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Current practices in hazardous waste management in Turkey

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ABSTRACT

As a consequence of restrictive national and international regulations; in recent years, efforts for a better management of hazardous wastes in Turkey have increased considerably. In this article, an overview of the current hazardous waste management practices in Turkey is provided. Initial efforts that have started with ratification of Basel Convention in 1994 are followed by substantial progress owing to alignment with the European Union's waste management acquis in early 2000's. Overview of the legislative framework indicates that currently, the rules laid down in legal documents are sufficient to establish an effective hazardous waste management system. However, the implementation and enforcement of the legislation is not complete yet as the implementation requires the considerable improvement of the current infrastructure. The quality of hazardous waste generation data, which is essential for proper design of hazardous waste management system, in Turkey is still of concern therefore, needs further attention. In terms of operational aspects, there are 138 recovery facilities licensed for hazardous waste, four licensed hazardous waste incineration and three licensed hazardous waste disposal facilities throughout Turkey. Due to the fact that established capacities of these facilities are below total hazardous waste generation amounts, new facilities are being planned to be built.

Keywords: Generation; Hazardous waste; Waste management; Turkey

1. Introduction

Worldwide concern about the disposal and transboundary movement of hazardous wastes was amplified in the late 1970s and early 1980s. The major concern was related to wastes being exported from industrialized nations for cheap disposal in inadequately prepared sites in developing countries. This concern gave rise to a global convention under the United Nations to control the transboundary movement of hazardous wastes and their disposal, commonly called the Basel Convention. The Basel Convention's key objectives are to:

- minimize the generation of hazardous waste and hazardous recyclable materials;
- ensure they are disposed in an environmentally sound manner and as close to the source of generation as possible;
- minimize the international movement of hazardous waste and hazardous recyclable materials.

Later, in the early 1990s, European Union (EU) countries laid down similar principles in the Directive on Hazardous Waste (91/689/EEC), as amended by Directive 94/31/EC.

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According to this piece of legislation, the approach to waste management is based on three main principles: waste prevention; recycling and reuse; and improving final disposal and monitoring. The directive provides record keeping, monitoring and control obligations from the "cradle to the grave", the waste producer to the final disposal or recovery. The key requirements of the directive have a number of infrastructure implications. They relate mainly to management and the careful handling of hazardous waste. The management of hazardous waste requires the following tools and technologies:

- Separate collection, transport and temporary storage with up-to-date facilities;
- Facilities for recycling, resource recovery and waste minimization;
- Incineration and final deposition at legal landfills.

Ministry of Environment and Forestry (MoEF), being the main regulatory body for hazardous waste management in Turkey is not only responsible for the development of the legal framework but also for the development and the implementation of a better hazardous waste management system in Turkey. This article summarizes the steps being taken for the development of a hazardous waste management in Turkey and outline of the current system with practical considerations.

2. Development of hazardous waste management system in Turkey

Efforts towards the development of a proper hazardous waste management system in Turkey started after the ratification of the Basel Convention in 1994. The Regulation on Control of Hazardous Wastes (RCHW) entered into force in 1995, but a considerable progress could not be achieved during the next 7–8 y. However, at the beginning of 2000s, accession period for Turkey to EU gave an impetus to the establishment of a hazardous waste management system. A great progress has been achieved in the harmonization of national waste legislation with the EU's waste management acquis and similar waste legislation has been developed. However, a parallel achievement could not be realized in the establishment of a sound hazardous waste management system, as this requires a heavy-cost investment. But, a great progress has been made regarding the development of such a system as well as capacity building. In the proceeding paragraphs, these developments are summarized.

Various projects have been carried out on both capacity building and establishment of a hazardous waste management system in a systematic manner. In Fig. 1, the main course of focus of the projects undertaken by the MoEF can be seen.

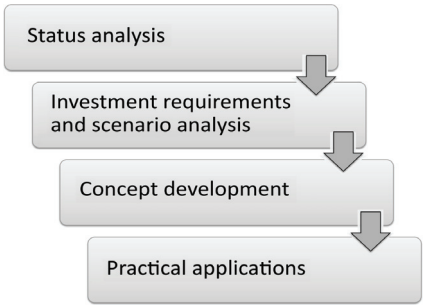

Fig. 1. Steps taken by MoEF for development of hazardous waste management system.

In 2001, MoEF initially focused on demonstrating the status of hazardous waste management problem and primary requirements for capacity building. As a part of status analysis, hazardous waste generation and disposal practices, institutional structure and legal framework have been evaluated and possible sources of problems were indicated [1]. However, no attempts have been made for the development of a nation-wide hazardous waste management system.

Later on, MoEF concentrated on the requirements for the establishment of a hazardous waste management system in terms of economical aspects. In 2003, the investment plan developed for the Directive on Hazardous Wastes (91/689/EEC) as a part of "Technical Assistance for Environmental Heavy-Cost Investment Planning, Turkey (TR/0203.03/001) Project" covered an assessment for investment requirements along with evaluation of several scenarios that involve locations and capacities of various facilities including transfer stations for hazardous waste transportation. Scenarios were selected to reflect the trade-off between regional and decentralized management of hazardous wastes. Building large-scale regional hazardous waste processing and disposal facilities reduce disposal costs but increase transportation distances and hence transportation costs. In order to reduce the transportation costs, an interim storage network is an option. In the project, establishment of five large scale incineration and disposal facilities along with a collection network and transfer stations at the locations where industrial activity is high was assessed to be the most feasible scenario for handling of hazardous wastes countrywide [2].

Later; in"Waste Management Twinning Project (TR/2003/EN/01)", a hazardous waste management concept was developed for Turkey aiming to determine mid-term and long-term measures and ways to establish a sufficient hazardous waste management structure all over Turkey. Emphasis was given to waste minimization and recovery operations. Requirement for self-sufficiency of disposal and recovery operations in terms of capacity was underlined [3].

In "LIFE HAWAMAN-Improvement of Industrial Hazardous Waste Management in Turkey (LIFE06 TCY/TR/000292) Project" completed in 2009, various aspects of hazardous waste management were covered with emphasis given to practical applications of management system. As a part of hazardous waste management concept, establishment of five large-scale integrated hazardous waste treatment facilities was recommended similar to "Technical Assistance for Environmental Heavy-Cost Investment Planning Project" [4]. Estimation of hazardous waste generation was carried out. In order to overcome a common problem related to identification of hazardous waste, a manual especially dealing with mirror entries was prepared [5]. One of the most important outcomes of the project is development of an internet-based waste declaration system, which created a more practical system of annual hazardous waste declarations submitted by generators to MoEF. At present, generators have become more willing to share information and participate in the hazardous waste management system to ensure proper management of their wastes. Finally, improvement of control and supervision of waste producers and waste disposal facilities was studied under LIFE HAWAMAN Project.

Current studies of MoEF are towards further improvement of hazardous waste management system. Some of the ongoing activities include the establishment of a waste tracking system that would enable MoEF to follow hazardous wastes starting from point of generation, throughout its transportation between facilities until they reach the final disposal. As will be further discussed in following sections, as a result of the need for additional hazardous waste facilities in Turkey, exploration of possibilities to establish these facilities in terms of technological and economical aspects is another issue that MoEF concentrates on. Finally, another project in progress deals with various aspects of the management system, including

- advancement of inspection capabilities of the Ministry through upgrading current information management systems and by use of waste generation factors;
- advancement of hazardous waste minimization practices which was never explored before; and
- lastly development of a decision-making framework for hazardous waste transportation and facility siting with proper technology selection by means of optimization methodologies.

3. Legislative framework

A comprehensive framework for the safe management of hazardous wastes is currently in place in Turkey comprising the regulations tabulated in Table 1 along with their EU counterpart. MoEF is still improving the legislative framework by publishing new regulations such as Regulation on Landfill of Wastes and Regulation on Incineration of Waste for which a draft is available online for public comment [6]. International waste management principles such as waste hierarchy and polluter pays principle shape the current Turkish hazardous waste management policies.

The Turkish legislative framework can be classified into three main groups; the ones related to general management concepts, specific types of wastes and finally disposal operations. As can be depicted from Table 1, national hazardous waste legislations cover major

Table 1
List of Turkish legislation on hazardous wastes [4]

Turkish legislation	EU counterpart
Regulation on General Principles of Waste Management	Directive 2006/12/EC on waste
Regulation on Control of Hazardous Wastes	Directive 91/689/EEC on hazardous waste
Regulation on Control of Waste Oils	Directive 75/439/EEC on the disposal of waste oils
Regulation on Control of Waste Vegetable Oils	–
Regulation on the Control of Used Batteries and Accumulators	Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators
Regulation on the Control of Packaging and Packaging Waste	Directive 94/62/EC on packaging and packaging waste
Regulation for Control of the Tyres Which Have Completed Their Life-Cycles (TCL)	–
Regulation on the Restriction of the use of Certain Hazardous Substances in Electrical and Electronic Equipment	Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment
Regulation for Control of Medical Waste	–
Regulation on Control of Polychlorinated Biphenyls and Polychlorinated Terphenyls	Directive 96/59/EC on the disposal of polychlorinated biphenyls and polychlorinated terphenyls (PCB/PCT)
Regulation on Control of End-Of-Life Vehicles (Draft)	Directive 2000/53/EC on End-Of-Life Vehicles
Regulation on Landfill of Waste (Draft)	Directive 1999/31/EC on the landfill of waste
Regulation on Incineration of Waste (Draft)	Directive 2000/76/EC on the incineration of waste

aspects of hazardous waste management in terms of general management practices, provisions on specific types of wastes and waste handling procedures. Consequently, it is clear that legislative framework is sufficient to establish an effectively working hazardous waste management system.

Identification and classification of hazardous wastes follows the same principles used in the EU hazardous waste legislation. European Waste Catalogue (EWC) [7] is incorporated in Regulation on General Principles of Waste Management as Annex 4. This list is structured in terms of two-, four- and six-digit entries, as is the case in EWC with identical definitions of absolute and mirror wastes.

4. Hazardous waste generation

The success of an applicable waste management system relies on good planning and enforcement, which in turn relies on detailed information about current situation to be present. Therefore, hazardous waste generation along with sectoral and geographical distribution is one of the key aspects in order to implement hazardous waste management system. It is possible to classify hazardous waste generation data sources into two; direct and indirect information sources. Direct information sources include statistical studies and annual declarations of hazardous waste generation to MoEF both of which employ information provided by generators. In Turkey, due to two main reasons direct information sources did not prove to have quality high enough to be used for planning purposes. First reason for this situation is generators' reluctance towards declaring the types, amounts and fate of hazardous wastes produced, to MoEF due to fines associated for not handling the hazardous wastes produced properly. Second important cause is the lack of knowledge of generators on how to identify and classify "hazardous wastes". The other type of information source that is indirect information sources, generally involves inventory studies of theoretical calculations using hazardous waste generation factors. These types of inventory studies aims to by-pass generators due to the problems associated with information provided by generators as discussed above. In addition to being used as the main information source whenever direct information is absent or incomplete, indirect information sources can also be used for confirmation of direct information.

Two important direct information sources on hazardous waste generation are Manufacturing Industry Survey conducted by Turkish Statistical Institute (TurkStat) and waste declaration forms collected by MoEF. TurkStat has released two statistics related to hazardous waste generation from manufacturing industry in 2000 and 2004 whose results are given in Table 2 [8]. In these releases, distribution based only on major industrial sectors was presented. According to initial statistics, food industry is the highest hazardous waste generator among the industrial sectors, which seems to be debatable result. Moreover, they lack geographical distribution and distribution according to waste types.

Waste declaration forms submitted by hazardous waste generators to MoEF on an annual basis are the second source for hazardous waste generation information. The return ratio of waste declaration forms had been very low owing to the reasons about direct information obtained from generators discussed previously. In addition, the majority of the forms submitted, contained insufficient and inconsistent data and was far from providing reliable data on industrial hazardous waste generation. Recently, MoEF started the internet-based declaration system. With the new system, the return ratio has shown an increasing trend although complete information flow from all hazardous waste generators is not established yet [9].

As Table 2 indicates, these two sources present contradictory results. Both data sets that rely on direct information obtained from hazardous waste generators are not detailed enough in terms of sectoral and geographic distribution. As a result, they could not be

Table 2
Comparison of hazardous waste generation data from various sources

Information source	TurkStat-2000	TurkStat-2004	MoEF (2008)	HAWAMAN	Yilmaz and Yetis
Total hazardous waste generation (10^6 tons/y)	1.31	1.12	4.60	1.35	1.70
Region with the highest contribution	–	–	–	Marmara	Marmara
Sector with the highest contribution	Food	Metal	–	Metal	Organic chemistry
Reference	[8]	[8]	[9]	[4]	*

*Unpublished data.

used for planning and monitoring purposes up to now. Apart from these information sources, some inventory studies are conducted over years, which constitute indirect information sources. One of the most recent studies was completed during LIFE HAWAMAN Project. This inventory study involved theoretical estimations of countrywide hazardous waste generation through use of employee based hazardous waste generation factors [4] using The Union of Chambers and Commodity Exchanges of Turkey (TOBB)'s industrial data base [10]. Output of this inventory is presented in Table 2. In an unpublished study, Yilmaz estimated a similar total generation using process based waste generation factors obtained from the literature based on raw material consumption or production figures.

Although total actual amount of total hazardous waste generation highly depends on the amount of mirror wastes, from Table 2, it can be inferred that total hazardous waste amount is in the range of 1.3–2.5 million tons/y.

5. Hazardous waste handling

Main components of the hazardous handling, consists of generation, storage, collection, transportation, treatment (whenever possible) and disposal of hazardous wastes. Generation of hazardous wastes should involve the waste prevention and waste minimization activities aside from the hazardous waste generating processes. Storage involves temporary storage of hazardous wastes either in the location of generation or specially designed temporary storage facilities/transfer stations suitable for hazardous wastes. Storage should not be confused with landfilling of hazardous wastes. Collection in the context of hazardous waste management refer to the step where hazardous wastes are accumulated before being sent to temporary storage facilities, treatment or disposal sites. By definition, recovery operations, which actually involve recovery, recycling and reclamation of the wastes, aim to obtain usable products from hazardous wastes. The list for possible recovery operations are given in Regulation on General Principles of Waste Management Annex 2B and mostly deals with energy, solvent, metal, acid/base and oil recovery. While the goal is to obtain usable products from recovery, in treatment it is only desired to eliminate the hazard properties of the wastes. It is important to note that not all the hazardous wastes are suitable for treatment or recycle. Disposal is the ultimate fate of most of the hazardous wastes. Transportation part of hazardous waste management system is the one where the wastes are conveyed to temporary storage, treatment or disposal facilities following collection of wastes.

Two key issues that draw attraction regarding hazardous waste handling are sufficiency in terms of capacity and waste-to-technology compatibility [11, 12]. Without hazardous waste facilities having sufficient capacity and variety to meet the demand that are the amount and types (i.e., recoverable, treatable, disposable etc.) of hazardous wastes produced respectively, it is impossible to say that hazardous waste handling is executed properly.

According to the data of November 2007, number of recycle plants with ad-hoc working permit and license reached up to 89 [13]. The classification of those plants according to recycling methods indicated in Annex 2B of Regulation on General Principles of Waste Management can be seen in Table 3. As can be seen, highest recovery in terms of tonnage, occurs in metal wastes followed by reclamation of waste oils. Recently, a pilot scale hazardous waste recovery plant with gasification has come into operation in Istanbul Kemerburgaz with 29,000 tons/y capacity. Energy recovery indicated in Annex 2B of Regulation on General Principles of Waste Management is another method for waste recovery. This type of recovery can be implemented in cement industry through co-incineration practices. Currently, 22 cement plants have license in R1 category (Table 3). Although co-incineration in cement factories seems to have a considerable capacity, it is worth mentioning that the realized capacity is much lower than full capacity. In 2008, 85,000 tons of hazardous and non-hazardous of wastes were incinerated in cement factories of which 60,000 ton was hazardous(personal communication). Consequently, current figures suggest that fulfilled hazardous waste incineration capacity of cement factories fall between 50,000–100,000 tons/y.

Table 3
Number of plants and recycle/recovery activities [13]

Code of recycle/ recovery	Number of plants with license	Total capacity (ton/y)
R1 (Cement factories)	22 + 1	527,460
R2 (Solvents)	3	9,350
R3 (Organics other than solvents)	7	17,477
R4 (Metals and metal compounds)	17	113,442
R5 (Inorganic materials)	4	1,955
R9 (Waste oils)	11	82,452
R11 (Use of wastes from R1–R10 operations)	3	14,570
R12 (Change of one of R1–R11 operations)	7	24,415
TOTAL	**75**	**791,121**

Table 4
Current capacities of disposal facilities [13]

Company name	Capacity
İZAYDAS (storage)	790.000 m^3 (occupancy ratio 20%)
İZAYDAS (incineration)	35.000 tons/y
PETKİM (incineration)	17.500 tons/y
TÜPRAŞ (incineration) (for own wastes)	7.750 tons/y
ERDEMİR (storage) (for own wastes)	6.084 tons/y
ISKEN (storage) (for own wastes)	115.000 m^3

In Table 4, numbers and capacities of hazardous waste disposal facilities in Turkey are given. Currently, total disposal capacity in Turkey is 60,250 tons/y (of which 43,750 tons/y is commercially available) for incineration and 905.000 m^3 for landfilling [13].

As mentioned before two important requirements to be met for a proper hazardous waste handling is capacity and technological suitability. In Table 5, detailed information on types of hazardous waste is presented from the unpublished work of Yilmaz and Yetis along with the established capacity of hazardous waste facilities. Total capacity for co-incineration is assumed to be as 75,000 tons/y, which is slightly over the actual capacity utilized in 2008.

From the comparison presented in Table 5, it is clear that established capacity for hazardous waste handling is below generation potential for Turkey even if lowest value is taken for estimation. Therefore, insufficient capacity of hazardous waste facilities when compared to the amount of hazardous waste produced is still one of the current bottlenecks of hazardous waste management in Turkey. This situation suggests a need for new investments for various facilities. Establishment of certain hazardous waste facilities is underway. List of these facilities along with their location and capacities are given in Table 6. As the handling capacity of hazardous waste facilities is increased, self-sufficiency, which was underlined in previous studies of MoEF will be realized. In terms of technology suitability, especially absence of chemical-physical treatment facilities is of major concern. Hazardous waste generators in Turkey are still having difficulty in differentiating wastewaters, which is not covered by hazardous waste legislation, with liquid hazardous wastes. Disposal of liquid hazardous wastes to sewage system is the consequence of this situation [4]. Outcomes of improper disposal of liquid hazardous wastes are the requirement for awareness raising on the issue and most importantly no apparent need for chemical-physical treatment facilities which actually is not the case.

Table 5
Comparison of established and required capacities according to destinations

Destination	Required capacity (tons/y)*	Established capacity [13]
Recovery/Recycling	367,550	263,660 tons/y
Chemical–Physical Treatment	471,250	–
Incineration	429,900	43,750 tons/y (incineration) + 29,000 tons/y (gasification) + 75,000 tons/y (co-incineration)
Landfilling	424,600	790,000 m^3

*Unpublished data.

Table 6
Integrated waste disposal facilities to be established [4]

Name of the project and location	Capacity	Present situation
Aegean Region Industrial Waste Disposal Complex Kırtıllı Tepe Mevkii Sandal Beldesi Kula–Manisa	Landfilling: 3.230.000 m^3 Incineration: 20.000 tons/y	Landfill brought in line on March 2009. Incinerator in planning stage.
ITC Invest Trading and Consulting AG-Integrated Waste Disposal Facility Çadırtepe Mevkii Sincan–Ankara	Gasification: 20–30 thousand tons/y (100 thousand tons/y with expansion)	Feasibility study completed
Türkiye Metal Sanayiciler Sendikası Bursa		Planning phase

6. Conclusion

A great deal of effort was spent for the development of a hazardous waste management system in Turkey starting from the early 2000s. Legislative framework for hazardous waste management is present and sufficient. The next step is to solve the problems practical issues. MoEF conducted and still continues to participate in various projects on hazardous waste management, which aims to solve these practical issues as well as to ensure proper planning of hazardous waste facilities. Moreover, monitoring capabilities of MoEF is also improved through numerous information management systems. Another important stakeholder of the system is of course, hazardous waste generators. It is

easily observed that attitude of hazardous waste generators towards management system is changing over time owing to exceptional endeavors of MoEF. Generators have become more willing to share information and participate in the hazardous waste management system to ensure proper management of their wastes. Aside from these promising developments, there are still some areas for which further attention is required. Enforcement and monitoring procedures still needs further improvements. An integrated approach to supervision is required that will involve all the stages of waste management starting from generation, to transportation, handling and disposal of hazardous wastes. Moreover, throughout the investment stage of facilities, variety of hazardous waste facilities in terms of processes employed in disposal and recovery should also be considered in order to provide waste-to-technology compatibility. By this it is believed that hazardous waste management system will be sufficient to serve all types of hazardous wastes by providing suitable technologies as well as serving total amount of hazardous wastes.

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