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Hospital waste management in El-Beheira Governorate, Egypt

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A B S T R A C T

This study investigated the hospital waste management practices used by eight randomly selected hospitals located in Damanhour City of El-Beheira Governorate and determined the total daily generation rate of their wastes. Physico-chemical characteristics of hospital wastes were determined according to standard methods. A survey was conducted using a questionnaire to collect information about the practices related to waste segregation, collection procedures, the type of temporary storage containers, on-site transport and central storage area, treatment of wastes, off-site transport, and final disposal options. This study indicated that the quantity of medical waste generated by these hospitals was 1.249 tons/day. Almost two-thirds was waste similar to domestic waste. The remainder (38.9%) was considered to be hazardous waste. The survey results showed that segregation of all wastes was not conducted according to consistent rules and standards where some quantity of medical waste was disposed of with domestic wastes. The most frequently used treatment method for solid medical waste was incineration which is not accepted at the current time due to the risks associated with it. Only one of the hospitals was equipped with an incinerator which is devoid of any air pollution control system. Autoclaving was also used in only one of the selected hospitals. As for the liquid medical waste, the survey results indicated that nearly all of the surveyed hospitals were discharging it in the municipal sewerage system without any treatment. It was concluded that the inadequacies in the current hospital waste management practices in Damanhour City were mainly related to ineffective segregation at the source, inappropriate collection methods, unsafe storage of waste, insufficient financial and human resources for proper management, and poor control of waste disposal. The other issues that need to be considered are a lack of appropriate protective equipment and lack of training and clear lines of responsibilities between the departments involved in hospital waste management. Effective medical waste management programs are multisectoral and require cooperation between all levels of implementation, from national and local governments to hospital staff and private businesses.

1. Introduction

Medical establishments play important roles in different activities by the use of modern technology to restore and maintain community health through different departments in the establishment and its firms. Medical establishments include hospitals, clinics, medical centres, private practices, home health care, blood banks, veterinary offices, clinical facilities, research laboratories, clinical laboratories, and all unlicensed and licensed medical facilities (Labib et al., 2005).

The World Health Organization (WHO), (2000) defines hospital solid waste as "*any solid waste that is generated in the diagnosis, treatment, or immunization of human beings or animals, in research pertaining thereto, or testing of biological, including but not limited to: soiled or blood-soaked bandages, culture dishes and other glassware*". It also includes discarded surgical gloves and instruments, needles, lancets, cultures, stocks and swabs used to inoculate cultures and removed body organs.

Health-care waste consists primarily of pathological, infectious, chemical, pharmaceutical, and domestic wastes as well as sharps that have been contaminated with blood, infectious agents, tissues, organs, etc (Alagöz and Kocasoy, 2008). More than 75% of these wastes have been generated from the Egyptian hospitals while the rest of them have been generated from other small health-care institutions (Helwa, 1998).

Globally, about 5.2 million people (including 4 million children) die each year from waste-related diseases (Akter, 2000). The waste generated from hospitals is now recognized as a serious problem that may have detrimental effects either on the environment or on human beings through direct or indirect contact. Exposure to hazardous health care waste can result in disease or injury (WHO, 1999). Diseases like typhoid, cholera, acquired immunodeficiency syndrome (AIDS), and viral hepatitis B can be transmitted through

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the mismanagement of hazardous hospital waste (Mato and Kassenga, 1997). Environmental nuisance may also arise due to foul odour, flies, cockroaches, rodents, and vermin as well as contamination of underground water tables by untreated medical waste in landfills (Nemathaga et al., 2008).

There is growing awareness worldwide of the need to impose stricter controls on the handling and disposal of wastes generated by health care facilities (DEFRA, 2005). In developed countries, legislation and good practice guidelines define medical wastes and state the various possible ways for collection, transport, storage and disposal of such wastes. Also, the best available technologies are used for the development of alternatives for proper disposal of medical wastes with minimal risks to human health and the environment (Tudor et al., 2005). Generally there is no single disposal practice as a solution to the problems of managing hospital waste, so in most cases, a number of practices include landfills, incineration, autoclaving, and recycling are used in combination. Each practice has its own weaknesses and strengths (Nemathaga et al., 2008). However, in developing countries, medical wastes have not received sufficient attention. In many countries, hazardous and medical wastes are still handled and disposed off together with domestic wastes, thus creating a great health risk to municipal workers, the public, and the environment (Silva et al., 2005). In other developing countries, waste disposal options are limited, and small-scale incinerators have been used as an interim solution.

Like many developing countries, Egypt strives to enhance its hospital waste management and achieve good management. Although decree No. 338/1995 and No. 1741/2005 of Environmental Law No.4 (1994) has issued to systematize integrated hospital waste management implementation, authorities are failing to install efficient system with respect to segregation, collection, transfer or treatment due to weakness of legislative enforcement. In addition, various difficulties are being faced at many governorates for implementation of integrated hospital waste management requirements in practice. A number of obstructions are being confronted in El-Beheira Governorate such as inadequate provision of budget allocation, lack of awareness and training about integrated hospital waste management system, etc. Lack of the governmental records and studies regarding waste quantities, characteristics and categorization in health care institutions of El-Beheira Governorate are also limiting factors to identify the existing management shortcomings. Therefore, this study was conducted to carry out an environmental health survey of medical establishments located in El-Beheira Governorate. Field visits were conducted to assess the current medical waste management practices used by hospitals in Damanhour City, to determine quantities of wastes generated as well as to investigate physical and chemical characteristics of wastes in order to recommend the appropriate waste management practices.

2. Background information

El-Beheira Governorate is one of the largest governates in Egypt, located in the west of the Nile Delta of the Rosetta branch. It covers an area of about 9122,84 km^2, and a population of about 4,999,462 million with an annual growth rate of 2.1%; 81.4% of them are living in rural areas (HAD, 2007; UNDP, 2006). It consists of 15 cities, 15 centres, 84 local units village, 491 main villages and 11 corporate, 10 chiefdoms, and 5980 manors (UNDP, 2006). Among cities, only Damanhour is the capital city which covers an area of about 391,42 km^2 representing 4.3% of total El-Beheira area and subdivided into 7 local units village, 57 main villages, and 824 Ezbas (UNDP, 2006). It has the highest population density of about 743,450 comprising 262,125 urban and 481,325 rural that is representing 14.8% of El-Beheira inhabitants (HAD, 2007; UNDP, 2006).

2.1. Waste quantities

In some Egypt's governorates, the quantities of medical waste generated in hospitals have been recorded from different medical services sources as presented in Tables 1–3, (Helwa, 1998).

3. Material and methods

3.1. Study setting and design

Damanhour City was selected for the following reasons:

- It has the only general and teaching hospital (National Medical Institute) with a total number of 590 beds (HAD, 2007).
- It has the highest percentage of El-Beheira public and private hospitals (15.3% and 38.8% respectively) with the highest percentage of different medical services types such as medical staff, beds number, etc (HAD, 2007; UNDP, 2006).

Damanhour's hospitals were stratified to cover the public and private sectors and half (50%) of them (eight) were randomly selected according to the proportional allocation method of sampling (Pedhazur and Schmelkin, 1991).

3.2. Data collection

The data gathered were based upon reviewing the statistical records of El-Beheira Governorate issued each year by the Health Affairs Directorate (2007) and a questionnaire distributed to the eight selected hospitals in Damanhour City. A questionnaire was used to assess the current hospital waste management system in terms of segregation, collection, transportation, treatment, and disposal based on the recommendations from the WHO (1999) and the Egyptian Prime Minister (1994) Executive Decree No. 338/1995 and No. 1741/2005 of Environmental Law No.4.

3.3. Sampling and analysis

The collection of hospital waste samples and quantitative analysis were carried out in 2008. The waste characterization study was carried out in accordance with WHO guidelines (1978). All of the wastes generated in 8 hospitals were weighed on a daily basis, during a period of six months. Unit generation rate in kg/bed/day was calculated by dividing the generation rate in kg/day on the total number of beds in the hospital. Then, in order to determine its physical and chemical characteristics, the waste was separated into different categories according to type of waste such as paper, textiles, plastic, glass, food residues, rubber, metal, etc. and waste categories were weighed again and determined in terms of weight

Table 1
Generation rate of medical waste generated in Cario University hospitals, Egypt.

Medical services source	Generation rate kg/bed/day
Indoor departments	0.50
Outpatient clinics	0.07
Surgical operating	1.20
Intensive care	0.75
Renal dialysis	1.00
Laboratories	0.06
Radiological department	0.40

Source: Helwa (1998).

Table 2
Quantity of medical waste generated in Giza, Alexandria, Asuit, and Al-Dqhlya governorates, Egypt.

Medical services source	Quantity kg/day
Laboratories	5.40
Rays	1.00
Surgical operating	6.90
Blood banks	0.80
Quarantine	7.00
Outpatient clinics	7.80
Receiving and emergencies	6.30
Morgue	1.70
Kitchens	12.50
Pharmacy	2.10
Laundries	8.40
Maintenance workshop	1.30

Source: Helwa (1998).

percentage. Samples were taken from each physical component of wastes in order to determine moisture content, volatile, and non-volatile substances according to Methods of Analysis of Sewage Sludge, Solid Wastes, and Compost (WHO, 1978). Then they were calculated for the whole hospital wastes. From the results obtained, the higher and lower calorific values (CV) of wastes generated were calculated according to equation of Japan Environmental Sanitation Center (1981) as follows:

$$\text{HigherCV} = 81(C - 3 \times O/8) + 57 \times 3 \times O/8 + 345(H - O/10) + 25S$$

$$\text{LowerCV} = \text{HigherCV} - 6(9H + M)$$

Where C, O, H, S and M are the percentage of carbon, oxygen, hydrogen, sulfur, and moisture in raw solid waste respectively.

The data from the survey were analyzed using Statistical Package for Social Sciences (SPSS) version 11.0 computer software package (Daniel, 1995).

4. Results

4.1. Survey of medical establishments in El-Beheira Governorate

The results of the survey through the records of Health Affairs Directorate (2007) showed that the medical establishments of El-Beheira Governorate fall under public and private sectors. All the public sector medical establishments belonged to the Ministry of Health. Table 4 and Fig. 1 present that the total number of beds in public hospitals of El-Beheira Governorate was 4733. The highest number (1967) of beds was found in central hospitals followed by specialized hospitals (955) while the lowest number (51) was in one-day surgery hospitals. Among El-Beheira cities, Damanhour had the highest percentage (27.6%) of beds. Despite Wadei El-Natron had the lowest percentage (1.4%) of beds, it had one bed per 486 inhabitants reflects its lower population density as presented in Table 4 and Fig. 2.

Fig. 3 shows the different types of public hospitals in El-Beheira Governorate where 13% of them were specialized, only 1% was general and teaching and the remainder was considered to be general hospitals. However, none of them were specialized and teaching. In this study, general hospitals refer to hospitals that provide a large array of medical services or typically the first patient contact. Specialized hospitals refer to hospitals that provide medical services for a particular group of patients, such as chest, eyes, fevers, tumors, etc.

Table 4 shows also the different medical services provided in the public hospitals of El-Beheira Governorate such as operating theatres, kidney dialysis units, analysis laboratories, and blood banks. The major blood bank was found in National Medical Institute of Damanhour City. Also, there were fourteen minor blood banks in the central hospitals of the remaining cities. The highest percentage (15%) of operating theatres was located in Etay El-Baroad Centre while the lowest percentage (1%) was in Wadei El-Natron Hospital. In addition, the highest percentage (11%) of analysis laboratories was found in Abu Almtamir hospitals while the lowest percentage (1%) was present in Edko hospitals. Kidney dialysis units distributed in all central hospitals, some fever hospitals and the National Medical Institute. Although the highest percentage (25%) of physicians was found in Damanhour, the ratio of citizens (possible patients) vs. physicians was 1190 reflects its higher population density.

Table 5 shows the distribution of private hospitals and other medical establishments in El-Beheira Governorate. It is evident that the highest numbers of private hospitals, polyclinics, and curative dispensaries were found to be in Damanhour City and their distribution percentage was 1.5% hospitals, 86.1% polyclinics, and 12.4% curative dispensaries as illustrated in Fig. 4.

4.2. Selected hospitals in Damanhour city

There are 16 hospitals in Damanhour city; 7 (43.8%) of them are private hospitals and the remainders are public hospitals (UNDP, 2006). According to the proportional allocation sampling, the highest percentage (62.5%) of selected hospitals belonged public sector while about one-third (37.5%) of them belonged private sector. Half (4) of selected hospitals were specialized while three of them was general hospitals and only one was general and teaching as shown in Table 6.

From Table 6, it is clear that the eight selected hospitals had a total of 1315 beds. The size of these hospitals ranged from 30 to 590 beds, with a mean bed occupancy of 52.7%. The number of medical staff in these hospitals ranged from 11 to 330 physicians, with an average of 72.

According to the different services provided in the surveyed hospitals, it was evident that all of them were having one laboratory or more for medical analyses, outpatient clinics, surgical department, radiological department, and laundries. Regarding the pharmacy and kitchens, they were devoid in only one of the surveyed hospitals. Besides half of these hospitals were having renal dialysis units and neonatal units, also 62.5% of them were having intensive care units. Only two of the surveyed hospitals were having endoscopy units. Lastly, each of the chemotherapy department and the blood bank were present in only one of hospitals under study.

4.2.1. Quantities of wastes generated

4.2.1.1. Generation rate. Table 6 represents that the quantity of medical waste generated by the surveyed hospitals was about 1249 kg/day and it varied from 11 to 52% of the hospitals wastes. It is evident that the medical waste generation rate ranged between 0.23 and 2.07 kg/bed/day with a mean of 0.85 kg/bed/day. The highest quantity (2.07 kg/bed/day) of medical waste was

Table 3
Generation rate of medical waste generated in Cario's hospitals, Egypt.

Generation rate kg/bed/day	Urban health centres	Hospitals
Minimum	5.40	0.50
Maximum	27.70	1.66
Mean	10.20	0.87

Source: Helwa (1998).

Table 4
Medical services of public hospitals in El-Beheira Governorate, Egypt.

Centres	The inhabitants number	Medical staff	The inhabitants number/medical staff	Beds number	The inhabitants number/beds number	Medical services			
						Blood banks	Operating theatres	Analysis laboratories	Kidney dialysis units
Damanhour	743450	625	1190	1308	568	1	14	31	2
Abu Almtamir	365639	157	2329	255	1434	1	7	37	2
Abu Homs	436725	170	2569	210	2080	1	6	22	1
El-Dillingat	320420	131	2446	297	1079	1	6	30	1
El-Mahmoudia	243701	112	2176	259	941	1	8	14	1
Etay El-Baroad	423323	193	2193	417	1015	1	15	30	1
Hushe Issa	229505	88	2608	161	1425	1	4	22	1
Rosetta	202888	81	2505	180	1127	1	5	14	1
Shbrakhitt	252570	127	1989	329	768	1	4	19	1
Kafr-Eldoar	853128	355	2403	584	1461	1	10	35	2
Kom-Hamada	436623	139	3141	300	1455	1	9	32	1
Wadei El-Natron	32098	121	265	66	486	1	1	8	1
El-Rahmanih	139967	79	1772	94	2489	1	3	11	1
Edko	165602	102	1624	168	986	1	4	4	1
Bader	153822	57	2699	105	1465	1	2	23	1
Total	4999461	2537	1971	4733	1056	15	98	332	18

Source:HAD(2007).

generated in private hospital while the lowest generation rate (0.23 kg/bed/day) was found in public hospital.

4.2.2. Characteristics of wastes generated

4.2.2.1. Physical characteristics

4.2.2.1.1. Physical components of the wastes. The composition of the whole generated waste was found to be 28% food residues, 24% paper, 19% plastic, 17% textile, 9% glass, 2% rubber, and 1% metal as presented in Table 7. Quantitative analysis indicates that food residues had the highest contribution of 28%. Paper had the second highest percentage with a range of 12.8% for the dialysis unit to 39.4% for the X-ray unit. Plastic was the third highest contributor. Values ranged between 1.8% for the laboratory and 28.3% for the emergency unit, with an average of 19.0% for the whole hospital. Textile also contributes a considerable percentage of ranging from 3.0% for the dialysis unit to 41.2% for the operating theater, while glass items percentage ranged between 4.6% for the emergency unit and 18.7% for the blood bank.

4.2.2.1.2. Waste categories according to WHO classification. In the meanwhile, the different waste components in this study were grouped under the nine categories stated by the WHO (1983) where domestic wastes constituted 61.1% of the total waste stream with a wide range extending from 48 to 89% while the rest 38.9% of the waste was of clinical nature. The highest percentage (64.8%) of medical wastes were infectious wastes while 22.5% were sharps, 7.2% were chemical and pharmaceuticals, 4.2% were pathological wastes, 0.8% were pressurized containers such as aerosols, cylinders of drugging and oxygen, and only 0.5% were radioactive wastes as shown in Table 8.

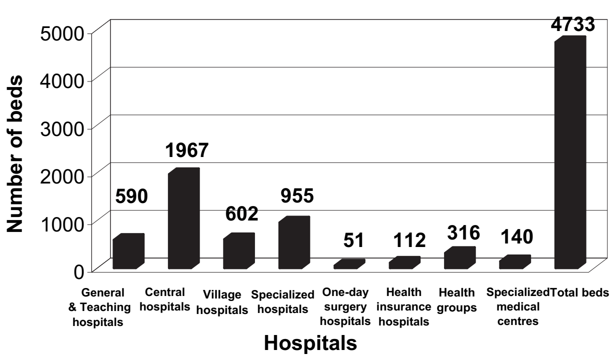

Fig. 1. Number of beds in the public hospitals and other public medical establishments in El-Beheira Governorate, Egypt.

4.2.2.2. Chemical characteristics. These are the moisture, ash, and combustible contents. It was evident from Table 9 that the moisture percentage of the whole generated waste samples found to be ranged from 14.9 to 54.3% with a mean of 35.6%. The mean value of ash and combustible content for the whole generated wastes was 3.9% and 60.5% respectively. In this study, the higher CV ranged between 1677.9 and 3812.4 kcal/kg with a mean of 2508.7 kcal/kg while the lower CV had a range from 682.7 to 3291.4 kcal/kg with a mean of 1658.4 kcal/kg.

4.3. Assessment of the current hospital waste management system

4.3.1. Waste segregation and collection

This study showed that although segregation of various medical waste types was carried out in all of the surveyed hospitals, none of them were conducted it properly according to consistent rules and standards. Waste segregation and collection patterns are presented in Table 10.

In the present study, the infectious wastes were not segregated from the main waste stream in a quarter of hospitals as shown in Table 10 and Fig. 5. Of these 25% hospitals, half were chest hospitals since their wastes contained plenty of cotton and tissues with the tuberculous patients sputum. In addition, the laboratory wastes included many slides and acid-fast stained smears.

Concerning sharps, they were found to be segregated in all surveyed hospitals where the majority (87.5%) of them used rigid, puncture-proof containers and the remaining one (12.5%) used cardboard boxes as shown in Fig. 6. Of the seven (87.5%) hospitals which used sharp containers that were not easily punctured, only one (14.2%) used yellow-colour containers while the remaining six (85.8%) used containers with different colours.

Three (37.5%) of the surveyed hospitals used specific procedures in handling pharmaceutical waste while the remaining five (62.5%) of hospitals disposed off it in the domestic waste stream. Of the 37.5% hospitals with specific procedures, only one (33.3%) returned their expired pharmaceutical materials back to the suppliers while the remaining two (66.7%) of hospitals disposed off it in red bags with the rest of the medical waste (Fig. 7).

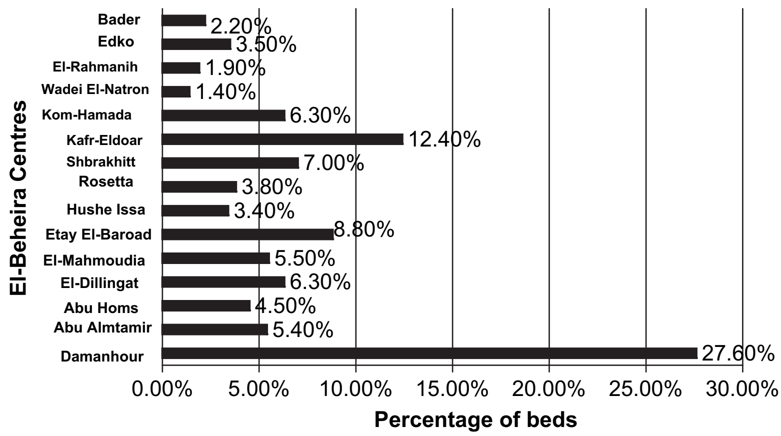

Fig. 2. Percentage of beds in different centres of El-Beheira Governorate, Egypt.

Pressurized containers (e.g., inhalers, spray cans, etc.) were disposed off with general/domestic waste in six (75%) of the surveyed hospitals that had not an obvious procedure for handling this type of waste while only two hospitals segregated them and disposed off as medical waste (Table 10).

Chemical waste was generated in laboratories and often in liquid form which was not segregated in 62.5% of the surveyed hospitals and was disposed off through the public sewerage system while only 37.5% of the hospitals collect the chemical waste in special containers, then pre-treatment procedure was applied prior to disposal in the sewerage system. As regards liquid waste such as body fluids, all the surveyed hospitals discharged it in the sewerage system (Table 10) while only two hospitals treated it with effervescent chlorinated tablets that can be diluted with tap water or sodium hypochlorite solution (10%) before poured it in the sewerage system.

Genotoxic and radioactive wastes were generated only in one of the hospitals. Genotoxic wastes were segregated in red colour bags while radioactive wastes were segregated in lead-lined bin or black coloured bags according to their category. The solid waste generated in this hospital includes cover papers, gloves, empty vials and syringes, radionuclide generators, items used by hospitalized patients after radionuclide therapy, sealed sources used in therapy, sealed sources used for the calibration of instruments, and other biological waste. In the liquid waste category it was found that residues of radionuclides, patient excreta, liquid scintillation solutions, and in the gaseous waste exhausted gas from patients in nuclear medicine. This hospital used radionuclides with relatively short half-lives. So, this hospital indicated that such waste was stored for decay period recognized as being equal to ten half-lives for radioactive isotopes whose half-lives were less than or equal to 90 days until its activity felled to the background level, and after that it was collected by the Atomic Energy Agency and treated it through specific management system. The radioactive waste in hospitals comprises many different types of waste. It may be of high activity such as a Technetium generator and sources used in radionuclide therapy, or low activity waste from biomedical procedures or research. It may be in solid, liquid, or gaseous form (Granholm and Chester, 2003). In this study, most of radioactive waste from the surveyed hospital was considered low-level radioactive waste.

More than half (75%) of hospitals disposed off waste containing heavy metals from X-rays into sewerage system while it was segregated into a plastic container prior to treatment in only 25% of hospitals. In addition to mercury-bearing dental wastes were not managed properly by 62.5% of hospitals.

Pathological waste was generated from three hospitals, so its mean was 1.6%, and these hospitals have taken excised body parts or organs away from the waste stream directly for burial reflects religious practices in Egypt.

In Damanhur hospitals, the utilization of colour-coded plastic bags was obvious where 87.5% of hospitals used red colour bags for infectious waste while the remaining (12.5%) hospitals used orange bags for it. Additionally, the ordinary black plastic bags placed

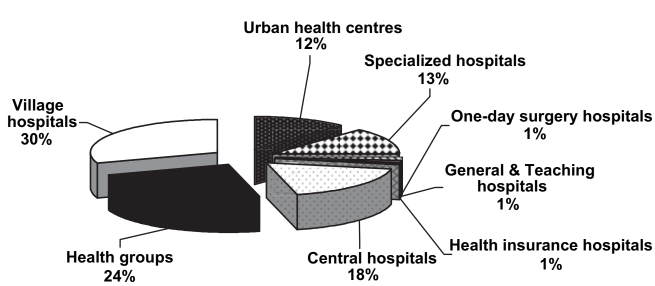

Fig. 3. Percentage of different types of the public hospitals and other public medical establishments in El-Beheira Governorate, Egypt.

Table 5
Private hospitals and other medical establishments located in El-Beheira Governorate, Egypt.

Centres	Private sector			
	Hospitals		Poly-clinics	Curative dispensaries
	No.	Beds	No.	No.
Damanhour	7	195	396	57
Abu Almtamir	2	16	90	2
Abu Homs	–	–	102	–
El-Dillingat	–	–	124	–
El-Mahmoudia	1	24	112	2
Etay El-Baroad	–	–	96	1
Hushe Issa	–	–	72	3
Rosetta	1	40	117	3
Shbrakhitt	–	–	104	–
Kafr-Eldoar	3	95	218	7
Kom-Hamada	3	100	130	–
Wadei El-Natron	–	–	9	2
El-Rahmanih	–	–	9	–
Edko	–	–	85	4
Bader	1	42	76	1
Total	18	512	1740	82

Source:HAD(2007).

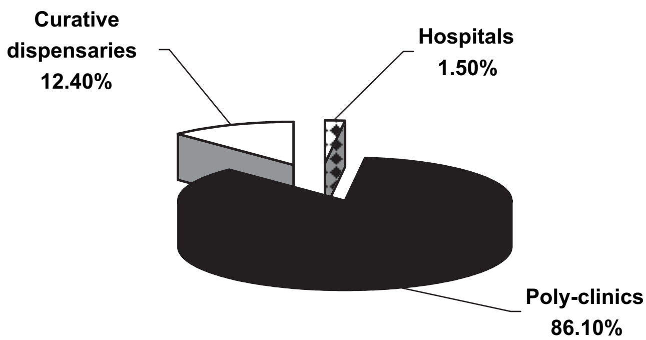

Fig. 4. Distribution percentage of different types of the private medical establishments in Damanhour City, Egypt.

inside plastic baskets were used for household refuse in all the selected hospitals. Also, it was found that all waste bags when two-thirds filled were sealed and labelled before leaving a medical area in only 62.5% of hospitals to differentiate it from domestic waste. The label showed the hospital name, the date, and department name.

The frequency of waste removal in 62.5% of the surveyed hospitals was once a day from the different departments except in dialysis units, intensive care units, and receiving and emergencies departments was once per working shift. Moreover, all wastes generated from the different departments were collected twice daily in a quarter and thrice daily in only one of the selected hospitals (Table 10). Two-wheeled trolley with a lid for transporting sealed waste bags into central storage rooms was used in only three of the surveyed hospitals and also be used for temporary storage of sealed waste bags within or near to the medical areas in only one of them. Additionally, other one of these hospitals used fixed, large, and covered plastic container for temporary storage of waste to avoid filled waste bags being piled on the floor where they could be knocked and split open. The number of trolleys assigned for medical waste transport ranged from 1 to 26 and they were black in colour. The remaining five (62.5%) surveyed hospitals used hand-carried bags by the employees to collect their waste bags (Table 11). It was also noticed that workers did not wear protective clothing during waste handling activities.

4.3.2. *Waste storage*

From Table 11, it was found that the storage area of medical wastes might be a chamber as indicated in 7 of the surveyed hospitals or eurobins as in one of hospitals and their numbers were three. None of hospitals under study were using refrigerators for pathological waste storage. All the central storage rooms were connected to sewerage system and water source. Also, they were easy to clean and some of them disinfected daily. Additionally, the storage rooms were safe, isolated and adequately ventilated. All central storage chambers had a limited access to only the personnel responsible of waste handling and their doors were labeled as hazardous area. Of these hospitals, only two had large plastic container for medical waste storage inside the central storage rooms.

The survey results indicated that the maximum time period for temporary storage was 12 h, while the maximum storage time in the central storage rooms was 2 days. Of the 7 hospitals which had chambers for medical waste storage, 6 had also separate rooms for domestic waste storage while the seventh one stored both domestic and medical wastes in a combined storage room. The rest one of the selected hospitals which stored its medical waste in eurobins, did not have chamber for domestic waste storage. Instead its domestic waste was stored in the hospital garden within large iron communal container.

4.3.3. *Waste treatment*

As presented in Table 12, medical waste treatment was found to take place in all of the selected hospitals. More than half (7) of them were using incinerators. Only one of them was equipped with an incinerator and its specifications are given in Table 13. From this table, this incinerator was batch-type and devoid of any air pollution control system. The operational frequency of this incinerator was 3 h daily and its treatment capacity was 120 kg/day. Loading and de-ashing operations were performed manually. The ash was removed through discharging door and disposed off with the non-clinical wastes. It was found that this hospital incinerated all its generated medical wastes. There was no regular maintenance program for this incinerator; maintenance was only conducted

Table 7
Composition of hospital waste generated in the selected hospitals located in Damanhour City, Egypt.

Ingredients	Average (% by wet weight)	SD
Food waste	28.00	14.58
Paper	24.00	7.60
Plastic	19.00	8.59
Textile	17.00	10.72
Glass	9.00	4.54
Rubber	2.00	0.42
Metal	1.00	0.51

Table 6
Quantity of hospital waste generated in the selected hospitals located in Damanhour City, Egypt.

Selected hospitals	Type			Sector		Medical staff	Annual occupancy rate in percentage	No. of beds	Generation rate of medical waste kg/day	Unit generation rate in kg/bed/day	Quantity of total hospital waste kg/day
	G	S	G and T	Public	Private						
1	X				X	11	47.1	30	23	0.77	209
2		X		X		26	6.1	60	24	0.40	60
3		X		X		35	38	210	48	0.23	117
4			X	X		330	104	590	836	1.42	2144
5		X		X		26	57	200	120	0.60	266
6	X				X	52	69	45	93	2.07	193
7		X		X		75	58	140	75	0.54	144
8	X				X	22	42	40	30	0.75	78
Total No.	3	4	1	5	3	579	–	1315	1249	–	3211
%	37.5	50.0	12.5	62.5	37.5	–	–		38.9	–	100
Min.						11	6.1	30	23	0.23	60
Max.						330	104	590	836	2.07	2144
Mean						72	52.7	164	156.1	0.85	401.4

G: General, S: Specialized, G and T: General and Teaching.

Table 8
Proportion of hospital waste generated in the selected hospitals located in Damanhour City, Egypt.

Type of waste	Range (%)	Average (%)
General	48.00–89.00	61.10
Infectious	10.00–53.00	25.20
Sharps	6.70–24.70	8.80
Chemical and pharmaceuticals	1.20–4.70	2.80
Pathological	0.00–2.80	1.60
Radioactive	0.00–0.23	0.19
Pressurized containers	0.12–0.37	0.31

when operational problems occurred. The maintenance was conducted by the private sector. In addition, the combustion chamber temperature of this incinerator was not reach to the right range needed for complete combustion. The location of this incinerator was not appropriate, being within 8–400 m of different hospital wings. Although the design, maintenance and operation of this incinerator did not comply with the safety specifications, other one of selected hospitals relied on it to treat its medical waste. However, other 5 hospitals were transported their medical waste into municipal and private incinerators. The last one of the surveyed hospitals autoclaved its medical waste on-site and packaged it in white plastic bags then disposed it as domestic waste.

4.3.4. Off-site transportation and final disposal

In all hospitals, the generated domestic wastes were transported directly to the municipal dumping site while the medical wastes were transported to local municipal incinerators in half (50%) of the hospitals by the municipality's trucks that did not comply with the safety requirements. Three of the surveyed hospitals showed no interest in this governorate facility because two of them have their own facilities and the third one relied on an incinerator owned by one of them. Hospitals' vehicle is used to transport its medical waste into this incinerator. The remaining one of hospitals transported their medical wastes to private incinerator and they carried out by the private contractor (Tables 12 and 14).

Regarding the off-site transportation frequency of medical waste, it was thrice weekly in 6 hospitals (75%). As regards transport time, it was at the morning in four hospitals, at midday in only one, and at afternoon in other one. However, the frequency of domestic wastes transportation was once daily at the morning in all hospitals as shown in Tables 12 and 14.

Training programs about medical waste management for doctors, nurses, and technicians were limited; about 37.5% of the hospitals had not provided training to doctors and other personnel about medical waste management and their potential hazards. About half of hospitals provided limited training for support staff, e.g., cleaning workers. Although medical waste steering committee was available in 6 of the hospitals and they were satisfied with the level of performance of their employees in their medical waste management, training programs for medical staff (nurses and doctors), waste handlers, operators, and maintenance engineers were requested by 5 of these hospitals. The majority of hospitals (87.5%) preferred attending annual training. Lack of financial support and medical waste management awareness were observed in about one-third of hospitals (37.5%).

Table 9
Physical-chemical characteristics and heating values of medical wastes generated from the selected hospitals located in Damanhour City, Egypt.

Parameters	Minimum	Maximum	Mean
Percentage of moisture content	14.9	54.3	35.6
Percentage of combustible content	44.3	86.2	60.5
Percentage of ash content	2.0	7.6	3.9
Higher-calorific value (kcal/kg)	1677.9	3812.4	2508.7
Lower-calorific value (kcal/kg)	682.7	3291.4	1658.4

Table 10
Waste segregation and collection in the selected hospitals located in Damanhour City, Egypt.

Waste segregation and collection	No.	Percentage%
Is segregation practiced:		
Yes	8.0	100
No	0.0	0.0
If yes, what is segregated:		
Infectious	6.0	75.0
Sharps	8.0	100
Chemical	3.0	37.5
Pharmaceuticals	3.0	37.5
Pathological	3.0	37.5
Pressurized containers	2.0	25.0
Fate of liquid wastes:		
Sewer	8.0	100
Others	0.0	0.0
Packaging:		
Plastic bag inside plastic basket	8.0	100
Plastic bag	0.0	0.0
Plastic basket	0.0	0.0
Carton box	0.0	0.0
Times of collection per day:		
Once	5.0	62.5
Twice	2.0	25.0
Thrice	1.0	12.5

5. Discussion

The management of medical waste is of great importance due to its potential environmental hazards and public health risks. So, characteristics of these wastes should be recognized to systematize waste management plan in order to be sure that they are being handled and disposed off in the most cost-effective, and with at least health risks to employees and to the community.

5.1. Quantities of wastes generated

5.1.1. Generation rate

In this study, it is clear that the generation rate of medical waste varied from 0.23 to 2.07 kg/bed/day with a mean of 0.85 kg/bed/day. This variation attributed to the different characteristics of the studied hospitals such as number of beds as well as the number and types of services offered. Any increase in the number of beds and services might change the waste generation rates. Such increase was confirmed by the finding of this study since more kg/bed/day was found to be generated from one of the surveyed hospitals which had large number of beds (590), services (26 departments), and high occupancy rate (104%). Also, the economic, social, and

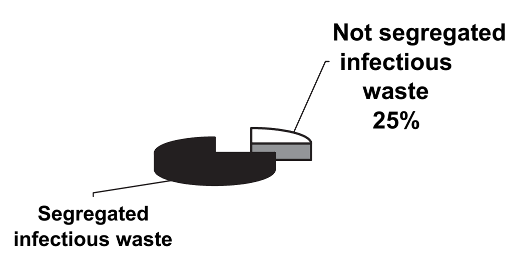

Fig. 5. Percentage of selected hospitals regarding segregation of their generated infectious wastes.

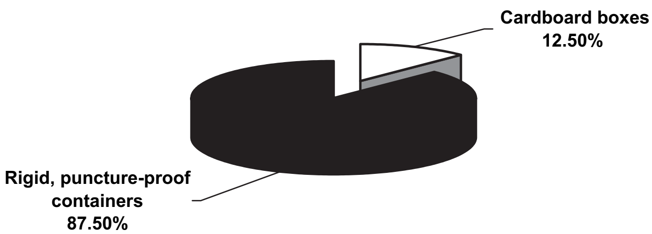

Fig. 6. Percentage of different types of sharp containers used in the selected hospitals of Damanhour City, Egypt.

cultural status of the patients as well as the level of instrumentation and the general condition of the area where the hospital is situated might change its amount of generated waste (Hassan et al., 2008). In addition when the peak occupancies occur, the occupancy rate may fluctuate from one season to another. Therefore, waste generation was determined in terms of daily output per bed (Hussein, 1997).

Outside Egypt, many studies have focused on the management of medical waste in countries such as the India (Patil and Shekdar, 2001) and Jordan (Abdulla et al., 2008) which revealed nearly similar results where the waste generation rate ranged from 0.5 to 2.0 and 0.5 to 2.2 kg/bed/day respectively. Some Arabic countries such as Saudi Arabia and Kuwait had higher health-care waste generation rates than those reported in the present study and ranged from 0.03 to 3.78 and from 3.65 to 5.4 kg/bed/day respectively (Franka, 2006). Moreover, in European hospitals, the generation rates of medical waste were 3.9 kg/bed/day in Norway, 4.4 kg/bed/day in Spain, 3.3 kg/bed/day in United Kingdoms, and 2.5 kg/bed/day in France (WHO, 1985). This may be due to the high economic level in these countries with increasing trend towards the use of disposable items. This finding confirmed the results of the present study where the highest weight of medical wastes generated per bed daily was from hospital located in high-standard area and calculated to be 2.07 kg. In addition to the use of more disposable items on the patient's expenses and meals brought to patient by his relatives which were added to the wastes.

Similar results were obtained by Abdulla et al. (2008), Abu Qdais (2005), and Birpinar et al. (2008) who found that the mean medical waste generation rates were 0.83, 0.61, and 0.63 kg/bed/day respectively. The results of this study were less than expected by WHO (1999) in medical waste generation in comparison to the Mediterranean region countries (1.3–3 kg/bed/day), Eastern Asia (1.8–2.2 kg/bed/day), and in Latin America (3.0 kg/bed/day) while more than those obtained by Franka (2006) who found that total health-care waste generated daily in Libya was 0.47 kg/bed/day. Additionally, the waste generation per day for the surveyed health care establishments in Bangladesh was found to be 1.9 and 1.28 kg/bed (Hassan et al., 2008; Alam et al., 2008).

Average generation rates of total medical wastes were estimated to be 3.49 and 1.88 kg/bed/day for public and private Jordanian hospitals respectively where the higher generation rate at general public hospital which serves a large number of patients while private hospital with a few number of specialists and that accommodates the lowest number of patients had low generation rate (Bdour et al., 2007). This finding is in contradiction with the results of this study where the private hospitals had higher generation rate of medical waste than public hospitals. This might be due to all surveyed private hospitals (3) were general which provide a large array of medical services while most (4) of surveyed public hospitals were specialized that provide medical services for a particular group of patients. The remainder surveyed public hospital was general and teaching with high generation rate of 1.42 kg/bed/day where it has large number of beds with high occupancy rates, large number of services offered, and it is also of low fees as regards treatment, residence or even surgical operations. Dehghani et al. (2008) found that the average of waste generation rates in the educational hospitals of Tehran University Medical Sciences was estimated to be 4.42 kg/bed/day.

This study revealed that medical wastes constituted 38.9% of the total waste stream with a wide range extending from 11 to 52%. In Mongolia, the percentage of medical wastes in the total waste

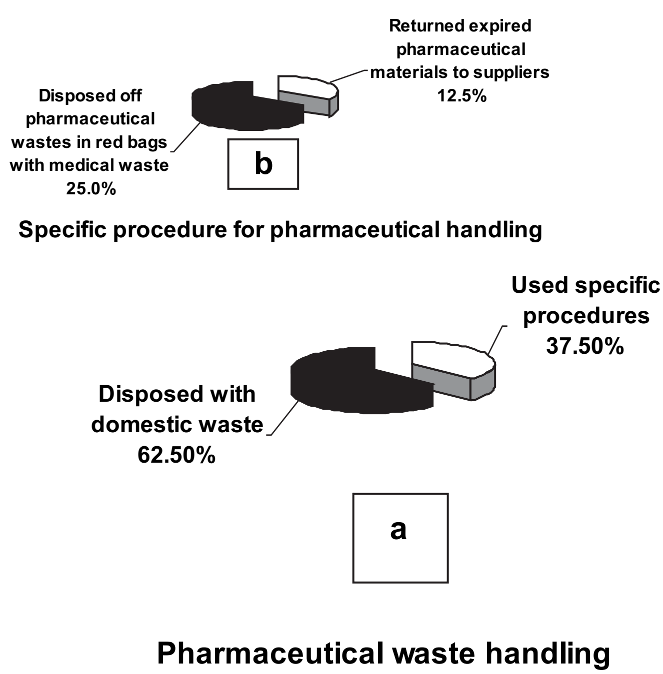

Fig. 7. Percentage of selected hospitals according to handling of their generated pharmaceutical waste.

Table 11
Waste storage in the selected hospitals located in Damanhour City, Egypt.

In-door waste storage	No.	Percentage %
Waste storage:		
Yes	8.0	100
No	0.0	0.0
Temporary storage facility:		
Yes	2.0	25.0
No	6.0	75.0
If yes, temporary storage container:		
Two-wheeled trolley with a lid	1.0	12.5
Fixed, large, covered plastic container	1.0	12.5
Central storage facility:		
Yes	8.0	100
No	0.0	0.0
Central storage area of medical waste:		
Separate chamber for medical waste	6.0	75.0
Combined chamber with domestic waste	1.0	12.5
Eurobins	1.0	12.5
Refrigerator	0.0	0.0
Central storage area of domestic waste:		
Separate chamber for domestic waste	6.0	75.0
Combined chamber with medical waste	1.0	12.5
Hospital garden within communal container	1.0	12.5
Availability of the following attributes at the central storage chamber:		
Connection to sewer system	7.0	87.5
Water source	7.0	87.5
Ventilation	7.0	87.5
Safe and isolated	7.0	87.5
Easy to clean	7.0	87.5
Daily disinfection	3.0	37.5
Large container for storage	2.0	25.0
Internal transport to storage area:		
Employees	5.0	62.5
Two-wheeled trolley	3.0	37.5
Acess to the storage chamber:		
Limited	7.0	87.5
Opened	0.0	0.0
Storage period:		
<24 h	0.0	0.0
24–48 h	8.0	100
>48 h	0.0	0.0

stream was comparatively high, ranging from 12.5% to 69.3%, which indicated poor waste handling practices (Enkhtsetseg et al., 2008).

5.2. Characteristics of wastes generated

In the present study, it is noticed that food residues constituted the main bulk of wastes generated with a wide range extending from 0% to 50%. This may be due to that 87.5% of hospitals had a kitchen while devoid in only one hospital and adds to the wastes from buying meals. Plastic constituted 19% of hospital waste stream. This high percentage is expected due to the widespread use of disposables rather than reusables for different purposes. The plastic percentage was in contrast to that obtained by Abdulla et al. (2008) and Bdour et al. (2007) in Jordanian hospitals and Dehghani et al. (2008) in Iran hospitals who reported that plastic accounts for 27%, 24%, and 29% respectively. The glass, by its turn, amounted for up to 18.7% of one hospital wastes because of the large number of empty vials and ampoules disposed of. As for rubber, its highest percentage (2.5%) was determined in hospitals having renal dialysis unit where it contain mainly filters, tubing and gloves which are all rubber-made.

Table 12
Treatment methods and off-site transport of medical waste in the selected hospitals located in Damanhour City, Egypt.

Medical waste treatment	No.	Percentage %
Treatment:		
Yes	8.0	100
No	0.0	0.0
Type of treatment:		
Incineration	7.0	87.5
Autoclaving	1.0	12.5
Others	0.0	0.0
Presence of privately-owned incinerators:		
Yes	1.0	12.5
No	6.0	75.0
If no, medical waste is transported into:		
Municipal incinerators	4.0	50.0
Private incinerators	1.0	12.5
Other hospitals' incinerator	1.0	12.5
How:		
Municipal trucks	4.0	50.0
Private trucks	1.0	12.5
Hospitals' vehicles	1.0	12.5
Distance of outside transport:		
Short	5.0	62.5
Long	1.0	12.5
Frequency of outside transport:		
Once daily	0.0	0.0
Thrice a week	6.0	75.0
Twice a week	0.0	0.0
Once a week	0.0	0.0
Time:		
Morning	4.0	50.0
Midday	1.0	12.5
Afternoon	1.0	12.5
Evening	0.0	0.0

In addition to these waste components, the different waste categories- as classified by the WHO (1983) – were also determined. It could be seen that domestic wastes made up 61.1% of the total waste stream and 38.9% were hazardous. Hassan et al. (2008) showed that the surveyed health-care establishments in Bangladesh generated 77.4% of non-hazardous wastes and about 22.6% were hazardous.

In the present study, the high percentage of infectious wastes (25.2%) may be due to absence of segregation in a quarter of selected hospitals and incomplete segregation in the remaining hospitals. It was clear that plastic can be considered as infectious wastes in the form of plastic boxes containing blood, plastic gloves for gynaecological, etc. Textile could be either fouled or contaminated with blood and human excreta. Similar results were obtained by Hussein (1997) who stated that about 28.6% of the hospital waste stream could be categorized as being infectious.

Table 13
Specifications of privately-owned incinerator by one of the selected hospitals in Damanhour City, Egypt.

Incinerator specifications	One of selected hospitals
Type of incinerator	Batch incinerator (single chamber incinerator)
Air emission control system	Absent
Cost	Fuel cost
Operational frequency	3 hours/day
Treatment capacity	120 kg/day
Fate of ash	With non-clinical wastes
Type of wastes incinerated	All generated medical wastes
Maintenance	By private sector

Table 14
Off-site transportation of domestic waste in the selected hospitals located in Damanhour City, Egypt.

Outside domestic waste transport	No.	Percentage %
Off-site transportation of domestic waste:		
Yes	8.0	100
No	0.0	0.0
If yes, to where?		
Dumping site	8.0	100
Communal containers	0.0	0.0
Open space	0.0	0.0
How?		
Employees	0.0	0.0
Wheeled vehicles	0.0	0.0
Municipality's trucks	8.0	100
Distance:		
Short	5.0	62.5
Long	3.0	37.5
Frequency of outside transport:		
Once daily	8.0	100
Thrice a week	0.0	0.0
Twice a week	0.0	0.0
Once a week	0.0	0.0
Time:		
Morning	8.0	100
Midday	0.0	0.0
Afternoon	0.0	0.0
Evening	0.0	0.0

Nevertheless, the United States Environmental Protection Agency (US EPA), (1989) assumed that only 10–15% of hospital wastes were potentially infectious. According to WHO (1999), approximately 85% of hospital wastes are actually non-hazardous, 10% are infectious, and around 5% are non-infectious but hazardous.

All metals (needles, blades, etc) and glasses (empty broken ampoules and vials) were grouped under the "sharps" category. Needles and sharps, among the most harmful items in Jordanian hospitals and medical laboratories, formed the lowest percentage by weight; a range between 0.75% and 4.8% was found (Bdour et al., 2007). Moreover, the placenta and the blood bags constituted the "pathological wastes" category.

Concerning the chemical characteristics of wastes, it was found that the whole waste generated in selected hospitals contain averages of 35.6% moisture, 3.9% ash and 60.5% combustibles. The high moisture percentage of hospital waste due to it includes food waste; it may be possible to allow self-incineration by separating this waste at source and subjecting it to composting. This was in agreement with another study in Alexandria, Egypt which recorded that the mean value of moisture, ash and combustible content for hospital wastes was 38.52%, 3.41%, and 58.04% respectively (Hussein, 1997). Lower results were obtained by Labib et al. (2005) who found that the moisture content ranged from 2.33 to 31.89%.

The CV is related to the amount of heat which can be released from the waste during combustion. It affects the incinerator design regarding the amount of supplementary fuel or the oxygen requirements needed to achieve proper incineration temperature (Velzy et al., 1990). Hirayama (1981) found that the optimum lower CV needed for complete self-sustained incineration is 900–1100 kcal/kg of waste. Excess air is added to cool the flue gas when the temperature increases by the heating content of the refuse in order to prevent slagging and refractory damage. When applying this finding on the lower CV obtained in this study, it was evident that wastes from 12.5% of hospitals need extra-fuel for complete incineration, those from 25% can be self-incinerated and those from the other 5 hospitals need cooling during the combustion process. Instead of adding fuel, it was also advised to blend wastes with low heat content together with those with higher heat content for obtaining a self-sustained combustion (Batstone et al., 1989).

5.3. Hospital waste management system

5.3.1. Waste segregation and collection

The results of the present study are consistent with the survey results done by Walker (1991) in Britian, Hussein (1997) in Egypt, and Abdulla et al. (2008) in Jordan who reported that the problems encountered in hospital waste management were inappropriate segregation of infectious wastes from non-infectious wastes into colour-coded bags and deficiency in plastic bags supply and bag holders. A study in Bangladesh revealed that there was no proper, systematic management of medical waste except in a few private heath-care establishments that segregate their infectious wastes. Some cleaners were found to salvage used sharps, saline bags, blood bags, and test tubes for resale or reuse (Hassan et al., 2008).

Although infectious waste was segregated at source in 6 hospitals, the other 2 hospitals were not practicing this segregation where one of them discarded mycobacterium cultures without autoclaving. The hazards caused by such waste mismanagement have been detected by the WHO (2003) which reported that *Mycobacterium tuberculosis* kills 2.7 million people each year in developing countries where the patients remain as the main reservoir of infection.

The most well known transmission route for infections from health-care waste is from needle stick injuries caused by sharps contaminated with blood. This is why loose sharp items should not be placed in plastic bags that are easily punctured. Also, to reduce the risk of airborne transmission avoids using open, uncovered waste containers (WHO, 2000). All surveyed hospitals were following WHO (2000), where sharps segregation was practiced (Table 10).

Pharmaceutical wastes and pressurized containers were disposed along with the general waste in Bangladesh heath-care establishments (Hassan et al., 2008). The present study revealed similar conditions (Table 10), where these wastes segregated in only 37.5% and 25% of hospitals respectively.

This study indicated that when liquid medical waste was not being treated appropriately, the discharge may lead to contamination of drinking water supplies and/or environmental degradation. As for disposing liquid wastes in the sewerage system, this was in accordance with the results of the survey conducted by Hussein (1997) who reported the same fate for wastewater of Alexandria hospitals, Egypt.

The proper packaging of hospital wastes prior to their ultimate destruction or disposal is the most crucial element of any waste management program to prevent contamination of handlers or of environment (WHO, 2000). The results of this study are in consistent with other studies in different countries which revealed that in US, all biomedical wastes were put in red bags while in Canada, the collection may be in red, orange, yellow, or blue bags according to the ministry classification of biomedical wastes (Brunner and Brown, 1988). In Istanbul, separate collection of different types of wastes is consistently practiced, but 25% of hospitals still use inappropriate containers for medical waste collection (Birpinar et al. 2008).

About one-third (37.5%) of the surveyed hospitals were not following WHO (2000) recommendations which stated that bag or sharps container should be replaced when it reaches two-thirds full. The reason for this is to reduce the risk of plastic bags splitting open and of an injury from a protruding sharp item in sharps containers. Neither symbols nor labels were marking the waste packaging in 3 of hospitals. This labelling is to enable managers and other personnel to trace any waste bag to its source if a problem is found, e.g., used sharps are contained in a bag or general and potentially infectious wastes are mixed in the wrong bags. It also allows medical managers to gather data on the amount of waste generated in each medical department and so ensure that the typical quantities of each waste type do not suddenly change (WHO, 1999; WHO, 2000).

In this study, the internal transport to storage area is carried out manually and handlers did not wear protective clothing in more than half of the surveyed hospitals (Table 11), increasing the potential risk of accidents and personal injury from protruding sharps and, all along the transport distance, wastes can fall from the baskets or the bags especially when are overloaded. In 46% of Iran hospitals, transferring of medical wastes to temporary stations was done manually (Dehghani et al., 2008). It was also noticed that both types of bags (red and black) are carried mixed in the same trolley. This increases the possibility of wastes becoming mixed and being transported along inappropriate disposal routes (WHO, 2000).

5.3.2. Waste storage

Central storage rooms are locations in special areas or in the grounds of a hospital where larger containers, e.g., 1.1 m^3 four-wheeled bins (eurobins) should be used to store waste until it goes for final disposal either on- or off-site (WHO, 2000).

The waste storage patterns in this study were partially different from those applied in Turkey hospitals where two chambers are used for hospital waste storage: the first is designated for domestic waste, is cleaned with running or pressurized water and its drain is connected to the city sewerage system. The second is for clinical wastes, is dry-cleaned and has a drainage system connected to an impermeable tank. Wastes may be stored for 24 h at 20 °C or 72 h at -7 °C to -13 °C (Kocasoy, 1995). Intermingling of infectious wastes with general waste in the health-care establishments is a threat to environmental health. In some health-care establishments in Bangladesh, all the infectious wastes were found to be separated from the non-infectious waste stream at the site of generation, but during disposal in the dustbins the wastes were then mixed together (Hassan et al., 2008). This finding confirmed the results of this study where one of selected hospitals had a combined storage chamber for both domestic and medical wastes, increasing the possibility of mixing wastes and consequently lacking of safely transportation and inappropriate final disposal.

5.3.3. Waste treatment

In agreement with this study which found that the most frequently used treatment practice for solid medical waste was incineration, Abdulla et al. (2008) revealed that most hospitals were depending on incineration to eliminate their wastes.

Incinerators can potentially emit a variety of harmful pollutants if they are not operated and maintained corrected and if gas-cleaning equipment is not fitted. These pollutants include particulate matter, acid gases, toxic metals, and toxic organic compounds products of incomplete combustion, e.g., dioxins, furans, etc (WHO, 1999). This should be expected from the only hospital which had an incinerator since it was devoid of such device. In addition, this incinerator operated below the recommended temperature. This latter means that, the waste was not completely destroyed then the ash moves to a cooler portion of the incinerator where it hardens into slag. This, by its turn, can clog airports, disable burner, corrode refractory, and interfere with the normal flow through the furnace. In combustion chamber, drying of wastes should takes place followed by burning of the dried materials. To ensure that the combustion chamber temperature should be at least 750 °C but not exceeded 1000 °C to avoid ash fusion and slagging (Batstone et al., 1989). Effective treatment requires long residence time ($>$2 or 3 s), high temperature (900–1200 °C), and good waste mixing with air (Christina et al., 1994).

The survey results done by Anyinam (1994) showed that 44.3% of Ontario hospitals used their privately-owned incinerators for waste treatment, 14.5% relied on other hospitals' incinerators and 2.7% hauled their wastes to landfills after autoclaving.

5.3.4. Off-site transportation and final disposal

In the present study, about two-thirds (62.5%) of hospitals were not following US EPA system under which the generator of any infectious waste would fill out a form and give a copy to the transporter which would give a copy to the disposal facility which would, by its turn, send back to the generator as assurance the waste was received (Johnson, 1988).

Similar results were obtained from a survey of several hospitals, private clinics, and nursing homes in Asia which revealed that the health-care personnel at these facilities had very little or no training in the handling, transport, treatment, or disposal of medical waste (CSG, 2002).

6. Conclusion

From the previous results, it was concluded that health-care waste management was strongly influenced by economic circumstances. This affected the quantity of medical waste that was disposed off improperly. Although the Egyptian Ministry of Health has developed regulations aimed at implementing integrated medical waste management that is based on environmental law decree No. 338/1995 and No. 1741/2005, such regulations need to be supplemented with stringent enforcement at both national and regional levels. To achieve this, policy makers and hospital administrators require both technical assistance and financial support.

The main findings and recommendations of the study were:

- The quantity of medical waste from the surveyed hospitals was about 1249 kg/day, with an average generation rate of 0.84 kg/bed/day.
- Segregation procedures of the different types of wastes were not consistently followed. Source segregation of medical waste, handling and transport, treatment, and disposal are basic elements of a management strategy that need to be outlined and regulated.
- Liquid medical waste was being discharged into municipal sewers in 75% of the surveyed hospitals without pre-treatment. There is a need to find proper procedure for handling liquid medical waste.
- Some of the storage facilities in the surveyed hospitals failed to meet the requirements. There is a need for upgrading the storage facilities in the hospitals.
- The most frequently used treatment for solid medical waste was incineration; one of the surveyed hospitals was equipped with an incinerator, but this facility did not meet the national pollution control regulations. Improper incineration practices have been adversely reflected on the public health of the surrounding communities. There is a need for upgrading medical waste incinerators to meet the requirements.
- Collection, off-site transportation, and final disposal in some surveyed hospitals were conducted by a private facility: with little experience and lots of over turns.

– Vehicles used for transportation of medical waste outside hospitals failed to meet the safety requirements. There is a need for safe regional transportation facilities.
– The study indicated a need for training programs for different levels of hospital staff from administrators and top managers to doctors and nurses, down to waste handlers and maintenance and incinerator operations staff.

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