

**ASSESSMENT OF HEALTHCARE WASTE MANAGEMENT
PRACTICES IN KHULNA CITY CORPORATION**

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DHAKA, BANGLADESH**

JULY, 2008



**ASSESSMENT OF HEALTHCARE WASTE MANAGEMENT
PRACTICES IN KHULNA CITY CORPORATION**

A THESIS

BY

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**Submitted to the Department of Civil Engineering.
Bangladesh University of Engineering & Technology, Dhaka.
In partial fulfillment for the requirements of the degree**

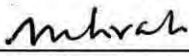
OF

MASTER OF ENGINEERING (ENVIRONMENTAL)

JULY, 2008

This thesis titled “**Assessment of Healthcare Waste Management Practices in Khulna City Corporation**” submitted by Mohammad Mehedi Hasan, Roll No. 100504507 (F), Session: October, 2005 has been accepted as satisfactory in partial fulfillment for the requirement of the degree of Master of Engineering in Environmental Engineering on July 19, 2008.

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DECLARATION

I hereby declare that the research work submitted herewith was performed by me as a research project in partial fulfillment of the requirements for the degree of Master of Engineering in Environmental Engineering from Bangladesh University of Engineering & Technology (BUET).

This thesis contains no material, which has been accepted for the award of any other degree from any other institutions. Further to the best of my knowledge and belief, the project contains no material previously published or written by another person except where specific references are made.

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MOHAMMAD MEHEDI HASAN

ACKNOWLEDGEMENT

At first I like to thank almighty Allah for giving me the ability to complete the work, my warmth gratitude goes to many people and organizations whose affable co-operation and advice helped me bringing my endeavor into realization.

I wish to express my esteemed gratitude and sincere thanks to acknowledge honorable and respected supervisor Dr. M. Habibur Rahman, Professor, Department of Civil Engineering, BUET, Dhaka for his constant support, careful supervision and guidance, keen interest, valuable criticism, active co-operation, advice, suggestion and uninterrupted encouragement to carry out this research work.

I am extremely indebted to all of my respectable teachers of the department for their whole hearted and continuous assistance, encouragement and guidance in carrying out this dissertation paper.

Sincere thanks towards the Superintendent of Khulna Medical College Hospital (KMCH) for his cordial assistance. I would also like to thank Mr. Safiul Alam Tapan, Supervisor, PRODIPAN and Mr. Abdus Sattar, Conservancy Officer, Khulna City Corporation (KCC) for their help.

At last but not least, my heartiest gratitude goes to my father, Md. Golam Mostofa, mother, Mrs. Feroza Khanam, sister, Anney for their blessing, inspiration, sacrifices, advice and moral supports through out the life.

Mohammad Mehedi Hasan

July, 2008

*Dedicated to Member's of My Family
and 'Mousumi', My Ex-classmate*

ABSTRACT

The management of healthcare waste is an emergent public health and environmental problem in Bangladesh in general and Khulna city in particular. In Khulna city, there are about 110 registered hospitals, clinics and diagnostic centers, generating about 1,883 kg of waste per day. The generation rate of total healthcare waste and hazardous healthcare waste in Khulna city has been found 0.85 kg/bed/day and 0.15 kg/bed/day, respectively and the hazardous portion accounts around 15% of the total generated waste. Generation rate of waste in the Govt. hospitals (0.87kg/bed/day.) is slightly higher than the private hospitals (0.84kg/bed/day).

Assessment of management system indicates that most of the worker (around 56%) did not receive any form of training for how to handle hazardous waste. And many (around 47%) of them did not use safety equipments and clothing. It is found from the study that, the average expenditure of existing waste management system of Govt. hospital, Private hospital and Diagnostic centre are Tk.13/kg of waste, Tk. 25/kg of waste and Tk.63/kg of waste respectively. Assessment of cost of different treatment options indicate that the cost of incineration will be around Tk. 28.00/kg of waste. The cost of microwaving will be Tk. 27.00/kg of waste and the cost of autoclaving will be Tk. 24.00/kg of waste. All types of hazardous healthcare wastes can be treated by incinerator and there are significant reductions in volume of wastes (90-95%). Microwaving is not suitable for pathological waste; reduction in volume is comparatively less than incineration (60-90%). On the other hand autoclaving is not suitable for pathological waste and no reduction in volume.

The application of this research will contribute to provide appropriate guideline for the future planning and design of healthcare waste management in Khulna city.

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ABBREVIATIONS

ADB	: Asian Development Bank
AIDS	: Acquired Immune Deficiency Syndrome
BBS	: Bangladesh Bureau of Statistics
BCAS	: Bangladesh Center for Advance Studies
BDT	: Bangladesh Taka
BUET	: Bangladesh University of Engineering and Technology
C&F	: Cost and Freight
CBO	: Community Based Organization
CD	: Custom Duty
CRF	: Capital Recovery Factor
DCC	: Dhaka City Corporation
DNA	: De-oxy ribo Nucleic Acid
DGHS	: Directorate Generals of Health Services
EPA	: Environmental Protection Agency
EPI	: Expanded Program on Immunization
GNCDC	: Garib Newaz Clinic and Diagnostic Centre
HBV	: Hepatitis B Virus
HCE	: Health Care Establishments
HCF	: Health Care Facilities
HCWM	: Health Care Waste Management.
HFWC	: Health and Family Welfare Center
HIV	: Human Immune Deficiency Virus
HNP	: Health Nutrition and Population
IAEA	: International Atomic Energy Agency
IARC	: International Agency for Research on Cancer
IBH	: Islami Bank Hospital
ICDDRDB	: International Center for Diarrhoeal Diseases Research in BD
JICA	: Japan International Co-operation Agency

KCC	: Khulna City Corporation
KMCH	: Khulna Medical College Hospital
MCCC	: Mother and Child Care Centre
MOHFW	: Ministry of Health and Family Welfare
NGO	: Non-government Organization
NIPSOM	: National Institute of Preventive and Social Medicine
OPD	: Out Patient Department
PVC	: Poly Vinyl Chloride
SDC	: Swiss Development Co-operation
SMA	: Statistical Metropolitan Area
THC	: Thana Health Complex
UN	: United Nations
UNCED	: United Nations Conference on Environment and Development
UNDP	: United Nations Development Program
USA	: United States of America
UHC	: Upazilla Health Complex
UCHP	: Urban Community Health Program
VAT	: Value Added Tax
WHO	: World Health Organization
WMO	: Waste Management Officer
WMT	: Waste Management Team

ACRONYMS

Kg	: Kilogram
MT	: Metric Ton
/	: Per
%	: Percentage
Tk.	: Taka
m ³	: Cubic Meter
Km	: Kilometer
>	: Greater Than
Kg	: Kilogram
≥	: Is Equal or Greater Than
=	: Equal To
°C	: Degree Centigrade
Kwh	: Kilowatt-hour
@	: At the Rate of
Btu	: British Thermal Unit

CHAPTER 1 INTRODUCTION



1.1 General

Health service is one of the basic needs of human beings. The right to health is now accepted internationally. The UN declaration conveys the right to food, shelter, education, medical care, treatment benefits, even holidays with pay. Government has also adopted the policy of health for all through the primary health care services. The WHO constitutions prepared in 1946, calls for equity in stating that the enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition. The right to health is also acquiring greater strength within national legal frameworks. Over 100 constitutions now enshrine health as a human right. The constitution of Bangladesh is no different from that. It describes that, “the state shall regard the raising of the level of nutrition and the improvement of public health as moving its primary duties”...(Article 18 [1]).

The trend of urbanization is increasing day by day in the world. In 1950, only about 28.9% of world population lived in urban areas while it went up to 43.3% in 1985 and it is estimated that in 2020 more than 62.5% of the world population will be living in urban areas (Palem, 1986). This also leads to increase in the number of health care facilities. According to World Bank (2000), infectious wastes have the potential of transmitting infectious agent to humans. Unintentional injuries may occur when the community is exposed to inadequately disposed waste. According to WHO (2000), summarized by Nasima Akter in a book “Bangladesh Environment 2002”, as a result of the reuse of non-sterilized syringes 8-16 million hepatitis B, 2 to 4.7 million hepatitis C and 80000 to 160000 HIV infections occur every year. Many of these infections could be avoided if syringes were disposed of safely.

Healthcare waste has become a problem in urban areas all over the world in the last few decades. “One estimate shows that some 5.2 million people (including 4 million children)

die each year from waste related diseases (WHO, 1999). Globally, the amount of municipal waste generated will be double by the year 2000 and quadruple by the year 2025" (Hoq, 1994). Concerned with this situation Agenda 21, adopted in the United Nations Conference on Environment and Development (UNCED) in Reo de Janerio in June, 1992 set the following goals and targets with regard to waste management in cities:

- All countries must establish waste treatment and disposal criteria and develop the ability to monitor the environmental impact of waste by the year 2000.
- By 2025, developing countries should ensure that at least half of the sewage, wastewater and solid waste are disposed according to national and international guidelines.
- By 2025, all countries shall dispose of all waste according to international quality guideline.

Due to expansion of medical facilities in the country, many hospitals, clinics, diagnostic centre are being established. Waste products from these clinics are not treated or destroyed properly, rather thrown in to the dustbins thereby creating health hazards. These waste products mix with solid waste from different households and are polluting the air, earth and water. Besides that viruses like pseudomonas, staphylococcus, streptococcus, ecolyentercoccus etc. are produced from these products. Infections result from these viruses including infections of liver, stomach, breathing infection and infection of reproductive organs, meningitis, AIDS, heamorrtetanus, diarrhea, tuberculosis and various skin diseases etc.

The prevalence of diseases that may be transmitted by healthcare waste alarming in Bangladesh. There is evidence of hepatitis B infection among 10 percent of children (5-10 age group) and 30 percent adults. About 5 percent of the total population in Bangladesh is thought to suffer from chronic hepatitis B infection. Although cases of HIV/AIDS are low in Bangladesh (about 13,000 cases recorded in 2001) in comparison to neighboring countries, nevertheless the numbers are rising (Sinha, 2004). Most of the healthcare wastes (e.g. syringes, needles, saline drips, discarded food, gauge and ampoules)

are collected by women and children who re-sell those despite of the deadly health risks. Poor management of healthcare wastes exposes health workers, waste handlers and the community to infections, toxic effects and injuries (Ecoaccess, 2004). Healthcare waste management is one of the most neglected parts of the managerial process in Bangladesh (Ullah, 1999). Bangladesh lacks both effective waste management facilities and relevant government policy and regulation to guide health providers and punish offenders (BELA 1996, Bangladesh Gazette 1997, 2000, and Dana 1999)

As it is seen from the foregoing literatures, concerns are growing about healthcare waste management globally including in the developing countries like Bangladesh to prevent the possible health hazards as well as the degradation of the environment. Several study findings (Akter et al, 1998, 1999a, 1999b, Akter 2000, Dana 1999) mostly focused on Dhaka metropolis showed that there is a lack of appropriate handling and disposal methods of medical waste. With recent rapid growth of private health sector, the need for safe and proper disposal of healthcare or clinical waste has become important not only for metropolis like Dhaka but also for other bigger cities in Bangladesh. Because, in many cases in these cities most of the hospitals and clinics both in government and private sector have either non-existent or out dated healthcare waste management system. Khulna metropolis is one of the worst affected (by improper HCW management) cities.

Khulna is the third largest city of Bangladesh. The rate of urbanization is quite high in Khulna district where 50.1% of the population live in urban areas ranking third highest in the country. Khulna SMA is experiencing high rate of increase of population in the last few decades mainly due to in migration. In 1961, the population of Khulna city was only 1,27,970, but in 1974, it increased to 4,37,302, in 1981, it was 6,46,395 and in 1991 it went up to 10,01,825. it is estimated that the present population of Khulna city is about 1.3 million which has an area of about 45.65 square kilometers.

To meet the demand of this large and increasing population, a good number of health facilities have developed in Khulna. The nearby small districts also depend on Khulna for better treatment facilities. This regional importance has also initiated the growth of health

sector in Khulna. Besides, couple of large government hospitals, many private clinics, some NGOs and KCC is providing health care facilities in Khulna. There are about 248 health centers in Khulna and the number is growing fast (Khandker, 1999). According to a report in the daily “Prabartan” on the 11th November, there are about 150 clinics and diagnostic centers in Khulna. These are mainly located within or around the central city area. Only 15% of them are concentrated in Khalishpur area, 5% in Daulatpur and 7% in Fulbarigate area; the rest are located in the “Sadar Thana”.

Khulna is currently facing the impacts of improper management of healthcare wastes. Realizing the intensity of the problem, some NGOs have already extended their helping hand to KCC for the management of healthcare waste, yet the existing management system is threat to environment and human health (Khandker, 1999). But no initiative has been taken to solve this ever increasing problem. It has been observed that awareness regarding public health hazards of healthcare waste among professional as well as general people is very poor (Khandker, 1999). If this condition is allowed to go on, in near future with the rapid growth of urbanization, the environmental condition as well as health condition of general people of city dwellers will be a horrible one. This research is conducted to identify the reasons behind the existing improper management system and an effort is made to explore the possibility of developing an environment friendly waste management system. This is the high time to take the appropriate measures to take necessary actions to streamline the wrong waste management behavior of health facilities in Khulna city.

1.5 Objective of the Study

Considering the above facts the present research work was undertaken with the following objectives:

- To investigate the existing waste management practices of selected public and private healthcare establishments in KCC.
- To assess the institutional arrangement for HCW management practices in the study area.
- Quantification and analysis of physical composition of HCW.

- Assess different technological options for their applicability in KCC for improvement of the present situation.

1.6 Limitation of the Study

1. Healthcare waste refers to all kind of wastes generated from the health care establishments. But this study has given more emphasis to the solid portion of the waste. Genotoxic waste, radioactive waste, chemical waste, pressurized containers, etc. need special treatment, which have not been included in the study.
2. For the study a reasonable number of health centers of Khulna city have been selected for survey. These health centers include hospitals, clinics, diagnostic centers and dental clinics. Other types of health facilities like EPI centers, Family Planning centers, health centers of educational institutes, industries, private chambers of the doctors and veterinary services have been excluded from the study as they do not generate significant amount of waste.
3. It needs to study the area for whole the year round, at including the time and seasonal variation. But it was totally impossible to study there for whole year round because of the class continuation, examination in the university.
4. Some time it had to depend on other person or institute to collect those data.
5. Information provided by the higher officials could not be always were very co-operative and reliable.

1.7 Scope

The study includes an in depth study of the existing rate of waste generation and present waste management system. This study contribute comparative information and recommendations about the proper management of healthcare waste which would assist in making local decisions to provide the most effective, economical and scientific management of healthcare waste in the study area. It identifies the available institutional arrangements and problem associated with healthcare waste management. This type of

study has also a great importance for the urban planner who bears the responsibility to create a healthy and sound environment for the urban dwellers.

1.8 Organization of the Project Work

The study has been presented in five chapter comprising different aspects of healthcare waste management.

Chapter 1 presents a brief introduction to the study along with objectives, limitation, and scope of the study and organization of the project work.

Chapter 2 compiles all relevant literature and information in connections with healthcare waste management and appropriate technologies.

Chapter 3 outlines the methodologies on the survey conducted in selected health care establishment on clinical waste management data sources, data collection procedures and selection of study area which has been followed for the study.

Chapter 4 outlines the present healthcare waste management of Khulna city provides description of the analysis process adopted in this study and presents the result of the analysis accompanied by discussion.

Chapter 5 summarizes the whole study and draws conclusion and recommendations and enlists provision for further study in this area.

CHAPTER 2

REVIEW OF LITERATURE

2.1 General

With the recent rapid growth of private health sector, the need of safe and proper healthcare waste disposal is becoming important. Healthcare waste is frequently described to be an environmental pollutant as well as presenting a serious health concern. The improper disposal of healthcare wastes may be catastrophic to the health, environment and the well being of the community. With the development of advanced health-care technology more hazardous by-products are created having their actual and potential damaging effects on our environment. At the same time some very infectious and serious diseases like HIV/AIDS, Hepatitis are rising alarmingly in the world as well as in Bangladesh. These facts mentioned above received the attention of sound health-care waste management in recent times. However, as Bangladesh is a low-income country, having severe lack in public awareness, here the management of wastes generated from health-care facilities has been receiving lower attention. And therefore, handling of health-care wastes is presently regarded as part of the municipal waste stream.

In Bangladesh, presently there are around 645 public and 288 private sector healthcare establishments (Line Director, 2000). With rapid increase in number of clinics and hospitals in the country, the generations of hospital wastes have been increasing considerably. But most of the hospitals do not have any provision for a safe disposal of hospital waste. Even in Dhaka, the capital city of Bangladesh, all kind of waste from hospitals including healthcare wastes, are dumped in the municipal waste collecting bins of the municipal authorities (ADB, 1998). Use of incinerator or any alternative methods for safe disposal of waste is almost absent in hospitals. There are only a few hospitals and clinics, which have onsite waste management system such as burning, burial, autoclave, waste segregation.

Therefore all kinds of healthcare waste should be properly treated and its disposal should be in such a way that there is no risk of any kind of diseases to the people of the

community. Special effort should be given by the people to become more aware and responsible for managing the health care waste especially the hazardous portion.

2.2 Definition of Healthcare Waste

The world health organization (WHO, 1999) has defined healthcare waste in the following way: “health-care waste includes all the waste generated by health-care establishments, research facilities, and laboratories. In addition, it includes the waste originating from “minor” or “scattered” sources—such as that produced in the course of health care undertaken in the home (dialysis, insulin injections, etc.)

Between 75% and 90% of the waste produced by health-care providers is non-risk or “General” health-care waste, comparable to domestic waste. It comes mostly from the administrative and housekeeping functions of health-care establishments and may also include waste generated during maintenance of health-care premises. The remaining 10-25% of health-care waste is regarded as “Hazardous” and may create a variety of health risks”

2.3 Categories of Healthcare Waste

2.3.1 General or Non-hazardous Waste

Non-hazardous (General) wastes are that portion of the health care waste that poses minimum degree of risk to human health. It is primarily composed of materials similar to domestic type waste; packing materials, non-infectious materials, that do not pose special handling problems to human health or the environment (Rahman et. al., 1999).

2.3.2 Hazardous Waste

Hazardous wastes are that portion of the wastes which includes infectious waste (contains pathogens in sufficient concentrations that exposure to it could result in disease), pathological waste (includes blood, body fluids, tissues, organs, body parts, etc.), sharps (needles, blades, syringes, scalpels, saws, broken glass, nails and any items that could cause a cut or puncture), and very small amount of pharmaceutical and chemical wastes (WHO, 1999)

WHO classified the healthcare wastes in nine categories. They are described in the Table-2.1

Table 2.1 WHO's Classification of Healthcare Waste.

Waste category	Description and examples
Infectious waste	Waste suspected to contain pathogens e.g. laboratory cultures; waste from isolation wards; tissues (swabs), materials, or equipment that have been in contact with infected patients; excreta.
Pathological waste	Human tissues or fluids e.g. body parts; blood and other body fluids; fetuses
sharps	Sharp waste e.g. needles; infusion sets; scalpels; knives; blades; broken glass
Pharmaceutical waste	Waste containing pharmaceuticals e.g. pharmaceuticals that are expired or no longer needed; items contaminated by or containing pharmaceuticals (bottles, boxes)
Genotoxic waste	Waste containing substances with genotoxic properties e.g. waste containing cytostatic drugs (often used in cancer therapy); genotoxic chemicals
Chemical waste	Waste containing chemical substances e.g. laboratory reagents; film developer; disinfectants that are expired or no longer needed; solvents.
Wastes with high content of heavy metals.	Batteries; broken thermometers; blood-pressure gauges; etc.
Pressurized containers	Gas cylinders; gas cartridges; aerosol cans.
Radioactive waste	Waste containing radioactive substances e.g. unused liquids from radiotherapy or laboratory research; contaminated glassware, packages, or absorbent paper; urine and excreta from patients treated or tested with unsealed radionuclide; sealed sources.

Sources: WHO, 1999

Infectious Waste

Infectious waste is suspected to contain pathogens (bacteria, viruses, parasites, or fungi) in sufficient concentration or quantity to cause disease in susceptible hosts. This category includes (WHO, 1999):

- Cultures and stocks of infectious agents from laboratory work;
- Waste from surgery and autopsies on patients with infectious diseases (E.g. tissues, and materials or equipments that have been in contact with blood or other body fluids);
- Waste from infected patients in isolation wards (e.g. excreta, dressings from infected or surgical wounds, clothes heavily soiled with human blood or other body fluids);
- Waste that has been in contact with infected patients undergoing haemodialysis (e.g. dialyses equipment such as tubing and filters, disposable towels, gowns, aprons, gloves, and laboratory coats);
- Infected animals from laboratories;
- Any other instruments or materials that have been in contact with infected persons or animals.

Pathological and Anatomical Waste

Pathological waste consists of tissues, organs, body parts, human fetuses and animal carcasses, blood, and body fluids. Within this category, recognizable human or animal body parts are also called anatomical waste. This category should be considered as a subcategory of infectious waste, even though it may also include healthy body parts (WHO, 1999).

Anatomical waste is a sub-group of pathological waste and consists in recognizable human body parts, whether they may be infected or not. Following the precautionary principal, anatomical waste is always considered as potential infectious waste (WHO, 2003)

Sharps

Sharps are items that could cause cuts or puncture wounds, including needles, hypodermic needles, scalpel and other blades, knives, infusion sets, saws, broken glass, and nails. Whether or not they are infected, such items are usually considered as highly hazardous health-care waste (WHO, 1999).

Pharmaceutical Waste

Pharmaceutical waste includes expired, unused, spilt, and contaminated pharmaceutical products, drugs, vaccines, and sera that are no longer required and need to be disposed of appropriately. The category also includes discarded items used in the handling of pharmaceuticals, such as bottles or boxes with residues, gloves, masks, connecting tubing, and drug vials. Since the Ministry of Health has taken specific measures to reduce the wastage of drugs, Health Care Facilities (HCF) should deal only with small quantities of pharmaceutical waste (WHO, 1999).

Genotoxic Waste

Genotoxic waste is highly hazardous and may have mutagenic, teratogenic or carcinogenic properties. It raises serious safety problems, both; inside hospitals and after disposal, and should be given special attention. Genotoxic waste may include certain cytostatic drugs (see below), vomit, urine or faeces from patients treated with cytostatic drugs, chemicals, and radioactive material.

Cytotoxic (or antineoplastic) drugs, the principal substances in this category, have the ability to kill or stop the growth of certain living cells and are used in chemotherapy of cancer. They are most often used in specialized departments such as oncology and radiotherapy units, whose main role is cancer treatment; however, their use in other hospital departments is increasing and they may also be used outside the hospital setting (WHO, 1999).

The most common genotoxic products used in health care are as follows (IARC, 1994):

Classified as carcinogenic

- Chemicals: benzene
- Cytotoxic and other drugs: azathioprine, chlorambucil, chlornaphazine, ciclosporin, cyclophosphamide, melphalan, semustine, tamoxifen, thiotepa, treosulfan
- Radioactive substances

Classified as possibly or probably carcinogenic

- Cytotoxic and other drugs: azacitidine, bleomycin, carmustine, chloramphenicol, chlorozotocin, cisplatin, dacarbazine, daunorubicin, dihydroxymethylfuratrizine (e.g. panfuran s—no longer in use), doxorubicin, lomustine, methylthiouracil, metronidazole, mito-mycin, nafenopin, niridazole, oxazepam, phenacetin, Phenobarbital, phenytoin, procarbazine hydrochloride, progesterone, sarcolysin, streptozocin, trichlormethine

Harmful cytostatic drugs can be categorized as follows:

- Alkylating agents: cause alkylation of DNA nucleotides, which leads to cross-linking and miscoding of the genetic stocks;
- Anti-metabolites: inhibit the biosynthesis of nucleic acids in the cell;
- Mitotic inhibitors: prevent cell replication.

Cytotoxic wastes are generated from several sources and can include the following (WHO, 1999):

- Contaminated materials from drug preparation and administration, such as syringes, needles, gauges, vials, packaging;
- Outdated drugs, excess (leftover) solutions, drugs returned from the wards;
- Urine, faeces, and vomit from patients, which may contain potentially hazardous amounts of the administered cytostatic drugs or of their metabolites and which should be considered genotoxic for at least 48 hours and sometimes up to 1 week after drug administration.

Chemical Waste

Chemical waste consists of discarded solid, liquid, and gaseous chemicals, for example from diagnostic and experimental work and from cleaning, housekeeping, and disinfecting procedures. Chemical waste from health care may be hazardous or non-hazardous; in the context of protecting health, it is considered to be hazardous if it has at least one of the following properties (WHO, 1999) includes (i) Toxic; (ii) Corrosive (e.g. acids of $\text{pH} < 2$ and bases of $\text{pH} > 12$); (iii) Flammable; (iv) Reactive (explosive, water-reactive, shock-sensitive); (v) Genotoxic (e.g. cytostatic drugs).

Non-hazardous chemical waste consists of chemicals with none of the properties, such as sugars, amino acids, and certain organic and inorganic salts. The types of hazardous chemicals used most commonly in maintenance of health-care centers and hospitals and the most likely to be found in waste are, (i) Formaldehyde; (ii) Photographic chemicals; (iii) Solvents; (iv) Organic chemicals; (v) Inorganic chemicals

Wastes with High Content of Heavy Metals

Wastes with a high heavy-metal content represent a subcategory of hazardous chemical waste, and are usually highly toxic. Mercury wastes are typically generated by spillage from broken clinical equipment but their volume is decreasing with the substituting of solid-waste electronic sensing instruments (thermometers, blood-pressure gauges, etc.) whenever possible, spilled drops of mercury should be recovered. Residues from dentistry have high mercury content. Cadmium waste comes mainly from discarded batteries. Certain “reinforced wood panels” containing leads are still used in radiation proofing of X-ray and diagnostic departments. A number of drugs contain arsenic, but these are treated here as pharmaceutical waste (WHO, 1999)

Pressurized Containers

Many types of gas are used in health care and are often stored in pressurized cylinders, cartridges, and aerosol cans. Many of these, once empty or of no further use (although they may still contain residues), are reusable, but certain types, notably aerosol cans, must be disposed of.

Whether inert or potentially harmful, gases in pressurized containers should always be handled with care; containers may explode if incinerated or accidentally punctured (WHO, 1999).

Radioactive Waste

Radioactive waste includes solid, liquid, and gaseous materials contaminated with radionuclide. It is produced as a result of procedures such as in-vitro analysis of body tissues and fluid, in-vivo organ imaging and tumor localization, and various investigative and therapeutic practices (WHO, 1999).

The type and form of radioactive material used in health-care establishments usually results in low-level radioactive waste. Waste in the form of sealed sources may be of fairly high activity, but is only generated in low volumes from larger medical and research laboratories. Sealed sources are generally returned to the supplier and so do not enter the waste stream (WHO, 1999).

2.4 Characteristics of Healthcare Wastes

Wastes generated at health care facilities are indeed varied both in composition and in quantity. Hospitals offer a wide range of services and encompass a variety of activities, each of which generates different characteristics waste. It is important to know what types and quantities of waste are generated at a facility for several reasons. Proper sizing of an on-site treatment system requires an accurate characterization of the waste generated. Some contracts for transportation and off-site disposal of waste are based on the quantity generated as well (Cross et al., 1990). For these requirements, the most accurate method of gathering data is to conduct a facility waste audit. These can be accomplished by in-house personnel or by an environmental engineering consulting firm specializing in infectious and hospital waste management.

2.5 Composition of Healthcare Wastes

The wastes generated in health care establishments is extremely heterogeneous in composition; however it can be generally described as a mixture of paper and cardboard, plastic, pathological waste, food waste, glass and metal. Factors affecting the amount of these elements present in the waste stream include the extent of laboratory/research activities, use of disposable, and the rate of surgeries scheduled.

The approximate compositions of various wastes generated in health care establishments are shown in Table-2.2.

Table 2.2 Waste Composition (Cross et al., 1990)

Types of Operation	%	%	%	%	%	%	%
	Paper	Plastic	Pathological	Food waste	Glass	Metal	Other
Administrative/ Clerical	100	-	-	-	-	-	-
Cafeteria	20	20	-	60	-	-	-
Surgery	60	30	10	-	-	-	-
Emergency Room	60	35	5	-	-	-	-
Intensive Care	60	35	5	-	-	-	-
Renal Dialysis	10	85	5	-	-	-	-
Laboratory	35	30	25	-	10	-	-
Nursery	45	35	-	5	15	-	-
Pharmacy	50	30	-	-	20	-	-
General Patient Care	60	35	-	5	-	-	-
Research	50	-	30	-	-	-	20*
Sharps	-	90	-	-	-	10	-

(*Animal Bedding)

2.6 Physical/Chemical Characteristics

In order to waste management practices in a health care establishment, it is often necessary to consider the physical and chemical characteristics of the waste stream. The chemical characteristics of healthcare waste are shown in Table-2.3.

Table 2.3 Chemical Characteristics of Healthcare Waste (Roteb, 1998)

Waste	Component	Moisture (%)	Incombustible Solid (%)	Heating value (MJ/kg)
Type no. 1	Rubbish and garbage	50	7	10.4
Type no. 2	Wet waste of hospital	70	5	6.2
Type no. 3	Pathological waste of hospital and laboratory	85	5	2.1

2.7 Type of Healthcare Establishment that Generate Waste

According to WHO (1983), there are many types of healthcare establishments that generate waste are described in the Table-2.4.

Table 2.4 Type of Healthcare Establishment that Generate Waste

Healthcare Establishments	Types
Hospitals	-General hospital -Specialized hospital -Sanatorium (TB)
Departments	-Paediatric -Oncology -Rehabilitation -Eye and ear -Psychiatric -Burns and trauma -Orthopedic -Respiratory diseases -Haemophilia
Clinics	-Physician -Dentist -Dialysis center -Alcohol treatment center -Drug treatment center -Abortion clinic -Maternity clinic -Thrombosis clinic
Long-term health care establishments	-Nursing home -Old peoples home -Home for the physically and mentally handicapped -Home care (such as home dialysis)
Support services	-Blood bank -Pharmacy -Medical/teaching centers -Mortuary -Central sterile supply -Laundry -Technical services
Laboratories	-Clinical -Pathology -Haematology -Chemistry -Research, including veterinary and genetic

Source: WHO, 1983

2.8 Sources of Healthcare Waste

The sources of health-care waste can be classified as major or minor according to the quantities produced. While minor and scattered sources may produce some health-care waste in categories similar to hospital waste, their composition will be different. For example (WHO, 1999):

- They rarely produce radioactive or cytostatic waste;
- Human body parts are not included;
- Sharps consist mainly of hypodermic needles.

The composition of wastes is often characteristic of the type of source. For example, the different units within a hospital would generate waste with the following characteristics:

Medical wards: mainly infectious waste such as dressing, bandages, sticking plaster, gloves, disposable medical items, used hypodermic needles and intravenous sets, body fluids and excreta, contaminated packaging, and meal scraps.

Operating theaters and surgical wards: mainly anatomical waste such as tissues, organs, fetuses, and body parts, other infectious waste, and sharps.

Other health-care units: mostly general waste with a small percentage of infectious waste.

Laboratories: mainly pathological (including some anatomical), highly infectious waste (small pieces of tissue, microbiological cultures, stocks of infectious agents, infected animal carcasses, blood and other body fluids), and sharps, plus some radioactive and chemical wastes.

Pharmaceutical and chemical stores: small quantities of pharmaceutical and chemical wastes, mainly packaging (containing only residues if stores are well managed), and general waste.

Support units: general waste only.

Health-care waste from scattered sources generally has the following characteristic composition:

Health care provided by nurses: mainly infectious waste and many sharps.

Physicians' offices: mainly infectious waste and some sharps.

Dental clinics and dentists' offices: mainly infectious and sharps, and wastes with high content of heavy-metal.

Home health care (e.g. dialysis, insulin injections): mainly infectious waste and sharps.

2.9 Factors Affecting Generation Rate

The factors that influence the quantity of healthcare waste generated include (Peavey et al., 1985) (i) Geographic location; (ii) Season of the year; (iii) Collection frequency (affects amount collected); (iv) Use of kitchen waste grinders; (v) Characteristics of populace (vi) Extent of salvaging and recycling; (vii) Public attitude; and (viii) Legislation.

2.10 Existing Healthcare Sectors in Bangladesh

The ministry of health and family welfare (MOHFW) has taken the decision to prepare a health sector program for Bangladesh. For this operation plan for five years (2005-2009), an estimated cost of BDT 257 million has been proposed (MOHFW, 2004).

The public health facilities in Bangladesh are divided into the following categories:

(i) Health and family welfare centers (UHC/HFWC); (ii) Thana (upazilla) health complexes (THC); (iii) District hospitals; (iii) Medical college hospitals; (iii) Other hospitals run by MOHFW or Other ministries.

In addition to this there are also a large number of private health care facilities throughout the country. A UHC/HFWC only treats outpatients for minor family health matters. A THC has approximately 31-50 beds, with an average occupancy rate of 50%. The types of diseases treated range from gastroenterology, gynecology and obstetrics, pediatrics, hematology, infectious diseases to pulmonary diseases. These centers also participate in the national Expanded Program on Immunization (EPI) and each serves as referral center for approximately 24 UHC/HFWC (MOHFW, 2004). Public sector health system is structured as a hierarchical pyramid with 5 layers includes (i) 3 at primary; (ii) 1 at secondary (iii) 1 at tertiary

Under the primary level there are 4300 Union health and family welfare centers and 414 Upazilla health complexes (Asadu, 2005). Secondary level health care services deliver services through 58 District hospitals and 55 Maternal and Child Welfare centers (Asadu, 2005). The tertiary level health service delivery is ensured through (i) 13 Medical college Hospitals; (ii) 10 Post graduate institutes and Hospitals (iii) 1 Dental college Hospital (iv)

20 Specialized Hospitals (v) 1 Homeopathic Medical college Hospital (vi) 1 Ayurvedic Degree college Hospital (Asadu, 2005).

A graphical presentation of the percentage of Health-Care Facilities (HCFs) in Bangladesh according to MOHFW is given in Figure-2.1.

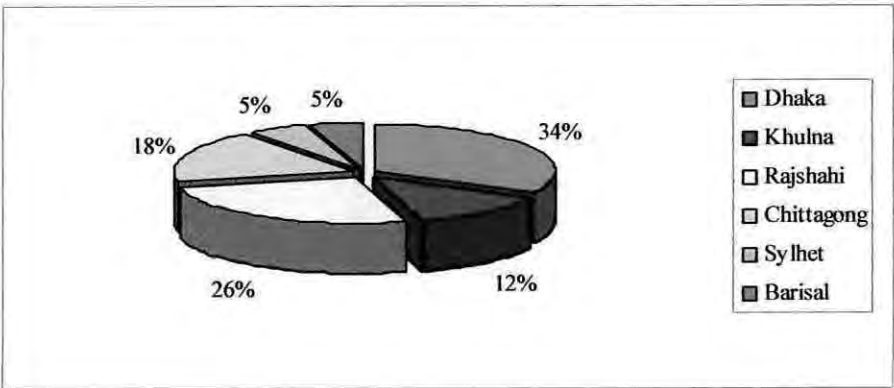


Figure 2.1 Numbers of Healthcare Facilities in Bangladesh

Dhaka with 34% has the highest number of HCFs (Appendix-J), Rajshahi has 26%, Khulna and Chittagong have 12% and 18% respectively. Sylhet and Barisal has the least number of HCFs with 5% (MOHFW, 2004).

In Figure 2.2, the total bed capacity available in Bangladesh has been compared with a few other countries.

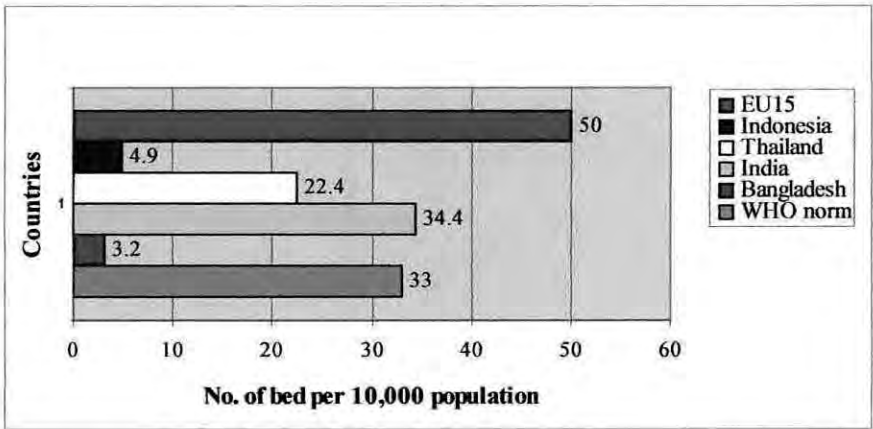


Figure 2.2 Comparisons of Bed Capacities According to WHO

The norm proposed by WHO states that there should be at least 33 beds per 10,000 populations. The current bed capacity for Bangladesh is 3.2 beds per 10,000 populations which is only 10% of the norm proposed by WHO. On the other hand the bed capacity for India (16 selected states) and EU15 average countries are 34.4 and 50 beds per 10,000 population respectively which are above the WHO norm. Therefore to reach the WHO norm a substantial increase in the bed capacities and of inpatient health facilities are necessary and expected (MOHFW, 2004).

2.11 Healthcare Waste Generation in Various Countries

The quantity of waste produced per bed per day differs greatly from one country to another, and above all depending on the attitude of hospital. The amounts of hospital waste produced by health care establishments in various countries are shown in Table-2.5

Table 2.5 Healthcare Waste Generation in Various Countries According to Institutional Category (WHO/EUROPE Publications ERS 1997)

Type of Hospital	Norway	Spain	UK	France	USA	Netherlands
University	3.9	4.4	3.3	3.35	5.24	4.2 to 6.5
General Hospital	-	-	-	2.5	4.5	2.7
Maternity	-	3.4	3.0	-	-	-
Mental Hospital	-	1.6	0.5	-	-	1.3
Geriatric	-	1.2	9.25	-	-	1.7

Monreal (1991) quoted figures of 1 to 4.5 kg/bed/day for generation of solid wastes from hospitals in Latin America. Figures in more detail are shown in Table- 2.6.

Table 2.6 Healthcare Waste Generation in Various Countries (Monreal, 1991)

Country	Year of study	Generation (kg/bed/day)		
		Minimum	Median	Maximum
Chile	1973	0.97	-	1.21
Venezuela	1976	2.56	3.10	3.71
Brazil	1978	1.20	2.63	3.80
Argentina	1982	0.82	-	4.20
Peru	1987	1.60	2.93	6.00
Argentina	1988	1.85	-	3.65
Paraguay	1989	3.00	3.80	4.50

The data are indicative only. There are variations from one institution to another. Waste output refers to all waste including general waste.

2.11.1 Hazardous Waste Generation in Various Countries

Today, infectious waste is very precisely defined; that is to say waste that is contained with pathogenic agents and due to the presence of diseases which, according to the current state of knowledge, may lead to such types of waste. The quantity of waste that is classified as infectious depends to a great extent on the concept of waste existing in a hospital and on the consequent implementation of its separation into groups. The amount of infectious waste per bed per day varies between 50 and 2500gms (Gerig, 1995). This figure is 150 gm in a single clinic of Dhaka city (BCAS, 1997).

Specified objectionable healthcare wastes which for reasons of ethical and esthetically aspects require a special disposal technique (0-5%) of the total waste. Waste from nursing, training and research department requiring special disposal for aesthetic reasons, mostly disposable (5-10%) of the total quantity. EPA (1978) guidelines suggested that 20-25% of healthcare waste should be considered as infectious. In contrast centers for disease control consider only 3-5% of healthcare waste as infectious.

This category comprises:

(i) Sputum pots; (ii) Drainage and evacuation tubes; (iii) Rodon bottles/systems, external feeding systems; (iv) Catheters; (v) Surgery gloves and other protective disposables; (vi) Stoma bags (for excreta); (vii) Artificial kidneys or dialysis fitters; (viii) Blood bags (ix) Bandages, gauze, tissues, cotton-wool etc. polluted with body fluids.

Remaining wastes from nursing, treating and research departments largely comparable with household waste (45-65%) of the total quantity (Roteb, 1998). This indicates that at least 5-15% of the total waste quantity should be considered as hazardous hospital waste and should be dealt with accordingly. The hazardous waste also comprises chemical, toxic or pharmaceutical waste including cytotoxin, cytostatics and radioactive wastes, biological wastes, infectious waste and sharp. Different countries show wide varying percentages of hospital hazardous waste depending on legislation, operational practices

and definitions. In view of the practically involved in the separation activities it is assumed that on average 15% to 20% of the total hospital waste generation is considered to be hazardous waste. The generation of hazardous healthcare waste in various countries is shown in Table-2.7.

Table 2.7 Hazardous Waste Generation in Various Countries (Roteb, 1998)

Name of the Country	Generation of Hazardous Waste (%)
Netherlands	5
Sweden	7
Germany	9
Denmark	14
USA	25
Italy	28

2.12 Healthcare Waste Generation in Asian Countries

Estimated amounts of healthcare waste generated in some Asian countries/cities have been graphically represented in Figure-2.3.

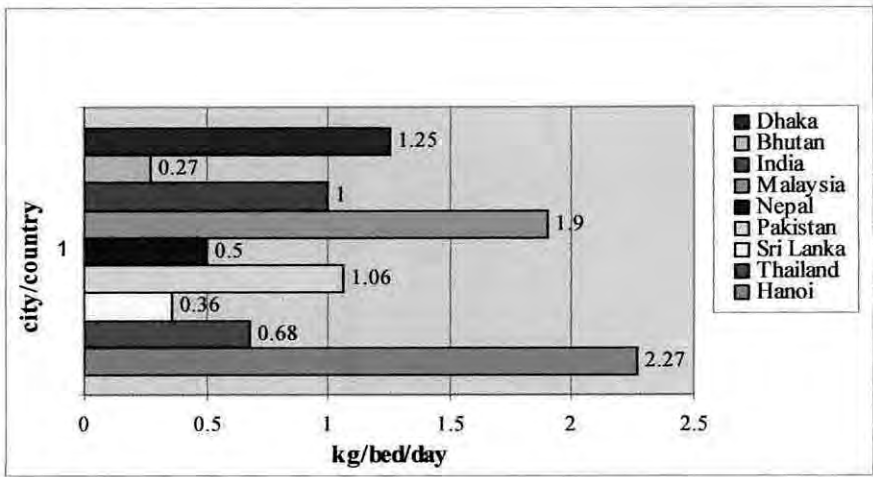


Figure 2.3 Estimated Avg. Healthcare Waste Generation in a Few Asian Countries/Cities (Visvanathan, 2006)

Figure-2.3 shows that, the total healthcare waste generation in Dhaka is 1.25 kg/bed/day and that in India is 1 kg/bed/day. This shows that the inadequate bed capacity of Dhaka city below the WHO norm rose the healthcare waste generation in the city in terms of kg/bed/day. At present among the 363 registered clinics, 200 clinics have 4000 beds

counted by DGHS. Though clinics are growing rapidly in Dhaka city, this growth is expected to be more to meet the WHO norm.

2.13 Healthcare Waste Generation in Bangladesh

The percentage of hazardous waste generated in each division of Bangladesh has been graphically represented in Figure-2.4.

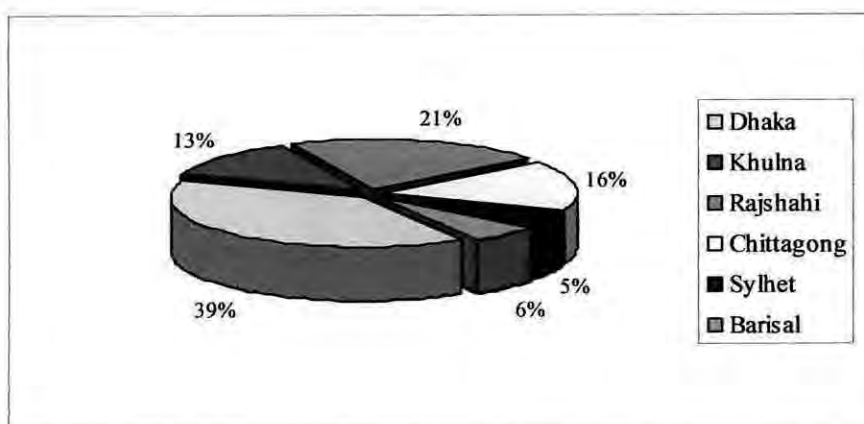


Figure 2.4 Distribution of Hazardous Waste Generation Divided on Divisions, 2001 (MOHFW, 2004).

From Figure-2.4, it can be seen that Dhaka division produces the largest fraction (39%) of hazardous waste and Sylhet produces the least with 5% (Appendix-J).

Factors that influence the waste generation rate (i) Population size; (ii) The quantity of segregation of the waste in the different types; (iii) The availability of different waste collection containers; (iv) Services provided by the various health care facilities. (v) The use of equipments and materials at the health care facility (MOHFW, 2004)

2.14 Hazards of Healthcare Waste

Health-care waste includes a large component of general waste and a smaller portion of hazardous waste. Exposure to hazardous health-care waste can result in disease or injury. The hazardous nature of health-care waste may be due to one or more of the characteristics includes (i) It contains infectious agents; (ii) It is genotoxic; (iii) It

contains toxic or hazardous chemicals or pharmaceuticals; (iv) It is radioactive; (v) It contains sharps.

All individuals exposed to hazardous health-care waste are potentially at risk including those within health-care establishments that generate hazardous waste, and those outside these sources who either handle such waste or are exposed to it is a consequence of careless management. The main groups at risk are the following:

- Medical doctors, nurses, health-care auxiliaries, and hospital maintenance personnel;
- Patients in health-care establishments or receiving home care;
- Visitors to health-care establishments;
- Workers in support services allied to health-care establishments, such as laundries, waste handling, and transportation;
- Workers in waste disposal facilities (such as landfills or incinerators), including scavengers.

The hazards associated with scattered, small sources of health-care waste should not be overlooked; waste from these sources includes that generated by home-based health care, such as dialysis, and that generated by illicit drug use (WHO, 1999).

2.14.1 Health hazards from Infectious Waste and Sharps

Infectious waste may contain any of a great variety of pathogenic microorganisms. Pathogens in infectious waste may enter the human body by a number of routes:

- (i) Through a puncture, abrasion, or cut in the skin;
- (ii) Through the mucous membranes;
- (iii) By inhalation;
- (iv) By ingestion

There is particular concern about infection with human immunodeficiency virus (HIV) and hepatitis viruses B and C, for which there is strong evidence of transmission via health-care waste. These viruses are generally transmitted through injuries from syringe needles contaminated by human blood.

The existence in health-care establishments of bacteria resistant to antibiotics and chemical disinfectants may also contribute to the hazards created by poorly managed health-care waste. It has been demonstrated, for example, that plasmids from laboratory strains contained in health-care waste were transferred to indigenous bacteria via the waste disposal system. Moreover, antibiotic-resistant *Escherichia coli* have been shown to survive in an activated sludge plant, although there does not seem to be significant transfer of this organism under normal conditions of waste-water disposal and treatment.

Concentrated cultures of pathogens and contaminated sharps (particularly hypodermic needles) are probably the waste items that present the most acute potential hazards to health.

Sharps may not only cause cuts and punctures but also infect these wounds if they are contaminated with pathogens. Because of this double risk of injury and disease transmission, sharps are considered as a very hazardous waste class. The principal concerns are infectious that may be transmitted by subcutaneous introduction of the causative agent, e.g. viral blood infections. Hypodermic needles constitute an important part of the sharps waste category and are particularly hazardous because they are often contaminated with patients' blood (WHO, 1999).

2.14.2 Health hazards from Chemical and Pharmaceutical Waste

Many of the chemicals and pharmaceutical used in health-care establishments are hazardous (e.g. toxic, genotoxic, corrosive, flammable, reactive explosive, shock-sensitive). These substances are commonly present in small quantities in health-care waste; larger quantities may be found when unwanted or outdated chemicals and pharmaceuticals are disposed of. They may cause intoxication, either by acute or by chronic exposure, and injuries including burns. Intoxication can result from absorption of a chemical or pharmaceutical through the skin or the mucous membranes, or from inhalation or ingestion. Injuries to the skin, the eyes, or the mucous membranes of the airways can be caused by contact with flammable, corrosive, or reactive chemicals (e.g. formaldehyde and other volatile substances). The most common injuries are burns. Disinfectants are particularly important members of this group. They are used in large

quantities and are often corrosive. It should also be noted that reactive chemicals may form highly toxic secondary compounds.

Obsolete pesticides, stored in leaking drums or torn bags, can directly or indirectly affect the health of anyone who comes into contact with them. During heavy rains, leaked pesticides can seep into the ground and contaminate the groundwater. Poisoning can occur through direct contact with the product, inhalation of vapors, drinking of contaminated water, or eating of contaminated food. Other hazards may include the possibility of fire and contamination as a result of inadequate disposal such as burning or burying.

Chemical residues discharged into the sewerage system may have adverse effects on the operation of biological sewerage treatment plants or toxic effects on the natural ecosystems of receiving waters. Similar problems may be caused by pharmaceutical residues, which may include antibiotics and other drugs, heavy metals such as mercury, phenols, and derivatives, and disinfectants and antiseptics (WHO, 1999).

2.14.3 Hazards from Genotoxic Waste

The severity of the hazards for health-care workers responsible for the handling or disposal of genotoxic waste is governed by a combination of the substance toxicity itself and the extent and duration of exposure. Exposure to genotoxic substances in health care may also occur during the preparation of or treatment with particular drugs or chemicals. The main pathways of exposure are inhalation of dust or aerosols, absorption through the skin, ingestion of food accidentally contaminated with cytotoxic drugs, chemicals, or waste, and ingestion as a result of bad practice, such as mouth pipetting. Exposure may also occur through contact with the bodily fluids and secretions of patients undergoing chemotherapy.

Experimental studies have shown that many antineoplastic drugs are carcinogenic and mutagenic; secondary neoplasia (occurring after the original cancer has been eradicated) is known to be associated with some forms of chemotherapy. Many cytotoxic drugs are extremely irritant and have harmful local effects after direct contact with skin or eyes.

They may also cause dizziness, nausea, headache, or dermatitis. Special care in handling genotoxic waste is absolutely essential. Any discharge of such waste into the environment could have disastrous ecological consequences (WHO, 1999).

2.14.4 Hazards from Radioactive Waste

The type of disease caused by radioactive waste is determined by the type and extent of exposure. It can range from headache, dizziness, and vomiting to much more serious problems. Because radioactive waste, like certain pharmaceutical waste, is genotoxic, it may also affect genetic material. Handling of highly active sources, e.g. certain sealed sources from diagnostic instruments, may cause much more severe injuries (such as destruction of tissue, necessitating amputation of body parts) and should therefore be undertaken with the utmost care.

The hazards of low-activity waste may arise from contamination of external surfaces of containers or improper mode or duration of waste storage. Health-care workers or waste-handling or cleaning personnel exposed to this radioactivity are at risk (WHO, 1999).

2.15 Public Sensitivity

The general public is very sensitive about the visual impact of anatomical waste, which is a recognizable human body part. In no circumstances is it acceptable to dispose of anatomical waste inappropriately, such as on a landfill. In some cultures, especially in a Muslim culture, religious beliefs require that human body parts be returned to a patient's family to be buried in cemeteries (WHO, 1999).

2.16 Impacts of Healthcare Waste on Public health

2.16.1 Impacts of Infectious Waste and Sharps

For serious virus infections such as HIV/AIDS and hepatitis B and C, health care workers, particularly nurses, are at greatest risk of infection through injuries from contaminated sharps (largely hypodermic needles). Other hospital workers and waste management operators out-side health-care establishments are also at significant risk, as are individuals who scavenge on waste disposal sites.

The overall situation, however, remains difficult to access, especially in developing countries. It is suspected that many cases of infection with a wide variety of pathogens have resulted from exposure to improperly managed health-care wastes in developing countries.

Many injuries are caused by recapping of hypodermic needles before disposal of containers, by unnecessary opening of these containers, and by the use of materials that are not puncture-proof for construction of containers.

Outside health-care establishments, the risk to the general public of HIV infection by this means is negligible. The risk of viral hepatitis B and C infection from contact with health-care waste may be more significant, as this virus is viable for longer than HIV (WHO, 1999).

2.16.2 Impacts of Chemical and Pharmaceutical Waste

While there is no significantly documented incidence of widespread illness among the general public due to chemical or pharmaceutical waste from hospitals, many examples may be found of extensive intoxication caused by industrial chemical waste. Moreover, many cases of injury or intoxication result from the improper handling of chemicals or pharmaceuticals in health-care establishments. Pharmacists, anesthetists, and nursing, auxiliary, and maintenance personnel may be at risk of respiratory or dermal diseases caused by exposure to such substances as vapors, aerosols, and liquids. To minimize this type of occupational risk, less hazardous chemicals should be substituted whenever possible and protective equipment should be provided to all personnel likely to be exposed. Premises where hazardous chemicals are used should be properly ventilated, and personnel at risk should be trained in preventive measures and in emergency care in case of accident (WHO, 1999).

2.16.3 Impacts of Genotoxic Waste

To date there are few data on the long-term health impacts of genotoxic health-care waste. This is partly because of the difficulty of assessing human exposure to this type of compound.

Numerous published studies have investigated the potential health hazard associated with the handling of antineoplastic drugs, manifested by increased urinary levels of mutagenic compounds in exposed workers. A recent study has demonstrated that exposure of personnel cleaning hospital urinals exceeded that of nurses and pharmacists. These individuals were less aware of the danger and took fewer precautions. The concentration of cytotoxic drugs in the air inside hospitals has been examined in a number of studies designed to evaluate health risks linked to such exposure (Pyy et.al., 1988). No significant publication has yet reported adverse effects on health resulting from mismanagement of genotoxic waste (WHO, 1999).

2.16.4 Impacts of Radioactive Waste

Several accidents resulting from improper disposal of nuclear therapeutic materials have been reported, with a large number of persons suffering from the results of exposure. In Brazil, one case of carcinogenic impact on the general population linked to exposure to radioactive hospital waste has been analyzed and fully documented. While moving, a radiotherapy institute left a sealed radiotherapy source in its old premises. An individual who gained access to these premises removed the source and took it home. As a consequences, 249 people were exposed, of whom several either died or suffered severe health problems (IAEA, 1988).

Many cases of exposure to radioactive health-care waste, and associated health problems, go unreported. The only recorded accidents involving exposure to ionizing radiations in health-care settings have resulted from unsafe operation of X-ray apparatus, improper handling of radiotherapy solutions, or inadequate control of radiotherapy (WHO, 1999).

2.17 Healthcare Waste Management

2.17.1 International Recommendations for Waste Management

The United Nations Conference on the Environment and Development (UNCED) in 1992 led to the adoption of Agenda 21, which recommends a set of measures for waste management. The recommendations may be summarized as follows:

- Prevent and minimize waste production.
- Reuse or recycle the waste to the extent possible.

- Treat waste by safe and environmentally sound methods.
- Dispose of the final residues by landfill in confined and carefully designed sites.

Agenda 21 also stresses that any waste producer is responsible for the treatment and final disposal of its own waste; where possible; each community should dispose of its waste within its own boundaries (WHO, 1999).

2.17.2 Development of a Waste Management Plan

During development of the waste management plan, every member of the waste management team (WMT) should carry out a review of existing waste management arrangements in his or her area of responsibility. Existing practices should then be evaluated in the light of the national guidelines and recommendations made to the waste management officer (WMO) on how the guide-lines can be implemented in each area. On the basis of the waste generation survey and these recommendations, the WMO should prepare a draft discussion document for the WMT. This discussion document should include details of the new waste management system. It should be divided into sections addressing the following issues (WHO, 1999):

- Present situation (waste management practices, personnel and equipment involved)
- Quantities of waste generated
- Possibilities for waste minimization, reuse, and recycling
- Waste generation
- On-site handling, transport, and storage practices
- Identification and evaluation of waste treatment and disposal options (on and off-site)
- Identification and evaluation of the options, and associated costs
- Record-keeping
- Training
- Estimation of costs relating to waste management (actual situation and proposed options)
- Strategy for implementation of the plan.

2.17.3 Policy Document and Technical Guidelines

The policy document should outline the rationale for the legislation, plus national goals and the key steps essential to the achievement of these goals. It may contain the following (WHO, 1999):

- Descriptions of the health and safety risks resulting from mismanagement of health-care waste;
- Reasons for sound and safe health-care waste management practices in health-care establishments;
- Listing of approved methods of treatment and disposal for each waste category;
- Warning against unsafe practices, such as disposing of hazardous health-care waste in municipal landfills;
- Management responsibilities within and outside health-care establishments;
- Assessment of the costs of health-care waste management;
- Key steps of health-care waste management: minimization, separation, identification, handling, treatment, and final disposal of waste; technical specifications for the implementation of each step should be described in separate technical guidelines;
- Record-keeping and documentation;
- Training requirements;
- Rules governing the protection of workers' health and safety.

The technical guidelines associated with the legislation should be practical and directly applicable. They should include the following specifications, with sufficient detail to ensure that safe practices are observed and appropriate standards achieved:

- Legal frame work covering safe management of health-care waste, hospital hygiene, and occupational health and safety (limits of emission of atmospheric pollutants and measures for protection of water resources may be addressed here or in the other national guidelines);

- The responsibilities of public health authorities, of the national environmental protection body, of the heads of health-care establishments, of the scattered and smaller producers of health care waste; and of the heads of any private or public waste disposal agencies involved;
- Safe practices for waste minimization;
- Separation, handling, storage, and transport of health-care waste;
- Recommended treatment and disposal methods for each category of health-care waste and for wastewater.

Gradual implementation of the law is recommended in preference to any attempt to introduce all measures simultaneously, particularly where existing practices are inadequate (WHO, 1999).

2.18 Management Procedure of Healthcare Waste

The subject of healthcare waste management is often focused on issues relating to disposal; however in developing proper management practices waste-handling procedure used throughout the health care establishment are considered as well. So a proper management procedure of healthcare waste includes (i) Waste segregation; (ii) Storage of waste; (iii) Waste handling; (iv) Collection of waste; (v) Transportation; (vi) Treatment and final disposal.

2.18.1 Segregation of Healthcare Waste

Segregation of healthcare waste is of great importance, because it allows special attention to be given to the relatively small quantities of waste that need it. Poor segregation may not only result in risks to staff and public, but may also increase handling and disposal costs considerably. Proper and timely separation of healthcare waste is very important part of the safe disposal of clinical waste. A simple color coding system is used to separate waste so that the different components can be treated safely. Color-coding system for clinical wastes of WHO has been shown in Table-2.8.

Table 2.8 Color-coding of Healthcare Wastes

Types of Waste	Color
Infectious waste	Yellow marked "INFECTIOUS"
Sharps	Yellow marked "SHARPS"
Pharmaceutical waste	Brown
General/Non hazardous	Black

Source: WHO, 1999

To ensure the smooth operation of a color coding policy different colored containers are provided throughout the hospital so that the waste can be separated at the source:

- Wards are provided with separate color-coded containers for non-hazardous and hazardous waste.
- All waste from operation theatres are defined as hazardous waste.
- Office/administration wastes are usually papers and packaging materials defined as non-hazardous waste.
- All waste leaving the pathology department is defined as hazardous waste must be rendered safe before disposal.

The recommended color-coding scheme for Bangladesh is given in Table-2.9.

**Table 2.9 Recommended Color-coding for Healthcare Waste for Bangladesh
(Waste Concern, 2005)**

Types of Waste	Container Specifications	Color Code
General Waste	Plastic Container	Green
Sharps	Paper/wooden rigid box	Yellow
Infectious Waste	Plastic bins/polythene bags	Red
Radioactive Waste	Special lead proof container approved by Atomic Energy Commission Bangladesh.	Red
Cytotoxic and Pharmaceutical Waste	Polythene Bags	Red
Liquid Waste	Plastic bowl/container	Red

In addition to the color coding of waste containers, the following practices are recommended:

- General healthcare waste should join the stream of domestic refuse for disposal.
- Sharps should all be collected together, regardless of whether or not they are contaminated. Container should be puncture-proof (usually made of metal or high-density plastic) and fitted with covers. They should be rigid and impermeable so that they safely retain not only the sharps but also any residual liquids from syringes. To discourage abuse, containers should be tamper-proof (difficult to open or break) and needles and syringes should be rendered unusable. Where plastic or metal containers are unavailable or too costly, containers made of dense cardboard are recommended (WHO, 19997); these fold for ease of transport and may be supplied with a plastic lining.
- Bags and containers for infectious waste should be marked with the international infectious substance symbol (Figure-2.5).
- Highly infectious waste should, whenever possible, be sterilized immediately by autoclaving. It therefore needs to be packaged in bags that are compatible with the proposed treatment process: red bags, suitable for autoclaving, are recommended.
- Cytotoxic waste, most of which is produced in major hospital or research facilities, should be collected in strong, leak-proof containers clearly labeled "cytotoxic wastes".
- Small amounts of chemical or pharmaceutical waste may be collected together with infectious waste.
- Large quantities of obsolete or expired pharmaceuticals stored in hospital wards or departments should be returned to the pharmacy for disposal. Other pharmaceutical waste generated at this level, such as spilled or contaminated drugs or packaging containing drug residues should not be returned because of the risk of contaminating the pharmacy; it should be deposited in the correct container at the point of production.
- Large quantities of chemical waste should be packed in chemical-resistant containers and sent to specialized treatment facilities (if available). The identity of

the chemicals should be clearly marked on the containers: hazardous chemical wastes of different types should never be mixed.

- Waste with a high content of heavy metals (e.g. cadmium or mercury) should be collected separately.
- Aerosol containers may be collected with general health-care waste once they are completely empty, provided that the waste is not destined for incineration.
- Low-level radioactive infectious waste (e.g. swabs, syringes for diagnostic or therapeutic use) may be collected in yellow bags or containers for infectious waste if these are destined for incineration.



Figure 2.5 International Infectious Substance Symbol

Since costs for safe treatment and disposal of hazardous health-care waste are typically more than 10 times higher than those for general waste, all general, i.e. non-hazardous, waste should be handled in the same manner as domestic refuse and collected in black bags. No health-care waste other than sharps should be deposited in sharps containers, as these containers are more expensive than the bags used for other infectious waste. Measures of this sort help to minimize the costs of health-care waste collection and treatment.

Appropriate containers or bag holders should be placed in all locations where particular categories of waste may be generated. Instructions on waste separation and identification should be posted at each waste collection point to remind staff of the procedures. Containers should be removed when they are three-quarters full.

Cultural and religious constraints in certain countries make it unacceptable for anatomical waste to be collected in the usual yellow bags; such waste should be disposed of in accordance with local custom, which commonly specifies burial.

2.18.2 Separation of Waste

All high-risk waste is clearly labeled after waste is separated at source and Color-coded plastic bags with suitable thickness are used. Color-coded bags are placed in color-coded metal bins in the wards and departments and are equally effective means of separating waste at source. A separate bin is provided in the kitchen or sluice for the disposal of food waste where the visitors act as attendants. These bins are emptied at least once daily and the internal lining is replaced after emptying.

2.19.3 Storage of Waste

- The color-coded bags in the wards are emptied when they are two-thirds full.
- They should be tied securely and labeled clearly.
- The bags should be carried by the neck and taken to pre-designated area of collection.
- The collection staff ensures that the waste is segregated properly according to the color-coding and sent to the appropriate destination.
- The bags are stored in vermin and vandal-proof cages ready for transportation to their destination.

A storage location for health-care waste should be designated inside the health-care establishment or research facility. The waste, in bags or containers, should be stored in a separate area, room, or building of a size appropriate to the quantities of waste produced and the frequency of collection. Recommendations for the storage area and its equipment for health-care waste are as follows:

- The storage area should have an impermeable, hard-standing floor with good drainage; it should be easy to clean and disinfect.
- There should be a water supply for cleaning purposes.

- The storage area should afford easy access for staff in charge of handling the waste.
- It should be possible to lock the store to prevent access by unauthorized persons.
- Easy access for waste-collection vehicles is essential.
- There should be protection from the sun.
- The storage area should be inaccessible for animals, insects, and birds.
- There should be good lighting and at least passive ventilation.
- The storage area should not be situated in the proximity of fresh food stores or food preparation areas.
- A supply of cleaning equipment, protecting clothing, and waste bags or containers should be located conveniently close to the storage area.

Cytotoxic waste should be stored separately from other health-care waste in a designated secure location. Radioactive waste should be stored in containers that prevent dispersion, behind lead shielding.

2.18.4 Waste Handling

- The color-coded bags should be handled only after they have been secured.
- The neck should carry the bags.
- Porters should wear protective clothing when transporting the bags.
- If external contamination occurs, the soiled bag should be placed inside a clean new bag, which should be tied securely.

2.18.5 Collection of Waste

Nursing and other clinical staff should ensure that waste bags are tightly closed or sealed when they are about three-quarters full. Bags should not be closed by stapling. Sealed sharps containers should be placed in a labeled, yellow infectious health-care waste bag before removal from the hospital ward or department. Wastes should not be allowed to accumulate at the point of production. A routine program for their collection should be established as part of the health-care waste management plan.

Certain recommendation should be followed by the ancillary workers in charge of waste collection:

- Waste should be collected daily (or as frequently as required) and transported to the designated central storage site.
- No bags should be removed unless they are labeled with their point of production (hospital and ward or department) and contents.
- The bags or containers should be replaced immediately with new ones of the same type.

A supply of fresh collection bags or containers should be readily available at all locations where waste is produced.

2.18.6 Transportation of Waste

On-site Transportation

The movement and transportation of waste internally and externally should be considered as part of a comprehensive hospital waste management in all hospital. Internally, waste is usually transported from its initial storage point to an assembly area or on-site incinerator by means of trolleys or handcarts. Such equipment should be cleaned regularly and issued only for waste transport.

Health-care waste should be transported within the hospital or other facility by means of wheeled trolleys, containers, or carts that are not used for any other purpose and meet the following specifications:

- (i) Easy to load and unload; (ii) No sharp edges that could damage waste bags or containers during loading and unloading; (iii) Easy to clean.

The vehicles should be cleaned and disinfected daily with an appropriate disinfectant. All waste bag seals should be in place and intact at the end of transportation.

Off-site Transportation

Waste being transported externally should present no public health risk provided it has been suitably treated, but its physical appearance or the identifiable color coded containers may give rise to object on aesthetic grounds. When hazardous waste is transported, the contents of all containers and their potential hazard should be identified in documents carried in the vehicle. The transport vehicle should have an enclosed leak-proof body and be cleaned after each use and disinfected when necessary (WHO, 1983).

Regulation and Control System

The health-care waste producer is responsible for safe packaging and adequate labelling of waste to be transported off-site and for authorization of its destination. Packaging and labelling should comply with national regulations governing the transport of hazardous wastes.

Labelling

All waste bags or containers should be labelled with basic information on their content and on the waste producer. This information may be written directly on the bag or container or on preprinted labels, securely attached. For health-care waste, the following additional information should be marked on the label includes (i) Waste category; (ii) Date of collection; (iii) Place in hospital where produced (e.g. ward) (iv) Waste destination

Labelling warns operative staff and the general public of the hazardous nature of the waste. The hazards posed by container contents can be quickly identified in case of accident, enabling emergency services to take appropriate action.

Design Criteria of Transporting Vehicles

Waste bags may be placed directly into the transportation vehicle, but it is safer to place them in further containers (e.g. cardboard boxes or wheeled, rigid, lidded plastic or galvanized bins). This has the advantage of reducing the handling of filled waste bags but results in higher disposal costs. These secondary containers should be placed close to the waste source.

Any vehicle used to transport health-care waste should fulfill the following design criteria:

- The body of the vehicle should be a suitable size commensurate with the design of the vehicle, with an internal body height of 2.2 meters.
- There should be a bulk head between the driver's cabin and the vehicle body, which is designed to retain the load if the vehicle is involved in a collision.
- There should be a suitable system for securing the load during transport.
- Empty plastic bags, suitable protective clothing, cleaning equipment, tools, and disinfectant, together with special kits for dealing with liquid spills, should be carried in a separate compartment in the vehicle.
- The internal finish of the vehicle should allow it to be steam-cleaned, and the internal angles should be rounded.
- The vehicle should be marked with the name and address of the waste carrier.
- The international hazard sign should be displayed on the vehicle or container, as well as an emergency telephone number.

Vehicles or containers used for the transportation of healthcare waste should not be used for the transportation of any other material. They should be kept locked at all times, except when loading and unloading. Open-topped skips or containers should never be used for transporting healthcare waste.

Routing of Waste Transporting Vehicles

Healthcare waste should be transported by the quickest possible route, which should be planned before the journey begins. After departure from the waste production point, every effort should be made to avoid further handling. If handling cannot be avoided, it should be pre-arranged and take place in adequately designed and authorized premises. Handling requirements can be specified in the contract established between the waste producer and the carrier.

2.18.7 Treatment and Disposal

The purposes of treatment is to change the biological character of the waste, or at least to significantly reduce its potential for causing damage before it is taken to its final resting place (Ullah, 1999). The change is biological character of healthcare waste disinfects it which reduces the infectious biohazardous properties of the waste (Townend et.al., 2000)

H CW treatment serves the following important functions (Townend et.al., 2000):

- Disinfecting and /or sterilizing infectious materials in the healthcare waste to reduce its microbiological hazard;
- Destroying the sharps in healthcare waste to minimize its physical hazard (and to prevent reuse of disposable syringes in the underground market);
- Rendering healthcare waste unrecognizable and un-offensive; and
- Achieving significant volume reduction.

Disposal is taken to mean the placing of the waste in its final resting place. Solid waste should never be disposed off to water because of the risks of chemical, microbiological and gross pollution. It follows that the only disposal route is to the land. However there are many ways in which solid waste is disposed off to land (Ullah, 1999)

2.29 Methods of Treatment

The two common techniques used to treat hazardous waste are:

- i) Incineration ii) Autoclaving

Other emerging currently available techniques include:

- i) Micro-waving; ii) Hydropulping; iii) Radiation; iv) Compaction; v) Sterilizer/ Shredder Unit; vi) Irradiation; vii) Inertization; viii) Distillation.

2.19.1 Incineration

Incineration is a suitable technology for the treatment of all types of infectious/hazardous wastes. Incineration utilizes combustion to reduce waste materials to noncombustible residue or ash and exhaust gases. This process actually serves as both treatment and

disposal of wastes. The excessive temperatures in the incinerator kill infectious agents, exhaust gases are vented to the atmosphere, and the ash are used for land filling.

Today and perhaps for the next many years incineration will remain the preferred method for the treatment of medical wastes. The advantages of this technology include the following:

- Suitable for all types of medical wastes (including pathological, laboratory, and hazardous waste types);
- Provides substantial reduction in volume and weight;
- Produces a sterile ash/noncombustible residue for disposal;

Air emissions are substantially reduced with the addition of air pollution control equipment to the system. Risks posed by the presence of toxic containment in the treatment residuals are mitigated by further treatment for stabilization.

Incineration is widely recognized as an acceptable means of disposal for infectious wastes, especially as it is difficult to handle sharps and pathological wastes. One can be certain that this technology will not be disallowed as treatment/disposal method.

In large city it is appropriate to use one incinerator to serve a number of health care establishments in the area. Care must be taken to ensure that the method of transport of the wastes to the central facility is safe and reliable. The incineration seldom is the best available technology to treat hospital waste in developing countries. However technological developments are under way to design small-scale incinerator that are suited to the nature of hospital waste. Waste types not to be incinerated are as follows:

(i) Pressurized gas containers; (ii) Large amounts of reactive chemical waste; (iii) Silver salts and photographic or radiographic wastes; (iv) Halogenated plastics such as polyvinyl chloride (PVC); (v) Waste with high mercury or cadmium content, such as broken thermometers, used batteries and lead-lined wooden panels; (vi) Sealed ampoules or ampoules containing heavy metals.

2.19.2 Autoclaving

Autoclaving is conceptually simple and has been proven over many years in the healthcare sector. Its use is increasing world-wide both as a pretreatment system prior to final disposal in the municipal Waste-to-Energy plants and for disposal in highly controlled situations in landfill sites.

Actually autoclaving is an oxidation process. In this case, steam is charged into an infectious waste in pressurized autoclave to kill the bacteria by heat. The sterilized waste from the sterilizer is subject to a testing procedure to determine the number of spores that can be incubated. If acceptable, the waste is then ground and or compacted and disposed off in a landfill. Sterilization and grinding/compaction do not destroy waste. It is eventually disposed off in a landfill. In order to achieve effective and efficient treatment through autoclaving, it is necessary to maximize exposure of the entire waste quantity to the desired temperature for sufficient period of time. The desired temperature is affected primarily by steam penetration, and thus, the degree of steam penetration is the critical factor in achieving the desired effect. Any condition that prevents proper steam penetration to the waste diminishes the effectiveness of a steam sterilization treatment system. In addition, any failure of equipment seals or valves resulting in a steam leak decreases the temperature of the sterilizer chamber and also decreases the effectiveness of the system. In order to ensure the system effectiveness, a steam sterilization process is monitored and all equipment should be routinely inspected. A testing program including periodic placement of biological indicators (spore strips) through the waste load, is the best method of ensuring proper system performance. The United States Pharmacopoeia recommends bacillus stearothermophilus as biological indicator steam sterilization.

2.19.3 Micro-waving

The micro-waving treatment system was developed in Germany and brought to the United States now being proposed for applications in the United States by a division of Combustion Engineering. In this area, waste is irradiated with micro-wave energy to distinct material. The automatically controlled Sanitec Micro-wave Disinfection System starts with refuge charge is electronically determined as part of the hopper-sequence.

Steam conveyed into the filling hopper aids circulation as well as disinfects the crusher chamber. A water mist is injected into the chamber to bind the dust particles. Refuse fall from the hopper into the crushing chamber, and the crushed material flows onto a screw conveyer below. Crushing reduces the material volume by about eight times its original volume. As the material is conveyed, it passes between several banks of microwave coil that are controlled by temperature sensors. The disinfected crushed material is removed from the Sanitec Chamber by another screw conveyer and deposited in refuge container for disposal. Along each processing step, various monitors and controls devices assure safe operation and complete sterilization.

The efficacy of microwave disinfection should be checked routinely by microbiological tests. The microwave process is used in several countries (e.g. USA) and is becoming increasingly popular. However, relatively high costs coupled with potential operation and maintenance problems mean that it is not yet recommended for use in developing countries.

2.19.4 Hydro pulping

Hydro pulping like incineration and autoclaving is also an oxidation technique. This process can be applied to hospital wastes can provide for the complete consolidation of most of the waste by misting the wastes with an agent during the shredding operation. Pulping system has an additional advantage is that they can provide for fluidized transport, as well as reduce the waste volume. A typical hospital installation provides pulping equipment at various locations through out the building or complex, with a central liquid extractor system used to remove moisture from the pulped waste before it is conveyed to the refuge disposal site. In this process it is necessary to segregate all materials that cannot be pulped before they enter the pulping system. This step is done principally to reduce equipment maintenance problem.

2.19.5 Radiation

Radiation of bulk materials and medical applications using radio nuclides has been used for some time. Now biological materials are being subjected to similar treatment. Radiation source, such as cobalt-60, at source strength of 100,000 curies is being considered. The irradiated waste itself has been reported to be non-toxic. The process and its necessary waste itself reported to be controls are to be further investigated by Norton, and in addition, they have commissioned a study by Dr. James Whitby (1990) a number of the University of Western Ontario, to determine what dosage of radioactivity would be required for the sterilization of different types of waste. Dr. Whitby currently estimates that megarads seem reasonable for sterilization of healthcare waste

2.19.6 Compaction

Compaction is a process that typically reduces four to five times' reduction in the waste volume. EPA guidelines discourage the use of compaction alone, although a compactor is a simple device. Large compactors have been used for many years for reducing the volume of infectious and general waste from hospitals. One of the advantages of the compaction is that there is volume reduction (up to 60%) in the size of infected waste but no reduction in weight. The safety of dealing with infectious waste is also improved in the handling of the containers at a landfill or a municipal incinerator. Because the compaction process does not sterilize the material, it is necessary to sterilize the material prior to compaction or to sterilize or incinerate it after compaction. Sending non-sterilized waste off-site for processing is not a good practice and has large potential liability problems.

2.19.7 Sterilizer / Shredder Unit

The most interesting future technique investigated is the sterilizer / shredder unit. Some special benefits of this technique are as follows:

- Potentially lower treatment costs twice than other techniques.
- Sterilization with reliable biological monitoring techniques available.

- Volume reduction and a change in the appearance of the waste possibly making it more acceptable to public scrutiny.
- Acceptable material for landfill or further treatment by incineration.

Shredding of waste before disinfection plus subsequent compacting can reduce the original waste volume by 60-90%.

2.19.8 Irradiation

A treatment system has been developed based on electron beams, which have the ability to destroy micro-organisms and sterilize a wide variety of materials. Electrons from the beam interact with the electrons in the molecular structure of the target material, depositing energy and breaking the chemical bonds of organic compounds and fragmenting microorganisms. While a material is being irradiated, it is never in contact with any radioactive materials, and the electrons used to treat the healthcare waste would not make it radioactive. All types of irradiation systems require extensive shielding to protect the workers.

2.19.9 Inertization

The process of “inertization” involves mixing waste with cement and other substances before disposal in order to minimize the risk of toxic substances contained in the waste migrating into surface water or groundwater. It is especially suitable, for pharmaceuticals and for incineration ashes with a high metal content.

The process is reasonably inexpensive and can be performed using relatively unsophisticated equipment. Other than personnel, the main requirements are a grinder or road roller to crush the pharmaceuticals, a concrete mixture, and supplies of cement, lime, and water. This technology is not applicable for infectious waste.

2.19.10 Destructive distillation

Technology is available in which the waste can be thermally distilled to produce gaseous products that are burned to make steam and to generate electricity. In this process the waste volume is reduced by 90%, and the weight reduced by 75%. Potentially hazardous

materials are chemically converted into clean-burning gases. This procedure has not been yet tried on healthcare waste.

2.19.11 Other Treatment Process

Other hazardous waste may be disposed of as follows:

- Cytotoxic drugs may be burnt or chemically degraded by well-qualified specialists, but should never be diluted and discharged to sewer.

- Radioactive materials may be sent back to the nuclear industry that supplied them. Most radioactive waste from medical establishments has a fairly low level of radioactivity and a short half-life. It may be possible to store such wastes under carefully controlled condition until the level of radioactivity is low so that they may be treated as other waste.

- High-pressure containers should be buried or sent back to their manufacturer but never burnt or processed mechanically.

2.20 Disposal of Healthcare Waste

Disposal is taken to mean the waste in its final resting place. Solid waste should never be disposed of to water because of the risks of chemical, microbiological and gross pollution –*there was a notorious case in eastern USA of syringes and other medical waste that had been illegally dumped at sea being washed up on recreational beaches; not only was the tourist industry badly affected, but sales of fish from that area were also depressed* (WHO, 1994). It follows that the only disposal route is to land. However there are many ways in which solid waste is disposed of to land. Before discussing the methods that may be used, the hazard factors to be considered will be reviewed.

- The most serious hazard is that materials that are designed for disposal in a landfill or dump may not ever reach that place, or may be removed after being placed there. The most obvious items in this category are syringes with needles, medicines, discarded clothing and bedding, and containers. The reintroduction of these items into society results in injury, infection or poisoning.

-Another hazard is that infections are spread by flies, rats or cockroaches that come into contact with infected tissues, dressings bedding.

-There is the possibility of chemical pollution of water sources if chemicals or drugs deposited in significant quantities. The spread of diseases by water by is unlikely if the disposal site is above the water table, unless it is sited directly on fissured rock; the passage of leachate that is contaminated by solid waste through unsaturated un-jointed granular material is likely to remove bacteria and viruses from the leachate.

-The open burning of solid waste causes unpleasant odors and smoke; the smoke is a hazard to traffic in the vicinity and contribute to lung disease.

Municipal landfills in many developing countries mostly fall short of accepted operational standards. The deposited waste is rarely covered with inert material at the end of each day's working, and the operational area is rarely limited to allow good control of operations and a rapid rise of level which helps to control flies. Only in some cases special wastes are deposited where they can be immediately covered with other wastes. Design or accident often practices open burning, and little attempt is made to restrict access by unauthorized scavengers.

The seriousness of the risks posed by reuse of or contact with hazardous hospital waste, suggests that the problem of controlling unauthorized access be of major concern. For this reason the option of disposing of the waste on the actual premises of the hospital is attractive, because it suggests the possibility of close supervision of the disposal area by people who understand the seriousness of the hazards. Burying on the site is feasible only if the hospital premises are big enough, and if the ground is relatively impermeable and if there are no shallow wells in or close to the hospital area. Since sharps are usually the main cause for concern, and make up only a small proportion of the total volume of the waste, it is appropriate to dispose of them in the hospital grounds and send the rest of the waste to the municipal disposal site.

The main problem associated with disposing of hazardous hospital waste on a municipal disposal site is difficult to control and supervision. Cash or threat to allow scavengers access to the waste may tempt drivers and labors involved in transporting the waste to the site. Difficulties are commonly experienced when trying to keep unauthorized people at disposal sites and a considerable force of armed guards may be needed to prevent scavengers from entering a site. For the scavengers access to the waste is essential for their livelihood, so they are not easily discouraged. They usually also seek access to the waste very early in the morning, so a 24-hour guard would be necessary.

The recommendation for a well-run landfill is that hazardous wastes are immediately covered by a meter thickness of ordinary wastes and always placed more than two meters from the edge of the deposited waste. Such a requirement is of little use in many landfills in developing countries because the standards of operation and control are generally so low.

An alternative approach is to use a specially constructed land-filling cell for hazardous hospital waste. The arrangement allows close supervision of the operation, and a 500 mm. thickness of cover is placed over the refuse to isolate it from vermin, and prevent landfill vehicles from disturbing it. However, the use of such a special cell encourages scavengers to concentrate their efforts there, unless the cell is effectively guarded 24 hours a day. The risks of disease transmission are greatly reduced if the hazardous wastes are effectively disinfected before disposal to land.

2.21 Choice of Treatment and Disposal Technologies

Incineration used to be the method of choice for most hazardous health-care wastes and is still widely used. However, recently developed alternative treatment methods are becoming increasingly popular. The choice of treatment system should be made carefully, on the basis of various factors, many of which depend on local conditions (WHO, 1999):

- Disinfection efficiency;
- Health and environmental considerations;
- Volume and mass reduction;
- Occupational health and safety consideration;
- Quantity of wastes for treatment and disposal/capacity of the system;
- Types of waste for treatment and disposal;
- Infrastructure requirements;
- Locally available treatment options and technologies;
- Options available for final disposal;
- Training requirements for operation of the method;
- Operation and maintenance consideration;
- Available space;
- Location and surroundings of the treatment site and disposal facility;
- Investment and operating costs;
- Public acceptability;
- Regulatory requirements.

In choosing a treatment or disposal method for health-care waste, particularly if there is a risk of toxic emissions or other hazardous consequences, the relative risks, as well as the integration in to the overall framework of comprehensive waste strategy, should therefore be carefully evaluated in the light of local circumstances.

2.22 Comparison of Advantages and Disadvantages of Waste Handling/Disposal Techniques

The comparison of advantages and disadvantages of waste handling/disposal techniques are shown in Table 2.10.

Table 2.10 Advantages and Disadvantages of Waste Handling / Disposal Techniques.

System	Advantages	Disadvantages
Incineration	• Suitable for all types of hospital wastes including pathological, laboratory and hazardous waste types. • Provides substantial reduction in volume and weight. Reduce the volume of waste by 90% to 95%. • Produces a sterile ash / non-combustible residue for disposal. • Special packaging is not necessary. • Special preliminary treatments are not necessary. • All hazardous and toxic elements can be destroyed effectively. • Moderate space is sufficient. • Landfill space can be saved. • Transport cost can be reduced. • Erection in the field. • Heat value is conserved • Minimum environmental impact is achieved through the extremely low gaseous and liquid emissions of modern incinerators. • High temperature in the combustion chamber gives guarantee for destroying all hazardous and toxic elements. • Utilization of valuable heat. • Wide ranges of sizes are available. • Wide range of accessories is available. • Service personnel not come in direct contact with waste. • Acceptable emissions standards can be maintained.	• Operation is usually not continuous; a maximum capacity of 10-12 hours per day can achieve, except for large systems. • It may emit unwanted pollutants such as dioxins and furans, acid gases, aerosols, CO and metal particulate if not properly designed and operated. • Investment cost is higher, principally due to the expense of the exhaust gas pacification systems. • Non-combustibles not reduced in volume (Ash, metal).
Autoclaving	• Suitable of sterilizing hazardous waste. • Do not raise public concern. • Minimum spatial requirements.	• Volume of waste can not be reduced. • Decontaminated waste retains the appearance of

System	Advantages	Disadvantages
		the waste following treatment. • Unsuitable for treating recognizable body parts • Landfills may have refused to accept autoclaved waste.
Microwaving	• Reduce volume of waste. • Low operating, processing and simple set up. • Minimum impact on the environment. • Improved public relations. • Complete sterilization of the waste.	• Not suitable for pathological waste. • Potential exposure to volatilized elements during loading, unloading, cleaning and maintenance. • Requires strict monitoring program.
Hydro pulping	• Reduction in volume. • Provide good disinfection. • Substantially changes appearance of waste.	• Adds substantial weight to product for disposal. • Difficult for bio-monitoring. • Chlorine solution discharged to POTW may not be acceptable.
Compaction	• Reduce volume of waste. • Relatively inexpensive.	• Does not reduce weight. • No disinfection. • May not render sharps unusable. • May cause leakage problem. • May cause difficulty in incineration or other treatment.
Sterilization /Grinding	• Low cost. • Good volume reduction. • Substantially changes appearance of waste. • Positive disinfection. • Not difficult to perform bio-monitoring.	• Moderate maintenance required.
Direct Irradiation	• Positive disinfection very reliable for providing good disinfection.	• Not demonstrated for infectious waste treatment. • Permitting expensive and special licenses required. • High capital cost.

System	Advantages	Disadvantages
Sterilization /Compaction	• Positive disinfection. • Good volume reduction. • Low cost. • Results in changes in appearance of waste.	• Extensive monitoring required. • No volume reduction • Difficult to perform bio-monitoring • No weight reduction

Source: Cross et al, 1990

2.23 Technical Specifications of Basic Technologies

2.23.1 Incineration System

Incineration is a high temperature dry oxidation process that reduces organic and combustible waste to inorganic, incombustible matter and results in a very significant reduction of waste volume and weight. This process is usually selected to treat wastes that cannot be recycled, reused, or disposed of in a landfill site. The process flow is illustrated schematically in Figure-2.6.

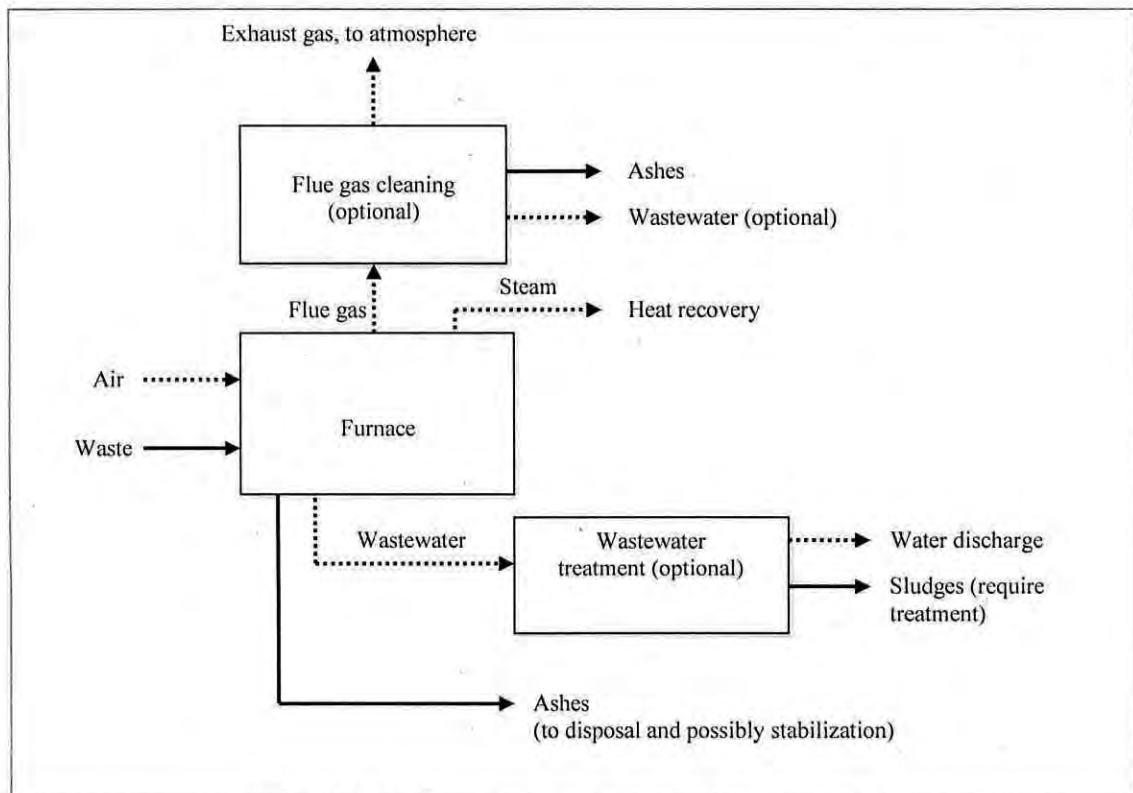


Figure 2.6 Simplified Flow Scheme of Incinerator

The combustion of organic compounds produces mainly gaseous emissions, including steam, carbon dioxide, nitrogen oxides and certain toxic substances (e.g. metals, halogenic acids) and particulate matter plus solid residues in the form of ashes.

A summary of the combustion criteria for the hazardous waste incineration are presented in the Table-2.11.

Table 2.11 Combustion Criteria of Incinerator

Parameter	Design / Performance Criteria
Burnout	≥95%
Combustion Efficiency	≥95%
Primary Chamber Temperature	≥1500° F
Secondary Chamber Temperature	≥1800° F
Secondary Chamber Gas Retention / Residing Time	>1.0 to 2.0 sec

Source: Cross et al, 1990

Healthcare / Medical Waste Incinerator Age Data

The estimated age of existing incinerators, which based on information, is presented in the Table-2.12.

Table 2.12 Available Healthcare / Medical Waste Incinerator Age Data

Medical facilities	Age (years)	
	Range	Average
Hospitals	1-33	14
Laboratories	10-21	16
Veterinary Facilities	3-21	16
Nursing Homes	3-21	13
Commercial Facilities	18-33	24
Other / Unidentified Facilities	7-30	16

Source: Turnberg, 1996

Types of incinerator

The two types of incinerators commonly used for infectious / hazardous waste destruction is:

1. Double-chamber pyrolytic incinerators, which may be especially designed to burn infectious health-care waste;
2. Rotary kilns operating at high temperature, capable of causing decomposition of genotoxic substances and heat resist-chemicals.

Rotary Kiln incinerator

Generally, the rotary kilns are used for very large or regional units. Rotary kiln incinerators consist of a slightly inclined cylinder (kiln) that rotates slowly during the combustion cycle. The rotation mixes the waste and moves it through the incinerator. During the process, the ash drops from the kiln into a conveyor and is transported to a waste collection hopper. Flue gas exits the kiln and enters a secondary chamber that is equipped with an auxiliary fuel burner and temperature control system. The secondary chamber is typically designed for 1-2 seconds of residence at 1200-1600°C. Available capacities of rotary kiln incinerators range from 0.5 to 3 tons/hour.

Pyrolytic incinerator

The most reliable and commonly used treatment process for health-care waste is pyrolytic incineration, also controlled air incineration or double-chamber incineration. The pyrolytic incinerator comprises a pyrolytic chamber and a post combustion chamber and functions as follows:

- In the pyrolytic chamber, the waste is thermally decomposed through an oxygen-deficient, medium-temperature combustion process (800-900°C), producing solid ashes and gases. The pyrolytic chamber includes a fuel burner, used to start the process. The waste is loaded in suitable waste bags or containers.

- The gases produced in this way are burned at high temperature (900-1200°C) by a fuel burner in the post-combustion chamber, using an excess of air to minimize smoke and odors.

Adequately maintained and operated pyrolytic incinerators of limited size, as commonly used in hospitals, do not require exhaust-gas cleaning equipment. Their ashes will contain less than 1% un-burnt material, which can be disposed of in landfills. Other important factors of a pyrolytic incinerator is given below-

- Fuel consumption of pyrolytic incinerators is between 0.03 and 0.08 kg of fuel-oil per kg of waste, or between 0.04 and 0.1m³ of gas fuel per kg of waste.
- Available capacities range from 200kg/day to 10 tons/day.

2.23.2 Microwaving System

A brief description of parameters and performance criteria of different available models of Microwaving system are presented in Table-2.13.

Table 2.13 Parameter and Performance Criteria of Available Models of Microwaving System (Turnberg, 1996)

Parameter	Model-HGA100	Model-HGA 250
Use	Central location in a medium to large medical facility or as a regional treatment center	Central location in a medium to large medical facility or as a regional treatment center
Size (overall)	24 ft long× 10 ft wide× 23 ft 6 in 17 ft high (flap open) or 11 ft high (flap closed)	9 ft 4 in. wide × 23 ft 6 in. long× 17 ft high (flap open) or 10 ft 11 in. high (flap closed)
Weight	18,000 lb.; particlizer adds 5000 lb.	22,000-lb.; particlizer adds 5000 lb.
Electrical requirements	Four generators with a high-frequency output (each) of 1.2 kW and an output frequency of 2450 MHz. 460/480 V ac. 150 A, 60Hz. Three-phase 60 kWh	Six generators with a HF output (each) of 1.2 kW and an output frequency of 2450 MHz. 460/480 V ac. 200 A, 60Hz. Three-phase 75 kWh nominal
Power consumption	60 kWh average	60 kWh average
Water requirements	¾-in NPT (National Pipe Thread) connect; The system uses from 8to 9 gal of water per hr. of steam generation	¾-in NPT (National Pipe Thread) connect; The system uses from 8to 9 gal of water per hr. of steam generation
Drain requirements	No sewer connect is necessary; all water generated from the steam mechanism is recycled and consumed within the unit without generating a liquid discharge.	No sewer connect is necessary; all water generated from the steam mechanism is recycled and consumed within the unit without generating a liquid discharge.
Load capacity	220 to 450 lb./hr Maximum amount treated per hour depends on waste contents (e.g. density, moisture)	550 to 900 lb./hr Maximum amount treated per hour depends on waste contents (e.g. density, moisture)
Total cycle time	Continuous treatment process; however, all waste is subjected to 203° F for a minimum of 30 minutes	Continuous treatment process; however, all waste is subjected to 203° F for a minimum of 30minutes
Treatment temperature	203° F for a minimum of 30 minutes	203° F for a minimum of 30 minutes
Exhaust air requirements	6 in. exhaust louver for air, which is discharged from a HEPA filter	6 in. exhaust louver for air, which is discharged from a HEPA filter
Filter system	24 in. long× 12 in. wide× 11.75 in. deep; 9.9995 percent efficiency at 0.12 micron	24 in. long× 12 in. wide× 11.75 in. deep; 9.9995 percent efficiency at 0.12 micron

2.23.3 Autoclaving System

Various parameter and performance criteria of Autoclaving system are presented in Table-2.14.

Table 2.14 Parameter and Performance Criteria of Available Models of Autoclaving System (Turnberg, 1996)

Parameter	Performance criteria
Use	Suitable for 150to 500 bed hospitals
Size (overall)	Approximately 511 ft ² ; allow a 6 ft all around; minimum ceiling height,16 ft.
Weight	8800 lb.
Electrical requirements	100 kilovolt-amperes (kVA), three phase
Power consumption	Approximately 80 kWh for the entire process; energy consumption is estimated at 0.7 to 1.6 kWh per pound of waste treated
Water requirements	5 gpm at psig
Steam requirements	400 to 30000 lb/day
Load capacity	400 to 2400 lb/ day
Decontamination time	Up to 2 hours
Total cycle time	Shredded waste is exposed to superheated steam (up to 1200°F in the evaporator: vapors formed in the evaporator are heated to about 2100°F in the detoxification reactor)
Exhaust air requirements	25 standard cubic foot/ minute (scfm) at 100 psig
Filter system	Vapors from the detoxification reactor are passed through adsorber beds to remove acid gases. Trace metals and organic

2.24 Review of Related Study

The Environment and Development Associates ('Prodipan') conducted a study, in '2000' in different clinics and hospitals of Khulna city aiming at formulating and demonstrating replicable models for hospital waste management. Results of the study showed that the method of waste disposal was improper and inadequate in most clinics and hospitals. The current practice of waste disposal was to dump all types of wastes in the nearest Khulna City Corporation (KCC) bins or adjacent low-lying areas. Hazardous wastes are openly burnt in some hospitals without any air emission and temperature control. Wastes are collected by the municipal waste-collection service, and are transported for final disposal

with municipal wastes. Most wastes were disposed of in municipal waste dumps and with municipal solid wastes. The knowledge of the hospital staff on the dangerous consequences of improper handling and disposal of hazardous wastes was very low. Many hospital staff had only a basic understanding of healthcare, and did not perceive handling or disposal of medical wastes as a hazard at all. The hospital staff, professionals and general people were not aware of the hazards of hospital wastes. Wastes were segregated at any hospitals. The medical staffs were not either informed on the need of segregation or apathetic to the consequences of not segregating various types of wastes. As a result, mixing of wastes led to contamination of potentially-recyclable components of general wastes and high risk of occupational exposure of workers. There was no trained staff in any hospital in Khulna city for waste handling and disposal. Most of the people in management were not concerned with the disposal system, and they believe that placing of wastes in the municipal bins or discharging it into the drains is enough. There was no environmental awareness program in any hospital in the Khulna city.

ICDDR(2001) in its Working Paper No. 144 describes the status of management and handling of healthcare wastes in Bangladesh and in the global contexts. The purpose of this study was:

- (a) To provide information on the hazards and practices of management of healthcare wastes for formulating policies, enacting legislation, and developing technical guidelines.
- (b) To identify the waste management practices and technologies those are safe, efficient, sustainable, economic, and culturally acceptable.
- (c) To enable the personnel associated with health care waste management to identify the systems suitable for their particular circumstances.
- (d) To raise awareness among those personnel who are involved in healthcare waste management about public health and environmental hazards those are associated with improper management of healthcare wastes.
- (e) To enable administrators of healthcare establishments to develop appropriate waste management plans.

The study documented the health-care waste management practices in Africa, South-east Asia, Europe, Latin America and Bangladesh. The study finds that there is a lack of

waste-management system in both government and non-government healthcare facilities. This improper and inadequate waste management system causes detrimental consequence to public health, environmental quality, and sustainability to the eco system. The hazardous waste when inappropriately managed may compromise the quality of patient care. Additionally, the wastes present occupational health risks to those who generate, handle, package, store, transport, treat, and dispose of them. These wastes may enhance environmental pollution and the spread of infectious disease, including acquired immunodeficiency syndrome (AIDS), hepatitis, tuberculosis, diphtheria, cholera, and many others. The necessity of a national program for clinical waste management was identified in the study. For this a seven-step action plan for development of a national program was recommended too.

The 'Bangladesh Centre for Advanced Studies' (BCAS) conducted a study, in 1998, clinics and hospitals in Dhaka city, Savar, and Narayanganj. It was observed that most hospitals in Dhaka city were situated in the residential area. The average distance of the hospitals from the nearest municipal dustbin was within 100 feet. The waste generated inside the hospitals was collected without any separation and by untrained, unprotected and unaware cleaners. None of those hospitals practiced proper separation or disposal. Many hospitals sold the empty saline bags, bottles, syringes, and other materials for recycling purposes. A training workshop was organized for the health professionals, health workers, and staff to raise awareness and to educate them about the hazards of medical wastes. After the training, an immediate change in waste management, such as separation of wastes at the point of generation (disposing wastes in properly-sealed colored bags, safe disposal of infected sharps) was observed. Unfortunately, the change was not sustained for a longer period. The reasons could be lack of facilities to carry the wastes, lack of proper guidelines, lack of practical laws for safe disposal of clinical wastes as well as its proper implementation, and lack of a treatment facility for medical wastes. Consensus among the private clinics owners and the policy-makers of the government and non-governmental organizations is also lacking which is crucial for healthy environment in the healthcare establishments.

The book 'Safe management of wastes from health-care activities (1999)' by WHO describes about the health risks that result from inadequate management of health-care waste and ways to minimize this risk. This hand book recommends safe, efficient, sustainable, and—it is hoped—affordable and culturally acceptable methods for the treatment and disposal of health-care waste, both within and outside health-care establishments. Particular attention is paid to basic processes and technologies; more sophisticated or advanced methods, many of which have been undergoing major developments, are often addressed in less detail. Methods of waste management for smaller health-care establishments in remote locations or with very limited resources are also recommended in this book. It may work as a basis for policy making in both national level and in individual medical institutions to improve health-care waste management.

A study conducted by NIPSOM (1994) reported by Khan (1994) in two THC near Dhaka in 1992, it has been observed that most of the time (64%) the wastes generated in those two THC was not disposed improper way. In a comparative study, done by NIPSOM in a Medical College Hospital and in a THC in the same year it has been observed that in Medical College Hospital the wastes were disposed more frequently than that of THC. In both the studies it has been observed that the wastes were disposed by dumping without being sorting. The hazardous and infectious wastes were not being treated before disposal.

The study conducted by Basel Action Network and Health Care without Harm (BAN & HCWH) entitled 'Clinical Waste in Developing Countries (1999)' emphasizes mainly on three things, an overview of clinical waste in context of developing countries, a case study of India and critique of the Basel Convention's TWG Draft Technical guidelines on the Environmentally Sound management of Bio-clinical and Healthcare Waste. In the overview section, the concept of clinical waste, risks associated with improper management of clinical waste and the problems encountered by incineration as a process of waste management has been discussed elaborately. In the second section, the present waste management practice in India has been documented briefly; it includes the rules and regulations present there in context of clinical waste management, the agencies

involved in waste management and the role of government. This section also recommends necessary actions for clinical waste management in developing countries. The third and the last section of the study presented the section by section critique of the Basel Convention's TWG Draft Technical guidelines on the environmentally sound management of Bio-clinical and Healthcare Waste.

Appleton and Ali (2000) in their study 'Risks from Healthcare Waste to the poor (2000)' reviews and documents key issues in the management and disposal of healthcare wastes in relation to the urban poor. This was done firstly through a review of the current literature and secondly by undertaking two short field studies in Pakistan and Bangladesh to identify good practice. The issues addressed in this study include-

- (a) Why healthcare waste is hazardous and what risks it poses.
- (b) Why the urban poor are considered to be most at risk from healthcare waste.
- (c) Ways in which these risks can be reduced.
- (d) What can be learnt from examples of good practice in South Asia.

The study findings show that the urban poor are potentially at greatest risk: firstly, their living environment suffers as a result of locally poor waste management and secondly, many people are forced to work with waste to provide a livelihood. The dilemma is that any improvements to healthcare waste management that involve reducing access to waste, so improving the environment, may have negative effects on the livelihoods of the poor. It is believed that the highest risk groups are those involved informally in reclaiming and recovering used healthcare waste material. This includes waste pickers who collect the recyclable portion of the waste and itinerant waste buyers who purchase the recyclable element of the waste that has been collected by the waste pickers in order to sell it on to recycling establishments. Awareness of the risks is generally low.

Three broad approaches were recommended to mitigating the risks:

1. Actions which reduce the actual hazards arising from the nature of the waste, such as source separation and waste treatment;

2. Direct and indirect actions which reduce the contact between people and the hazardous waste, for example through improved containment and use of protective equipment; and
3. Measures which directly protect the population, such as immunization.

Jackson et al. (1986) in their "Issues and options for the safe destruction and disposal of used injection materials" showed from their study in the developing countries that contaminated medical wastes find their way into municipal garbage poses obvious health risks, both in terms of direct exposure and environmental contamination. Their study suggests that holistic approaches to syringe use and clinical waste disposal need to be utilized in addressing the situation outlined.

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Pruss et.al. (2004) reported on "Clean Dhaka Master Plan" conducting by the 'Japan International Cooperation Agency' (JICA) explaining about the management pattern of Survey Report on HMW in Dhaka City. JICA focused the problems of handling and mismanagement of existing system of solid waste transportation and dumping. In addition, they formulated a master plan regarding the solid waste management in Dhaka city with the target year of 2015 covering-

- (a) Collection, transportation, disposal and final disposal of solid wastes;
- (b) Administration organization, institutional building, and public participation; and
- (c) Planning of facility and material maintenance, maintenance management, and the WHO (2002) mainly focused on six different steps for the development of a healthcare waste management plan:
 - (a) Designate a responsible person;
 - (b) Conduct a health care waste management (HCWM) survey and invite suggestions;
 - (c) Recommended HCWM improvements and prepare a set of arrangements for their implementation;
 - (d) Draft the HCWM plan;
 - (e) Approve the HCWM plan and start implementation; and

(f) Review the HCWM plan

The study entitled 'Medical Waste Management: A Review (2000)' of Akter (2000) has three objectives:

- (a) To understand the various handling and disposal procedures of clinical waste in different countries
- (b) The knowledge and awareness of individuals involved in medical waste generation, handling and disposal, and
- (c) The potential impacts of the waste stream on both human health and natural environment.

The study found that there were a variety of methods used by the medical facilities which dispose their wastes including burning, burial, entombing, selling, dumping and removed by municipal bins, which is quite unsafe and it was also found that both clinical and non-clinical wastes were thrown together. The study identified insufficient awareness of magnitude of the medical wastes and severe contamination of infectious wastes to the environment in laboratory analysis. The major health risks of medical waste were identified in the study.

The study entitled 'Scenario of Hospital Waste Management in Bangladesh' conducted by Akter (2002) investigated the waste management system of four government hospitals (2500 beds), one private hospital, two private clinics (around 600 beds) and two diagnostic centers of Dhaka city. These covered 49% of total hospital beds in Dhaka. The study findings showed that a satisfactory clinical waste management system is severely lacking in Bangladesh. At present there have no rigorous laws and regulations in this field. It was found that the waste was dumped together in a public place such as hospital surroundings, the road side or City Corporation dustbin. Some staff members of the hospitals surveyed were suffering from various kinds of infectious diseases such as viral hepatitis B/C, typhoid, skin disease, diarrhea, dysentery, tuberculosis and malaria. The study also discovered that improved that improved hospital waste management system

has only recently been introduced in a small number of private hospitals and clinics in Dhaka.

Enayetullah and Sinha (2001) reported on 'Bangladesh Legal Aid Services Trust' (BLAST) which conducted a study in 1999, in three health care establishments, namely Sir Salimullah Medical College Hospital, Holy Family Hospital and Bangabandhu Sheikh Mujib Medical University, to assess the consequences due to current status of healthcare waste-management systems. It has been found that there was no national plan for sound disposal of healthcare wastes. There was no local or national authority to look after waste management. There was also no national law for proper management of healthcare wastes.

Nurunnabi (1997) reported on Initiative for People's Development (IPD) which conducted a project on the "Medical Waste Management Action Plan in Dhaka City" started on 2000 funded by the UNDP through the Project Management Unit (PMU). The IPD surveyed 24 clinics through a questionnaire method. They provided training for awareness campaigning. They developed handouts regarding the waste and its management for the nurses, waste handlers and ward boys and so on. The project lasted for about eight months and finished in 2001.

Mirza et al. (1996) conducted a study that there was insufficient awareness of the magnitude of the medical waste issue at all levels. There had been no formal/informal training of staff on how to dispose of healthcare wastes. Medical officers were generally aware that medical wastes could pose a problem, but most thought they were handling the situation sufficiently. Some of them (38.1%) mentioned that they had not received any training on how to handle medical wastes. Few of them mentioned that they had academic training on nursing or public health but not specifically on medical waste issues. Nurses, laboratory technicians and cleaners had no training on handling procedures and disposal methods.

Damodar et al. (1980) conducted a research at St. Anthony's Hospital in St. Petersburg, Fla. and reported that on-site incineration of the entire hospital waste load with

appropriate air pollution controls is the best available means of processing prior to disposal. The rendering of all waste to an innocuous state by incineration before it leaves the site is considered the most environmentally acceptable system and can result in considerable economic savings as well.

Rahman and Ali (2000) reported that use of incineration or any alternative methods for safe disposal of waste was almost absent in hospitals in Bangladesh. There were only a few hospitals and clinics, which had on-site waste management system such as burning, burial, autoclave, waste segregation.

Alamgir et.al. (2003) in his work entitled 'Management of Clinical Waste in Khulna City (2003)' reported the treatment system of 44 hospital / clinic / healthcare establishment of Khulna city. He stated that the wastes were separated by the users at the source in different categories such as needle and sharp parts, reusable wastes, surgical wastes and food and vegetables wastes by depositing them separately in four bins marked in different colors. Food and vegetables wastes were dumped with other municipal solid wastes in the same site of KCC. Re-usable wastes were shredded and stored for recycling after proper cleaning; needle and sharp wastes are encapsulated in a 7 ft. deep concrete chamber. Remaining general medical wastes are burned in a locally made burning unit and the residues were then dumped in a nearby pit

Khandker (1999) in his work entitled 'Clinical Waste Management in Khulna City (1999)' had tried to identify the clinical waste management system in Khulna and its health hazards. Waste was categorized in two types in the study, composite waste and disposable syringes. It was estimated that the average daily clinical waste generated from each of the 248 health centers in Khulna city was about 6 kg. So the total waste generated in Khulna city was about 1488 kg per day. There was no separate healthcare waste management system for the city; waste was collected and disposed with other solid wastes. About 30-40 disposable syringes were thrown away from each of the facilities. The total number of disposed syringes and needles were about 8680 per day. It was estimated that 10% of those syringes were collected by hospital staffs or 'Tokais' for re-use. These syringes and needles are dangerous for health because of contagious germs. It

is highly responsible for injury related HIV and other diseases. Awareness regarding the health hazard associated with healthcare waste was lacking in general people as well as related health professionals and conservancy workers.

The study (Kaisar et.al., 2006) encompasses on an in-depth analysis of the present condition of waste management system of selected Health Care Centers (HCCs) in SCC (Sylhet City Corporation) and an assessment has been performed for the improvement of hospital sanitation situation. It is observed that the average waste generation rate for hospital and clinics is 0.93 kg/bed/day and the hazardous waste was 0.21 kg/bed/day. The proportion of non-hazardous and hazardous waste is about 77% and 23% respectively.

Haque, (2008) conducted a study in different hospitals of Chandpur municipality to assess the existing waste management and also to assess different technological options for improvement of the present situation. It has been found that the rate of waste generation was about 1.04 kg/bed/day and the hazardous waste was 0.17 kg/bed/day. The proportion of non-hazardous and hazardous waste is 84% and 16% respectively. The contribution of infectious, sharps and pathological wastes was about 9%, 3.25% and 3.75% respectively.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The methodology for this study includes selection of study area, field data collection, location and category of hospitals with a view to obtain the representative figures to assess the different technological options for improved healthcare waste management.

3.2 Selection of the Study Area

The study area was selected with a view to determine the type (infectious and non-infectious nature) and rate of healthcare wastes, number of beds and ownership of the hospitals i.e. public ownership, private ownership, standard of health facilities with specialization in different branch. The purpose of such selection was to obtain a representative feature of existing healthcare waste management status of Khulna municipality. The names of the selected HCEs are shown in Table-3.1.

Table 3.1 List of Health Care Establishments Surveyed

SL. No.	Health Care Establishments	No. of bed	Category
1	Khulna Medical College Hospital(KMCH)	500	Government
2	Khulna General Hospital(KGH)	150	Government
3	Mother and Child Care Center(MCCC)	10	Government
4	Khulna Sishu Hospital(KSH)	100	Private
5	Garib Newaz Clinic and Diagnostic Center(GNCDC)	50	Private
6	Islami Bank Hospital(IBH)	40	Private
7	Dabs Clinic(DC)	30	Private
8	Khalishpur Clinic(KC)	25	Private
9	Fair Health Clinic(FHC)	15	Private
10	Decent Dental Clinic(DDC)	--	Dental clinic
11	Mahanagar Diagnostic Centre(MDC)	--	Diagnostic centre
12	Setu Diagnostic Centre(SDC)	--	Diagnostic centre

3.3 Location of the Study Area

Khulna is the third largest metropolitan city of Bangladesh, stands on the bank of the Rupsha and the Bhairab rivers. It is in the south western part of the country with its location at 22°48" to 22°54" north latitude and 89°31" to 89°34" east longitudes

(Microsoft Encarta Reference Library, 2007). It is the administrative headquarters for Khulna district and division and the regional center for higher education. Historically it also served as the center for jute and paper industries, as the main shipping center and transit point for the western half of Bangladesh.

3.4 Area and Demographic Characteristics

In the 12th December of 1884, Khulna Pourashava was established with an area of 11.89 sq. km. later in 1984, it was upgraded to a City Corporation. Khulna city experienced tenuous population growth accompanied by periodic changes to its jurisdiction and service population. According to 1974 census, KCC administrated an area of about 38.52 sq. km. with 0.467 million population. In 1991 this increased to 45.47 sq. km. with 31 wards having 0.638 million population (Report on Urban Areas, 1997). In the year 2001 the area increased to 45.65 sq. km. at the same time, population increased to 0.73 million (BBS, 2001).

3.5 Definition of Healthcare Establishments

The health care establishments that generate wastes generally include hospitals and their departments, clinics, pathological centers and laboratories and support services. In this study the government, autonomous and private hospitals or clinics those are generating a considerable amount of hospital waste daily have been considered as health care establishments. Though there are about 230 nos. EPI (Out Reach and Fixed Center), centers, 21 nos. Family Planning center, 6 nos. Maternity Clinic and 39 nos. OPD in the Khulna City Corporation area but they have not been considered as health care establishments in this study, as those are not providing with hospital beds neither generating formidable amount of wastes.

3.6 Definition of Healthcare Waste

In this study, healthcare wastes have been defined as all types of waste generated from a health care establishment, whether it is infectious or non-infectious in nature.

3.7 Classification of Wastes

In this study, the healthcare wastes have been classified into four categories on the basis of their composition and potential hazards. Though WHO (1999) classified healthcare wastes in nine categories (infectious, pathological, sharps, pharmaceutical, genotoxic, chemical waste, waste with high content of heavy metals, pressurized containers and radioactive waste), but it is extremely difficult to conduct such survey in the context of the Khulna city hospitals. For this study, the infectious waste, sharps and plastic type wastes have been termed as 'hazardous waste'. And general wastes have been termed as 'non-hazardous waste' (Ullah, 1999).

The four categories are-

1. General waste:

it includes kitchen waste, foods, paper, foil, packet of medicine, etc.

2. Hazardous waste

- a) Infectious waste: it includes gauge, bandage, human organ, blood, tissue and other body fluids, etc.
- b) Sharps: needles, broken and unbroken glass, blade and all other sharp type materials.
- c) Plastic type waste: saline bags, syringes, tubes, ampoule, vial, etc.

The wastes like radioactive waste, pressurized containers, heavy metals, genotoxic wastes are either not found or produced in a very insignificant amount in health care establishments of the study area and they have been excluded from the study. The pharmaceutical wastes that generate from drugs, chemicals, have been included with the infectious waste.

3.8 Existing Healthcare Facilities of KCC

Existing health facilities in Khulna city is given Table-3.2.

Table 3.2 Different Types of Existing Health Care Facilities in Khulna City.

Type of facilities		Number of facilities
Government hospital / clinic		10
Private hospital / clinic		69
Family planning center		21
Diagnostic center and dental clinic		31
EPI center	Out reach center	168
	Fixed center	63
OPD (Out Patient Department)		39
Maternity clinic		6
Total		407

Source: Field survey '07 and UCHP (Urban Community Health Programme)

3.9 Preliminary Field Investigation

Preliminary information about the study area was attained by field investigation. During the period, primary field investigation were maintained carefully requiring the aim, scope and objective of the study. Infrastructure of the HCEs, dustbin condition and facilities, municipal dustbin condition, drainage system, building arraying etc. were observed at a glance to make an idea about the study area.

3.10 Questionnaire Preparation

Questionnaires were prepared by studying previous researches (Chaudhary, 2004) on this topic and covered all basic requirements needed for healthcare waste management. The questionnaire was prepared with a list of questions that were simple and easy to understand for the respondent, comparatively short in size, uncontroversial, less technical terms and vague and in a logical sequence to test applicability of them in the study area. It is noted that four sets of questionnaire (Appendix-I) was prepared for different categories of respondents (viz. patients, cleaners, nurse, technician, doctors administrative officers and waste management authorities)

3.11 Survey Design

A field survey was carried out to analyze the existing situation of healthcare waste in terms of rate of generation, handling, treatment, storage and disposal in Khulna city. The survey was designed in such a way that it covered all possible sectors involving healthcare waste management.

3.12 Field Survey and Data Collection

3.12.1 Primary Data Collection

Primary data were collected from both government and private HCEs

Data Collection from Government HCEs

Since there was no systematic management of healthcare waste in the government hospital of the study area, the collected wastes were separated following the above classification (Stated in page No.-70) and weighted at the ward. Balance, bucket, hard paper box, bowls and polythene bags were used as tools for collection and weighting. General wastes were collected in bucket, infectious and pathological wastes were collected in polythene bags and sharp wastes were collected in hard paper box. This sample weighing system was done eight times (at once per day) in each HCEs (15th July-15th August/ 2007) that gives the waste generation rate.

Data Collection from Private HCEs

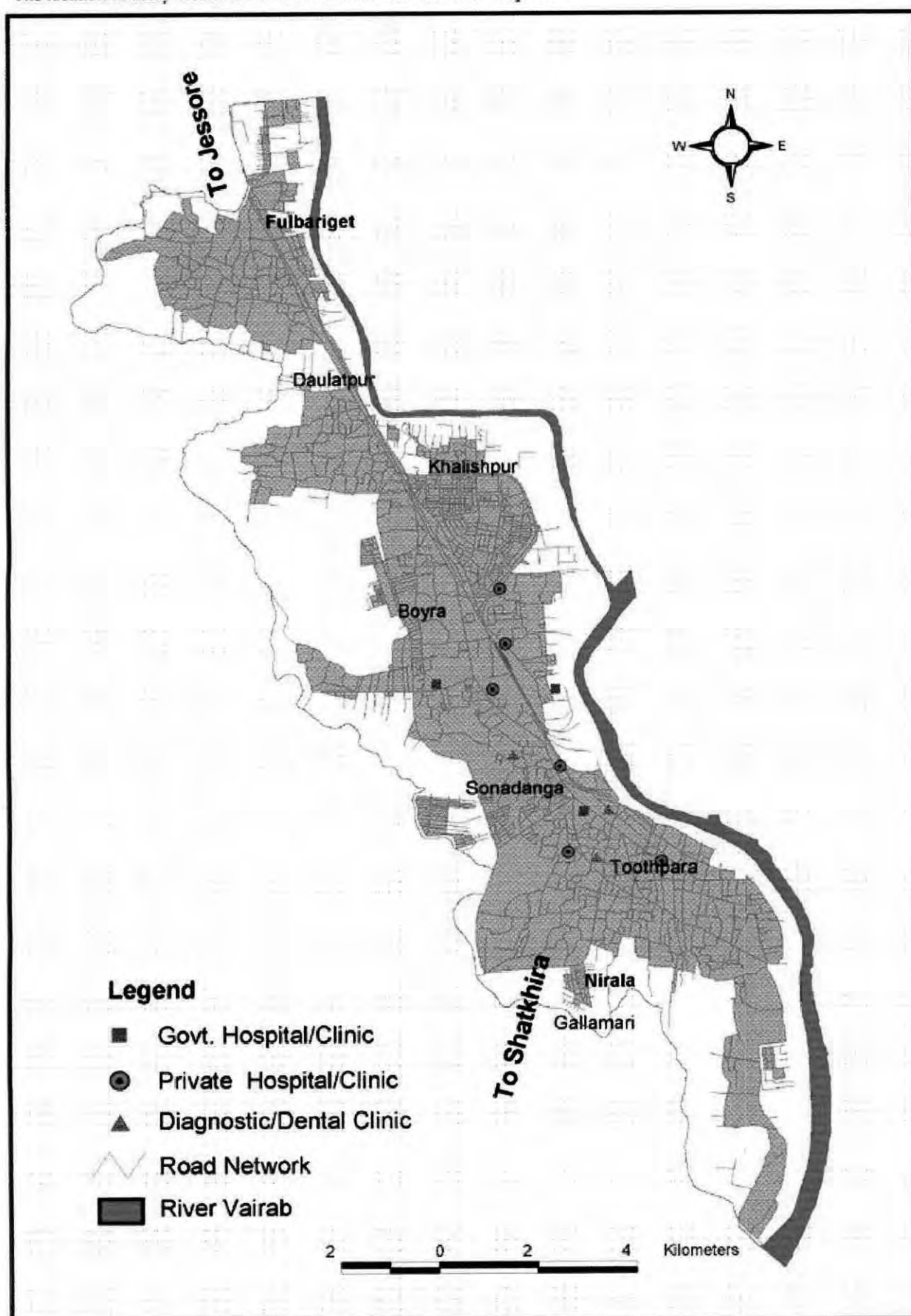
PRODIPAN, an NGO, has been working under the “Hospital Waste Management Project” at the studied HCEs since May 2000, financially supported by Swiss Development Corporation (SDC), UNDP and World Bank. Consequently systematic healthcare waste management was being implemented and the above classification (Stated in page No.-70) was properly followed. So wastes were weighted instantly while PRODIPAN was collecting the wastes. The readings of the generated wastes were reported according to its classification at once per day.

3.12.2 Secondary Data Collection

Secondary data were collected from various government and private organizations like KCC, PRODIPAN, UCHP etc. and different workers, official personnel and some publications, journals, and different web site's report. Secondary data also collected to focus the present healthcare waste management status in Khulna city.

3.13 Location of Study Hospitals/Clinics

The location of study Health Care Establishments are shown in Map-3.1.



Map 3.1 KCC Area Map Showing Location of Different Study Hospitals/Clinics

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

To achieve the objective of the study as outlined in chapter-1, the information and data obtained from physical survey, secondary sources have been accumulated and analyzed.

The findings of the study are presented in four sections of this chapter. The first section deals with generation of healthcare waste in different Health Care Establishments (HCEs). The second section deals with involvement of different institutional arrangement for healthcare waste management in Khulna city. The third section deals with present practice of healthcare waste management in Khulna city. The level of knowledge and awareness of individuals involved in the hospital premises also reviewed. Last section deals with different technological options and their applicability in order to improve the existing waste management status in Khulna city.

4.2 Healthcare Facilities

Khulna is the third largest city of Bangladesh. At the same time it is experiencing a rapid growth rate of population, which is 1.96 in the Khulna Statistical Metropolitan area (BBS, 2001). To meet the demand of this growing population, the number of health centers, particularly in private sector is also growing fast.

Table 4.1 Healthcare Establishments in Khulna City

Type of HCEs	Size	Total		Surveyed		
		No. of HCEs	No. of beds (approximate)	No. of HCEs	No. of beds	Percentage of beds
Govt. Hospital	Above 100 beds	2	650	2	650	100
	50-100 beds	1	50	0	0	0
	Below 50 beds	7	110	1	10	9.09
	Total	10	810	3	660	81.48
Private clinics/Hospital	Above 100 beds	0	0	0	0	0
	50-100 beds	3	250	2	150	60
	Below 50 beds	66	990	4	110	11.11
	Total	69	1240	6	260	20.96
Diagnostic centers and Dental clinics	--	31	--	3	--	--
Grand Total	--	110	2050	12	920	44.87

Source: Field survey, 2007

Table-4.1 shows that, at present there are 110 registered HCEs in Khulna city. Among them 69 are private hospitals which are 63% of the total number of health centers. These private hospitals have a capacity of 1240 beds. Only three of these hospitals have more than 50 beds and the rest have a capacity of about 15 beds on average. On the other hand, 10 Government hospitals have a total capacity of 810 beds. Among them one has 500 beds, one has 150 beds, one has 50 beds, four has 20 beds and the rest three have 10 beds in each. There are 21 diagnostic centers and 10 dental clinics in the city. The above table also shows that, in total there are 2050 bed in different health centers of the city and about 45% of them has been included in the survey. However, it is apparent from 'Prodipan (2007)' that the total number of HCEs in Khulna city is more than 153 nos. that include both registered and non-registered.

4.3 Generation of Healthcare Waste

The generations of total healthcare waste (hazardous and non-hazardous) for different Health Care Establishments (HCEs) of Khulna City are shown in Table-4.2.

Table 4.2 Generation Rate of Healthcare Waste in the Study Area

No	Hospital/ clinic/ Diagnostic Center	Total generated waste(kg)/bed/ day or DC/day (for Diagnostic/ Dental Clinic)	Mean kg/be d /day	Std. Devia tion	Haz. Waste (kg)/bed /day or DC/day (for Diagnostic/ Dental Clinic)	Mean kg/bed /day	Std. Devia tion	% Haza rdous	% Gene ral waste
1	KMCH	0.90	0.85	0.025	0.18	0.15	0.014	20	80
2	KGH	0.87			0.15			17.5	82.5
3	MCCC	0.85			0.16			19	81
4	KSH	0.82			0.15			19	81
5	GNCD	0.83			0.16			19	81
6	IBH	0.85			0.14			16	84
7	DBC	0.82			0.13			16	84
8	KC	0.86			0.16			18	82
9	FHC	0.84			0.14			16	84
10	DDC	2.76	4.35	1.513	0.55	1.37	0.737	20	80
11	MDC	5.77			1.98			34	66
12	SDC	4.54			1.58			35	65

Source: Field survey, 2007

DC: Diagnostic Centre/ Dental Clinic

Table-4.2 shows that, the waste generation rate is little higher in the government hospitals (0.87 kg/bed/day) than the private once (0.84 kg/bed/day). Though the waste generation per bed per day does not fluctuate much among different health centers,

which is evident from the low value of standard deviation. The average waste generation per bed per day in Khulna city has been found 0.85 kg, which is less than the healthcare waste generation rates of 4.5 kg in U.S.A, 2.7 kg in Netherlands and 2.5 kg in France. The lower rate of waste generation is mainly depends upon geographical location, living standard, waste collection facilities. In Latin American countries like Chile, Brazil, Argentina, Venezuela etc. this figure vary from 1-4.5 kg/bed/day (Monreal, 1991). Thus it may be mentioned that the waste generation rate of Khulna city are nearly close to the figure of developing countries of Latin America. However this figure is very close to the generation rate of 1.04 kg/bed/day in Chandpur municipality (Haque, 2008) and also close to that of Sylhet city where the waste generation rate is 0.93 kg/bed/day (Kaisar et.al., 2006) The healthcare waste fractions of Khulna City are shown in Figure-4.1.

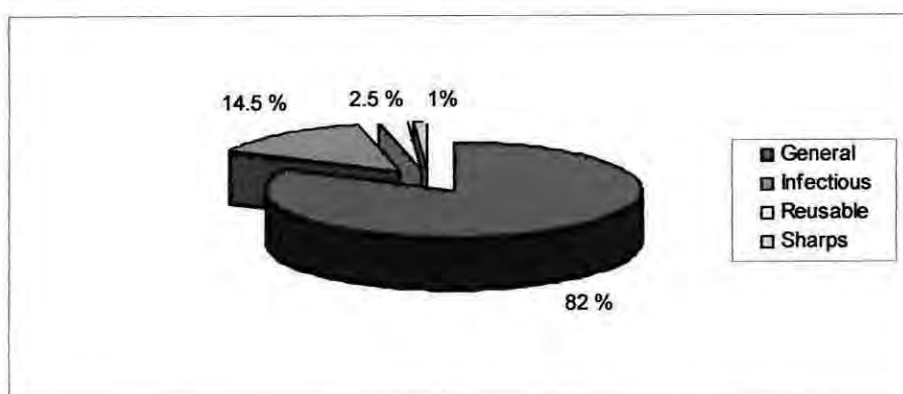


Figure 4.1 Healthcare Waste Fraction of Khulna City

Table 4.3 Total Amount of Healthcare Wastes Generated in Khulna city*

Type of health center	General waste (kg/day)	Infectious waste (kg/day)	Plastic type /Reusable waste (kg/day)	Sharp waste (kg/day)	Grand Total (Kg/day)
Govt. Hospital	573	102	20	11	706
Private Hospital	860	151	21	10	1042
Diagnostic center	93	20	10	12	135
Total	1526	273	51	33	1883
*this includes total wastes only from 110 registered HCEs and excludes total wastes generated from more than 43 non-registered HCEs					

Source: Field survey, 2007

Table-4.3 shows that, about 1883 kg of healthcare wastes are generated daily from 110 registered HCEs in Khulna city. Most of them are generated in private hospitals (55%) as

In total about 273 kg of infectious wastes are daily generated in Khulna city; most of them are produced by the private (55%) and government hospitals (37%). About 42% of plastic type or reusable waste and 30% of sharps are daily disposed by the private clinics and hospitals. On the other hand the Government hospital generates 34% of the sharps and 39% of plastic type or reusable waste of Khulna city. These large amounts of unorthodox wastes deserve extra attention.

The importance or necessity for the proper management of healthcare waste can be sensed from the above table which shows that, about 130 metric tons of hazardous wastes are generated in Khulna city each year. Among them more than 51% are produced by the private hospitals, 37% by the Government hospitals and the rest 12% by the diagnostic centers. This ever increasing amount of hazardous waste, if not managed properly will cause severe health hazards and environmental problems.

4.4 Generation of Hazardous Healthcare Waste

The rate of generation of hazardous wastes from hospitals in Khulna City has been found 0.15 kg, i.e. 18% of total hospital waste as shown in Table-4.2 which are nearly close to the hazardous waste generation rates of 0.17 kg/bed/day in Chandpur municipality (Haque 2008; Ullah, 1999) and 0.21 kg/bed/day in Sylhet City (Kaisar et. al., 2006). On the other hand the generation rate of hazardous wastes of different countries are found 5% in Netherlands, 7% in Sweden, 9% in Germany, 14% in Denmark, 25% in U.S.A. and 28% in Italy. This may happened that, different countries showing widely varying percentage of generation rates depends upon the definition of hazardous wastes, category and types of hospitals, legislation and operational practices etc.

Generation rate of hazardous waste of study hospitals per bed per day are shown in Figure- 4.2.

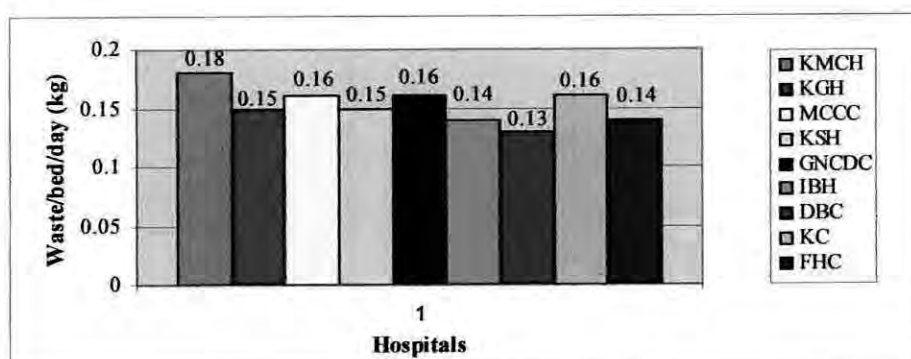


Figure 4.2 Generation of Hazardous Healthcare Waste (Field Survey, 2007)

4.5 Comparison of Hazardous Waste Generation in the Surveyed HCEs

The quantities of different categories of waste generated by the hospitals have been estimated based on the data from a one month duration survey at different hospitals of Khulna city. It has been found that per bed per day waste generation vary slightly from hospital to hospital as shown in Appendix-A. It has been found in analysis that the quantity of waste generated per bed per day was slightly higher in Government hospitals. For example, In DBC, the generation of hazardous waste was 0.13 kg / bed / day out of total waste generation of 0.82 kg / bed / day, where as in KMCH the generation of hazardous waste was 0.18 kg / bed / day out of total waste generation of 0.90 kg / bed /

day. This is mainly due to the different types of service available and high occupancy rate by patients in government hospital. As health care facility costs less in public hospitals than private clinics, general people prefer to go public hospital. For this reason, the waste generation rate in public hospital is greater than the private hospitals.

But the figure is exceptional for KC and GNCDc where the generation rate has been found 0.16 kg / bed / day. This variation is due to the reason that for improved treatment facilities; better customer services- the rich classes of patient are taking the opportunity of improved treatment from such health care facilities.

Table 4.4 Different Categories of Healthcare Waste (% by weight) in Study Area

HCEs	General	Infectious	Reusable	Sharps
KMCH	80.00	17.00	1.90	1.1
KGH	82.00	14.00	2.68	1.3
MCCC	81.00	13.00	4.38	1.4
KSH	81.00	15.00	2.28	1.3
GNCDc	81.00	16.00	1.90	1.2
IBH	84.00	14.00	1.44	0.7
DBC	84.00	14.00	1.68	0.5
KC	82.00	15.00	2.41	1.1
FHC	84.00	12.00	3.30	0.89
% of Haz. and Non-hazardous waste	82 %	14.5 %	2.5 %	1%

Source: Field survey, 2007

Table-4.4 shows that about 82% waste generated is non-hazardous waste and the rest 18% is hazardous waste. Among the hazardous waste, 14.5% is infectious, 2.5% is reusable and 1% is sharp wastes.

4.6 Institutional Arrangements for Healthcare Waste Management in Khulna city

At the local level, public organization (KCC) and private organization (an NGO) are working for the management of healthcare waste in Khulna City Corporation.

4.6.1 Public Organization Involved in Healthcare Waste Management

Khulna City Corporation and is the responsible authority for the removal, collection and disposal of all types of waste. According to section 75(1) of the Khulna Municipal Corporation Ordinance 1984, "The Corporation shall make adequate arrangements for the removal of refuse from all public streets, public latrines, urinals, drains and all buildings and land vested in the corporation and for the collection and proper disposal of such refuse". Nothing has been said in the ordinance about the clinical waste management separately. This is the reason why the health centers dispose their hazardous wastes in public dustbins with other wastes. Khulna City Corporation (KCC) is the public body for the management of wastes in Khulna city. KCC does not have any special arrangement for the collection and disposal of healthcare wastes as they are not obliged to do according to their ordinance.



Plate 4.1 Transportation of Healthcare Waste by Open Truck Creates Public Nuisance and Causes Unpleasant Odor

Collection, Transportation and Disposal

KCC collects the healthcare wastes in the same vehicle with other wastes from the public dustbins twice a day. KCC has 32 trucks and about 170 wheel carts for the collection of wastes. After collection, the healthcare wastes are dumped together with other wastes.

Table 4.5 Vehicles Used by KCC for Waste Management.

Type of vehicle	Capacity	Number
Truck	5 tons	17
	3 tons	10
Trolley	5 tons	5
Wheel cart	--	170

Source: KCC, 2007

Though KCC has 32 trucks but at a time highest 26 trucks go for waste collection. The trucks collect wastes only from primary dustbins. The wheel carts are used to bring wastes from the secondary dustbins to the primary dustbins.



Plate 4.2 Photograph Showing Final Disposal Site of Waste at Rajbandh of Khulna City

Dumping Site

KCC dumps its waste in the dumping ground near Rajbandh, about 7 km. south of Khulna city. KCC also dumps their waste for land filling purpose at different locations of the city. It increases the risk of health hazard of the local community. The following flow chart (Figure-4.3) shows the disposal method of waste by KCC.

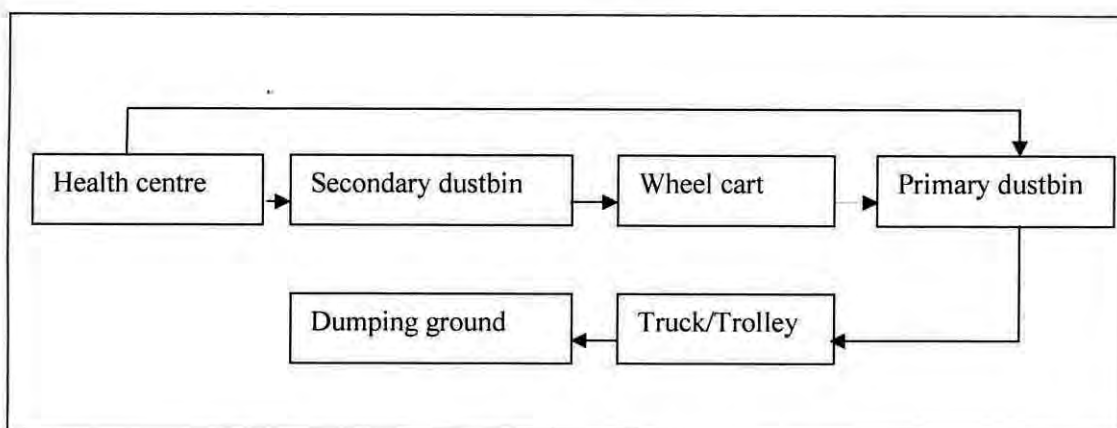


Figure 4.3 Disposal Method of Waste by KCC

Manpower

The conservancy department of KCC is the responsible department for solid waste management. They have only 130 stuffs for the management of solid waste of the whole city.

Table 4.6 Persons Engaged in Waste Management of KCC

Serial no.	Designation	Number
1	Conservancy officer	1
2	Assist. Conservancy officer	2
3	Supervisor	34
4	Driver	28
5	Waste handler	65
Total	-	130

Source: Office Record, Conservancy Department, KCC, 2007

Technical Capability

As the governing body of Khulna city, KCC has some distinctive strength in its side-

- KCC has an institutional setup to run any project efficiently.
- KCC has a large fleet of vehicles for waste management.
- As a public organization, KCC has the legal arrangements for waste management that also enables them to collect service charges for such services.

Service Cost

Table 4.7 Monthly Expenditure for Waste management

Purpose	Description	Amount/month (Tk)
Salary	Conservancy officer	14000
	Assist. Conservancy officer	18000
	Supervisor	132300
	Driver	158200
	Waste handler	284050
	Sub-total	606550
Maintenance cost	Fuel cost of trucks and trolley	297095
	Maintenance cost of trucks and trolley	176000
	Engine oil	63158
	Repair of wheel carts	1924
	Sub-total	538177
Materials supplied	Bleaching powder	5625
	Others	2257
	Sub-total	7882
	Total	1152609

Source: Office Record, Accounts Department, KCC, 2007

Table-4.7 shows that, about 47% of the money spent for waste management goes for the maintenance purpose of the vehicles. 53% money is spent to give salaries of the stuffs engaged in solid waste management.

Weakness of KCC

- KCC collects the healthcare waste together with other solid waste which is extremely harmful for the people of the local community as well as for the environment.
- Lack of manpower specially trained manpower is a vital problem for KCC.
- The conservancy department of KCC identifies the lack of resources as the main reason for not having any arrangement to handle the healthcare wastes separately.
- No research is conducted by KCC, neither there is any such search facility to identify the extent of different problems and to provide guidelines to mitigate that.

4.6.2 Private Organization Involved in Healthcare Waste Management

‘Prodipan’, an NGO is the only private organization involved in healthcare waste management in Khulna city. They started their healthcare waste management service in May, 2000 with funding from Swiss Development Co-operation (SDC), UNDP and World Bank. At that time, they started their project with 20 health centers which has now risen up to 64 nos. among their 153 nos. HCEs (registered and non-registered) list. It is mentionable that, only 21 HCEs are registered and 43 HCEs are non-registered among the 64 nos. HCEs served by ‘Prodipan’.

Table 4.8 Health Centers Served by Prodipan

Ownership	Total no. of HCEs	Served by ‘Prodipan’	Percentage (%)
Govt. Hospital	10	1	10.00
Private Hospital (registered and non-registered)	143	63	44.05
Total	153	64	41.83

Source: Prodipan, 2007

Very recently ‘Khulna General Hospital’ has come under the service of ‘Prodipan’, which the only Government hospital is served by them. But the fact is Khulna General Hospital is not yet paying service charge, Prodipan is doing it voluntarily. Among the 63 private health centers served by Prodipan, 17 are diagnostic centers and the rest 46 are clinics or hospitals.

Collection and Transportation

Prodipan’s plan is to segregate waste at the source of generation. For this their program is to provide each health center with at least a set of four covered drums to dispose four types of waste separately. The four drums are marked with four different colors for easy identification. The number of set of drums may vary with the size of the health center. But actually it has been found that many health centers have been provided with less than four drums. An auto van of 1.0 ton capacity is used for transportation of healthcare waste from the health centers. Normally the collection starts in the morning every day from the same clinic and same time.



Plate 1.3 Pick-up Vans Used for Transportation of Healthcare Waste.

Final Disposal Method

Safe disposal is the most important thing in the management of healthcare wastes. The methods adopted by 'Prodiphan' for safe disposal of the waste is as follows (Table-4.9).

Table 4.9 Disposal Method of Healthcare Waste Adopted by 'Prodiphan'

Serial no.	Waste type	Disposal method
1	Gauge, bandage, human organ etc.	Burned after washing
2	Needle and all other sharp type material	Disposed in a concrete pit.
3	Syringe, vial, ample, saline bags etc.	Crushed in a shredder machine and disposed in a concrete pit.
4	Kitchen waste	Open dumping, composting

Source: Prodiphan, 2007



Plate4. 4 Shredding Machine Used for Shredding Plastics.



Plate 4.5 Segregated Saline bags, Syringes and Tubes by Prodiphan in Treatment plant

‘Prodipan’ has developed a locally made simple burning chamber to burn the gauge, bandages, human organs etc. (Plate-4.7). It helps to reduce the volume of waste significantly. The reminders are disposed of by open dumping. Needle and all other sharp type materials are disposed in a concrete pit to check them from spreading germs. The syringes and saline bags are sliced in small pieces and then dumped in another concrete pit (Plate-4.8). ‘Prodipan’ is trying to go for composting especially aerobic compost with the general type of waste. But a recent study showed that in many cases even the general wastes of the health centers contain infectious germs.



Plate 4.6 Locally Made Burning Pit at ‘Rajbandh’

Dumping Site

Khulna City Corporation has allocated a piece of land in their final disposal site (Rajbandh) to dispose the healthcare waste properly. It is about 7 km. south to the city. ‘Prodipan’ has fenced its disposal site. There is concrete blocked box to dispose the needle and sharps. There is also a locally made incinerator or burning pit to burn the infectious waste.



Plate 4.7 Concrete Pit for the Disposal of Syringes, Saline bags and sharps



Plate 4.8 Chlorination Tank for Disinfecting Tubes and Plastics

Manpower

Table 4.10 Staffs of 'Prodipan' Engaged in Healthcare Waste Management

Serial no.	Designation	Number
1	Supervisor	1
2	Driver	1
3	Waste collector	1
4	Treatment worker	1
Total	--	4

Source: Prodipan, 2007

'Prodipan' started their project with six staffs in the year of 2000. In order to bring down their service cost, they reduced two of their staffs in 2001- one supervisor and one trainer but had to add one- the treatment worker. The supervisor has to supervise and give required guidelines to the staffs of the health centers related with this service. He is also responsible for the enrolment of more clinics and diagnostic centers in this service. The collectors collect waste from the health centers and put them in the auto van. The treatment worker is positioned at the dumping site and responsible for the final disposal of waste.

Technical Capability

‘Prodipan’ has some special technical capabilities to handle the wastes properly.

- ‘Prodipan’ supplied covered drums marked with four colors to dispose four types of waste in separate drums to ensure segregation of waste at the source.
- The auto van used for the collection of waste has been specially modified to carry the four types of waste separately.
- ‘Prodipan’ has developed a locally made burner to burn the infectious waste by manual batch loading system. The ashes are removed regularly.
- Two concrete blocked boxes have been made at the disposal site. The smaller one is used to dispose the needles and sharps and another one to dispose saline bags, syringes and other reusable plastic materials after crushing in the shredder machine.
- ‘Prodipan’ has skilled manpower particularly for healthcare waste management.

Income and Expenditure

‘Prodipan’ takes service charge from the hospital they serve. The service charge is fixed depending on the size (bed number), income and paying capability of the health center. Though, mutual agreement between the two parties is the most important factor in determining the service charge. Recently ‘Khulna General Hospital’ has come under the service coverage of ‘Prodipan’.

Table 4.11 Monthly Income of ‘Prodipan’ as Service Charges

Source	Amount (Tk)	Percentage (%)
Hospitals/Clinics	17500	85.15
Diagnostic centers	3050	14.84
Total	20550	100.00

Source: Prodipan, 2007

Most of the service charge is coming from the clinics and hospitals as they produce more waste than the diagnostic centers. At the same time ‘Prodipan’ is serving more hospitals (46) than pathological laboratories (17).

Table 4.12 Monthly Expenditure for Healthcare Waste Management

Purpose	Description	Rate	Amount/month
Salary	Supervisor	@ of 7000 Tk. per person	7000
	Driver	@ of 2800 Tk Per person	2800
	Waste collector	@ of 1700 Tk Per person	1700
	Treatment worker	@ of 1500 Tk Per person	1500
	Sub-total		13,000
Maintenance	Fuel cost of supervisor	-	1000
	Fuel cost of auto van	@ of 340 Tk. per day	10200
	Auto van maintenance	-	1800
	Motor cycle maintenance	-	350
	Burning pit maintenance	-	100
	Sub-total		13,450
Materials	Bleaching powder/detol	@ of 60 Tk. per day	1800
	Burning materials (oil, paper)	@ of 10 Tk. per day	300
	Mask 6 piece	@ of 10 Tk.	60
	Gloves 3 pair	@ of 45 Tk.	135
	Soap 6 piece	-	75
	Tiffin 3 person	@ of 5 Tk. per day	450
	Sub-total		2,820
	Total		29,270

Source: Prodipan, 2007

Table-4.12 shows that, about 44% of the service cost is spent to give the salary of the stuffs. Maintenance of vehicles costs 46% of the monthly expenditure and almost 10% for purchasing the required materials.

It is also evident from the above two tables that the cost of service is much higher than the service charge collected. The monthly deficit is Tk. 8720; only 70% of the service cost is recovered.

Weakness of the System

There are a couple of significant weaknesses of the present healthcare waste management system of 'Prodipan'-

- 'Prodipan' do not use any incinerator and burn infectious waste in a locally made burning pit at a comparatively low temperature (about 400°C or below). It may in some cases cause unfinished burning and in case of presence of any type of plastic

material in the waste, experts opine that, “this is more harmful as it helps in producing dioxin gas”

- At present, ‘Prodipan’ disposes the needles and all other sharp material in a concrete pit. This can be feasible at small scale; but in case of whole city, where yearly generation of sharp type waste is about 12 Metric tons, the waste volume reduction is necessary.
- ‘Prodipan’ practices the same procedure for the reusable/plastic type waste (syringes, saline bags etc.). But as they are generated in a huge amount (18.62 Metric tons / year in Khulna city) and can neither be burned in normal burners nor disposed on the ground, they are need alternative way of disposal.
- The present healthcare waste management system of ‘Prodipan’ is not a cost effective one. This project is not internally balanced. The continuity of the project is totally dependent on the availability of foreign aid.

4.7 Present Management Status of Healthcare Wastes in Khulna city

4.7.1 Existing Situation

It is observed that existing healthcare waste collection, handling and disposal practices of all the hospitals involved transport of wastes by ward boys, maid nurses and other employees from the point of generation to initial storage points in each unit. Healthcare waste is seen to be dumped at various corner of the hospital (Rahman, 1996). Waste normally collected from small bowl or plastic bin, provided for each bed in a hospital or clinic and put them either in a large size plastic bag or bucket. These plastic bags or wastes from buckets are then put in a pushcart and carried to the nearest municipal bins for dumping. The municipal bins are normally placed either in hospital premises or outside the hospital. Wastes from operation theater, laboratory and hospital kitchen are also dumped into municipal bins. KCC trucks carried them to the landfill area for final dumping. The flow diagrams of existing waste management are shown in Figure-4.4.

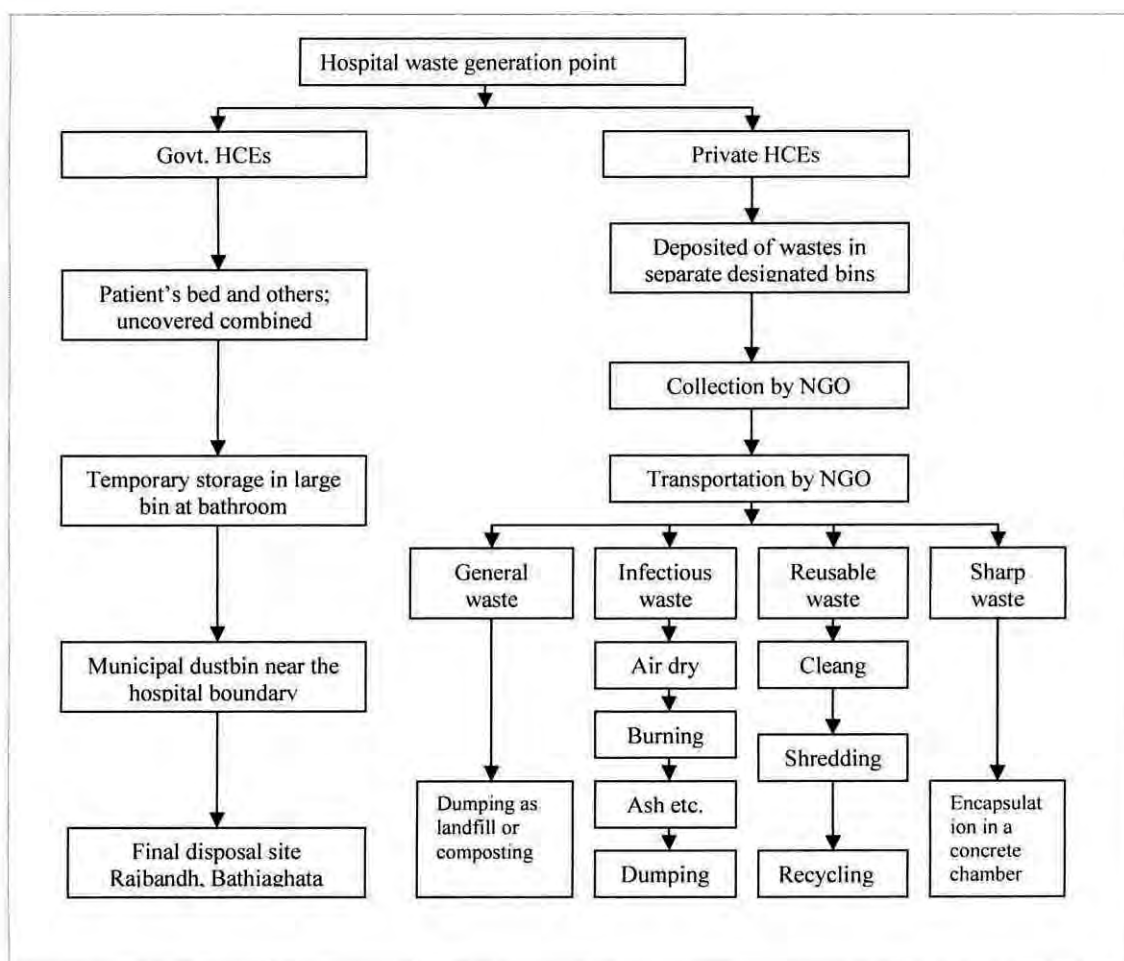


Figure 4.4 Flow Diagram of Existing Healthcare Waste Management in Khulna city

4.7.2 Impact of Present Practices:

The present system of HCWM in KCC is environmentally ineffective, inefficient and hazardous to health. No proper segregation has been practiced in HCEs it was observed that, 81% of healthcare waste is non-hazardous and may be treated as general solid waste. Due to lack of proper segregation, this large portion of non-hazardous waste is unnecessarily polluted by hazardous waste. Besides, there is no separate collection bin for healthcare waste and all kinds of waste from hospitals including reusable and sharp wastes, is dumped in the municipal waste collection bins (Plate-4.9). This ill practice creates the possibility of contamination of whole mass of solid waste by infectious HCW. Healthcare waste contains both biodegradable and non-biodegradable polymers. There is

no procedure for separation the non-biodegradable polymers from residues when the residues are dumped in a



Plate 4.9 Scavenger collecting recyclable HCW near a HCEs



Plate 4.10 HCW clogs sewers of Khulna General Hospital

municipal landfill. The non-biodegradable portion create tremendous problem in municipal solid waste management. The microorganisms may create a cyst to survive in adverse condition and contaminate the environment. Liquid wastes produced from all HCEs are discharged directly into municipal sewer lines (Plate-4.10). Chemical used in HCEs is a potential source of water pollution (WHO, 1983). Direct disposal of faeces and urine of infectious patients in municipal sewer system may cause outbreak of epidemic diseases.

Open dumping of healthcare waste has also been observed in some HCEs that create the possibility of contamination of soil, ground water, surface water and air. It creates public nuisance. It clogs sewers, drains, encroach roadways, diminishes landscape aesthetics and causes unpleasant odors. In an open dump, there is ready access of domestic animals to the hazardous waste and subsequently potential spread of disease and chemical contamination through the food chains. Besides, in some HCEs, HCW has been burnt (Plate-4.11) When waste containing plastics is burnt, dioxin is produced which can cause cancer, birth defects, decreased psychomotor ability, hearing deficits, cognitive defects and behavioral alternations in infants.



Plate 4.11 HCW has been burnt inside the KMCH premises



Plate 4.12 Unhygienic collection of waste in a Government Hospital

Most of the municipal bins are not properly designed (Plate-4.9). Vectors like rodent, birds, flies etc. can enter the bins easily and scatter the wastes. Flies also sit on the uncovered plies of rotting garbage. These promote mechanical transmission of fatal diseases like Diarrhea, Dysentery, Typhoid, Hepatitis and Cholera. Under moist conditions, mosquito transmits many types of infections like Malaria and Yellow fever. Similarly dogs, cats and rats also transmit a variety of diseases including Plague and Flea born fever, as they mostly live in and around the refuse. A high tendency of contracting intestinal, parasitic and skin diseases is found in workers engaged in collecting refuse. Surface run-off directly from waste deposit in bins may contaminate surface water.



Plate 4.13 Scavenger collecting reusable medicine packets.



Plate 4.14 Reusable bottles and syringes are also gathered for selling purpose

A large number of people depend on the recycling operation of solid and healthcare waste in KCC area. People pick up used syringes from the HCW and sell them (Plate-4.14). Many drug addicts reuse these syringes that can cause hepatitis, AIDS and other dangerous and contagious diseases. The scavengers engaged in recycling operation are

extremely poor, do not have education and unaware of harmful consequences of exposure of contaminated and hazardous waste (Rahman, 1996). They collect wastes from the street and dustbin for the desired material in bare hand (Plate-4.13) without any protection and unaware of the nature of the materials present. Thus they are at risk from sharps, pharmaceuticals and chemicals and from direct contact with infectious materials. So scavengers involved in recycling face a high risk of silent epidemics of infectious diseases like viral hepatitis, typhoid, pneumonia, gangrene, AIDS etc. Also recycling of infectious objects may pose serious health hazard to their users.

If HCW has not been managed properly it will be harmful to the environment. It not only poses a threat to the employees working in the hospital but also to the people surrounding that area. Infectious waste can cause diseases like hepatitis A&B, AIDS, Typhoid, Boils etc. the lack of proper attention of HCWM, could mean that the people around the HCEs are also liable to be exposed to health hazards, as hazardous wastes are more often disposed off to the common waste bins designated to collect domestic waste. As a result, health care workers, patients waste handlers; waste pickers & general public are exposed to health risk from infectious wastes, chemicals & other HCW

4.7.3 On-site Handling of Healthcare Waste

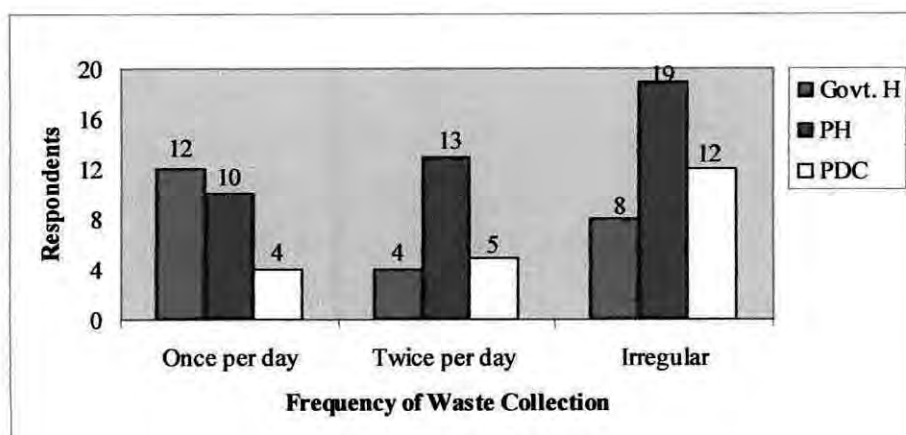


Figure 4.5 Frequency of On-site Handling (Patient's bed to storage place) of Waste

In the studied Government hospitals, twenty four (28%) respondents were reported in measuring the onsite handling (from patient's bed to temporary storage place) of generated hospital waste. At Government hospitals, the frequency of onsite waste handling was categorized as once per day, twice per day and irregular. The respondents were twelve, four and eight respectively and they were 14%, 5% and 9% respectively of the total respondents. At private hospitals the frequency of onsite waste handling was categorized as once per day, twice per day and irregular. The respondents were ten, thirteen and nineteen respectively and they were 11%, 15% and 22% respectively of the total respondents. At private diagnostic centers the frequency of onsite waste handling was categorized as once per day, twice per day and irregular, respondents were four, five and twelve respectively and they were 5%, 6% and 14% respectively of the total respondents (Appendix-J).



Plate 4.15 Collection of Waste in a Private HCEs



Plate 4.16 Colored Containers for Separation of H CW in GNCDC

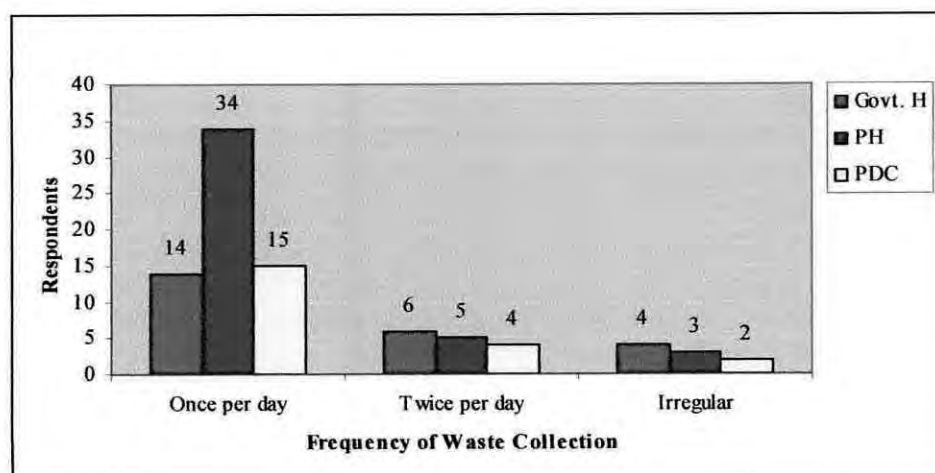


Figure 4.6 Frequency of On-site Handling (storage place to municipal dustbin or NGO's van) of Waste

In the Government hospitals, the frequency of storage place to municipal dustbin was also reported through twenty four (28%) respondents, in where fourteen (16%), six (7%) and four (5%) respondents reported as once per day, twice per day and irregular respectively. In private hospitals, the frequency of storage place to NGO's van was reported through forty two (48%) respondents in where thirty four (39%), five (6%) and three (3%)



Plate 4.17 Healthcare Waste Disposed in City Corporation bin near the KMCH

respondents reported as once per day, twice per day and irregular respectively. In addition, in private diagnostic centers, the frequency of storage place to NGO's van was reported through twenty one (24%) respondents, in where fifteen four and two

respondents reported as once per day, twice per day and irregular respectively (Appendix-J).

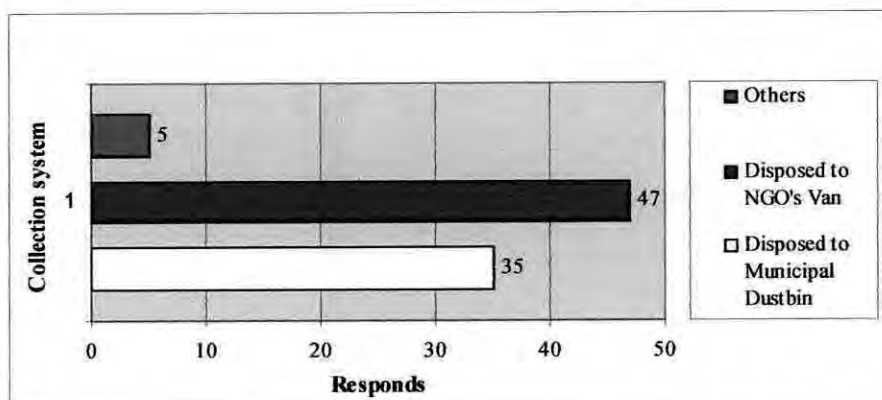


Figure 4.7 Graphical Presentation of Disposal Place of Waste in the Study HCEs.

In the study (Figure-4.7), thirty five respondents disposed their waste in municipal dustbin and they were 40% of the total respondents, forty seven respondents disposed their waste in NGO's van and they were 54% of the total respondents and five respondents reported as others and they are 6% of total respondents. The highest (54%) reported for NGO's collection system and the lowest (6%) respondents reported as no isolation (Fig 4.7).

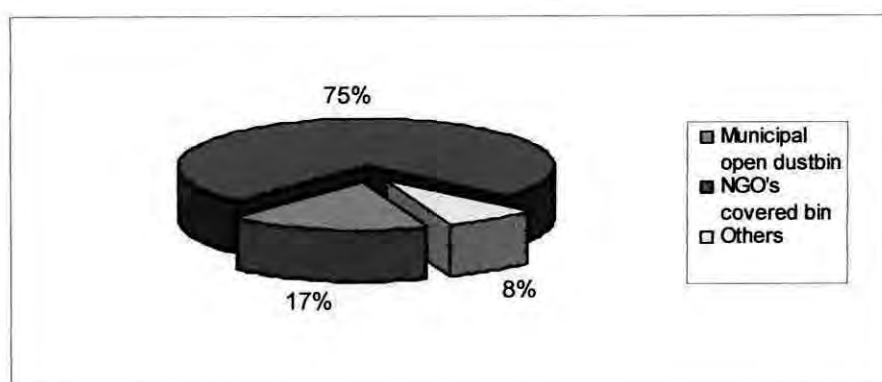


Figure 4.8 Graphical Presentation of Preferable Waste Collection System

In the studied HCEs fifteen respondents preferred municipal open dustbin for their waste collection and they are 17% of the total respondents, sixty five respondents preferred NGO's covered bin for their waste collection and they are 75% of the total respondents

and seven respondents had no appropriate comments and they are 8% of the total respondents (Figure 4.8).

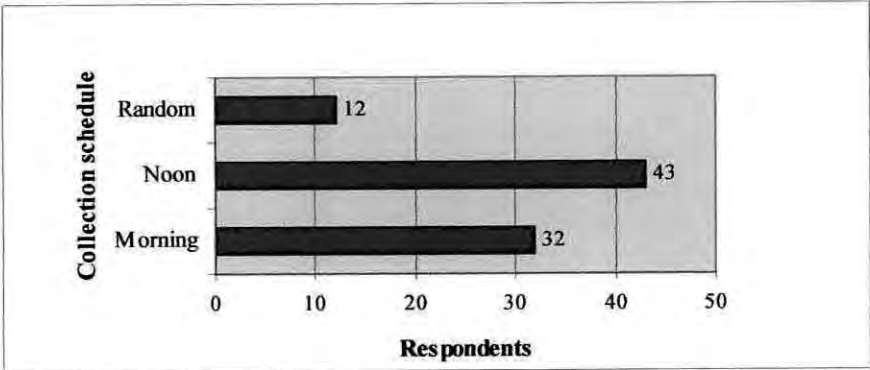


Figure 4.9 Time of Waste Collection from Secondary Source to Final Disposal Place

From secondary source to final disposal place in the studied HCEs, thirty two respondents reported that waste collection was at morning and they were 37% of the total respondents, forty three respondents reported at noon and they were 49% of the total respondents and the rest twelve reported for random collection schedule and they were 14% of the total respondents (Figure 4.9).

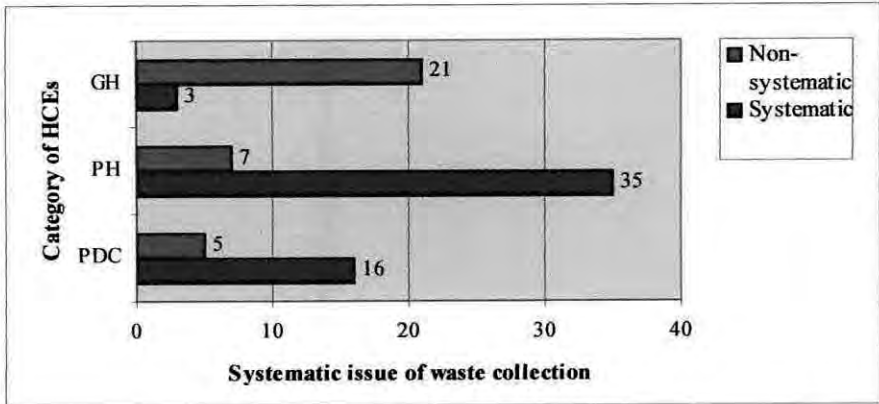


Figure 4.10 Graphical Presentation of Systematic Issue of Waste Collection

In the studied healthcare establishments (HCEs), out of eighty seven respondents twenty four respondents were from government healthcare establishments and they were 28% of the total respondents. In the government HCEs, three respondents reported that the present collection system of waste was systematic and they were 3% of the total

respondents, twenty one reported that the present collection system of waste was non-systematic and they were 24% of the total respondents. In private HCEs, forty two respondents reported in where thirty five respondents reported as systematic waste collection, they were 40% of the total respondents, and seven respondents reported as non-systematic waste collection and they were 8% of the total respondents. In private diagnostic centers, twenty one respondents were conducted in where sixteen respondents reported as systematic and they were 18% of the total respondents, five respondents reported as the present collection system is non-systematic and they were 6% of the total. In the studied HCEs, 62% respondents reported that the existing collection is systematic and the rest 38% reported as non-systematic (Figure 4.10).

Mehrdad et al., (2004) conducted a study to assess healthcare waste management, personnel training and current rules and regulations concerning this issue in university hospital in fars, Iran. They reported that separation of hazardous and non-hazardous wastes was not done according to define and standard rules. Healthcare wastes were disposed along with municipal wastes. Islam et al., (1993) reported that most hospitals, clinics and laboratories did not have any waste management system in place. All wastes are collected together and are dumped in a common place, such as roadside, hospital surroundings, and dustbin of the Khulna City Corporation. It was found that used saline bags, syringes, vials slides, empty packets and bottles were collected and sold. Hospital authorities and cleaners collect the healthcare wastes and sell it to whole-sellers.

PRODIPAN, a national NGO was working in the studied private HCEs and without some limitation, there was systematic onsite handling, storage, collection, transportation and ultimate disposal system. Consequently, the overall management of healthcare waste was positive.

4.7.4 Transportation and Disposal System of Government Hospital Waste

Healthcare waste is collected and transported to a bin for temporary storage by hospital cleaners. In Govt. HCEs, open containers are used for off-site transport of waste from the sites of production (different wards) to the KCC bin. The KCC has the responsibility for off-site transport of the waste for final disposal or dumping. The studied three Govt.

hospitals disposed their waste at 'Rajbandh', Bathiaghata dumping site that belongs to KCC. Some people are engaged in collecting, segregating and selling the used hazardous wastes. Out of three the studied Govt. HCEs, only KGH treated their waste with the help of 'PRODIPAN'.

4.7.5 Transportation and Disposal System of Private Hospital Waste

In the studied private HCEs, healthcare waste has been treated and 'PRODIPAN' a national NGO was working there. This NGO is involved in transportation of all healthcare waste separately. Healthcare waste treatment plant is situated at Rajbandh, near Khulna city and it is 0.5 acre plot in 'Rajbandh' managing from KCC. The over all process of healthcare waste management in the studied private HCEs by 'PRODIPAN' is presented before.

4.7.6 Awareness and Training on Healthcare Waste Management

The materials presented here are aimed at providing the level of awareness and training needs. The following section focuses the existing level of awareness mentioning the safety equipment scenario, satisfaction level etc. of different respondents; describes the needs of training, methods of training on healthcare waste management generated in HCEs; and concentrates the opinion of the respondents about existing management and some concluding remarks on the overall awareness.

Level of Awareness

This survey indicated that thirty four respondents among the interviewees were female, they were 39% respondents, fifty three interviewees were male respondents, and they were 61%. Out of sixteen, eleven nurses were female, the rest was five and their average age was 31 years. Five nurses had level of education were up to HSC, the rest eleven nurses had professional nursing certificate and their length of average service was 9 years. Out of fifteen cleaners eight were female, the rest seven is male and their average age was 34 years. All the cleaners are illiterate and their length of average service was 8 years. Out of eleven technicians, ten is male and the rest one is female and their average age was 35 years. All of the technicians had training certificate and their length of average service was 7 years. In the studied HCEs, sixteen doctors were respondents and

of them six were female, ten were male and their average age was 41 years. They were academic medical certificate holder and their length of average service in their profession was 15 years. Out of twelve HCEs ten administrators or administrative officers were respondent and all were male having their average age 50 years. All the administrative officers are academic certificate holder. The patients were also conducted as they were the main corresponding of the HCEs, eight were female, eleven were male and their average age was 36 years. Five patients were illiterate; eleven patients were up to HSC and the rest two were graduate (Table-4.13). All of the respondent's opinions have been considered for addressing the awareness and training needs.

Table 4.13 General Profile of the Respondents in the Studied HCEs

Occupation	Number of respondent			Avg. age (year)	Level of Education /Training					Avg. Service length (years)
	Male	Female	Total		Illiterate	Up to HSC	B.Sc	Nursing	Medical / Training	
Patients	11	8	19	36	6	11	2	--	--	--
Nurse	5	11	16	31	--	5	--	11	--	9
Cleaners	7	8	15	34	15	--	--	--	--	8
Technicians	10	1	11	35	--	--	--	--	11	7
Doctors	10	6	16	41	--	--	--	--	16	15
Administrators	10	0	10	50	--	--	--	--	10	5
Grand Total	53	34	87	38	21	16	2	11	37	*9

Note: * The calculated value is excluding the patients.

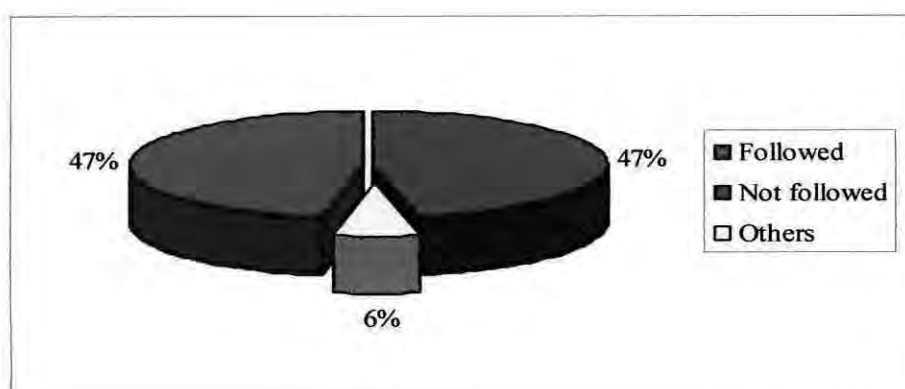


Figure 4.11 Safety Equipment Scenario of the Studied HCEs

In measurement of following safety equipments against spreading of diseases, seven respondents of Govt. HCEs reported that they observed the using to safety equipments and they are 8% of the total respondents. Fifteen respondents of the Govt. HCEs observed

not using of safety equipments, they are 17% of the respondents and two respondents of the Govt. HCEs reported as no specific comments and they are 2% of the total respondents. Twenty three, sixteen and three respondents of the private HCEs observed as followed, not followed and others respectively and they are 26%, 18%, 4% respectively. Eleven and ten respondents of the private diagnostic centers observed as followed and not followed respectively and they are 13% and 12% respectively (Appendix-J).



Plate 4.18 Destroying Needles by the Needle Destroyer in a PDC

Healthcare waste management was systematic and proper management is maintained by 'PRODIPAN' in the studied private HCEs that was large portion of studied HCEs. Consequently, 47% respondents recommended for following safety equipment.

Training Issues for the Respondents of HCEs

The field survey shows different levels of awareness from different respondents. The management authority of HCEs and doctors got ideas about the healthcare wastes and its negative impacts. They pointed out that they are willing to manage the generated waste properly, but due to lack of financial support and proper system, they are unable to do it. Nurses got their training on healthcare waste as a part of their professional training, but due to the lack of the system, they are unable to apply their theoretical knowledge they gathered from their training. Some nurses told with little frustration that they are on the brink of forgetting the waste management system. In addition, most of the technicians,

cleaners and ward-boys are not aware properly about the healthcare wastes and its risk issues. The patients were frightened about the infectious diseases and they were highly conscious about the present condition.



Plate 4.19 Nurses got Training on Healthcare Waste Management Arranged by 'Prodipan'

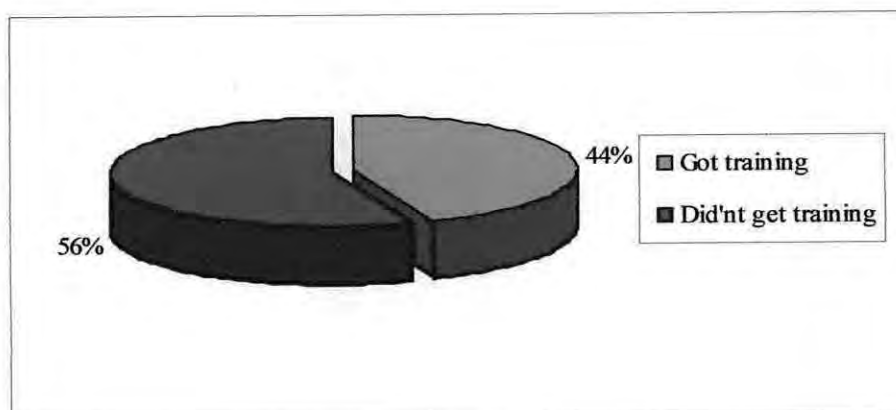


Figure 4.12 Training Issues for the Respondents in HCEs

In the measurement of getting training of the studied HCEs, 44% staffs got training on the healthcare waste management and 56% staffs did not get training of the total respondents. In Govt. hospitals five respondents commended for getting training and they were 7% of the total respondents. On the other hand fourteen respondents reported as they did not get training on the healthcare waste management and they comprised 21% of the total respondents. In the private hospitals, nineteen respondents informed that they got

training and fifteen respondents reported tat they did not get training and they were 28% and 22% of the total respondents. In the private diagnostic centers six respondents got training, nine respondents did not get training and they were 9% and 13% respectively of the total respondents (Appendix-J).

Training Methodology

It also investigated from field survey that almost all the respondents from all the surveyed HCEs focused their opinion in favor of training concerning the waste management. In connection with the training methods, about seventy eight percent of the respondents (78%) showed their interest in video and lecture, followed by video (10%), lecture (7%) and others (4%). In the Govt. HCEs out of 28% respondents of the total 1%, 3%, 22% and 1% respondents opinioned for lecture, video, video& lecture and others respectively for training method. In the private hospitals out of 50% respondents of the total 4%, 4%, 38% and 3% respondents focused for lecture, video, video& lecture and others respectively for training method. In addition, in private diagnostic centers out of 22% respondents of the total 2%, 3% 18% respondents opinioned for lecture, video and video& lecture respectively (Appendix-J)

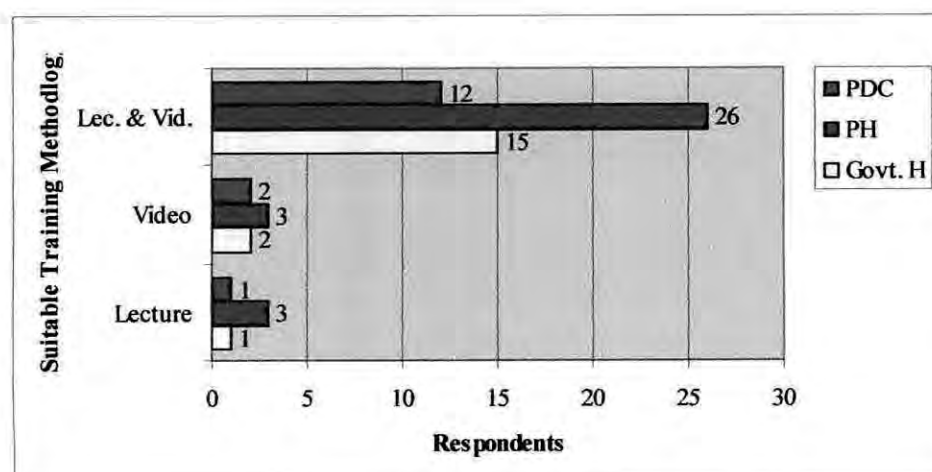


Figure4.13 Respondents' Opinion in Suitable Methodology for Proper Training in the HCEs

The voices of the respondents were mainly confined to the in-house waste collection procedure, segregation, incineration and safety dumping. Moreover, some respondents urged for reinforcement and imposing waste related laws.

4.7.7 Opinion about Existing Healthcare Waste Management

Forty three respondents stated as satisfactory of existing healthcare waste management and they were 49% of the total respondents. Where two, twenty nine and twelve respondents recommended as satisfactory the existing management systems were Govt. HCEs, private HCEs and private diagnostic center respectively and they were 2%, 33% and 14% respectively. Forty four respondents expressed unsatisfactory on existing healthcare waste management and they were 51% of the total respondents. Where twenty two, thirteen and nine respondents opinioned that the existing management systems were unsatisfactory Govt. HCEs, private HCEs and private diagnostic center respectively and they were 25%, 15% and 10% respectively (Appendix-J).

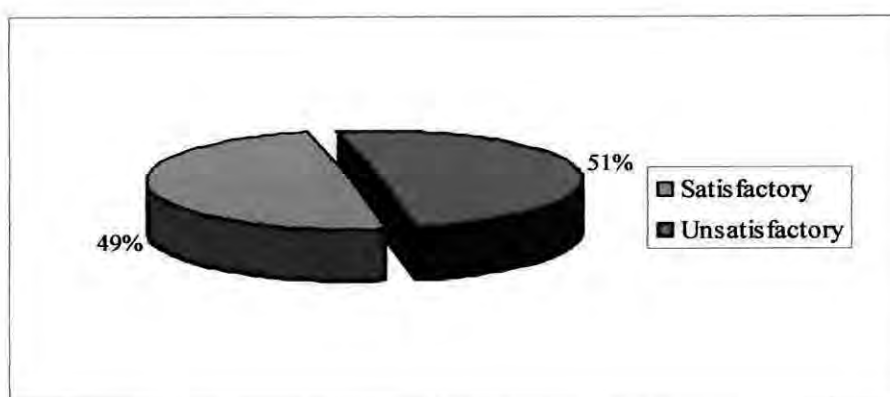


Figure 4.14 Satisfaction Rate of Existing Waste Management of HCEs

The rate of unsatisfactory (51%) is more than satisfactory (49%). Both rates are approximately equal for sound management of private healthcare waste management. Comments of unsatisfactory came on the basis of various problems. The problems that faced by the patients, cleaners, nurses, technicians, doctors as well as administrative authority are: No environment friendly dustbin for waste disposal, no separate dustbin for separate medical waste collection, dustbin is not in a suitable location, waste collection

system is unhygienic, irregular collection system, hazardous waste are spreading here and there due to lack of onsite treatment facility etc.

UNEP (1997) conducted another study at the Dhaka Medical College Hospital in 1995 and reported that there was also a lack of awareness on the consequences of unhygienic disposal of the healthcare waste and absence of training facilities for the concerned staff. Besides, there was a shortage of supply of equipment and materials required for the disposal of healthcare wastes.

4.7.8 Others Opinion of the Respondents

Most of the respondents showed their negative opinion in the present healthcare waste management systems. Only a very few respondents mentioned the good in-house management of the waste segregation. It is noted here that private HCEs (as mentioned earlier) segregate the infectious waste for treatment and disposal. Govt. HCEs had no treatment facility. They mentioned that infectious waste could cause HIV/AIDS and hepatitis. Moreover, they are presently facing stink and afraid of contaminating diseases from the infectious waste. They also mentioned here some probable steps that could overcome the problems:

- Use of apron, mask and gloves during handling the patients and segregating and disposal of waste;
- Use of WHO guided color-coded bins for segregated wastes;
- Training for awareness could be of great help concerning to this issue;
- Formulating, amendment and imposing the relevant laws could prevent the improper management of health wastes.

4.8 Making Waste Management System of Khulna City Efficient

4.8.1 Context

In this section it has been tried to define the term ‘Healthcare Waste Management’ and how the efficiency of the system can be ensured. The objective is to provide proper guidelines and recommendations regarding efficient management of healthcare wastes in context of Khulna city.

4.8.2 Efficient Management of Healthcare Waste

The management system of healthcare waste can be said efficient if it is a safe, effective, sustainable and—it is hoped—affordable and culturally acceptable method for the treatment and disposal of health-care waste, both within and outside health-care establishments (WHO, 1999). Health-care waste management, as well as posing technical problems, is strongly influenced by cultural, social, and economic circumstances. A well designed waste policy, a legislative framework, and plans for achieving local implementation are prerequisites for the sustainability of a proper waste management system.

The term ‘Solid Waste Management’ is used to describe a system incorporating the storage, collection, transfer and transport, recycling, resource recovery and disposal of municipal solid waste (Cointreau, 1994; reprinted in Huysman, 2001). In this study, which deals mainly with the solid portion of the healthcare wastes, the term ‘Healthcare Waste Management’ means a system that includes the preliminary disposal, on site as well as off site collection and transportation, segregation and final disposal of the wastes generated from the health care establishments. The process and method adopted for waste management should be technically and financially sustainable in the long term. It has to be also ensured that there are no adverse health and environmental consequences of waste handling, treatment and disposal activities. For ensuring this, the steps or actions required have been discussed in the following sections.

4.8.3 Legal Provisions

National legislation is the basis for improving health-care waste practices in any country. It establishes legal controls and permits the national agency responsible for the disposal of health-care waste, usually the ministry of health, to apply pressure for their implementation. Bangladesh yet lacks such type of law. The ministry of environment or national environmental protection agency may also be involved; there should be a clear designation of responsibilities before the law is enacted.

The law should be complemented by a policy document, and by technical guidelines developed for implementation of the law. This legal document should specify regulations on treatment for different waste categories, segregation, collection, storage, handling, disposal and transport of waste, responsibilities and training requirements; it should take into account the resources and facilities available in the country concerned and any cultural aspects of waste-handling.

The law should include the following:

- A clear definition of hazardous health-care waste and of its various categories;
- A precise indication of the legal obligations of the health-care waste producer regarding safe handling and disposal;
- The type of container to be used;
- How to preserve harmful waste products;
- For how long the wastes can be stored;
- The nature of on-site and off-site transportation of waste;
- Which type of technology to be used for the treatment of waste;
- Specifications for record-keeping and reporting;
- Specifications for an inspection system to ensure enforcement of the law, and for penalties to be imposed for contravention;
- Designation of courts responsible for handling disputes arising from enforcement of or noncompliance with the law.

According to latest information, a Draft Ordinance, entitled Bio-Medical Waste Management and Administration Ordinance, with specific guidelines for the disposal, storage, collection and dumping of clinical wastes have been reviewed by the Permanent Parliamentary Committee and now lying with the Ministry of Law and Parliamentary Affairs for review.

4.8.4 National Plan

Formulation of objectives and planning for their achievement are important for improving health-care waste management at the national, regional and local level. Surveys on the generation of waste will be the basis for identifying opportunities—and setting targets—for waste minimization, reuse, recycling and cost reduction.

A national management plan will permit health-care waste management options to be optimized on a national scale. A national survey of health-care waste will provide the relevant agency with a basis for identifying actions on a district, regional and national basis, taking into account conditions, needs and possibilities at each level. An appropriate, safe and cost-effective strategy will be concerned principally with treatment, recycling, transport and disposal options.

4.8.5 Waste Minimization

In case of health care establishments, it is quite difficult to minimize the amount of waste generation. Though significant reduction of the waste generated in health-care establishments of Khulna city may be encouraged by the implementation of certain policies and practices, including the following:

Source Reduction

Measures such as purchasing restrictions to ensure the selection of methods or supplies that are less wasteful or generate less hazardous waste. For example, steam disinfection instead of chemical disinfection.

Recyclable Products

It means the use of materials that may be recycled, either on-site or off-site. Reducing the toxicity of waste is also beneficial, by reducing the problems associated with its treatment or disposal. For example, the authorized officer could investigate the possibilities of purchasing PVC-free plastics that may be recycled or of goods supplied without unnecessary packaging.

Medical and other equipment used in a health-care establishment may be reused provided that it is designed for the purpose and will withstand the sterilization process. Reusable items may include certain sharps, such as scalpels, glass bottles and containers etc. after use; these should be collected separately from non reusable items, carefully and may then be sterilized for reuse.

4.8.6 Waste Segregation

Careful segregation (separation) of waste matter into different categories helps to minimize the quantities of hazardous waste. Segregation should always be the responsibility of the waste producer, should take place as close as possible to where the waste is generated, and should be maintained in storage areas and during transport. The same system of segregation should be in force throughout the country. The best solution is to segregate the waste at the source of generation. To ensure that, the following observations and recommendations are important for the health centers of Khulna city-

- The wastes have been categorized in four groups for this study i.e. infectious waste; sharps, reusable/plastic type waste (syringes, saline bags, tubes etc.) and general waste. This type of segregation is commonly practiced in Bangladesh (Prodipan, 1999; Shehab, 1999)
- At present an open bucket or bowl is kept beside each bed for the disposal of all types of waste it is recommended that this bowl or bucket will be used only for the disposal of general waste. An additional small covered bucket should be kept beside each bed for the disposal of infectious waste.

- It is proposed that there will be four small covered plastic drums (currently used by ‘Prodipan’) for the four types of waste in each ward or for each 15 beds. Each operation theater will also have four containers. The diagnostic centers will be provided with a set of four drums.
- Each of the containers will be colored according to the international color coding policy i.e. infectious waste-yellow with label ‘INFECTIOUS’; sharps-yellow with label ‘SHARPS’; syringes, saline bags etc.-brown and general waste- black. (WHO, 1999).
- It will be the responsibility of the nurses to dispose the sharps and syringes, saline bags etc. to their respective containers as they are handled by the nurses. The infectious and general wastes will be collected by the cleaners from the bed side pots and will be disposed in the respective drums.
- The hospital authority will have to have strong monitoring system to ensure that the wastes are being segregated properly.

Requirement of Disposal Pots/Containers

At present there are about 2050 bed in 79 health centers of Khulna city. The number of diagnostic centers and dental clinics are 31. It is assumed that there is one operation theater in each health center.

Table 4.14 Number of Containers Required for the Disposal of Waste

Type of container	Description	No. of containers
Small covered drum	@ 4 pc. per 15 beds	547 pc.
	@ 4 pc. per operation theater	316 pc.
	@ 4 pc. per diagnostic center	124 pc.
Subtotal		987 pc.
Small covered bucket	@ 1 pc. per bed	2050 pc.
Large drums	1 drum for each of the four compartments of the Truck	4 pc.

4.8.7 On-site Collection, Storage and Transportation of Waste

On-site collection, storage and transportation of waste are required only for the large health centers. In case of small health centers wastes are directly transferred from the disposal containers to the off-site transport vehicle.

Collection

The wastes are collected by the cleaners. Certain recommendations should be followed by the ancillary workers in charge of waste collection:

- Waste should be collected daily (or as frequently as required) and transported to the designated central storage site.
- The containers for the disposal of waste should not be removed from its place.

On-site Transport

Healthcare waste should be transported within the hospital or other facility by means of wheeled trolleys, containers, or carts which meet the following specifications:

- Easy to load and unload;
- Those are not used for any other purpose
- No sharp edges that could damage waste bags or containers during loading and unloading;
- Easy to clean.
- It should have enough protection to control the spreading of germs during transportation.

The vehicles should be cleaned and disinfected daily with an appropriate disinfectant.

Storage

A storage location for health-care waste should be designated inside the health-care establishment or research facility. The waste should be stored in a separate area, room or building of a size appropriate to the quantities of waste produced and the frequency of collection. Recommendations for the storage area and its equipment are listed below:

- The storage area should have an impermeable, hard-standing floor with good drainage; it should be easy to clean and disinfect.
- There should be a water supply for cleaning purposes.
- The storage area should afford easy access for staff in charge of handling the waste.
- It should be possible to lock the store to prevent access by unauthorized persons.
- Easy access for waste-collection vehicles is essential.
- There should be protection from the sun.
- The storage area should be inaccessible for animals, insects and birds.
- There should be good lighting and at least passive ventilation.
- The storage area should not be situated in the proximity of fresh food stores or food preparation areas.

Storage times for healthcare waste (i.e. the delay between production and treatment) should not exceed the following (WHO, 1999):

- Temperature climate: 72 hours in winter
 48 hours in summer
- Warm climate: 48 hours during the cool season
 24 hours during the hot season

In case of Khulna, it is needed to dispose the waste finally within 24 hours.

4.8.8 Off-site Transportation

The transportation of waste from the source of generation to the treatment or final disposal point has to be made safe. The vehicle should be a covered one. The waste should be carried in “Intermediate bulk containers—large rigid or flexible bulk containers made from a variety of materials such as wood, plastics, or textile (The United Nations, 1997). The following observation and recommendations are important in choosing a mode of transportation of healthcare wastes in Khulna-

- The daily generation rate of healthcare waste is about 1882 kg at present in khulna city. So a truck with 2 ton capacity will be good enough to serve the health centre of the city.
- The truck has to be divided in four compartments for the four types of waste. Through the size of the compartments will be determined according to the rate of generation of different types of waste. It is proposed that there will be a large compartment with about 80% of the space of the truck to carry the general waste; the rest of the space has to be equally divided in three compartments for the carrying of other three types of waste.
- The smaller three compartments, made for the carrying of hazardous wastes should have one large drum in each to prevent any type of leakage of waste during the transportation.
- The waste handler with the truck will be responsible for loading the waste in the truck.

Vehicles or containers used for the transportation of health-care waste should not be used for the transportation of any other material. They should be kept locked at all times, except when loading and unloading.

4.8.9 Assessment of Different Technology for Proper Management of HCW in the Context of Khulna city

In general, treatment options may be available either on or off-site. But for Khulna, a central treatment facility is proposed as the generation of hazardous waste from individual hospitals is not high enough to run a treatment facility by every individual clinic or hospital. The treatment options include incineration, microwaving, autoclaving, hydro pulping, compaction, etc. The comparative advantages and disadvantages of different waste handling/disposal techniques have been discussed in Chapter-2, not for just theoretical depiction, but to make easier to choose a technique appropriate for Khulna city.

Incineration

By analyzing the advantages and disadvantages of different treatment methods mentioned in the Table-2.10, it is seen that incineration is a perfect method, which is suitable for all types of healthcare wastes both hazardous and non-hazardous. This is because that the waste normally averages very high in heat value nearly 9400 Btu / lb. which equal that of low-grade coals.

The method significantly reduces the volume of waste by more than 95% which is highest among all the methods. The reminders are in the form of ash lowering the disposal and transport cost and also saves the landfill space which is of particular importance in a land constraint country like Bangladesh. In incineration, complete combustion of the waste at high temperature in the combustion chamber with long period of resetting in sterile ash and also gives guarantee of destroying all hazardous and toxic elements. The process works independently at the composition of waste and does not require special monitoring. Unwanted emitted pollutants can be substantially reduced with the addition of air pollution control devices of the system. Modern incineration plants are equipped with systems for the purification of exhaust gases meet the present emission limit.

The disadvantage of the method is that it is not a continuous operation process, maximum operation period is 10-12 hours for small sizes with a capacity of 0.4-2 ton per day. In Khulna city, the present generation of the waste is about 1.88 ton /day and the hazardous waste is about 0.35 ton /day. So a small sized incinerator will be good enough to comply with the situation.

Due to large investment required for new plant, several health centers may join to setup a plant centrally. These types of plants are now being founded in many countries of the world. The incineration is currently the most acceptable method for treating hazardous waste for its effectiveness.

Microwaving

From analyses of advantage and disadvantages of microwave as mentioned in Table-2.11, it is seen that Microwaving is an effective commercially available treatment technology for treating healthcare hazardous waste with the exception of pathological and chemical waste. Microwaving system has minimum impact on the environment than those from an incinerator because there is no combustion emissions produced by the Microwaving system. But the system requires strict monitoring program. An important benefit of microwaving system is that treated waste, which is reduced in volume by approximately 60-90% with the shredders, can be safely disposed off in a low cost municipal landfill.

Autoclaving

Autoclaving are suitable for sterilizing hazardous waste, but volume of the waste can not be reduces in this process. It is not suitable for treating recognized body parts. Moreover the decontaminated waste remains the appearance of the waste following treatment. Health impact attributed to autoclaving may not be documented. Operators may be exposed to hazardous constituents in steam emissions. Study needed on emissions from autoclave. Even those autoclaves are widely used in many countries to treat infectious waste generated by different kind of health care establishments.

Hydropulping

Hydropulping have required water content of approximately 80% as a result an increase in weight, however the resultant volume can be as little as 30% of the original volume.

The use of pulping system for hospital waste is highly controversial. Experience has revealed a difficulty in pulping plastics and cloths. Broken glass and metal grinding have caused sever equipment and plumbing wear. Separation of waste by the pulpers has not always been successful and equipment failure is common. It is necessary to segregate all materials that can not be pulped before they enter the pulping system. This step must be done principally to reduce equipment maintenance problem. Separation before pulping means additional handling at the source of waste generation. Separation of healthcare

wastes is generally an unsatisfactory requirement not only for the manpower required but also for the health hazard creation. So, the use of hydropulping for healthcare wastes is not suitable method for Khulna city.

Compaction

The advantage of this technology is that there is volume reduction of waste (up to 60 percent) in the size of the hazardous waste but not reduction in weight. Due to reduction in volume the waste can be handled easily by the containers at a land filled or to incineration, but there is risk of leakage of containers during handling. In this method it is not possible to sterilize the waste. It is necessary to sterilize the waste prior to compaction or to sterilize or incinerate it after compaction. Sending non sterilized waste off-site for processing is not a good practice and mostly uneconomic, so this method is not appropriate for the city like Khulna.

Sterilization (Grinding / Compaction)

The advantages of these technologies are that, there is good volume in reduction of waste, but no reduction in weight. If the waste does not undergo immediately in incineration plant, there is a risk of decomposition at room temperature. Disposal after sterilization also requires further supervision. In case of sterilization-grinding moderate maintenance are required resulting higher cost involvements. Again sterilization-compaction methods require extensive monitoring. Considering the matters, these methods are not suitable for Khulna city

Direct Irradiation

The reliability for providing good disinfection is an advantage of direct irradiation method. But the major disadvantages are high capital cost, no volume reduction and not suitable for infectious waste. It has also requires extensive monitoring of the process. So this method would not be suitable for the country like Bangladesh.

4.8.10 Protection of the Waste Handlers

The production, segregation, transportation, treatment and disposal of health-care waste involve the handling of potentially hazardous material. Protection against personal injury is therefore essential for all workers who are at risk. The individuals responsible for management for health-care waste should ensure that all risks are identified and that suitable protection from those risks is provided.

The type of protection clothing used will depend to an extent upon the risk associated with the health-care waste, but the following should be made available to all personnel who collect or handle health-care waste particularly for the proposed waste management system in Khulna:

- Helmets, with or without visors—incinerator operator.
- Face masks—incinerator operator and waste collector.
- Overalls (coverall)—incinerator operator and waste collector.
- Industrial aprons—incinerator operator and waste collector.
- Leg protectors and/or industrial boots—incinerator operator and waste collector.
- Disposable gloves (medical staff) or heavy-duty gloves (waste workers)—incinerator operator and waste collector.

Industrial boot and heavy-duty gloves are particularly important for waste workers. The thick soles of the boots offer protection in the storage area, as a precaution from spilled sharps, and where floors are slippery.

Operators of manually loaded incinerators should wear protective face visors and helmets. During ash and slag removal and other operations that create dust, dust masks should be provided for operators.

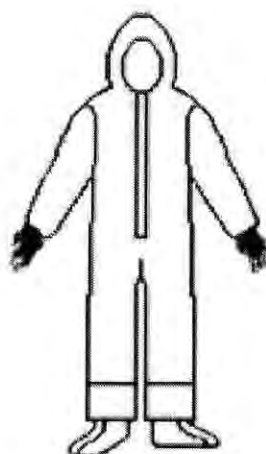


Figure 4.15 Recommended Protective Clothing for Health-Care Waste Transportation

4.8.11 Training of the Healthcare Personnel

A policy for the management of health-care waste cannot be effective unless it is applied carefully, consistently and universally. Training of health-care personnel in implementing the policy is thus critical if a waste management program is to be successful. The overall aim of training is to develop awareness of the health, safety and environmental issues relating to health-care waste and how these can affect employees in their daily work. It should highlight the roles and responsibilities of health-care personnel in the overall management program.

According to WHO (1999) training activities should be designed for and targeted to four main categories of personnel:

- Hospital managers and administrative staff responsible for implementing regulations on health-care waste management;
- Medical doctors;
- Nurse and assistant nurses;
- Cleaners, porters, auxiliary staff and waste handlers.

Since action is needed at management level, by those producing the waste as well as by the waste handlers, training of all of these categories of personnel is equally important. Medical doctors may be educated through senior staff workshops and general hospital

staff through formal seminars. The training of waste managers and regulators, however, could take place outside the hospitals at public health schools or in university departments.

Staff education programs should include:

- Information on and justification for all aspects of the health-care waste policy;
- Information on the role and responsibilities of each hospital staff member in implementing the policy;
- Technical instructions, relevant for the target group on the application of waste management practices.

The training program could be developed by the national government agency (Department of Health) or local Government (Khulna City Corporation) or by an international or development agency working in this field ('Prodipan').

4.8.12 Public Awareness

Promotion of the appropriate handling and disposal of healthcare waste is important for community health and every member of the community should have the right to be informed about potential health hazards.

The objectives of public education on health-care waste are the following:

- To prevent exposure to health-care waste and related health hazards; this exposure may be voluntary, in the case of scavengers or accidental as a consequence of unsafe disposal methods.
- To create awareness and foster responsibility among hospital patients and visitors to health-care establishments regarding hygiene and health-care waste management.
- To inform the public about the risks linked to health-care waste, focusing on people living or working in close proximity to, or visiting health-care establishments, families of patients treated at home and scavengers on waste dumps.

The following methods can be considered for public education on risks, waste segregation or waste disposal practices in Khulna city:

- Poster exhibitions on health-care waste issues including the risks involved in scavenging discarded syringes and hypodermic needles.
- Explanation of the waste management policy to incoming patients and visitors. This may be difficult to achieve, in which case the distribution the leaflets should be considered.
- Information poster exhibitions in hospitals at strategic points such as waste bin locations, giving instructions on waste segregation. Poster should be explicit using diagrams and illustrations to convey the message to as broad an audience as possible including illiterate people.

For maximum effectiveness, all information should be displayed or communicated in an attractive manner that will hold people's attention.

4.8.13 Investment and Operational Cost analysis of Different Options

The non-hazardous waste which forms the majority of waste can be disposed in ways similar to domestic waste. Only the hazardous waste needs to be treated.

Investment Cost Analysis Criteria

Investment cost includes the cost of plant, transporting truck, disposal containers, freight, custom duties, Value Added Tax (VAT), inland transport, land, building construction and miscellaneous. The capital cost was annualized over the loan maturity period. The annualized capital cost was calculated by multiplying the total capital cost by the Capital Recovery Factor (CRF).

$$CRF = \frac{r(1+r)^N}{r(1+r)^N - 1} \quad (\text{Ghee, 1991})$$

Where,

r = Interest rate

N = Loan maturity period

The loan maturity period has been determined by the average life period of that particular component.

Annual Operational and Maintenance Cost Analysis Criteria

The operational cost includes the cost of labor, driver, operator/ technician, power, fuel plastic containers and maintenance. The calculations of annual operational cost are based on a 3.5 hrs. operation per day with 350 days per year. The inputs required for each technology are given in Table-4.15.

Table 4.15 Description of the Inputs Required for the Treatment and Transportation of Waste

Inputs	Description	No. required
Incinerator /Microwave/ Autoclave	100 Kg/hr capacity	1
Building for incinerator	Around 200 sq. feet concrete building	1
Operator	--	1
Helper	Waste handler	1
Covered Truck	2 ton capacity, four compartments	1
Driver	--	1
Helper	Waste collector	1

The annual operational cost depends on the annual volume of hazardous waste to be treated. The analysis made on total yearly generation of hazardous waste based on present study data. The calculations are as follows:

- Generation rate of hazardous HCW = 0.15 kg/bed/day
- Total quantity of daily hazardous waste = 356 kg.
- Total quantity of yearly hazardous waste = 129.99 MT.
- Total number of hospital beds in Khulna city = 2050

The detail analysis of operating cost of 3 basic technologies (a) Incineration (b) Microwaving and (c) Autoclaving are presented in appendix B, C and D respectively

Treatment Options

Based on Appendix B, C and D generalized summaries of hazardous healthcare waste treatment options are shown in Table-4.16 for three basic technologies.

Table 4.16 Comparison of Healthcare Waste Treatment Technologies

Treatment Technology	Category of waste to be treated	Volume Reduction%	Operation cost per kg (Tk.)
Incineration	All	90-95	28.28
Microwaving	All except pathological	60-90	27.00
Autoclaving	All except pathological	0	24.27

From Table-4.18, it is found that all types of hazardous healthcare wastes can be treated by incineration. There are significant reductions in the volume of wastes (90-95%). Operating cost per kg of waste will be Tk. 28.28. Microwaving is not suitable for pathological waste; reduction in volume is comparatively less than incineration (60-90%). Operating cost for treatment per kg of waste will be Tk. 27.00. On the other hand autoclaving is not suitable for pathological waste and no reduction in volume (0%). The operating cost for treatment per kg of waste will be Tk. 24.27.

For selecting an efficient and effective waste management system, the factors which are to be considered includes evaluation and categorization of the types of waste to be treated, selection of an on-site or off-site system or a combination of both, selection of a type of equipment appropriate for the city, local regulation and cost. It is seen from the above discussion that incineration is better option in respect of performance though the operating cost is slightly more than the other option and thus suitable for Khulna city.

4.8.14 Comparison of Incinerator Operating Cost

Comparison of Operating Cost between Govt. Hospitals and SWM Sector of KCC

From Table-4.9, we have to know that the monthly expenditure of KCC in SWM sector is Tk.1152609

So, daily expenditure incurred = $\frac{1152609}{30}$ = Tk. 38420 (say).

Now, from study hazardous waste generation rate = 0.15 kg/bed/day. Total number of Govt. hospital bed in khulna city is 810 Nos. (Table-4.1)

So if incinerator would be installed then expected daily expenditure for incineration of hazardous waste per kg will be Tk 28.28 i.e. per bed cost = $28.28 \times 0.15 = 4.24$ Tk. [For 1 kg it will require Tk 28.28 for incineration]

It has been found that the daily expenditure of present healthcare waste management system of the Khulna Medical College Hospital is Tk. 2.40 per bed/ day (Appendix-E) if incinerator would be installed then the total expected cost per bed per day will be = Tk. 2.40 + Tk. 4.24 = Tk.6.64. Then total daily expenditure for 810 bed (Govt. hospital bed) = $810 \times \text{Tk. } 6.64 = \text{Tk. } 5378.00$. The comparison between existing and expected expenditure of KCC SWM and Govt. hospital waste management are presented in Table-4.17.

Table 4.17 Comparison between Existing and Expected Expenditure of KCC SWM and Govt. Hospital Waste Management

Component	Expenditure (Tk.)	
Present expenditure per bed per day	2.40	
Expected expenditure per bed per day if incinerator be installed	4.24	
Total daily Expected expenditure per bed per day	6.64	
Daily increase in cost	64%	
For Govt. 810 bed daily Expected expenditure		5378.00 (sec 4.6.14.1)
Daily present expenditure of KCC SWM		38420.00 (sec 4.6.14.1)
Total daily Expected expenditure		43798.00
Daily increase in cost if KCC operates incinerator		12%

It is found that the average expenditure of existing waste management system of Government hospital per bed per day is Tk. 2.40 (Appendix-E). If incinerator would be installed for treatment, then the extra cost per bed per day will be Tk. 4.24 that is the total expenditure for incineration of hazardous waste will become Tk.6.64 that means the increase in cost per bed per day for new option will be 64 %. On the other hand from Appendix-E, it is seen that the income of KMCH per bed per day is Tk. 7.40 i.e. the hospital authority can contribute up to 100 % of their present revenue earning to the operational cost if incinerator be installed. Alternatively it is seen from Table-4.30 that present per day expenditure for solid waste management of KCC is Tk. 43798.00. The expected daily expenditure of Govt. hospitals if incinerator would be installed will be Tk. 5378.00. Now if KCC takes the authority for operation of incinerator, then per day expenditure will become = Tk 38420.00 + Tk.5378.00 = Tk. 43798.00 i.e. the increase is only 12 % of daily present SWM expenditure of KCC.

Comparison of Operating Cost for Private Hospitals

The comparison of operating cost of incinerator for private hospitals if incinerator installed, presented at Table-4.18.

Table 4.18 Comparison between Existing and Expected Expenditure in Private Hospitals / Clinics if Incinerator be Installed

Component	Expenditure (Tk.)
Present expenditure per bed / day	3.55
Expected expenditure per bed / day if incinerator be installed	4.24
Total daily expected expenditure per bed /day	7.79
Daily increase in cost per bed / day if incinerator be installed	54%

It is found that expenditure of existing waste management per bed per day of 'Islami Bank Hospital' is Tk.3.55 (Appendix-F). If incinerator would be installed for treatment, then the extra cost per bed per day will be Tk.4.24 i.e. total expenditure for treatment of hazardous waste will become = Tk 3.55 + Tk 4.24 = Tk 7.79. The increase in cost per bed per day for new option will be 54 %. On the other hand from Appendix F, it is seen that

the income of ‘Islami Bank Hospital’ per bed per day is Tk. 899.00. So the hospital authority can contribute for operation of incineration by spending easily only 0.86 % per bed per day of their present daily income.

Comparison of Operating Cost for Private Diagnostic Centre

The comparison of operating cost of incinerator for Private Diagnostic Centre if incinerator installed, presented at Table-4.19.

Table 4.19 Comparison between Existing and Expected Expenditure in Private Diagnostic Centre if Incinerator be Installed

Component	Expenditure (Tk.)
Present expenditure of diagnostic centre / day	124.00
Expected expenditure of MDC / day if incinerator be installed	39.00
Total daily expected expenditure of diagnostic centre /day	163.00
Daily increase in cost of MDC/ day if incinerator be installed	24%

It is found that expenditure of existing waste management of Mahanagar Diagnostic Centre per day is Tk.124.00 (Appendix-G). If incinerator would be installed for treatment, then the extra cost of MDC per day will be Tk. $28.28 \times 1.37 = 39.00$ [For 1 kg it will require Tk 28.28 for incineration and hazardous waste generation rate per Diagnostic Centre per day is 1.37 kg. (Table-4.2)] i.e. total expenditure for treatment of hazardous waste will become = Tk. $39 + \text{Tk. } 124 = \text{Tk. } 163$. The increase in cost of diagnostic centre per day for new option will be 24%. On the other hand from Appendix G, it is seen that the income of Mahanagar Diagnostic Centre per day is Tk. 32917.00. So the diagnostic authority can contribute for operation of incineration by spending easily only 0.5% daily income per day of their present daily income.

4.8.15 Executive Authority

The above discussion shows that the project requires large investment, skilled manpower and institutional arrangement. The question is obvious- who will execute the project. The following alternatives could be explored-

Private organization

The Government of Bangladesh is also encouraging private entrepreneurs for even delivering community services like water supply, power supply etc. So there is an opportunity of the private sector to play an important role in the management of healthcare waste. There can be two types of private organizations according to their nature-

- Non-profit organization: Generally the NGOs and CBOs are termed as Non-profit organizations. They are fully dependent on the foreign donors for the finance of the projects. Unavailability of donation can make the project unsuccessful. This could not be an acceptable option for running such a large investment project.
- Commercial organization: commercial private entrepreneurs can also invest money to run the project on a commercial basis. But they will invest only when there will be a definite opportunity of making profit. For that, all the health centers are needed to be involved within the project. But a commercial entrepreneur does not have and means to ensure that only the authorized agency- KCC can.

The above discussion shows that neither non-profit nor commercial organization is capable enough to run the project effectively. So a public organization is proposed.

Public organization

Khulna City Corporation is the responsible authority for the collection and disposal of all types of waste in the city. So ideally it is the authority that would run the project. Moreover KCC has good institutional arrangements like legal provision; own dumping ground, office setup, relationship with the related government agencies and acceptance among the people. It has the power to impose fees or charges for the management of

hazardous waste. The most important constraint of KCC is the unavailability of fund. As KCC is already heavily dependent on the central Government for its budget, the obvious question is how KCC will invest so large amount of money for the healthcare waste management project. In this case, central Government may allocate additional budget for concerned local authority.

In a view of the above analysis, the ownership and operation of the incinerator in initial stage should be with the local authority like KCC. A Flow diagram of the expected improved system of Healthcare waste management is presented in Figure-4.16.

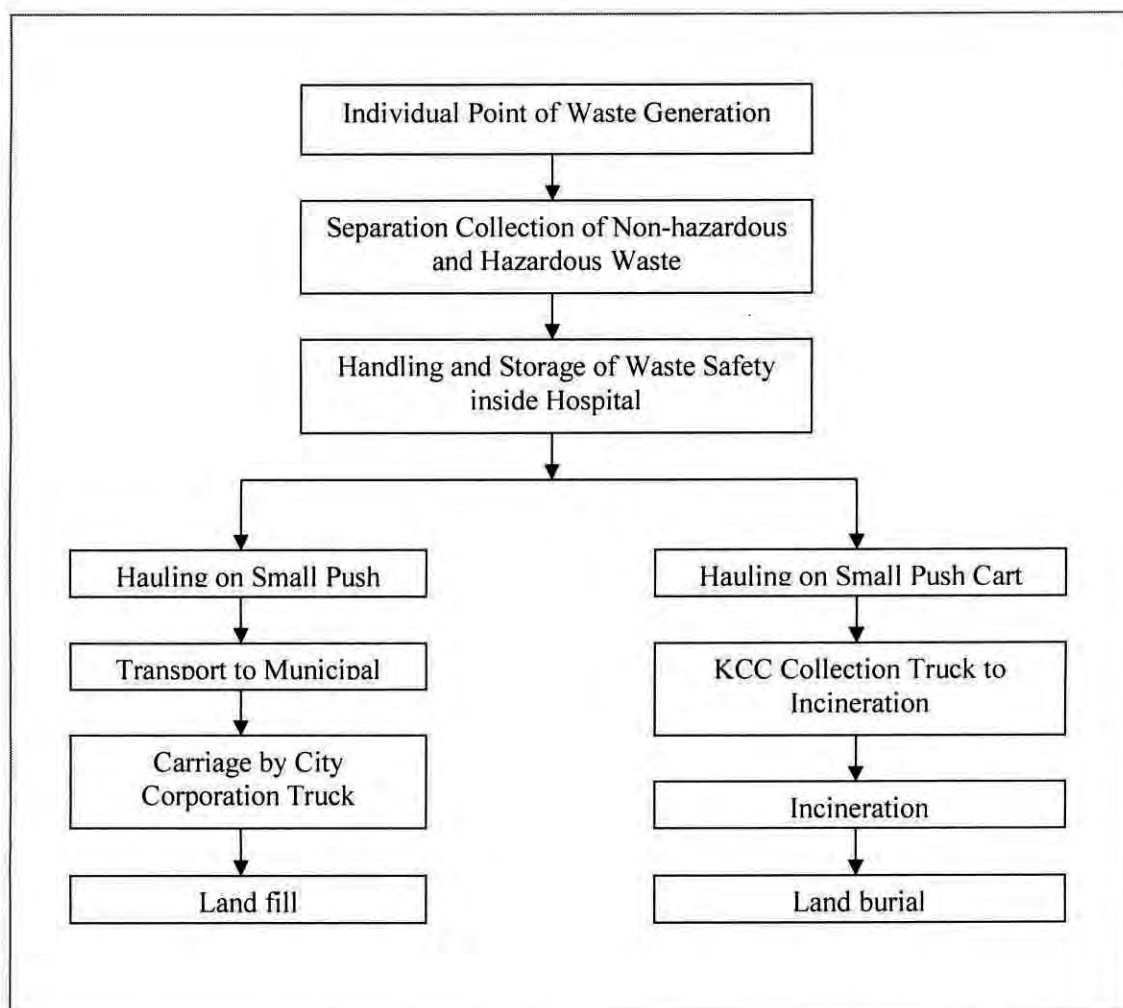


Figure 4.16 Flow Diagram of Improved System of Healthcare Waste Management

4.8.16 Concluding Remark

The numbers of HCEs are increasing day by day due to the huge increase in population. Still the hospitals are failing to meet the demand of the population. The waste generation rate varies from hospital to hospital depending upon the number of occupied beds in the hospitals. For this reason waste generation rate is higher in public hospitals than private hospitals.

The average healthcare waste generation rate (hazardous and non-hazardous) is about 0.85 kg per bed per day. Generation rate of waste per bed per day is slightly higher in the Govt. hospitals (0.87kg.) than the private hospitals (0.84kg). The generation rate of hazardous waste is 0.15 kg per bed per day (Table-4.2). The proportion of non-hazardous and hazardous wastes is 82% and 18% respectively (Table-4.4). The contribution of infectious waste, sharps and reusable/plastic type wastes are about 14.5%, 1 and 2.5%, respectively (Figure-4.1)

The present system of waste management has many drawbacks. Starting from collection of waste, segregation, treatment and final disposal nothing is done properly. Hazardous waste is not treated separately in almost all hospitals.

Intervention is required at all the stages of waste management-from the formulation of appropriate laws, segregation of waste, transportation of waste to the final disposal method. Among different treatment options, it has been found from the study that the incineration system is the most suitable one for Khulna city considering performance and cost effectiveness. However, the system should be maintained properly with appropriate air pollution control apparatus/device.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

From the overall review of the existing condition of healthcare waste management system in Khulna City, the following conclusions can be drawn:

- About 130 (Table-4.3) metric tons of hazardous waste is yearly generated in Khulna city from 110 registered HCEs. However, it is apparent from 'Prodipan (2007)' that the total number of HCEs in Khulna city is more than 153 nos. that include both registered and non-registered. If not managed properly, the patients and personnel involved in health care establishments, scavengers and the people around the health centers face a high risk of silent epidemics of infectious diseases like viral hepatitis, typhoid, gangrene, AIDS etc. Thus the proper management of healthcare waste has become an urgent necessity.
- The average waste generation rate in healthcare establishments is about 0.85 kg per bed per day that contains about 0.15 kg per bed per day of hazardous waste (Table-4.2). The proportions of hazardous and non-hazardous wastes are 82% and 18% respectively (Figure-4.1).
- It is evident from questionnaire survey of about 68 respondents that around 44% staffs got some form of training on the healthcare waste management and 56% staffs did not get any form of training (Figure-4.12) in existing waste management practices. Only around half of the respondents (47%) reported that they use safety equipment and clothing and around 47% respondents reported that they do not use any safety equipment and clothing (Figure-4.18).
- Sharps are handled in a carefree manner (Plate-4.14). Instead of using puncture proof box for needles and syringes ordinary bags and containers are used. This increases the possibility of spreading infectious diseases like hepatitis B, hepatitis C, HIV etc. by

needle and sharp injuries. In many situations, Plastics, sharps etc. are separated from the total healthcare waste for selling them to small vendors at low prices for recycling and reuse.

- Most of the HCEs (89 nos. out of more than 150 registered and non-registered hospitals, clinics and diagnostic centers) dispose of their generated waste including pathological waste (Figure-4.11) without disinfection and segregation directly into the KCC bins (Plate-4.17). This causes surface and ground water pollution problem. Locally made burning pit (Plate-4.6) is used by an NGO to burn infectious waste collected from selected HCEs at a comparatively low temperature (about 400°C or below). But this causes air pollution problems particularly in presence of plastics.
- It is found from the study that, the average expenditure of existing waste management system of Govt. hospital, Private hospital and Diagnostic centre are Tk.13/kg of waste, Tk. 25/kg of waste and Tk.62/kg of waste respectively.
- Assessment of cost of different treatment options indicate that the cost of incineration will be around Tk. 28.00 / kg of waste. The cost of microwaving will be Tk. 27.00 / kg of waste and the cost of autoclaving will be Tk. 24.00 / kg of waste. All types of hazardous healthcare wastes can be treated by incinerator and there are significant reductions in volume of wastes (90-95%). Microwaving is not suitable for pathological waste; reduction in volume is comparatively less than incineration (60-90%). On the other hand autoclaving is not suitable for pathological waste and no reduction in volume.

5.2 Recommendations

In Khulna city, healthcare waste is generally disposed of in the same way as ordinary domestic waste. In order to arrange a proper and systematic healthcare waste management, the following recommendations should be considered:

- Attempt should be made to segregate hazardous and non-hazardous portions. Color-coding of waste bags/containers should be adopted.
- KCC should start a separate collection and disposal system for healthcare waste.
- Protective clothing, masks, essential safety equipments are supplied to the waste handlers, employees, in-patients and out-patients which decrease the possibility of acquiring diseases like hepatitis, HIV/AIDS from the contaminated waste
- There is no penal action against improper disposal of hazardous waste. Therefore, it is necessary to formulate appropriate laws for the management of healthcare waste. There is the need of a National Waste Management Policy and National Waste Disposal and Management Guideline for Bangladesh.
- Awareness building of hospital staff and as well as the public about the harmfulness and proper handling of waste is necessary. Arrangement of training regarding sound management could minimize the health risk.
- Recycling and reuse of infected plastics and sharps needs to be stopped.
- A strong monitoring system should be developed to monitor the whole management system
- Increase involvement of private sector and NGOs in overall management process of healthcare waste for the city.

5.3 Future Research Direction

The present study has mainly focused on the existing waste management scenario of Khulna city and on the fact that how can it be made more efficient and acceptable one. A more detailed study about the potential hazards from improper management of the health care wastes is yet to be determined for Khulna city.

Again, the possibility of managing the healthcare waste at regional level has not been considered in this study. The nearby cities may develop a network between them for the treatment of the hazardous waste at a central treatment plant. A further detailed study is required to explore the economic and financial feasibility of such a regional level management option.

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APPENDIX A

Data Collection from Studied Health Care Establishments

Data Collection from KMCH

Duration: 15th July – 15th August / 2007

Total No. of bed: 500

Date	General Waste (Kg)	Infectious Waste (Kg)	Plastic type Waste (Kg)	Sharp Waste (Kg)	Grand Total (Kg)	Average Weight (Kg)	Std. Deviation
16/07/2007	298.61	56.08	5.78	4.62	365.09	406.39	21
18/07/2007	313.55	68.33	6.73	3.16	391.77		
23/07/2007	336.20	59.27	7.58	4.81	407.86		
25/07/2007	324.77	73.50	9.25	4.46	411.98		
29/07/2007	328.35	66.02	8.82	4.00	407.19		
13/08/2007	346.50	74.39	6.56	5.23	432.68		
14/08/2007	326.05	69.27	7.92	5.75	408.99		
15/08/2007	340.51	71.50	9.00	4.58	425.59		
Total	2614.54	538.36	61.64	36.61	3251.15		

Generation of Total waste (kg)	3251.15
Generation of waste (kg) / bed / day	$\frac{3251.15}{500 \times 8 \times 0.90^*} = 0.90$
Generation of Hazardous waste(kg)	636.61
Generation of Hazardous waste (kg) / bed / day	$\frac{636.61}{500 \times 8 \times 0.90^*} = 0.18$
Non-hazardous waste (%)	80
Hazardous waste (%)	20

* Max. Average Occupancy 90 %

Data Collection from Khulna General Hospital

Duration: 15th July – 15th August / 2007

Total No. of bed: 150

Date	General Waste (Kg)	Infectious Waste (Kg)	Plastic type Waste (Kg)	Sharp Waste (Kg)	Grand Total (Kg)	Average Weight (Kg)	Std. Deviation
16/07/2007	95.00	16.25	3.30	1.50	116.05	117.06	5
18/07/2007	97.20	12.50	3.75	1.75	115.20		
23/07/2007	98.00	18.00	3.00	0.98	119.98		
25/07/2007	94.55	10.89	2.95	1.27	109.66		
29/07/2007	97.84	16.20	3.50	2.00	119.54		
13/08/2007	95.30	15.00	2.58	1.55	114.43		
14/08/2007	98.85	22.50	2.85	0.95	125.15		
15/08/2007	95.50	16.00	3.20	1.77	116.47		
Total	772.24	127.34	25.13	11.77	936.48		

Generation of Total waste (kg)	936.48
Generation of waste (kg) / bed / day	$\frac{936.48}{150 \times 8 \times 0.90 *} = 0.87$
Generation of Hazardous waste (kg)	164.24
Generation of Hazardous waste (kg) / bed / day	$\frac{164.24}{150 \times 8 \times 0.90 *} = 0.15$
Non-hazardous waste (%)	82.5
Hazardous waste (%)	17.5

* Max. Average Occupancy 90 %

Data Collection from MCCC

Duration: 15th July – 15th August / 2007

Total No. of bed: 10

Date	General Waste (Kg)	Infectious Waste (Kg)	Plastic type Waste (Kg)	Sharp Waste (Kg)	Grand Total (Kg)	Average Weight (Kg)	Std. Deviation
16/07/2007	06.55	1.50	0.27	0.10	8.42	8.06	1
18/07/2007	05.92	0.90	0.23	0.15	7.20		
23/07/2007	07.00	1.20	0.50	0.12	8.82		
25/07/2007	06.25	0.85	0.37	0.10	7.57		
29/07/2007	05.50	1.00	0.44	0.09	7.03		
13/08/2007	06.27	1.35	0.29	0.15	8.06		
14/08/2007	06.80	0.80	0.35	0.09	8.04		
15/08/2007	07.84	1.00	0.38	0.12	9.34		
Total	52.13	8.60	2.83	0.92	64.48		

Generation of Total waste (kg)	64.48
Generation of waste (kg) / bed / day	$\frac{64.48}{10 \times 8 \times 0.95^*} = 0.85$

Generation of Hazardous waste (kg)	12.11
Generation of Hazardous waste (kg) / bed / day	$\frac{12.11}{10 \times 8 \times 0.95^*} = 0.16$

Non-hazardous waste (%)	81
Hazardous waste (%)	19

* Max. Average Occupancy 95 %

Data Collection from Khulna Sishu Hospital

Duration: 15th July – 15th August / 2007

Total No. of bed: 100

Date	General Waste (Kg)	Infectious Waste (Kg)	Plastic type Waste (Kg)	Sharp Waste (Kg)	Grand Total (Kg)	Average Weight (Kg)	Std. Deviation
15/07/2007	59.00	12.65	1.20	0.60	73.45	77.63	4
17/07/2007	71.55	09.00	0.85	1.00	82.40		
19/07/2007	65.20	12.84	1.55	0.45	80.04		
22/07/2007	54.52	10.60	2.00	1.80	68.92		
24/07/2007	65.20	11.45	2.95	0.65	80.25		
09/08/2007	63.88	10.82	1.30	1.52	77.52		
11/08/2007	61.56	13.90	1.78	1.20	78.44		
12/08/2007	64.25	12.80	2.50	0.50	80.05		
Total	505.16	94.06	14.13	7.72	621.07		

Generation of Total waste (kg)	621.07
Generation of waste (kg) / bed /day	$\frac{621.07}{100 \times 8 \times 0.95^*} = 0.82$

Generation of Hazardous waste (kg)	115.91
Generation of Hazardous waste (kg) / bed /day	$\frac{115.91}{100 \times 8 \times 0.95^*} = 0.15$

Non-hazardous waste (%)	81
Hazardous waste (%)	19

* Max. Average Occupancy 95 %

Data Collection from GNCDC

Duration: 15th July – 15th August / 2007

Total No. of bed: 50

Date	General Waste (Kg)	Infectious Waste (Kg)	Plastic type Waste (Kg)	Sharp Waste (Kg)	Grand Total (Kg)	Average Weight (Kg)	Std. Deviation
15/07/2007	31.00	5.80	1.55	0.38	38.73	37.43	3
17/07/2007	25.51	4.31	0.80	0.45	31.07		
19/07/2007	30.50	6.91	0.97	0.50	38.88		
22/07/2007	32.53	5.32	0.25	0.67	38.77		
24/07/2007	30.82	7.21	0.50	0.36	38.89		
09/08/2007	27.91	6.82	0.67	0.50	35.90		
11/08/2007	33.87	6.50	0.75	0.22	41.34		
12/08/2007	30.12	5.00	0.20	0.55	35.87		
Total	242.26	47.87	5.69	3.63	299.45		

Generation of Total waste (kg)	299.45
Generation of waste (kg) / bed /day	$\frac{299.45}{50 \times 8 \times 0.90 *} = 0.83$

Generation of Hazardous waste (kg)	57.19
Generation of Hazardous waste (kg) / bed /day	$\frac{57.19}{50 \times 8 \times 0.90 *} = 0.16$

Non-hazardous waste (%)	81
Hazardous waste (%)	19

* Max. Average Occupancy 90 %

Data Collection from IBH

Duration: 15th July – 15th August / 2007.

Total No. of bed: 40

Date	General Waste (Kg)	Infectious Waste (Kg)	Plastic type Waste (Kg)	Sharp Waste (Kg)	Grand Total (Kg)	Average Weight (Kg)	Std. Deviation
15/07/2007	31.25	4.27	0.48	0.15	36.15	34.19	3
17/07/2007	28.00	5.00	0.35	0.20	33.55		
19/07/2007	26.81	4.25	0.50	0.15	31.71		
22/07/2007	32.50	5.28	0.40	0.50	38.68		
24/07/2007	30.00	6.08	0.46	0.18	36.72		
09/08/2007	25.00	4.25	0.90	0.30	29.94		
11/08/2007	25.00	5.18	0.42	0.25	30.85		
12/08/2007	31.10	4.13	0.45	0.28	35.96		
Total	229.66	38.44	3.96	2.01	273.56		

Generation of Total waste (kg)	273.56
Generation of waste (kg) / bed /day	$\frac{273.56}{40 \times 8 \times 1.00 *} = 0.85$

Generation of Hazardous waste (kg)	44.41
Generation of Hazardous waste (kg) / bed /day	$\frac{44.41}{40 \times 8 \times 1.00 *} = 0.14$

Non-hazardous waste (%)	84
Hazardous waste (%)	16

* Max. Average Occupancy 100 %

Data Collection from Dabs Clinic

Duration: 15th July – 15th August / 2007

Total No. of bed: 30

Date	General Waste (Kg)	Infectious Waste (Kg)	Plastic type Waste (Kg)	Sharp Waste (Kg)	Grand Total (Kg)	Average Weight (Kg)	Std. Deviation
15/07/2007	20.50	3.00	0.38	0.13	24.01	23.43	2
17/07/2007	19.40	2.80	0.40	0.11	22.71		
19/07/2007	22.75	3.90	0.35	0.20	27.20		
22/07/2007	21.00	4.20	0.46	0.15	25.81		
24/07/2007	17.80	2.80	0.50	0.10	21.20		
09/08/2007	19.24	3.50	0.43	0.18	23.35		
11/08/2007	17.22	2.00	0.29	0.08	19.59		
12/08/2007	20.00	3.13	0.34	0.11	23.58		
Total	157.91	25.33	3.15	1.06	187.45		

Generation of Total waste (kg)	187.45
Generation of waste (kg) / bed /day	$\frac{187.45}{30 \times 8 \times 0.95^*} = 0.82$

Generation of Hazardous waste (kg)	29.54
Generation of Hazardous waste (kg) / bed /day	$\frac{29.54}{30 \times 8 \times 0.95^*} = 0.13$

Non-hazardous waste (%)	84
Hazardous waste (%)	16

* Max. Average Occupancy 95 %

Data Collection from Khalishpur Clinic

Duration: 15th July – 15th August / 2007

Total No. of bed: 25

Date	General Waste (Kg)	Infectious Waste (Kg)	Plastic type Waste (Kg)	Sharp Waste (Kg)	Grand Total (Kg)	Average Weight (Kg)	Std. Deviation
15/07/2007	15.00	2.50	0.35	0.12	17.97	20.46	2
17/07/2007	18.50	3.00	0.27	0.38	22.15		
19/07/2007	16.00	3.20	1.50	0.15	20.85		
22/07/2007	19.00	4.80	0.32	0.13	24.25		
24/07/2007	18.25	2.50	0.43	0.10	21.28		
09/08/2007	15.80	2.28	0.28	0.50	18.86		
11/08/2007	16.50	2.50	0.30	0.12	19.42		
12/08/2007	14.50	3.50	0.50	0.39	18.89		
Total	133.55	24.28	3.95	1.89	163.67		

Generation of Total waste (kg)	163.67
Generation of waste (kg) / bed /day	$\frac{163.67}{25 \times 8 \times 0.95^*} = 0.86$

Generation of Hazardous waste (kg)	30.12
Generation of Hazardous waste (kg) / bed /day	$\frac{30.12}{25 \times 8 \times 0.95^*} = 0.16$

Non-hazardous waste (%)	82
Hazardous waste (%)	18

* Max. Average Occupancy 95 %

Data Collection from Fair Health Clinic

Duration: 15th July – 15th August / 2007

Total No. of bed: 15

Date	General Waste (Kg)	Infectious Waste (Kg)	Plastic type Waste (Kg)	Sharp Waste (Kg)	Grand Total (Kg)	Average Weight (Kg)	Std. Deviation
15/07/2007	11.10	1.25	0.15	0.10	12.60	11.28	2
17/07/2007	09.88	1.77	0.35	0.12	12.12		
19/07/2007	07.65	1.00	1.12	0.09	09.86		
22/07/2007	08.00	0.80	0.18	0.12	09.10		
24/07/2007	09.90	1.88	0.38	0.07	12.23		
09/08/2007	06.75	0.97	0.15	0.12	07.99		
11/08/2007	12.00	1.39	0.50	0.10	13.99		
12/08/2007	10.17	2.00	0.15	0.09	12.41		
Total	75.45	11.06	2.98	0.81	90.30		

Generation of Total waste (kg)	90.30
Generation of waste (kg) / bed /day	$\frac{90.30}{15 \times 8 \times 0.90^*} = 0.84$

Generation of Hazardous waste (kg)	14.85
Generation of Hazardous waste (kg) / bed /day	$\frac{14.85}{15 \times 8 \times 0.90^*} = 0.14$

Non-hazardous waste (%)	84
Hazardous waste (%)	16

* Max. Average Occupancy 90 %

Data Collection from Decent Dental Clinic

Duration: 15th July – 15th August / 2007

Total No. of bed: 0

Date	General Waste (Kg)	Infectious Waste (Kg)	Plastic type Waste (Kg)	Sharp Waste (Kg)	Grand Total (Kg)	Average Weight (Kg)	Std. Deviation
15/07/2007	2.25	0.28	0.23	0.10	2.86	2.76	1
17/07/2007	2.98	0.22	0.12	0.13	3.45		
19/07/2007	2.50	0.43	0.09	0.10	3.12		
22/07/2007	1.51	0.50	0.17	0.15	2.33		
24/07/2007	1.63	0.15	0.15	0.11	2.04		
09/08/2007	2.32	0.20	0.12	0.13	2.77		
11/08/2007	1.70	0.28	0.13	0.10	2.21		
12/08/2007	2.78	0.17	0.20	0.18	3.33		
Total	17.67	2.23	1.21	1.00	22.11		

Generation of Total waste (kg)	22.11
Generation of waste (kg) /day	$\frac{22.11}{8} = 2.76$

Generation of Hazardous waste (kg)	4.44
Generation of Hazardous waste(kg) /day	$\frac{4.44}{8} = 0.55$

Non-hazardous waste (%)	80
Hazardous waste (%)	20

Data Collection from Mahanagar Diagnostic Centre

Duration: 15th July – 15th August / 2007

Total No. of bed: 0

Date	General Waste (Kg)	Infectious Waste (Kg)	Plastic type Waste (Kg)	Sharp Waste (Kg)	Grand Total (Kg)	Average Weight (Kg)	Std. Deviation
15/07/2007	4.50	0.92	0.70	0.65	6.77	5.77	1
17/07/2007	3.77	1.00	0.50	0.50	5.77		
19/07/2007	4.00	1.65	0.48	0.80	6.93		
22/07/2007	3.92	0.56	0.27	0.68	5.43		
24/07/2007	4.20	0.50	0.68	0.29	5.67		
09/08/2007	2.50	1.00	0.50	0.37	4.37		
11/08/2007	3.90	0.50	0.29	0.61	5.30		
12/08/2007	3.55	1.00	0.41	1.00	5.96		
Total	30.34	07.13	3.83	4.90	46.20		

Generation of Total waste (kg)	46.20
Generation of waste (kg) /day	$\frac{46.20}{8} = 5.77$

Generation of Hazardous waste (kg)	15.86
Generation of Hazardous waste (kg) /day	$\frac{15.86}{8} = 1.98$

Non-hazardous waste (%)	66
Hazardous waste (%)	34

Data Collection from Setu Diagnostic Centre

Duration: 15th July – 15th August / 2007

Total No. of bed: 0

Date	General Waste (Kg)	Infectious Waste (Kg)	Plastic type Waste (Kg)	Sharp Waste (Kg)	Grand Total (Kg)	Average Weight (Kg)	Std. Deviation
15/07/2007	3.20	0.80	0.25	0.44	4.69	4.54	1
17/07/2007	2.50	0.92	0.31	0.50	4.23		
19/07/2007	3.80	1.00	0.50	0.28	5.58		
22/07/2007	2.32	0.58	0.27	0.65	3.82		
24/07/2007	2.78	1.00	0.50	0.69	4.97		
09/08/2007	3.51	0.50	0.20	0.32	4.53		
11/08/2007	3.00	0.81	0.25	0.40	4.46		
12/08/2007	2.55	0.55	0.41	0.55	4.06		
Total	23.66	6.16	2.69	3.83	36.34		

Generation of Total waste (kg)	36.34
Generation of waste (kg) /day	$\frac{36.34}{8} = 4.54$

Generation of Hazardous waste (kg)	12.68
Generation of Hazardous waste (kg) /day	$\frac{12.68}{8} = 1.58$

Non-hazardous waste (%)	65
Hazardous waste (%)	35

APPENDIX B

Cost Analysis of Incineration System

Data for Cost Analysis of Incineration System

- | | |
|---|------------|
| 1. Quantity of Hazardous Waste per year (Generation rate)
(0.15 kg / bed / day and total no. of bed are 2050 Nos.) | =129940 kg |
| 2. Daily operating period (maximum) | =3.5 hrs |
| 3. Days of operation per year | =350 days |
| 4. No. of incinerator of 100 kg / hr. capacity maximum | =1 Nos. |
| 5. Transporting Vehicle of 2 ton capacity | =1 Nos. |
| 6. Estimated average life of Incinerator | =14 yrs. |
| 7. Estimated average life of Transporting Vehicle | =10 yrs. |
| 8. Estimated average life of Container | =3 yrs. |
| 9. Interest rate per year | =12.5% |
| 10. Loan maturity period | =14 yrs. |
| 11. Capital Recovery Factor | Where, |

$$CRF = \frac{r(1+r)^N}{r(1+r)^N - 1}$$

r = interest rate

N = Loan maturity period

Cost of Incinerator

1. Capital Cost

Item	Description	Cost (Tk)
Price of incinerator	100 kg / hr (capacity)	5000000*
Spare parts (for 10 years)	--	300000
Freight LS	--	200000
C & F price (Sum of 1,2&3)		5500000
CD, VAT and other fees	82.5% of C & F price	4537500
Inland transport from Ctg. Port to Khulna LS	--	25000
Installation Supervision cost by one expert (3 weeks)	--	375000
Land	Provided by KCC	--
Building construction	200 sq. feet (Tk.2000/sq.feet)	400000
Installation cost	5% of the price of incinerator	250000
Subtotal		11087500
Contingency 10% of Subtotal		1108750
Total		12196250

*The value is including the cost of air pollution control device

Estimated average life of incinerator = 14 years

Loan maturity period = 14 years

Rate of interest = 12.5%

$$CRF = \frac{0.125(1+0.125)^{14}}{(1+0.125)^{14} - 1} = 0.154$$

Annualized capital cost = Tk. 18, 78,222

2. Operation and Maintenance Cost (Annual)

Item	Description	Cost (Tk)
Operator	@ 5000 Tk. per month	60000
Labour	@ 3500 Tk. per month	42000
Fuel-oil consumption	@ 0.08 kg per kg of waste	312000
Electricity consumption	@ 6125 kWh (commercial rate Tk. 4.5/-)	27562
Maintenance cost	10% of C&F price per year	550000
Total		991562

Cost of Transporting Truck

1. Capital Cost

Item	Description	Cost (Tk)
Vehicle	2 ton capacity	850000
Spare parts (for 10 years)	--	100000
C & F price		950000
CD, VAT and other fees	82.5% of C & F price	783750
Inland transport cost from Ctg. Port to Dhaka LS	--	10000
Sub-Total		1743750
Contingency 10% of Subtotal		174375
Total		1917625

Estimated average life of the truck = 10 years

Loan maturity period = 10 years

Rate of interest = 12.5%

$$\text{CRF} = \frac{0.125(1+0.125)^{10}}{(1+0.125)^{10}-1} = 0.18$$

Annualized capital cost = Tk. 3, 45,173

2. Operation and Maintenance Cost (Annual)

Item	Description	Cost (Tk)
Driver	@ 5000 Tk per month	60000
Helper	@ 3500 Tk per month	42000
Fuel consumption	@ 30 km per day; 5 km/liter; Tk.33/liter	69300
Maintenance cost	10% of the purchase price per year	191763
Total		363063

Cost of Waste Container

1. Number of Containers Required for the Disposal of Waste

Type of container	Description	No. of containers
Small covered drum	@ 4 pc. per 15 beds	547 pc.
	@ 4 pc. per operation theater	316 pc.
	@ 4 pc. per diagnostic centre/dental clinic	124 pc.
Sub-total		987 pc.
Small covered bucket	@ 1 pc. per bed	2050 pc.
Large drums	1 drum for each of the four compartments of the truck	4 pc.

2. Capital Cost

Item	Description	Cost (Tk.)
Price of small covered drum	@ Tk. 150 per drum	1,48,050
Spare drums (for 3 years)	@ 20 drums per year	9,000
Small covered bucket	@ Tk. 30 per bucket	61,500
Spare bucket (for 3 years)	@ 100 bucket per year	9,000
Large drums	@ Tk. 1200 per drum	3,600
Total		2,31,150

Estimated average life of containers = 3 years

Loan maturity period = 3 years

Rate of interest = 12.5%

$$\text{CRF} = \frac{0.125(1+0.125)^3}{(1+0.125)^3 - 1} = 0.419$$

Annualized capital cost = Tk. 96852

Total Annual Cost

1. Total Cost

Sector	Annualized capital cost (Tk)	Operation and maintenance cost (Tk)	Total (Tk)
Incineration	1878222	991562	2869784
Transportation	345173	363063	708236
Container buying	96852	--	96852
Total	2320247	1354625	3674872

2. Calculation of Operation Cost per Kg of Healthcare Waste

The operational costs depend on the generation of annual quantity of hazardous wastes to be burned in the incinerator. As per study total yearly quantity of hazardous waste would be approximately 129940 (based on present operation rate);

So, operation cost / kg = $\frac{3674872}{129940} = 28.28$ Tk.

APPENDIX C

Cost Analysis of Microwaving System

Data for Cost Analysis of Microwave

- | | |
|---|------------|
| 1. Quantity of Hazardous Waste per year (Generation rate)
(0.15 kg / bed / day and total no. of bed are 2050 Nos.) | =129940 kg |
| 2. Daily operating period (maximum) | =3.5 hrs |
| 3. Days of operation per year | =350 days |
| 4. No. of Microwave of 100 kg / hr. capacity maximum | =1 Nos. |
| 5. Transporting Vehicle of 2 ton capacity | =1 Nos. |
| 6. Estimated average life of Microwave | =14 yrs. |
| 7. Estimated average life of Transporting Vehicle | =10 yrs. |
| 8. Estimated average life of Container | =3 yrs. |
| 9. Interest rate per year | =12.5% |
| 10. Loan maturity period | =14 yrs. |
| 11. Capital Recovery Factor | Where, |

$$CRF = \frac{r(1+r)^N}{r(1+r)^N - 1}$$

r = interest rate
N = Loan maturity period

Cost of Microwave

1. Capital Cost

Item	Description	Cost (Tk)
Price of Microwave including installation	100 kg / hr (capacity)	5000000
Spare parts (for 10 years)	--	200000
Freight LS	--	200000
C & F price (Sum of 1,2&3)		5400000
CD, VAT and other fees	82.5% of C & F price	4455000
Inland transport from Ctg. Port to Khulna LS	--	25000
Land	Provided by KCC	--
Building construction	200 sq. feet (Tk.2000/sq.feet)	400000
Subtotal		10280000
Contingency 10% of Subtotal		1028000
Total		11308000

Estimated average life of Microwave = 14 years

Loan maturity period = 14 years

Rate of interest = 12.5%

$$\text{CRF} = \frac{0.125(1+0.125)^{14}}{(1+0.125)^{14} - 1} = 0.154$$

Annualized capital cost = Tk. 1741432

2. Operation and Maintenance Cost (Annual)

Item	Description	Cost (Tk)
Operator	@ 5000 Tk per month	60000
Labour	@ 3500 Tk per month	42000
Electricity consumption	@ 63000 kWh (commercial rate Tk. 4.5/-)	283500
Maintenance cost	10% Of C&F price per year	540000
Total		925500

Cost of Transporting Truck

1. Capital Cost

Item	Description	Cost (Tk)
Vehicle	2 ton capacity	850000
Spare parts (for 10 years)	--	100000
C & F price		950000
CD, VAT and other fees	82.5% of C & F price	783750
Inland transport cost from Ctg. Port to Dhaka LS	--	10000
Sub-Total		1743750
Contingency 10% of Subtotal		174375
Total		1917625

Estimated average life of the truck = 10 years

Loan maturity period = 10 years

Rate of interest = 12.5%

$$\text{CRF} = \frac{0.125(1 + 0.125)^{10}}{(1 + 0.125)^{10} - 1} = 0.18$$

Annualized capital cost = Tk. 3,45,173

2. Operation and Maintenance Cost (Annual)

Item	Description	Cost (Tk)
Driver	@ 5000 Tk per month	60000
Helper	@ 3500 Tk per month	42000
Fuel consumption	@ 30 km per day; 5 km/liter; Tk.33/liter	69300
Maintenance cost	10% of the purchase price per year	191763
Total		363063

Cost of Waste Container

1. Number of Containers Required for the Disposal of Waste

Type of container	Description	No. of containers
Small covered drum	@ 4 pc. per 15 beds	547 pc.
	@ 4 pc. per operation theater	316 pc.
	@ 4 pc. per diagnostic centre/dental clinic	124 pc.
Sub-total		987 pc.
Small covered bucket	@ 1 pc. per bed	2050 pc.
Large drums	1 drum for each of the four compartments of the truck	4 pc.

2. Capital Cost

Item	Description	Cost (Tk.)
Price of small covered drum	@ Tk. 150 per drum	1,48,050
Spare drums (for 3 years)	@ 20 drums per year	9,000
Small covered bucket	@ Tk. 30 per bucket	61,500
Spare bucket (for 3 years)	@ 100 bucket per year	9,000
Large drums	@ Tk. 1200 per drum	3,600
Total		2,31,150

Estimated average life of containers = 3 years

Loan maturity period = 3 years

Rate of interest = 12.5%

$$\text{CRF} = \frac{0.125(1+0.125)^3}{(1+0.125)^3 - 1} = 0.419$$

Annualized capital cost = Tk. 96852

Total Annual Cost

1. Total Cost

Sector	Annualized capital cost (Tk)	Operation and maintenance cost (Tk)	Total (Tk)
Micro waving	1741432	925500	2666932
Transportation	345173	363063	708236
Container buying	96852	--	96852
Total	2183457	1288563	3472020

2. Calculation of Operation Cost per Kg of Healthcare Waste

The operational costs depend on the generation of annual quantity of hazardous wastes to be burned in the Microwave. As per study total yearly quantity of hazardous waste would be approximately 129940 (based on present operation rate);

So, operation cost / kg = $\frac{3472020}{129940} = 27.00$ Tk.

APPENDIX D

Cost Analysis of Autoclaving System

Data for Cost Analysis of Autoclave

- | | | |
|-----|--|------------|
| 1. | Quantity of Hazardous Waste per year (Generation rate)
(0.15 kg / bed / day and total no. of bed are 2050 Nos.) | =129940 kg |
| 2. | Daily operating period (maximum) | =3.5 hrs |
| 3. | Days of operation per year | =350 days |
| 4. | No. of Autoclave of 100 kg / hr. capacity maximum | =1 Nos. |
| 5. | Transporting Vehicle of 2 ton capacity | =1 Nos. |
| 6. | Estimated average life of Autoclave | =14 yrs. |
| 7. | Estimated average life of Transporting Vehicle | =10 yrs. |
| 8. | Estimated average life of Container | =3 yrs. |
| 9. | Interest rate per year | =12.5% |
| 10. | Loan maturity period | =14 yrs. |
| 11. | Capital Recovery Factor | Where, |

$$CRF = \frac{r(1+r)^N}{r(1+r)^N - 1}$$

r = interest rate

N = Loan maturity period

Cost of Autoclave

1. Capital Cost

Item	Description	Cost (Tk)
Price of Autoclave	100 kg / hr (capacity)	3800000
Spare parts (for 10 years)	--	200000
Freight LS	--	200000
C & F price (Sum of 1,2&3)		4200000
CD, VAT and other fees	82.5% of C & F price	3465000
Inland transport from Ctg. Port to Khulna LS	--	25000
Land	Provided by KCC	--
Building construction	200 sq. feet (Tk.2000/sq.feet)	400000
Installation Cost	20% of C & F price	840000
Subtotal		8930000
Contingency 10% of Subtotal		893000
Total		9823000

Estimated average life of Autoclave = 14 years

Loan maturity period = 14 years

Rate of interest = 12.5%

$$\text{CRF} = \frac{0.125(1+0.125)^{14}}{(1+0.125)^{14}-1} = 0.154$$

Annualized capital cost = Tk. 1512742

2. Operation and Maintenance Cost (Annual)

Item	Description	Cost (Tk)
Operator	@ 5000 Tk per month	60000
Labour	@ 3500 Tk per month	42000
Electricity consumption	@ 70000 kWh (commercial rate Tk. 4.5/-)	315000
Maintenance cost	10% of C&F price per year	420000
Total		837000

Cost of Transporting Truck

1. Capital Cost

Item	Description	Cost (Tk)
Vehicle	2 ton capacity	850000
Spare parts (for 10 years)	--	100000
C & F price		950000
CD, VAT and other fees	82.5% of C & F price	783750
Inland transport cost from Ctg. Port to Dhaka LS	--	10000
Sub-Total		1743750
Contingency 10% of Subtotal		174375
Total		1917625

Estimated average life of the truck = 10 years

Loan maturity period = 10 years

Rate of interest = 12.5%

$$\text{CRF} = \frac{0.125(1 + 0.125)^{10}}{(1 + 0.125)^{10} - 1} = 0.18$$

Annualized capital cost = Tk. 3,45,173

2. Operation and Maintenance Cost (Annual)

Item	Description	Cost (Tk)
Driver	@ 5000 Tk per month	60000
Helper	@ 3500 Tk per month	42000
Fuel consumption	@ 30 km per day; 5 km/liter; Tk.33/liter	69300
Maintenance cost	10% of the purchase price per year	191763
Total		363063

Cost of Waste Container

1. Number of Containers Required for the Disposal of Waste

Type of container	Description	No. of containers
Small covered drum	@ 4 pc. per 15 beds	547 pc.
	@ 4 pc. per operation theater	316 pc.
	@ 4 pc. per diagnostic centre/dental clinic	124 pc.
Sub-total		987 pc.
Small covered bucket	@ 1 pc. per bed	2050 pc.
Large drums	1 drum for each of the four compartments of the truck	4 pc.

2. Capital Cost

Item	Description	Cost (Tk.)
Price of small covered drum	@ Tk. 150 per drum	148050
Spare drums (for 3 years)	@ 20 drums per year	9000
Small covered bucket	@ Tk. 30 per bucket	61500
Spare bucket (for 3 years)	@ 100 bucket per year	9000
Large drums	@ Tk. 1200 per drum	3600
Total		231150

Estimated average life of containers = 3 years

Loan maturity period = 3 years

Rate of interest = 12.5%

$$\text{CRF} = \frac{0.125(1+0.125)^3}{(1+0.125)^3 - 1} = 0.419$$

Annualized capital cost = Tk. 96852

Total Annual Cost

1. Total Cost

Sector	Annualized capital cost (Tk)	Operation and maintenance cost (Tk)	Total (Tk)
Autoclaving	1512742	837000	2349742
Transportation	345173	363063	708236
Container buying	96852	--	96852
Total	1954767	1200063	3154830

2. Calculation of Operation Cost per Kg of Healthcare Waste

The operational costs depend on the generation of annual quantity of hazardous wastes to be burned in the Autoclave. As per study total yearly quantity of hazardous waste would be approximately 129940 (based on present operation rate);

$$\text{So, operation cost / kg} = \frac{3154830}{129940} = 24.27\text{Tk.}$$

APPENDIX E

Breakdown of Existing Expenditure of Healthcare Waste Management of KMCH

Breakdown of Existing Expenditure of Healthcare Waste Management System of KMCH (Monthly Basis)

E1 Cost of Consumed Materials (July, 2007)

Sector	Expenditure
Cleaning goods (bleaching powder, soap, soda, phenol, harpic, savlon, floor brush, spirit, jute or scrubber, etc.)	38000
Disposal pot (bowl, bucket, waste tray)	5000
Gloves/ aprons for cleaners/ sweepers	5000
Cost of Final disposal	3500
Total	51500

E2 Cost of Personnel Associated with Waste Management

i. Total number of cleaner = 33 nos. @ Monthly salary 2800/ cleaner
 $= 33 \times 2800 = \text{Tk. } 92400 - [A]$

ii. Considering 20% input of [A] involved in
Waste management activities such as Ward master,
Ward boy, Section head, Store officer, Department head, etc. = Tk. 18480

Total of E2 = Tk. 110880

E3 Total Monthly Expenditure

= Summation of E1+E2
= Tk. 51500 + Tk. 110880 = Tk. 162380.00

Now considering maximum occupancy of 90%, the cost / bed / day = $\frac{162380.00}{500 \times 30 \times 0.90} = \text{Tk. } 12.00$

From survey result it has been found that the hazardous healthcare waste generation rate / bed / day is 0.18 kg and the total waste generation rate / bed / day is 0.90 kg. So the existing expenditure for hazardous waste management per bed per day is,

$$\frac{12.00}{0.90} \times 0.18 = \text{Tk. } 2.40$$

E4 Monthly Income of KMCH

Fiscal year	Amount (Tk.)	Source of income
2005-2006	1264286.00	- Cabin charges - Paying charge - Testing charge - Admission fee - Tender schedule sale, etc.
2006-2007	1397040.00	
Total 2 years income	2661326.00	
Monthly income	$2661326.00 / (2 \times 12)$ = 110889.00	
Income / bed / day	$110889.00 / (30 \times 500)$ = 7.40	

Source: Field survey, 2007

APPENDIX F

Breakdown of Existing Expenditure of Healthcare Waste Management of Islami Bank Hospital

Breakdown of Existing Expenditure of Healthcare Waste Management System of Islami Bank Hospital (Monthly Basis)

F1 Cost of Consumed Materials (July, 2007)

Sector	Expenditure
Cleaning goods (bleaching powder, soap, soda, phenol, harpic, savlon, floor brush, spirit, jute or scrubber, etc.)	5000
Disposal pot (bowl, bucket, waste tray)	1500
Gloves/ aprons for cleaners/ sweepers	500
Cost of Final disposal	900
Total	7900

F2 Cost of Personnel Associated with Waste Management

i. Total number of cleaner = 5 nos. @ Monthly salary 3000/ cleaner
 $= 5 \times 3000 = \text{Tk. } 15000 - [A]$

ii. Considering 20% input of [A] involved in
Waste management activities such as Ward master, Sister
Ward boy
 $= \text{Tk. } 3000$

Total of F2 $= \text{Tk. } 18000$

F3 Total Monthly Expenditure

= Summation of F1+F2
 $= \text{Tk. } 7900 + \text{Tk. } 18000 = \text{Tk. } 25900.00$

Now considering maximum occupancy of 100%, the cost / bed / day = $\frac{25900.00}{40 \times 30 \times 1} = \text{Tk. } 21.58$

From survey result it has been found that the hazardous healthcare waste generation rate / bed / day is 0.14 kg and the total waste generation rate / bed / day is 0.85 kg. So the existing expenditure for hazardous waste management per bed per day is,

$$\frac{21.58}{0.85} \times 0.14 = \text{Tk. } 3.55$$

F4 Monthly Income of IBH

Fiscal year	Amount (Tk.)	Source of income
2005-2006	12000000.00	• Cabin charges • Paying charge • Testing charge • Admission fee, etc.
2006-2007	13900000.00	
Total 2 years income	25900000.00	
Monthly income	$25900000.00 / (2 \times 12)$ $= 1079167.00$	
Income / bed / day	$1079167.00 / (30 \times 40)$ $= 899$	

Source: Field survey, 2007

APPENDIX G

Breakdown of Existing Expenditure of Healthcare Waste Management of Mahanagar Diagnostic Centre

Breakdown of Existing Expenditure of Healthcare Waste Management System of Mahanagar Diagnostic Centre (Monthly Basis)

G1 Cost of consumed Materials (July, 2007)

Sector	Expenditure
Cleaning goods (bleaching powder, soap, soda, phenol, harpic, savlon, floor brush, spirit, jute or scrubber, etc.)	4000
Disposal pot (bowl, bucket, waste tray)	1000
Gloves/ aprons for cleaners/ sweepers	500
Cost of Final disposal	300
Total	5800

G2 Cost of Personnel Associated with Waste Management

i. Total number of cleaner = 2 nos. @ Monthly salary 2500/ cleaner

$$\text{Total of G2} = 2 \times 2500 = \text{Tk. 5000}$$

G3 Total Monthly Expenditure

= Summation of G1+G2

$$= \text{Tk. 5800} + \text{Tk. 5000} = \text{Tk. 10800.00}$$

$$\text{Now the waste management cost of Mahanagar Diagnostic Centre/ day} = \frac{10800.00}{30} = \text{Tk. 360.00}$$

From survey result it has been found that the hazardous healthcare waste generation rate of Mahanagar Diagnostic Centre / day is 1.98 kg and the total waste generation rate of MDC / day is 5.77 kg. So the existing expenditure for hazardous waste management of Mahanagar Diagnostic Centre per day is,

$$\frac{360.00}{5.77} \times 1.98 = \text{Tk. 124}$$

G4 Monthly Income of MDC

Fiscal year	Amount (Tk.)	Source of income
2005-2006	11600000.00	Testing charge
2006-2007	12100000.00	
Total 2 years income	23700000.00	
Monthly income	23700000.00 / (2 x 12) = 987500.00	
Income /day	987500.00 / 30 = 32917	

Source: Field survey, 2007

APPENDIX H

Profile of the Respondents for the Questionnaire Survey

Table 1. Profile of the Respondents for the Questionnaire Survey

Occupation	Respondent's number		Avg. age (year)	Level of Education					Avg. Service length (year)
	Male	Female		Illiterate	Up to HSC	BSc.	Nursing	Medical/ Training	
Khulna Medical College Hospital (KMCH)									
Patients	2	1	39	1	2				-
Nurse	-	2	34				2		14
Cleaners	1	-	48	1					27
Technicians	1	-	37					1	12
Doctors	2	1	42					3	17
Administrator	1	-	57					1	4
Sub-total	7	4	43						15
Khulna General Hospital									
Patients	1	1	42	1	1				-
Nurse	-	1	28				1		8
Cleaners	1	1	37	2					12
Technicians	-	-							-
Doctors	1	-	47					1	22
Administrator	1	-	54					1	3
Sub-total	4	3	42						11
Mother and Child Care Centre (MCCC)									
Patients	-	-							-
Nurse	-	1	36				1		16
Cleaners	1	1	39	2					12
Technicians	-	1	42					1	15
Doctors	-	2	45					2	20
Administrator	-	-							-
Sub-total	1	5	41						16
Khulna Sishu Hospital									
Patients	-	-							-
Nurse	-	2	32				2		12
Cleaners	1	1	36	2					8
Technicians	1	-	39					1	10
Doctors	1	1	48					2	23
Administrator	-	-							-
Sub-total	3	4	39						13
Garib Newaz Clinic and Diagnostic Center (GNCDC)									
Patients	1	1	31		1	1			-
Nurse	-	2	25				2		5
Cleaners	1	-	29	1					4
Technicians	1	-	31					1	2
Doctors	1	-	40					1	15
Administrator	1	-	44					1	6
Sub-total	5	3	33						6
Islami Bank Hospital (IBH)									
Patients	2	-	34		2				-
Nurse	1	-	37		1				13
Cleaners	1	-	29	1					6
Technicians	1	-	37					1	6
Doctors	1	-	28					1	2
Administrator	1	-	49					1	3
Sub-total	7	0	36						6

Occupation	Respondent's number		Avg. age (year)	Level of Education					Avg. Service length (year)
	Male	Female		Illiterate	Up to HSC	BSc.	Nursing	Medical/ Training	
Dabs Clinic									
Patients	-	1	34		1				-
Nurse	-	1	26				1		4
Cleaners	-	1	29	1					3
Technicians	1	-	33					1	6
Doctors	1	-	41					1	15
Administrator	1	-	46					1	4
Sub-total	3	3	35						6
Khalishpur clinic									
Patients	1	1	35	1	1				-
Nurse	-	1	28				1		6
Cleaners	1	-	36	1					9
Technicians	1	-	39					1	11
Doctors	-	1	35					1	9
Administrator	1	-	49					1	6
Sub-total	4	3	37						8
Fair Health Clinic									
Patients	-	1	25		1				-
Nurse	1	1	27		1		1		5
Cleaners	-	1	34	1					7
Technicians	1	-	37					1	7
Doctors	1	-	30					1	4
Administrator	1	-	47					1	7
Sub-total	4	3	33						6
Decent Dental Clinic									
Patients	1	-	48			1			-
Nurse	1	-	37		1				13
Cleaners	-	1	28	1					3
Technicians	1	-	29					1	1
Doctors	1	-	39					1	12
Administrator	1	-	46					1	5
Sub-total	5	1	38						7
Mahanagar Diagnostic Centre									
Patients	2	1	39	1	2				-
Nurse	1	-	36		1				12
Cleaners	-	1	29	1					4
Technicians	1	-	30					1	2
Doctors	1	-	49					1	22
Administrator	1	-	54					1	5
Sub-total	6	2	40						9
Setu Diagnostic Centre									
Patients	1	1	34	2					-
Nurse	1	-	28		1				5
Cleaners	-	1	31	1					3
Technicians	1	-	33					1	3
Doctors	-	1	43					1	16
Administrator	1	-	49					1	5
Sub-total	4	3	36						6
Total	53	34	--						-
Grand Total	87		38						9*

*The calculated value is excluding patient's respondents.

APPENDIX I

Questionnaire

Interview Schedule for Administrator /Doctor / Nurse
Department of Civil Engineering
Bangladesh University of Engineering and Technology, Dhaka
Survey Schedule

On

Assessment of Healthcare Waste Management Practices in Khulna City Corporation

Sample No.:

Date:

.....
(Please answer the following questions)

Q1. Hospital's name:

Address:

Q2. Name of the respondent:

Age	Sex	Education			Occupation	Service length
		Illiterate	Up to HSC	Graduate		

Q3. How many beds are in your hospital/clinic?

Bed number:

Out door patient:

Q4. Is there any facility of disposing the hospital's waste? (use √)

Ans: i) Yes

ii) No,

If yes, please mention of existing practice.

From	To	Frequency		
		Once/day	Twice/day	Irregular
Patient's bed	Temporary storage place			
Temporary storage place	Out of the HCEs			
Temporary storage place	NGO's van			
Outdoor	Municipal truck			
Others				

Q5. Which types of waste collection system of the Health Care Establishments (HCEs) are you preferred?

i) Municipal open dustbin

ii) NGO's covered bin

iii) Others

Q6. Is there any facility of Healthcare waste treatment as well as management system?

i) Yes

ii) No

If yes, who collects the wastes from your hospitals/clinic? (use √)

i) Hospital authority

ii) Municipal authority

iii) Organization's name:

How? Please, mention it as below

Q12. Expenditure for Healthcare waste management (Expenditure ofmonth)

Sector	Number/description	Expenditure (monthly)
Cleaning goods (bleaching powder, soda, soap, phenol, harpic, savlon etc.)		
Disposal pot (bowl, bucket, waste tray)		
Glove/aprons for cleaners		
Wage of the cleaners and sweepers		
City corporation		
NGO		
Total		

Q11.Do you satisfied on the present system of healthcare waste management in this hospital?

i) Yes

ii) No

If no, which problems are you facing? Please mention it:

1.
2.
3.

Q12. What is your suggestion for better healthcare waste management?

.....

.....

Thanks for your co-operation

Signature of the interviewer

Interview Schedule for Cleaners/ Technicians
Department of Civil Engineering
Bangladesh University of Engineering and Technology, Dhaka
Survey Schedule

On

Assessment of Healthcare Waste Management Practices in Khulna City Corporation

Sample No.:

Date:

.....
(Please answer the following questions)

Q1. Hospital's name:

Address:

Q2. Name of the respondent:

Age	Sex	Education			Occupation	Income/month
		Illiterate	Up to HSC	Graduate		

Q3. Which types of wastes are being generated? (gm/bed)

Type of waste	Name of the waste
Reusable waste	syringe (without needle), saline bags, blood bags, bottle of medicine, plastics materials etc.
Sharp waste	scissors, blade, needle (without syringe), broken glass etc.
General waste	kitchen waste, refuse of food materials, fruits materials, vegetables, clothes, papers, packing materials, water bottle etc.
Infectious waste	gauge, cotton, tissue, organs, human fetuses, dressings, bandages, sticking plaster, gloves, disposable medical items, waste of operation theater, pathological waste etc.

Q4. Is there any facility of disposing the Healthcare waste? (use √)

i) Yes

ii) No

If yes, state the pathway of disposing the clinical wastes?

From	To	Frequency		
		Once/day	Twice/day	Irregular
Patient's bed	Temporary storage place			
Temporary storage place	Out of the HCE			
Temporary storage place	NGO's van			
Outdoor	Municipal truck			
Others				

Q5. Which types of waste collection system of the HCEs you are preferred?

i) Municipal open dustbin

ii) NGO's covered bin

iii) Others

i) Yes ii) No

i) Hospital authority ii) Municipal authority

How? Please, mention it as below

Location of the treatment facility	Applicable method	Which types of wastes are treated
	Only incineration	
	Incineration and Dumping	
	Incineration and no treatment	
	Stream sterilization, Dumping and no treatment	
	Stream sterilization and no treatment	
	Stream sterilization, chemical treatment and dumping	
	chemical treatment and dumping	
	No treatment and dumping	
	No treatment	

i) Yes ii) No iii) Others

i) Mask ii) Gloves iii) Gum boot iv) Apron

i) Yes ii) No

i) Yes ii) No

i) Yes ii) No

i) Yes ii) No

i) Name of the training: ii) Organization's name: iii) Duration of training:

Q12. Do you think the necessity of proper training on Healthcare waste management?

i) Yes

ii) No

If yes, which method is suitable for proper training? (use ✓)

i) Lecture

ii) Video

iii) Practical

iv) Lecture and video

v) Lecture and practical

vi) All the system

vii) Others

Q13. What is your suggestion for better Healthcare waste management?

.....
.....

Thanks for your co-operation

Signature of the interviewer

Interview Schedule for Patients
Department of Civil Engineering
Bangladesh University of Engineering and Technology, Dhaka
Survey Schedule

On
Assessment of Healthcare Waste Management Practices in Khulna City Corporation

Sample No.:

Date:

.....
(Please answer the following questions)

Q1. Hospital's name:

Address:

Q2. Name of the respondent:

Age	Sex	Education			Occupation	Income/month
		Illiterate	Up to HSC	Graduate		

Q3. How many members belong to you (as assistance) in the hospital? (Including you)

- i) One ii) Two iii) Three iv) Four or above

Q4. Which type of waste are you generating?

Type of waste	Name of the waste
Reusable waste	syringe (without needle), saline bags, blood bags, bottle of medicine, plastics materials etc.
Sharp waste	scissors, blade, needle (without syringe), broken glass etc.
General waste	kitchen waste, refuse of food materials, fruits materials, vegetables, clothes, papers, packing materials, water bottle etc.
Infectious waste	gauge, cotton, tissue, organs, human fetuses, dressings, bandages, sticking plaster, gloves, disposable medical items, waste of operation theater, pathological waste etc.

Q5. Is there any facility of disposing the Healthcare waste? (use √)

- i) Yes ii) No

If yes, where do you dispose your hospital waste? (use √)

- i) Open container ii) Covered container iii) Open container (in door)
iv) Open container (out door) v) Covered container (in door) vi)
Covered container (out door) vii) Open space iii) Here and there ix) Others

Q6. Do you know the pathway of disposing the Healthcare wastes?

From	To	Frequency		
		Once/day	Twice/day	Irregular
Patient's bed	Temporary storage place			
Temporary storage place	Out of the HCEs			
Temporary storage place	NGO's van			
Outdoor	Municipal truck			
Others				

Q7. Which types of waste collection system are you preferred?

- i) Municipal open dustbin ii) NGO's covered bin iii) Others

Q8. Do you observe the use of safety equipments for Healthcare waste management?

- i) Yes ii) No iii) Others

If yes, state the safety equipments.(use ✓)

- i) Mask ii) Gloves iii) Gum boot iv) Apron

Q9. Do you know the infectious effects of Healthcare waste?

- i) Yes ii) No

Q10. Is the existing waste management of Health Care Establishment systematic?

- i) Yes ii) No

Q11. What is your suggestion for better Healthcare waste management?

.....

Thanks for your co-operation

Signature of the interviewer

Interview Schedule for Waste Management Authorities
Department of Civil Engineering
Bangladesh University of Engineering and Technology, Dhaka
Survey Schedule

On
Assessment of Healthcare Waste Management Practices in Khulna City Corporation

Sample no:

date:

.....

.....
(Please answer the following question)

Q1. Name of the authorities:

Address:

Q2. Number of hospital served:

Q3. Collection method of Healthcare waste:

- (i) In the same vehicle with other garbage
- (ii) In separate vehicle

Q4. Type of vehicle used for the collection of Healthcare waste:

- (i) Covered truck
- (ii) Uncovered truck
- (iii) Covered tempo
- (iv) Uncovered tempo

Q5. Frequency of collection:

- (i) Once a day
- (ii) Twice a day

Q6. Is segregation done before dumping?

- (i) Yes
- (ii) No

If the answer is 'No' then omit question no. 7.

Q7. Segregated waste and their dumping:

Serial no.	Segregated waste	Disposal process
1		
2		
3		
4		

Q8. Dumping of Healthcare waste:

- (i) With other garbage in open place
- (ii) Not with other garbage but in open place
- (iii) Incinerated
- (iv) Buried
- (v) Burned
- (vi) Recycled

Q9. Use of protective gloves and aprons:

- (i) Use gloves and aprons

- (ii) Use only gloves
- (iii) Do not use protective materials

Q10. If there is no special arrangement for HCW management, then the reason for this:

- (i) Lack of awareness
- (ii) Lack of budget
- (iii) Lack of manpower
- (iv) Lack of infrastructure
- (v) Lack of institutional provision.

Q11. Number of workers:

Serial no.	Responsibility	Number
1	Driver of the waste carrying vehicle	
2	Waste handlers	
3		
4		
5		

Q12. Fixed cost:

Serial no.	Item	Number	Cost
1	Vehicle (truck)		
2	Vehicle (van)		
3	Incinerator		
4			
5			
6			

Q13. Running cost:

Serial no.	Sector	Cost/month
1	Vehicle (oil, tire etc.)	
2	Electricity (for incinerator)	
3	Wage of the workers	
4		
5		
6		

14. Future plan for Healthcare waste management:

APPENDIX J

Different Tables and Flow Chart

Table J1 Number of Health Care Facilities in Bangladesh, 2001 (MOHFW, 2004)

Division	Number of Health-care Facilities					
	District Hospitals	MOHFW	Private	Thana HCF	Union HCF	Small outdoor clinics
Dhaka	15	20	279	102	409	34
Rajshahi	14	10	113	113	410	17
Chittagong	11	6	80	91	258	20
Khulna	10	4	120	49	131	10
Barisal	6	2	7	40	70	4
Sylhet	3	5	21	22	84	4
Total	59	47	620	417	1362	89

Table J2 Estimated amount of Health Care Waste in Bangladesh, divided on Division, 2001 (MOHFW, 2004).

Divisions	General wastes (kg/day)	Sharps (kg/bed)	Other infectious waste (kg/day)
Dhaka	8379	413	3009
Rajshahi	4696	213	1687
Chittagong	3514	173	1262
Khulna	2752	136	989
Barisal	1290	64	463
Sylhet	1052	52	378

Table J3 Frequency of On-site Handling (patient's bed to storage place) of Waste

HCEs	Total respondents		Once per day		Twice per day		Irregular		Total
	R	(%)	R	(%)	R	(%)	R	(%)	
Govt. H	24	28	12	14	4	5	8	9	28
PH	42	48	10	11	13	15	19	22	48
PDC	21	24	4	5	5	6	12	14	24
Total	87	100	26	30	22	25	39	45	100

HCEs = Health Care Establishments, R = Respondents, Govt. = Government, PH = Private Hospital, PDC = Private Diagnostic Center.

Table J4 Frequency of On-site Handling (storage place to municipal dustbin or NGO's van) of Waste

HCEs	Total respondents		Once per day		Twice per day		Irregular		Total
	R	(%)	R	(%)	R	(%)	R	(%)	
Govt. H	24	28	14	16	6	7	4	5	28
PH	42	48	34	39	5	6	3	3	48
PDC	21	24	15	17	4	5	2	2	24
Total	87	100	63	72	15	18	9	10	100

HCEs = Health Care Establishments, R = Respondents, Govt. = Government, PH = Private Hospital, PDC = Private Diagnostic Center.

Table J5 Safety Equipment scenario of the Studied HCEs

Types of HCEs	Total respondents		Followed		Not followed		Others	
	R	(%)	R	(%)	R	(%)	R	(%)
Govt. H	24	28	7	8	15	17	2	2
PH	42	48	23	26	16	18	3	4
PDC	21	24	11	13	10	12	0	0
Total	87	100	41	47	41	47	5	6

HCEs = Health Care Establishments, R = Respondents, Govt. = Government, PH = Private Hospital, PDC = Private Diagnostic Center.

Table J6 Training Issues for the Respondents in HCEs

Types of HCEs	Total respondents		Got training		Did not get training	
	R	(%)	R	(%)	R	(%)
Govt. Hospitals	19	28	5	7	14	21
Private Hospitals	34	50	19	28	15	22
Private Dental/Diagnostic Centers	15	22	6	9	9	13
Total	68	100	30	44	38	56

HCEs = Health Care Establishments, R = Respondents

Table J7 Respondents' Opinion in Suitable Methodology for Proper Training in the HCEs

Category of HCEs	Total respondents		Lecture		Video		Lecture & Video		Others	
	R	(%)	R	(%)	R	(%)	R	(%)	R	(%)
GH	19	28	1	1	2	3	15	22	1	1
PH	34	50	3	4	3	4	26	38	2	3
PDC	15	22	1	2	2	3	12	17	0	0
Total	68	100	5	7	7	10	53	78	3	4

HCEs = Health Care Establishments, R = Respondents, Govt. = Government, PH = Private Hospital, PDC = Private Diagnostic Center.

Table J8 Satisfaction Rate of Existing Waste Management of HCEs

Types of HCEs	Total respondents		Satisfactory		Unsatisfactory	
	R	(%)	R	(%)	R	(%)
Govt. Hospitals	24	28	2	2	22	25
Private Hospitals	42	48	29	33	13	15
Private Dental/Diagnostic Centers	21	24	12	14	9	10
Total	87	100	43	49	44	51

HCEs = Health Care Establishments, R = Respondents.

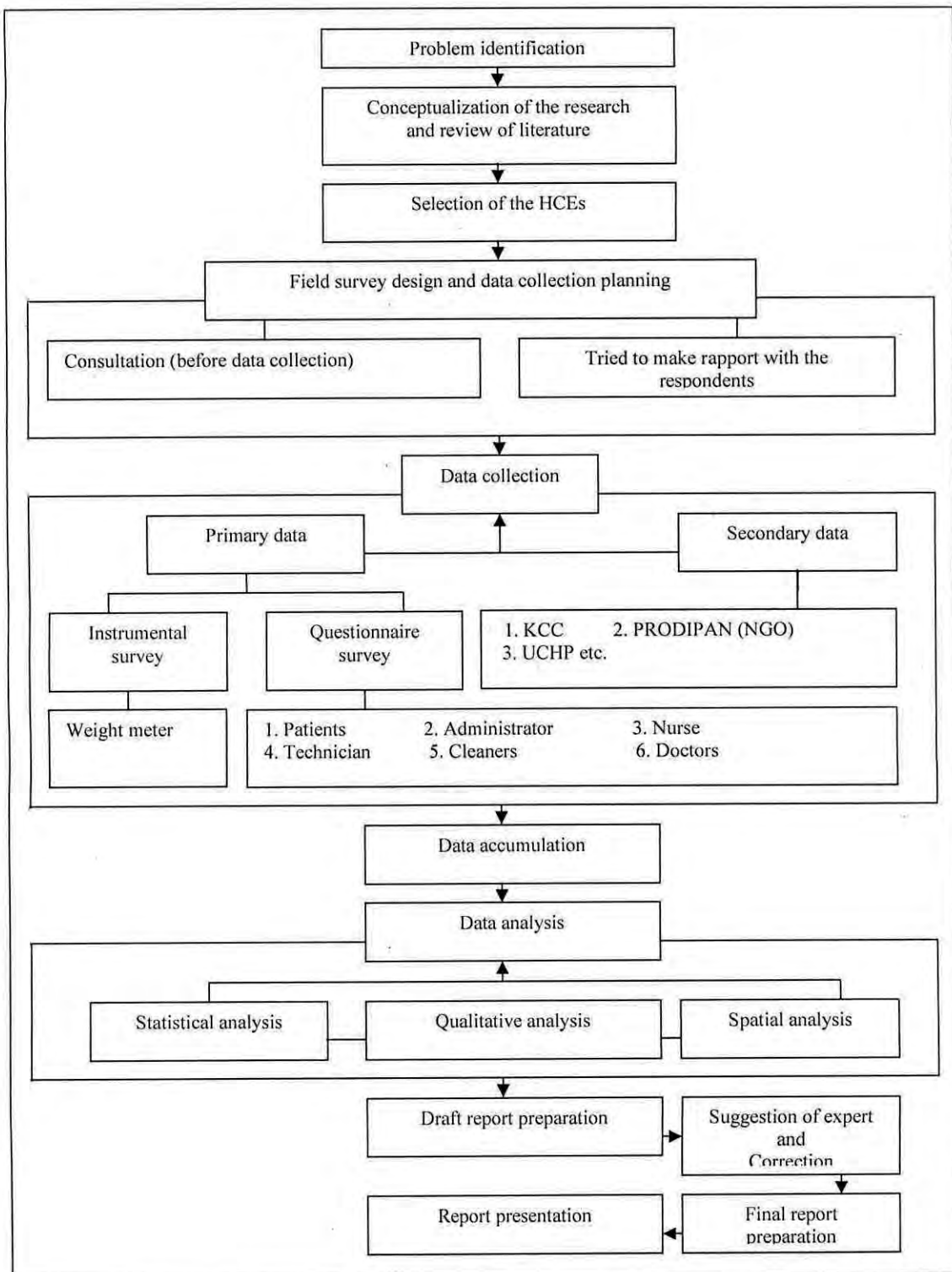


Figure J1 Flow Diagrams Showing the Methodology of the Study

