and takes 3 of them, one for its self-records and the others to be sent to MoEF, and waste generator. The driver of the vehicle carries the remaining signed copy of the tracking forms to the waste generator.

Turkey is divided into 7 geographical regions according to such factors as climate, location, flora and fauna, human habitat, agricultural diversities, transportation, and topography (Fig. 1). The industrial development within these geographical regions was also affected by these defining characteristics. As a result, largest part of all industry has accumulated in the Marmara Region, with the Aegean Region being the second most industrially developed [50]. A study conducted by Akgungor [50] revealed that majority of Turkey's manufacturing industry employment is located in the Marmara Region where Istanbul is the primary source of attraction for being a major financial and industrial district. Marmara Region covers more than 45% of industry employment, creating almost half of the value added in Turkish manufacturing industry [50]. Other metropolitan regions where industry employment is high around a local industry centre are Izmir district (Aegean Region), Adana district (Mediterranean Region) and Ankara (Central Anatolia) district. These four vicinities cover roughly 70% of total manufacturing employment [50]. The location of HWM facilities also reflects the location of the industrial facilities; the numbers of HWM facilities are given in Table 1.

The capacities of current incinerators and HW landfills are given in Table 4. IZAYDAS (Izmit hazardous and clinical waste incinerator) has been the first and only incinerator in Turkey between 1996 and 2003. In 2003, PETKIM incinerator was established to incinerate the HW of PETKIM petrochemical industry. A capacity of 10,000 tons/year was booked for the other HW generators. TUPRAS Turkish Petroleum Refineries, ERDEMIR iron and steel factory, ISKEN coal fired power plant, use their facilities for their own HW. In August 2007, IZAYDAS announced that it was working with full capacity and could not meet the demand. Some of the HW generators were advised by the MoEF to send their waste for incineration in several European countries such as Germany.

Turkish manufacturing industry produces over 1.195 million tons/year HW. More than 877,000 tons/year of this waste is disposed with legal or illegal methods. There are only

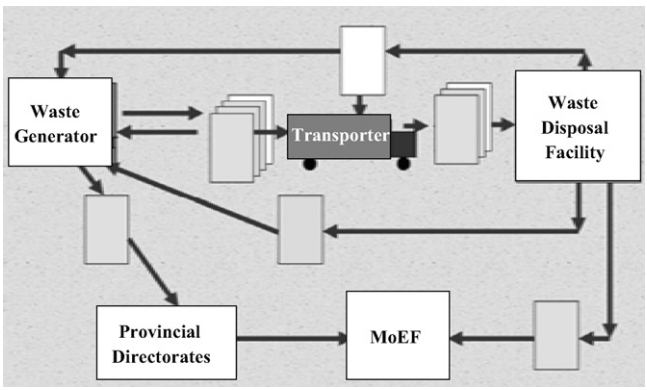

Fig. 7. Hazardous waste tracking flow diagram.

Table 4
Capacities of the facilities for ultimate disposal of the hazardous waste [2].

Name of the firm	Capacity (tons/year)
IZAYDAS Landfill (Regional)	160,000
IZAYDAS Incinerator (Regional)	35,000
PETKIM Incinerator (for the factory's own waste and other HW generators)	17,500
TUPRAS Incinerator (for the factory's own waste)	7,750
ERDEMIR Landfill (for the factory's own waste)	6,084
ISKEN Landfill (for the factory's own waste)	11,000
Total	237,334

Table 5
Amounts of the mineral oil and waste oil collected, recovered, and disposed [2].

Year	Mineral oil in the market (tons/year)	Total waste oil collected (tons/year)	Recovered (tons/year)	Used as additional fuel (tons/year)	Ultimate disposal (tons/year)
2004	306,112	1,414	447	955	12
2005	314,230	11,785	2,039	9700	46
2006	323,400	26,836	14,429	12,400	7
2007	350,000	34,280	16,900	17,300	80

three facilities (IZAYDAS incinerator, IZAYDAS landfill, and PETKIM incinerator), which could accept the HW from manufacturing industry (Table 4). The total capacity of the existing regional HW facilities is 212,500 tons/year, which accounts for about 24% of the HW to be disposed. It is apparent that there is not enough facility to dispose 76% of the HW that needs to be disposed. According to the State of Environmental Report of Istanbul in 2005, prepared by Istanbul MoEF Provincial Directorate, only 1% of 750,000 tons/year HW generated in Istanbul was sent to regional HW facilities [51]. The remaining part is either disposed to the nature without any control, or reused in the production, or landfilled with municipal waste [51].

2.3. Special wastes

Special waste is defined as waste which must be handled in a particular manner and for which particular rules apply [52]. With a view to developing stricter standards for special wastes, the Turkish administration recognized the need for assistance in terms of legislative measures, monitoring requirements, methods of measurements and enforcement. To help address the issue, the German Federal Ministry for Environment, Nature Conservation and Nuclear Safety was selected for a two year Twinning project aimed specifically at developing the capacity in institutional, technical and financial issues within the Turkish MoEF [53]. The project comprised studies on waste oil, waste batteries and accumulators, polychlorinated biphenyls and terphenyls, end-of-life vehicles and European Waste Catalogue [54].

Management of waste oils and waste batteries and accumulators are defined as special wastes, and organized under specific regulations. Recycling of these wastes is done either by the organizations established by the facilities operating in the related sector or the companies with special recycling license. In recent years, there has been an increase in the number of such organizations and special-licensed companies [20]. Special Wastes Directorate of MoEF was designated as the competent authority for the management of these special wastes.

2.3.1. Waste oils

The inventory of waste oils is composed from the information in waste oil declaration forms collected from major generators, activity reports from waste oil recovery facilities, and waste lubricating oil study reports. The total amount of mineral oils on the market was approximately 350,000 tons/year in 2007, with approximately 150,000 tons/year of that ending up as waste oil. In 2007, 34,280 tons of waste oil was collected, which was only 23% of the amount expected [2]. A significant portion of waste oil is burned through illegal ways and converted to energy [20]. Waste oils began to be regulated in 2004; an increase of 5% in collection is expected for each year since the implementation of the regulation. It is expected that 40% of the waste oil amount will be legally collected and registered by 2012. There are 17 licensed oil recovery facilities in Turkey. Table 5 gives the amounts and disposal methods of the waste oil collected between 2004 and 2007. Cement factories are also licensed for using the hazardous waste oils as additional fuel oil.

Directive 75/439/EEC on disposal of waste oils had been transposed into the 2004 Regulation on Waste Oils Control [55]. Special Wastes Directorate of MoEF is responsible for setting annual quotas for collection of waste oils by oil producers and for issuing licences for subjects dealing with transport, regeneration or disposal of waste oils. Establishment of a system for auditing and introducing obligation to facilities of keeping record are the deficiencies that should be eradicated in the management of waste oils.

2.3.2. Waste batteries and accumulators

Within the scope of EU pre-accession programs, the Project for the Establishment of System for the Collection of Mobile Battery and Accumulator Wastes in Turkey was conducted with the technical support of Holland [20]. It aimed at harmonizing EU Directives with the national legislation. The Regulation on the Control of the Waste Battery and Accumulators prepared within the scope of the project was published and put into effect on 31 August 2004. Directives 91/157/EEC and 93/86/EEC on batteries and accumulators have been transposed into the regulation. In the regulation the recycling activities are encouraged and framed with specific standards. In order to safeguard recycling of batteries and accumulators, quota application has been introduced to producers [20]. The sectors producing wastes subject to quota application are encouraged to establish associations and organizations for recycling. In line with the existing legislation, Special Wastes Directorate of MoEF has a general competence for the implementation of the directive, while the Undersecretariat of Foreign Trade is in charge of import control of batteries and accumulators. For the purpose of collection, disposal and recycling of used batteries and accumulators, producers and importers may establish non-profit compliance schemes (at the moment there are three of them) and to apply (along with other private-owned companies) for a licence issued by MoEF. All collected batteries are stored whereas collected accumulators are recycled and their components reused by the industry [20].

The inventory of waste batteries and accumulators is composed of information from the activity reports of recovery facilities and from deposit-refund study reports. The amount of batteries and accumulators on the market is approximately 10,000 tons/year and 74,000 tons/year, respectively. After the regulation put into effect in 2004, the MoEF started inventory studies on this subject. The recorded waste batteries and waste accumulators amounted to 229 tons and 45,476 tons in 2007, respectively [2] (Tables 6 and 7). The waste batteries and accumulators collected are 2% and 67% of the amounts put on the market, respectively [2] (Tables 6 and 7). There are serious legal gaps and illegal practices in treatment, shipment and landfilling of batteries and accumulators. Besides, another problematic area is that these special HW are disposed together with municipal wastes.

2.4. Regulatory and institutional structure

HW was first regulated via the Turkish Environment Law of 1983 [22]. This law is comprised of several provisions regarding HW generators, imports, and hazardous chemicals, and of penalties for HW related infractions. With the amendment made in 2006,

Table 6
Amounts of the waste batteries collected, recovered, disposed [2].

Year	Total batteries in the market (tons/year)	Total waste batteries collected (tons/year)	Recovered (tons/year)	Municipal landfill-special cells (tons/year)	Ultimate disposal (tons/year)
2005	9,297	31		24	7
2006	11,500	199	52	134	13
2007	11,000	229	41	188	0.1

Table 7
Amounts of the waste accumulators collected, recovered, disposed [2].

Year	Total accumulators in the market (tons/year)	Total waste batteries collected (tons/year)	Recovered—lead (tons/year)	Recovered—plastics (tons/year)	Ultimate disposal—acidic water (tons/year)	Ultimate disposal—filter dusts (tons/year)
2005	66,000	10,000	6,000	1,200	2,200	600
2006	65,000	26,442	15,866	3,173	5,817	1,586
2007	67,000	45,476	27,286	5,457	10,005	2,728

fancy prices provided for in this law for the actions causing environmental pollution are extremely high. For instance, for those who landfill HW without taking precaution or is not in compliance with the standards, fine to be imposed is 11,040 Euro [22]. Those who do not abide by the rules regarding HW shall be given fine from 46,000 Euro to 460,000 Euro (three-folds for institutions, organizations and facilities) [22]. Those who import or export HW without notification are envisaged to be given a fine of 920,000 Euro [22]. According to this law, the authority for the execution of these penalties is the MoEF. When necessary; MoEF can delegate this power (together with its control power) to provincial directorates, which form the environment audit teams. 50% of the administrative fines imposed by the institutions and authorities to whom control power is delegated are registered as revenue to budgets of these institutions in order to cover the expenses of the controls to be carried out in accordance with this law and to be used for other environmental services. So far, the power to impose fines has been vested solely in the MoEF [20]. The success of the implementations changes from one province to another and from one year to another depending on the implementers. Despite the high level of environmental problems and environmental disasters happening within the framework of these problems, it is observed that the amounts of the fines accrued has remained to be low; even in most of the provinces, no fine is imposed at all [20]. For instance, in 2004, the amount of fine imposed due to violation of the Law on Environment was 2,900,300 Euro [20].

Turkish HW regulation [23] was first prepared in accordance with the Turkish Environmental Law and Basel Convention in 1995. This regulation is comprised of provisions for such items as responsibilities of waste generators, disposal facility operators, waste transportation, recovery and disposal options, and transportation of waste out of country borders.

Turkey has been in the process of adopting the EU Directives since it was recognized as an EU candidate country in 1999. Some EU Directives have been adapted to the national legislation and studies are still going on for the adoption of the remaining ones. A substantial progress has been made in the adoption of the EU legislation on HWM with the adoption of the implementation regulations on HW, used batteries and accumulators, waste oils. The 'HW Control Regulation' of 1995 was updated in 2005 in order to meet the EU criteria [56]. The regulation was revised to comply with the EU Council Directive of 1975 on waste (75/442/EEC) [57], the Council Directive of 1991 on HW (91/689/EEC) [58], the European Waste Catalogue (2000/532/EC) [18], the Landfill Directive (99/31/EC) [59], the Incineration Directive (2000/76/EC) [60], and the Waste Transportation Directive (93/259/EC) [49]. The national HW terminology was adapted to the EU HW terminology with this revision of the regulation. In 2008, the Regulation for General Principles of Waste Management was put into effect in order to cover and list all the types of wastes listed in the European Waste Catalogue. Although HW Control Regulation provides for the HW disposal facilities to be recorded and licensed; relevant terms and conditions are not specified as clear and detailed as in EU HW Directive [19]. Regarding the incineration of wastes, a separate regulation corresponding to the Directive No: 2000/76/EC on Waste Incineration does not exist. Instead, the purposes of the Directive on Waste Incineration are distributed in HW Control Regulation and Solid Waste Control Regulation of 1991 [19]. Table 8 gives the transposed articles of EU Directives into Turkish national regulations concerning HW.

As defined by Turkish Environment Law, the Turkish MoEF has the authority to establish the cooperation and coordination necessary to implement these regulations. The duties of MoEF are thus (1) To evaluate all information submitted by provincial MoEF

Table 8
Transposed articles of the EU Directives concerning hazardous waste into Turkish national regulations [2].

Name of the EU Directive	Transposed article of the EU Directive	Corresponding National Regulation
75/442/EEC Waste Framework Directive	General provisions (Articles 7,9,10,12,13,14,15,16 and Annex I and Annex II)	Hazardous Waste Control Regulation
2000/532/EC European Waste Catalogue	Waste list (Hazardous and non-hazardous)	Hazardous Waste Control Regulation (Annex 6 and 7) Regulation for General Principles of Waste Management
91/689/EC Hazardous Waste Directive	All articles and provisions	Hazardous Waste Control Regulation
99/31/EC Landfill Directive	Technical provisions for landfilling the hazardous wastes (waste acceptance, etc.)	Hazardous Waste Control Regulation (Section 7 and Annex 11)
2000/76/EC Incineration Directive	Technical provisions for incinerating the hazardous wastes (emission criteria, etc.)	Hazardous Waste Control Regulation (Articles 20,21 and Annex 16,17) Solid Waste Control Regulation (Section 7)
93/259/EC Directive on the Transportation of Wastes	Provisions on transboundary movement of the wastes (transit, export, import, etc.)	Hazardous Waste Control Regulation (Section 8 and Annex 9,10)

Table 9
Integrated industrial waste pre-treatment and disposal facilities planned [2].

Location	Capacity	Process
Mediterranean Region (Mersin)	• Hazardous waste landfill (Capacity: 14, 666 tons/year) • Incinerator (Capacity: 7,368 tons/year) • Physico-chemical pre-treatment (Capacity: 1,585 tons/year)	Matter for the courts
Marmara Region (Kocaeli-Gebze)	• Incinerator (Capacity: 48,000 tons/year)	EIA* Stage
Aegean Region (Manisa)	• Hazardous waste landfill (Capacity: 160,000 tons/year) • Incinerator (Capacity: 20,000 tons/year)	EIA* Stage
Marmara Region (İstanbul)	• Hazardous waste landfill (Capacity: 100,000 tons/year) • Incinerator (Capacity 1st stage: 50,000 tons/year) (Capacity 2nd stage: 50,000 tons/year) • Physico-chemical pre-treatment (Capacity: 20,000 tons/year)	EIA* Stage
Central Anatolian Region (Ankara)	• Gasification (Capacity: 20,000–30,000 tons/year)	Feasibility studies completed

* EIA stands for Environmental Impact Assessment.

directorates and supervise as necessary; (2) To prepare waste management plans for HW and to inform the public; (3) To approve locations for, license, and supervise operations of disposal facilities; and (4) To enforce the monitoring of closed disposal facilities for 20 years.

The provincial MoEF directorates are responsible for (1) Forwarding applications for new disposal facility establishment to the MoEF after polling the opinions of local committees; (2) To give license for the temporary storage of HW in a facility's own area; (3) To identify facilities operating in the provincial borders that fall under the HW regulation jurisdiction and to notify the MoEF; (4) To give license to HW transport companies and their vehicles; (5) To supervise and inspect all recovery-disposal facilities within the provincial borders; (6) To evaluate annual waste declaration forms submitted by waste generators; (7) To determine the amount of HW produced in the province; (8) To prepare the three-year provincial HWM plans, and (9) To ensure the implementation of HWM plans within the provincial borders.

2.5. Steps for the future management of hazardous wastes

Within the framework towards harmonizing with the EU Environmental Acquis, a study conducted by the MoEF sets out a management system for the disposal of wastes in accordance with both the national and EU legislations [19,61]. An international consortium called Envest Planners on behalf of the MoEF carried out this EU supported project [19,61]. According to the adopted proposal of this project, in addition to existing facilities, five additional integrated HW disposal facilities shall be established. Marmara, Aegean, and Mediterranean Regions, which are more industrialized than the others, were prioritized for new HW disposal facilities. The selection of these regions was based on the geographical distribution of HW generating facilities and the distances to these facilities. These facilities will be developed in two stages within 20 years. Less industrialized regions were planned to be included in the transfer network of the integrated plans. Interim storage plants, which include physical–chemical pre-treatment, are also planned for the less industrialized regions. Table 9 gives details on the planned HW disposal and pre-treatment facilities. According to ENVEST Planners [61] the management of HW according to the waste management hierarchy requires the following infrastructure:

1. Facilities for recovery, recycling and waste minimization;
2. Facilities for the collection, transfer and temporary storage of HW separate from other type of wastes (storages, vehicles, warehouses, maintenance and repair facilities, transfer stations);
3. Incinerators and HW landfills for final disposal.

In parallel to the above mentioned infrastructure requirements, institutional capacity building is another important issue for the management of HW. In order to realize this, institutional capacity strengthening programs should be started, awareness raising programs should be implemented and staff training programs should be conducted. The action plan for future HWM improvements is given in Table 10. Investment cost estimations for the establish-

Table 10
Action plan targets for the hazardous waste management in Turkey between 2006 and 2012 [2].

Subject of the activity	Planned activities	2006	2007	2008	2009	2010	2011	2012
Legislation	Alignment of the HW* Directive	X						
	Revision (after the General Waste Framework, Incineration, and Landfilling Directives were enforced.)			X				
Inventory, planning and automation	Initiation of web-based collection of the HW* data			X				
	Development of the HW management plan			X	X			
	Continuous web-based collection of the HW* data				X	X	X	X
Main activities	Training of the MoEF and Provincial Directorates' staff on EWC**, licensing, and monitoring waste management activities		X	X	X	X	X	X
	Training of the Provincial Directorates' staff on HW classification			X	X	X	X	X
	Training of the trainers to inform waste generators on waste transportation, waste declaration, etc.			X	X	X	X	X
	Establish and activate the planned interim storages and landfills					X	X	X
	Establish and activate the planned incinerators					X	X	X

* HW stands for hazardous waste.
** EWC stands for European Waste Catalogue.

Table 11
Investment cost estimations for the establishment of the requirements of the HWM system [61].

Investments	Cost of investments, million Euro
Incineration facilities	853
Storage areas	110
Transfer stations	74
Total	1037

ment of the requirements of the HWM system made by Envest Planners [61] are given in Table 11 (costs related to increasing the institutional capacity are excluded). As seen in Table 11 the total investment cost is calculated to be above 1 billion Euros, with the prices of 2004.

3. Discussion: challenges

Countries might face different levels of different challenges owing to their specific conditions. For example it is reported that there is no specific policy on IHW in Malaysia, and the existing management approach prioritizes the use of final treatment and disposal system rather than the precautionary principle [37]. Lack of listing and identification are among the most important HWM problems in Malaysia [37]. In Taiwan, because of the lack of proper treatment facilities and technologies, part of HW was shipped abroad for recycling, and the rest was disposed of domestically [62]. The bulk of the HW from small-scale factories is reported to be dumped into waterways and land-disposed sites without any pre-treatment [63]. It is also reported that Taiwan not only needs to strengthen HW import, export, and transshipment management measures and other regulation frameworks, but also needs good coordination between agencies to implement control strategies [62]. The establishment of HWM facilities, the sound management of industrial waste and industrial waste exchange are reported to be focused on in the next years [62]. In Chile, an important fraction of HW is mixed with non-hazardous wastes, being mainly landfilled and producing serious environmental impacts regarding hazardous content in landfill leachate [29]. Splitting strategies for HW recovery are reported as a necessity in Chilean industry that may reduce the disposal rate of these wastes in municipal landfills and impulse resource, recovery and recycling of valuable materials in these wastes [29]. In India, even though HW are regulated, they are often mixed with other wastes and disposed off indiscriminately posing health and environmental risk [64–66]. In the USA, state and local governments and citizens have fought the siting of HW handlers and generators within their regions accompanied by a pressure to site HWM facilities [67]. As HW generators ship their waste over highways and railroads to large, specialized HWM facilities, such shipments often cross state borders creates a perception of inequality that another state gains wealth by manufacturing, and one's own state becomes their dumping ground [67]. It is reported that there are data quality problems in Finnish HW information system [34]. Orloff and Falk [68] reported that worldwide, landfilling is the most popular means of waste disposal, and in some countries landfilling may consist of nothing more than burying the wastes in an unlined excavated pit, or worse, dumping them on the surface of an unused tract of land.

Probst and Beierle [11] reviewed the evolution of HWM programs in eight countries (4 developed and 4 developing), and identified some key components for a successful HWM system, suggesting some general lessons for those countries contemplating the creation of their own HWM programs. They reported that HWM programs evolve through a complex process subject to the particular economic, political, legal, and cultural context of individual countries; and as programs evolve the countries typically pass through five major stages [11]:

1. Identifying the problem and enacting legislation,
2. Designating a lead agency,
3. Promulgating rules and regulations,
4. Developing treatment and disposal capacity,
5. Creating a mature compliance and enforcement program.

1. Turkey has identified the HWM problem in 1983 when the Environmental Law was put into effect. However, the first implementation regulation was published in 1995, and revised according to the EU *acquis* in 2005. The concerns in the country peaked when dozens of barrels filled with HW buried in the ground in Tuzla near Istanbul (Marmara Region) [9]. Turkish Government has been recognizing for a while that a HWM problem exists, and enacted legislation to address it.
2. Turkish MoEF has been designated as the leading agency in HWM. MoEF has the authority to draft, implement, and enforce HWM regulations.
3. Turkey has established the legal basis for the regulatory program, identified which wastes will be subject to regulation in line with EU *acquis*, and identified specific technical, procedural, and information requirements for waste treatment, storage and disposal facilities for HW generators.
4. Turkey's licensed regional HW disposal facilities are capable of disposing of only a small portion of the country's annual HW output, raising questions over the whereabouts of the remaining material. Therefore, several projects have been conducted to identify the needs for treatment and disposal capacities. Turkey is at the stage of developing treatment and disposal capacity. New HWM facilities are planned to be constructed by 2012.
5. There have been some efforts to create a mature compliance and enforcement program but the HWM history of the country told that these efforts have been insufficient. It is not an easy issue influencing the behaviour of generators and operators of HWM facilities to ensure that HW is properly managed. Additionally, without adequate facilities it is very difficult to hold the regulated community accountable for proper HWM. Probst and Beierle [11] pointed out that establishment of this 'culture of compliance' takes a number of years.

It can be concluded that Turkey has made a considerable progress for the first three major stages in the evolution of its HWM program. However, the last 2 stages remain to be solved in the near future. Germany, Denmark, the United States, and Canada began the HWM program development during the 1970s, and most of their regulatory programs were fully operational by the end of 1980s [11]. Malaysia, Thailand, Hong Kong, and Indonesia began focusing serious attention on HWM in the late 1980s and early 1990s, and are still some way from having fully operational programs [11].

The HWM program development in a country does not always mean that 'environmental ethics' has shown the same development [69]. There are still significant weaknesses in global HW management. Although there are many international agreements to control the movement of HW, the HW was sent to developing countries by many alternative ways [69]. Better waste management has been high on the EU agenda for the last 20–30 years. Although the shipment of waste is regulated at EU and international levels, the number of reported illegal shipments is increasing each year [70].

Turkey is among the countries that regulate their HWM activities in accordance with the EU. However, several HW scandals have plagued Turkey's national environmental agenda since the 1980s. Turkey, three sides of which is surrounded by seas, under the threat posed by the HW containing barrels left on the coasts by other coun-

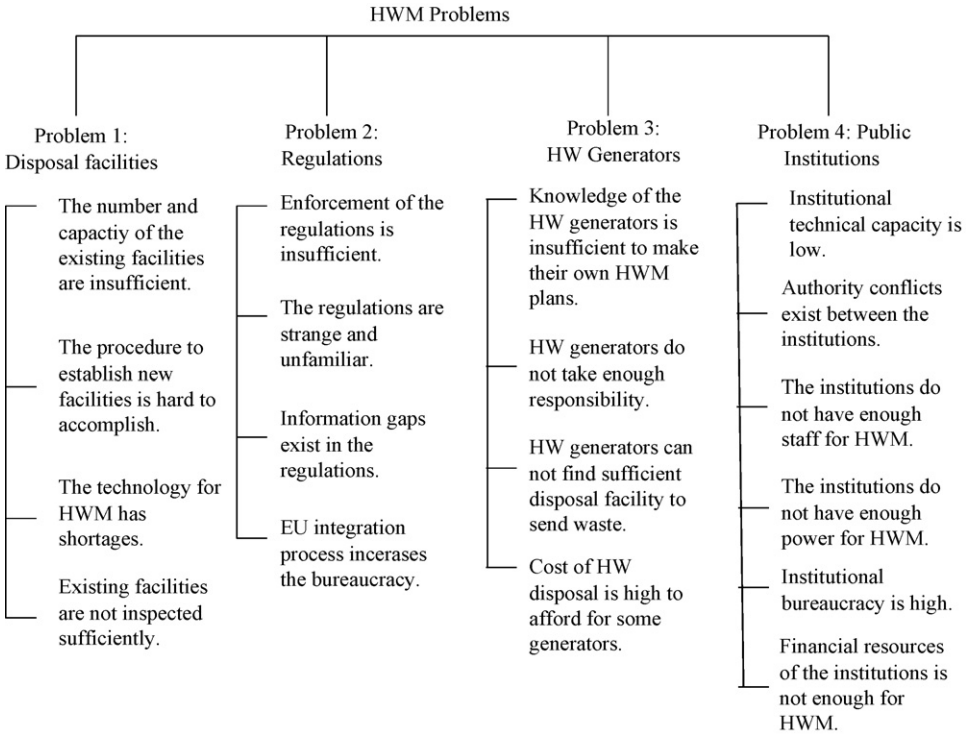

Fig. 8. A problem tree for the prioritized HWM problems.

tries and hazardous chemicals released to seas from shipwrecks. Such disasters lead to the devastation of Turkey's unique nature as well as significant amount of financial loss [20]. Recently there have been a number of shipwrecks at Turkish Straits and Marmara Sea, and the loads of these ships, which were generally composed of oil products and other hazardous materials caused dense pollution on coasts and seas [20].

Turkey has legislated HWM regulations since 1995. The EU integration process allowed support for public utilities to better enforce the regulations and pushed the HW generators to employ proper HWM efforts. The changes in HWM practices that came with the EU integration process were not well understood at first and were met with resistance from several public institutions and industries [32]. Salihoglu et al. [32] prepared a questionnaire and conducted interviews with representatives from public utilities with authority over HWM practices, waste generators, disposal facility operators, waste transporters, consultant firms, and researchers. The problem tree in Fig. 8 shows the problems prioritized by these HWM stakeholders. Several of the problems listed in Fig. 8 have since been addressed or fallen in their priority level. For example, the number of disposal facilities increased when the number of cement plants licensed to incinerate HW and the number of licensed recovery companies increased. The number of private entrepreneurs willing to establish new HWM facilities also increased. Many educational activities have been conducted by the MoEF to familiarize HW generators and regulation implementers with the new EU-based regulations. Authority conflicts have been solved now that the MoEF holds all the power regarding HWM. A SWOT analysis was made to summarize the strong and weak sides of the HWM in Turkey and the opportunities and threats to be faced (Fig. 9).

HWM in Turkey has a tendency to continue to be a challenge in the near future. The reasons can be listed as follows:

1. There is need for deterrents preventing HW generation. Although the waste generators must cover all the costs as required by the principle of "polluter pays" in the legislation for HWM, there is not any arrangement in this regard. As known, the main objective of this principle is encouraging the generators to use clean technologies and decrease the amount of the HW. There is need for arrangements in order to make the generators assume all the costs of wastes.
2. Although HW minimization and recycling is the most prioritized policy, there will be a need for additional final HW disposal facilities in Turkey according to the strategic planning studies [61]. Although there are entrepreneurs willing to establish such facilities, the scarcity will continue to exist. Since industry is concentrated in the west regions of Turkey, entrepreneurs want to establish HWM plants in these regions. However, the population density is high in these regions, so public reaction arose during the location selection process for these planned facilities during the Environmental Impact Assessment. Additionally, the regions where the industry is condensed are also valued for characteristics such as the quality of agricultural soils and tourism potential. This presents barriers to public acceptance of establishing HWM facilities. This problem for the development of HWM strategies has roots in previous regional development plans that led industry to develop in several concentrated regions in Turkey
3. There is a need to strengthen the administrative capacity of MoEF and its provincial Directorates by increasing the number of staff employed. Without sufficient administrative capacity it would not be possible to operate an effective HWM system. Although the MoEF conducts studies for administrative capacity based on inventory, supervision, and monitoring issues, and educational activities, the scarcity in the number of staff exists. The action plan for better HWM does not cover increasing the number of staff involved, which is currently insufficient to realize all the HWM responsibilities of the MoEF and the directorates, even if they are well qualified. For example, there are more than 10,000 HW generators in Istanbul city in Turkey [71], but no more than ten staff members would be responsible for supervising all of these generators.

Fig. 9. A SWOT analysis for the hazardous waste management in Turkey.

4. There is a need to establish a mechanism to meet the necessity of high quality data, which is of great importance in the formulation and implementation of HWM policies. The studies conducted by OIE and MoEF, and construction of an electronic database for HW indicate that the shortcomings of this area will possibly be eradicated in the short term. An HW inventory is being drafted by asking HW generators to use a web-based declaration system. If properly used by the generators, the system would provide all manors of statistical evaluations regarding waste management. However, although declaration of the HW quantity is an obligation of the HW Regulation, the system is based on the generator's own will to declare the amounts of HW because the generator knows that the institutional capacity of the MoEF and provincial directorates is insufficient to monitor the gaps in the system and supervise every HW generator. The registered volume of the generated waste is thus greatly dependant on the degree of awareness and compliance in the industry with regard reporting and proper management of HW. Supervision of HW generators will be needed, and as previously stated, it would be impossible to supervise every generator. As a result, HW statistics will always have some deficiencies. The history on HW inventory development showed that waiting for the responsible behaviour of the generator would be useless. For instance, according to the Regulation on HW Control, establishments producing HW are obliged to notify the MoEF annually about the amount of the waste they produce by means of filling "HW Notification Form". However, neither the waste generators have the necessary sensitivity to send these forms to the MoEF nor the MoEF itself has imposed any sanctions so far to the firms that do not fulfill their liabilities. Another important factor for the waste generators is their being unaware of their liabilities and not fulfilling them. They do not have sufficient information about the concept of HW. Establishing a sound database for waste is at the same time Turkey's liability to EU and other international organizations such as OECD of which the country is a member.
5. Social and environmental consciousness together with the will and decisiveness of the governments are necessary for implementing a functional HWM. The manufacturing industry is the main source of HW for most countries and regions of Europe [12]. From a government point of view, industrial and economical developments are often linked together. The idea of creating disincentives for potential industrial investors by imposing proper HWM regulations can thus be cause for some hesitation. This subtextual agenda can decrease a government's use of environmental fines and penalties in order to increase the number of the environmental investments and to increase the number of staff involved in HWM. Education and training activities are also affected by these perceived competing agendas of economic growth and environmental protection. Many educational activities are conducted, but their real aim is not to change this perceived conflict in the subconscious, or to convince people that HWM is no less important than any other business process. Education should not be considered as an isolated concept, and should be supported by the business activities of the government. It should be a part of a true change in beliefs, rather than being just a required activity. If environmental protection is not presented as necessary and as a potentially economically lucrative industry in itself, such education activities and regulations would be a waste of time; illegal HW shipments would continue to increase, and HW would continue to be disposed of indiscriminately, posing health and environmental risks.

4. Conclusions

Lack of reliable information regarding HW generation and insufficient technical and institutional infrastructure has led to serious problems in HWM in Turkey. Turkey's licensed regional HW disposal facilities are capable of disposing of only a small portion of the country's annual HW output, raising questions over the remaining waste. Especially in recent years, increase in the number of environmental disasters has become inevitable when the capacity problem with regard to HW disposal combines with the inadequacy in the control and monitoring mechanisms. In order to establish an effective waste management in Turkey, not only institutional strengthening but also effective implementation of the regulations, regular auditing, establishing an information exchange platform through which up-to-date data regarding production, recycling and disposal of HW can be monitored are required. Adequate number of personnel and equipment must be provided to the MoEF and its provincial directorates, and necessary provisions should be taken in order to eradicate the external effects and subjective approaches during the imposition of fines for HW disposal violations. Punitive power of the provincial MoEF directorates should also be strengthened.

A study was conducted by the MoEF to identify the investment needed for the proper management of HW in accordance with both national and EU legislations. Accordingly, the cost of total investment required for establishing the incomplete parts of the national HWM system, excluding the investments to be made by the private sector, is estimated to be 1 billion Euros. Additionally, the development and/or improvement of the existing institutional capacity is an urgent necessity. Systemic policies are also needed to be developed for the private sector to assume an effective role in HWM; because it would be difficult to get result from the planned works only with the investment opportunities of the public sector.

Despite the differences in the country-specific circumstances, Turkey has been experiencing HWM problems similar to those countries that have experienced rapid economic growth and industrialization. The evolution of Turkey's HWM program is at its final stages of increasing treatment and disposal capacities for HWM and creating a mature compliance and enforcement program. Subsequent laws and policies are expected to focus mainly on encouraging the HW minimization and recycling issues.

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