Waste Management

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I. INTRODUCTION

All types of human activity produce diverse residues called "wastes," and these differ in terms of quantity and quality and in their properties from one country to another. Waste treatment methods also vary according to the circumstances and capabilities of respective countries. In this chapter, we intend to bring to attention the waste issue in Arab countries by highlighting quality, quantity and efforts made to address it according to available information and data.

II. IDENTIFICATION AND CLASSIFICATION

Waste in the general sense of the word is whatever is left behind from any activity and has no primary or secondary use at source, though it might be of value if present in a different site where more suitable conditions are provided for ample utilization.

This concept underlines three important points, namely:

- Wastes are not found in nature but are generated from various activities, such as domestic, industrial, agricultural and others;
- Some wastes could be of no consequence and must be disposed of because there is no chance of putting them to use;
- Wastes could be cost-effective resources, as they might contain components that can be appropriately used if the right means are employed.

Wastes can be classified according to their original condition or source of generation or magnitude of hazard.

Classification of wastes according to their nature

Wastes are classified into two types according to their nature: solid and liquid waste.

- **Solid wastes** are the solid or semi-solid substances left behind from ordinary human day-to-day and other activities and are disposed of at source as residues of no value, because they are not considered to be worth keeping. They could, however, be of benefit in a different site or under different circumstances, where more adequate conditions are likely to be provided, which would allow reuse or recycling processes (EEAA, 2000; EEAA, 2001).

- **Liquid wastes** are the remains of daily activities in liquid form, such as wastewater, industrial effluents and agricultural drainage. Sediments

TABLE 1 QUANTITY OF SOLID WASTE AS PER ITS SOURCE IN SOME ARAB COUNTRIES [1]

Source of Waste	Egypt Million tons/year [2]	Kuwait 1,000 tons/year	Bahrain 1,000 tons/year [2]	Qatar 1,000 tons/year	Emirates 1,000 tons/year
Municipal (domestic)	15-16	905	680	563	2,120
Demolition and construction	3-4	1,149	-	782	3,631
Industrial	4.5-5.0	7	140	64	95
Agricultural	25-30	-	-	-	615
Sludge	1.5-2.0	-	-	-	-
Health Care	0.10-0.12	33	911	450	-
Dredging of canals and drains	20	-	-	-	-

Sources: 1. GCC 2004 ; 2. 2005 data, Egypt Ministry of State for Environmental Affairs 2006

known as sludge resulting from sanitary wastewater and industrial effluent treatment processes constitute the solid strand of these liquid wastes.

Generally speaking, residues contain manifold types of materials, with some having harmful or rather serious bearing, directly or indirectly, on sanitation, environment and national economy. These are called hazardous wastes.

Segregation of solid wastes according to the source of generation

1- Municipal solid waste or "garbage" comes from residential units, alongside commercial, service, educational and health facilities, streets, gardens, markets, hotels, and recreational places. It also covers waste of small factories and camps.
2- Industrial solid waste resulting from medium and large-scale industrial activities containing hazardous ingredients, such as chemicals and heavy metals.
3- Construction and demolition as well as road building debris which include numerous components that can, for example, be appropriately recycled for utilization in building and construction works.
4- Health care waste from hospitals, health service units such as dispensaries, polyclinics, medical centres, pharmaceutical laboratories and veterinary units, which produce both household-like waste and high-risk waste.
5- Residues of wastewater and industrial effluent treatment processes as well as sludge of sewage pits and sampling tanks, which also contain high percentage of organic matter, pollutants and infectious organisms.
6- Wastes from dredging canals and drains in the form of plant and animal residues (for example grass and dead birds) and also black mud. These wastes can be re-used if they do not contain hazardous substances.
7- Agricultural waste resulting from various farming activities, including:
   - Agricultural crop remains, suitable for recycling and the production of energy, or animal feed and fertilizers.
   - Pesticides residues and agricultural fertilizers, which are regarded as hazardous waste, and thus require safer methods of handling.
   - Animal manure and sludge of sewage pits and sanitary wastewater tanks.

III. NON-HAZARDOUS WASTE

Quantities and Rates of Non-Hazardous Wastes

While statistics and data on quantities of solid waste in most Arab countries are not available, Table 1 shows the quantity of solid waste in some countries, according to published data and information collected from local sources.

There is no definitive or common rate for all Arab countries at which wastes are generated, as this differs from one country to another and among different regions within the same country, according to community characteristics, social conditions and average income in each area. Quantities of generated waste are mainly correlated to population increases as well as economic, industrial and urban development.

TABLE 2 RATES AND QUANTITIES OF MUNICIPAL SOLID WASTE IN SOME ARAB COUNTRIES

Country	Population-2006 (approximately) [1] (x1000)	Average Rate of Generated Municipal Solid Waste kg/per capita/day	Estimated Gross Quantity of Municipal Solid Waste ton/Year (millions) [6]
Total Arab Countries	318,321	Approximately 0.7	81.300
Egypt	71,348	0.63 [2]	16.400
UAE	4,229	1.20 [3]	1.850
Bahrain	746	2.70 [5]	0.735
Saudi Arabia	23,678	1.40 [3]	12.100
Oman	2,577 **	0.70 [3]	0.658
Qatar	838	1.30 [3]	0.398
Kuwait	3,052	1.40 [3]	1.560
Yemen	22,650	0.45 [4]	3.720
Jordan	5,600	0.90 [4]	1.840
Morocco	31,567	0.33 [4]	3.800
Syria	18,701	0.50 [4]	3.410
Tunisia	10,131	0.60 [4]	2.220
Sudan	36,297	0.60 *	7.950
Iraq	28,808	0.87	9.150
Lebanon	3,917	0.60	0.858
Mauritania	3,054	0.90	1.004

Source:
1. LAS 2007;
2. Egypt Ministry of State for Environmental Affairs 2006, 2007;
3. GCC 2004;
4. Al Yousfi;
5. Egypt Environmental Affairs Association 2007;
6. Calculated using population and average waste generation rates
* Only the city of Khartoum
** Year 2003

With regard to solid municipal waste, the gross generated quantity from Arab countries is estimated at 81.3 million tons annually on the basis of an average rate of around 0.7 kg per capita daily. Table 2 shows the average rate and quantity of solid municipal waste produced in some Arab countries, based on population figures, according to available data. The quantity of municipal solid waste which is adequately treated is less than 20%, while recycled waste does not exceed 5% of the gross quantity of residues.

Components of Municipal Solid Waste

Municipal solid waste is comprised of a relatively high percentage of organic matter, while other materials such as paper, glass, plastics and minerals are less organic. Table 3 shows that the proportion of organic waste to total waste ranges between 35% in Bahrain and 63% in Jordan.

These wastes also contain some hazardous substances such as drug residues, expired medicines, chemicals, paints, household insecticides and their empty containers, used dry batteries, and electrical and electronic equipment.

Organic components represent a source of compost material intended for the improvement of soil properties, and, if properly sorted and recycled, for the production of electricity from methane gas. The remaining components (paper and glass, for example) are subject to recovery upon proper segregation and reuse processes of manufacturing of similar or different products, which yield revenues as well as economic returns in the form of health benefits. These practices are still very limited in the Arab region.

Efforts by Some Arab Countries in Solid Waste Management

Some Arab countries have pursued an integrated waste management strategy, namely handling waste as recoverable resources through a series of integrated interrelated links involving successive stages (birth-to-death life cycle), starting with at-source generation (where waste is reduced quan-

titatively, qualitatively and hazard-wise), followed by in-house storage and later multi-source amassing and transport to suitable sites for phased stockpiling or treatment. This strategy develops the possibility of recycling recoverable materials and the environmentally safe final disposal. However, problems still persist in respect of making this system operational. Efforts in this regard can be highlighted as follows:

Gulf Cooperation Council (GCC)

The GCC member countries devised a uniform waste management system that was adopted in December 1997 to codify waste treatment (whether domestic, commercial or industrial, inactive or hazardous), curtail its haphazard handling, and put in place a monitoring mechanism for waste production, storage, transport, treatment and disposal by applying techniques inhibiting harmful effects on the health, safety and prosperity of humans and ensuring long and short-term environment protection.

Nonetheless, the rate of solid waste generation in Bahrain was raised from around 1.3-1.6 kg to almost 2.7 kg per capita/day as a result of growing family income, increased purchasing power alongside flourishing urban and trade businesses. Bahrain's Environment Protection Law includes articles on waste, and waste management is undertaken by the Ministry of Municipality Affairs and Agriculture together with a 50-50 private sector partnership. These wastes are disposed of by land filling, which does not seem to be the optimal way of doing it as far as Bahrain is concerned, bearing in mind the shortage of land for this purpose, in addition to social problems and others related to environment, development and operation. At present, waste sorting and recycling processes are being implemented regarding for example paper, carton, minerals, plastic and tires, with some of these materials exported after being compressed to scale down their size (GCC, 2004).

Sudan

The solid waste situation in Sudan is not much different from that in other Arab countries with similar circumstances. For example, in Khartoum Governorate (with a population of approximately 5 million), the solid waste generated ranges between 0.6 and 1 kg per capita/day (totalling 3,200 tons). Only 35% of this quantity is transferred to landfills, while the remaining 65% is disposed of in open dumps. Foremost among the problems facing solid waste management in Sudan are the following:

- Absence of solid waste management strategies;
- Limited financial resources coupled with outdated machines and equipment, poor maintenance operations, and low wages;

TABLE 3 **COMPONENTS OF SOLID MUNICIPAL WASTE IN SOME ARAB COUNTRIES**

Country	Organic materials %	Paper %	Plastic %	Mineral %	Glass %	Wood %	Textile %	Others %	Total %
Egypt[1]	50-60	10-25	3-12	1.5-7.0	1.0-5.0		1.2-7.0	11.0-30.0	100
Bahrain[2]	35	28	6	12	5		8	6	100
Saudi Arabia[3]	37	28.5	5.2	8.3	4.6	8	6.4	2	100
Oman[2]	40	26	12	11	5		6		100
Qatar[2]	45	18	15	4	10	5	3		100
Kuwait[2]	50	20	12.6	2.6	3.3	4.8	4.8	1.9	100
Yemen[3]	55	14	13	2	1.5			14.5	100
Jordan[3]	63	11	16.8	2.1	2.1			5	100
Syria[3]	62	4	7	6	4			17	100
Iraq[3]	63	1	1	1.1	1.6			32.3	100
Lebanon[3]	58	18	8	2.4	8			6.6	100
Dubai[3]	42	6	10	3	3			16	100
Abu Dhabi[3]	49	6	12	6	9			18	100

Sources:
1. Egyptian Ministry of State for Environmental Affairs 2006;
2. GCC 2004;
3. Al Yousfi

- Meagre basic infrastructure, low-level efficiency of existing systems, degraded road conditions and deficiency of land-use planning to identify final disposal sites;
- Non-governmental organizations are short of sufficient resources and are in need of subsidies to strengthen their partnership with the government in envisaging policies on solid waste management (El Sayed, 2006).

Tunisia

Dealing with the solid waste issue, and tackling the problem of increasing quantities accumulated as a result of production and consumption patterns in the country, can only materialize through the adoption of an integrated waste management concept.

The common method of solid waste disposal in Tunisia is uncontrolled land filling sites designated for waste disposal, considered as temporary sites, to be gradually changed into controlled dumpsites. The problem of accumulated waste with its impacts on environment is one that the Tunisian government has so far failed to resolve notwithstanding the fact that Tunisia was the first Arab country to promulgate a special law on waste (GCC, 2004).

Egypt

Gross solid municipal waste generated daily is estimated at approximately 44,630 tons with a general average of 0.63 kg per capita/day (ranging between 0.2-0.35 in rural areas and 0.4-1.3 in urban areas). These wastes include organic matter, paper, plastic, etc, with relative density amounting to almost 0.3 ton/cubic meter and humidity percentage reaching 30% to 40%, whereas the thermal content is proportionally low.

The general average of waste collection efficiency is put at almost 65%; i.e. 35%, or nearly 15.6 thousand tons, are not systematically collected on a daily basis. In Egypt, the Environment Protection Law contains articles on waste. In July 2000, the national strategy for solid municipal waste management was released and a national program was developed to encompass 13 integrated projects.

The state adopted thermal and biological treatment methods but favoured bio-treatment by composting with recyclables recovery, which proved effective since 1995 as regards expanded manufacture of waste by converting it into compost materials. The number of plants designed and established in Egypt was 66 in 2005, the capacity of each amounting to 10 tons/hour, thus possibly recycling nearly 22% of the aggregate generated municipal waste daily if these plants were fully operated; unfortunately, some of them struggled with sustained administrative problems.

The remaining wastes or treatment process residues are disposed of either in controlled or informal landfills. The state therefore headed for phased transformation into sanitary dumping in appropriate sites. 52 sites were already selected and designated in conformity with environment protection and human health standards, of which 4 were established and made functional and the rest, due to various problems and obstacles, are yet to be completed (Egyptian Ministry of State for Environmental Affairs, 2006, 2007).

Yemen

With reference to the incredible increases in solid waste quantities in Yemen, legislation was issued in 1999 on establishing the Municipal Cleaning Fund that provided for three underlying strategies:

decentralization, cost recovery and private sector participation in waste management. In 2000, the Sanaa Institution was incorporated into Yemen's waste management efforts. Besides sorting waste, it undertook segregating and amassing components not subject to decay and exporting some of it to such countries as India, China, Lebanon, Greece, Saudi Arabia and UAE, for recycling. Thus it can be said that amounts transformed into compost materials were increased, and consequently revenues were earned and environmental benefits accrued. Moreover, part of the recyclable components is sold to agents whereas non-recyclables are once again returned to the dumpsite.

Jordan

In Jordan, no national strategy for solid waste management has been drafted. The average rate of solid municipal waste surge is estimated at around 0.77 kg per capita daily, most of which is collected and transported to a systematically regulated dumpsite. In addition to recycling operations carried out at the informal sector level, initiatives for utilizing organic waste for bio-gas production were launched.

Table 4 shows the percentage of treated solid municipal waste and different ways of their disposal in some Arab countries based on limited data made available in recent years (Metap RSWMP, 2004).

Table 4 shows low treatment and recycling rates in general, and the reliance on disposal in open dumps or landfills.

IV. HAZARDOUS WASTE

The term "hazardous waste" is used as an indication of all residues representing hazard in connection with human health and environment upon use, storage, treatment or disposal. This is due to their characteristics, quantities and concentrations, thereby demanding special procedures for their circulation and disposal (Center for Curbing Environmental Risks, Cairo University, 2006).

TABLE 4 PERCENTAGES OF SOLID WASTE TREATMENT AND RECYCLING IN SOME ARAB COUNTRIES

Item/Country	Syria	Lebanon	Egypt	Jordan	Palestine	Tunisia
Quantity						
Million tons annually	3.65-5.50	1.4	15.3 (2001)	1.46	1.1 (2001)	1.8
Surge Rate						
Countryside	0.20-0.40	0.5-0.7		0.65		0.2
Urban areas	0.40-0.50	0.75-1.1		0.7-0.850		0.8
Collection processes %						
Rural areas	Unspecified	95.0	General Average	95.00	General Average	90.0
Urban areas	80.00	100.0	65.0	95.00	75	95.0
Treatment						
Transformation into compost materials %	Less than 5.00	80.0	Less than 22.0			4.0
Re-cycling %	Less than 15.00	8.0				5.0
Final disposal						
Land filling %	Less than 25.00	46.0		85.00		50.0
Open dumps %	Over 60.00	38.0		15.00		44.6
Generated Waste						
Annual increase	2.50-3.50	6.5 (Beirut)	3.4	3.00	4	2.0

TABLE 5 ESTIMATION OF HAZARDOUS WASTE QUANTITY ON GDP BASIS

State	World Bank Classification	GDP estimates for 2006 (in $ million)	Waste Hazard Coefficient Ton/$billion	Estimates of hazardous waste quantity (Around 1000 tons)
Egypt	Medium-Low	107,378	2,000	214
Saudi Arabia	High	348,673	Over 2,000	Over 697
UAE	High	164,865	Over 2,000	Over 329
Kuwait	High	101,904	Over 2,000	Over 203
Bahrain	High	15,828	Over 2,000	Over 31
Oman	Medium-High	35,656	2,000	71
Qatar	High	52,722	Over 2,000	Over 105
Yemen	Low	21,196	1,000	21
Jordan	Medium-Low	14,258	2,000	28
Morocco	Medium-Low	65,899	2,000	132
Syria	Medium-Low	34,190	2,000	68
Tunisia	Medium-Low	31,416	2,000	63
Lebanon	Medium-High	23,285	2,000	46
Sudan	Low	43,894	1,000	44
Mauritania	Low	2,713	1,000	3

Source: World Bank 2007

The US Environment Protection Agency, the European Waste Catalogue, the Canadian Environment Protection Law, the Basel Convention On the Control of Transboundary Movements of Hazardous Waste, and many national environment laws of Arab countries have set out definitions of hazardous waste under which hazard-incurring attributes apply when the wastes are flammable, corrosive, effective, oxidizing, irritating (non-erosive), toxic, harmful, distorting, cancroid or contagious, not to mention the quality of post-final disposal potential transformation and generation of toxic gases.

Hazardous Waste Sources

Hazardous wastes are generated from activities such as:

- Heavy industries, as well as medium industries: these produce the bulk of hazardous waste in most Arab countries.
- Agricultural activities: expired or invalid fertilizers and pesticides and their empty packs.
- Oil-related activities: numerous hazardous wastes result from oil drilling, refining, transportation and utilization.
- Therapeutic and health-care activities: waste generated from hospitals, health treatment units, private clinics, pharmacies and drug stores.
- Research and lab activities: examples are expired chemicals and interaction residues.
- Service activities: sanitary wastewater stations, car-service stations, photograph laboratories, printing houses and dry-cleaning shops.
- Military operations: massive quantities of hazardous waste are generated, mainly from land and marine mines and expired ammunition, and lately from depleted uranium.
- Garbage and municipal waste: garbage contains some hazardous waste of such materials as expired medicines, chemicals, paints, insecticides and their empty containers, consumed dry batteries, and electrical and electronic equipment. Slaughter house wastes include dead animals or infectious parts or remains of animals, amounting to sanitation hazard.
- Illicit trafficking in hazardous waste: some countries face attempts by other countries to export hazardous waste into their territories under the cover of recycling or reuse.

Many activities commonly engender hazardous wastes which are not confined to just one activity, such as:

- Residues of electric and electronic equipment such as computers- televisions, telephone sets, photocopiers, fax machines, and recorders.
- Oil-related waste (machine oils – brake and motor oils).
- Expired or non-conforming chemical substances.
- Chemicals and pesticides' empty packs.

- Used batteries and car tires.
- Equipment not suitable for use, with components containing asbestos or PCB or CFC.

Hazardous Waste Quantities

One main determinant for sound hazardous waste management rests with the insufficiency of available updated data relating to relevant quantities from different sources. A report issued in 2004 (GCC, 2004) put forward the following estimates of hazardous waste quantities in some Gulf Cooperation Council member states during the second half of the 1990s:

Bahrain	95,000 tons/year
Saudi Arabia	220,000 tons/year
Oman	81,000 tons/year
Qatar	75,000 tons/year
Kuwait	120,000 tons/year

To determine the quantity of hazardous waste, surveys and statistical studies need to be conducted. There are methods that can be applied to estimate quantities of hazardous waste including reference to universally acknowledged standards.

- By applying coefficients for weak hazardous waste according to WHO lists for 1993.
- By conforming to standards of the US Environment Protection Agency (EPA).

Applying the GDP method (see box 1), the gross domestic product of all Arab countries in 2006 can be estimated at approximately $1,276,282 million. Taking into account progress and development scales depending not only on income levels but also on other criteria related to education, training, scientific research, trade movement and others, Arab countries are categorized as developing countries, some in the development stage characterized by variant incomes. Therefore it can be said that the aggregate quantity of hazardous waste is estimated between 1,276 and 2,552 thousand tons from Arab countries combined, i.e. between 1.6 and 3.2% of the gross quantity of solid municipal waste. Based on the World Bank country classification according to average per capita estimates of 2005, the quantity of hazardous waste is calculated at over 3,055 thousand tons, or nearly 4% of the aggregate quantity of solid municipal waste as shown in Table 5. Given the unavoidable inaccuracy of these estimates, more effort is needed to determine the exact quantities which can then become the basis from which to embark on sound planning for its safe handling.

Estimates of the quantity of specific types of hazardous waste (such as health-care residues)

The quantity of health-care waste in some Arab countries is estimated as follows:

UAE	2,739 ton/year
Oman	2,112 ton/year
Bahrain	755 ton/year
Qatar	516 ton/year
Saudi Arabia	18,860 ton/year
Kuwait	2,038 ton/year
Lebanon	5,568 ton/year
Morocco	10,605 ton/year
Syria	9,750 ton/year

Despite the inaccuracy of hazardous waste estimates in general, there is obvious disparity in health-care waste quantity compared to gross hazardous waste, with a percentage ranging between less than 1% (for Qatar and Bahrain) and 8.6% (for Saudi Arabia), thus corroborating the significance of regularly updating data and scrutinizing existing data for inconsistencies.

Egypt

The total health-care waste is estimated at approximately 390,901 kg/day including around 109,514 kg/day as hazardous (about 28%) generated from 165,138 beds in health care facilities around the country; therefore the average output of such waste can be perceived as:

2.37 kg/bed/day	gross waste
0.66 kg/bed/day	hazardous waste

GLOBAL ESTIMATES OF HAZARDOUS WASTES ON GDP BASIS

For developing countries	**1,000** ton/$billion
For countries in the development stage	**2,000** ton/$billion

Yemen

A sample-based study in 2002, which covered 49 health facilities in Yemen, revealed that the generation rate of related waste ranged between 1–2.1 kg/bed/day, 0.58 of which were hazardous.

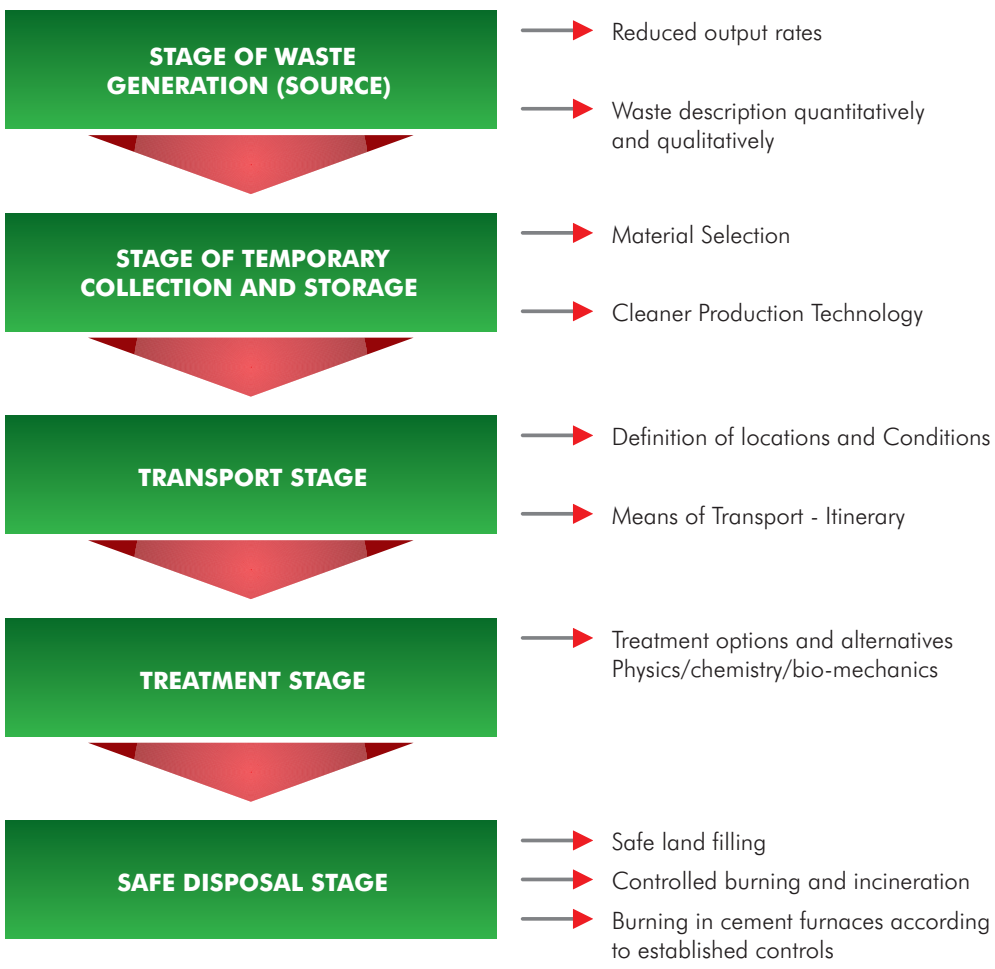
Hazardous Waste Management

The following diagram shows stages of hazardous waste management from generation to final disposal.

Handling these wastes differs from one country to another according to conditions and capabilities with regard to meeting the requirements of the full-fledged system. Given limited data and information, it becomes difficult to identify the management efficiency level as far as Arab countries are concerned; however some important deliverables are outlined to this effect:

- In GCC member countries, a unified system for health-care waste management was set and adopted in April 2001.
- Bahrain established a law on environment with articles dealing with hazardous waste focusing on the concept of at-source reduction and segregation by applying cleaner production techniques. A special site is designated for final disposal.
- Saudi Arabia developed relevant standards and guidelines.
- Oman issued a law and a statute on management, and furnished some equipped sites in addition to temporary storage of some of these wastes and burning in special incinerators of medical waste.

FIGURE 1 STAGES OF HAZARDOUS WASTE MANAGEMENT SINCE GENERATION



- Kuwait elaborated a law and set standards for environment protection while using burning and incineration plus land filling (sterilization of medical waste).
- Qatar has special incinerators for medical wastes.
- Tunisia provided a special site for hazardous waste treatment.
- Egypt developed a law on hazardous wastes, also a strategy and work program for healthcare waste. It laid down relevant rules, controls and guidelines, adopted life-cycle, cleaner production and at-source reduction concepts and used burning, incineration and disposal in cement furnaces and waste landfills.

V. ELECTRICAL AND ELECTRONIC WASTE (EEW)

Electrical and electronic waste is what remains from the production and use of electrical and electronic equipment, their parts and inputs, including:

- Manufacturing processes and production waste, such as plastic, glass and mineral materials, rubber and the like, in addition to oils, lubricants and inks which all contain heavy metals such as lead, cadmium, chrome, nickel and zinc, as well as precious elements (such as gold and silver).
- Waste resulting from operational processes, which include:
  - Inputs of operating electrical and electronic equipment such as batteries, charging cards, magnetic tapes, printing inks and used oils;
  - Expired equipment;
  - Equipment or parts thereof that were irreparably damaged, broken or became dysfunctional and no longer fit for use.
- Outdated equipment or parts thereof, namely all electrical and electronic equipment, their attachments and operational inputs are considered wastes if proved unfit or unable to cope with technological advancement and modern requirements (Abu El Saud, 2004).

Quantity and Components of Electrical and Electronic Equipment

Available data reveals that electronic and electrical wastes represent a small percentage of the aggregate waste generated in any country. For example, this type of waste in the European Union member states accounts for 1% of the total generated waste (European Parliament, 1998), while in the US it ranges between 2% and 5% of the gross quantity of solid municipal waste, and is increasing by 3% to 5% annually. Assuming an average rate of around 3%, the quantities of electrical and electronic residues of Arab countries can be estimated as shown in Table 6.

A 2004 report by the Department of Environmental Health in the State of California (California IWMB, 2004) indicated that electronic equipment waste includes more than 1,000 substances in varying, mixed or blended quantities regarding different ingredients of equipment, some are hazardous and others are of value for possibly being regarded as recyclables. Some examples are:

- Lead which is found in glass screens of TV sets and computer monitors;
- Plastic materials and heavy metals in printed circuit boards;
- Batteries containing nickel, chrome, and other heavy metals;
- Hazardous polychlorinated substance (PCBs) found in condensers.
- Brominated flame retardants;
- Mercury found in medical apparatuses and cellular phones;
- Plus gold and silver, being precious elements seen as a source of economic value on account of their potential recovery.

The same report states that each computer contains 3.7 pounds of lead, 11.4 pounds of plastic, 0.006 pounds of cadmium and 0.001 pounds of mercury. These figures have been used to estimate quantities of various substances available in computers used across the Arab countries (Table 6). Until now, used or obsolete computers and other electronic and electrical equipment end up in dumps, while they should be segregated to reuse some components, recycle others, and properly dispose of hazardous contents. Still, a limited portion is recycled or reused, largely on selective basis and through private initiatives.

It must be recognized that with electronics continuously advancing and in view of increased dependence thereon, it is certain that for the few coming years, much equipment and accessories will be generated as waste requiring safe disposal.

TABLE 6 QUANTITY AND CONTENTS OF ELECTRICAL AND ELECTRONIC EQUIPMENT WASTE

State	No. of cellular phones/100 persons [1]				No of Personal Computers [1]			
	1996 [4]	2004	2005	2006	1996 [5]	2002	2003	2004
Egypt	6.7	10.92	19.10	23.86	337,745	1,120,000	2,000,000	2,300,000
Saudi Arabia		38.21	57.64	78.05		3,300,000	5,045,000	8,476,000
Kuwait		57.16	78.34	88.57		285,000	400,000	450,000
Bahrain		90.77	103.04	121.71		107,000	114,000	121,000
Oman	17.1	31.82	51.94	69.59	24,133	95,000	106,000	118,000
Qatar		66.59	62.15	109.06		110,000	121,000	133,000
Yemen		3.47	5.17	9.54		145,000	200,000	300,000
Jordan		28.93	55.02	74.40		200,000	245,000	300,000
Morocco	20.9	31.24	40.89	52.07	45,642	500,000	600,000	620,000
Syria	2.3	12.87	15.49	23.96	20,538	330,000	500,000	600,000
Tunisia	5.2	37.43	56.32	71.88	60,896	335,325	400,372	472,132
Lebanon	22.7	24.91	27.78	30.53	15,355	300,000	350,000	400,000
Sudan		3.04	5.21	12.66		200,000	348,000	606,000

Sources:
1. ESCWA Report for 2007;
2. Calculated on the basis of 3% of total solid municipal wast;

Efforts made to this end are very limited (according to available data). In Egypt, one of the mobile companies collected consumed batteries of cellular phones from the Egyptian market for recycling in the United Kingdom in collaboration with Phone Back Company. The company also collected fitting parts of photocopiers and printers for reshipping to the mother company abroad (Egyptian Ministry of State for Environmental Affairs, 2007). Etisalat, the UAE based telecommunications giant, has also announced a mobile phone recycling initiative.

Safe Alternatives Regarding Disposal of Electrical and Electronic Equipment

To achieve safe management of these wastes and redress effects related to environment and health of unsystematic disposal processes carried out in solid waste unloading sites or by burning, the optimal approach hinges on the adoption of the "reduction, reuse, recycling and recovery" principle by applying advanced high-tech procedures and activities and clean technology during the manufacturing and production stage, and other means relevant to the post-operation stage. These activities are promoted by a framework of appropriate and supportive legislation based on specific and agreed policies. Figure 2 shows the hierarchical arrangement of this management.

VI. CROSS-BORDER HAZARDOUS WASTE MOVEMENT

Many countries have recourse to the export of hazardous waste to other countries which are able to handle it. Such movement is governed by the Basel Convention which controls the Transboundary Movements of Hazardous Wastes. This Convention was adopted in 1989 and entered into force in 1992.

Under this Convention, members are not authorized to proceed with export and import processes or transnational transfer of hazardous waste except in accordance with controls and procedures articulated in the Convention.

19 Arab countries have ratified this Convention and some of them are in the process of exporting hazardous waste to other state parties. Vessels carrying hazardous waste shipments are allowed by some other countries to cross their borders. Some examples from the Arab region:

- In 1996, Yemen exported 262 tons of expired pesticides to Britain for disposal. Between 1999-2004, around 152,500 tons of expired batteries were exported to Indonesia.

- In 2001, Bahrain exported 761.45 tons of acid lead batteries to Indonesia and about 27 tons of chemical waste to Canada for treatment and disposal.

Estimated quantity of wastes for 2004 (Ton/Year)	Estimated computer contents/2004 (tons) [3] Lead	Plastic	Cadmium	Mercury
480,000	3,860.0	11,889	6.30	1.050
348,000	14,255.0	43,906	22.10	3.700
39,000	757.0	2,331	1.23	0.200
20,400	203.5	627	0.33	0.055
180,000	197.5	611	0.32	0.055
9,065	223.7	689	0.36	0.060
99,600	504.0	1,554	0.82	0.120
54,000	504.0	1,554	0.82	0.120
108,900	1043.0	3,116	1.69	0.280
96,000	1009.0	3,108	1.64	0.270
65,100	793.8	2,445	1.29	0.210
25,400	672.7	2,072	1.09	0.180
219,000	1,019.0	3,139	1.65	0.270

3. Calculated according to components of electronic equipment waste, California IWMB 2004;
4. World Bank – Development Indicators for Africa, 2002;
5. Calculated against the number of population and world development indicators – World Bank 1988-2002

- In 1996, Tunisia exported batteries containing cadmium and lead to some EU countries. In 2001, 65 tons of electric transformers containing poly-chloro bi-vinyl compounds were exported to a private establishment in France.

- In the Sultanate of Oman, used oils are exported.

Egypt permits navigation across the Suez Canal of ships carrying hazardous waste for purposes of recycling, reuse or final disposal in compliance with respective national conditions in addition to provisions set forth in relevant international conventions. Saudi Arabia is set to operate observation and control systems applicable to crossing and anchored ships in ports.

VII. LIQUID WASTE

Liquid waste is the wastewater resulting from using water for different purposes.

Quality and Quantity

- Agricultural Wastewater: These are liquids resulting from water used in irrigation. Irrigation and agriculture water accounts for the main percentage of water utilized in most Arab countries. Moreover, agricultural wastewater drainage differs in percentage according to type of crops, technology applied and climate condition, ranging between 30% and 90%.

- Industrial Effluents: These are liquids resulting from water consumed or used in major industrial activities. A report indicated that only 5% of the water used in industry is consumed and unrecoverable. These liquids include organic pollutants and chemical substances posing, in most cases, environmental and health risks.

TABLE 7 WASTEWATER IN SELECTED ARAB COUNTRIES

State	Wastewater Estimates Million m^3/year
Algeria	1,069
Egypt	4,394
Jordan	171
Kuwait	160
Lebanon	362
Libya	308
Morocco	817
Oman	76
Saudi Arabia	1,546
Syria	479
Tunisia	349
UAE	424
Yemen	212

Source: Estimated at 80% of domestic consumption, EarthTrends 2005

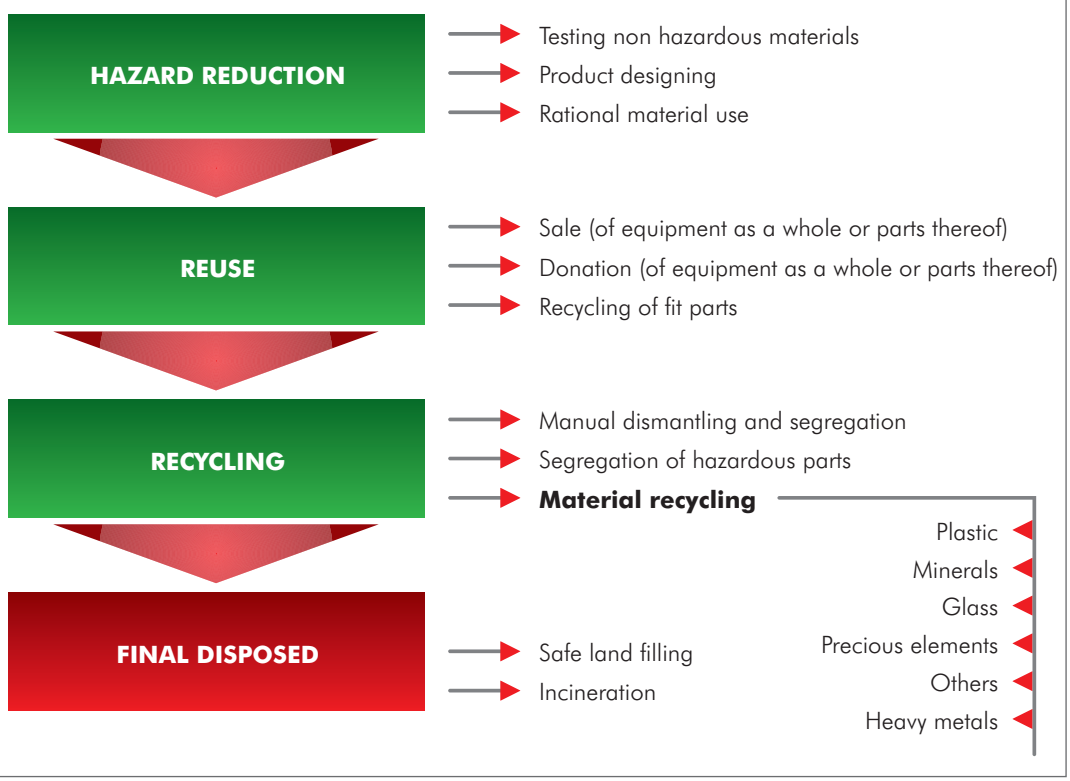
- Drainage/Sewage: This results from using water in domestic, commercial and other municipal purposes. Though constituting the smallest percentage of water utilization, it is normally pathogen-bearing water that may cause illnesses, in addition to hazardous chemical substances, especially if mixed with industrial effluents. Wastewater is responsible for almost 80%-90% of water consumption in household activities.

Table 7 shows estimates of wastewater generated and industrial effluent contamination levels in Arab countries for 2000. Table 8 indicates quantities of recoverable treated wastewater.

Methods of handling liquid waste

Methods of handling wastewater differ from one country to another. However, in view of

FIGURE 2 HIERARCHICAL ALIGNMENT OF ELECTRICAL AND ELECTRONIC EQUIPMENT WASTE TREATMENT AND DISPOSAL



the limited water resources available, it is generally required that this water is reused, directly or indirectly, according to environment protection and sanitation standards. Many Arab countries have issued codes and controls for the use of wastewater, but reuse levels remained limited.

In Egypt, and within the framework of synergy of ministries of environment, housing and agriculture together with private sector participation, part of the treated sanitary wastewater is utilized in afforestation and cultivation of wood trees to partly absorb environment-polluting gases (especially carbon dioxide), provide job opportunities and yield returns. Up till 2005, 11,195 acres were cultivated consuming around 492,000 cubic meters daily of treated sanitary wastewater (about 0.01% of its gross quantity). In 2006, the basic infrastructure for cultivating a further 890 acres was finalized and this activity is planned to be continued.

Abu Dhabi and Dubai use most of the treated wastewater in irrigation, mainly for landscaping purposes. Although 60% of the wastewater generated in Kuwait is treated by advanced reverse-osmosis process, making it safe for any type of use, certain taboos still restrict full utilization.

TABLE 8 REUSABLE TREATED WASTEWATER

Country	Volume of reusable treated wastewater (million cubic meter/year)	Percentage of wastewater %
Egypt	200.00	4.60
Jordan	65.00	38.00
Kuwait	52.00	32.50
Lebanon	2.00	0.55
Oman	9.00	11.80
Qatar	0.13	
Saudi Arabia	122.60	7.90
Syria	550.00	
Yemen	185.30	87.40

Source: UN Economic and Social Commission for West Asia (ESCWA) 2005

VIII. CONCLUSION

Some Arab countries have embarked on the application of an integrated environment management approach towards waste, and demonstrated deliverables especially with regard to non-hazardous waste. However, the Arab countries are still faced with numerous challenges embodied in:

- Lack of surveys, statistics and consequently data and information on hazardous waste in particular;
- Lack of enforcement of environmental legislation;
- Limited technical infrastructure, plans and strategies;
- Insufficient financial resources;
- Low-level of awareness;
- Incomplete institutional structure and limited participation of non-governmental organizations.

Subsequently, it is worth noting that in the best scenario, what is needed is a multi-component integrated system involving full waste life cycle stages starting from waste generation to final disposal, taking into consideration the principle of reducing the consumption, reuse, recycling and recovery. In all processes, the following steps should be duly taken:

- Provide appropriate environmental legislative frameworks and give effect to international conventions regulating them;
- Promote national institutional capacities and coordination with international organizations to control locally-generated hazardous wastes and prevent their illicit trafficking;
- Provide human resources in sufficient numbers, and in terms of appropriate capacity and efficiency, specify their roles and responsibilities at all levels and develop sustained training programs;
- Sensitize entities concerned at all levels and the community in general regarding issues pertaining to waste management;
- Provide necessary funds from different sources and always bear in mind local circumstances;
- Encourage research and development activities to ensure that technologies are adequately provided to curb waste surges and secure their safe handling.

There is widespread acceptance that waste management is a challenge that Arab countries have to address by adopting an integrated approach. A first prerequisite for any such endeavour would be the collection of accurate data, which is still lacking, and mostly based on estimates.

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