



FCULTY OF GRADUATE STUDIES

Hazardous Waste Management in the West Bank and Gaza Strip

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Abstract

This thesis “Hazardous Waste Management in the West Bank and Gaza Strip” aim at studying Hazardous Waste Management (HWM) practices including Healthcare Waste Management (HCWM) as a case study. Limited resources coupled with a fast growing population cause a high pressure on the environment which results in many environmental problems. The hazardous and healthcare wastes are obvious components of such problems.

Literature was collected and analyzed to identify the extent of the problem and its related issues. Many expert meetings were conducted as well as field visits. Comparative analysis of Palestinian and regional HW legislations and management practices were conducted.

The study looked at the regional experiences in HWM and it found that the Egyptian experience can be benefited from the most in the region.

The results revealed two proposed management systems for HWM and HCWM that would help the Palestinian health sector to enhance and develop health and environmental services. The proposed management systems, including new approaches for collection, separation, storage, transportation, treatments and disposal of HWM and HCWM, will minimize health and environmental risks as well as they will minimize associated costs. These proposed systems will deal with at least 2500 tons/year of clearly identified hazardous waste as well as and additional 354 tons/year of hazardous healthcare waste.

The study recommended developing appropriate regulations, finding financial resources, promoting more cooperation between various stakeholders, waste separation at source, establishing of small centralized hazardous waste treatment and disposal facility, and on-site pretreatment.

Further research is recommended for economical cost-benefit analysis for the disposal and treatment options.

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List of abbreviation

BAN	Basel Action Network
BC	Basel Convention
CAS	Chemical Abstract Service
CEHA	Centre for Environmental Health Activities
CEO	Chief Executive Officer
EEAA	Egyptian Environmental Affairs Agency

EPA	Environmental Protection Agency
EQA	Environmental Quality Authority
GCHWM	Gaza City Hazardous Waste Management
GS	Gaza Strip
HCFs	Healthcare facilities
HCW	Healthcare Waste
HCWM	Healthcare Waste Management
HHW	Household Hazardous Waste
HW	Hazardous Waste
HWM	Hazardous Wastes Management
HWMP	Hazardous Waste Management Project
IWIC	International Waste Identification Code
IME	Israeli Ministry of Environmental
MOHMP	Ministry of Health Master Plan for Healthcare Waste
Mt	metric tones
PCBs	Polychlorinated Biphenyls
pH	Hydrogen ion concentration
PCBS	Palestinian Central Bureau of Statistic
TCLP	Toxicity Characteristic Leaching Procedures
TSDF	Treatment, Storage and Disposal Facilities

UNEP	United Nation Environment Program
USEPA	United Stated Environmental Protection Agency
WB	West Bank
W H O	World Health Organization

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Chapter 1

Introduction

1.1 Background

The dilemma of Hazardous Wastes Management (HWM) has been recognized seriously worldwide. Especially in developing countries, this problem is severely compounded by other socio-economic and technological predicaments and priorities. The Arab region as the rest of the planet is still faced with serious challenges emanating from our current unsustainable patterns of production and consumption (Al-Yousfi, 2002).

Although the majority of the Arab countries have already ratified the Basel Convention (BC), they are yet to set up practical mechanisms for addressing problems caused by the generation and management of hazardous waste (Abdelhady, 2002). The national legislations established in accordance with BC are still impeded by the severe shortage in infrastructures suitable for HWM, as well as the deficit in trained personnel to tackle the various aspects of the problem.

Only few countries have already constructed treatment, disposal and incineration facilities (e.g., TSDF); however, the vast majority lacks the technological and financial means to build such sophisticated systems (Abdelhady, 2002).

Hazardous and Healthcare waste environmental issues attract the attention in both developing and non developing countries. In the absence of protective HWM facilities, aggravated by weak regulatory and enforcement frameworks as well as inadequate regional cooperation, the problem of hazardous waste will continue to be a serious developmental and environmental challenge in the Arab countries. To face this challenge, the United Nation Environment Program (UNEP) is striving towards the development of national and regional policies that integrate hazardous chemicals and wastes management (Williams, and Shahzad, 2002.).

1.2 Problem Definition

With the very limited environmental resources and the rapid population growth in the West Bank and the Gaza strip (WB and GS) a high pressure is exerted on the environment mainly due to the increase of waste generation and relatively the increase of the amount of hazardous wastes (HW), (Table (1.1)). There are many environmental problems in west Bank and Gaza, but the Hazardous and Healthcare waste is an obvious one. Until now there is no accurate information regarding the quantities generated, and no inventory is

done in this field. Although, the WB and GS are not industrial areas, it does not mean they do not produce HW. There are a number of local industries, such as tanning, electroplating, paint, healthcare...etc, that produces HW. These industries need a good and proper system to manage the wastes produced. So far there is no clear system for managing HW neither by the specific industries nor by relevant governmental bodies.

Table (1.1) Summary Statistics, Palestinian Territory (PCBS, 2005)

Year	Mid Year Population	Growth Rate (%)
2002	3.394.046	3.5
2003	3.514.868	3.5
2004	3.637.529	3.4
2005	3.762.005	3.3
2006	3.888.292	3.3
2007	4.016.416	3.2
2008	4.146.164	3.1

1.3 Objectives

The main objectives of the study are:

- A- To study, analyze and recommend suitable HW management practices in WB and GS.
- B- To present a case study of Healthcare Waste Management in the WB and GS.

1.4 Methodology

To achieve the above mentioned objectives, the following methodology has been adapted.

- Identifying the Study Area: The study area is limited to The WB and GS
- Defining and classifying Hazardous waste: This was done according to UNEP, World Bank and international conventions (Basel Convention) definitions and standards.
- Critical Literature Review: Available literature and legislation resources were collected and studied to identify the extent of the problem and related issues. Regional data from neighboring countries were also reviewed.

- Diagnosis of the status of HW management in Palestine: Many visits and experts meetings were conducted as well as field visits to the institutions concerned with HW management and to various industries and landfills to diagnose the problem of HW management. Also identifying polluting industries in the WB and GS.
- Selecting an Appropriate Hazardous Waste Management System: The various proper steps and processes in the management of hazardous waste are presented and explained. From Generation through separation, storage, transportation, treatment, recovery to disposal.
- Healthcare Waste Management Case Study: West Bank and Gaza Strip. Many visits and experts meetings were conducted as well as field visits to the institutions concerned with Healthcare waste and to various hospitals and clinics to diagnose the problem of healthcare waste management. Information on healthcare waste generated quantities were collected and presented in the study. Also the existence or nonexistence of healthcare management system is reported.

1.5 Thesis Outline

The thesis consists of eight chapters:

Chapter 1 is an introduction for the thesis.

Chapter 2 discusses the various international and regional definitions of hazardous waste and presents the characteristics and classifications of hazardous waste.

Chapter 3 reviews the various legislations including Palestinian, Israeli, and Egyptian legislations and laws and shows the similarities and the differences among them.

Chapter 4 reviews the regional experiences in Hazardous waste management including Jordanian, Egyptian and Israeli. Also a recent and important HW management in Alexandria, Egypt were discussed and lessons drawn from that project.

Chapter 5 presents the status of HW management in Palestine including various industries to diagnose the problem of HW management and identifying polluting industries.

Chapter 6 various steps and processes in the management of hazardous waste are presented and explained from generation to disposal, through separation, storage, transportation, treatment and recovery.

Chapter 7 Case Study on Healthcare Waste Management was studied in order to diagnose the problem of healthcare waste management. Information on generated quantities are presented in the study. Healthcare management system is reported and discussed.

Chapter 8 Conclusion and recommendations are presented.

Chapter 2

Definition and Classification of HW

2.1 Introduction

The first step in developing a program to manage hazardous wastes to protect human health and the environment is determining exactly what constitutes a hazardous waste. Decisions have been made on which wastes to be classified as hazardous based on national and regional priorities. In situations where hazardous wastes pose imminent danger to public health or the environment, the decision to target a particular industry or waste is clear. However, deciding which wastes to classify as hazardous from a huge list of all the wastes generated in a region or country is challenging. We can take advantage of hazardous waste definitions established under the Basel Convention, by other multi-national organizations and by countries with a similar industrial base. Lists of wastes targeted also can be used for elimination by the United Nations Environment Programme (UNEP, 2000). We must adopt criteria on which to base our definition. These may include (Asfari, 2002):

- The waste's hazardous characteristics (e.g., toxicity and ignitability),
- Certain specific toxic components (e.g., PCBs and arsenic),
- Specific types of materials (e.g., organic solvents and explosives),
- The processes from which hazardous wastes originate, such as refining, and
- Specific wastes such as chemical waste-water treatment sludges.

Defining hazardous waste is a difficult task, but the establishment of a proper management frame-work should not be delayed by debates about what constitutes a hazardous waste. Pragmatic working definitions can be adopted initially and refined as our hazardous waste management program is developed. Another important consideration is whether there will be a single, national definition and list of hazardous wastes, or whether regional or local governments will develop their own definitions that add to or subtract from the national hazardous waste lists (UNEP, 1991).

Determining which wastes will be classified as hazardous for the purposes of regulation is not a simple task, since there are tens of thousands of wastes that can be hazardous for many different reasons (D'Sa, 2003). Defining hazardous waste also has financial implications, since management of regulated wastes may be more costly. In developing an organized approach to hazardous waste identification and classification, international organizations and countries have used a variety of approaches including: classification by chemical characteristics (such as ignitability or explosivity); categories of industrial by-products that have undergone specific processes (such as fly ash); technology of origin (such as electroplating); generic groups (such as oily waste); and specific lists of wastes or waste types (Al-Yousfi., 2002).

2.2 Hazardous waste is defined as:

According to the Abdelhady, 2002, hazardous waste is defined as:

"Waste of activities and processes or its ashes which retain the properties of hazardous substances and have no subsequent original or alternative uses, like clinical waste from medical treatments or the waste resulting from the manufacture of any pharmaceutical products, drugs, organic solvents, printing fluids, dyes and painting materials".

And hazardous waste in Oman was defined in Ministerial decision No. 18/93, Regulation for the Management of Hazardous Waste, 2 February 1993, as follows:

Any waste arising from commercial, industrial, agricultural or any other activities which, to its nature, composition, quantity or any other reason is hazardous or potentially hazardous to human health, plant or animals, soil, air, or water. This includes explosive, radioactive or flammable substances, which may cause diseases as well as those issued by a decision of the Minister.

United Nation Environment Program (UNEP)

The United Nations Environment Programme states that hazardous wastes are those wastes which, by reason of their chemical reactivity, toxic, explosive, corrosive or other characteristics, cause danger or are likely to cause danger to health or the environment, whether alone or when coming into contact with other wastes. Hazardous waste can include solids, liquids, gases, sludges, and contaminated containers and can come from commercial, agricultural, industrial or even household sources. Hazardous wastes include those wastes that cannot be managed safely and effectively by the current waste disposal systems.

World Bank

The World Bank suggests that hazardous waste can be defined in a number of ways including: hazardous characteristics (e.g., toxicity and flammability), certain toxic components (e.g., PCBs and arsenic), types of materials (e.g., organic solvents and explosives), processes from which hazardous wastes originate, such as refining and clinical work, and/or specific waste streams such as chemical waste-water treatment sludges.

Palestinian Environmental Law 1999

According to the Palestinian Environmental Law No7 of 1999, hazardous waste is defined as the waste generated by the various activities and operations or the ash thereof, which preserve the characteristics of hazardous

substance which have no usage, such as atomic waste, medical waste, or refuse emanating from the manufacturing of pharmaceutical products, medicines, organic solvents, dyes, paints, pesticides or any other similar hazardous substance.

2.3 Hazardous waste characteristics

2.3.1 General Characteristics

A waste can be classified as hazardous if it exhibits any of the following characteristics:

Ignitibility

Ignitibility relates to the potential of waste material to cause a fire during storage, disposal, or transport. Used organic solvents and waste oils are examples of ignitable materials; if they are part of a waste stream, the waste will be classified as hazardous. The waste can be ignited if it has any of the following properties:

1-If a liquid has a flash point < 60 C.

2-If a solid material can cause fire through friction, absorption of moisture or spontaneous chemical changes.

3-If it is an ignitable compressed gas.

4-If it is an oxidizing material.

The US Environment Protection Agency (USEPA) assigns a HW number of (D001) for ignitibility.

Corrosivity

The Hydrogen ion concentration (pH) is a good measure of corrosivity. Waste containing material of very high pH (12.5) or very low pH (2) can produce dangerous reactions with other materials in the waste. Acidic waste (from many industrial processes) is an example of corrosive waste. Many hazardous wastes contain materials that corrode steel drums, causing the hazardous waste to leak into the environment.

The USEPA assigns a HW number of (D002) for corrosivity.

Reactivity

Some constituents of a waste may be unstable and may have the potential to cause explosion at any stage of the waste management cycle. Used cyanide solvents are example of reactive wastes.

A solid waste exhibits the characteristic of reactivity if a representative sample of the waste has any of the following properties (Hasan, 1996):

1. It is normally unstable and readily undergoes violent change without detonating.
2. It reacts violently with water.
3. It forms potentially explosive mixtures with water.
4. When mixed with water, it generates toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.
5. If it is a cyanide- or sulfide-bearing waste which, when exposed to pH conditions between 2 to 12.5, can generate toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.
6. It is capable of detonation or explosive reaction if it is subjected to a strong initiating source or is heated under confinement.
7. It is readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure.
8. It is a forbidden explosive
USEPA assigns a HW number of (D003) for Reactivity.

Toxicity

Toxicity is the ability of a substance to cause death, injury, or impairment to an organism that comes in contact with it. Ingestion, inhalation, and dermal contact are common modes of contact. A waste can be tested for toxicity by using a standard test to evaluate the toxicity of a toxic contamination. EPA use Toxicity Characteristic Leaching Procedures “TCLP” (EPA test method 1311). This method depends on the maximum concentration of certain toxic substance compared to a regulated list of these substances such as heavy metals, pesticides, and some hydrocarbons. These are regulated in USA in code of federal regulations No 40, parts 260-299. Table (2.1) explain the extract of the Maximum Concentration of Contaminants for the Toxicity Characteristic (Watts and Wiley, 1998).

Table (2.1) Extract of the Maximum Concentration of Contaminants for the Toxicity Characteristic (Watts and Wiley, 1998)

EPA HW No	Contaminant	CAS No	Regulatory Level (mg/L)
D004	Arsenic	7440-38-2	5.0
D005	Barium	7440-39-3	100.0
D018	Benzene	71-43-2	0.5
D006	Cadmium	7440-43-9	1.0
D019	Carbon tetrachloride	56-23-5	0.5
D020	Chlordane	57-74-9	0.03
D021	Chlorobenzene	108-90-7	100.0
D022	Chloroform	67-66-3	6.0
....
....
D043	Vinyl chloride	75-01-4	0.2

2.3.2 Basel Characteristics

According to Williams, 2002, the hazardous wastes characteristics identified in the Basel Convention are summarized as follows:

- “Unknown (H0 designation). Wastes may be classified a hazardous waste if: (i) they are chemical or industrial wastes of an unknown origin; (ii) the wastes are generated for research and the properties and impacts to the environment are unknown; or (iii) the generator designates the chemical or waste materials as a hazardous waste due to information known to the generator; or (iv) the Municipality designates the waste to be a hazardous waste.
- Explosive (H1 designation). A waste may be classified as an explosive waste if it is a solid or liquid substance (or mixture of substances), which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings.
- Inflammable Liquids (H3 designation). Liquids, mixtures of liquids, and/or liquids containing solids in solutions or suspension that gives off an inflammable vapor at temperatures of not more than 60.5 °C in a Closed-Cup Test, or not more than 65.6 °C in an Open-Cup Test.

- Inflammable Solids (H4.1 designation). Solids, other than those classified as explosives, which under conditions encountered in transport are readily combustible, or may cause or contribute to fire through friction.
- Substances or Wastes Liable to Spontaneous Combustion (H4.2 designation). Substances or wastes that are liable to spontaneous heating under normal conditions encountered in transport, or to heating up in contact with air, and being then liable to catch fire.
- Substances or Wastes that, in Contact with Water, Emit Inflammable Gases (H4.3 designation). Substances or wastes that, by interaction with water, is liable to become spontaneously inflammable or to give off inflammable gases in dangerous quantities.
- Oxidizing (H4.4 designation for International Waste Identification Code (IWIC) and H5.1 designation for Basel Convention). Substances that are not necessarily combustible, may by yielding oxygen cause, or contribute to, the combustion of other materials.
- Organic Peroxides (H5.2 designation for Basel Convention, not listed for IWIC). Organic substances or wastes that contain the bivalent O-O structure and are thermally unstable substances that may undergo exothermic self-accelerating decomposition.
- Poisonous (Acute) (H6.1 designation for Basel Convention, not listed for IWIC). Substances or wastes liable either to cause death or serious injury or to harm health if swallowed or inhaled, or by skin contact.
- Infectious Substances (H6.2 designation for Basel Convention, not listed for IWIC). Substances or wastes containing viable microorganisms or their toxins that are known or suspected to cause disease in animals or humans.
- Toxicity (Delayed or Chronic) (H5 designation for IWIC, and H11 designation for Basel Convention). Substances or wastes which, if they are inhaled or ingested or if they penetrate the skin, may involve delayed or chronic effects, including carcinogenicity.

- Corrosives (H6 designation for IWIC, and H8 designation for Basel Convention). Substances or wastes that, by chemical action, will cause reversible or irreversible damage when in contact with living tissue, or, in case of leakage, will materially damage or destroy other items or the transport vehicle.
- Liberation of Toxic Gases in Contact with Air or Water (H10 designation for IWIC and Basel Convention). Substances or wastes those by interaction with air or water are liable to give off toxic gases in dangerous quantities.
- Hazardous Leachate (H11 designation for IWIC and H13 designation for Basel Convention). Substances or wastes that, after disposal, yield another material such as leachate that possesses any of the Hazardous Waste Characteristics.
- Ecotoxic (H12 designation for IWIC and Basel Convention). Substances or wastes that if released present or may present immediate or delayed adverse impacts to the environment by means of bio-accumulation and/or toxic effects upon biotic systems.

The Basel Convention requires the completion of two forms, and requires waste classification information to be provided in those forms. Waste classification is based on the following:

- " number (part of the designation system from Annex I);
- Physical description (liquid, sludge, solid);
- UN Number (the UN code number for waste dangerous goods).
- Composition (nature, e.g., toxicity, and concentration of the most hazardous components);
- "H" Code number from Annex III “.

Chapter 3

Legislations of Hazardous Waste

3.1 Introduction:

Some countries have comprehensive HW regulations such as the USA, and other countries may have limited or no regulations in this aspect. Palestine as an emerging state has had a good start at HW regulations. In this chapter we will present Palestinian and regional HW regulations and make a comparative study.

3.2 Palestinian Legislation:

After 1994, the Palestinians gained limited autonomy: first over most of the Gaza Strip and Jericho in 1994, and subsequently over other parts of the West Bank during 1996. Since the Palestinian National Authority took over control, some environmental issues have been addressed.

In September 1995, the Oslo-II agreement was signed between Israel and Palestine Liberation Organization. This agreement' includes an environmental chapter, which addresses amongst others hazardous waste management.

In October 1999, the Palestinian Environmental Strategy was published. This strategy elaborates a vast number of environmental issues. A considerable number of articles of the Strategy deal with HW.

In July 1999, the Palestinian Environmental Law was enacted. This law states that the generators of HW must comply with orders and directives of the Ministry of Environmental Affairs (now Environment Quality Authority (EQA)) and of the competent agency. These orders and directives (byelaws) are still to be elaborated. In addition, lists of waste that are considered hazardous still have to be introduced in the byelaws.

3.2.1 Oslo-II Agreement (September 1995)

The Oslo-II agreement between Palestine and Israel (transfer of authority) explicitly mentions hazardous waste in article 12:

Item A1:

This sphere includes, inter alia, licensing for crafts and industry, and environmental aspects of the following: sewage, solid waste, water, pest control (including anti-malaria activities), pesticides and *hazardous substances*, planning and zoning, noise control, air pollution, public health, mining and quarrying, landscape preservation and food production.

Item B5:

Both sides shall respectively adopt, apply and ensure compliance with internationally recognized standards concerning the following:

- levels of pollutants discharged through emissions and effluents: acceptable levels of treatment of solid and liquid wastes, and agreed ways, and means for disposal of such wastes
- the use, handling and transportation (in accordance with the provisions of Article 38 (Transportation)) and storage of *hazardous substances and wastes* (including pesticides, insecticides and herbicides)
- standards for the prevention and abatement of noise, odour, pests, and oilier nuisances, which may affect the other side.

Item B6:

Each side shall take the necessary and appropriate measures to prevent the uncontrolled discharge of wastewater and/or effluents to water sources, water systems, and water bodies, including ground water, surface water and rivers, which may affect the other side and to promote the proper treatment of domestic and industrial wastewater, as well as *hazardous wastes*.

3.2.2 Palestinian Environmental Law No. 7/1999 (July 1999)

The Palestinian Environmental Law defines HW as: waste generated by the various activities and operations or the ash thereof, which preserve the characteristics of hazardous substance, which have no usage, such as atomic waste, medical waste, or refuse emanating from the manufacturing of pharmaceutical products, medicines, organic solvents, dyes, painting, pesticides or any other similar hazardous substance.

Article 11:

The Ministry of Environmental Affairs, in co-ordination with the competent agencies, shall issue one or more lists of hazardous substances and wastes.

Article 12:

No person shall be authorized to manufacture, store, distribute, use, treat, or dispose any hazardous substance or waste whether it is solid, liquid, or gas, unless in accordance with the orders and directives specified by the Ministry of Environmental Affairs (currently Environmental Quality Authority) in co-ordination with the competent agencies.

Article 13:

A. It is forbidden to import any hazardous wastes into Palestine.

B. It is forbidden to pass hazardous waste through the Palestinian territories or through the territorial water or free economic zone of Palestine, unless a special permit is obtained from the Ministry of Environmental Affairs (currently Environment Quality Authority).

Article (14)

The Ministry, in coordination with the competent agencies shall designate the environmental conditions for the import, distribution, manufacturing, use, and storage of pesticides, substances, and agro-chemical fertilizers, which may pose hazards to the environment.

Article 15:

The Ministry in coordination with competent agencies, shall set instructions and standards specified for the agrochemicals that are allowed to be imported, manufactured and distributed in Palestine, and shall verify observance of it.

Article 19:

A. The Ministry of Environmental Affairs (currently Environmental Quality Authority), in co-operation with the competent agencies, shall specify standards to regulate the Percentage of pollutants in the air which may cause harm or damage to public health, social welfare and the environment.

B. Each facility, which will be established in Palestine, shall abide by these standards: every existing facility shall make necessary changes in a manner that makes it conform to these standards within a period that does not exceed three years.

Article 20:

Every facility owner shall provide all means to ensure the necessary protection for workers and the neighbors of the facility in compliance with the conditions of occupational safety and health, against any leak or emission of pollutants in or out of the working place.

Article 29:

The Ministry of Environmental Affairs (currently Environmental Quality Authority), in co-ordination with the competent agencies, shall set standards and norms For collecting, treating, reusing, or disposing waste and storm water in a sound manner, which comply with the preservation of the environment and public health.

Article 30:

No person shall be allowed to discharge any solid or liquid or other substance unless a process conforms to the conditions and standards that the competent agencies determine.

Article 59:

Any facility owner or operator that provides incorrect or misleading information regarding the environmental aspects of the facility he owns or operates, shall be penalized by imprisonment for a period not exceeding six months or a fine of not more than two thousand Jordanian Dinars or the equivalent thereof in the legally circulated currency, or by the two Penalties.

Article 62:

Any person who violates the provision of Article 12 of this law shall be punished by a fine of not less than 1 000 and not more than 3 000 Jordanian Dinars or the equivalent thereof in the legally circulated currency or not more than three years of imprisonment, or by the two penalties

Article 63:

A. Any person that violates the provisions in Article 13, section A of this law shall be sentenced to life imprisonment with hard work, in addition to confiscating or eliminating the wastes at the violator's expense.

B. Any person who violates the provision in Article 13, section B of this law shall be penalized by a fine of not less than 3 000 and not more than 20 000 Jordanian Dinars or the equivalent thereof in the legally circulated currency or the imprisonment for a period not less than three years and not more than fifteen years, or by the two penalties.

3.2.3 Palestinian Environmental Strategy (October 1999)**Chapter 6.2.3 (Solid Waste Management):**

- Item 6 Setting up a separate system for collection and disposal of hazardous industrial waste, small domestic household waste and infectious hospital waste”.
- Item 10 “Monitoring and enforcement systems to support these measures”.

Chapter 6.2.4 (Agricultural and Irrigation Management):

- Item 4: This will also include the establishment of regulations regarding storage and disposal of surplus quantities of pesticides.
- Item 5: “Setting up a system of collection, disposal and, if possible reuse of wasted plastic sheets’.

Chapter 6.2.5 (Industrial Pollution Control):

- Item 1: “Setting industrial air emissions and wastewater standards, in particular for the chemical industry, tanning industry, textile dyeing industry, foaming industry, electroplating and metal industry, olive oil mills, quarrying and stone cutting and charcoal industries. The wastewater standards should include pre-treatment requirements and standards for discharge into the sewer system, as well as full-treatment requirements for direct discharge.
- Item 2: Regulations regarding the use of burning fuels, including prohibition or limitation of used oil or other ‘dirty’ sources of energy’.
- Item 4: “Setting regulations for industrial solid and hazardous waste management, including prevention of uncontrolled dumping of waste and waste burning”.

- Item 5 underlines: “Setting regulations for industrial zones, including the establishment of common environmental protection measures, facilities and regulations for traffic and noise emissions”.
- Item 6 for: “Monitoring and enforcement systems to support these measures”.

3.3 Regional environmental legislations for HW

3.3.1 Relevant environmental legislation in Israel for HW

In Israel there are several sectoral laws that deals with hazardous waste:

The Plant Protection Law, 1956, put the regulation of the use of pesticides, and of the import, sale, distribution and packaging of pesticides, fertilizers and other materials, under the responsibility of the Ministry of Agriculture

The Licensing of Business Regulations, 1990, provides the legal framework for the control of the disposal of HW in Israel. The owner of a plant producing HW has to dispose this waste within six months of its generation at the national Israeli hazardous waste disposal site, Ramat Hovav. The owner has to keep documents proving that the waste has been disposed of according to the regulations.

The Hazardous Substances Law, 1993, provides the Ministry of Environment with the authority for the comprehensive management of hazardous substances, classification of hazardous substances, licensing requirement, control of manufacture, import, export, packaging, commerce, transfer, storage, maintenance and use.

By Israeli law, hazardous waste originated in Israel must be taken to the Ramat Hovav hazardous waste treatment site. In 1992, most of the country’s toxic waste still remained untreated because less than 50 % of the HW was brought to Ramat Hovav. The current situation about transport to and treatment of HW at Ramat Hovav could not be verified.

There are several ministries and national authorities involved in hazardous substances control In Israel, with responsibility for the implementation of over 100 laws and regulations. The following gives an overview of their involvement and responsibilities.

- Ministry of Health: Extensive authority through the Licensing of Business Law and the Public Health Ordinance to regulate hazardous substances in food products, in particular pesticide residues, as well as medical and pharmaceutical products, and cosmetics.
- Ministry of Agriculture: Complete jurisdiction regarding registration and application of pesticides.
- Ministry of National Infrastructure: Authority to enforce water pollution standards, through the Israeli National Water Commissioner. Regulatory in

its capacity as overseeing Ministry for Israel's petrochemical industry as well as electric and fuel utilities.

- Ministry of Interior: Direct responsibility for services involving potential emergencies from accidents involving hazardous substances through the firefighting units, and indirectly, through local authorities and Municipalities.
- Ministry of Labour and Welfare: Overall responsibility for regulating occupational exposures to hazardous substances through the Safety in Work Ordinance 1970, and a series of additional labour laws.
- Ministry of Transport: Regulation of transport of hazardous substances and wastes via the air, sea, and on land according to relevant legislation.
- Ministry of Industry and Commerce: Indirect involvement through its overall regulation of industry and direct responsibility regarding import and export of materials and as administrators of the Israel Bureau of Standards.
- Prime Minister's Office: As the responsible agency for nuclear development, its role focuses on regulation of nuclear facilities and wastes.
- Ministry of Energy: Responsibility for Israel's petrochemical industry, for electric and fuel utilities and for the supply of fuel.
- Ministry of the Police: Direct responsibility and command during accidents involving hazardous substances.
- Ministry of the Environment: Beyond its media-specific authorities to reduce toxic air, water, and marine pollution, the Ministry of the Environment plays a central role in specifying conditions for handling and treatment of hazardous materials and wastes.

And The following is a description of the most relevant Israeli legislation and regulations in relation with HW:

3.3.1.1 Hazardous Substances Law, 1993

The Hazardous Substances Law originates from the separation of existing authorities within the framework of the Pharmacists Ordinance, and is based upon the government decision to transfer responsibility for toxic substances and harmful chemicals from the Ministry of Health to the Ministry of the Environment. Regulations of pharmaceuticals and medical drugs remain the responsibility of the Ministry of Health.

With its attached listings of toxic substances and harmful chemicals, it provides the Israeli Ministry of the Environment with authority for a comprehensive "cradle to grave" management of hazardous substances.

The Minister of the Environment is responsible for the implementation of this law. He may promulgate regulations as to:

- classification of hazardous substances, in accordance to their use, degree of toxicity or risk

- manufacture, import, export, packaging, commerce, issue, transfer, storage maintenance and use of hazardous substances.

The Law defines “harmful chemicals” and “poisons” as substances that are specified in the appendices to the law. The “poisons” list includes those hazardous substances that, in the opinion of the Ministry of the Environment, should be controlled and supervised. It is based on the list of materials specified in the “Orange Book” of the UN, which gives Recommendations on the Transport of Dangerous Goods, except for explosives. Hazardous substances (including chemicals) are listed and quantified within a recently amended annex and within attached regulations. The law establishes a permit requirement for any premise dealing with hazardous substances. This so-called Poisons Permit, which is issued by an official appointed by the Minister of the Environment, is only granted once the appointed official is satisfied that the individual applying for the permit is familiar with the features of the hazardous substances in the possession of the business, their risk level, and the neutralization means available to the plant in case of an accident. The Ministry of the Environment guidelines require that Poisons Permits are only issued following physical examination of the plant or installation.

The holder of a Poisons Permit is required to maintain a toxic substance register in which details of all sales and purchases of hazardous materials have to be recorded. These record books facilitate tracking of the movement of hazardous materials throughout the country.

The law prohibits import of hazardous materials by anyone not holding a permit or authorization by the appointed official. Israel’s legislation on the import and export of goods prohibits the release from customs any hazardous substance before customs officials ascertain that the importer possesses the necessary permit. The Ministry of the Environment is currently working with the customs authority on integrating the customs code number with the listing of hazardous substances that is enumerated in the law.

A recent amendment to the law (April 1997) has further strengthened its ‘effect. It did so by enabling the introduction of conditions into the permit, enlarging penalties, widening judiciary powers to issue performance orders, adding powers to issue administrative eviction orders, Imposing personal liability on company directors and applying obligations, and responsibilities on the state and its organs.

The above mentioned new penalties include high fines ranging from maximum sums of 150 000 NIS to 1 200 000 NIS and maximum imprisonment periods of between six months and three years, according to the severity of various violations which are specified in the law.

An authorized representative of the Minister of the Environment may enter any premise handling hazardous substance, with the exception of a pharmacy selling medicines, for purposes of inspection or investigation. Samples may be collected, and the representative may prohibit the sale of certain hazardous substances until the completion of the investigation.

The data provided in the Poisons Permit are an important tool in the Ministry of the Environment's efforts to widen its supervision and control over the hazardous substances found in every industrial plant in Israel. Supervision and control extend to such essential activities as manner of storage, signposting, emergency response capability, hazardous waste disposal, and emissions control. Implementation of the law has also helped the information and Response Centre for Hazardous Substances to accumulate additional data on the types of hazardous substances used in Israel, quantities, and manner of use as well as to identify users and locations.

The Minister of the Environment may, with the approval of the Knesset Interior and Environmental Committee, set fees for the issue or renewal of permits.

3.3.1.2 Licensing of Business Law, 1968

The Licensing of Business Law, despite its apparently general nature and its being legislated In 1968, is a central and vital tool in environmental enforcement in Israel. It shows clearly, how licenses can be used as a tool to achieve environmental goals in the field of HW.

The law authorizes the Minister of the Interior, in conjunction with the Minister of the Environment, to 'designate and define by order, businesses requiring a license, in order to ensure therein appropriate sanitary conditions, the prevention of nuisances and annoyances and compliance with the provisions of the laws regulating to planning and building.'

According to this law, all business activities are required to operate under a Business License. Licenses are subject to prior approval by the Ministry of the Environment, Health, Police, Labour and Welfare or Agriculture, depending on the type of business. Each of these ministries may make the issue of the license conditional upon compliance with certain conditions.

The Ministry of the Environment uses its authority to impose environmental provisions within the framework of the license, which may include inter alia, limitations on emissions to the environment and terms for the handling of hazardous substances, hazardous waste and other wastes.

Operation of a business without a license or in contravention to the conditions of the license or to business licensing regulations is a criminal offence. The law provides efficient tools for the supervision of industries

and businesses, by allowing for the administrative or judicial closure of businesses not abiding by the law, its regulations and / or special conditions. In recent years, a variety of environmental regulations have been promulgated within the framework of this law, including regulations on hazardous waste disposal, hazardous industrial plants, pest extermination and sanitary conditions in gasoline stations.

-The local authority is the licensing authority in the area of the Municipality or local council, otherwise a person empowered by the Minister of Interior serves in that capacity. License applications must be approved by a person empowered to do so by the Minister of the Environment, or Internal Security, or Agriculture, as the case may be.

-The Minister of Interior may regulate the safety conditions, and the Minister of the Environment may regulate sanitary conditions necessary in businesses requiring a license.

-Terms of licensing, such as their period of validity, fees and renewal policies are prescribed by general regulations or regulations specific to particular classes of businesses.

- Persons running a business without a license or in contravention of the Law or its regulations are liable to a fine or imprisonment for six months. The Court may further order that the business be closed. A person who refuses to present his business license to an official on demand is liable to a fine or imprisonment for three months.

3.3.1.3 Licensing of business regulations (Disposal of HW) 1990

These regulations oblige owners of industrial plants to dispose of hazardous wastes originating or found in their plants, as soon as possible after production and no longer than 6 months from production, to the central plant for neutralization and treatment of hazardous wastes at Ramat Hovav. The HW site is operated by the Environmental Services Company that was established in 1990 as a state-owned and controlled waste company for the explicit purpose of operating the site. Disposal or treatment of hazardous waste elsewhere for the purposes of recycling, reuse or other reasons requires the prior approval of the Ministry of the Environment.

3.3.1.4 Abatement of nuisances regulations (Used oil) 1993

These regulations state that, in order to prevent air pollution and contamination of water resources and in order to preserve a proper quality of the environment, an oil exchanger will not pour out, burn, or remove used oil in his/her possession and will not permit others to do so unless otherwise stated in these regulations.

The regulations require oil exchangers to establish used oil collection facilities, with prescriptions of size, placement, and technical specifications. The regulations further address the disposal of the used oil, the documentation of possession and disposal, and the penalties for non-compliance, amounting to six months imprisonment or a fine.

3.3.1.5 Hazardous substances regulation (Import & export of HW) 1994

Israel was one of the original signatories of the Basel Convention on the Control of Transboundary Movements of HW, and their Disposal in 1989. Israel ratified the convention in 1994, following the promulgation of these regulations aiming to provide the legal basis for the implementation of the convention. The regulations prohibit the import into, or export of hazardous wastes from Israel, except under a permit certificate issued by the Ministry of the Environment. Permit certificates for the import or export of hazardous wastes are issued only for recycling purposes. They are never issued for the import or export of hazardous waste for purposes of disposal, nor are they issued if the waste is destined for or originates from a country that is not a party to the Basel Convention.

Import is conditional also on the provision of data to the Ministry of the Environment on the type of hazardous waste and its composition, based on results obtained in an Israeli laboratory. It is required that the hazardous waste be transferred to Israel, stored, maintained and treated in a manner that will not damage the environment. In the case of export, it is required that the competent authority under the Basel Convention provides its written consent to receive the waste, and export must proceed according to its requirements. Moreover the issuing of a permit certificate is subject to conditions imposed by the Ministry of the Environment, and it may be withhold if the conditions or requirements set forth in the regulations are not met. Holders of permit certificates are required to report on quantities of imported or exported HW according to the requirements of the Ministry of the Environment.

The Oslo-II treaty applies equally for Israel and Palestine. This treaty and some Israeli laws, if strictly enforced, could protect the inhabitants of the Occupied Territories against the consequences of smuggling of hazardous substances into the territories as well as the marketing and selling of dangerous pesticides, of which some are internationally banned.

3.3.2 Relevant environmental legislation for HW in Egypt

3.3.2.1 Environmental Law

Law number (4) of 1994 promulgating the environmental law and its executive regulation EGYPT

Article 29:

It is forbidden to displace hazardous substances and waste without a license from the competent administrative authority. The executive regulations of this Law shall determine the procedures and conditions for granting such a license and the authority competent to issue these licenses.

The ministers shall, each in his field of competence, issue in coordination with the Minister of Health and EEAA a list of the hazardous substances and waste referred to in para one of this article.

Article 30:

Management of hazardous waste shall be subject to the rules and procedures laid down in the executive regulations of this Law. The executive regulations shall designate the competent authority, which, after consulting EEAA, will issue the list of hazardous waste to which the provisions of this Law shall apply.

Article 31:

It is forbidden to construct any establishment for the treatment of hazardous waste without a license issued by the competent administrative authority after consulting the EEAA. Disposal of hazardous waste shall be in accordance with the conditions and criteria set forth in the executive regulations of this Law. The Minister of Housing shall, after consulting with the Ministries of Health and Industry and the EEAA, designate the disposal sites and determine the conditions of the license to dispose of hazardous wastes.

Article 32:

It is forbidden to import hazardous waste or to allow its introduction into or its passage through Egyptian territories. It is forbidden without a permit from the competent authority to allow the passage of ships carrying hazardous waste in territorial seas or in the exclusive maritime economic zone of the ARE.

Article 33:

Those engaged in the production or circulation of hazardous materials, either in gas, liquid or solid form, are held to take all precautions to ensure that no environmental damage shall occur

The owner of an establishment whose activities produce hazardous waste pursuant to the provisions of this Law shall be held to keep a register of such waste indicating the method of disposing thereof, and the agencies contracted with to receive the hazardous waste. The executive regulations shall determine the data to be recorded in the said register and the EEAA shall be responsible for following up the register to ensure its conformity with the facts.

3.3.2.2 Executive regulation of law number 4 of 1994 Egypt Hazardous Substances and Waste

Article 25:

It is forbidden to displace and use hazardous substances and waste without a license from the competent authority indicated for each as there in below:

- 1.** Hazardous agricultural substances and waste, including pesticides and fertilizers –Ministry of Agriculture.
- 2.** Hazardous industrial substances and waste - Ministry of Industry.
- 3.** Hazardous pharmaceutical, hospital and laboratory substances and waste and domestic insecticides - Ministry of Health.
- 4.** Hazardous petroleum substances and waste - Ministry of Petroleum.
- 5.** Hazardous substances and waste from which ionizing radiation is emitted - Ministry of Electricity - Nuclear Energy Authority.
- 6.** Hazardous inflammable and explosive substances and waste - Ministry of Interior.
- 7.** In respect of other hazardous substances and waste, the respective bodies competent to issue a license for their displacement shall be designated by a decree of the Minister for Environmental Affairs on the basis of a proposal by the CEO of the EEAA. The ministers heading the ministries mentioned in this Article shall, each within his scope of competence and in coordination with the Minister of Health and the EEAA, issue a table of hazardous substances and waste specifying:
 - A.** The types of hazardous substances and waste falling within his ministry scope of competence and their respective degrees of danger.
 - B.** The constraints to be observed in the displacement of each.
 - C.** The means of disposing of the empty containers of such substances after their displacement.
 - D.** Any other constraints or conditions the minister deems important to add.

Article 26:

The applicant for a license shall submit his application in writing to the competent authority as defined in Article (25) of these Executive Regulations in accordance with the following procedures and conditions:

Procedures for granting a license:

The license to handle hazardous substances and waste shall have a maximum validity period of five years unless an event entailing its review occurs. The competent administrative authority may, pursuant to the provisions of Article (40) hereof, grant temporary licenses for short periods as necessity dictates.

The body or individual wishing to obtain a license for the displacement of hazardous substances or waste shall submit an application containing the following data:

1- Handler of hazardous substances and waste:

- Name of establishment
- Address and telephone No.
- Site and area of establishment
- Contour maps of the site
- Level of underground water
- Safety equipment in the establishment
- Information concerning insurance
- Programme for monitoring the environment in the area surrounding the establishment

2- Producer of hazardous substances and waste (full name, address, telephone and fax numbers).

3- A complete description of the hazardous substances and waste intended to be handled and the nature and concentration of the dangerous elements contained therein.

4- The amount of hazardous substances and waste intended to be handled annually and a description of the method of packing to be used (barrels - tanks - loose).

5- The means to be used in storing hazardous substances and waste and the storage period for each, as well as an undertaking to place a clear written description on the container indicating its contents, the degree of danger thereof and how to act in an emergency.

6- The available means of transport (by land - rail - sea - air - internal waterways), their routings and schedules.

7- A complete statement of the method intended to be used for the treatment and disposal of the hazardous substances and waste for the displacement of which a license is sought.

8- A commitment not to mix hazardous substances and waste with any other type of waste produced by social and production activities.

9- A commitment to keep registers containing detailed accounts of the sources, quantities and types of hazardous substances and waste, the rates and periods of their collection and storage and the means of their transport and treatment, to furnish such data on request, and not to destroy the registers for a period of five years running from the date they are first opened.

10- A commitment to take all procedures as are necessary to ensure the proper packing of hazardous substances and waste during the collection, transportation and storage phases.

11- A detailed description of the emergency plan for confronting all unforeseen circumstances which guarantees the protection of human beings and the environment.

12- A certificate of previous experience in the field of handling hazardous substances and waste.

13- A declaration of the veracity of data stated in such document.

Conditions for granting a license:

1- Completion of all required data.

2- Availability of personnel trained in the handling of hazardous substances and waste.

3- Availability of means, resources and systems required for the safe handling of these substances.

4- Availability of requirements to confront the risks which may result from accidents occurring during the handling of these substances.

5- That no harmful effects to the environment and public health shall result from the activity for which a license is sought.

Article 27:

The license to handle hazardous substances and waste shall be issued in consideration of a cash payment to be determined by a decree from the competent minister. The license shall be valid for a maximum period of five years subject to renewal.

The licensing authority may revoke the license or suspend the activity by a reasoned decision in the following cases:

1- If the license was issued as a result (of the submission) of incorrect data.

2- If the license violates the conditions of the license.

3- If the performance of the activity results in dangerous environmental effects which were unforeseen at the time the license was issued.

4- The emergence of sophisticated technology which may, with minor modifications, be applied, and the use of which would lead to a marked improvement in the environment and the health of the workers.

5- If the EEAA concludes that it is unsafe to handle any of the substances and wastes.

The licensing authority in coordination with the EEAA and the Ministry of Health may request the applicant to fulfill such other conditions as it deems necessary to ensure the safe handling of these substances,. In all cases, the

applicant for a license may not handle hazardous substances and waste before obtaining the license made out on the relevant form which must be kept by the person in charge of the handling to be presented on request.

Article 28:

The management of hazardous wastes shall be subject to the following rules and procedures:

1- Engendering Hazardous Waste:

The establishment which engenders hazardous waste shall be held to do the following:

A- Try hard to reduce the rate at which such waste is produced, both quantitatively and qualitatively, by developing the technology used, employing clean technology and selecting alternatives for the primary product or the raw material which are less harmful to the environment and public health.

B- Categorize the waste produced, in terms of both quantity and quality, and register the name.

C- Establish and operate units to treat waste at source, provided the EEAA approves the treatment system as well as the technical specifications of these units and their operational programmes. In case of difficulty of treatment or disposal of hazardous waste at source, the establishment producing such waste shall be held to collect and transport it to the disposal sites determined by the local authorities and the competent administrative and environmental bodies. The displacement of such waste shall be subject to all the conditions and provisions prescribed in this respect by these Executive Regulations.

2- Stage of Collecting and Storing Hazardous Waste:

A- Determine specific locations for the storage of hazardous waste meeting safety conditions to prevent the occurrence of any harm to the public or to those persons exposed to such waste.

B- Store hazardous waste in special containers made of a solid, non-porous, leak-proof material. These containers are to be hermetically sealed and their capacity must be commensurate with the quantity of hazardous waste stored therein or conform to the standards set for the storage of such waste according to type.

C- Place a clear sign on the hazardous waste containers indicating their contents and warning of the dangers which may result from handling them imprudently.

D- Lay down a schedule for the collection of hazardous waste so that it is not left for long periods in the storage containers.

E- Producers of hazardous waste shall be held to provide the above-mentioned containers, wash them after each use and not place them in public places.

3- Stage of Transporting Hazardous Waste:

A- It is prohibited to transport hazardous waste by other than the means of transport run by the establishments licensed to manage hazardous waste. Those means of transport must meet the following conditions:

1- Transport trucks shall be fitted with all safety equipment and shall be in good working condition.

2- The capacity of such trucks and their shift schedule shall be commensurate with the quantities of hazardous waste.

3- They shall be driven by trained drivers capable of taking independent initiatives, particularly in emergencies.

4- They shall bear clear signs indicating the dangerous nature of their cargo and the best manner of dealing with emergencies.

B- Routing of trucks transporting hazardous waste shall be determined and civil defense bodies shall be immediately notified of any changes therein, so as to enable them to act rapidly and decisively in emergencies.

C- Trucks transporting hazardous waste shall be prohibited from passing through residential and other populated areas and through the city centre during daytime.

D- The address of the garages where hazardous waste trucks are parked, as well as the number and date of their license, must be notified to the competent authority.

E- Trucks transporting hazardous waste must be washed and sterilized after each use in accordance with the directives issued by the Ministry of Health in coordination with the competent administrative body designated in Article (40) of these Executive Regulations.

4- The following must be observed when authorizing the passage of ships carrying hazardous waste:

A- Prior notification is a requisite. The competent administrative body shall be entitled to withhold authorization if there is a risk of environmental pollution.

B- In case of authorization, all necessary precautions as prescribed in international conventions must be taken, and the ship must have the guarantee certificate referred to in Law No. 4 of 1994.

5- Stage of Treatment and Disposal of Hazardous Waste:

A- The sites selected to house utilities for the treatment and disposal of hazardous waste shall lie at a distance of at least three kilometres from populated and residential areas, and shall be held to meet the conditions and provide the equipment and installations set forth below:

1- The area of the site must be proportionate to the quantity of hazardous waste so that such waste does not remain in storage for extended periods.

- 2- The site shall be encircled with a brick wall standing at least 2.5 meters high.
- 3- The site shall be provided with more than one gate of suitable width, allowing the easy entry of trucks transporting hazardous waste.
- 4- The site shall be provided with a water source and W.C. facilities.
- 5- The site shall be provided with all the protection and safety requirements prescribed in labour and vocational health laws, as well as with a telephone line.
- 6- The site shall be provided with all the mechanical equipment which can facilitate the work process.
- 7- The site shall be provided with warehouses equipped to preserve hazardous waste pending its treatment and disposal. Equipment shall differ according to the type of hazardous waste received by each utility.
- 8- The utility shall be provided with an incinerator for burning certain type of hazardous waste.
- 9- The utility shall be provided with the necessary equipment and installations for sorting and classifying certain types of hazardous waste with the intention of reutilizing and recycling them.
- 10- The site shall have a sanitary ditch of an adequate capacity for burying the incinerated remains.

B- Processes for the treatment of hazardous waste which may be reused and recycled shall be carried out within the following framework:

- 1- Reutilization of some hazardous waste as fuel to generate energy.
- 2- Recovery of organic solvents and their reutilization in extraction processes.
- 3- Recycling and reusing some organic substances from hazardous waste.
- 4- Reusing ferrous and non-ferrous metals and their compounds.
- 5- Recycling and reusing certain non-organic substances from hazardous waste.
- 6- Recovery and recycling of acids or alkalines.
- 7- Recovery of substances used in reducing pollution.
- 8- Recovery of certain components of ancillary elements.
- 9- Recovery of used oil and reutilizing it after its refinement, with due consideration to the relationship between environmental and economic returns.

C- Processes for the treatment of hazardous waste which cannot be reutilized and recycled shall be carried out within the following framework:

- 1- Injecting hazardous waste amenable to pumping into saltmines, wells and natural reservoirs in areas far from residential and populated areas.

2- Burying hazardous waste in pits specially prepared for this purpose and isolated from the other components of the environmental system.

3- Treating hazardous waste biologically by using certain types of living micro-organisms to bring about its decomposition.

4- Treating hazardous waste physically or chemically by evaporation, dilution, calcification, assimilation, sedimentation, etc.

5- Incineration in special incinerators designed to prevent the emission of gases and fumes into the surrounding environment.

6- Permanent storage (such as placing hazardous waste containers inside a mine).

D- Taking all procedures which guarantee limiting and reducing the production of hazardous waste through:

1- Developing and generalizing the use of clean technology.

2- Developing suitable systems for the management of hazardous waste.

3- Expanding the reutilization and recycling of hazardous waste after treatment whenever possible.

E- Setting a periodic programme to monitor the various components of the environmental system (organic and non-organic) in the sites of utilities and their surroundings for the treatment and disposal of hazardous waste.

Licenses shall be withdrawn and work in the utility suspended upon the appearance of any indications of damage to the eco-systems surrounding the utility.

F- Establishments licensed to handle and manage hazardous substances and waste shall be responsible for any damage caused to third parties as a result of non-compliance with the provisions of these Executive Regulations.

The EEAA shall be competent to review the hazardous waste schedules, which are subject to the provisions of the Law, with the cooperation of the ministries concerned in regard to the schedules issued by them in this connection.

Article 29:

It is prohibited to construct any establishment for the purpose of treating hazardous waste except with a license issued by the competent governorate after consulting the EEAA, the Ministry of Health, the Ministry of Labour and Manpower, and the ministry concerned with the type of waste according to the provisions of Article (25) of these Executive Regulations, after ensuring that such establishment satisfies all the conditions which guarantee the safety of the environment and the staff employed thereat.

Disposal of hazardous waste shall be effected in accordance with the conditions and criteria prescribed in Article (28) of these Executive Regulations.

The Minister of Housing, after consulting the ministries of Health and Industry and the EEAA, shall determine the locations and conditions for the disposal of hazardous waste.

Article 30:

It is prohibited to import hazardous waste or to allow its entry into or passage through the territory of the Arab Republic of Egypt.

It is prohibited, without a license from the competent administrative department in the Ministry of Maritime Transport or in the Suez Canal Authority, each within the scope of its competence, to allow the passage of ships carrying hazardous waste, in the Territorial Sea or the Exclusive Economic Zone of the Arab Republic of Egypt, provided the EEAA is notified withal.

Article 31:

Those in charge of the production or displacement of hazardous substances, whether in their gaseous, liquid or solid states, shall take all due precautions to ensure the non occurrence of any environmental damage, and shall be held in particular to observe the following:

(A) That the site on which such substances are to be produced or stored is selected with due regard to the conditions prescribed according to the type and quantity of those substances.

(B) That the design of the buildings inside which hazardous substances are to be produced or stored conforms to the engineering standards to be observed for each type of such substances, as determined by a decree to be issued by the Minister of Housing after consulting the EEAA. The said buildings shall be subject to periodic inspections by the licensing administrative body.

(C) That the conditions prescribed in respect of the means of transport or the storage sites of such substances are provided so as to guarantee that no harm shall come to the environment or to the health of employees or citizens.

(D) That the technology and equipment used in the production of such substances shall not result in damage to the establishment, the environment or harm to the staff.

(E) That buildings shall be adequately fitted out with safety, alarm, protection, combat, fire-fighting and first aid systems and equipment, in the numbers and quantities determined by the Minister of Labour and Manpower after consulting the EEAA, the Ministry of Health and the Civil

Defense Department in coordination with the competent administrative authority.

(F) That an emergency plan is in place to confront any potential accidents which may occur during the production, storage, transportation or handling of such substances, provided the plan is reviewed and approved by the licensing authority after consulting the EEAA and the Civil Defense Department.

(G) That staff in these establishments are subjected to periodic medical checkups and that they are treated for any vocational diseases at the expense of the establishment by which they are employed.

(H) That establishments producing hazardous substances insure their workers for the amounts to be determined by a decree from the Minister of Manpower in coordination with the Ministry of Insurance and Social Affairs, after consulting the EEAA and the Ministry of Health, provided the amounts of the insurance take into account the degree of danger to which each category of workers is exposed inside each productive unit.

(I) That workers handling such substances are informed of the dangers involved and of the necessary precautions to be taken when handling them, that they are fully aware of all this information and that they have received adequate training in this regard.

(J) That the inhabitants of the regions surrounding the sites where hazardous substances are produced or handled are informed of the possible dangers of these substances and the method of facing such dangers, and that they are familiar with the alarm systems to be used in case of an accident and with the procedures to be followed on its occurrence.

(K) Establishments producing and handling hazardous substances are held to compensate citizens injured in the locations surrounding the production or storage sites for injuries caused by accidents resulting from these activities or from harmful emissions or leakages there from. Those assigned to the production and handling of hazardous substances shall submit an annual report on the extent of their commitment in implementing the necessary precautions.

Article 32:

Establishments engaged in the production or importation of hazardous substances shall, when producing or importing such substances, observe the following conditions:

Firstly: Container specifications:

(A) The type of container in which these substances are placed must be suitable for the type of substance therein, tightly closed and difficult to damage.

(B) The capacity of the container must be easy to lift or transport without exposing it to damage or harm.

(C) The inner lining of the container must be made of a material that is not affected by storage throughout the period when the substances contained therein are active.

Secondly: Container information:

(A) Contents of container, their active substance, and the degree of its concentration.

(B) Total and net weight.

(C) Name of producer, date of production and production number.

(D) Nature of danger and symptoms of toxicity.

(E) First aid procedures to be taken in case of exposure.

(F) Safe method of opening, emptying and using container.

(G) Safe storage method.

(H) Methods of disposal of empty containers.

All the information shall be written in Arabic in a style that is easy for an ordinary person to read and understand, and the words must be legible and prominently displayed on the container. They must be accompanied by diagrams indicating the method of opening, emptying, storing and disposing of the containers as well as by the international symbols for danger and toxicity.

Article 33:

The owner of an establishment whose activity results in hazardous waste pursuant to the provisions of these Executive Regulations shall be held to keep a register of such waste and the method of its disposal, as well as of the names of the parties contracted with to receive the said waste, as follows:

1) Name and address of the establishment.

2) Name and job title of the person responsible for filling in the register.

3) The period covered by the current data.

4) The special conditions issued for the establishment by the EEAA.

5) A list of the types and quantities of hazardous waste resulting from the establishment activity.

6) Method of disposal thereof.

7) The parties contracted with to receive the hazardous waste.

8) Date on which the form is filled.

9) Signature of the officer in charge.

3-4 Regional Legislation Analysis

As seen from above it is evident that some countries have comprehensive HW regulations and others have limited or new regulations. This depends on the existence of industries and the early understanding and appreciation of the dangers of HW to the environment.

In Israel HW legislations seem to be the oldest in the region. They are spread over several sectoral laws such as: The Plant Protection Law 1956, Licensing of Business Law 1968, Safety in Work Ordinance 1970, Licensing of business regulations (Disposal of HW) 1990, Hazardous Substances Law 1993, Abatement of Nuisances Regulations (Used Oil) 1993 and Hazardous substances regulation (Import & export of HW) 1994. This indicates extensive, but fragmented, legislations that helps to manage HW robustly especially with the existence of central HW facility at Ramat Hovav.

Egypt had enacted its environmental law in 1994. This is relatively new where the HW regulations are cited in several articles within the law articles 25-33. The articles cover HW in a systematic and comprehensive manner. But as these regulations are relatively new and not tested to the fullest they are considered to be good but not mature enough.

Palestine have the newest HW legislations. They started within the Oslo II Treaty 1994 where certain parts in the treaty touched on management of HW. In 1999 the Palestinian environmental law was enacted and the HW articles are 11-15, 19, 20, 21, 30, 59, 62 and 63. These articles tackle HW in general and need to be developed in executive regulations taking into considerations regional experiences to make them easily implementable.

Chapter 4

HAZARDOUS WASTES MANAGEMENT IN THE REGION

4.1 Introduction

Until recently, the Arab countries have trivialized the problems caused by the generation of hazard waste. In fact several countries classify all wastes generated from industry as industrial waste whether hazardous or not. Some countries have fallen victims to illegal trafficking and dumping of hazardous wastes, where several shipments of toxic wastes are allegedly entered the region for disposal (Stone, 1999). Nonetheless, the majority of Arab countries have already ratified the Basel Convention (BC) for the Control of Transboundary Movement of Hazardous Wastes.

As industrial developments and urban expansions proliferate in the Region, the rates of hazardous waste generation will continue to rise. Chemical and petrochemical industries are the major contributor to hazardous waste generation; however, other industries and facilities are contributing as well (e.g., mineral and metal processing, hospitals and laboratories...etc.). Small and medium size enterprises, such as electroplating shops, tanneries, auto-repair workshops and garages, have also their share in generating hazardous waste. Municipal waste can as well contain certain portions of hazardous wastes (e.g., chemical solvents, cleaning products, and batteries).

There are no accurate database on the amounts and types of hazardous wastes generated in the Region, but alarmingly, the data compiled in Jordan indicate that the rate of hazardous waste generation per capita is comparable to those of most industrialized countries (16-28 kg/year) (Al yousfi, 2002).

Treatment, storage and disposal facilities (TSDF) of hazardous wastes are quite scarce in the Region (e.g., some TSDF exist in UAE and Saudi Arabia), and when they exist are inadequate to handle the large quantities of waste produced in the Region as a whole. Only few countries have already begun to implement measures to remedy the dangers of hazardous waste by building disposal and incineration facilities (Batstone, 1989). However, others may not find these solutions feasible because of economic constraints, or the hazardous waste quantities generated in a small country are not sufficient to justify the high cost expenditures on such sophisticated facilities. Some examples show that industrial wastes (including hazardous) are either stored for years on the site or intermingled with municipal wastes for ultimate disposal. This will undoubtedly creates numerous contaminated sites that are candidates for environmental assessment, remediation and rehabilitation. In the absence of protective TSDF, aggravated by lack of

legal enforcements and a deficient regional cooperation, the problem of industrial wastes in general and hazardous wastes in particular will continue to cause major health, environmental and developmental challenges in the Region (Al yousfi, 2002).

4.2 Hazardous Waste Management approach in Egypt

The main sources of hazardous waste in Egypt are, Industry, Petroleum activities, Laboratories, Agriculture, Mining, Clinics and Hospitals, Public Services and Electronic waste.

4.2.1 Framework of Egyptian Environment Law

The framework of Egyptian Environment law tackles the management of Hazardous waste in several phases

Generation Phase:

- Minimize rate of generation and characterize the waste qualitatively and quantitatively.
- There are: 300,000t/y generated from the industrial sector .and 25,000t/y generated from hospital and health care firms.

Collection and Storage Phase:

- Identification of storage site.
- Storage time limit.
- Labels.

Transportation Phase:

- Authorized trucks.
- Routes.
- Trucks cleaning.
- Civil Defense.

Treatment Phase:

- Sites selection.
- Sites characteristics.
- Treatment and Disposal Technologies (Physical, Chemical, Biological, Incineration).

4.2.2 Treatment of recyclable HW

- Alternative fuel.
- Recycling of Organic Solvents, acids and bases, old catalysts and used oils
- Reuse of ferrous and non ferrous metals.

4.2.3 Treatment of non recyclable HW

- Injection
- Permanent storage
- Biological treatment
- Incineration

4.2.4 Hazardous waste management experience

The Hazardous Waste Management Project (HWMP) in Alexandria, A Finnish – Egyptian Cooperation Project, has been established for the designing and building of a site for the treatment of inorganic hazardous waste in Nasreya, Alexandria, including additional operations within the field of hazardous waste management. Outlined below is a description of what has been achieved and what the plans are until the end of the project period (September 2006). In addition, a proposal is discussed, although as yet unofficial, concerning the entire usage of the site of Nasreya within the next 10 – 15 years.

The first phase aimed at assisting the Governorate of Alexandria and the Egyptian Environmental Affairs Agency (EEAA) to establish a sustainable management system for industrial hazardous waste and construct a special landfill and pre-treatment facilities for 2-3 categories of hazardous waste in Alexandria. The project was to demonstrate how to enforce the environmental law and manage hazardous wastes with environmentally sound and financially viable practices. The expected results of the first phase as specified in the Project Document were:

- A permanent Hazardous Waste Management Unit in Alexandria is established;
- Licensed and safe services for collection and transport of hazardous waste are available;
- Licensed treatment services for hazardous waste are available;
- A hazardous waste storage facility is available;
- A licensed landfill for controlled disposal of hazardous waste is available;
- A significant part of the major hazardous waste generators have joined the service system;
- A plan for extending the services to all main industrial hazardous waste groups is made.
- Hazardous Waste Minimisation and Handling at Source.
- Hazardous Waste Administration.
- Hazardous Waste Recycling, Treatment and Disposal Facilities.
- Hazardous Waste Collection and Transportation Systems.
- Laboratory Services.

The plan shall be based on “polluter/waste producer pays” principle, minimizing public subsidies. Waste producer pays principle can be adopted gradually with a fixed time schedule for achieving full financial sustainability.

The project has defined a price structure for the treatment of HW to be disposed in the landfill. “Polluter pays principle” has been adopted, the treatment price payable by the waste producers includes all costs arising from the operations, as well as depreciations of the investments.

Investment costs are not included in the treatment price as the project was a grant supported scheme by the Finnish Government.

4.2.5 Plant Layout

The Plant consists mainly of the following:

1- Physical/Chemical Treatment unit, with a capacity of the 4000 tons/year.

This facility will treat liquid and sludge inorganic hazardous waste such as: galvanic baths containing heavy metals, acidic and alkaline liquids and sludge, and waste containing chromates (hexavalent chromium).

2- Solidification-Stabilization Unit

This system is basically a cement mixer used to stabilize certain inorganic waste too soluble or dusty to be placed in the landfill without additional treatment. The waste is mixed with regular cement and in certain cases additional chemicals may be added to reduce the solubility of the waste.

3- Storage area for inorganic waste

A covered storage unit will be constructed for the inorganic waste. The area is about 230 m² and it will be divided in two parts, one for drums and containers containing waste, and the other for equipment and materials needed in the operations.

4- Transfer station for organic hazardous waste

A covered area of about 230 m² will be constructed for the needs of transferring organic hazardous waste to a suitable treatment facility, if available (e.g. cement kiln, oil recycling system, solvent distillation). *Organic hazardous waste will only be received in cases where a final treatment address is known prior to receiving the waste.*

4.2.6 Lessons learned

The lessons learned from the Egyptian experience are:

1. The statutory HW lists of the competent authorities as well as the technical and administrative guidelines prepared by the EQA will be essential for the development of hazardous waste management.
2. Based on an operating HW management system, the development of the fee system towards the Polluter Pays Principle, in the future, have to provide sufficient funds to cover both operational running costs as well as capital costs for the maintenance and further development of HW related activities.
3. Upgrading of the laboratory and training of its staff are considered important sustainability factors.
4. For good implementation, effective communication and flow of information between the different stakeholders is essential.
5. The expertise of an international HW operator can be used to begin a national HW project in Palestine.

4.3 Hazardous Waste Management in Jordan

Jordan produced 25,600 tons of industrial HW in the year 2002, and by 2015 it is anticipated to increase to 52,780 tons annually. The main components are used oils and heavy metals (Alfayez, 2005).

It also produce 3,470 tons of medical waste in 2002, estimated to increase to 5,100tons annually by 2015 (Alfayez, 2005).

Most hazardous wastes are stored at the production site or dumped with domestic solid waste into landfills not designed to receive hazardous wastes. There is a Lack of accurate data regarding quantities and types of hazardous waste.

4.3.1 Legal Framework

The following are the main sources of HW legislations in Jordan:

- Public Health Law No. 54 (2002) requires monitoring of all medical waste generated by the country's medical facilities.
- Regulation No. 43 (1999), The Management and Circulation of Harmful and Hazardous Materials.

- Law No. 12 (1995), The Law on Environmental Protection, provided some guidance on hazardous waste since it included requirements to protect the environment (air, soil and water). This law was replaced in early 2003 with Environmental Protection Law No. 1. The new law's requirements for hazardous industrial waste management are more precise.

4.3.2 Institutional Framework

The General Corporation for Environmental Protection which, until recently, was responsible for the administration of all matters concerning hazardous waste, has been dissolved and its responsibilities have been transferred to the new Ministry of the Environment created in January 2003.

The Ministry of Health through its Environmental Health Directorate regulates the management of hazardous medical waste.

4.3.3 Disposal Facilities

A central hazardous waste treatment and disposal facility is in the final planning stages. Its proposed location is in the Tuba region.

The initial storage capacity of the proposed facility will be minimal (around 3,000 tons). The next phase of the project, adding the incinerator and the wet chemical treatment plant, will provide additional treatment capacity of 15,000 to 30,000 tons per year. The construction costs are estimated to US\$15- 20 million. An additional amount of US\$10 million is also needed to construct a road to link the Amman-Aqaba highway to the site.

4.3.4 Overall Assessment

- A monitoring and reporting mechanism should be established to estimate the quantities of hazardous waste produced in the country, to better understand treatment and disposal practices and to identify the most important hazardous waste issues requiring urgent attention.
- Private sector involvement in hazardous waste management should be encouraged through incentive measures.
- There is an urgent need to develop a comprehensive regulatory framework for hazardous waste with clear and realistic standards applicable to all industrial facilities in Jordan and taking into consideration regional standards. Issuance of specific standards and control limits on key hazardous waste such as heavy metals and

persistent organic pollutants (POPs) and pesticides should be emphasized.

- For hazardous industrial waste generators, provide in plant information and awareness on hazardous waste management, reduction and cleaner production.
- Cooperation with neighboring countries in the field of hazardous waste management, through the METAP program, should be improved. For instance, beneficial cooperation can be achieved through training and awareness program development and data, experience and knowledge sharing.
- A formal and intensive capacity building program for Ministry of Environment and relevant staff of other ministries in Amman and in all regional offices should be developed and implemented. Training areas include:

- Health risks associated with pollutants.
- Waste minimization techniques and recycling technologies and approaches.
- Treatment technologies and disposal safety measures.
- Legal and regulatory environment.

4.4 Hazardous waste management in Israel

Hazardous waste generation in Israel has been estimated to be 300000 tons in 2003.

4.4.1 Legislation

As mentioned in chapter 3 the main source of HW legislation in Israel are:

Hazardous Substances Law

The law regulates holders of hazardous substances including generators of hazardous waste, transporters, treatment and recycling sites, transit stations and disposal sites.

Hazardous Waste Import & Export Regulations 1994

Israel ratified the Basel Convention on the control of trans-boundary movements of hazardous wastes and their disposal, in December 1994. Import and export are implemented accordingly.

Hazardous waste Disposal Regulations 1990

Hazardous waste must be disposed of at a central treatment facility “Ramat Hovav” and for that a special permit is needed for shipping the waste for recycling and treatment.

4.4.2 Distribution of the Treatment of Hazardous waste

Figure (4.1) shows the percentage of HW treatment and recycling in Israel 2003. The major percentage (59%) is disposed, and 39% are recycled.

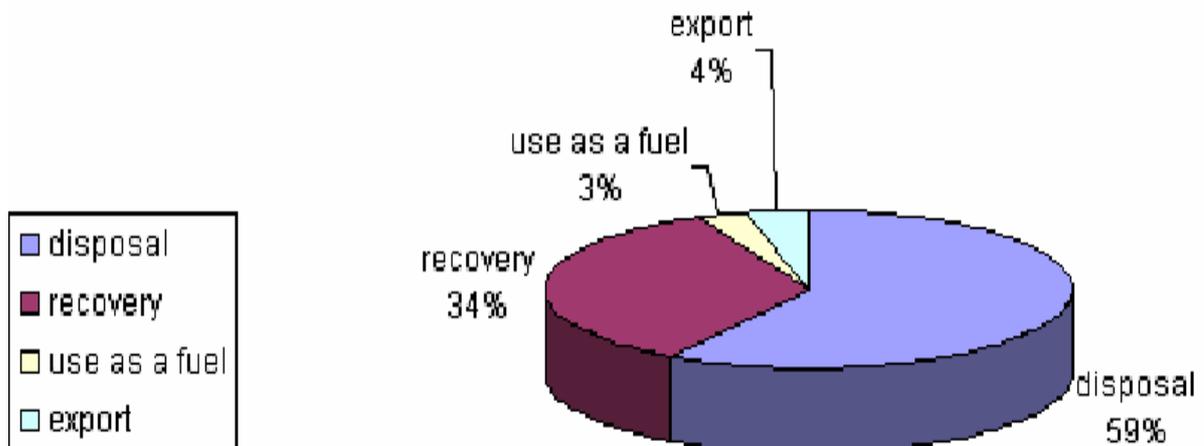


Figure (4.1) Distribution of the Treatment of Hazardous waste (IME, 2003)

4.4.3 Reduction at Source

An Initiative for cleaner production is taking place in Israel to reduce HW at source, such as the recovery of acid at acid production facilities.

4.4.4 Recovery Operations

In 2003, recovered hazardous wastes were 108,000 tons, where one third reused, 8% used for energy generation, and the rest recycled.

4.4.5 Reuse and Recycling

Example of reuse of HW are:

1. Used acids for the production of fertilizers; phosphoric acid from phosphate rock.
2. Alumina oxides and calcium fluoride as supplement to the raw material in the production of Portland cement clinker.
3. Solvents reclamation
4. Precious metals (gold, silver)

5. Metals (Zn, Cu, Pb, Sn, W)
6. Used oil

4.4.6 Disposal

The total amount of disposed hazardous wastes was 115,000 tons in (2002) and 174,000 tons in (2003).

The most common method is land filling, and most disposal treatments are done at Ramat Hovav.

4.4.6.1 Ramat Hovav HW treatment and disposal site

Ramat Hovv, located in the Negev Desert about 12 km South of Be'er Sheva, was designated as a National disposal site for HW in 1977. Geological, hydrological and demographic factors led to the selection of this location. The original plan for Ramat Hovav envisaged its operation as a treatment plant and not merely a dumping ground. However, from the time of the site opening in 1979 to 1987, no wastes that arrived at the site were treated. In 1982, the site was closed after many mishaps. In 1988, the first neutralization facility began operating at the site. Meanwhile the mishaps continued, including a series of fires, ultimately leading to the sacking of the site manager in 1989. The site was reopened in June 1993.

The quantities of HW which reached the site increased from 7 000 metric tons (mt) in 1985 to 25 000 mt in 1988, to 44000 mt in 1989, 40000 mt in 1991, and 48500 mt in 1993. Only about half of the HW produced annually reaches the site. The apparent decline between 1989 and 1991 is due to an in house recycling by a large number of manufacturers of pesticides.

In the year (2003) some 13000 mt of HW arrive at Ramat Hovav annually (IME, 2003). No clear explanation for the decrease of this amount could be found. Most of the wastes reaching Ramat Hovav come from industrial plants in the vicinity. Many producers of HW throughout Israel, some generating as little as one to thirty mt of HW annually, still are not treating or disposing of their HW as required by regulations.

The wastes at Ramat Hovav are divided into three categories: inorganic wastes, solid wastes, and organic wastes. Inorganic wastes are treated in a chemical-physical plant, where they are neutralized and detoxified. These processes produce an aqueous solution of salts, which are transferred to evaporation ponds. These ponds are sealed with polyethylene sheets, according to U.S. EPA standards. They are controlled by a drainage system

with a monitoring well, in order to control leakages. The water is evaporated from the ponds by solar energy and the salts precipitate.

Non-leachable solid wastes are disposed of in a secured landfill, which is sealed and controlled according to the U.S. EPA standards.

The plant also recycles certain materials. Copper oxide is produced from the printed circuits industry and is sold as a secondary resource to industry. Bisulphate is produced from thionilchloride wastes and used in the plant as a reagent for another treatment.

The environmental situation around the site has dramatically deteriorated over time. The rock subsoil is fissured, leading to penetration of poisonous materials into the aquifer and subsequently In the Besor stream, leading to a die-off of most of the vegetation. The area is inhabited by over 11 000 people. Odour nuisance and complaints of respiratory tracts are common.

Due to the series of mishaps and the environmental pollution around the site, there are plans to close the site and open another HW treatment and disposal site elsewhere. The organic HW at Ramat Hovav (some 40000 mt stored in barrels), which accumulated there over time, is to be incinerated, and after decommissioning the site will be cleaned, neutralized and covered.

4.4.6.1.1 Distribution of Hazardous waste Treated in Ramat Hovav

The figure (4.2) shows the distribution of hazardous waste that is treated in Ramat Hovav.

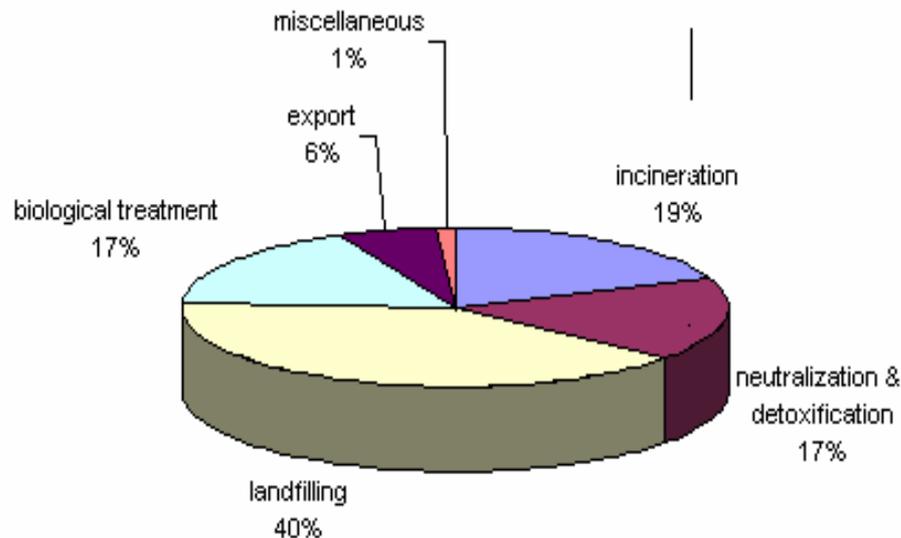


Figure (4.2) distribution of hazardous waste treated in Ramat Hovav (IME, 2003)

4.4.7 Central Treatment Facilities

Central treatment facilities besides Ramat Hovav employ the following:

- Neutralization (acids and bases).
- Physico-chemical treatment (cyanid, chromates, heavy metal).
- Emulsion and water-oil mixture treatment.
- Steam Stripping (light organic).
- Desalination.
- Evaporation and Precipitation Ponds

4.5 Management Comparison

As seen from the previous review of HW management in the region, it is evident that countries in the region have various levels of HW management.

Egypt has relatively new established procedures for HW management including collection storage treatment and disposal. A major project was established in Alexandria to construct a HW management facility to receive,

treat and dispose HW in safe and licensed manner with some recycling are taking place. This is considered as, although large, as a pilot (model) scheme for HW in Egypt.

While Jordan is at the beginning of HWM road, most HW is stored at production sites and other waste is dumped with municipal waste. But a central HW facility is underway in the Tuba region to handle the 26,000 tons of HW generated in Jordan every year.

Israel has gone some way on the road of HWM where a well regulatory system is in place. Also a good experience in the various stages of HWM from collection, treatment and disposal are managed robustly in the central facility at Ramat Hovav. Approximately one third of all HW is recovered for further use as well as 3% are being used as a form of fuel. Although a significant portion of Israeli HW is illegally smuggled and dumped in the West Bank, such as in Tulkarm, Nablus, Hebron and former Israeli settlements in Gaza Strip

Chapter 5

Status of HW Management in the Gaza Strip and West Bank

5.1 Introduction

In Palestine, there are inadequate procedures for hazardous waste management, and there is no inventory for hazardous waste or HW identification list. So it is difficult to determine which waste is hazardous and non hazardous. There is a hazardous waste cells in Gaza used for expired medicine and chemical laboratory waste, and is currently operating. The concrete cell has a life span of eight years only and the chemical wastes involved are both liquids and solids. Meanwhile there are no facilities in the West Bank for temporary storage, treatment or long term storage of hazardous waste (UNEP, 2003; EQA, 2005).

It is difficult to estimate the amounts of hazardous waste generated in the West Bank and Gaza Strip, in part because of the absence of separation, segregation and inventories. In the West Bank, and Gaza Strip the amount has been estimated at 2,500 tons per year. This amount refers to waste that has been clearly identified as hazardous. The true amount is likely to be much higher (UNEP, 2003).

5.2 Hazardous Waste Types

5.2.1 Industrial HW from West Bank and Gaza Strip

Industrial hazardous waste in the Gaza Strip is generated mainly from print and photography shops, from the use of printer toner, chemicals, and film degrading. Mechanic workshops produce waste oil, grease, break fluid and batteries (EQA, 2005).

The textile industry generates waste from dyes, chemicals, oil, grease, and other chemicals. Paper factories use bleach, glues, and auxiliary chemicals. Other industries producing hazardous waste include construction materials, woodwork, plastics, batteries, leather tanning, metalwork, and food processing (UNEP 2003).

In Gaza Strip the estimated amount of hazardous waste generated annually from the industries is 803 tons. At present, management of hazardous waste is impeded due to absence or lack of centralized facilities for recovery and treatment of waste, scarcity of information on source of hazardous waste and lack of experience lead to the wide spread practices of illegal dumping with municipal wastes (Abo-Qumbos, 2002), and what make things worse, is the presence of semi-industrial areas that are distributed among residential areas

because of the absence of industrial areas during the occupation period and due to the lack of recourses (Wadi and Nashwan, 2001)

There are many industries in the West Bank and the Gaza Strip that generate hazardous waste and they are as follows (UNEP, 2003):

5.2.1.1 Food processing:

Large amounts of liquid and solid waste are generated from food processing and the contents of the generated waste are (UNEP, 2005):

- Cleaning and blanching agents,
- Salt and suspended solids such as fibers and soil particles.
- Pesticide residues washed from the raw materials

5.2.1.2 Textiles Industry:

It is estimated that the West Bank has 71 textile-dyeing facilities. The textile industry uses vegetable fibres such as cotton, animal fibres such as wool and silk; and a wide range of synthetic materials such as nylon, polyester and acrylics. Polyester accounts for about 50% of synthetics (UNEP, 2003; EQA, 2005).

The Hazardous substances used for textile are shown in Table (5.1) (UNEP, 2005).

Table (5.1) Hazardous Substances Used for Textile (UNEP, 2005)

-Ethylene glycol	-Methyl ethyl ketone
-Toluene	-Nonylphenol polyethylene glycol ether
-2-Butoxyethanol	-Bis(2-ethylhexyl) phthalate
-Tetrachloroethylene (halogen)	-Antimony (and its compounds)
-Nitrilotriacetic acid (and its salts)	-Lead (and its compounds) (heavy metal)
-Isopropyl alcohol brominated flame-retardants (Halogen)	

And the textile waste characteristics are explained in Table (5.2) (UNEP, 2005):

Table (5.2) Textile Waste Characteristics (UNEP, 2005)

-Greases including yarn (BOD/COD)	-Waste dye solutions: acetic Acid, caustic soda (inorganic waste)
-Copper (heavy metal)	
-Pesticides	

There are 16 textile factories in GS, and wastewater from the textile may cause pollution problems to the environment (EQA, 2005).

5.2.1.3 Tanneries:

Tanning is a complex combination of mechanical and chemical processes, and the heart of the process is the tanning operation itself in which organic or inorganic materials become chemically bound to the protein structure of the hide and preserve it from deterioration. There are 19 tanning facilities within the West Bank and 10 of them are in Hebron. The substances generally used to accomplish the tanning process are chromium compounds (UNEP, 2003). The annual liquid waste release from tanneries is 30,000 m³, and annual solid waste release from tanneries is: 690 tons.

The major hazardous substances and wastes are listed in Tables 5.3 and 5.4 below.

Table (5.3) Hazardous Substances Used in Tanneries (UNEP, 2005)

-Ethylene glycol	-n-Butyl alcohol
-Toluene	-Sulphuric acid
-2-Ethoxyethanol	-Dibutyl phthalate
-2-Butoxyethanol	-N-Methyl-2-pyrrolidone
-Bis(2-ethylhexyl) phthalate	-Nonylphenol polyethylene glycol ether
-Xylene (mixed isomers)	-Chromium (and its compounds)
-Formaldehyde	-Sulphuric acid
-Formic acid	
-Isopropyl alcohol	

Table (5.4) Hazardous Waste Generated from Tanneries (UNEP, 2005)

-Fleshings and lime split waste	-Sludges free of chromium
-Liming waste	-Waste tanned leather (blue sheetings, shavings, cuttings, buffing dust) containing chromium
-Degreasing wastes containing solvents (without a liquid phase)	-Wastes of dressing and finishing
-Tanning liquor containing chromium	-Wastes from chemicals used in leather processing
-Tanning liquor free of chromium	
-Sludges containing chromium	

5.2.1.4 Shoe manufacture:

A range of hazardous substances are used in the manufacturing of shoes, including the process of shoe/sole surface preparation, and Hazardous substances usually used in shoes factories are as in Table (5.5).

Table (5.5) Hazardous Substances Usually Used in Shoes Factories (UNEP, 2005)

-Ethylene glycol	-Sulphuric acid
-Toluene	-Dibutyl phthalate
-2-Ethoxyethanol	-N-Methyl-2-pyrrolidone
-2-Butoxyethanol	-Nonylphenol polyethylene glycol ether
-Bis(2-ethylhexyl) phthalate	-Chromium (and its compounds)
-Xylene (mixed isomers)	-Methyl ethyl ketone,
-Formaldehyde	-Sulphuric acid
-Formic acid	-mineral spirits,
-Isopropyl alcohol	-isopropanol,
-Heptane,	
-n-Butyl alcohol	

5.2.1.5 Metal construction:

The metal workshops use a range of hazardous substances, such as heavy metals, phenol (and its salts), dioxins, furans, cyanides, and several dangerous halogenated hydrocarbons. Estimates of annual solid hazardous waste generation is 1,016 tons and liquid hazardous waste generation is 1,200 tones (UNEP, 2003). There are many kinds of metal construction activities in Palestine such as Iron, Aluminum and Copper. In Secondary Aluminum production materials used are: scrap, chips, and dross. The pre-treatment to remove undesired substances of scraps is done by shredding, sieving,

magnetic separation and drying. The Process is done used is smelting in rotary kilns under a salt cover. Salt slag can be processed and reutilized, and for removal of magnesium from the melt, hazardous substances such as chlorine and hexachloroethane are often used, which may produce dioxins and dibenzofurans.

5.2.1.6 Wood furniture:

Wood furniture manufacturing process involves protective properties to wood and painting. Three main types of preservatives are used:

- water based,
- organic solvent based
- and tar and oil..

Different oil base and solvent base paints are commonly used in furniture paint. These solvents, paints and oils produce hazardous waste. Furniture workshops owners, storage facilities and individual decorators have to take care of the use, storage and disposal of these materials (EQA, 2005).

5.2.1.7 Electronic component manufacture:

Although this industry is very limited in Palestine it, there are some hazardous wastes generated from this industry as shown in Table (5.6) below (UNEP, 2005).

Table (5.6) Hazardous Waste Generated from Electronic Component Manufacture (UNEP, 2005).

-alkaline solutions or solids	-silted oil from spark Edoder filter
-aluminium	-wire drawing lubricant with copper
-beryllium compounds- TV's	cleaning mixture
contaminated kerosene	-glycerol
-PBB's - dielectric fluids	-mill scale
-plastic/metal transistors or	-oily rags
resistors	-paint slurry from wet back
-polystyrene granules and foam	scrubber
-selenium based photo receptor	-used motor oil
from photocopy drums	-waste shellac
-thallium - specialised electrical	-waste solvents
equipment	-cutting fluids, cutting oil
	-vacuum pump oil, hydraulic oils
	-used gear oil

5.2.1.8 Electroplating and surface-coating industry

Electroplating is an electrochemical process that involves the deposition of a thin protective layer onto a prepared metal surface. The process involves pretreatment (cleaning, degreasing and other preparation steps), plating, rinsing and drying. The cleaning and pretreatment stages involve a variety of solvents (often chlorinated hydrocarbons) and surface stripping agents including caustic soda and a range of strong acids. The plating solutions are acidic or alkaline and may contain complexing agents such as cyanides. The annual solid and liquid waste generation are 1.8 tons solid waste and 96 tons liquid waste for all electrical industry (UNEP, 2003).

There are three electroplating factories in the GS. Its activity is electroplating metals (e.g. copper, iron and aluminum) with chromium, nickel, copper or silver (EQA, 2005)

Coating of surfaces for decoration and/or protection, and coating operations include spraying, dip coating, flow coating, roller coating and electro coating. Various type operations include spraying using air-atomized, airless-electrostatic or hot-spray methods.

The HW generated from Surface-Coating Industries are shown in Table (5.7) (UNEP, 2005).

Table (5.7) HW Generated from Surface-Coating Industries (UNEP, 2005)

-cyanidic (alkaline) wastes containing heavy metals other than chromium	-phosphatizing sludges
-cyanidic (alkaline) wastes which do not contain heavy metals	-wastes and sludges from nonferrous hydrometallurgical processes
-Cyanide free wastes containing chromium	-sludges from copper hydrometallurgy
-acidic pickling solutions	-sludges from zinc hydrometallurgy (including jarosite, goethite)
-acids not otherwise specified	-wastes from the production of anodes for aqueous electrolytical processes

5.2.1.9 Paint industries

Although this industry is very limited in Palestine it is worth mentioning that the paint manufacturing process involves the mixture of different agents such as pigments and solvents: ethylbenzene and similar organic compounds, various acids, metals acrylates, alcohols. The estimated amount

of solid and liquid HW generation from this industry is 8 and 201 tons respectively (UNEP, 2003).

The hazardous wastes generated from Paint industries are:

- wastes from paint and varnish
 - halogenated solvents
 - free of halogenated solvents
- waste from water based paints and varnishes
- powder paints
- hardened paints and varnishes
 - halogenated solvents
 - free of halogenated solvents
- aqueous sludge containing paint or varnish
- aqueous suspensions containing paint or varnish
- paints, inks, adhesives and resins

5.2.2 Used oil

Used oil is any oil that has been refined from crude oil or from any synthetic hydrocarbon oil that has been used, and as a result of such use has become unsuitable for its original purpose due to the presence of impurities or the loss of original properties.

Types of mineral oils:

- Engine oil – includes crankcase oils from gasoline, and diesel engines
- Brake fluid
- Gear oils
- Transmission fluids
- Hydraulic oils and fluids
- Compressor oils
- Refrigeration oils
- Industrial process oils
- Electrical insulating oil – except oil likely to contain PCBs
- Neat metalworking fluids and oils
- Heat transfer oils.

Classification of oil wastes:

- automotive engine lubrication and circulating oils – including engine oil, transmission fluids, final drive and drive-line fluids, brake fluids and power steering fluids, hydraulic oils, turbine oils, heat transfer oils, compressor oils, industrial gear oils.
- used metal working/cutting oils – including neat cutting, grinding, machine, rolling, quenching and coating oils, and undiluted soluble metal-working fluids (these should never be mixed with anything).

- electrical insulating oils. If these contain PCBs or other chlorinated organics they must not be mixed with any other oil.

Used oil release data:

- 2, 500 m³ per year
- according to the Ministry of Transportation (MOT) the number of vehicles are:
 - West Bank: 165 000
 - Gaza : 53 500
- Quantity of oil per car per year: 10 liters (average)
- Used mineral oil is imported from Israel and recycled as lubricant in stone factories and metal processing.

No collection systems and no adequate treatment capacity are available in the GS and the WB.

Used mineral oil is also reused thermally as secondary fuel.

5.2.3 Industrial Zones in settlements (ARIJ, 2004)

There are at least seven industrial zones in the settlements in the West Bank. These industrial zones occupy an area of approximately 302 hectares. . Table (5.8) lists the Jewish industrial zones in the West Bank and the area each one of them occupies.

Table (5.8) Jewish Industrial Zones in The West Bank (ARIJ, 2004)

Industrial Zone	District	Area (hectare)
Hinnanit	Jenin	10.99
Barqan	Nablus	14.87
Ariel	Nablus	14.84
Ma'ale Efrayim	Nablus	2.58
'Atarot	Jerusalem	145.78
Mishor Adummim	Jerusalem	109.92
Qiryat Arba'	Hebron	3.35
Total		302.00

Israel has moved many of its polluting industries from places inside Israel to areas near the 1967 border or inside colonies. For example, a pesticide factory in Kfar Saba which produces dangerous pollutants has been moved to an area adjacent to Tulkarm. The wastewater from these factories has damaged the citrus trees and polluted the soil in the area, in addition to the damage that it may cause to the groundwater.

It is estimated that at least 200 Jewish industrial factories are located within the West Bank. These factories are either located in the Jewish industrial zones or inside Jewish colonies. Information about Jewish industrial activities in the West Bank is scarce. Some of their products are identified, but detailed information on quantities produced, labors and waste generated is not available. The major industries within these industrial zones include: Aluminum, leather tanning, textile dyeing, batteries, fiberglass, plastics, and other chemical industries. (Table 5.9) lists some Jewish industries in the West Bank

Table (5.9) Some Jewish Industries in The West Bank (ARIJ, 2004)

District	Industrial Location	Industry
Nablus	Barqan	Aluminum, fiberglass
		plastic, electroplating
	Allon Morieh	Aluminum, food canning and textile dyeing
	Shilo	Aluminum and leather tanning
Ramallah	Halmeesh	Fiberglass and leather tanning
	Givout hadasha	Rubber
	Nili	Aluminum
	Shelta	Fiberglass and plastic
	'Atarot	Aluminum, cement, plastic, food canning and others
Hebron	Qiryat Arba'	Winery, building blocks, tiles and plastic

5.2.4 Medical Waste in West Bank and Gaza Strip

Medical waste covers several categories: infectious waste, pathological waste, pharmaceutical waste, genotoxic waste, chemical waste, wastes with high heavy metal content, pressurized containers, and radioactive waste. Such wastes may be generated at hospitals, clinics and other health care facilities, but also at research laboratories, mortuaries and blood banks. The total estimated produced by the non-public medical establishments were about 432 tons including 418 tons in the WB and 14 tons in the GS (PCBS, 2000). The medical (health care) waste will be discussed in more details later.

5.2.5 Agriculture Waste

Agriculture relies heavily on the use of fertilizers and pesticides. Severe misuse and uncontrolled use of pesticides and fertilizers are reported in the WB and the GS. According to the Ministry of Agriculture, hazardous wastes generated by agriculture consist of:

-empty pesticide containers, rinse waste from container and application equipment and contaminated greenhouse plastics.

According to the Environment Quality Authority reports, in the West Bank and Gaza Strip, a total of 123 pesticides are currently used, some of which are internationally suspended, banned or regulated by the Stockholm Convention. Although the Palestinian Authority is not a party to the Stockholm Convention, the Environment Quality Authority prohibits the passage of internationally banned chemicals. Despite these efforts, illegal chemicals still may find their way into the market. DDT is reportedly used for fishing and used oils are employed as herbicides.

5.2.6 Household Hazardous Wastes (HHW)

It consists of unusable or unwanted household products that can harm human health or the environment if improperly disposed.

Common categories of HHW include:

- **Ignitable wastes:** easily catch fire (e.g., paint thinner, brush cleaner, gasoline, kerosene, fuel oils, and oil-based paints);
- **Toxic wastes:** poisonous or harmful if swallowed, inhaled or exposed to the skin (e.g., pesticides, wood preservatives, paint strippers, latex paint which contains mercury, and spot removers);
- **Corrosive wastes:** acidic or alkaline and can corrode or cause chemical burns (e.g., battery acids, pool acids, concrete cleaners, and drain, oven and toilet bowl cleaners).

Examples of HHW

- Latex and oil paints in any size can, paint can be liquid or dried.
- Aerosol cans of any kind
- Paint-related products, such as paint thinner, stains, turpentine, polyurethane, polishes and acetone
- Automotive products, including motor oil, brake fluid, antifreeze and gasoline
- Any battery, from car and truck batteries to button batteries, lead acid batteries, alkaline batteries, nickel cadmium batteries and lithium batteries
- Propane gas cylinders, 20 pound and 30 pound
- Mercury debris (including thermometers)
- Gardening supplies, such as solid or liquid pesticides, insecticides, herbicides and fertilizers
- Household cleaners, such as bleach, oven cleaners, bathroom cleaners and any other alkaline/corrosive or acid cleaner
- Polychlorinated biphenols (PCBs, for example, electrical switches and ballasts)
- Fluorescent bulbs

5.2.7 Used Tyres Generation

There are obvious problem in used tyre generation in the WB and GS approximately 3 million tyres are generated every year (UNEP, 2005). Thus creating a serious waste problem. These tyres can be recycled and reused in different ways such as:

- Rubber recycling
- Energy recovery
- Landfilling and stockpiling
- Construction applications
 - lightweight fill for embankments and retaining walls
 - leachate drainage material at municipal solid waste landfills
 - alternative daily covers at municipal solid waste landfills
 - insulating layers underneath road surfaces and behind retaining walls.

5.2.8 Asbestos

Asbestos is the name given to a group of minerals that occur naturally as masses of strong, flexible fibers that can be separated into thin threads and woven. There are different natural types including:

- Chrysotile
- Amosite

- Crocidolite
- Anthophyllite

These fibers are not affected by heat or chemicals and do not conduct electricity. For these reasons, asbestos has been widely used in many industries. It has carcinogenic effects when inhaled through human lungs and it cause lung cancer. The main uses of asbestos are:

- Construction: strengthening cement and plastics, insulation, fireproofing, sound absorption.
- The shipbuilding industry: insulate boilers, steam pipes, hot water pipes, nuclear reactors.
- Automotive industry : vehicle brake shoes and clutch pads.
- Asbestos cement sheet and pipe products used for water supply and sewage piping, roofing and siding, casings for electrical wires, fire protection material, chemical tanks, electrical switchboards and components, and residential and industrial building materials;
- Friction products, such as clutch facings; brake linings for automobiles, railroad cars, and airplanes; and industrial friction materials;
- Products containing asbestos paper, such as table pads and heat-protective mats, heat and electrical wire insulation, industrial filters for beverages, small appliance components, and underlying material for sheet flooring;
- Asbestos textile products, such as packing components, roofing materials, heat- and fire-resistant clothing, and fireproof draperies;and
- Other products, including ceiling and floor tile; gaskets and packings; paints, coatings, and sealants; caulking and patching tape; and plastics.

5.2.8 Radioactive Waste

There are some sources of radioactive waste, including radioactive hospital waste, potentially radioactive waste from industry, lightning rods, fire alarm equipment, and potentially radioactive material from Israeli military sources.

Chapter 6

Appropriate Hazardous Waste Management System

6.1 Introduction

According to the existing situation analysis of the HW in WB and GS the following management system is recommended.

6.2 Hazardous Waste Management Hierarchy

Hazardous waste management is defined as the handling, storage, transportation, processing, treatment, recovery, recycling, transfer and disposal of hazardous waste (Humboldt State University, 2004). "Hazardous waste management" means the systematic control of the collection, source separation, storage, transportation, processing, treatment, recovery, and disposal of hazardous waste (NY, 2002) the following figure (6.1) shows the management track for hazardous waste.

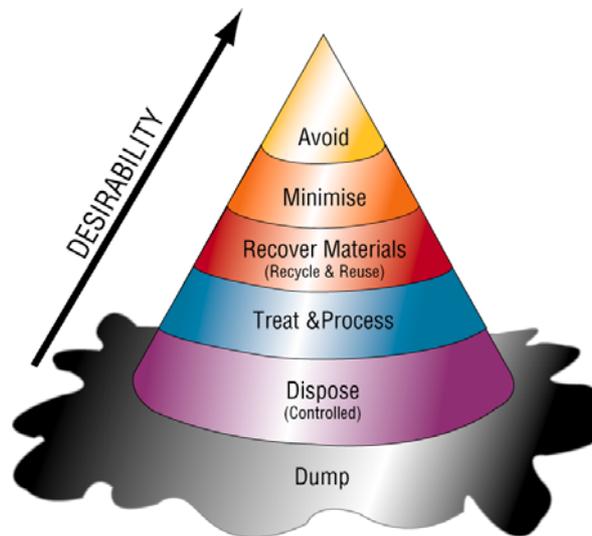


Figure (6.1) Management Track for HW
Source: David C Wilson 1993, 1997, 2001

6.2.1 Waste avoidance by virtue of cleaner production

Industries should initiate policies and plans for cleaner production processes in order to avoid and minimize the production of raw materials waste and other by-products.

6.2.2 Separation and Segregation

Separating hazardous wastes from non-hazardous wastes is required as the cost for safe management of hazardous wastes are much higher than those

for non-hazardous waste. A facility should avoid contaminating non-hazardous waste with hazardous waste because mixing of wastes will not only increase waste management costs but can limit disposal options as well (USEPA, 2000).

Segregation means taking the necessary steps to prevent the mixing of chemically unrelated or incompatible materials in the same storage unit (USEPA, 2001). Segregation is important because it enhances safety and reduces subsequent treatment costs. For example, ignitable wastes should be separated from oxidizers or sources of ignition to prevent fire or explosions. Solvents capable of forming peroxides should be separated from other wastes as peroxides are highly explosive compounds sensitive to heat, friction, impact, and light (Humboldt State University, 2004). Segregating wastes within the same material type is also a good idea as it streamlines the waste management process. When wastes that will ultimately be subject to the same treatment are consolidated, treatment costs generally are lower (USEPA, 2001).

Some general rules that can be applied regarding segregation include (USEPA, 2001):

- Segregating non-halogenated waste solvents from halogenated solvents, such as separating acetone, a non-halogenated solvent, from carbon tetrachloride, a halogenated solvent;
- Separating physical waste states (i.e., liquids, solid), such as separating rags and solvents by allowing the solvent to drain from the rag by gravity or wringing;
- Separating metal-containing waste from non-metal containing waste, such as separating solvents used to remove grease from plastic surfaces and solvents used to clean newly-milled metal parts;
- Separating highly toxic waste from less toxic waste, such as separating PCB-contaminated transformer oil from used vehicle oils;
- Separating waste types (i.e., flammables, corrosives, oxidizers, poisons etc.); and
- Separating acids and bases.

6.2.3 General Storage

Facilities generate waste as a result of manufacturing or using any number of products including agricultural chemicals, inorganic and organic chemicals, dye stuffs, paints, pesticides, specialty chemicals, plastics and petrochemicals, and drugs and pharmaceuticals. Some of these wastes will be non-hazardous and some will be hazardous. For those wastes qualifying as hazardous, safe storage can begin immediately after the waste is generated (NY, 2002). A hazardous waste management program can include requirements for capturing wastes immediately on generation, either as they exit a manufacturing process, or when they have ceased being used as products, and storing them in a protective manner (Orloff, 2002).

Storage standards can be influenced by the type of waste. It is crucial that staff handling wastes know what wastes are generated by each process or chemical used onsite. Maintaining a process and chemical-use flowchart is helpful to tracking waste generation (Humboldt State University 2004)

Storage Unit Selection

Storage units typically are selected based upon a waste's chemical properties. For example, generators usually store corrosive materials in a plastic unit to prevent rusting and the potential for leaks that might otherwise occur in a metal unit. If storage in a metal unit cannot be avoided, however, a plastic liner can be added to avoid direct contact between the waste and the unit itself (USEPA, 2000)

Waste quantities also come into play when selecting an appropriate storage unit. For small amounts of waste, a container tends to be more practical and economical. When there is less extra space in a unit, a generator will not be as tempted to fill the extra space with a different, and perhaps incompatible waste stream. Compatible wastes can be consolidated when necessary to fill up a storage unit, and for safety reasons, this should occur in a centralized storage area. (USEPA, 2001)

6.2.4 Transportation

The transportation system should have adequate infrastructure, including roads and vehicles, to ensure the safe transport of hazardous waste. Also, the transportation system should operate under clear and well-defined regulations that are specific enough to be easily understood and followed (Granados and Peterson, 1999). These regulations should be designed to protect the health and safety of drivers, waste handlers, emergency response personnel and the public. All citizens should be made aware of the requirements for the safe collection and transport of hazardous waste in their communities (Hsing, 2003).

The structure of hazardous waste transportation program will depend on a number of factors including:

- The types and quantities of hazardous waste requiring transport;
- Availability of suitable containers (drums, boxes, storage tanks etc.);
- Availability of equipment (e.g., front end loaders to move the containers);
- Availability of trucks, trains, vessels or aircraft capable of safely transporting hazardous wastes;
- The distance and safety of access to facilities where treatment and disposal will occur;
- The safety of transport over roadways and bridges;
- Access to rail transport and the condition of railways for safety during transportation;
- Labelling system should be clear and well known to the public to ensure general safety
- Access to navigable waterways; and
- Availability of aircraft that could be designated safe to transport hazardous waste

6.2.5 HW treatment

Chemical, physical and biological treatment processes are employed to reduce the volume of the waste and render it non-hazardous so as to re-use the waste or dispose of it in a safe manner.“” Some of the most common chemical treatments include cyanide oxidation, chromate reduction, neutralization of acids or bases and heavy metal precipitation. Physical treatment includes removal of hazardous materials by distillation, emulsion breaking, extraction or other physical processes (George Washington University, 2001). The primary purpose of biological treatment is to convert soluble or colloidal organic substrate to CO₂, H₂O and settleable matter that can be removed by sedimentation (EEA, 2000). The application of treatment processes depends upon the available technology and its economic feasibility. More information is needed on what treatment processes exist, what types of wastes can be handled by different processes, what residual and environmental discharges are produced by these processes and what treatment process costs will be incurred.

The hazardous waste treatment technologies may be grouped into the following methods

- Physical treatment
- Chemical Treatment;
- Biological treatment

- Thermal Treatment

6.2.5.1 Physical Treatment

Solidification is a waste disposal process in which a hazardous waste is transformed into a non-hazardous solid product by fixation or encapsulation. In fixation, a chemical or physical process and a solidifying agent is used to solidify the waste. Encapsulation is a process in which the waste is surrounded by a binder after it has been solidified by a chemical agent. This process produces a durable, impermeable and supposedly an environmentally safe product (Trezza and Ferraiuelo, 2002). Solidification has been used to treat various hazardous wastes such as wastes from steel mills, plating and lead smelting plants, food production sludge and sulfur residues (Cullinane, 1986). Solidification has been used solely for treating radioactive waste, even though it has the highest cost compared to other disposal means (Choon-Keun Park, 2000). Currently, the stricter regulations have made solidification a popular choice for waste disposal. Five different types of solidification processes depending on the solidifying agents have been developed. These are silicate and cement based, lime based, thermoplastic based, organic polymer based and encapsulation techniques (Conner, 1990). The process of stabilization/solidification can be classified into the following categories, (Visvanathan, 1996): Cement based solidification, Lime based solidification, Organic polymer techniques and Thermoplastic encapsulation techniques.

Evaporation

Evaporation ponds release the liquids to the atmosphere. Use of evaporation ponds is not considered to be an appropriate technology if the hazardous waste contains volatile organics constituents, or hazardous constituents that may be toxic or dangerous when released to the atmosphere (UNEP, 1991).

6.2.5.2 Chemical treatment

Several chemical treatment procedures are available to destroy hazardous waste or to make it less hazardous thereby preparing it for further processing (Indiana University Bloomington, 2001).

Oxidation: Conventional chemical oxidation processes involving various oxidizing agents such as potassium permanganate, chlorine and hydrogen peroxides have been used for some time to treat polluted water (Patil and Pokhrel , 2004). The main limitation of such processes is such that they can

react with only a limited number of organic materials (UNEP, 1991). Either in the wet oxidation process the suspended and dissolved organic or inorganic materials in aqueous waste streams are oxidized. It is an industrial wastewater treatment technique which has been used to treat waste streams too toxic to be biodegraded but too dilute to be economically incinerated (Indiana University Bloomington, 2001).

Neutralization: In this process acid or base is added to a hazardous waste to achieve a pH of 7 (neutrality). Neutralization does not result in the destruction of a waste; instead it renders it more suitable and less hazardous for additional treatment. The process is applicable to aqueous and non-aqueous liquids, slurries and sludges, and is widely used in waste treatment (Indiana University Bloomington, 2001).

6.2.5.3 Biological treatment

Biological processes involve chemical reactions that take place in or around micro-organisms (UNESCO, IHE, 2004). The organic compounds degradation is carried out by these microorganisms. These processes can be optimized by controlling the amount of dissolved oxygen, adding nutrients and adjusting the concentration of microorganism or influent waste (UNESCO, IHE, 2004). Biological systems can be either aerobic or anaerobic. Anaerobic systems use the bacteria that can only exist in the absence of molecular oxygen. Such systems have slower reaction rates and produce much less sludge than aerobic systems. Biological treatment is one of the most economical alternatives for dilute aqueous waste streams (UNESCO, IHE, 2004).

6.2.5.4 Thermal Treatment

The last option before the ultimate disposal is the incineration (EPA, 2005). Incineration reduces the volume of hazardous waste and destroys the hazardous components to a large extent; however, 100% destruction is yet to be realized. A destruction efficiency of greater than 99.9999% has been accomplished for dioxins, PCBs and different toxic and hazardous wastes with infrared incineration (NY, 2002). Treatment technologies that include chemical, physical and biological treatment technologies also reduce the volume of hazardous waste and render them non-hazardous (EPA, 2005). The EPA has conducted tests at over 50 different full-, pilot-, or laboratory-scale hazardous waste thermal destruction facilities in the United States and Europe (NY, 2002). The results of most of these performance tests have shown that properly designed and operated combustion processes are capable of achieving or exceeding the EPA hazardous waste destruction and

emission standards (NY, 2002). Currently incineration technology is the most effective and widely applicable technology (Reddy, 2003). EPA is studying the impact of toxic metals, products of incomplete combustion and process failure on emissions to answer many questions, such as arsenic, barium, beryllium, chromium, lead, mercury, nickel and zinc are of great concern because of their presence in many hazardous waste and possible adverse effects on human health due to exposure to emissions (EPA, 2005). Techniques are being developed to evaluate and control incomplete combustion by-products (Niessen, 1994).

There are over 25 cement kilns currently using more than a million tons of waste annually in the USA. In France also 21 cement works are authorized by the Ministry of Environment to burn waste. Cement kilns are used for burning toxic chemical wastes in many other countries like Canada, Sweden and Norway (Reddy, 2003). Figure (6.1) shows a HW incinerator.

The first class of combustion units is hazardous waste incinerators. Incineration is the combustion of hazardous waste primarily for destruction (i.e., disposal). Incineration is a method of thermal destruction of primarily organic hazardous waste using controlled flame combustion (EEA, 2000).



Figure (6.1) Hazardous Solid Waste Incinerator (Reddy, 2003).

Incineration is advocated for the following types of wastes, namely (Visvanathan, 1996):

- biologically hazardous wastes;
- wastes which are resistant to biodegradation, and persistent in the environment;
- liquid wastes which are highly volatile and therefore can be easily dispersed;

- liquid wastes which have flash point below 40°C;
- wastes which can not be disposed of in a secured landfill site;
- wastes containing organically bounded halogens, lead, mercury, cadmium, zinc, nitrogen, phosphorous or sulphur.

6.2.6 Recovery, Recycling, and Reuse

Recovery of waste energy or valuable material is becoming an increasingly viable option, as ultimate disposal options become more strictly regulated and expensive. Resource recovery typically involves recycling and re-use, either with or without pretreatment for purification before re-use. It can be attractive both for economic and environmental reasons (USEPA, 2000). Recycling of wastes may be done by either the original generators or other firms. For large generators strong economic incentives exist in recycling option. However, for small generators this option may not be viable (NY, 2002). The waste from a given industry may contain material of value to another industry. Examples include solvent recovery, recovery of phenols from coking wastes, sulfur recovery from stack gas cleanup and metal and/or acid recovery from various pickle liquors (NY, 2002). Industrial waste exchanges generally accept waste from one site and provide it as process input to another industry (NY, 2002). Recoverable materials may exist in a waste stream, as metals or metal oxides, acid solution of metal salts etc (Sauer, 1996). The recovery process may need one or more processes of chemical and physical treatment. The selection of the processes depends upon the specific character of the waste and the desired end-product and, therefore, requires careful consideration (Sauer, 1996). The areas having the greatest potential for recovery include recovery of materials from concentrated organic liquids, e.g. distillation and recovery of waste solvent, recovery of metals from industrial sludges and metal plating wastes, e.g. recovery of chromium, copper and nickel from spent plating baths (Sauer, 1996).

The most common implementation of this strategy is the use of spent solvents or waste oils for steam generation (USEPA, 2005). In general, few incineration systems for toxic waste decomposition have been designed to recover energy since auxiliary fuel is almost always needed to ensure complete combustion, with minimization of undesirable atmospheric emissions (Reddy, 2003). However, knowledge of detailed feed combustion and careful blending of wastes fed to an incinerator will reduce the auxiliary fuel needs and thus reduce direct energy costs associated with incineration

(USEPA, 2000). Heat recovery and recovery of fuel value are two basic types in which energy recovery can be achieved. In the heat recovery mode, the heat-exchangers may be utilized to preheat the combustion air or generate the steam for heat or power production. In the second type, the energy recovery is the utilization of the fuel value directly (USEPA, 2005). One of the important applications of this type of energy recovery is utilization of these materials as feed for rotary kiln in cement manufacture (Reddy, 2003).

6.2.7 Disposal in a Landfill

A landfill is a disposal facility where the hazardous wastes are placed and stored in the soil, figure (6.2) (Visvanathan, 1996). Sanitary landfill is a land disposal site with an isolation of the waste from the environment and humans (IHE, 2004).

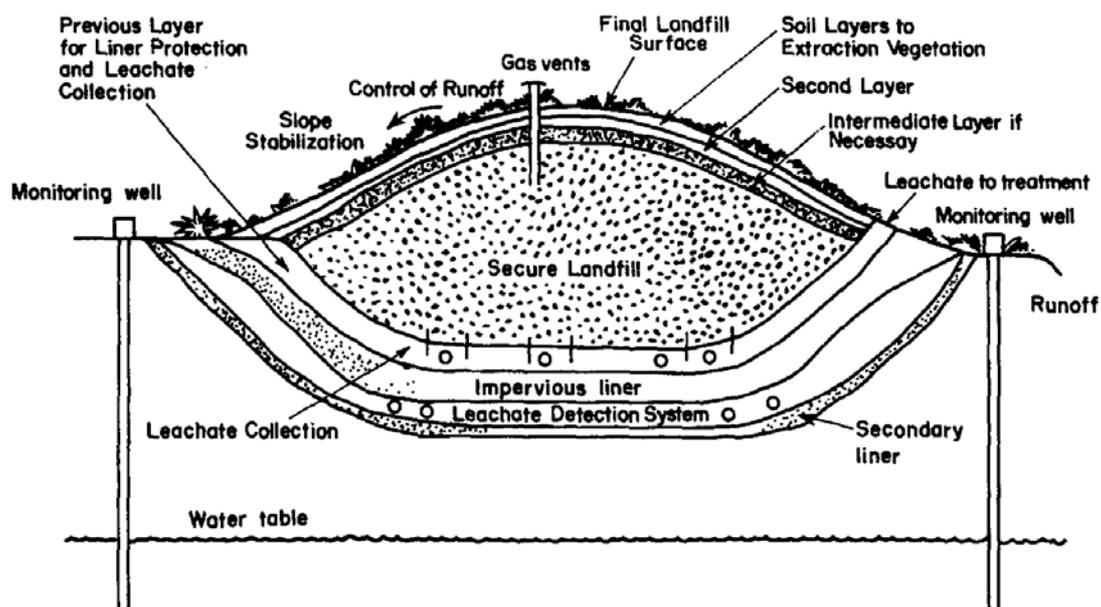


Figure (6.2) Schematic cross-section of a landfill (Visvanathan, 1996)

The major design elements of hazardous wastes landfills are listed below (UNEP, 1993):

- (a) Double liners separated by a permeable layer such as sand.
- (b) A leak detection system between the liners.
- (c) A leachate collection and removal system above the top liner.

- (d) Water run-on and run-off control systems.
- (e) A final cover to minimize infiltration of precipitation into the closed landfill

Landfill performance issues to be considered in a design include (EEA, 2000):

- Proposed volume of waste for disposal.
- Physical and chemical characteristics of the waste.
- Hydrogeological characteristics of the site.
- Quantity, quality, and direction of ground-water flow.
- Ground-water use and withdrawal rates.
- Topographic information.
- Climatological conditions.
- Hydrologic data including surface flow patterns.
- Amount and uses of nearby surface waters, along with associated water quality standards
- Quality of nearby surface waters.
- Potential for waste volatilization and wind dispersal.
- Existing quality of the air.
- Land use and zoning patterns.
- Physical and chemical properties of the soil underlying the facility that supports an in-place liner.
- Permeability of the liner material.
- Potential pressure head of leachate on the liner.
- Potential for damage to the liner system during installation of an in-place liner.
- Potential volume of leachate or contaminated run-off that could be produced at the facility.
- Source and characteristics of potential cover material.
- Potential for health risks due to human exposure to waste constituents.
- Potential damage to wildlife, crops, vegetation, and physical structures due to exposure to waste constituents.

Chapter 7

**Healthcare Waste Management
Case Study: West Bank and Gaza Strip**

7.1 Healthcare waste definition:

There are several definitions of healthcare waste (HCW). In the **United Kingdom** HCW is defined as “Any waste which consists wholly or partly of human or animal tissue, blood, or other body fluid, excretions, drugs or other pharmaceutical products, swabs or dressings, or syringes, needles or other sharp instruments, being waste which unless rendered safe may prove to be hazardous to any person coming into contact with it and any other waste arising from medical nursing, dental, veterinary, pharmaceutical or similar practice, investigations, treatment, care, teaching or research, or the collection of blood for transfusion, being waste which may cause infection to any person coming into contact with it “.

According to **WHO** HCW is defines as “medical wastes which include all the wastes generated by healthcare establishments, research facilities, and laboratories. In addition, it includes the waste originating from “*minor*” or “*scattered*“ sources such as that produced in the course of healthcare undertaken in homes (dialysis, insulin injections, etc.)”.

According to **USEPA** HCW is defined as “any type of waste generated by a biomedical institution including hospitals, medical laboratories, animal experimentation units and clinics”.

According to the **PCBS** in there environmental survey for Healthcare Centers, 2004 Healthcare Waste is defined as ”any waste coming out of healthcare provided in hospitals or other healthcare centers”. However the waste resulting from healthcare at home is not included in this definition.

From the definitions mentioned above it seems that all are similar in the general context, but they vary in the degree of details. The Palestinian PCBS Definition should be more elaborated and developed to include some specific details.

7.2 Classification of Healthcare Wastes:

The WHO classification is:

Infectious wastes: they are the wastes which contain pathogens; so that they pose a serious threat, such as culture from laboratories, waste from surgery and autopsies on patients with infectious diseases, waste contacted infected patients and any other instruments or materials that have been in contact with infected persons or animals.

Pathological wastes: It includes human tissues or fluids e.g. body parts, blood and other body fluids and fetuses.

Sharps : any item that could cause a cut or puncture, especially needles, infusion sets, scalpels, knives, blades and broken glass.

Pharmaceutical wastes: It consists of /or contains pharmaceuticals including: expired, no longer needed, containers, packaging, items contaminated by or containing pharmaceutical bottles, boxes and drug vials.

Genotoxic wastes: It consists of, or contains substances with genotoxic properties” mutagenic, teratogenic and carcinogenic” and includes cytotoxic, antineoplastic drugs and genotoxic chemical. Genotoxic wastes are generated from several sources and may include the following:

- Contaminated materials from drugs preparation such as: syringes, needles and vial packaging.
- Expired drugs returned from the wards.
- Urine, feces and vomit from patients.

Chemical wastes: It consists of, or contains chemical substances, including: Laboratory chemicals, film developer, disinfectants expired or no longer needed solvents, cleaning agents and others.

Heavy metals: It consists of materials and equipment with heavy metals and/or their derivatives including batteries, thermometers, and manometers.

Pressurized containers: Consisting of full or empty containers and with pressurized liquids, gas, or powdered material, including gas containers and aerosol cans.

Radioactive waste: Includes unused liquids from radiotherapy or laboratory research, contaminated glassware, packages or absorbent paper, urine and excreta from patients treated or tested with unsealed radio nuclides.

However, other classifications were provided by other organizations. For practical purposes, more simplified classifications were used in developing countries. According to the Palestinian Ministry of Health 2005 there are five categories:

- 1-General waste, or Non-hazardous waste.
- 2- Sharps.
- 3- Infectious waste.
- 4- Chemical and pharmaceutical wastes.
- 5- Other hazardous medical wastes.

According to the Technical Guidelines on Environmentally Sound Management of Biomedical and Healthcare waste provided by the Conference of the Parties to the Basel Convention on the Control of Trans-boundary Movements of Hazardous Waste and their Disposal (December 2002), healthcare waste are classified as explained in figure (7.1) (WHO, 2005).

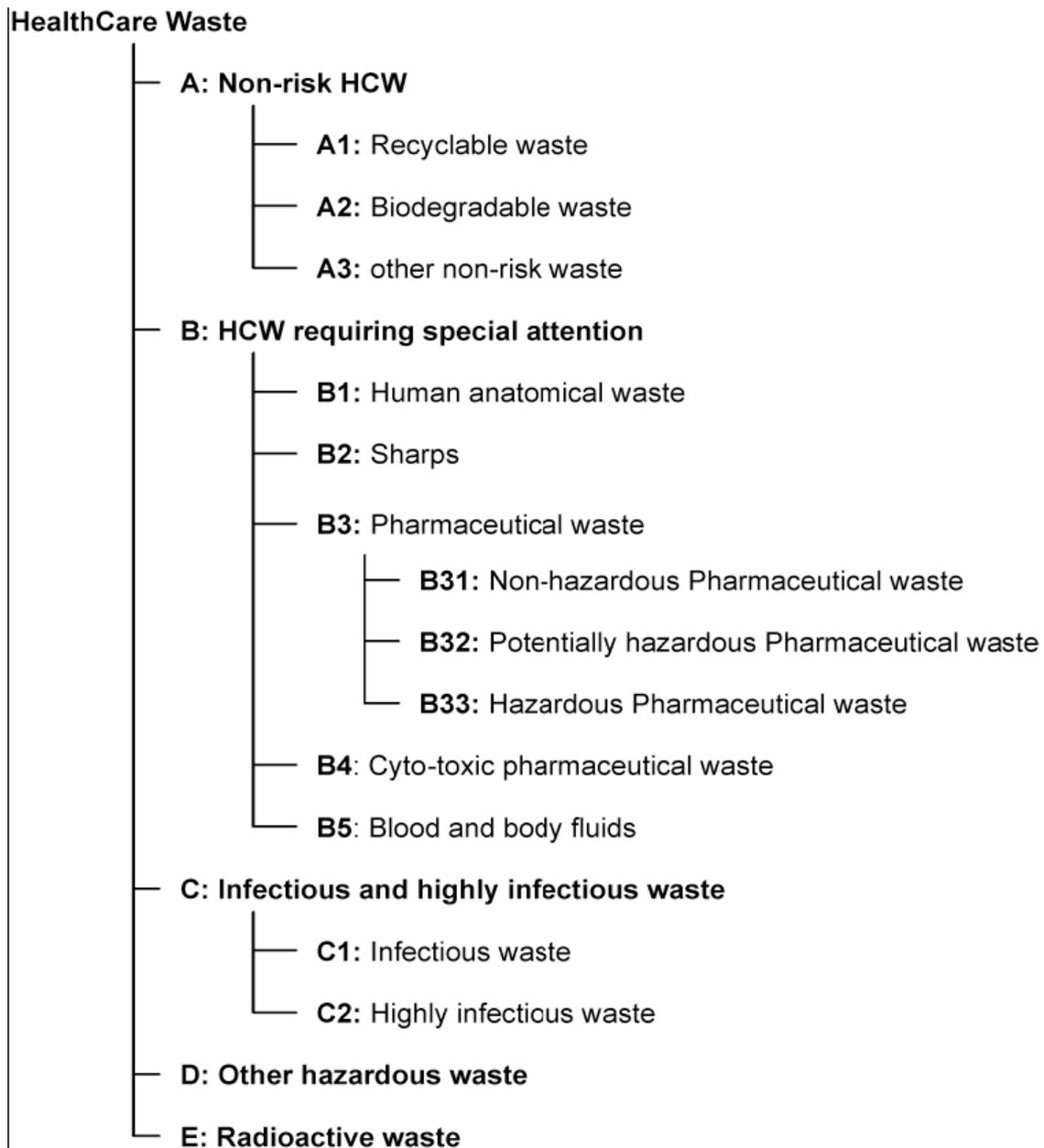


Figure (7.1) classification of HCW (WHO, 2005)

According to the Health and safety Commission of the European community there are five categories (groups) as follows (Massrouji, 2000):

Group A:

All human tissues, including blood (whether infected or not) animal carcasses and tissue from veterinary centers, hospitals and Laboratories, and all related swabs and dressings.

- 1- Waste material where the assessment indicates a risk, for example, infectious disease cases.
- 2- Solid surgical dressings, swabs and other soiled waste from treatment areas.

Group B:

Discarded syringe needles, cartridges, broken glass and other contaminated disposables, sharp instruments or items.

Group C:

Microbiological cultures and potentially affected waste from pathology department and other clinical or research laboratories.

Group D:

Certain pharmaceutical products and chemical wastes.

Group E:

Items used to dispose of body fluids assessed as not falling within group A, this includes disposable bed pans, incontinence pads, stoma bags and urine containers

7.3 Generation:

According to the Ministry of Health Master Plan for Healthcare Waste 2005(MOHMP), the quantities according to classification of HCW in Gaza Strip are shown in the table (7.1).

Table (7.1) Classification of HCW in Gaza Strip (MOHMP, 2005)

Classification of HCW	Amount(kg)	%
Non risk	698.01	80.00
Sharps	13.08	1.50
Blood/Fluid Body	9.59	1.10
Infectious waste	143.09	16.40
Other (e.g .radioactive)	8.725	1.00
Total	872.52	100.00

In the West Bank the classified quantities of healthcare waste are shown in Table (7.2)

Table (7.2) Classification of HCW in West Bank (MOHMP, 2005)

Classification of HCW	Amount(kg)	%
Non risk	207.680	64.0
Sharps	12.980	4.0
Blood/Fluid Body	8.113	2.5
Infectious waste	81.113	25.0
Other (e.g .radioactive)	17.850	4.5
Total	324.500	100.0

The situation with respect to healthcare waste (HCW) management in the West Bank and Gaza Strip has been a matter of concern for some time. The Ministry of Health Environmental Directorate is responsible for monitoring of landfilling and treatment, including problems arising from solid waste, in cooperation with EQA and municipalities.

Atyani (1996) estimated the amount of domestic waste generated in Ramallah hospital to be 3.53 kg/bed/day with clinical portion to be 36% of the total waste generated, and also she estimated waste generation in Khalid Maternity and Surgery Hospital to be 2.4 kg/bed/day with 50% clinical portion, also Zoarab (1997) estimated the total amount of solid waste in Shifa Hospital in Gaza City to be 1 ton/day of which 35 % are medical wastes.

The master plan for Healthcare Waste (MOHMP, 2005) estimated the volume of HCW being generated in the WB and GS; currently WB healthcare facilities produce 1.29kg/bed/day while those in the GS produce 1.3 kg/bed/day. Qumboz, (2002) has found that, the amount of medical waste generated in healthcare organisations is about 8 tons/day, and about 2.67kg/capita/day in Shifa Hospital (MOH annual Report, 2001). Given the fact that only about 10-25% of the HCW is hazardous, treatment and disposal costs could be greatly reduced if a proper segregation is performed. Segregating hazardous from non-hazardous wastes also reduces greatly the risks of infecting workers handling HCW.

The quantities of waste generated from healthcare facilities are different from one country to another from some facility to another and sometimes from one district to another, and there are some examples from different regions explained in the tables below (7.3, 7.4, 7.5).

Table (7.3) Total Waste Generation from Healthcare by Region (Massrouji, 2000)

Region	Daily waste generation (kg/bed)
North America	7-10
West Europe	3-6
Latin America	3
Eastern Asia	
High income countries	2.5-4
Low income countries	1.8-2.2
Eastern Europe	1.4-2

Table (7.4) Quantity of Healthcare Waste (Kg/bed. day) by Country

(Jouda & Jaber, 2004)

Type of hospital	Norway	Spain	UK	France	USA
University hospital	3.9	4.4	3.3	3.4	5.2
General hospital				2.5	4.5
Maternity hospital		3.4	3		
Mental hospital		1.6	0.5		
Geriatric hospital		1.2			

Table (7.5) HCW Generation by Hospitals in Latin America (Jouda & Jaber, 2004)

Country	Year of Study	Generation (kg/bed.day)
Chile	1973	1.09
Venezuela	1976	3.12
Brazil	1978	2.53
Argentina	1988	2.75
Peru	1987	3.5
Paraguay	1989	3.77

According to the Palestinian Ministry of Health, 2003 the distribution of hospitals and beds in the GS and WB are shown in table (7.6)

Table (7.6) Distribution of Hospitals and Beds in the WB and GS (MOH, 2003)

Healthcare Provider	West Bank No of Beds	West Bank No of hospital	Gaza Strip No of hospital	Gaza Strip No of Beds
Ministry of Health	1152	11	12	1462
UNRWA	58	1	0	0
NGOs	1073	21	10	416
Private sector	479	21	2	39
Total	2762	54	24	1917

The monthly estimated quantities produced by the healthcare centers in WB and GS where about 380.9 tons of solid wastes and 5.8 thousands cubic meters of liquid wastes including 274.8 tons and 1.9 thousands cubic meter in the West Bank and 106.1 tons and 3.9 thousands cubic meter in GS (PCBS, 2004).

7.4 Segregation and Collection

The key to minimization and effective management of healthcare waste is separation and identification of the waste. The success of any waste segregation system depends on its simplicity, the simpler the procedure the smaller will be the risk of human error (Zoarob, 1997). This is useful as it prevents healthcare waste from being diluted with domestic waste stream (massrouji, 2000).

According to PCBS, 49.0% of healthcare centers in (WB and GS) perform separation of healthcare waste components, and 70.6% of the healthcare centers separate some components while 29.4% of the healthcare centers separate all the components. However, the percentage of the healthcare centers that perform general waste separation is 58.4%, whereas 55.4% of the healthcare centers separate infectious waste. The quantities of separated waste at healthcare centers were estimated at 145.2 tons of solid wastes and 83.3 cubic meters of liquid wastes (PCBS, 2004).

According to MOH master plan 2005, different categories of healthcare waste must be sorted into different colour-coded plastic bags or containers.

This will help in the identification of the waste and will facilitate the disposal and treatment of the waste (MOHMP, 2005).

According to the (GCHWM, 2001) the recommended colour coding for healthcare waste is given in table (7.7):

Table (7.7) recommended colour coding for healthcare waste (GCHWM, 2001)

Type of waste	Colour of container and markings	Type on container
Highly infectious waste	Yellow marked "HIGHLY INFECTIOUS"	Strong, leak-proof plastic bag or container suitable to be autoclaved
Other infectious waste, pathological and anatomical waste	Yellow	Leak-proof plastic bag or container
Sharps	Yellow marked "SHARPS"	Puncture-proof container
Chemical and pharmaceutical waste	Brown	Plastic bag or container
Radioactive waste	--	Lead box, labeled with the radioactive symbol
General healthcare waste	Black	Plastic bag



Figure (7-2) On-site collection, transportation, and storage of waste

Atyani (1996) suggested segregating healthcare waste as:

- 1- General waste stored in the same place and same ways as municipal waste, and it should be stored away from infectious waste.

- 2- The toxic and noxious waste should be segregated from other waste, sharps should be disposed in special boxes which can be firmly closed and strong enough.
- 3- Infectious waste must be treated in the hospital by disinfection or sterilization.
- 4- Solid radioactive waste must be compacted in plastic bags and then stored in metallic containers in lead drums to allow decay.

Massruji, 2000 mentioned in her thesis “WHO emphasized that waste should not be accumulated at the point of production. A routine program for their collection should be established as a part of the healthcare management plan”.

The periodicity of collection is from 4 to 6 times per a week in 59.0% of the healthcare centers, and the non separated waste was collected from 4 to 6 times per week in 44.9% of the healthcare centers in WB and GS (PCBS, 2004).

Nursing and other clinical staff should ensure that waste bags are tightly closed or sealed when they are about three-quarters full. Light-gauge bags can be closed by tying the neck, but heavier-gauge bags probably require a plastic sealing tag of the self-locking type, and bags should not be closed by stapling (Jouda & Jaber, 2004).

7.5 Transportation and Storage

“The transportation in the healthcare centers in the WS and GS that perform separation of general waste is done manually in 96.7% of the healthcare centers, and 1.9% of the healthcare centers use special carriages. It is done manually for infectious waste in 97.0%, and 1.1% of the healthcare centers use special carriages. While in the centers that do not perform separation of waste it was transported manually in 96.3% of the healthcare centers and the special carriages are used in 2.2% of the healthcare centers”(PCBS, 2004).

On-site transport of the waste should be made using designated, labelled trolleys or carts that are made of suitable material. The trolleys or carts used for transport should not be used for any other purpose and should meet the following specifications (MOHMP, 2005):

- 1-easy to load and unload
- 2-have no sharp edges so as not to damage bags or containers while loading and unloading

3-have smooth, impermeable surfaces which are easy to clean, and the trolleys and carts should be cleaned and disinfected daily.

HCW are temporarily stored before being treated / disposed of on-site or transported off-site. A maximum storage time should not exceed 24 hours. Non-risk HCW should always be stored in a separate location from the infectious / hazardous HCW in order to avoid cross-contamination (WHO, 2005).

A list of requirements for the storage area is:

- 1-The storage area should have an impermeable, hard-standing floor with good drainage (i.e. a floor drain); it should be easy to clean and disinfect.
- 2-There should be a water supply for cleaning purposes.
- 3-The storage area should afford easy access for staff in charge of handling the waste.
- 4-It should be possible to lock the store to prevent access by unauthorized persons.
- 5-Easy access for waste-collection vehicles is essential.
- 6-Sufficient space to accommodate a weekend accumulation or in case of incinerators failure .
- 7-There should be protection from the sun.
- 8-The storage area should be inaccessible for animals, insects, and birds.
- 9-There should be good lighting and at least passive ventilation, where possible air conditioning should be provided.
- 10-The storage area should not be situated in the proximity of fresh food stores or food preparation areas.
- 11-A supply of cleaning equipment, protective clothing, and waste bags or containers should be located conveniently close to the storage area. In addition the floors should be easy to clean and provided with a drain.
- 12-Cytotoxic waste should be stored separately from other healthcare waste in a designated secure location.
- 13-Radioactive waste should be stored in containers that prevent dispersion, behind lead shielding. Waste that is to be stored during radioactive decay should be labelled with the type of radionuclide, the date, and details of required storage conditions.

For transportation of waste from the healthcare facilities to their disposal areas, it should be safely packaged and properly labelled. Staff working in transportation must have the appropriate protective clothing. They are also to have access to the washing facilities within the storage areas. During transport, conditions such as vibration, changes in temperature, humidity or

atmospheric pressure should be avoided wherever possible (MOHMP, 2005).

Before transporting the HCW some markings should be clear and give information about what the packages contain , and the information should include:(MOHMP, 2005).:

- waste category
- date of collection
- place of production in HCF
- waste destination
- United Nation substance class
- United Nations packaging symbol,(e.g. infectious symbol.)
- mass or volume of waste

The information will inform the operative staff and the public of the nature of the hazardous waste. The municipalities, which are mostly responsible for HCW transport, make no differentiation between waste collected from residential areas and that collected from healthcare facilities (HCF); this obviously leads to a mixing of waste in the same truck and being taken to the same end dump site (MOHMP, 2005).

7.6 Treatment and Disposal

Currently, the most treatment method commonly used is the open burning where 64.2% of the healthcare centers (HCC) use it, 14.7% of them use chemical treatment and 8.3% use disinfection. The quantities of treated waste were about 62.9 ton and 159.8 cubic meters in the HCC in WB and GS (PCBS, 2004).

In disposal stage, the waste is compiled in a place then transferred to the place of final disposal. About 61.7% of the HCC compile waste in local authority open containers, 9.7% of the HCC use local authority closed containers, and 5.6% of the HCC open container, while 3.9% of the HCC in HCC closed containers and 19.1% of the HCC don't use a containers, and 86.0% of the used containers are made from metals (PCBS, 2004).

The local authority transfers the waste to the place of final disposal (83.1% of the HCC). The place of final disposal was a dumping site owned by the local authority for 84.7% of the HCC in WB and GS. The periodicity of waste final disposal was 4 to 6 times per week for 53.7% of the HCC (PCBS, 2004).

7.6.1 Gaza Strip

According to the survey that was conducted under the first phase of Regional Solid Waste Project, the results show that 70% of the collected HCW in GS is being incinerated, while 20% is being burnt in the open air, frequently in bins. The remaining collected HCW and the ash from the incineration invariably end up in municipal waste dumps. No documentation or registry of any data on incinerated items is made. In some cases the situation has worsen in Gaza where HCW has been witnessed in and around general bins in major urban centers and includes infectious waste, sharps and general waste from HCF. Where HCFs have the capacity to treat infectious and pathological waste (30% of HCFs in Gaza) more than 90% of the HCW is incinerated. With regards to liquid waste 95% in GS is disposed of in the sewer system. It is unclear where the remaining 5% ends up, but most likely it gets disposed of along with the solid waste, subsequently ending up in municipal sites (MOHMP, 2005).

7.6.2 West Bank

“In the WB, many hospitals are using autoclaving to treat positive bacterial cultures, blood samples, syringes or any waste produced from testing or treatment of patients. In other hospitals, waste from isolation rooms, if available, is dealt with as general waste. As mentioned previously and according to the results of the survey, most of the waste (about 65%) is disposed of in open dumping sites, 15% is disposed of by open burning, and less than 10% is incinerated. Incinerators are only available in Nablus and Jericho cities and, they were part of a Spanish donation to the Ministry of Local Governments. During the survey that had been carried out as part of a Regional Solid Waste Project, the incinerator in Jericho was out of order while the one in Nablus was working with very low efficiency, and in such a way that waste items can still be recognized after being incinerated. The incinerator has a very low chimney. The research which was carried out by Chemical Engineering Department at Al-Najah University showed that this incinerator is polluting the atmosphere and should not be used. Similar to the situation in the GS, the liquid waste, which contains pathogens, blood and hazardous chemicals, about 92% of it is disposed of in the public sewer system. It is likely that the remaining part is disposed of together with solid waste” (MOHMP, 2005).

Each class of HCW requires specific treatment and the major categories could be (WHO, 2005):

- Sharps;
- Infectious and cytotoxic;

- Organic (blood and body fluid wastes, human anatomical waste...).

According to the MOH Master Plan, 2005 the recommended method for disposal of healthcare wastes and colour-coding are explained in table (7.8).

Table (7.8): Recommended Colour-coding & Method of Disposal for Healthcare Waste (MOHMP, 2005)

Types of wastes	Colour of container	Marking on Container	Characteristic of Container	Method of waste Treatment & and Disposal
Infectious waste	Yellow	Infectious waste	Strong, leak-proof plastic bag or container	Low Temp Autoclave/incineration (Once engineered or sanitary landfills have been constructed it can be disposed of there)
Highly infectious waste	Yellow	Highly Infectious	Strong and leak-proof plastic bag or container capable of being autoclaved	Low Temp Autoclave/incineration (Once engineered or sanitary landfills have been constructed it can be disposed of there)
Sharps	Yellow	Sharps	Puncture-proof container	Needle Destruction/encapsulation
Chemical waste	Brown		Plastic bag or container	Encapsulation and/or safe burial on HCF site. Once engineered or sanitary landfills have been constructed it can be disposed of there.
Pharmaceutical waste	- Black bags for not expired drugs		- Plastic box of 30 litre size	Disposed of as domestic waste
	- Red bags for expired drugs			

Cytotoxic waste	Red	Cytotoxic Waste	Strong leak-proof containers	
Radioactive waste		-----	Lead box labelled with radioactive symbol	Returned to supplier, or Decayed in the department
General waste (non-hazardous)	Black		Plastic bag	Direct to landfill

7.7 Healthcare Waste Management Suggested Model

The lack of policies, strategies and enforcement of legislation for the handling and disposing of healthcare waste (HCW) in many developing countries in the Eastern Mediterranean Region of the World Health Organization has resulted in poor management of such wastes. As a result many healthcare establishments in the Region are increasingly exposing patients and medical and support staff in healthcare establishments to avoidable health risks. Moreover, improper management of HCW could have serious implications for public health and the general environment (WHO, 2002).

The impact of HCW may be reduced by introducing a process of healthcare waste management (HCWM) planning within healthcare establishments (WHO, 2002).

The literature review for the current situation of HCWM explains that, the majority of healthcare facilities have many gaps in their HCWM systems. Examples of this include:

- lack of proper segregation, handling, transport and disposal of waste
- no definition of responsibilities and roles
- lack of coordination between medical departments and those involved in the management of healthcare waste..
- lack in legislations.

Each HCF should have an HCWM plan which should include collection points and routes of waste transport (BAN, 1999). A timetable of the frequency of collection should also be set-up. It should provide heavy duty gloves, industrial boots and apron for waste collectors; ensure that waste containers are appropriately sealed, removed and replaced immediately when they are no more than three-quarters full; and ensure that hazardous / infectious HCW and non-risk HCW are collected on separate trolleys which should be marked with the corresponding colour (black/or yellow) and washed regularly.

It is suggested to use HCWM planning from WHO as shown in (Figure 7.2) with some adoption that is suitable to our situation and wastes that are generated from HCWFs.

step	location	healthcare waste stream	key points
0		waste minimization	<i>purchasing policy; stock management; recycling of certain types of waste...</i>
1	in medical unit	generation	
2		segregation at source	<i>one of the most important steps to reduce risks and amount of hazardous waste</i>
3	in health facility	collection + on-site transport	<i>protective equipment; sealed containers; specific easy to wash trolleys</i>
4		on-site storage	<i>lockable easy to clean storage room; limited storage time of 24-48 hours</i>
5		on-site treatment / disposal	<i>adequate storage room; limited time of max 48 hours</i>
6	outside of health facility	off-site transport	<i>appropriate vehicle and consignment note; HCF is informed about final destination</i>
7		off-site treatment / disposal	<i>appropriate vehicle and consignment note to ensure...</i>

Figure (7.3): Synopsis of the HCW Stream (WHO, 2005)

The focus should be on the safe practices/procedures for healthcare waste segregation, internal collection and storage. These measures have the greatest impact in reducing poor hygiene practices. Improvements with respect to waste segregation, internal storage and collection in each HCF should consist, at least, of the following (WHO, 2002):

7.7.1 Generation

The amount of HCW generated in the WB is estimated at about 1040tons/year and about 728tons/year in the GS. According to WHO the percentage of hazardous waste from HCW is 20%, so the amount of hazardous healthcare waste (HHCW) in WB and GS is 354 tons/year, and all recommended consider this amount. Incineration used to be the method of choice for most hazardous healthcare wastes and is still widely used (WHO, 1998).

7.7.2 Segregation

According to the WHO (2002)

- Separation of healthcare waste into three categories (general waste ,hazardous healthcare waste and sharps);
- Colour coding of bags/containers or clear labelling of bags and containers to differentiate between waste categories; see table (7.9)
- Use of posters and checklists to help segregate the waste;

- Use of labels for closed yellow-bagged waste;
- Use of holders to contain highly infectious waste bags/containers;
- Existence of safety measures (protective clothing etc.) and emergency response (in case of stick injuries, etc.);
- Awareness-raising and hands-on training.

Table (7.9) Labelling of HCW containers (WHO, 2005)

Category	Labelling	International symbols
human anatomical waste	Danger! Anatomical waste, to be incinerated or deeply buried	
sharps	Danger! Contaminated sharps, do not open	
cytotoxic pharmaceutical, (blood and body fluids, infectious waste	Danger! Hazardous infectious waste	
highly infectious waste	Danger! Highly infectious waste, to be pre-treated	
Potentially hazardous pharmaceutical waste Hazardous pharmaceutical waste Other hazardous waste	Danger! To be discarded by authorized staff only	
Radioactive health-care waste	Danger! Radioactive waste	

7.7.3 Internal storage

- Separate temporary storage areas and containers for hazardous and general wastes, photo (1).

- Temporary storage areas/containers located away from patient areas.
- Fixed collection schedule for temporary stored bagged waste.
- Periodic cleaning and disinfection of temporary storage areas and containers.



Photo (1) Temporary storage container

7.7.4 Internal transport

- Fixed collection schedule for each waste category (three-bin system).
- Dedicated trolleys and wheeled containers (leakproof with cover) for collection and transport of hazardous waste colour coding system or (if not feasible) coloured signs for trolleys and wheeled containers to differentiate between trolleys for general and hazardous waste photo (2), (3).
- Periodic disinfection and cleaning of trolleys and wheeled containers.
- Existence of safety measures (e.g. protective clothing) and emergency response (e.g. in case of spills, occupational injuries).
- Awareness-raising and hands-on training.



Photo(2) Colour coding system for wheeled containers



Photo (3) Internal transportation of yellow bagged (yellow for hazardous and black for general HCW) waste by yellow wheeled containers.

7.7.5 Awareness

Proper education and training must be offered to all workers from doctors to ward boys, to laborers and rag pickers to ensure an understanding of the risks that wastes pose, how to protect themselves, and how to manage wastes (especially how to properly segregate). Education and training programs must be developed which speak to each population in a way that will best meet the needs and build understanding and change behavior in that population.

When a new staff member is engaged, it is highly recommended that a specific clause regarding the safe management of HCW be included in the contract, so as to make the new employee fully aware of the importance of this part of his/her work and made liable in this respect (WHO, 2005).

7.7.6 HCW treatment and disposal

The recommended technology for HCW treatment and disposal should always be driven with the objective of minimizing negative impacts on health and the environment. Several technologies exist to treat or dispose of HCW including:

- 1) Incineration in double chamber incinerators;
- 2) Needle destruction;
- 3) Wet thermal treatment (autoclaving);
- 4) Chemical disinfection;
- 5) Microwave irradiation; and
- 6) Sanitary landfill, including encapsulation.

For more details on HCW treatment and disposal technologies, see annex II.

7.7.6.1 Incineration

Incineration is a high-temperature dry oxidation process that reduces organic and combustible waste to inorganic, incombustible matter and results in a very significant reduction of waste volume and weight. This process is usually selected to treat wastes that cannot be recycled, reused, or disposed of in a landfill site (WHO, 2005)

Incinerators designed especially for treatment of health-care waste should operate at temperatures between 900 and 1200°C. Low-cost, high-temperature incinerators of simple design are currently being developed, and a system designed specifically for health-care and pharmaceutical waste in low-income countries. (WHO, 1998)

Incineration in municipal incinerators

It is economically attractive to dispose of infectious health-care waste in municipal incinerators if these are located reasonably close to hospitals. As the heating value of health-care waste is significantly higher than that of domestic refuse, the introduction of relatively small quantities of health-care

waste will not affect the operation of a municipal incinerator. Municipal incinerators are usually of a double-chamber design, with an operating temperature of 800°C in the first combustion chamber and gas combustion in the second chamber at temperatures of, typically, 1000–1200°C (WHO, 2005).

It is strongly recommend to use a two chamber incinerators due to the following:

- Elimination of health risks due to the complete destruction of the waste.
- The waste is non-recognizable.
- Fully destroys micro-organisms and sharps.
- Reduces significantly volume and weight of the waste.
- Destroys all types of organic waste (liquids, pharmaceuticals, and other solids).
- Significant quantities of waste can be treated (except for batch incinerators).

7.7.6.2 Autoclaving

Autoclaving is an efficient wet thermal disinfection process. Typically, autoclaves are used in hospitals for the sterilization of reusable medical equipment. They allow for the treatment of only limited quantities of waste and are therefore commonly used only for highly infectious waste, such as microbial cultures or sharps. It is recommended that all general hospitals, even those with limited resources, be equipped with autoclaves. The advantages and disadvantages of autoclaving wastes are the same as for other wet thermal processes discussed in this section. The physical requirements for effective steam autoclave treatment are normally different from those required for sterilizing medical supplies. Minimum contact times and temperatures will depend on several factors such as the moisture content of the waste and ease of penetration of the steam. Research has shown that effective inactivation of all vegetative microorganisms and most bacterial spores in a small amount of waste (about 5– 8kg) requires a 60-minute cycle at 121°C (minimum) and 1 bar (100kPa); this allows for full steam penetration of the waste material(WHO, 1998).

7.7.6.3 Encapsulation

Disposal of health-care waste in municipal landfills is less advisable if it is untreated than if it is pretreated. One option for pretreatment is encapsulation, which involves filling containers with waste, adding an immobilizing material, and sealing the containers. The process uses either cubic boxes made of high-density polyethylene or metallic drums, which are

three-quarters filled with sharps and chemical or pharmaceutical residues. The containers or boxes are then filled up with a medium such as plastic foam, bituminous sand, cement mortar, or clay material (Gayathri, 2004). After the medium has dried, the containers are sealed and disposed of in landfill sites.

This process is relatively cheap, safe, and particularly appropriate for establishments that practice minimal programme for the disposal of sharps and chemical or pharmaceutical residues. Encapsulation alone is not recommended for non-sharp infectious waste, but may be used in combination with burning of such waste. The main advantage of the process is that it is very effective in reducing the risk of scavengers gaining access to the hazardous health-care waste (WHO, 1998).

7.7.6.4 Sharps

Sharps represent one of the most problematic and hazardous types of waste generated within HCFs. Syringes and needles are of particular concern because they constitute an important part of the sharps and are very often contaminated with blood (WHO, 2005).

Needle cutters are installed at the point of use in order to cut the needle from the syringe immediately after use. The needle is inserted into the device, and cut off mechanically by blades. The needle drops into a container, which once full, can either be put in a sharp pit or incinerated. Also, already commercialized types of devices are still being tested. They are relatively inexpensive, robust, easy to use and transport, safe and appropriate in remote areas lacking electricity supply.



Photo (4) A needle remover / cutter

Why technology shown in photo (4) is chosen

- Once it has been constructed the pit is simple to use and does not require any maintenance.
- There are no operational costs. The capital costs remain limited.
- There are no emissions of air pollutants since the needle isn't incinerated.
- The volume reduction is similar to the one obtained with incineration.
- These devices are robust (they can cut between 200'000 and 400'000 needles before the blades need to be changed) (WHO, 2005).
- All types of syringes and needle sizes can be dealt with.

7.7.6.5 Sanitary landfills

Sanitary landfills are designed to have at least four advantages over open dumps: geological isolation of wastes from the environment, appropriate engineering preparations before the site is ready to accept wastes, staff present on site to control operations, and organized deposit and daily coverage of waste.

Disposing of certain types of health-care waste (infectious waste and small quantities of pharmaceutical waste) in sanitary landfills is acceptable; sanitary landfill prevents contamination of soil and of surface water and groundwater, and limits air pollution, smells, and direct contact with the public (WHO, 1998).

Some recommendations to be taken into account when designing and operating sanitary landfills include:

- Possible access to site and working areas for waste delivery and site vehicles.
- Presence of site personnel capable of effective control of daily operations.
- Division of the site into manageable phases, appropriately prepared, before landfill starts.
- Adequate sealing of the base and sides of the site to minimize the movement of wastewater (leachate) off the site.
- Adequate mechanisms for leachate collection, and treatment systems if necessary.
- Organized deposit of wastes in a small area, allowing them to be spread, compacted, and covered daily.
- Surface water collection trenches around site boundaries.
- Construction of a final cover to minimize rainwater infiltration when each phase of the landfill is completed.

Guidance for HCWM per category of waste is explained in annex (IV).

Chapter 8

Conclusions and recommendations

Conclusions and Recommendations

- It is clear from the study that there is no authorized specific body responsible for hazardous and healthcare waste management in WB and GS. Also, there is no clear procedure for managing HW or a special institutional setup to deal with HW and HCW.
- There is good experience in HWM practice in the region that we can learn and benefit from.
- Most of the hazardous and healthcare waste generated in the WB and the GS are mixed with municipal waste due to the bad segregation practices at the source. Accordingly, the amounts of HW and HCW increase.
- Early understanding, by decision makers, of managing HW usually results in the reduction of contamination of natural resources and associated costs for later or future remediation.
- Hazardous waste regulations (bylaws) should be developed to provide strict controls for collection, treatment, storage, transport, disposal, monitoring, and reporting of hazardous wastes and healthcare wastes.
- The classifications and inventory of hazardous wastes should be prepared, preferably, in line with the Basel Convention.
- Awareness, training and capacity building program and activities in HW and HCW management should target the public, industries and decision makers.
- Pre-Treatment of HW should be performed at the source where it is being produced to minimize the quantities of hazardous waste to

be treated. Pretreatment should be performed to the National Industrial Effluent Treatment Standards.

- It is recommended to establish small centralized hazardous waste treatment and disposal facility.
- The treatment systems for hazardous waste should be cost-effective and easily adaptable to many different waste streams and waste concentrations.
- HWM must cope with limitations in financial and human resources. Therefore, hazardous waste management decisions should be based on the best available science and technology.
- Because of economic limitations, an incremental approach can be followed in managing hazardous wastes. Low-technology efforts to reduce the health and environmental impacts of hazardous wastes are better than none.
- From visits and meetings in different ministries, there is a lack of coordination among different ministries and even in some ministries among the different departments.
- Traditional public health practices emphasize prevention. This principle should be extended to hazardous waste management where generators of hazardous waste should be encouraged to develop techniques and processes that minimize the generation of wastes. If the production of hazardous wastes cannot be avoided, the wastes should be recycled or re-used for other purposes.
- Used oil should have a special system for collection and recycling preferably by private operators. Further research should be done to explore recycling solutions.

- Governmental agencies should be open and candid in informing the public of potential environmental health threats from hazardous wastes. Government officials should present a clear and realistic description of potential risks to the public so that right and implementable decisions can be made with strong public support.
- Promote an integrated hazardous waste management strategy in the region through coordination and cooperation among neighbor states, like Egypt and Jordan, and encourage bilateral agreements.
- Introduce the concepts of risk assessment and life cycle assessment in tracking chemicals and waste.
- Promote the implementation of Cleaner Production and Sustainable Consumption Strategies in the Region and the establishment of National Cleaner Production Centers.
- Encourage industry and local communities in the region to participate in voluntary initiatives, in the areas of HWM.
- Further research is recommended for economical cost-benefit analysis for the disposal and treatment options.

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Annexes

Annex I

Categories of Wastes to Be Controlled

- Y1 Clinical wastes from medical care in hospitals, medical centers and clinics
- Y2 Wastes from the production and preparation of pharmaceutical products
- Y3 Waste pharmaceuticals, drugs and medicines
- Y4 Wastes from the production, formulation and use of biocides and phytopharmaceuticals
- Y5 Wastes from the manufacture, formulation and use of wood preserving chemicals
- Y6 Wastes from the production, formulation and use of organic solvents
- Y7 Wastes from heat treatment and tempering operations containing cyanides
- Y8 Waste mineral oils unfit for their originally intended use
- Y9 Waste oils/water, hydrocarbons/water mixtures, emulsions
- Y10 Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs)
- Y11 Waste tarry residues arising from refining, distillation and any pyrolytic treatment
- Y12 Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish
- Y13 Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives
- Y14 Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on man and/or the environment are not known
- Y15 Wastes of an explosive nature not subject to other legislation
- Y16 Wastes from production, formulation and use of photographic chemicals and processing materials
- Y17 Wastes resulting from surface treatment of metals and plastics
- Y18 Residues arising from industrial waste disposal operations and wastes having as constituents:
 - Y19 Metal carbonyls
 - Y20 Beryllium; beryllium compounds

Y21 Hexavalent chromium compounds
Y22 Copper compounds
Y23 Zinc compounds
Y24 Arsenic; arsenic compounds
Y25 Selenium; selenium compounds
Y26 Cadmium; cadmium compounds
Y27 Antimony; antimony compounds
Y28 Tellurium; tellurium compounds
Y29 Mercury; mercury compounds
Y30 Thallium; thallium compounds
Y31 Lead; lead compounds
Y32 Inorganic fluorine compounds excluding calcium fluoride
Y33 Inorganic cyanides
Y34 Acidic solutions or acids in solid form
Y35 Basic solutions or bases in solid form.
Y36 Asbestos (dust and fibres)
Y37 Organic phosphorus compounds
Y38 Organic cyanides
Y39 Phenols; phenol compounds including chlorophenols
Y40 Ethers
Y41 Halogenated organic solvents
Y42 Organic solvents excluding halogenated solvents
Y43 Any congener of polychlorinated dibenzo-furan
Y44 Any congener of polychlorinated dibenzo-p-dioxin
Y45 Organohalogen compounds other than substances referred to in this Annex (e.g. Y39, Y41, Y42, Y43, Y44)

Annexes (II)

HCW treatment and disposal technologies

The choice of a technology for HCW treatment and disposal should always be driven with the objective of minimizing negative impacts on health and the environment. Several technologies exist to treat or dispose of HCW. They include: 1) Incineration in rotary kilns or double chamber incinerators; 2) Burning in single chamber incinerators; 3) Wet thermal treatment (autoclaving); 4) Chemical disinfection; 5) Microwave irradiation; 6) Sanitary landfill, including inertization and encapsulation.

Not all these technologies can be used for the treatment or the disposal of all categories of HCW. The suitable treatment and disposal technologies

according to the different categories of HCW are presented in the table below.

Incineration is not the same as burning. **Incineration** is one of the only technologies that can treat all types of HCW properly and has the advantage of reducing significantly the volume and weight of the waste treated. Incinerators nevertheless require skilled operators, extensive flue gas emission control systems and, frequently, imported spare parts. Incineration generates ash residues and air emissions can contain pollutants such as dioxins and heavy metals.

Burning in small-capacity single chamber “incinerators” is a technique often used in HCFs in low income countries. These installations may nevertheless constitute a serious air pollution hazard to the surrounding area due to the relatively low operation temperatures and the lack of emission control systems. If biomedical and health-care waste are treated with single chamber “incinerators”, waste fractions such as cytotoxic drugs, chemicals, halogenated materials or waste with a high content of heavy metals (batteries, broken mercury thermometers, etc.) *should not be treated* with this type of system (see table above).

Incineration /	Advantages	Drawbacks
<p>Pyrolytic or double chamber incinerators (incineration at 800–900°C)</p> <p>Rotary kiln (incineration at 1200°C and higher)</p>	<ul style="list-style-type: none"> <input type="checkbox"/> Elimination of health risks due to the complete destruction of the waste <input type="checkbox"/> The waste is non-recognizable <input type="checkbox"/> Fully destroys micro-organisms and sharps <input type="checkbox"/> Reduces significantly volume and weight of the waste <input type="checkbox"/> Destroys all types of organic waste (liquids, pharmaceuticals, and other solids) <input type="checkbox"/> Important quantities of waste can be treated (except for batch incinerators) 	<ul style="list-style-type: none"> <input type="checkbox"/> High investment costs <input type="checkbox"/> Requires skilled staff to operate <input type="checkbox"/> Continuous monitoring required <input type="checkbox"/> High maintenance, especially for rotary kilns <input type="checkbox"/> Relatively high operation costs; costs rise with the level of sophistication of the emission control systems <input type="checkbox"/> For batch incinerators: limited capacity <input type="checkbox"/> Emits toxic flue

		gases (including dioxins and furans) <input type="checkbox"/> Generates residues that need safe land-filling
Single chamber “incinerators” (incineration at low temperatures 300-400°C)	<input type="checkbox"/> Good disinfection efficiency <input type="checkbox"/> Reduces significantly volume and weight of the waste <input type="checkbox"/> No need for highly trained operators	<input type="checkbox"/> Significant emission of atmospheric pollutants <input type="checkbox"/> Need for periodic removal of slag and soot <input type="checkbox"/> Inefficiency in destroying thermally resistant chemicals and drugs <input type="checkbox"/> No destruction of sharps

Autoclaving is the exposure of waste to saturated steam under pressure in an enclosed container. Preparation of material for autoclaving requires segregation to remove unsuitable material and shredding to reduce the size of the individual pieces for greater treatment efficiency. Small autoclaves are common for sterilization of medical equipment but HCW autoclaves can be a relatively complex and expensive systems requiring careful design, appropriate segregation of materials, and a high level of operation and maintenance support. The output from an autoclave is non-hazardous material that can normally be land-filled with municipal waste. There is also a wastewater stream that needs to be disposed of with appropriate care and control. Furthermore, large autoclaves may require a boiler with stack emissions that will be subject to control.

Steam Disinfection	Advantages	Drawbacks
	<input type="checkbox"/> Relatively simple to operate (a known technology at health-care facilities) <input type="checkbox"/> Environmentally sound technology	<input type="checkbox"/> Relatively expensive to install and operate <input type="checkbox"/> Requires boiler with stack emissions controls

		<input type="checkbox"/> Relatively high maintenance costs <input type="checkbox"/> Cannot be used to treat some special wastes <input type="checkbox"/> Generates contaminated wastewater that needs special treatment
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Microwave irradiation is based on the use of a high energy electromagnetic field that heats up rapidly the liquids contained in the waste causing the destruction of the infectious components. The HCW passes through a preparative process which may include segregation to remove undesirable material before it is shredded and then eventually humidified prior to being treated in the irradiation chamber. At the end, the waste goes through a compactor before being disposed of.

Similar to the autoclaving technique, the output from a microwave facility is considered non-hazardous and can be land-filled together with municipal waste. Since the technology does not involve the application of steam, there is a minimal generation of wastewater which can be recycled to the system. Since electricity is the main source of energy for operating this technology, gas emissions are also minimal compared to incineration or even autoclaving, which can require the combustion of fuel for the generation of steam.

Microwave	Advantages	Drawbacks
	<input type="checkbox"/> The shredding and compacting process reduces the volume of the waste <input type="checkbox"/> Once treated, waste can be land-filled with other municipal waste <input type="checkbox"/> No air pollution	<input type="checkbox"/> Highly sophisticated and complex <input type="checkbox"/> Important investment and running costs <input type="checkbox"/> Only solids can be treated and only once shredded <input type="checkbox"/> Cannot be used to treat some special wastes such as pharmaceuticals, and

		cytotoxic waste <input type="checkbox"/> Highly skilled operators required <input type="checkbox"/> No reduction of the weight of the waste treated
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Chemical disinfection, used routinely in HCFs to kill microorganisms on medical equipment has been extended to the treatment of HCW. Chemicals (mostly strong oxidants like chlorine compounds, ammonium salts, aldehydes, and phenolic compounds) are added to the waste to kill or inactivate pathogens. This treatment is most suitable for treating liquid wastes such as blood, urine, stools or hospital sewage. Thermal sterilization should nevertheless be given preference over chemical disinfection for reasons of efficiency and environmental considerations.

Chemical treatment	Advantages	Drawbacks
	<input type="checkbox"/> When applied, the shredding process reduces the volume of the waste	<input type="checkbox"/> _ Can't be used to treat some special wastes such as pharmaceuticals, and cytotoxic waste <input type="checkbox"/> Highly skilled operators required <input type="checkbox"/> Chemicals used are themselves also hazardous and require special precautions/equipment when used <input type="checkbox"/> Final disposal must be same as for untreated special HCW <input type="checkbox"/> Generates hazardous waste water that needs treatment

Land disposal of untreated HCW isn't recommended and should only be used as a last resort option. When this solution has to be used, it is important the HCW be disposed of in a *sanitary landfill* and rapidly covered: one technique consists in excavating a trench in mature municipal waste at the base of the working face and immediately covering it with a two-metre thick layer of fresh municipal waste.

Alternatively, a specially constructed *burial pit* can be used. Ideally it should be lined with a material of low permeability such as clay to prevent pollution of shallow groundwater and have a fence around it to prevent scavengers accessing the waste. HCW should be covered immediately with a layer of soil

after each load. For added health protection and odor suppression, it is suggested that lime be spread over each waste load. Once the pit is filled, it should be sealed off

Technique	Advantages	Drawbacks
<p>Safe land filling Trench method (HCW is buried in a trench excavated in other waste)</p>	<ul style="list-style-type: none"> <input type="checkbox"/> Simple and inexpensive to operate <input type="checkbox"/> No specific construction costs required <input type="checkbox"/> Operates within readily available landfill system <input type="checkbox"/> Waste pickers are unable to access the health-care waste 	<ul style="list-style-type: none"> <input type="checkbox"/> Special health-care waste is not treated and remains hazardous <input type="checkbox"/> High demand for coordination between collector and landfill operator <input type="checkbox"/> Reduces awareness amongst healthcare workers of the need to segregate waste categories <input type="checkbox"/> Potentially long/costly transportation to landfill
<p>Safe land filling Separate disposal cells (HCW is deposited in specifically designed cells)</p>	<ul style="list-style-type: none"> <input type="checkbox"/> Simple and relatively inexpensive to manage if operated in connection with existing landfill 	<ul style="list-style-type: none"> <input type="checkbox"/> Special health-care waste is not treated and remains hazardous <input type="checkbox"/> Requires a safe

	for other waste	landfill with fencing <input type="checkbox"/> Requires control of scavenging and animals <input type="checkbox"/> Needs conscientious operation according to manual
Encapsulation (Filling containers with waste adding an immobilising material and sealing the container)	<input type="checkbox"/> Simple, low-cost and safe <input type="checkbox"/> May be used for sharps <input type="checkbox"/> Efficient way of reducing the risk of scavengers gaining access to the waste	<input type="checkbox"/> Not recommended for non-sharp waste <input type="checkbox"/> Must be considered as a temporary solution
Inertization (Mixing waste with cement before disposal in order to minimise the risk of leakage of toxic substances contained in the waste)	<input type="checkbox"/> Simple, low-cost and safe <input type="checkbox"/> May be used for pharmaceutical waste	<input type="checkbox"/> Not applicable to infectious HCW

Annex III

List of Hazardous Characteristics

H1 Explosive: An explosive substance or waste is a solid or liquid substance or waste (or mixture of substances or wastes) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such speed as to cause damage to the surroundings.

H3 Flammable liquids: The word "flammable" has the same meaning as "inflammable." Flammable liquids are liquids, or mixtures of liquids, or liquids containing solids in solution or suspension (for example, paints, varnishes, lacquers, etc., but not including substances or wastes otherwise classified on account of their dangerous characteristics) which give off a flammable vapour at temperatures of not more than 60.5 C, closed-cup test, or not more than 65.6C, open-cup test. (Since the results of open-cup tests and of closed-cup tests are not strictly comparable and even individual

results by the same test are often variable, regulations varying from the above figures to make allowance for such differences would be within the spirit of this definition.)

H4.1 Flammable solids: Solids, or waste solids, other than those classed as explosives, which under conditions encountered in transport are readily combustible, or may cause or contribute to fire through friction.

H4.2 Substances or wastes liable to spontaneous combustion Substances or wastes which are liable to spontaneous heating under normal conditions encountered in transport, or to heating up on contact with air, and being then liable to catch fire.

H4.3 Substances or wastes which, in contact with water emit flammable gases. Substances or wastes which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.

H5.1 Oxidizing: Substances or wastes which, while in themselves not necessarily combustible, may, generally by yielding oxygen cause, or contribute to, the combustion of other materials.

H5.2 Organic Peroxides: Organic substances or wastes which contain the bivalent-O-O- structure are thermally unstable substances which may undergo exothermic self-accelerating decomposition.

H6.1 Poisonous (Acute): Substances or wastes liable either to cause death or serious injury or to harm health if swallowed or inhaled or by skin contact.

Annex (IV)

Guidance for HCWM per category of waste

A (non-risk HCW)

Non-risk HCW, if well segregated, can be disposed of with the domestic waste. Depending on the quantities of this category of waste, it might be worth investigating ways of recuperating/recycling items such as paper and cardboard as well as plastic and metal cans that come from the administration and kitchen. Left-over food from the kitchen as well as garden waste (leaves, etc) can be recycled into valuable compost.

B1 (human anatomical waste)

It is primarily for ethical reasons that special requirements must be placed on the management of waste human body parts, organs and tissues. The waste must be collected in appropriate containers or bags as soon as possible at the place where it is generated. It must be kept in tight receptacles and under stable low temperature (5-8°C) conditions when stored temporarily for a

prolonged period of time. Intermediate storage takes place at a location that is accessible only to trained personnel (in general the mortuary).

Normally, the waste must always be incinerated completely in an appropriate facility. Household waste incineration plants are, as a rule, not suitable for the incineration of amputated body parts, removed organs and placentas. Crematoria are usually used to dispose of amputated body parts. When cremation (or incineration) isn't possible/acceptable, waste can be buried in a dedicated area.

Exemptions and special provisions

Where only small quantities of these wastes are generated (e.g. in medical practices), they can be collected in appropriate containers and managed jointly with the municipal waste.

B2 (sharps)

Sharps require that measures be taken to prevent injury and infection during their handling within and outside of the HCFs. They have to be collected and managed separately from the other categories of HCW: the collection containers (safety boxes) must always be puncture and leak-proof.

The storage of sharps to be disposed of should always take place at a location that is accessible only to trained personnel. Once the safety boxes are sealed, they can be disposed of with the other infectious waste depending on the type of disposal technology that is selected.

Special provisions for needles and syringes

All *disposable syringes and needles* must be discarded immediately following use. Syringes even without needles must be considered as unsafe. Needles should never be recapped. In addition, under no circumstances are used syringes or needles, or safety boxes, to be disposed of in normal garbage or dumped randomly without prior treatment.

Two possibilities currently exist to dispose of needles and syringes:

- They can be collected in safety boxes that are then disposed of with the infectious HCW if the disposal/treatment technologies are suitable: incineration or encapsulation are in general the adequate treatment technologies. This option is certainly the safest since it minimizes the handling of the syringe and the needle. Other options include shredding and autoclaving;
- They can also be “treated on the spot”. The treatment consists either in destroying the needle using a needle destroyer or separating the needle from the syringe using a device where the needle drops directly in a puncture-proof container.

B3 (pharmaceutical waste)

Pharmacy department stores in each HCF should be rigorously managed to reduce the generation of pharmaceutical waste. Especially, stocks of

pharmaceuticals should be inspected periodically and checked for their durability (expiration date). Stock positions should be recorded on a regular basis.

While pharmaceutical wastes of class B31 can be managed jointly with municipal waste, pharmaceutical wastes of classes B32 and B33 should be considered as hazardous and their management should take place in an appropriate waste disposal facility. Ideally, they should be returned to a national central collection point to ensure they are properly neutralized. Alternatively and only if the return cannot be ensured, an inertization⁴ technique may be used and the inerted waste disposed of in a sanitary landfill.

B4 (cytotoxic pharmaceutical waste)

The risks posed by cytotoxic pharmaceuticals are primarily of relevance for persons who come into contact with them during preparation and during or after their use. It has long been common practice in hospitals that the number of persons who come into contact with these products is small. Specific guidance on this is available⁵. These wastes usually arise at central locations, i.e. in pharmacies and laboratories and they are also often found at places where the ready-to-use cytotoxic solutions are prepared.

The precautions taken during the use of cytotoxic pharmaceuticals must also be applied on their journey outside the respective establishment, as releases of these products can have adverse environmental impacts. The management of these wastes, in covered and impermeable containers, must therefore be strictly controlled. Solid containers must be used for collection. The use of coded containers is recommended. For reasons of occupational safety, cytotoxic pharmaceutical wastes must be collected separately from pharmaceutical waste and disposed of in a hazardous waste incineration plant.

B5 (blood and body fluids waste)

Special requirements must be imposed on the management of this category of waste from the point of view of infection prevention in and outside the HCFs. Double bags or containers made of strong and leak-proof material are used for the collection of these wastes.

If a household waste incineration plant is available or a *controlled* sanitary landfill site exists, this waste can be disposed of with the general domestic waste. However, in the Sub-Saharan context, this category of waste should be disposed of with the HCW of category C1 (infectious waste) since no proper household waste incineration plant or controlled sanitary landfill currently exists in the country.

C1 (infectious waste)

Infectious wastes must be collected in leak-proof containers carefully sealed and transported to a central storage facility/delivery point in a way that precludes direct contact. They must either be incinerated or be disinfected prior to final disposal using a recognized method, preferably treatment with saturated steam (autoclaving). Disinfected wastes may be disposed of in the same way as domestic waste. The disinfection plants must be operated under the operating parameters prescribed for waste disinfection, and this mode of operation must be documented and controlled.

If autoclaving is the selected option for infectious waste treatment, the efficiency of the vapour disinfection plant must be verified by a recognized institution when the plant is first put into operation and at regular intervals thereafter (e.g. twice a year), using appropriate microbiological indicators.

Exemptions and special provisions

Body fluids and excreta of infected patients with hazardous communicable diseases can be discharged to the sewerage system if there is a strict separation between the waste and drinking water installations and the sewerage system is connected to a wastewater treatment plant. In other cases, the body fluids and excreta have to be disinfected before being discharged to the sewerage system.

Exceptionally, infectious waste can be disposed of by using a special area in a controlled landfill if there is no risk of contamination of ground or drinking water and the infectious waste is directly covered with earth or other material.

C2 (highly infectious waste)

Some medical areas produce HCW that can reasonably be suspected to be contaminated with highly contagious pathogens. Such sources include: all laboratory samples containing body fluids, tissues or faecal stools; isolation wards; and medical research facilities handling class 3 or higher pathogens.

Waste from these sources should always be pre-treated at source and then placed into yellow bags before joining the waste stream within the hospital. Autoclaving at a temperature of 121°C at 1-1.5 bars for at least 20 minutes should be the selected pre-treatment option. However, if a *distinct* autoclave is not available at source to ensure a thermal treatment, highly infectious waste can be disinfected in a concentrated 2% solution of sodium hypochlorite and left overnight before being discarded in a specific yellow bag properly sealed and itself discarded with the infectious HCW of category C1.

D (other health-care waste)

Large quantities of *chemicals* should be returned to the supplier for adequate treatment. Considering that there is currently a lack of appropriate treatment facilities for chemicals in most of the Sub-Saharan countries of Africa, on-

site disposal must therefore be foreseen. In such circumstances, noncorrosive and non-flammable chemicals may be encapsulated separately to avoid unwanted chemical reactions after neutralisation.

Waste with high contents of *heavy metals* should normally be treated in specific recycling/ treatment facilities. Alternatively, as for chemical waste, it may be encapsulated. Waste with high contents of heavy metals, in particular mercury or cadmium, should never be incinerated.

E (radioactive waste)

With the noticeable exception of Cobalt (^{60}Co), their half-life is reasonably short (6 hours for $^{99\text{m}}\text{Tc}$, 8 days for ^{131}I and 74 days for ^{192}Ir) and the concentrations used remain low. A proper storage with an appropriate retention time is sufficient to allow decay to background level. Radioactive waste should be placed in large containers or drums and labelled with the radiation symbol showing the radionuclide activity on a given date and the period of storage required

Containers or tanks with radioactive waste that has not yet decayed to background level, should be

stored in a specifically marked room with thick concrete walls (minimum 25 cm). *Non-infectious radioactive waste*, which has decayed to background level, should follow the non-risk HCW stream while *Infectious radioactive waste*, which has decayed to background level, should follow the infectious HCW stream. *Liquid radioactive waste* should be discharged into the sewerage system or into a septic tank only after it has decayed to background level in buffer tanks.

الخلاصة

إدارة النفايات الخطرة في الضفة الغربية و قطاع غزة

هذه الرسالة " إدارة النفايات الخطرة في الضفة الغربية و قطاع غزة" تهدف إلى دراسة طرق إدارة النفايات الخطرة متضمنة النفايات الطبية كحالة خاصة. إن محدودية المصادر و النمو السكاني السريع و المرتفع في الضفة الغربية و قطاع غزة سبب ضغطا كبيرا على البيئة و التي سببت العديد من المشاكل البيئية، و تعتبر النفايات الخطرة و الطبية من العناصر الواضحة لمثل تلك المشاكل.

جمعت المراجع و حالت لتحديد مدى المشكلة و النتائج المتعلقة بها. والعديد من الزيارات أجريت لخبراء في مجال البحث بالإضافة إلى زيارات ميدانية.و تم إجراء مقارنة تحليلية للقوانين وطرق إدارة النفايات الخطرة في فلسطين و الدول المجاورة.

لقد نظرت هذه الدراسة علي إدارة النفايات الخطرة في المنطقة ووجدت أن التجربة المصرية هي الأكثر فائدة.

هذه الرسالة خلصت إلى العديد من التوصيات و إلى نظامين جديدين لإدارة النفايات الخطرة و إدارة النفايات الطبية و التي ستساعد القطاع الصحي الفلسطيني و ستعزز و تطور الخدمات البيئية و الصحية. النموذج المقترح يتضمن تطبيق جديد لطرق جمع، فصل، تخزين، نقل، معالجة، و التخلص من النفايات الخطرة و النفايات الطبية، و ستساعد هذه الأنظمة للإدارة في التقليل من المخاطر البيئية و الصحية في الضفة الغربية قطاع غزة و كذلك ستساهم في التقليل من التكلفة الاقتصادية لإدارة النفايات الخطرة و الطبية. هذان النظامان المقترحان سوف يتعاملان مع كمية 2500 طن سنويا من النفايات الخطرة بالإضافة إلى 354 طن سنويا من النفايات الطبية الخطرة.

هذه الرسالة خلصت إلى العديد من التوصيات ومنها التطوير المناسب للتشريعات و اللوائح التنفيذية الخاصة بالنفايات الخطرة و البحث عن مصادر التمويل و برفع مستوى التعاون بين مختلف المؤسسات المعنية بإدارة النفايات الخطرة و فصل النفايات في المصدر و إنشاء مرافق المعالجة و التخلص في مواقع مركزية صغيرة و توصي أيضا بالمعالجة الأولية في مكان إنتاج النفايات.

أيضا يوصى بعمل أبحاث إضافية لدراسة و تحليل أي طرق المعالجة افضل من الناحية الاقتصادية.

الخلاصة

إدارة النفايات الخطرة في الضفة الغربية وقطاع غزة

هذه الرسالة " إدارة النفايات الخطرة في الضفة الغربية وقطاع غزة" تهدف إلى دراسة طرق إدارة النفايات الخطرة متضمنة النفايات الطبية كحالة خاصة. إن محدودية المصادر و النمو السكاني السريع و المرتفع في الضفة الغربية وقطاع غزة سبب ضغطا كبيرا على البيئة و التي سببت العديد من المشاكل البيئية، و تعتبر النفايات الخطرة و الطبية من العناصر الواضحة لمثل تلك المشاكل.

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