Survey

on

Quantitative and qualitative assessment of medical waste generation and management in Dhaka North City Corporation and Dhaka South City Corporation

PRISM

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Declaration

I do hereby confirm that all the numeric data and qualitative informations were derived during the data collection from all the Healthcare Establishments (HCEs) which was conducted by PRISM. Our deep effort was contributed to find out the quantitative data and qualitative information from all the functional HCEs in Dhaka city to make a comprehensive plan for the management of medical waste.

The materials and references from other research and reports were duly acknowledged and quotations and paraphrases aptness indicated.

Kh Anisur Rahman
January 2013

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January 2013

Executive Summary

1. Introduction

Medical wastes may present a mechanism for transmission of diseases as it contains highly toxic chemicals, heavy metals and pathogenic viruses and bacteria. In the last few decades, human activities associated with life patterns have resulted in the growth of the medical sector. Consequently, large amounts of medical waste are being generated on a daily basis due to use of disposable medical products and the increase of healthcare activities. Many countries have maintained the proper management system for handling and safe disposal of medical waste to minimize the risk. In developing countries, medical waste has not received adequate attention, particularly when it is disposed of together with the domestic waste. As a consequence it may be a cause of disease amongst waste cleaners, waste pickers, collectors, and recycling waste operators.

Bangladesh, a developing country facing rapid population growth, extensive health problems, low educational status and environmental pollution. Heavy influx of migrants; hospitals, clinic, private individual practitioners, dental clinics, diagnostic centres and pathology services are a growing feature of health care provision. But the facilities for waste disposal from healthcare establishments (HCEs) cannot cope with the growing demands. The situation is especially serious in Dhaka city the capital of Bangladesh

According to the Directorate General of Health (DG Health), Government of Bangladesh, there are more than 1200 HCEs situated in Dhaka City, generating an estimated 200 tons of waste a day. Therefore, the scale of problem is large and the need for detailed scenario and accurate research study is urgent. Before research, the total numbers of HCEs need to be identified by conducting wide ranged survey as there is no accurate database is available for Dhaka city on the number of HCEs.

2. Rationality of the survey

The quantification of medical waste generation is an emerging worldwide concern. There have been a number of reports dealing with the total waste generated in Dhaka and in Bangladesh. The estimates of total waste generation in the city range from 7.2 tones per day to 400 tones per day. The wide range of estimates obtained, and the basis on which

these estimates have been established, probably means that they are not sufficiently reliable to allow the planning of a more effective waste management system for the city.

In the study area, there has been no rigorous identification and estimation of medical waste generation based upon a thorough HCE survey. Thus, quantitative estimation and qualitative assessment of medical waste generation is needed to estimate the potential risk and as a basis for any waste management plan for a pollution free city.

3. Aims and objectives

The aims of this survey are to identify the total number of functioning HCEs in the Dhaka City corporation area and explore the risks related to medical waste management. In addition, to gain and quantify the total volume of waste generation in the study area is one of the main aims. The objectives of this survey were to undertake the total number of HCE, an assessment of the current situation of medical waste management practice and characterization of medical waste generated in Dhaka City and to use a rigorous full coverage sampling method to gain a reliable estimate of the total waste generation in Dhaka city. The main objectives of this study are

(a) To identify the total functioning HCEs situated in the two parts of Dhaka City Corporation area.
(b) To identify the volume of total medical waste generation, source, segregation at source and disposal pattern in the Dhaka city area.
(c) To identify the occupational health hazards and environmental pollution by the medical waste and their impact among city dwellers and individuals.
(d) To make a comprehensive management and treatment plan, and
(e) To analyse potentialities related to medical waste.

4. The term Medical waste in the present survey

In the present survey, the term medical waste defines all kind of waste generated from healthcare establishments such as general waste, sharps, pathological waste, kitchen waste, mortuary waste etc. This therefore includes both non-hazardous and hazardous waste constituents.

5. General Description of survey Area

The selected survey area is located in the middle part of Dhaka District (Dhaka City Corporation area). At present 'Dhaka City Corporation' is divided in two parts (North and South) and two self-governing body charged with the running of affairs for the city.

6. Survey Approach

All survey is conducted by a set of ideas and judgment about the nature of work. In the survey approach, one or more data collection techniques could be used. Observational approach, questionnaire survey and in-depth interview (formal and informal) method were applied for collection of quantitative and qualitative data with closed and open questions. Answers to questions were obtained in face-to-face interviews. The primary data were collected by field observations, questionnaire survey and interviews through relevant participatory methods. The secondary information was collected through a literature survey on medical waste studies (relevant published and unpublished reports, documents, newspaper, and magazine). Both probability and non-probability sampling of techniques were used in this survey. Each HCE was considered as a one sample and the total number of the functioning HCEs situated in the City corporation area was considered.

Definition of population (HCE): A total of all HCEs functioning in Dhaka City Corporation area (North and South) was considered in the present survey, which formed the statistical population.

Table 1

Functioning HCEs in Dhaka City Corporation

Strata	**DCC North**	**DCC South**	**Total (%)**
Hospitals	85	89	174 (17)
Clinics	118	46	164 (16)
Diagnostic/pathology	143	66	209 (21)
Dental clinic	289	176	465 (46)
Total	**635**	**377**	**1012**

Source: Field survey, 2012.

7. Results and Findings

The number of HCE in DNCC is highly concentrated than DSCC. Most of the largest public hospitals such as; Dhaka Medical College Hospitals (DMCH), Sir Salimullah Medical College Hospitals (SSMCH), BSMMU were located in the DSCC.

In DNCC a large number of the HCEs, (32%) were located in the main residential area, while 6% were located in industrial areas, 21% were located in commercial areas, 39% were located in mixed use areas and a few of the HCEs (2%) were located in the government allocated area. In DSCC similarly large number of the HCEs, (56%) were located in the main commercial area, while 23% were located in residential areas, 9% were located in industrial areas, 11% were located in mixed use areas and a few of the HCEs (1%) were located in the government allocated area.

Of the surveyed HCEs, only 5% were located in an enclosed site with more than one building while 16% were housed in a single dedicated building, and 14% were located in a shared building, 30% were located in a single floor and 35% were located in a shared floor in DNCC. More or less similar pattern was observed in the DSCC in the context of establishment structure. Of the surveyed HCEs in DSCC, similarly 5% were located in an enclosed site with more than one building while 13% were housed in a single dedicated building, and 18% were located in a shared building, 16% were located in a single floor and 48% were located in a shared floor.

This pattern of location may present significant dangers in the context of urban public health and safety in the Dhaka City Corporation area.

The percentages of the doctors and nurses are more or less similar while office staff is the highest (DNCC 31% and DSCC 36%). Surprisingly the cleaners who are responsible for waste collection and management was found to be lowest in the North (9%) and second lowest in the South (12%).

The data shows that, for residential facilities, such as hospitals and clinics, the rate of waste generation was 1.63 kg/bed/day in DNCC and 1.99 kg/bed/day in DSCC, of which the highest percentage (by weight) was from residential facilities providing services for patients

(1.63 kg/bed/day in hospitals and 1.36 kg/bed/day in clinics in DNCC and 1.99 kg/bed/day in hospitals and 1.79 kg/bed/day in clinics in DSCC). On the other hand, non residential facilities, such as pathology/diagnostic centres and dental clinics were not generated such an amount of large volume of waste. However, the rate of waste generation kg/patient/day was in hospital 0.77 kg/patient/day, in clinic 0.65 kg/ patient /day, in pathology/diagnostic centres 1.5 kg/ patient /day and in dental clinics 0.35 kg/ patient /day in the DNCC and in hospital 0.84 kg/patient/day, in clinic 2.1 kg/ patient /day, in pathology/diagnostic centres 0.16 kg/ patient /day and in dental clinics 0.88 kg/ patient /day in the DSCC. The diagnostic and pathology centres were generated large volume of waste kg/patient/day due to the main contributors were laboratory and research sections.

Generated waste is 22.7 tons/day in the DNCC where 16.9 tons/day (74.45%) is non-hazardous and about 5.8 tons/day (25.55%) is hazardous; and generated waste is 27 tons/day in the DSCC where 19.87 tons/day (73.6%) is non-hazardous and near about 7.13 tons/day (26.4%) is hazardous.

These estimates were obtained by stringent weighing of waste in carefully chosen, rigorous methods, surveyed of all functioning HCEs in the DCC areas, including non-residential diagnostic centers and dental clinics. This study used a particular design of waste generation in a broad range of Health Care Establishments (HCEs) to indicate that the amount of waste produced in Dhaka can be estimated to be 48 ± 5 ton per day. The proportion of this waste that would be classified as hazardous waste by World Health Organization (WHO) guidelines was found to be approximately 24% (12 ± 2.5 ton day^{-1}). The amount of waste, and the proportion of hazardous waste, was found to vary significantly with the size and type of HCE. The average waste generation rates were found 1.81kg/bed/day in the surveyed HCEs.

There were rarely any procedures for dealing with these wastes separately. Out of the total HCEs, 12% managed their waste properly in the DNCC and 7% in the DSCC, 36% managed partially in the DNCC and 30% in the DSCC, and most of the HCEs 52% in the DNCC and 63% in the DSCC were disposed their waste without any management. They disposed of the waste into the open DCC bins without any system. It means a maximum amount of waste was colleted by scavengers and waste collectors for recycling. It was observed that, in this

process, waste was repacked and resold, and finally underwent secondary recycling. In each case the process involved, at most, simple washing. Disinfection or sterilisation was not observed. Internal storage facilities are poorly managed and are also used for other activities.

Most of the waste workers experienced accidental injury, itching, eye burns, skin rash and coughs replied when asked through informal dialogue. In-depth study will help to find out the correlation between risk groups resulting from medical waste handling and also will help to develop a sampling regime to better study of environmental health.

This is the first study to attempt this type of thorough estimation of medical waste and assessment of risk on environmental health in the Dhaka City Corporation area with a wide range of full coverage of the HCEs located. PRISM has been trying to develop this management practice since 2005 from non-governmental position to minimize the risks and for better environment in this Dhaka City Corporation area with the collaboration of City Corporation authority. This attempt is partially successful in the context of different issues, but till need to develop more effort.

Acknowledgments

If I were to acknowledge everyone who contributed to the completion of this survey, it would take as long as it took to write the report. Therefore, I want to apologize to anyone omitted here.

Thanks to the individuals of the surveyed HCEs whose patience, professionalism and field support help us to complete this journey.

I express my sincere thanks to the officials of DNCC and DSCC, for their diligent support and patience.

Many thanks are also due to the incredibly talented group of colleagues whom I had the privilege of working with during the survey I was at Field site. I thank the colleagues that I met during the survey. A special thanks goes to ???????, who helped me to collect many of the contact address and secondary information's used in this survey.

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Chapter I

Introduction: General Background

1.1. Introduction

Medical waste plays an important role in the transmission of diseases. It contains highly toxic chemicals, heavy metals and pathogenic viruses and bacteria. This can lead to the pathological dysfunction of the human body. Due to risks of infection, physical injury and of dermal contact to potentially harmful pharmaceuticals, it is now considered a serious threat to environmental and occupational health. In the last few decades, human activities associated with life patterns have resulted in the growth of the medical sector. Consequently, large amounts of medical waste are being generated on a daily basis due to use of disposable medical products and the increase of healthcare activities. Hence, significant adverse health risks associated with medical waste are also gradually increasing. Therefore, many countries have maintained the proper management system for handling and safe disposal of medical waste to minimize the risk. In developed countries, modern technologies such as incineration, autoclaving etc, are used for treatment and final disposal of medical waste. These methods can minimize the risks to health and the environment. However, in developing countries, medical waste has not received adequate attention, particularly when it is disposed of together with the domestic waste. As a consequence it may be a cause of disease amongst waste cleaners, waste pickers, collectors, and recycling waste operators. Furthermore, medical waste presents an increasingly high risk to doctors, nurses, technicians, drain cleaners, sweepers, hospital visitors and patients due to disorganized management. Risk minimization for medical waste has become a major concern worldwide. In most countries there is a growing awareness that the enormous amount of hazardous medical waste generated, not only result in huge disposal costs, but also creates the potential for the spread of disease.

Bangladesh, a developing country facing rapid population growth, extensive health problems, low educational status and environmental pollution. A defining trend for

its economy and society is the rapidly growing urban population. As a result of heavy influx of migrants; hospitals, clinic, private individual practitioners, dental clinics, diagnostic centres and pathology services are a growing feature of health care provision. But the facilities for waste disposal from healthcare establishments (HCEs) cannot cope with the growing demands (PRISM, 2005). Until 2004 no authorised proper medical waste treatment plant or dumping facilities had been established. This was due to; the lack of public awareness, an absence of specific laws and rules and poor application of legislation by the Local Government. The situation is especially serious in Dhaka city the capital of Bangladesh. The problems associated with hazardous waste may be concentrated in Dhaka city, due to it being the largest urban centre in Bangladesh. Dhaka, already has a variety pollution issues, medical waste may add a new dimension of potential health hazards.

The rapid growth of disorganized HCEs in Dhaka City has resulted in an environmental health hazard. According to the Directorate General of Health (DG Health), Government of Bangladesh, there are more than 1200 HCEs situated in Dhaka City, generating an estimated 200 tons of waste a day (Lawson, 2003). A number of reports published in the daily newspapers, and also by development agencies, such as World Health Organization (WHO), International Centre for Diarrhoeal Disease and Research in Bangladesh (ICDDRB) shown that there is a high incidence of cholera, typhoid, dysentery, infective hepatitis, polio and dengue among people who live in Dhaka (WHO, 2000; Andersen and Pettersson, 2003). The incidence is higher in areas where a high number of hospitals, clinics and diagnostics centers are located particularly in the residential areas. Dhaka City Corporation (DCC) recognized these areas as a "red zone" for these diseases (Dhaka City Corporation, 2002).

Therefore, the scale of problem is large and the need for detailed scenario and accurate research study is urgent. Before research, the total numbers of functioning HCEs need to be identified by conducting wide ranged survey as there is no accurate database is available for Dhaka city on the number of functioning HCEs.

It has been reported in the previous survey report conducted by the PRISM (PRISM, 2005) that medical waste is disposed of indiscriminately along with

household and municipal waste into open DCC bins (Figure 1.1). The HCEs authority frequently handled and disposed of their medical waste along with litter, in domestic bins, drains or even in canals, drains and general sewerage systems. In some cases, surgically removed anatomical body parts are also dumped in to the road site bin. Waste cleaner/collectors of HCEs collect the medical waste from HCE and hand it over to waste dumping operators to dispose of. The waste scavengers then scavenge the waste from the disposal sites near the HCE's. They sort through the waste searching for saleable items like syringes, saline bag, plastic materials, cans, metals etc. from medical waste. The items are collected, washed, repacked and resold to the public. This may create a cycle of disease transmission (Borg, 2005). Therefore, the incidence of diseases that may be transmitted by medical waste is alarming in Dhaka city. Figure 1.2 shows the medical waste collected by scavengers.

Figure 1.1 Medical waste with general waste

Figure 1.1: Different type of medical waste disposed of along with general waste in open DCC bin near the HCE premises. Therefore, scavenger can collect medical waste.

Figure 1.2: A scavenger is collecting the infectious medical waste (saline bag and tube, syringe etc.) without any precautions.

1.2. Previous practice before PRISM interventions

Patwary *et al.* (2009a) reported that 37 ± 5 tonnes of medical waste, including domestic and recyclable waste, is being generated from hospitals, clinics and other

HCEs on a daily basis in Dhaka. Only 10% of the surveyed HCEs followed proper disposal procedures, as specified in the WHO Code of Practice (WHO 2004), to collect and manage medical waste and 25% were followed partial waste management procedures. The remaining HCEs (65%) collected their waste without any segregation and placed it in DCC bins. Waste was collected by DCC from bins and road sides near the HCEs. Ahmed *et al*., (2006) reported that 20% of the observed facilities in one city administrative 'ward' had adopted a proper segregation system. Partial segregation procedure was observed in 24% of HCEs, but this was generally ineffective, as in these establishments the segregated wastes were subsequently mixed together as they were collected from the site of production and taken for temporary storage. It seems likely that it should be relatively straightforward to achieve complete segregation in these HCEs if some additional training were available to waste management operatives.

In the reported HCEs, employees were observed using unsuitable and unlabelled containers and plastic bags, without colour codes or biohazard signs, contrary to the WHO Code of Practice (WHO, 2004). Medical waste from these establishments was mixed with municipal waste even when the waste was blood-stained and potentially infectious. This mixing of hazardous materials with general waste makes the total waste infectious and represents a serious hazard to workers and the general public. It was observed that in some cases surgically removed anatomical body parts are also dumped into road side bins. Although, not part of the main focus of that survey, it was observed that liquid waste and wastewater of HCEs discharged into the general drains and sewerage system without the necessary precautions.

Patwary *et al*., (2009b), in their study, observed storage facilities of a few small HCEs in Dhaka. They noted that most of the surveyed HCEs had no temporary storage system or facilities. Most of the HCEs (68%) disposed of all of their waste into the general DCC domestic waste bins located outside the premises. In each case, it was observed that this followed a period of temporary storage, sometimes in an open space within the hospital, clinic or pathological centre premises, sometimes in a room along with stationery and medical supplies. Storage areas for medical waste were not well secured and sharps containers and other recyclable waste were frequently taken by scavengers to be recycled. In the study area, most of the HCEs stored infectious sharps containers in general utility areas without any proper

labelling or other precaution; this practice may also result in contaminated injection equipment being scavenged and reused. The lack of correctly controlled internal storage may be linked to the observation that employees at many HCEs offered contaminated items for sale to scavengers and recycling operatives, mostly to melt down plastics for recycling, but sometimes for repackaging and resale.

Their study also observed that most of the waste workers were not concerned about the injuries which may occur as a result of chemical absorption, dermal contact, inhalation or ingestion. WHO (1999) reported that injuries to the skin, eyes or mucous membranes are frequently caused by contact with flammable, corrosive or reactive chemicals which may result in headaches, eye irritation, dizziness, difficulties in concentration, fatigue, respiratory function disruption and many other symptoms. Subsequently, there was no monitoring program of waste workers' occupational health and safety. Waste management, and the control of infections and accidents arising from contaminated waste, is not considered one of the main activities of HCEs. Therefore, no record was kept of the trend of waste workers to fall ill or suffer accidents related to waste management.

It was observed in their survey that cleaners and waste collectors working in most of the HCEs within the patient ward even in the mortuary department, Dhaka City Corporation (DCC) and treatment facilities usually did not wear sufficient PPE during waste handling. This was supported when participants were questioned about their understanding of occupational health; 78% reported that they did not use any chemicals or detergents during the cleaning of equipment, while 73% of participants did not regularly wear PPE during waste handling, and only 18% wear PPE daily during waste handling. DCC and most HCEs failed to provide any PPE to employees, while scavengers and other unofficial waste handlers had no opportunity to obtain PPE.

As might be expected, this lack of suitable precautions seems to result in a significant number of potentially serious injuries, and most waste management workers (94%) reported that they had experienced accidental injury within the previous month, mostly from used needles and other sharps, and of these 28% were considered serious by the respondents. This is much higher than the rates observed in other countries. Rahman and Ali (2000) reported that in Japan 67% of HCE staff

reported accidental injuries, compared with 50% in Peru and 18% in USA. It is possible that the difference is even greater than it seems as there is no possibility of compensation for injuries suffered in Bangladesh, and so no incentive to remember or report an injury. Many of the injuries reported in this study involve foot injuries resulting from standing on sharps, or hand injuries from handling sharps. These could easily be addressed by provision of PPE. The provision of education and training would also help to address the issue. As an illustration of the issues arising from a lack of training, some respondents reported that some members of the community use some of the waste receptacles, such as sharps containers, to store food, while some HCE staffs were observed giving out used hazardous waste bin bags to patients to carry their personal belongings.

A small proportion of HCE and DCC waste management workers indicated that they had heard about protective uniforms, but had never seen them. Of the 9% who reported that they occasionally use PPE, most of them mentioned that they only do so when required to, often due to an official visit by external dignitaries. When questioned, they were found not to be aware of hazards arising from needles or sharps. Only 23% of participants reported that they had received even basic introductory information on occupational safety related to medical waste management, and most of these indicated that this information was provided by an NGO PRISM. This lack of education is also reflected in the personal hygiene of respondents; many reported that they did not follow basic hygiene practices following exposure to medical waste, including potentially hazardous waste.

DCC waste management workers, treatment workers and others involved in collection and disposal of general waste are exposed to an additional risk to do contamination of materials in city bins with hazardous waste. This places an additional requirement to supply training and PPE to these workers. This requirement is not being met. DCC workers were not found to be aware of hazards, and were not supplied with any PPE. Even if the general city waste were not contaminated with medical waste, this would be unacceptable, but given the levels of contamination found in this survey, the situation is especially serious.

The reported study has focused on threats to HCE and waste management workers, who may be at high risk. There is also a risk to the general population, for whom

contact with hazardous medical wastes is more likely to occur after it has been dispersed in the environment. This is likely to disperse the hazard, vastly increasing the number of people potentially exposed.

Chapter II

Rationality, Aims and Objectives of the Survey

2.1. Rationality of the survey

The quantification of medical waste generation is an emerging worldwide concern. The rapid growth of medical and patient related services has resulted in an increase not only in the use of chemicals and drugs, but also increase in the use of disposable items and consequently, large amounts of medical waste are being generated on a daily basis. In most developing countries there is a growing concern that the enormous amount of hazardous medical waste generated, not only results in a huge disposal costs, but also creates the potential for the spread of diseases.

There have been a number of reports dealing with the total waste generated in Dhaka and in Bangladesh. The estimates of total waste generation in the city range from 7.2 tones per day to 400 tones per day. A number of the estimates included from the best resourced studies, are associated with a particular project, the primary purpose of which may not have been to obtain a reliable estimate of total waste generation. Others use extrapolation from studies undertaken in other countries, while still others do not provide details of the basis of their estimates. The wide range of estimates obtained, and the basis on which these estimates have been established, probably means that they are not sufficiently reliable to allow the planning of a more effective waste management system for the city.

In the study area, there has been no rigorous identification and estimation of medical waste generation based upon a thorough HCE survey. Thus, quantitative estimation and qualitative assessment of medical waste generation is needed to estimate the potential risk and as a basis for any waste management plan for a pollution free city. Any waste management plan should be based upon a reliable estimate of the amount of total waste generated. Therefore, PRISM conducted this survey which results will provide medical waste generation in a broad range of the HCEs through a full coverage of HCEs situated in the Dhaka City Corporation area. These estimates will be obtained by surveyed total of HCEs, including non-residential diagnostic,

pathology centres and dental clinics. It was intended to gather information that would contribute to the development of medical waste management plans for the Dhaka City Corporation area as an example of developing countries, which could be adapted according to circumstances. It is likely that this would be helpful to minimize the risks of health and safety.

Therefore, the objectives of this survey were to undertake the total number of functioning HCE, an assessment of the current situation of medical waste management practice and characterization of medical waste generated in Dhaka City and to use a rigorous full coverage sampling method to gain a reliable estimate of the total waste generation in Dhaka city.

2.2. The term Medical waste in the present survey

Medical waste is defined as any solid or liquid waste that is generated from treatment of human beings in a hospital or clinic, from clinical diagnosis and pathological testing and from medical research (WHO, 2002). It comprises sharps, non-sharps, blood, body fluids, dressing materials, surgically removed body tissues, chemicals, pharmaceuticals, medical devices and radioactive materials (Lee and Huffman, 1996; WHO, 2002). The waste generated from HCEs both as hazardous and non hazardous are considered as medical waste in this survey. WHO (1999) defines only 10 – 25% of waste generated from healthcare establishment as clinical in nature. The terms of the hospital waste and medical waste have often been described interchangeably (Mato and Kaseva, 1999). Lee *et al.*, (2002) used the term medical waste to deal with all types of waste generated by Healthcare Establishments rather than hospital waste. In Bangladesh, most of the researchers used the term waste generated from HCEs as "medical waste" (Akter *et al.*, 2003; Patwary *et al.*, 2009a). In the present survey, the term medical waste defines all kind of waste generated from healthcare establishments such as general waste, sharps, pathological waste, kitchen waste, mortuary waste etc. This therefore includes both non-hazardous and hazardous waste constituents.

2.3. Aims and Objectives

The aims of this survey are to identify the total number of the HCEs in the Dhaka City Corporation area and explore the risks related to medical waste management. In addition, to gain and quantify the total volume of waste generation in the study area is one of the main aims. The main objectives of this study are:

(f) To identify the total functioning HCEs situated in the two parts of Dhaka City Corporation area.
(g) To identify the volume of total medical waste generation, source, segregation at source and disposal pattern in the Dhaka city area.
(h) To identify health hazards and environmental pollution caused by medical waste and their impact among city dwellers and individuals.
(i) To make a comprehensive management and treatment plan, and
(j) To analyse potentialities related to medical waste.

In exploring these objectives the survey is timely in the context of a developing country, as an area like Dhaka.

2.4. Benefit of the survey

The survey selection is concurrent with the risk of medical waste contamination associated with existing management practice in Dhaka. It is also concerned with the city framework and national strategy in determining the minimization of risk. In a city with various pollution issues, medical waste may adds a new dimension of potential health hazards in Dhaka. It is expected that the overall study findings would provide a better understanding of the risks associated with medical waste. In addition, the study will also serve as indicator of the infectious and hazardous waste volume as well as magnitude of medical waste.

2.5. General Description of survey Area

The selected survey area is located in the middle part of Dhaka District (Dhaka City Corporation area). **Dhaka**, population 16,560,000 (BBS projection for metropolitan area), largest city and administrative centre of Bangladesh. The city is situated on the bank of Buriganga River, at $23^{0}42`0"$ north latitude and $90^{0}22`30"$ east longitude. It was discovered more than 1500 years ago and passed from local to Mughal rule and later to the British. It became the capital of East Pakistan in 1947, and later of Bangladesh following its independence in 1971 (BBS, 2006). At present

'Dhaka City Corporation' is divided into two parts (North and South) and two self-governing body charged with the running of affairs for the city. The two City corporation areas are divided into several 'wards' (administrative zone). Dhaka is undergoing an expansion into a modern metropolis and is fast becoming the political, cultural, commercial and industrial heart of the country.

2.6. Database Consideration

Many research organisations, groups and individuals are now working on medical waste, specifically, in the area of waste minimization technology rather than the angle of health and environmental hazards. They mainly focus their research on medical waste problems associated with minimization, land filling, autoclaving, in-house management, transportation, engineering and so on. Most of the research outputs available in Dhaka city are based on observational and/or sampling based study. There is a need for a thoroughly substantive piece of survey to identify the total functioning HCEs and estimate the total volume of waste. With respect to this observation, the PRISM decided to conduct this survey.

2.7. Ethical Consideration of Research Topic

The main ethical considerations for this survey mainly focus on future medical waste management planning. The main issue in this regard is that, the city dwellers are facing risks and are environmentally distressed. To select the issues for survey rather than directly helping the distressed people is an ethical decision. It is realized that the study will ultimately show the way to a better and more thoughtful approach to the development of an environmental framework on medical waste and its associated risks. The study will make a direct contribution by highlighting the scale of risk and in generating medical waste information, which will be helpful to formulate policy.

Chapter III

Medical waste and Risks: General review

3.1. Introduction

Medical waste is defined as any solid or liquid waste that is generated from treatment or immunisation of human beings in a hospital or clinic, diagnosis and pathological test and from medical research. It comprises sharps, non-sharps, blood, surgically removed body tissues, chemicals, pharmaceuticals, medical device and radioactive materials (Lee and Huffman, 1996; WHO, 2002). Medical waste generation depends on a number of factors; waste management systems, type of HCEs, specializations of HCEs, percentage of reusable items employed and of patients' treatment duration.

3.3. Sources of medical waste

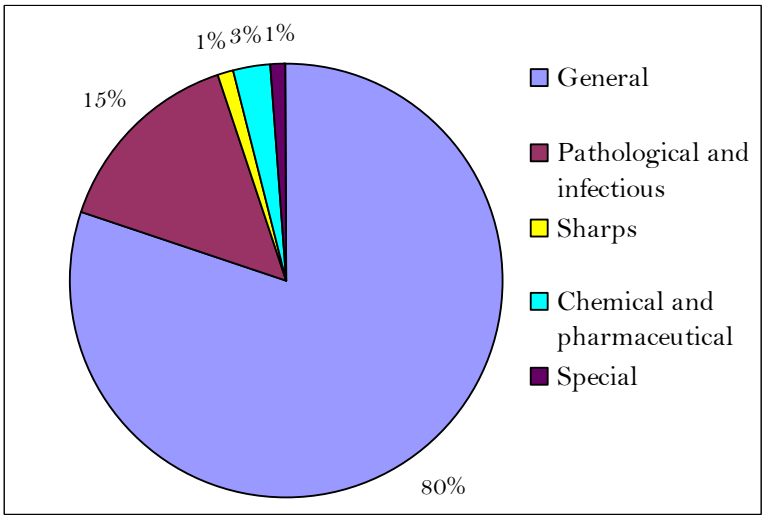
The composition of medical wastes is frequently varied and characteristic of the type of source. However, the different sources of medical waste within a healthcare establishment are administration/support services, patient service/ward, laboratories, operation theatre, house keeping, disinfecting activities, emergency, research, blood bank, pharmacy, laundry, kitchen, engineering and public areas. Medical waste also includes small or scattered sources from the home such as dialysis, insulin injection, medicine packages etc. (Tudor *et.al.*, 2006).

3.4. Type of medical waste and their potential health risks

Medical waste is mainly categorised into hazardous and non-hazardous (Askarian *et.al.*, 2004). Hazardous medical waste includes pathological, infectious, sharps and chemical wastes which is normally generated in labour wards, operation theatres, laboratories, etc. (Or and Akgill, 1994; Mato and Kaseva, 1999). Non-hazardous medical waste is mainly general waste like paper, clothes, wool, kitchen waste etc. that have no special associated handling problems, health, or environmental risks (Alvim-Ferraz and Afonso, 2003). This is mainly generated from patients' ward areas, out-patient-department (OPD), kitchens, offices, administrative support unit etc. In developing countries, medical waste generation is usually lower than in developed countries (Chu *et. al.*, 1998 and UNEP, 2003). But the hazardous range of

medical waste is more or less similar. Only 15-20% of medical wastes are infectious or hazardous in developed and developing countries (World Bank 2003). Figure 2.1 shows the classification of waste generation.

Figure- 2.1 Classification of waste generation



According to World Health Organization (WHO), and World Bank the classification of hazardous medical waste is as follows.

3.5. Infectious waste

Infectious waste is mainly pathogenic (bacteria, viruses, parasites, or fungi), which when present in adequate amounts cause diseases in susceptible hosts (Ghosh *et. al.*, 2005). Sissgaard *et.al.*, (1994) and Ray *et.al.*, (2005) described that pathogenic micro-organisms can enter the human body through a number of routes mainly ingestion, inhalation and dermal contact. Antibiotic-resistant *Escherichia coli* has been shown to survive in an activated sludge plant, which is a risk for environment (Yeperen and Rutten, 1997). Infectious waste is generated from the treatment of patients suffering from infectious diseases. This category includes;

- Infectious agents from tissue culture and stocks used in the laboratory for research work;
- Tissues, and materials or equipment in contact with blood or other body fluids in waste from surgeries and autopsies;

- Infected patients waste such as excreta, dressings with infected or surgical wounds, clothes heavily soiled stained human blood or other body fluids from isolation wards;
- Waste such as dialysis tubing and filters, disposable towels, gowns, aprons, gloves and laboratory coats from contact with infected patients undergoing haemodialysis;

3.6. Pathological and anatomical waste

Pathological waste consists of surgically removed recognizable tissues, organs or body parts, dead human foetuses and placentas, blood, and body fluids.

3.7. Sharps

Sharps waste is composed of needles, hypodermic needles, scalpels and other blades, knives, infusion sets, saws, broken glass, culture dishes, blood vials, and nails (Kizlarly *et.al.*, 2004). The items of this category are typically considered as highly dangerous whether or not they are infected (Blenkharn, 2006). Many reports in the literature have shown that infection with human immunodeficiency virus (HIV) and hepatitis virus B and C are mainly transmitted through occupational injuries from infectious sharps. Sharps are frequently infected by HIV or hepatitis virus affected human blood and fluid (Hagen *et.al.*, 2001).

3.8. Pharmaceutical waste

Pharmaceutical wastes are date expired, unused, spilt, contaminated pharmaceutical products, drugs, vaccines, sera etc. Its also includes discarded items used in the handling of pharmaceuticals, such as bottles or boxes with pharmaceutical residue, gloves, masks, connecting tubing, and drug vials etc. (Linninger and Chakraborty 2001; Ozbek and Sanin, 2004). Improperly managed pharmaceutical waste may be hazardous to human health and the environment.

3.8. Genotoxic waste

Genotoxic wastes are generated from patients treated with cytotoxic drugs. These include vomit, urine, or faeces from patients, chemicals, and radioactive material, syringes, needles, bandage, vials and packing. These wastes are highly hazardous and may have mutagenic, teratogenic, carcinogenic and cytotoxic effect (Giuliani *et.*

al., 1996). The common route of genotoxic waste to effect human health is inhalation of dust or aerosols, absorption through the skin, ingestion of food accidentally contaminated with cytotoxic drugs, chemicals, and ingestion (Radetski *et. al.*, 2004). Most of the cytotoxic drugs are highly irritant and have risks associated with direct contact with skin or eyes. It is also caused dizziness, nausea, headache, allergy and dermatitis are all symptoms produced by cytotoxic drugs (Claxton *et.al.*, 1998).

3.9. Chemical waste

Chemical waste includes discarded solid, liquid, and gaseous chemicals generated from medical treatments (Hess, 2002). These can be organic or inorganic. Organic chemical waste generated in HCE's through disinfecting and cleaning activities, chemical solutions for treatment and diagnosis, vacuum-pump oils from medical equipments, insecticides from diagnostic and experimental work, medical equipment cleaning and housekeeping (Pinizzotto and Baker, 2000; Mohee, 2005). It may be hazardous or non-hazardous; but in the context of protecting health, it is considered to be hazardous (Rong-Hua *et. al.*, 2006) if it has at least one of the following properties:

- Toxic;
- Corrosive (e. g. acids of pH < 2 and bases of pH > 12);
- Flammable;
- Reactive (explosive, water-reactive, shock-sensitive);
- Genotoxic (e. g. cytostatic drugs).

Formaldehyde is a significant component of chemical waste from healthcare establishments because of its widespread use to clean and disinfect equipment (Goldberg, 1996; WHO, 2004). Photographic fixing and developing solutions, which contain nitric acid, are used in X-ray departments and these are also highly hazardous chemical waste (Adani *et. al.*, 2005). Wastes containing solvents such as methylene chloride, chloroform, trichloroethylene, and refrigerants are classes as chemical waste. Non-halogenated compounds such as xylene, methanol, acetone, isopropanol, toluene, ethyl acetate, and acetonitrile are generated in pathology, histology laboratories and engineering departments (Goldberg, 1996; Daggan *et.al.*, 1999; Pinizzotto and Baker, 2000). These are highly toxic to human health. The

Agency for Toxic Substances and Disease Registry (ATSDR) found that people living around hazardous waste dumping sites are at potential health risk due to their exposure to chemical waste.

Inorganic chemical waste consists mainly of acids and alkalis such as sulphuric, hydrochloric, nitric, and chromic acids, sodium hydroxide and ammonia solutions (Agramunt *et.al*, 2003). Oxidants, such as potassium permanganate ($KMnO_4$), potassium dichromate ($K_2Cr_2O_7$), reducing agents, such as sodium bisulphite ($NaHSO_3$) and sodium sulphite (Na_2SO_3), are used in medical treatment and generate hazardous chemical waste (Pinizzotto and Baker, 2000). Non-hazardous chemical waste consists of chemicals with none of the above properties, such as sugars, amino acids, and certain organic and inorganic salts (WHO, 2004).

3.10. Waste with high content of heavy metals

Wastes with high heavy-metal content are hazardous due to their highly toxic nature and the variety of negative impacts on human health (Christensen, 1995 and Riley *et. al*., 2003). One of the most dangerous heavy metals is mercury generated through spillage from broken clinical equipment and dentistry (Graney *et. al*., 2004; Murray and Holmes, 2004; Randall and Chattopadhyay, 2004). Cadmium is another highly toxic metal and is a generated waste from discarded batteries in HCE (Granero and Domingo, 2002). "Reinforced wood panels" containing lead is used in radiation proofing of X-ray and diagnostic departments (Oostdam *et. al*., 1999). A number of drugs contain arsenic which is risk for human health (Suner *et.al*., 1996; WHO, 2004).

3.11. Pressurized containers

Pressurized containers include gas cylinders, cartridges, aerosol cans etc, (Daggan *et.al*., 1999). There are various pressurized containers used in medical facilities and used containers are also considered as medical waste.

3.12. Radioactive substances

Radioactive waste can be solid, liquid or gaseous (Lioyd, 2003 and Adani *et. al*., 2005). The ionizing radiations in medicine include the X – rays, α- and β- particles and γ-rays discharged through radioactive substances (Espartero *et. al*., 1999).

- α- *Particles* include protons and neutrons and positively charged. They have a low penetration power, which is hazardous to humans mostly when inhaled or ingested (Hillman *et.al.*, 2004; Souto and Kimpland, 2004).
- β- *Particles* consist of electrons which are negatively or positively charged with a significant ability to penetrate human skin; they affect health through ionization of intracellular proteins and proteinaceous components (Donnell *et. al.*, 2004).
- γ-*Rays* are electromagnetic radiations which are similar to X-rays but the wavelength is shorter than X-rays. Penetrating power is high and lead (or thick concrete) protecting is required to reduce their intensity (Souto and Kimpland, 2004).

The category of diseases such as headache, dizziness, vomiting, respiratory function disorder is caused by radioactive waste (Espartero *et. al.*, 1999 and Betti, 2000). It can affect genetic materials in human body function, destroy tissues and cause amputation of human body parts (Zucchetti and Ciampichetti, 2004).

3.13. Pathogenic micro-organism in medical waste

The function of micro-organism resistance activity is based on the survival ability. Survival ability is dependant on temperature, humidity, ultraviolet, organic nutrient, presence of predators etc (Kiimmerer *et. al.*, 1997). Micro-organisms can breed and survive in medical waste if the survival condition is suitable (Kiimmerer *et. al.*, 1997). The hepatitis B virus can survive for a long time in arid air and or boiled water (Brooks *et.al.*, 2004). Moreover, it can stay alive on some antiseptic mediums and in 70% ethanol. In 60° C temperature it can remain viable for 10 hours (Brooks *et.al.*, 2004 and Longmore *et. al.*, 2004). However in comparison, HIV is much less resistant and survives in at temperatures of 56 °C (Longmore *et. al.*, 2004). Pathogenic organisms and bacteria, yeasts, protozoa, intestinal and other worms, flukes, virus can survive in adverse conditions for long periods of time (Hamer, 2003).Vectors such as rats, flies, and cockroaches, which feed or breed on medical waste, are well known passive carriers of microbial pathogens (Avery *et.al.*, 2004).

3.14. Diseases Outbreak

Medical waste is cause of diseases like hepatitis (jaundice), and HIV/AIDS (Kassenga *et. al.*, 1997; Ahmed and Chowdhury, 2003;). These may be transferred through saleable medical items like syringes (Kabir *et al*, 2004). MRSA, diarrhoea, leptospirosis, typhoid and cholera are transferred through improper management of medical waste. Salmonella and Shigella species are highly concentrated in hospital wastewater, which is a dangerous threat for people living around and using that wastewater (Chintis *et. al.* 2004). Healthcare discharged water contains highly toxic metals and chemicals such as trichloroethylene (TCE), lead, tetrachloroethylene, arsenic, benzene, copper, zinc, cadmium, toluene, DDT, nickel etc. which can cause serious diseases like skin diseases and arsenicosis (Santarsiero and Ottaviani, 1995; Mumtaz *et. al.* 2004). Sahrma *et.al.*, (2007) stated that potential for transmission of heavy metal infection is increased in vegetable when discharged wastewater comes into irrigation.

3.15. Conclusion

From the above discussion of medical waste related literature, medical waste is considered environmental and public health risks due to inappropriate handling and or disposal. It was found from a literature, that there are different levels of risks associated with viral and bacterial waste, sharps and infectious waste, toxic and radioactive waste. The chapter has addressed and explored selected research output on medical waste from several literatures. The next chapter will focus on the data collection methods, procedures and sampling system to explore the aims and objectives of this study.

Chapter IV

Survey Approach

4.1. Introduction

This chapter presents an overview of how the actual fieldwork to conduct the survey was staged as well as the details of the data collection and analysis, and also considers the method's strengths and weaknesses. The discussion of the survey approach is needed to provide a rationale for the research and an understanding of the theoretical framework that were used to direct the data analysis and interpretation.

4.2. Theoretical Orientation and Survey Approach

All survey is conducted by a set of ideas and judgment about the nature of work. In the survey approach, one or more data collection techniques could be used (Neuman, 1994). Survey researcher decides to adopt one or more techniques for data collection considering appropriateness based on the practical factors that are: expectation of data quality, costs, number of response rates, level of expected errors and time of data collection.

4.3. Quantitative and Qualitative Approach

Quantitative research is to gather, analyse and interpretation of data quantitatively (Galal and McDonnel, 1997) which is based on quantification. On the other hand, qualitative research is based on perceptions that vary with person and time (Rich and Ginsburg, 1999; Urquhart, 2001). In qualitative research, reliable adherence to a philosophical angle, thoroughness in collecting data, and consideration of all the data to produce a theory is not subjected to rigorousness (Melia, 1996). Qualitative research encompasses many dimensions and continuously presents new ideas (reconstructing) that can be recognised (Silverman, 1993 and Wolcott, 1994).

Observational approach, questionnaire survey and in-depth interview method was applied for collection of quantitative and qualitative data with closed and open questions followed by Hague (1993). Answers to questions were obtained in face-to-

face interviews. This is the most common method for data collection (Casley and Lury, 1982).

According to Oppenheim (1992), a good design is one that permits its execution with simplicity, clarity, practicability and completeness. It has been observed that many questionnaire surveys have produced little or no useful information because they were not properly designed (Hague, 1993). Moreover, several sources of bias such as the possibility of the self-selection of respondents and prediction of the sample size could be affects the research during survey design (Casley and Lury, 1982).

4.4. Fieldwork for data collection

4.4.1. Survey Plan

The field survey plan was designed to collect data which specifies the medical waste generation, composition, volume and magnitude in the survey area. The primary data were collected by field observations, questionnaire survey and interviews through relevant participatory methods. The secondary information was collected through a literature survey on medical waste studies (relevant published and unpublished reports, documents, newspaper, and magazine).

4.4.2. Gain Access

The main difficult stage of the fieldwork was to gain access to the 'survey field site'. The field investigation was started during the September to November 2012. A series of meeting was arranged with the relevant government and non-government organisations and personnel concerned with medical waste related issues in Dhaka. Simultaneously an introductory meeting was organized with the two parts of DCC authority. The DCC authority willingly permitted to work in DCC area. A 'reconnaissance' survey was organised for realization on primary idea of the overall condition and number of HCEs in the study area.

4.4.3. Sample frame of HCEs

Both probability and non-probability sampling of techniques were used in this survey. Probability measures provide the decision makers with the means for quantifying the uncertainties which affect the choice of appropriateness actions which is essential in quantitative analysis. The determination of sample size was

considered with a number of issues under the assumption. Each HCE was considered as a one sample and the total number of the HCEs situated in the City corporation area was considered. This report is based on both the part of Dhaka City Corporation.

(a) **Definition of population** (healthcare establishment). A total of all HCEs functioning in Dhaka City Corporation area (North and South) were considered during field survey, which formed the statistical population.

Table 4.1

Functioning HCEs in Dhaka City Corporation

Strata	DCC North	DCC South	Total (%)
Hospitals	85	89	174 (17)
Clinics	118	46	164 (16)
Diagnostic/pathology	143	66	209 (21)
Dental clinic	289	176	465 (46)
Total	**635**	**377**	**1012**

Source: Field survey, 2012.

(b) **The creation of sampling frame.** No sampling procedure was followed as the main objective of the survey was to prepare a list of functioning HCEs in the survey area.

(c) **The choice of non-probability sampling.** The strategy of drawing sample size for qualitative information, purposive sampling criteria was applied. This requirement corresponds to Miles and Huberman's 'feasibility' attribute. Managing the relationship with informants, or 'front-end-management' (Wainwright, 1997), is an important aspect of participatory qualitative research validity.

4.5. Survey stages

4.5.1. Observational approach

This section describes the out line of sequence in which the fieldwork was conducted through observational approach. Fieldwork was started by social network mapping which is a systematic technique for quick adjustment to field site. This technique is normally used in field based data collection procedure to discover areas within a community. Social network mapping was used in this survey as a means to build rapport, to gain an initial understanding of the social dynamics within the study area, and to get to know the physical layout of the field site. This procedure was done by walking around the facility (HCEs), informal dialogue approach with the relevant people, taking photographs (pictorial data) and so on. This technique was also used to draw a map of the physical layout of the HCEs to prepare a study area map and was also used for final data analysis and interpretation.

Observational approach was used in the data collection process as it allows an individual or individuals to have an idea about the firsthand data on programs, processes, or behaviours. This technique can also provide unanticipated outcomes. The technique is also expensive and time consuming. It requires well-qualified person otherwise may affect the behaviour of participants which may be a typical observation. As a trained person the Field Investigators could avoid these limitations.

4.6. Survey conduction

A series of meetings were arranged with the HCEs authority (Owner, Manager, responsible personnel) and were briefed about the survey. The HCEs authority allocated a specific person who would assist during survey period. As it was difficult to collect data simultaneously from different HCEs, 12 field investigators were recruited. They were all briefed of the ethical issues regarding the questionnaire survey and data collection. A number of training programs were organized on survey objectives for field investigators on how to measure the waste quantity, volume, segregation of hazardous and non-hazardous waste, bin-bag placing and data recording procedures. A pilot study was conducted ensuring the accuracy of data collation procedure. The field investigators and HCEs allocated persons worked together under survey coordinator's direct supervision.

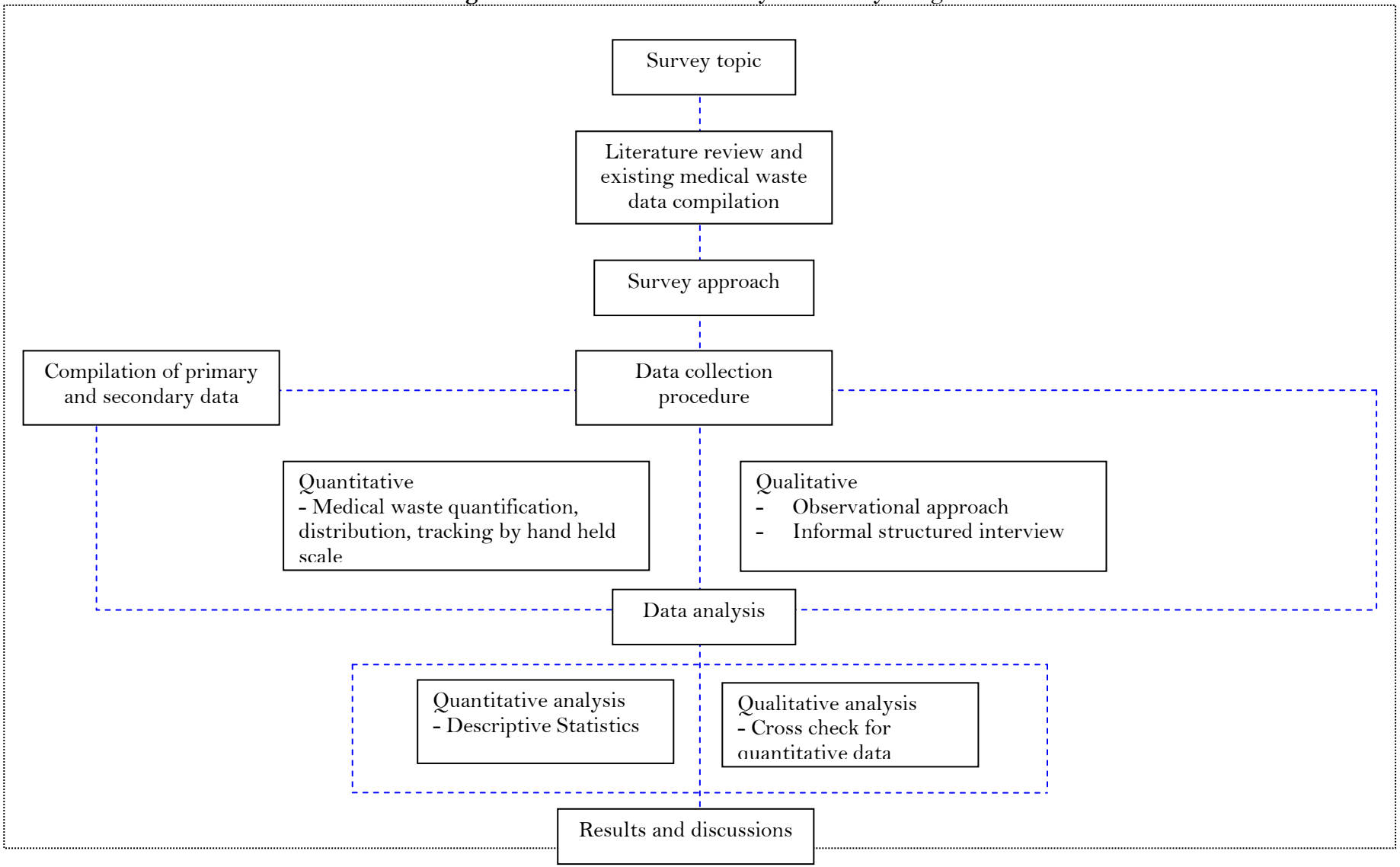
4.7. Questionnaire survey method in sequence for HCEs

The waste collection data was recorded on shift basis, three times in a day (morning 4 am to 12 pm, afternoon 12 pm to 8 pm and night shift 8pm to 4 am) due to variation of waste generation quantity/volume and quality. The HCE designated person placed the allocated bin-bag in each ward and department during morning shift. At the end of morning shift, Field Investigators examine bin-bags from each department/ward and replaced a new one to continue the survey program accurately. The bin-bags were individually weighed through hand held scale and recorded the data in a prescribed form for each department and ward. After that, the waste was categorised as hazardous and non-hazardous as designed in the questionnaire and weighed again. The weight measurement was cross checked by both field investigator and HCEs allocated person. It is noted that the radiochemical data was gathered from HCEs information record book. The qualitative section of the questionnaire was also recorded in the form during the survey period by face to face interview. The collected data were analysed and discussed.

4.8. Informal structured interview

A number of informal dialogue approaches were arranged with patients and with their attendants in the HCEs during the survey. It was revealed that the patient's socio-economic status is one of the most important factors of waste generation. Moreover, some dialogue approach was organized with waste collector, cleaners, waste scavengers and waste recycle operator on medical waste.

Figure 4.1. Flow chart of survey and survey design



4.9. Data analysis

The data was recorded in MS Excel (version 14) and analysed by descriptive statistical method. The qualitative data was reduced by code and analysed. A total of 1437 structured questionnaire surveyed, of the survey area where 644 from the hospitals, 88 from the private clinics and 231 from the pathology/diagnostic centres and 474 from dental clinics.

4.10. Problems and limitations

It is extremely difficult to be exhaustive in enumerating problems which can have an influence on the accuracy of the results. Statistical error is not the only one; also there is chance of error in the structure of a questionnaire. The limitations and problems were described in the research procedure section in different stages. It was solved and elaborated.

4.11. Concluding remarks

This chapter describes the approach of survey and methodology. This chapter begins with different survey approaches. This is followed by a rationale for the survey type, and description of the procedures that were adopted during the fieldwork. This chapter mainly concentrates on the multi-methods of data collection events and data analysis systems under the framework of field survey and design.

Chapter V

Results and Findings

This chapter summarizes the findings related to medical waste issues in the survey. Data regarding the generation rates, sources, composition, disposal and recycling of medical waste were accumulated and analyzed. The transferability of risk related to the nature of medical waste was also observed.

5.1. Types of location of the HCEs

The number of HCE in DNCC is highly concentrated than DSCC. Most of the largest public hospitals such as; Dhaka Medical College Hospitals (DMCH), Sir Salimullah Medical College Hospitals (SSMCH), BSMMU were located in the South. All of the clinics, pathology, diagnostic labs and dental clinics surveyed were private, while 25% of the hospitals were public and 75% private.

Table 5.1 shows the types of location of the surveyed HCEs in DNCC. A large number of the HCEs, (32%) were located in the main residential area, while 6% were located in industrial areas, 21% were located in commercial areas and 39% were located in mixed use areas (residential coexisting with government and private sector commercial activities). A few of the HCEs (2%) were located in the government allocated area.

Table 5.1 Types of location of Surveyed HCEs in the DNCC

Type of location	**Healthcare Establishment**				
	Hospitals (%)	Clinics (%)	Pathology/ diagnostic (%)	Dental (%)	Total (%)
Residential	23 (27%)	31 (26%)	34 (24%)	118 (41%)	206 (32%)
Industrial	3 (4%)	6 (5%)	5 (3%)	22 (8%)	36 (6%)
Commercial	17 (20%)	18 (15%)	25 (17%)	75 (26%)	135 (21%)
Mixed area	29 (34%)	63 (54%)	79 (55%)	74 (25%)	245 (39%)
Government Allocated	13 (15%)	--	--	--	13 (2%)
Total (%)	85 (13%)	118 (19%)	143 (23%)	289 (45%)	635 (100%)

Table 5.2 shows the types of location of the surveyed HCEs in DSCC. A large number of the HCEs, (56%) were located in the main commercial area, while 23%

were located in residential areas, 9% were located in industrial areas and 11% were located in mixed use areas (residential coexisting with government and private sector commercial activities). A few of the HCEs (1%) were located in the government allocated area.

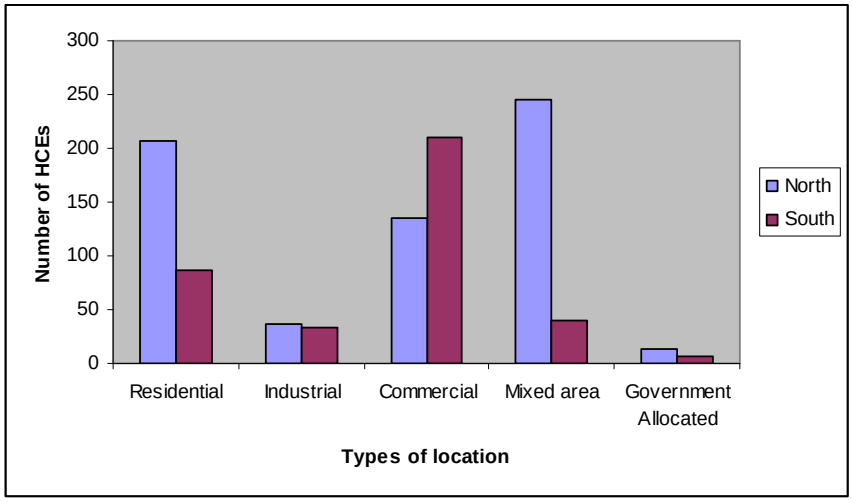
This pattern of location may present significant dangers in the context of urban public health and safety in the Dhaka City Corporation area.

Table 5.2 Type of location of Surveyed HCEs in the DSCC

Type of location	**Healthcare Establishment**				
	Hospitals (%)	Clinics (%)	Pathology/ diagnostic (%)	Dental (%)	Total (%)
Residential	24 (27%)	13 (28%)	7 (11%)	42 (24%)	86 (23%)
Industrial	23 (26%)	5 (11%)	4 (6%)	2 (1%)	34 (9%)
Commercial	31 (34%)	16 (35%)	46 (70%)	117 (66%)	210 (56%)
Mixed area	5 (6%)	11 (24%)	9 (14%)	15 (9%)	40 (11%)
Government Allocated	6 (7%)	1 (2%)	0 (--)	0 (--)	7 (1%)
Total (%)	89 (24%)	46 (12%)	66 (17%)	176 (47%)	377 (100%)

The comparison of type of location of the surveyed HCEs between DNCC and DSCC were presented in figure 5.1.

Figure: 5.1 Type of location of the surveyed HCEs between DNCC and DSCC



Dhaka is a fast growing city, ranked 11th in the world by population (16.5 million). Expansion of the city is limited due to physical constraints. Commercial buildings are predominantly built and managed by the private sector, and mixed use for

developments, such as shopping malls and residential complexes, are popular. A large number of the private HCEs are established in residential areas, or within shopping malls. Senior management and owners of the HCEs indicated, through informal interviews, that they have established their activities in residential areas to maximize convenience for their patients; as most people have no private transport, and there is no free ambulance service. HCEs, established in residential areas allow easy and timely access in an emergency. As there is a lack of legislation by the city authority, HCEs are allowed to dispose of their hazardous medical waste into general city corporation waste containers intended for domestic waste. This leads to mixing of medical waste and domestic waste, resulting in all waste becoming hazardous. However, it was identified during the interview that management did not consider the health and safety issues for the residents of the risks of medical waste and some of them were not interested in discussing this issue.

5.2. Type of Establishments Structure

When preparing the study area plans it became obvious that small and medium sized HCEs were generally situated with limited space within densely populated residential areas. No external storage was found in any of the surveyed HCEs. Table 5.3 shows the types of establishment in the surveyed DNCC and in table 5.4 DSCC accordingly.

Table 5.3 Types of building and housing structure of Surveyed HCEs in the DNCC

Establishment Structure	**Healthcare Establishment**				
	Hospitals (%)	Clinics (%)	Pathology /diagnostic (%)	Dental (%)	Total (%)
Single building	26 (31%)	65 (55%)	6 (4%)	5 (2%)	102 (16%)
Shared building	33 (38%)	18 (15%)	15 (10%)	22 (8%)	88 (14%)
Single floor	03 (4%)	21 (18%)	52 (37%)	111 (38%)	187 (30%)
Shared floor	0 (--)	3 (3%)	70 (49%)	151 (52%)	224 (35%)
*+1 in a campus	23 (27%)	11 (9%)	--	--	34 (5%)
Total (%)	85 (13%)	118 (19%)	143 (23%)	289 (45%)	635

* More than one building in a particular campus.

Of the surveyed HCEs, only 5% were located in an enclosed site with more than one building while 16% were housed in a single dedicated building, and 14% were located in a shared building, 30% were located in a single floor and 35% were located in a shared floor in DNCC.

Table 5.4 Types of building and housing structure of Surveyed HCEs

Establishment Structure	**Healthcare Establishment**				
	Hospitals (%)	Clinics (%)	Pathology /diagnostic (%)	Dental (%)	Total (%)
Single building	35 (39%)	8 (17%)	6 (9%)	0 (--)	49 (13%)
Shared building	25 (28%)	11 (24%)	11 (17%)	20 (11%)	67 (18%)
Single floor	11 (12%)	20 (43%)	27 (41%)	3 (2%)	61 (16%)
Shared floor	3 (4%)	7 (15%)	18 (27%)	153 (87%)	181 (48%)
*+1 in a campus	15 (17%)	0 (--)	4 (6%)	0 (--)	19 (5%)
Total (%)	89	46	66	176	377 (100%)

* More than one building in a particular campus.

More or less similar pattern was observed in the DSCC in the context establishment of structure. Of the surveyed HCEs in DSCC, similarly 5% were located in an enclosed site with more than one building while 13% were housed in a single dedicated building, and 18% were located in a shared building, 16% were located in a single floor and 48% were located in a shared floor.

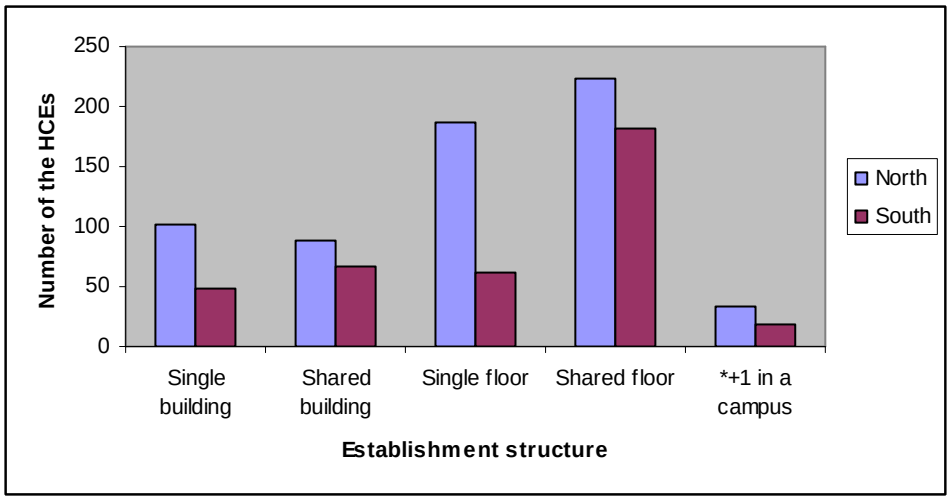
All of the HCEs located in a single building or a shared in a building or floor were privately owned or rented. In some of those facilities examined, the space required for even basic provision for proper waste segregation, storage and disposal would significantly reduce the number of beds or tests that the facility could support and so reduce profitability. Thus most HCEs have insufficient space to setup secured temporary storage for waste, or to install appropriate equipment for decontamination or final disposal of hazardous waste.

It was observed that none of the HCEs have an Effluent Treatment Plant (ETP) suitable for highly contaminated liquid waste. HCEs located in a single building discharged liquid waste directly to the municipal general sewerage system, and HCEs located on shared floors in a building discharged liquid waste into the building general sewerage. It was also found that some HCEs discharged liquid waste into adjacent lakes and water bodies that were also used by local residents for washing and household purposes, as well as for agriculture. At present HCEs liquid

waste is discharged to the domestic septic tank, general sewerage system or connected directly to the public sewage network. Liquid waste and wastewater was not being treated appropriately, the discharge may lead to potential contamination of drinking water supplies, ground water contamination and/or environmental degradation.

During formal and informal interviews, respondents from management of the surveyed HCEs indicated that this was not done due to lack of space, but also most of them did not have a positive attitude towards establishments of ETP. None of the HCE owners or managers was found to have considered waste management when establishing their business. Interviews with academics indicated that this was not due to the unwillingness of the architect or engineer, but due to the unwillingness of the HCE owner and management. The comparison of establishment structure between the two parts of DCC were presented in the figure 5.2

Figure 5.2: The comparison of establishment structure between DNCC and DSCC



5.3. Frequency of the services

Table 5.5 and table 5.6 Shows the frequency of the services in a day of the conducted HCEs in the DNCC and DSCC accordingly. A large number of patients either indoor or outdoor were received service from the HCEs on a daily basis. The frequencies of

the different types of service were extrapolated with the different type of generated waste accordingly.

Table 5.5 Frequency of services on a day of the Surveyed HCEs (DNCC)

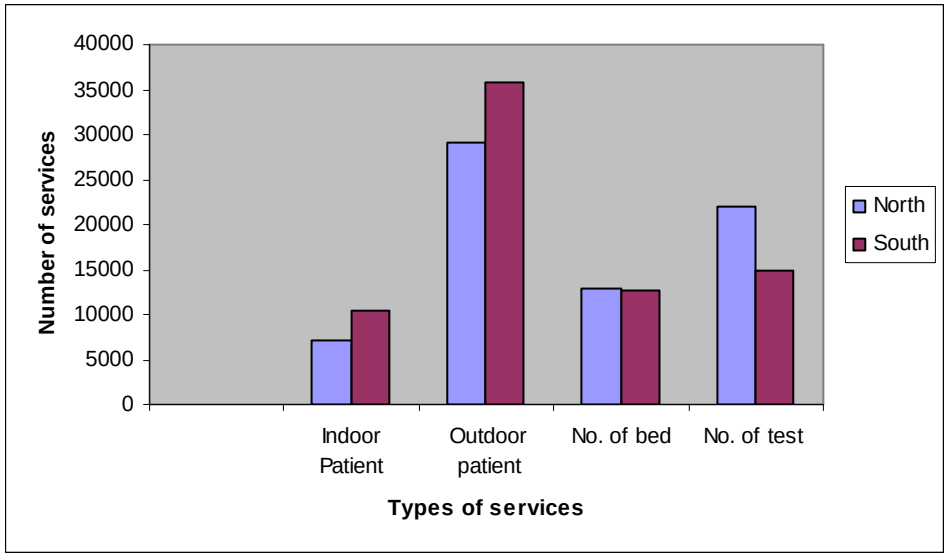
Types of service	**Healthcare Establishment**				
	Hospitals	Clinics	Pathology /diagnostic	Dental	Total
Indoor Patient	3250	3860	--	--	7010
Outdoor patient	14250	11540	2050	1290	29130
No. of bed	6790	5560	--	580	12930
No. of test	4665	5057	10950	1272	21944

Table 5.6 Frequency of services in a day of the Surveyed HCEs (DSCC)

Types of service	**Healthcare Establishment**				
	Hospitals	Clinics	Pathology /diagnostic	Dental	Total
Indoor Patient	9188	1290	--	--	10478
Outdoor patient	24469	1607	9069	585	35730
No. of bed	10307	1950	--	310	12567
No. of test	10350	1560	2018	872	14800

The comparison of the frequency of services of the conducted HCEs between two parts of DCC was presented in the figure 5.3.

Figure 5.3: Frequency of services of the conducted HCEs between DNCC and DSCC



5.4. Manpower of the HCEs

Table 5.7 and table 5.8 shows the total manpower of the surveyed HCEs in the DNCC and DSCC accordingly. The percentages of the doctors and nurses are more or less similar while office staff is the highest (DNCC 31% and DSCC 36%). Surprisingly the cleaners who are responsible for waste collection and management was found to be lowest in the DNCC (9%) and second lowest in the DSCC (12%).

This result could be illustrated that why the medical waste is not managed properly. It is obvious that the HCE owners and senior officials are not fully interested to manage the waste properly. Therefore, they are not concerned to recruit or involve designated person for particularly waste management issue. In some case, it was found and observed during the survey that the person who are responsible for office work are also responsible for waste management. In addition some of the cleaners are responsible for other purposes such as laundry work, kitchen work and patient service. Some of the junior nurses are also responsible for waste management was found in a number of HCEs.

Table 5.7 Manpower of the Surveyed HCEs in the DNCC

Establishment Structure	**Healthcare Establishment**				
	Hospitals	Clinics	Pathology	Dental	Total (%)

			/diagnostic		
Doctors	2012	2129	589	432	5162 (24%)
Nurses/brothers	2185	2365	276	358	5184 (24)
Office staff	2689	2980	513	310	6492 (31%)
Technicians	822	763	155	78	2622 (12%)
Cleaners	1017	1212	182	211	1818 (9%)
Total (%)	8725	9449	1715	1389	21278

Table 5.8 Manpower of the Surveyed HCEs in the DSCC

Establishment Structure	**Healthcare Establishment**				
	Hospitals	Clinics	Pathology /diagnostic	Dental	Total (%)
Doctors	4067	169	505	232	4973 (21%)
Nurses/brothers	5746	170	45	160	6121 (26%)
Office staff	6267	366	1725	130	8488 (36%)
Technicians	325	47	389	50	811 (3%)
Cleaners	2313	114	197	190	2818 (12%)
Total (%)	18718	866	2861	722	23211 (100%)

5.5. Source, composition and generation of waste in the surveyed HCEs

Table 5.9 and table 5.10 shows the composition of the waste generation of the surveyed HCEs in the DCC north and South accordingly. The data shows from the North that the highest percentage (76%) of the generated waste is non-hazardous while 24% (5 tonnes) is hazardous and clinical waste in nature.

Table 5.9 Waste generation in the Surveyed HCEs (DNCC)

Category of Waste	**Healthcare Establishment**				
	Hospitals (%)	Clinics (%)	Pathology /diagnostic (%)	Dental (%)	Total (%)
General	8955 (80%)	5337 (70%)	2250 (74)	352 (77%)	16894 (76%)
Pathological and infectious	690 (7%)	783 (10%)	435 (14 %)	27 (6%)	1935 (9%)
Radioactive	4 (0.04)	5 (0.01%)	4 (0.2%)	1 (0.2%)	14 (0.6%)
Chemical	106 (1 %)	120 (1.5%)	210 (7%)	20 (4%)	456 (2%)
Sharps	580 (5%)	625 (8%)	26 (1%)	20 (4%)	1251 (6%)
Pharmaceutical	52 (0.5%)	38 (0.50%)	86 (2.8)	12 (3%)	188 (1%)
Plastic	710 (6%)	672 (8%)	20 (1%)	25 (5%)	1427 (6%)
Total	11097 (100%)	7580 (100%)	3031 (100%)	457 (100%)	22165 (100%)

The data shows from the South that the highest percentage (74%) of the generated waste is non-hazardous while 26% (near about 7 tonnes) is hazardous and clinical waste in nature.

The percentage of the hazardous and non-hazardous waste obtained from both of the city corporations is higher than the WHO medical waste code of conduct but not significant.

Table 5.10 Waste generation the Surveyed HCEs (DSCC)

Category of Waste	**Healthcare Establishment**				
	Hospitals (%)	Clinics (%)	Pathology /diagnostic (%)	Dental (%)	Total (%)
General	15540 (75%)	2550 (73%)	850 (56%)	220 (71%)	19160 (74%)
Pathological and infectious	1430 (7%)	291 (9%)	185 (12%)	35 (11%)	1941 (7%)
Radioactive	25(0.12%)	5 (0.14%)	12 (0.7%)	0	42 (0.1%)
Chemical	785(4%)	180 (5%)	110 (7%)	20 (6%)	1095 (4%)
Sharps	980 (5%)	160 (4%)	75 (5%)	20 (6%)	1235 (4%)
Pharmaceutical	785 (4%)	90 (2%)	190 (13%)	10 (3%)	1075 (4%)
Plastic	1045 (5%)	220 (6%)	90 (6%)	5 (2%)	1360 (5%)
Total	20590 (100%)	3496 (100%)	1512 (100%)	310 (100%)	25908 (100%)

It was found from the survey that most of the waste volume is from kitchens in both hospitals and in clinics providing food services for patients. However, in the pathology/diagnostic centres, the main contributors to medical wastes are from the laboratory and research sections. This difference is probably due to the fact that these non-residential facilities do not produce a high volume of non-hazardous waste as a result of non-medical patient care, and so the medical waste is seen to be a higher percentage of the total.

The comparison of the waste generation by categories between the DNCC and DSCC are presented in the following figures.

Figure 5.4: Total waste generation by composition in the DCC area

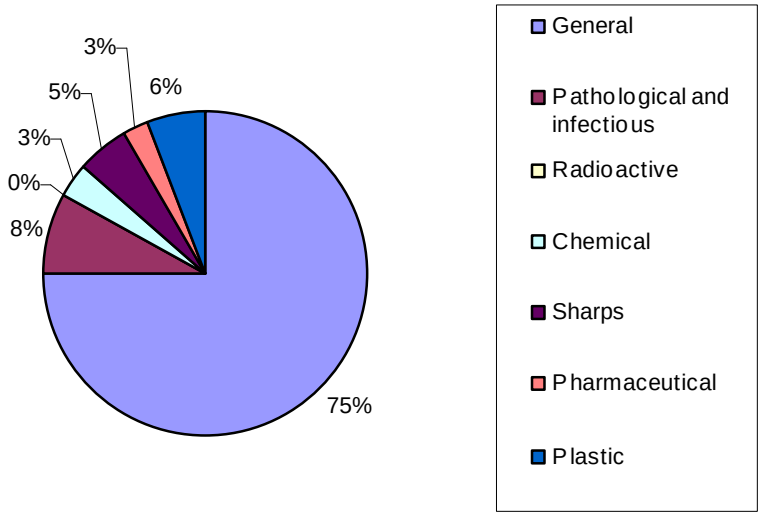


Figure 5.5: Waste generation by composition in the DNCC

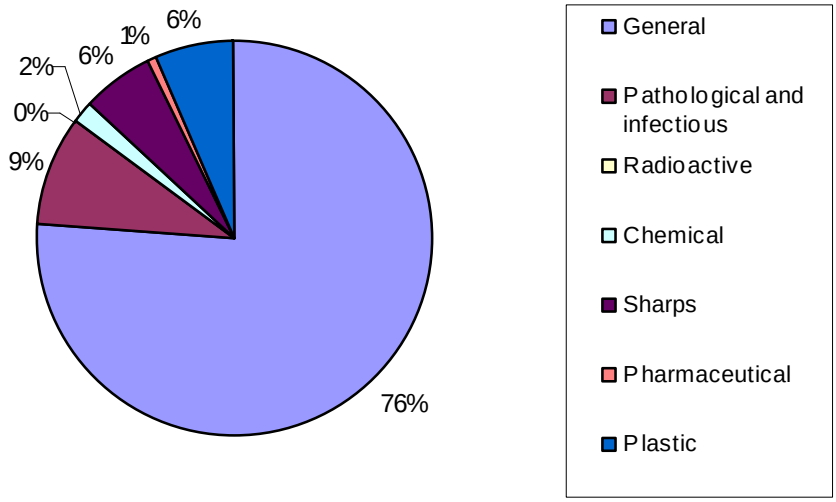
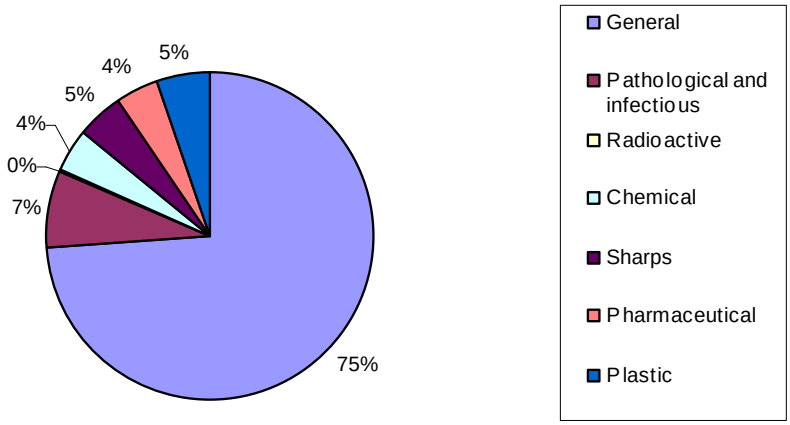


Figure 5.6: Waste generation by composition in the DSCC



The total waste generation by category of composition of surveyed DNCC and DSCC is presented in the table 5.11

Table 5.11

Waste category	Hospitals		Clinics		Path/Diagnostic		Dental		Total	
	North	South	North	South	North	South	North	South	North	South
General	8955 (80%)	15540 (75%)	5337 (70%)	2550 (73%)	2250 (74%)	850 (56%)	352 (77%)	220 (71%)	16894 (76%)	19160 (74%)
Pathological and infectious	690 (7%)	1430 (7%)	783 (10%)	291 (9%)	435 (14 %)	185 (12%)	27 (6%)	35 (11%)	1935 (9%)	1941 (7%)
Radioactive	4 (0.04%)	25(0.12%)	5 (0.01%)	5 (0.14%)	4 (0.2%)	12 (0.7%)	1 (0.2%)	0	14 (0.6%)	42 (0.1%)
Chemical	106 (1 %)	785(4%)	120 (1.5%)	180 (5%)	210 (7%)	110 (7%)	20 (4%)	20 (6%)	456 (2%)	1095 (4%)
Sharps	580 (5%)	980 (5%)	625 (8%)	160 (4%)	26 (1%)	75 (5%)	20 (4%)	20 (6%)	1251 (6%)	1235 (4%)
Pharmaceutical	52 (0.5%)	785 (4%)	38 (0.50%)	90 (2%)	86 (2.8%)	190 (13%)	12 (3%)	10 (3%)	188 (1%)	1075 (4%)
Plastic	710 (6%)	1045 (5%)	672 (8%)	220 (6%)	20 (1%)	90 (6%)	25 (5%)	5 (2%)	1427 (6%)	1360 (5%)
Total	11097 (100%)	20590 (100%)	7580 (100%)	3496 (100%)	3131 (100%)	1512 (100%)	457 (100%)	310 (100%)	22165 (100%)	25908 (100%)

The larger facilities obviously generate more waste simply because they deal with more patients, so the data is also presented in terms of kg/bed^{-1}, kg/patient^{-1}and kg/test^{-1} in table 5.12 for DNCC and table 5.13 for DSCC.

Table 5.12 Waste generation rate in surveyed HCEs DNCC

HCEs	Patients			Waste generation rate			
	Residents	Outdoor	Test	Kg^{-1}	**Average**		
					kg/bed^{-1}	kg/patient $^{-1}$	kg/test^{-1}
Hospitals	6790[a]	14250	4665	11097	1.63	0.77	2.5
Clinics	5560	11540	5057	7580	1.36	0.65	1.5
Pathology / diagnostic	--	2050	10950	3031		1.5	0.3
Dental	--	1290	1272	457		0.35	0.4
Total	12350	29310	21944	22165			

Table 5.13 Waste generation rate in surveyed HCEs DSCC

HCEs	Patients			Waste generation rate			
	Residents	Outdoor	Test	kg/day	**Average**		
					kg/bed^{-1}	kg/patient $^{-1}$	kg/test^{-1}
Hospitals	10307[a]	24469	10350	20590	1.99	0.84	1.9
Clinics	1950	1607	1560	3496	1.79	2.1	2.2
Pathology / diagnostic	--	9069	2018	1512		0.16	0.7
Dental	--	350	872	310		0.88	0.3
Total	12257	35495	14800	25908			

*(--) no indoor patients,
[a] Number of beds.
Average waste generation rate determined by total per day waste generation in context of beds, patients and tests.

Generated waste is 22 tons/day where 17 tons/day (76%) are non-hazardous and about 5 tons/day (24%) are hazardous in the DCC North; and around 26 tons/day where 19 tons/day (74%) are non-hazardous and near about 7 tons/day are

hazardous in the DCC South. The average waste generation rates were found 1.63kg/bed/day in the surveyed HCEs.

These estimates were obtained by stringent weighing of waste in carefully chosen, rigorous methods, surveyed of all the functioning HCEs in the DCC areas, including non-residential diagnostic centers and dental clinics. This study used a particular designed of waste generation in a broad range of Health Care Establishments (HCEs) to indicate that the amount of waste produced in Dhaka can be estimated to be 48 ± 5 ton per day. The proportion of this waste that would be classified as hazardous waste by World Health Organization (WHO) guidelines was found to be approximately 25% (12 ± 2.5 ton^{-1}). The amount of waste, and the proportion of hazardous waste, was found to vary significantly with the size and type of HCE.

5.6. Segregation system used in the surveyed HCEs

Table 5.14 and table 5.15 shows the current status of existing management system of medical waste in the surveyed HCEs of DNCC and DSCC accordingly.

Table 5.14 Management practice of the Surveyed HCEs (DNCC)

Establishment Structure	Healthcare Establishment				
	Hospitals (%)	Clinics (%)	Pathology /diagnostic (%)	Dental (%)	Total (%)
Proper	8 (9%)	12 (10%)	11 (8%)	47 (16%)	78 (12%)
Partial	35 (42%)	67 (57%)	43 (30%)	86 (30%)	231 (36%)
Without	42 (49%)	39 (33%)	89 (62%)	156 (54%)	326 (52%)
Total	85 (100%)	118 (100%)	143 (100%)	289 (100%)	635 (100%)

Table 5.15 Management practice of the Surveyed HCEs (DSCC)

Establishment Structure	Healthcare Establishment				
	Hospitals (%)	Clinics (%)	Pathology /diagnostic (%)	Dental (%)	Total (%)
Proper	5 (6%)	8 (17%)	9 (13%)	4 (3%)	26 (7%)
Partial	39 (44%)	21 (46%)	16 (25%)	36 (20%)	112 (30%)
Without	45 (50%)	17 (37%)	41 (62%)	136 (77%)	239 (63%)
Total	89 (100%)	46 (100%)	66 (100%)	176 (100%)	377 (100%)

Most of the HCEs collected their waste without any management in both of the city corporation area (North 52% and South 63%); however, 36% of surveyed HCEs used a partial segregation (segregated but mixed with hazardous and non-hazardous)

procedure in the DNCC and 30% in the DSCC. Only 12% follows proper management procedures in the DNCC and 7% in the DSCC.

This result is better findings from the previous study by Patwary et al., (2009) which was done before PRISM intervention where he found that HCEs collected their waste without any management (68.12%); partial, 24% and only 7% follows proper segregation procedures. This achievement was increased due to the NGO PRISM activity of medical waste management. When asked the question regarding training issues (Table 5.16) related to medical waste handling during the survey, most of the respondents replied that they have received training from PRISM (86%).

Table 5.16 Training received by the Surveyed HCEs Staff

Training	**Healthcare Establishment**				
	Hospitals	Clinics	Pathology /diagnostic	Dental	Total
Received	1705	2021	356	58	4140
By PRISM	1506	1780	254	34	3574 (86%)
By others	199	241	102	24	566 (14%)

5.7. Temporary storage and waste disposal trend in the surveyed HCEs

In the present study there was no proper designated storage facility for medical waste was found in most of the surveyed HCEs. It was observed that in most of the surveyed hospitals and clinics, collected wastes are temporarily stored in an open space within the hospitals, clinics and pathological centres premises which then dumped into the domestic waste bins located outside the premises. In some HCEs, collected waste sometime temporarily stored in a room. They then dump these wastes again into nearby domestic bin once/twice per day. However, it was not stored regularly. Storage areas for medical waste were not well structured.

NGOs PRISMs collected (46%) waste by separate container and transported by specially designated vehicle for final disposal (Figure 5.7). Rest of the wastes (54%) are collected by DCC from bin and road site near HCEs. It was observed liquid

waste and wastewater of surveyed all HCEs is discharged into the general sewerage system.

(A) (B)

Figure 5.7 Picture A shows the medical waste transportation vehicle for Dhaka City and Picture B shows the medical waste treatment plant, the only officially formal treatment plant operating by PRISM.

5.8. Medical waste recycle situation in the study area

It was observed that Recyclable medical wastes (RMW) are collected by waste collectors and scavengers without taking any precaution. Although, no facility currently is operating with a proper program to recycle wastes such as syringe, paper, cardboard, plastics, metals, can and glass. Most of the RMW are collected together with the general waste.

5.9. Concluding remarks

This chapter described the quantification of medical wastes generated from different HCEs and existing practice related to risks. The collected data showed that all the surveyed HCEs generate both of hazardous and non-hazardous waste including pathological, syringes, sharps and glasses, textile stained with blood and papers, chemical, pharmaceuticals, infectious and left over food. The outcome of this result is discussed in the next chapter with the framework of magnitudes and risks of medical waste. Next chapter will present some comparative analysis using numeric and graphical figure of the survey results between the DNCC and DSCC.

Chapter VI

Discussions

6.1. Introduction

Individuals working with medical waste frequently face the risk of occupational exposure to hazardous waste. Many scholars suggests that waste management workers who handled hazardous medical waste are especially at risk of communicable diseases like diarrhea and dysentery, blood-transmitted infectious diseases, gastroenterological, respiratory and skin infections (Marinkovic *et.al*., 2007). In the present survey report, presented data indicate that there might be growing health risks in the study area because of rapidly expanding HCEs and growing number of individuals working with medical waste.

6.2. Waste generation by different categories of HCEs

Unless it becomes mixed with hazardous waste, medical waste is mostly non-hazardous. Major contributor to hazardous waste is laboratories, morgue and operation theatres in this category. This high percentage is to be expected due to the widespread use of disposable items such as medicine bottles, blood bags, packing materials, syringes and catheters.

According to composition of medical waste described by the WHO (Pruess *et.al*, 1999) generally, 10 – 25% of generated waste from HCEs is hazardous. In the present survey report, average 25% wastes were hazardous. The composition of medical waste depends upon different parameters, such as the size of the HCE, type of patient care provided and the waste segregation system. The data shows that hospitals generate large volumes of total waste. This is partly due to the large numbers of patients on each site, but the amount of waste per bed is lower than that found in clinics. Within this group, the government hospitals included in the survey generated more waste than the private clinics. Since medical treatment costs in the public hospitals are lower so more patients are admitted in these hospitals. It has been reported that teaching facilities in government hospitals and other private medical college hospitals do increase the volume of waste; both hazardous and non-hazardous. HCEs with teaching facilities in Europe have a waste generation rate

which is more than that in Dhaka City were namely 3.9kg/bed/day in Norway, 4.4 kg/bed/day in Spain, 3.3 kg/bed/day in UK and France, where maternity HCE generation rates were 3.5 kg/bed/day in Spain, and 3 kg/bed/day in UK (Bdour *et.al.*, 2006). However, the HCEs with teaching and maternity facilities waste generation were found in hospitals 1.63 kg/bed^{-1}. The generation rate kg/bed^{-1} is higher then other studies by Pruss *et. al.*, 1999 and Da Silva *et.al.*, 2005. The differences are probably due to socio-economic and cultural conditions, living standard of the patients, and availability of temporary storage facilities and also ways of waste categorising and segregation system.

Each surveyed private clinic accommodates a small number of patients and employs a small number of specialists. This category of HCE may attract more affluent patients due to better treatment with modern facilities. This may explain the increased waste production from clinics; waste generation rates in clinics were found to be higher per test than for the other two categories. This is expected as because more affluent patients are likely to bring personal supplies of food and medicines with them to the clinic.

The third and fourth category of HCE surveyed, pathology/diagnostic centres and dental clinics accordingly treat patients on a day-care basis. This may explain why those included in the survey produced less waste when compared to the other categories of HCE. Many authors suggest that the quantity of generated wastes at pathology/diagnostic centres appears to depend mainly on two factors: number of tests/day and nature of the tests (Silva *et al.*, 2004 and Bdour *et al.*, 2006). Average waste generation rate in surveyed pathology/diagnostic centre is comparable with Jordan, where the rate of generation found 0.034-0.102 kg/test-day (Bdour, 2006). Although this category of HCE produces less waste, however, in the present study shows that the proportion of hazardous waste is much higher. This is expected as these facilities do not produce kitchen or other non-hazardous wastes associated with caring for residential patients.

6.3. Segregation and Temporary Storage of Medical Waste

Patients and their visitors, health care workers and workers related to the waste management/cleaners within HCE are at risk from waste at their sources of generation. Rapparini *et al.*, (2007) described that 70% healthcare workers are exposed to health risk from blood-borne pathogens in Brazil. In addition, improperly segregated or unlabelled wastes also present a hazard to individuals outside the HCE. During the collection period, most of the operators used normal containers and plastic bags, without colour codes or biohazard signs to show that they contain hazardous waste, which is contradictory to the Code of Practice (WHO, 2004). The collected wastes were observed to be mixed together by waste cleaners and collectors as they collect for temporary storage and have no idea about risk transmission. Medical waste was also mixed with municipal waste during collection by DCC waste crews from DCC bins, even when the waste was infectious stained with bloodborne pathogens. This mixing of hazardous materials with general waste makes the total waste infectious and represents a serious hazard to workers and the general public. This is similar to the findings of Sabour *et al.*, (2007) who studied the mixing of infectious waste with non-hazardous medical waste in Jordan. However, the scenario is quite better in the HCEs who are under the program of PRISM medical waste management service.

The data from table 5.7 shows waste management system inside the HCEs premises which is related to temporary storage and disposal trend. Most of the HCEs employed cleaners and waste collectors, who disposed of waste to open DCC bins near HCEs. This was necessary due to a lack of well structured temporary internal waste storage facilities inside the HCE premises. Miyazaki *et al.*, (2007) reported that 95% municipal workers experienced with needle stick accidents in Japan.

No external storage was found in most of the surveyed HCEs. Significantly lower number of HCEs was identified with temporary storage facilities in the study area with an inadequate infrastructure which is under the PRISM activities. Therefore, sharps containers and other recyclable waste are frequently placed in insecure storage facilities may also result in contaminated injection equipment being scavenged and reused.

6.4. Occupational health risk to medical waste worker

Hazardous waste containers can capable of nosocomial diseases transmission in individuals who are exposed to (Neely *et al*., 2003). In the survey area, most of the HCEs stored infectious sharps containers in general utility area without any proper labelling or other precaution. Cleaners and waste collectors in most of the HCEs usually did not wear sufficient protective uniforms during waste handling which circumstantially increases the risk of accidents. A small proportion of waste workers indicated that they have heard about the protective uniforms from the PRISM personnel, but never had seen them. They stated through in-depth interviews that they are not aware of such hazards or associated risks from needles or sharps related accident.

DCC and NGO workers are involved in a range of activities such as collection, transportation, operation/treatment of processing systems and final disposal of wastes. Potential risks to their health (DCC individuals) arising from medical waste have not been considered. Therefore, most of the waste management workers of DCC have experienced accidental injury mostly from used needles and other sharps.

6.5. Waste Scavenging and Recycling

Individuals working with medical waste may exposed to, through collecting and cleaning of medical waste for recycling, or through waste scavenging (Tamplin *et.al*., 2004). There is potentially an additional serious risk to patients due to reuse of recycled items. A large volume of waste is collected for recycling by HCE waste collectors or by Scavengers. The collected waste was found to include discarded plastic materials and metals contaminated with blood, discarded medical equipment and other waste mixed with infectious agents. It is important for workers to know and understand the potential risks of medical waste recycling. The waste recyclers used the collected waste as raw materials for secondary products, which they handled without any disinfection/sterilisation.

In one type of recycling process, scavengers melt the plastic in an open container heated by burning kerosene or other fuel. This produces toxic fumes which can cause serious health effect when inhaled (WHO/WPRO, 2003). During the present survey, it was observed that most of the recycle operators experienced itching, eye burns, skin rash and coughs. Furthermore, accidental injuries such as sharp wound,

minor or major burn, skin inflammation were also found among recycle operators. This may cause disease transmission to waste recyclers from medical waste.

6.6. Improper discharged of waste water and risk

Liquid waste was not extensively studied as part of this phase of the project. Initial observations support the supposition that all HCEs surveyed discharged their liquid waste and wastewater into the general sewerage system along with chemical and pharmaceutical waste (antibiotics and other drugs), heavy metal (mercury, phenols, derivatives and other chemicals) used in HCEs for medication purpose. This may create potentially diseases out break and stop natural ecosystem due to toxic effects (Mbongwe *et al*., 2007 and Hafliger *et.al*., 2000). This type of practice is of massive magnitude, and requires urgent consideration in regards risks. Therefore, this aspect will be further studied in the next phase of the research.

6.7. Concluding remarks

The various functions of activities with medical waste in the HCEs and study area were thoroughly surveyed and studied. The present medical waste management in the surveyed HCEs is unsafe in point of in-house management such as; collection, segregation, storage, transportation, treatment and final disposal. In the study area present medical waste disposal environment may be a risk for the environment and community as well as to public health aspects. PRISM has been trying to develop this management practice since 2005 from non-governmental position to minimize the risks and for better environment in this Dhaka City Corporation area with the collaboration City Corporation authority. This attempt is partially successful in the context of different issues, but till need to developed more effort.

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