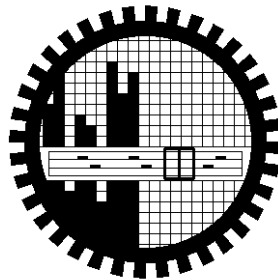


DEVELOPMENT OF A HOSPITAL WASTE MANAGEMENT INDEX FOR MAJOR CITIES IN BANGLADESH

by

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MASTER OF SCIENCE IN CIVIL ENGINEERING (ENVIRONMENTAL)

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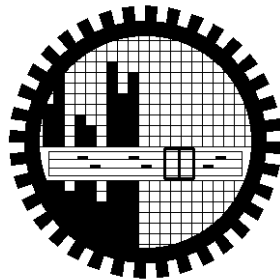
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A thesis submitted to the Department of Civil Engineering,
Bangladesh University of Engineering and Technology, Dhaka
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DEDICATIONS

This thesis is dedicated to my supervisor Dr. Mahbuboor Rahman Choudhury who was so kind and considering throughout the thesis. His proper guidance and motivation was the key to the successful completion of this study.

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Abstract

Health care or medical solid wastes, if not managed properly, can pose serious health damage and spread various diseases. The main objective of this study was to develop a hospital waste management index (HWMI), which would indicate the overall condition of medical waste management in a hospital. A list of thirty three parameters having significant influence on medical waste management was identified from relevant national and international guidelines. The relative importance grading of these parameters was done to understand which parameters were more important with respect to overall hospital waste management. The grading values (from 5 to 1) were reflective of qualitative significance of parameters: „most important“, „important“, „essential (loss of life may not occur, but other losses and injuries are high)“, „essential (damage of health and injuries are considerable)“ and „not essential (but preferable)“, respectively. Importance grading of the parameters were collected from eight experts from relevant Government (DGHS, DoE, DU) and non-government (Prism, ICDDR,B) authorities working in the field of hospital waste management. From the experts“ evaluation, the parameters were ranked based on the weighted average of relative importance grading of each parameter. A total of 30 hospitals were physically surveyed (twenty four hospitals inside Dhaka city and six hospitals outside Dhaka city) to assess condition of the selected parameters and a rating of each parameter was done (on a scale of 0 to 5). Physical survey rating values (from 5 to 0) represented qualitative conditions of parameters like „excellent“, „good“, „average“, „poor“, „very poor“ and „absent“, respectively. Relative importance grading from experts and assessment of the parameters from physical survey were combined to produce a Hospital Waste Management Index (HWMI), which provided a dimensionless single value indicating overall waste management condition of a given hospital. Comparisons were made between hospitals having different management (Government. or non-government.) or locations (inside vs. outside of the capital city). Privately owned and operated hospitals showed better hospital waste management scenario compared to Government hospitals. The average HWMI for Government and private hospitals were found to be 2.85 and 3.07, respectively. From the comparison of hospitals inside and outside Dhaka it was found that, although hospitals inside Dhaka scored better points in most of the parameters, the average HWMI of hospitals inside and outside Dhaka are 2.98 and 2.86 respectively, which is not statistically significant. This close value of HWMI resulted due to high difference in some ratings of parameters in favor of hospitals outside Dhaka city.

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CHAPTER 1

INTRODUCTION

1.1 General

The concern for environmental protection has gained its momentum since the middle of the last century. The emergence of a large number of scientific materials has shown how the degrading environment has become an overall threat to the existence of all the leading species (Zerin and Ahmed 2009). Improper management of solid waste is one of the vital reasons behind environmental degradation. There are various types of solid waste including municipal, industrial, agricultural, health care wastes and many more. Health care or medical wastes are one of the solid wastes that can pose serious health damage and spread various diseases if it's not managed properly. Hospital wastes are highly infectious and hazardous. They may carry the germs of dreadful disease like hepatitis B and C (jaundice), AIDS etc. If the hospital waste is not separately collected or treated, the mixture of hospital waste and municipal waste makes the entire waste stream a great public health hazard. Improvement of waste management practices in clinics and hospitals is essential to prevent the spread of infectious disease.

Medical waste is a waste material generated at health care facilities such as hospitals, clinics, physician's offices, dental practices, blood banks, veterinary hospitals/clinics as well as medical research laboratories and clinics. The Medical Waste Tracking Act, 1988 of USA defines medical waste as "Any solid waste that is generated in the diagnosis, treatment or immunization of human beings or animals, in research pertaining thereto or in the production or testing of biological."(Onel 1989) This definition includes but not limited to: blood soaked bandages, culture dishes and other glassware, discarded surgical gloves, instruments and needles, removed body organs, discarded lancets etc. Medical waste stream is very complex in nature. These wastes include infectious, hazardous, radioactive and other general wastes. (Akter 2000)

Medical waste, due to its content of hazardous substances, poses serious threats to environmental health. The hazardous substances include pathological and infectious material, sharps, and

chemical wastes. In hospitals, different kinds of therapeutic procedures (i.e. cobalt therapy, chemotherapy, dialysis, surgery, delivery, resection of gangrenous organs, autopsy, biopsy, Para clinical test, injections etc.) are carried out and result in the production of infectious wastes, sharp objects, radioactive wastes and chemical materials. In developing countries, medical waste has not received much attention and it is so often disposed of together with domestic waste. Improper medical waste management is alarming in Bangladesh and it poses a serious threat to public health.

1.2 Background

In 1992, WHO came forward to facilitate a consultative meeting on “Managing Medical Waste in Developing Countries” at its headquarter followed by dissemination of its outcomes among member states. In the same year (June, 1992), United Nations Conference on Environment and Development (UNCED) in Rio de Janerio set the following goals and targets with regard to waste management in cities (Akter 2000):

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

Subsequently in 1995, WHO-SEAR (South East Asia Region) supported a survey on hospital waste management practices in its member countries which covers 9 countries of this region. Survey reveals that hospitals in this region were having no waste management plan or procedure and no legislation or guideline. Afterwards in 1996, WHO-SEAR facilitated a regional consultative meeting in Thailand, followed by outlining an action plan. Meanwhile India (1998) had shown progress in framing legislation in this region. For the sound management of hazardous hospital waste, WHO-SEAR suggested guiding principles and practices to be followed by countries of this region.

Medical waste presents a high risk to doctors, nurses, technicians, sweepers, hospital visitors and patients due to arbitrary management. A common observation in Dhaka City is that poor

scavengers, women and children collect some of the medical wastes (e.g. syringe-needles, saline bags, blood bags etc.) for reselling despite the deadly health risks. People of Dhaka city as well as Bangladesh are under the threat of getting infected to numerous diseases because of improper handling, management and disposal of hospital wastes. In Dhaka city 5000 tons of wastes are disposed of everyday which include domestic, construction and dangerous medical waste (Zerin and Ahmed 2009). According to Dhaka City Corporation (DCC) the city produces 4500-5000 tons of wastes every day among which only 1% is clinical and biomedical waste (Nasreen, 2005). In general Bangladeshi hospitals produce 9-12kg of solid waste per patient per day. Hospitals produce relatively small quantities of radioactive or hazardous chemical waste, but potentially infectious biomedical waste constitutes as much as 20% of the total hospital waste. Many hospitals throw their wastes in the nearby dustbins and street children gets in direct contact with it. On an average, 10-20kg of waste is dumped on road side dustbins by each clinic or hospital of Dhaka city (Zerin and Ahmed 2009). Although, organizations like PRISM are working very hard to collect and dispose hospital wastes safely in Dhaka city, it is not possible for them to cover all the clinics and tertiary hospitals. Similar picture is found outside Dhaka also. In Sylhet city, it is found that the average waste generation rate for hospitals and clinics is 0.934 kg/bed/day, for diagnostic centers and outside clinics it is 0.0414 kg/bed/day. The percentage of hazardous waste produced from hospitals/clinics and diagnostic centers are 22.92% and 36.03% respectively. There are no well-defined rules and regulations for hospital waste management in Sylhet City Corporation, hospital waste does not get proper attention and disposal of solid waste or hazardous waste is not properly done (Sarkar, Haque et al. 2006). In other cities of Bangladesh and for villages and Upazillas situation is even worse (Hossain and Uddin 2014).

Waste management in our country is running in an old traditional way for decades. At present our aim should be ensuring proper handling and disposal of hospital waste. A reduction in the indiscriminate disposal of hospital waste will give immediate benefits to the service providers and community, safety at the hospital, improvement of local quality of environment and results in lowering the level of pollution to the eco-system. Although it is not possible to achieve the goal at once, an incremental approach is the best strategy towards a sustainable system.

1.3 Objectives

This study aims to assess the overall situation of hospital waste management in different hospitals of Bangladesh. The specific objectives of the study are:

- (1) To identify significant parameters related to hospital waste management and prepare a relative importance ranking among these parameters.
- (2) To assess the current condition of identified parameters related to hospital waste management in different hospitals of Bangladesh.
- (3) To analyze the data statistically to represent the variability of hospital waste management practices with respect to management and location of the hospitals.
- (4) To develop a single Hospital Waste Management Index (HWMI) for assessing the overall condition of waste management in the hospitals in Bangladesh.

1.4 Scope Of The Study

Scopes of the study are given below:

- 1) It will develop a scale to observe the overall solid waste management scenario in a hospital.
- 2) Existing solid waste management scenario in different hospitals can be ascertained and linked to issues like management, location, users etc.
- 3) It will help hospitals to improve their waste management condition by improving on those parameters in which they have scored poor grading during assessment.
- 4) It will provide information within the National Health Service (Waste Management) policy and give guidance on their implementation.
- 5) It will help in the development of “Policy” and “Legislation” on hospital waste management.

CHAPTER 2

LITERATURE REVIEW

2.1 General

2.1.1 Definition of Hospital Waste

Hospital waste refers to the waste resulting directly from patient's diagnosis, prevention, research, alleviation of disablement and treatment purpose, as well as waste generated from all other departments of the health care establishment (Ministry of Health and Welfare, 2001).

2.1.2 Classification of Hospital Waste

Wastes generated in the health care establishment are in solid, liquid and gaseous forms. Health care waste comprises not only the by-product of health care activities but also the waste from administrative activities, housekeeping, patient themselves, support services etc. that's from every corner of the health care establishment. The composition of the waste varies from country to country, among hospitals within the same country even among departments within the same hospital. Medical waste can be classified in different ways. But in all the classification the most important thing is the hazardous part of the waste which causes severe damage to the public health.

Hospital wastes are mainly of four types depending on their physical state (Ministry of Health and Welfare, 2010). They are:

- 1) Solid Waste
- 2) Liquid Waste
- 3) Gaseous Waste, and
- 4) Radioactive Waste

Among which solid waste can be categorized in two types: i) General Waste and ii) Hazardous Waste. General waste includes the sand, dust, toilet wastes, kitchen waste, wools and other wastes that may generate from daily life activities in the office, patients' wards, outdoor areas etc. Hazardous waste can be classified into Sharp waste, Infectious waste and Non-infectious waste.

On the other hand, WHO classifies medical waste in two main types, Hazardous waste and Non-hazardous waste. Non-hazardous waste is same as described before. Hazardous waste includes

pathological waste, infectious waste, sharp waste and chemical waste. This classification is mainly based on the type of the medical waste.

2.1.3 Sources of Hospital Waste

Sources and description of different types of hospital wastes are given below:

Table-2.1: Sources of different types of hospital wastes

Type of waste	Description/ Example	Site of generation
General waste	Mainly recyclable wastes like papers, clothes, packing boxes, medicine containers, administrative waste, metals, polythenes, plastic containers etc. Some non-recyclable waste like kitchen waste is also included.	<ul style="list-style-type: none"> • Administrative • Support service • Patient service • Laboratories
Pathological waste	Tissues, organs, body parts, blood products & body fluids, placenta, product of concepts, human excreta etc.	<ul style="list-style-type: none"> • Patient service • Laboratories • Operation theatre
Infectious waste	Wastes from surgery, waste from patients with infectious diseases, swabs, wound dressing, linen, soaked bandage, surgical accessories, soiled plaster casts, culture materials, wastes from hemodialysis etc.	<ul style="list-style-type: none"> • Patient service • Laboratories • Operation theatre
Sharp waste	Needles, syringes, intravenous set, scalpel, saw, blades, broken glass, nails and sharps generated from support service.	<ul style="list-style-type: none"> • Patient service • Laboratories
Radioactive waste	Wastes generated from nuclear medicine department, radiotherapy departments, radioimmunoassay, solid, liquid and gaseous wastes contaminated with radioactive materials, left over radioactive medicine etc.	<ul style="list-style-type: none"> • Laboratories • Nuclear medicine center • Patient service
Anatomical waste	Waste from Gynecological, Orthopedic and General surgery, Eye, ENT, OBs ward etc.	<ul style="list-style-type: none"> • Operation theatre • Laboratories
Liquid waste	Blood, pus, vomit, suction fluids, serum fluids, waste water etc.	<ul style="list-style-type: none"> • Patient service • Laboratories • House keeping • Disinfecting

Type of waste	Description/ Example	Site of generation
Pharmaceutical waste	Date expired or contaminated medicine, no longer required medicine, leftover medicine, spilled medicine, vaccines etc.	<ul style="list-style-type: none"> • Patient service • Support service

2.1.4 Risks Associated with Hospital Wastes

A part of the medical waste is hazardous and can pose serious threat to health and environment. There are mainly two types of risks or hazards with medical waste:

- i) Health Hazards, and
- ii) Environmental Hazards

Risks associated with medical waste are briefly described below:

- i) Health Hazards related to medical waste:

There is a risk of injuries related to medical waste handling and carrying by waste hauler or cleaner. For example, cut injury punctuated wound, laceration, strain and sprain of the joint of limbs and backache etc. Some common cases of injury due to exposure to medical waste inside or outside of hospital are as follows (Akter, Chowdhury et al. 1998):

- Hands cut due to handling broken glass.
- Injured by needle and fingers permanently damaged.
- Right hand or both legs become paralyzed due to injury by the needle.
- Skin diseases on legs, hands and body.
- Pus due to injury sometimes.
- Ulcer on legs, etc.

Sharp wastes, which include syringes and needles, have the highest disease transmission potential amongst all categories of medical waste. Almost 85% of the sharp injuries are caused between their usage and subsequent disposal. More than 20% of those who handle them encounter „stick“ injuries (Zerin and Ahmed 2009). Injuries from needle-stick and sharps occur frequently in developing countries, and safer disposal facilities and routine hepatitis B vaccine should be adopted.

A small part of the total medical waste is infectious. Still, because of ethical question and infection risks, it is a focal point of public interest. Infectious waste contains different kind of pathogens or organisms that is potential for infection or disease if it is not properly disposed. Table below shows few examples of different pathogens and disease caused by them.

Table-2.2: Examples of different pathogens and disease caused by them (Akter, Chowdhury et al. 1998)

Name of the pathogen	Disease caused by the pathogen
Bacteria	Tetanus, gas, gangrene and other wound infection, anthrax, cholera, other diarrhea type diseases, enteric fever, shigellosis, plague etc.
Virus	Various hepatitis, poliomyelitis, HIV-infections, HBV, TB, STD rabies etc.
Parasitic	Amoebiasis, giardiasis, ascariasis, ankylostomiasis, taeniasis, echinococcosis, malaria, leishmaniasis, filariasis etc.
Fungal infections	Various fungal infections like candidiasis, cryptococcosis, coccidioidomycosis etc.

Hazardous medical waste poses risk to the workers handling them. Hazardous medical waste consists primarily of chemical and discarded cytotoxic drugs. The chemicals used for the testing and sampling are potentially harmful to the laboratory technicians and environment. Most of the chemicals are poured down the sink and drained out next to the clinics which have potential risk of coming in contact with people. Some of the main health risks of medical wastes are summarized below:

- Contamination of drinking water. Possibility of leachate entering an aquifer, surface water or drinking water system.
- Non-biodegradable antibiotics, antineoplastic and disinfectants disposed of into sewage system may kill bacteria necessary for the treatment of sewage. Antineoplastic plashed into water courses may damage aquatic life or contaminate drinking water.
- Burning of waste at low temperature or in open container results in release of toxic pollutants (e.g. dioxins) into the air.
- Carcinogenic waste such as heavy metals, chemical solvents and preservatives pose serious human health risks not only to the workers but also to the general public as well.
- Unprotected and insecure landfill may pose health risks to the scavengers and inhabitants at the vicinity.

ii) Environmental Hazards:

The following are the environmental impacts associated with the improper disposal of medical wastes:

- Pollutants from medical waste (e.g. heavy metals and PCBs) are persistent in the environment.
- Accumulation of toxic chemicals within soil (proximity to humans, agricultural fields, soil organism, wild life, cattle).
- Ground water contamination, decrease in water quality.
- Bio-accumulation in organisms“ fat tissue and bio-magnify through the food chain.
- Repeated and indiscriminate application of chemicals over a long period of time has serious adverse effects on soil microbial population- reducing the rate of decomposition and generally lowering the soil fertility.
- Pathogens lead to long term accumulation of toxic substances in the soil.
- Windblown dusts from indiscriminate dumping also have the potential to carry hazardous particulates.
- Public nuisance (e.g. odors, scenic view, block the walk way, aesthetics etc.)
- Combination of both degradable and non-degradable waste increase the rate of habitat destruction due to the increasing number of sites necessary for disposal of waste.
- Plastic bags, plastic containers, if not properly destroyed may contaminate the soil and also reduces the chance for water percolation into the soil during precipitation.
- Open air burning does not guarantee proper incineration and releases toxic fumes (dioxin) into the atmosphere from the burning of plastics or PCBs.

2.2 Hospital Waste Management

2.2.1 Definition

Hospital waste management can be defined as the practice of generating, handling, separating, collecting, carrying, storage and finally disposing the waste as per the policy of the hospital. Level of knowledge, attitude of the waste generator and their practice are the key issues for successful waste management (Ministry of Health and Family Welfare, 2001).

Waste management varies with different circumstances for each hospital. But three major issues should be taken into account:

- The risks involved (financial, technical and legal).
- The cost of each option.
- The managerial skill and time required.

Careful management of hospital wastes is required to achieve the goal of minimizing occupational health hazard and for creating environmentally friendly hospitals.

2.2.2 Strategies for hospital waste management

2.2.2.1 In house waste management

In house waste management is nothing but the practice of waste management inside the hospital. For effective in house waste management, formulation of objective and effective time bound planning is needed. Planning requires the strategy and allocation of resources according to the identified priorities. Elements of in house waste management include waste minimization, waste identification and segregation, waste collection, waste transportation inside hospital, waste storage and waste disposal etc. (Ministry of Health and Family Welfare, 2001)

2.2.2.2 Waste minimization

Administration and staffs should play positive role in minimizing the amount and type of waste. Minimizing waste may eventually reduce handling and operation cost. Waste minimization should be done by the following ways (Ministry of Health and Family Welfare, 2001):

- Source reduction by purchasing and supplying materials which generate less hazardous waste. For example, plastic disposable goods should be limited as far as possible because of its non-biodegradability and other suitable goods should be used to replace it.
- Recyclable products should be used more.
- Old stocks and goods that have short term expiry period should be used first rather than keeping in store for long time.
- Expiry date of goods should be checked every time before receiving and supplying goods to the hospital staffs and patients.
- Flow of goods like chemicals and pharmaceuticals should be monitored.
- After every 3 months, the expiry date of different drugs and equipment should be monitored

2.2.2.3 Waste identification and segregation

Identification and segregation are the key elements of waste management and has a major influence on the treatment and disposal options for different types of wastes. Identification and segregation of all hospital wastes should be ensured at its" point of generation. Segregation is the responsibility of the generators. Senior managers should monitor and review the policies and practices on the segregation of wastes. Segregation is a safe practice for waste generators and handlers (Ministry of Health and Family Welfare, 2001). During waste identification and segregation, the following guidelines should be followed:

- If general wastes and hazardous wastes are mixed together, the mixed waste should be considered as hazardous waste.

- If any staff is confused about the type the waste, the waste should be considered as infectious waste during segregation.
- Pharmaceutical wastes should be collected separately so that it can be returned to the supplier or manufacturer.
- Radioactive wastes should be collected in a separate lead proof container. Radioactive wastes should not be incinerated and rather it should be collected, treated and disposed as per instruction of the “Atomic Energy Commission” of Bangladesh.
- All drainage bags, bags used in infusion and transfusion, all types of tubes should be shredded before putting into collection containers.
- All wastes should be dropped/collected in respective colored containers, where the color indicates the type of the wastes to be collected in that container.

2.2.2.4 Waste collection

Waste collection is an essential part of hospital waste management. Waste should be collected in a container as per color code. Waste handlers should collect the waste from the containers as per specified time approved by the hospital authority or at specified times of the day. Wastes should be collected at least twice a day e.g. at the morning and before evening. The following guidelines should be followed for waste collection:

- If bag is used inside the containers, when the bag fills up to three fourth of its size, the neck of the bag should be tied tightly with rope. Then the bag should be taken away for disposal. While moving bags containing wastes, it’s important to hold the bag at its neck and avoid dragging, throwing and holding at the bottom.
- The sharp waste container should be sealed by tape.
- Containers should be emptied frequently depending upon the quantity and nature of wastes.
- All wastes should be weighted before collection and recorded in Kg.
- Containers should not be transported if damaged or leaked. Waste containers should be washed after disposal of waste.
- In case of leakage, breakage or spillage of infectious waste, the spillage should be gently collected in a new bag. The area should be soaked with 2% Lysol solution for 15-20 minutes, then it should be washed and wiped.
- Collection and transportation of radioactive waste should be done in a lead proof box, as per the guidelines of Atomic Energy Commission of Bangladesh.

2.2.2.5 Waste containers and its placement

Generally waste containers are placed at the hospital entrance, outdoor, patient waiting room, outside the wards, in the corridor and other necessary places. Different types of wastes should be collected in different containers and similar types of wastes should be collected in same

container. For this reason, containers having different colors are used to separately collect different types of waste.

Containers having 6 different colors are generally used to collect 6 different types of wastes (Ministry of Health and Family Welfare, 2010). They are listed below:

Table-2.3: Different color containers for collecting different types of wastes.

Color of the container	Type of waste to be collected
Black	General waste
Yellow	Infectious waste
Red	Sharp waste
Blue	Liquid waste
Green	Recyclable waste
Silver	Radioactive waste

Waste containers should be impervious, washable rigid with average size. In a hospital, all types of wastes are not found everywhere. Different types of wastes are generated at different places and different colored containers should be placed in such a way that the type of waste to be collected in that container and the generated waste at that place match with each other. Placement of different colored containers is described below:

- Black containers (for general waste) should be placed at entrance, exit, outdoor, patient waiting room, in the corridor at 50 yards distance and other places where general wastes are likely to be generated.
- Yellow containers (for infectious waste) should be placed outside the ward, OT, labor room, casualty, emergency, pathology dept., laboratory, OPD and other necessary places.
- Red containers (for sharp waste) should be placed at all points of sharp waste generation especially in clinical pathology dept., OT, emergency and within the ward at nurse's station.
- Stainless steel bowl should be placed under each patients bed and also other places like laboratories, OT, labor room etc. Blue container should be taken at places where bowls are placed and the liquid waste then can be collected into the container.
- Green container (for recyclable waste) and Silver container (for radioactive waste) are generally placed beside the nurses' station at the wards.

2.2.2.6 Sharp waste separation

Sharp waste separation is a crucial part of hospital waste management. Sharp waste poses serious threat to the waste handlers and should be separated at the point of generation. Following guidelines can be followed for sharp waste separation:

- Syringes and other sharps should be made unfit for reuse by cutting, mutation, shredding or crushing after using. At the end of a task, needle and nozzle of a syringe should be cut down with cutting device.
- Cutting device should be available at all possible places of sharp generation. The number of cutting device should be equal to the number of technologists. Cutting device should be emptied daily into the container for sharps (blue container).
- Needles should not be recapped after use. If recapping is done, single handed recapping should be adopted.
- All sharps should be soaked with 0.5% chlorine solution for 10 minutes or with Lysol solution for 5minutes before putting them into the boxes for sharps.
- Sharp wastes should be segregated depending on contamination with body fluid.

2.2.2.7 Waste transportation inside hospital

Wheeled cart or trolley should be used for transportation of hospital wastes. There should be separate trolley/cart for collection of waste containers and these cart or trolleys should not be used for any other purposes except waste transportation inside hospital. The cart/trolley will follow designated route marked by the hospital director or waste management officer. The trolley or cart should be leak proof, easy to clean and should be cleaned after each use. The waste collection containers will be carried in the trolley directly to the temporary waste storage place.

2.2.2.8 Waste storage

The waste collected in different containers is stored at a temporary storage place, from where it will be handed over to City Corporation for safe disposal or directly disposed at a nearby landfill. This temporary waste storage place should be very carefully selected because if it spreads then it will easily come in contact with patients and common people moving inside or around the hospital. For proper selection of temporary waste storage, following instructions can be followed:

- The waste storage place should have sufficient size to accommodate the amount of waste collected daily from that hospital.
- The floor of the waste storage place should be hard, impermeable with good drainage facility.
- The floor should be above probable flood level.
- The waste storage place must not have any access for common people, but the waste handlers should have easy access into it.
- The waste storage place should have water supply facility, sufficient ventilation and should be protected from sun. Cleaning equipment and fire-fighting equipment should be also provided.

2.2.2.9 Waste disposal

The collected waste stored at the temporary storage should be disposed properly. There are various ways of disposing this waste. In Bangladesh, normally City Corporation cars collect waste from hospitals and they would dispose it to a landfill. But in recent time, there are some private organizations coming forward to improve the scenario of medical waste collection, treatment and disposal. One of these organizations is Prism Bangladesh (Zerin and Ahmed 2009). Medical wastes generated in different hospitals of Dhaka city is collected either by Prism Bangladesh or by Dhaka City Corporation.

In some hospitals it is found that, the general waste is disposed at a nearby dustbin and only the hazardous type of wastes are handed over to some private organization or City Corporation. It is also an effective way for small hospitals. But in this case careful inspection should be provided to ensure that no hazardous waste is mixed with the general wastes.

2.2.2.10 Health and safety

Following health and safety measures should be taken to ensure a healthy environment inside a hospital:

- Waste handlers should use protective clothing and equipment such as helmet, goggles, gown, service boots, gloves etc.
- Immunization facility, especially for “Tetanus” and “Hepatitis-B” should be provided to all the ward boys, sweepers, nurses and everyone associated with waste management.
- Hand washing facility should be provided at every floor of the hospital so that the waste handlers can easily clean their hand when needed.
- Inside of the hospital should be regularly cleaned to ensure a healthy environment.
- Used gloves, masks, aprons etc. must be cleaned or disinfected before reuse. The best practice will be to discard a used glove, mask etc. and using a new one every time.
- Staff should be trained about health safety, for example about waste segregation, appropriate packing, covering waste during transportation, appropriate waste storage etc.
- Pre-service and periodic medical checkup of the staff associated with hospital waste management should be ensured by the hospital authority.
- Written instructions should be provided regarding the procedures to be taken in the event of spillage of accidents.

2.2.2.11 Personnel management

All the hospitals must have designated personnel for monitoring and supervision of the waste management system of that hospital. All staffs should strictly follow the waste management standards and all department heads should take care of the waste management of his/her department. For management of the personnel related to waste management in a hospital, following steps can be taken:

- One person should be designated as “Waste Management Officer” from the existing manpower of the hospital who will be responsible for the overall waste management of the hospital.
- A committee should be formed to monitor and supervise any issue related to waste management in that hospital.
- Responsibilities of staff at different levels should be clearly mentioned. Staff should be directly accountable to the Waste Management Officer for their performance regarding waste management.
- A daily report of waste generation should be submitted to the Waste Management Officer by concerned staff. A monthly meeting of the committee and Waste Management Officer in this regard will be very fruitful.

2.2.2.12 Record keeping

Record keeping is very important to analyze the overall condition of waste management system in that hospital. A person with computer facility should be assigned to keep record on different issues like waste quality, waste quantity, operating cost, source of origin of waste, method of disposal etc.

Effective record keeping will facilitate waste management in the following ways:

- Documentary evidence of the work.
- Assessment of the expenditure.
- Identification of quantity and type of waste generated.
- Identification of high risk waste, site of production and storage.
- Identification of damage and cost during any unavoidable accidents related to waste management.
- Formation of future plans for sustainability.
- Providing data to inspire better investment in the future.

2.2.2.13 Monitoring and Supervision

The main objective of monitoring and supervision is to support on job performance and skill development. A supervisory person or a supervision team should be formed who will supervise the waste management situation periodically and thus ensure maintaining records, sending of daily reports to Waste Management Officer (WMO)/ Director etc. Proper monitoring and supervision will bring out and deficiency or problems within the system and it will also help providing proper solution to any problem regarding waste management.

2.3 Treatment and Disposal of Hospital Waste

A significant portion of the hospital waste contains infectious waste. If this infectious waste is directly dumped into landfill or into some dumping area then the whole waste stream becomes infectious and poses serious threat to waste handlers, environment and common people. That is why treatment of infectious waste before disposal is essential to make it risk free.

2.3.1 Objective

- To make the waste pathogen free.
- Reduction of volume in order to reduce requirements of storage and transportation facilities.
- Separation of recycle items.
- Minimizing operational risk.

2.3.2 Treatment and Disposal Strategies

Waste treatment is defined as a process that changes the character of hazardous waste into less hazardous or non-infectious waste. Treatment may or may not reduce the volume of waste. There is no perfect or ideal method of waste treatment, each technology has its advantages and disadvantages. Generally, selection of waste treatment procedures depends on various factors like –

- Amount of waste generated
- Type of hospital
- Environmental regulation
- Geographical location
- Technology available
- Related cost etc.

The treatment and disposal strategy should be technically achievable and economically sound. The final choice of treatment system should be adopted carefully by considering all the probable factors stated earlier.

2.3.3 Treatment Options for Hospital Wastes

There are different treatment options for different types of hospital wastes. One of the most common ways of treatment is using incinerator to burn all the waste. But this is only feasible if the hospital can afford an incinerator and if there is suitable place to locate the incinerator.

In some hospitals it is found that there is no suitable place to locate such incinerator and also the hospital authority is not capable enough to afford such facility. In those cases there are various probable options for treatment or disposal of the generated hospital wastes depending on the type of waste.

Different treatment/disposal options for different types of hospital wastes are listed below:

Table-2.4: Treatment/disposal options for hospital wastes.

Type of waste	Treatment / Disposal option
General waste	<ul style="list-style-type: none"> • Recycle and reuse. • Dispose to municipal or public dustbin. • Burial into pit within hospital premises. • Sell to the vendors.
Infectious waste Sharp waste and Pathological waste	<ul style="list-style-type: none"> • Burial into pits within hospital premises. • Incineration.
Radioactive waste	<ul style="list-style-type: none"> • Return to suppliers or manufacturers. • Take measures as per instruction of AEC.
Anatomical waste	<ul style="list-style-type: none"> • Burial into pits within hospital premises. • Incineration.
Liquid waste	<ul style="list-style-type: none"> • Discharge into sewer after neutralization. • Return to supplier or manufacturer. • Sanitary landfill.
Pharmaceutical waste	<ul style="list-style-type: none"> • Return to supplier or manufacturer. • Burial into pits within hospital premises. • Discharge into sewer. • Incineration.

2.3.4 Treatment of Radioactive Wastes

Safe management of radioactive waste should be a subject of national health strategy. Radioactive hospital wastes should be collected, packaged and securely stored as per instructions of Atomic Energy Commission of Bangladesh. If radioactive waste is mixed with infectious waste, radioactive component should be addressed first followed by suitable treatment for the infectious components (Ministry of Health and Family Welfare, 2001). Some common treatment and disposal options of radioactive wastes are given below:

- i) Returning to supplier.
- ii) Recycling and making reusable.
- iii) Storage by encapsulation.

Some additional remarks to be considered are:

- Disposable syringes containing radioactive residue should be emptied at designated location and stored in marked sharp container to allow decay of any residual activity.
- Solid radioactive containers such as bottles glass wires should be destroyed before disposal, public access should be avoided.

- Strong radioactive wastes (both solid and liquid) should be stored for decay in marked lead shield container until activity is reduced to authorized clearance levels.
- In case of therapeutic radioactivity, hospitals must be checked for radioactive contamination.

2.3.5 Recyclable Wastes

A major portion of the general waste can be reused after proper treatment such as autoclaving or chemical disinfection. The hospital authority can legalize recycling of waste by selling the waste to the vendors at a fixed time interval depending upon the amount of collection, as money earning source for hospital.

Recyclable wastes in a hospital may include all kinds of papers, uncontaminated clothes, packing boxes, medicine strips, plastic containers, damaged metallic containers, mineral water bottles, administrative waste, polythene bags, empty metallic cans, wood, corrugated packing materials, rubber materials, medicine containers, unbroken bottles, intact injection vials, hypo solution used for developing films etc. During recycling, plastic materials should be shredded to change its original shape.

2.3.6 Chemical Disinfection

To prevent hazard to human health and environment, it is necessary to treat certain categories of wastes before disposal. Chemical disinfection is more suitable for treating liquid waste than solid wastes. Chemicals are added to the waste to kill or inactivate pathogenic organism (Ministry of Health and Family Welfare, 2001).

Commonly used chemicals are listed below:

- Sodium hypochloride solution: 20ml/L for clean and 200ml/L for dirty waste
- Calcium hypochloride: 1.4g/L for clean and 14g/L for dirty waste
- Chloramine: 20g/L for clean and 10-20g/L for dirty waste.
- Methylated spirit (70%): disinfection of surface on which bleach cannot be used.
- Hand wash with alcohol (70% methyl alcohol): 1% glycerin is added for disinfection of hands.
- Savlon (1%)
- Bleaching powder.

General guidelines for the use of chemical disinfectants are given below:

- Materials should be completely immersed in chemicals.
- Disinfectant should be allowed to act for 30 minutes.
- Chemicals should be kept covered and should be changed frequently, at least once a day.

- Manufacturer instruction should be strictly followed for operation while using the chemicals.

2.3.7 Disposal of Hospital Waste

Disposal of Hospital waste is a very critical issue. Majority of the environmental impacts and health problems are related to the disposal of this waste. In management of hospital waste, disposal is a very important thing to look at.

Disposal of wastes generated in hospital sometimes depend on the location of the hospital. In city areas like Dhaka, Chittagong etc. a common practice of disposing hospital waste is handing it over to the City Corporation and then City Corporation carry it to the landfill to finally dispose it (Sarkar, Haque et al. 2006). Unfortunately, in our country most of the City Corporations are still not capable enough to collect wastes from all the hospitals. That is why; inclusion of private sector in this regard is very useful to solve the problem. In Dhaka city, PRISM Bangladesh foundation is already working to collect and dispose of the waste generated in hospitals. Situation of hospital waste collection and disposal has much improved in Dhaka city since PRISM started to work. On the other hand for hospitals not located within a City Corporation, there are various ways of disposing hospital wastes. Burning the wastes in incinerator is one of the safest ways, where the residue from incinerator can be disposed to the public bins or municipal/pouroshova bins or can be used for landfilling. There are other options like burying the waste into a pit.

In all cases, during disposal of hospital waste the following things should be kept in mind:

- While disposing waste in the municipal bins, mutilation / shredding should be such that unauthorized reuse is prevented.
- In case of incineration, no chemical pretreatment is required.
- Incineration is useful in town area especially where a number of hospitals are present, thickly populated area and hospital land area is not large enough.
- Burial of waste can be taken as an option for treatment where hospital land area is large enough, less populated, far apart from habitant and number of hospitals is less.
- Clinical waste must be chemically treated before storage.
- Commonly chemical treatment is done using 1% hypochlorite solution 0.5% chlorine solution.
- Waste collecting bags should not be made of chlorinated plastics. Labels should be of non-washable materials and prominently visible.

CHAPTER 3

METHODOLOGY

3.1 General

The research methodology was based on selecting key parameters that have potential impact on the hospital waste management, determining relative importance of those selected parameters and then assessing the condition of those selected parameters in different hospital throughout the country. A relative importance ranking of the parameters was prepared. Physical survey was conducted in hospitals inside and outside Dhaka city to assess the condition of the important parameters. Based on the survey result the parameters were graded for each hospital. In the end, relative importance grading and physical survey results were combined to calculate an index that will represent the overall condition of waste management in a hospital. Thus in this way an index (Hospital Waste Management Index) was introduced to indicate the condition of a hospital waste management system.

3.2 Selection of Parameters

Important parameters were selected in such a way that the parameters were related to all the stages in a waste management system starting from generation to disposal of waste. It was assumed that the waste management condition of any hospital depends on the conditions of these parameters. That means, if these parameters are properly addressed in a waste management system, the overall waste management condition of the hospital will be satisfactory. Relevant Government and Non-government guidelines were studied to select these parameters (Ministry of Health and Welfare, 2001; Akhter, 2000; Akhter et al., 1998)

The selected parameters and their description are given below:

Table-3.1: List of selected parameters and their descriptions.

Serial No.	Name of the Parameter	Parameters Description
1	Policy & Strategy	Defined policy and strategy regarding waste management in the hospital.
2	In house waste management system	Waste management system inside the hospital.
3	Waste Production Control	Minimizing waste production by proper management and timely action.
4	Waste Identification	Identification of different types of wastes based on its characteristics
5	Waste Separation	Separation of wastes at its production place

Serial No.	Name of the Parameter	Parameters Description
6	Colorful Container	After primary separation, keeping different types of wastes in different colored containers where each color indicates a particular type of waste.
7	Waste Measurement	Measuring the weight/mass of the wastes before final disposal on regular basis.
8	Safe Collection	Protective measures to be taken during collection of wastes.
9	Safe Transportation	Safe transportation of wastes for temporary preservation.
10	Fixed time of collection	Fixed time of collecting wastes everyday
11	Maintenance of Collection Trolleys	Cleaning of waste collection trolleys after every time it's used.
12	Temporary storage	Temporary storage of wastes for certain period of time before final disposal.
13	Proper waste storage place	Selection of proper waste storage place with sufficient facilities.
14	Danger Sign/ Indication	Placing a danger sign on the entrance door of the waste storage place to prevent general people from entering there.
15	Waste Transformation	Transformation of hazardous wastes into non-hazardous waste.
16	Safe Disposal	Safe disposal of that non-hazardous waste.
17	Sharps separation and disposal	Separation of sharp wastes and safe disposal following proper procedure.
18	Incineration	Placing incinerators away from populated area.
19	Protected Landfill	Residue from incinerator is dumped into a protected landfill.
20	Chemical Disinfection	Addition of chemicals to the wastes to kill/inactivate the pathogens.
21	Radioactive, pathogenic & toxic waste managements	Waste management for radioactive, pathogenic and toxic wastes.
22	Health Safety	Health Safety facilities for the workers doing hospital waste management.
23	Hand washing Facility	Proper Hand washing facility for workers at every floor of a hospital.
24	First Aid and Treatment	First Aid and immediate treatment facility for workers.
25	Occupational Safety	Occupational safety is related to the job satisfaction of the workers doing hospital waste management.
26	Training Facility	Training on hospital waste management for workers.
27	Education	Minimum level of education required for workers.

Serial No.	Name of the Parameter	Parameters Description
28	Record Keeping	Collection of day to day information of amount of waste produced, collected, transported and disposed etc.
29	Monitoring and Supervision	Effective monitoring and supervision of the waste management system.
30	Capacity Development	Developing capacity including manpower, equipment etc.
31	Proximity of disposal site	It refers to the distance at which the waste is being disposed from the location of it's source.
32	Encapsulation of hazardous, chemical, sharp and pathogenic waste	It refers that these kind of waste should be encapsulated and never be exposed to open air before destroying.
33	Sincerity of waste workers and health care personnel	Ethical responsibility of workers for being utmost careful in their job.

3.3 Determination of Relative Importance of Selected Parameters

There are various factors responsible for good hospital waste management. In this study, 33 (thirty three) parameters were identified that can effect a waste management system of a hospital. But all the parameters are not equally important. Some parameters are more crucial towards achieving the goal of effective hospital waste management system. In order to distinguish the more important parameters from all the listed parameters, a relative importance factor of selected parameters was necessary.

In order to do the relative importance grading of the parameters, definition of weights for grading was defined in the following way:

Table-3.2: Definition of weights for each parameter

Weight	Description of Consequences
5	Most Important- If not present, very high damage of both life and health may occur
4	Important- If not present, considerable damage of both life and health may occur
3	Essential- loss of life may not occur, but other losses and injuries are high
2	Essential- damage of health and injuries are considerable
1	Not Essential but preferable

Based on this description of weightage, the selected parameters were individually graded by 8 (eight) experts. Experts were selected based on their knowledge and work experience in this regard an all these experts are national experts.

List of the experts including their name and designation are given below:

Table-3.3: List of experts and their designation

Name of the Expert	Designation of the Expert
Dr. Saiedur Rahman	Assistant Director Directorate General of Health Services (DGHS), Mohakhali, Dhaka-1212.
Dr. A.S.M. Nazmul Haque	Deputy Program Manager MWM, ESD DGHS, Mohakhali, Dhaka-1212.
Dr. Tarit Kanti Biswas	Freelance Consultant in Environment & Health Safety.
ATM Mustafa Kamal	Associate Professor Dept. of Soil and Environmental Science Dhaka University (DU), Dhaka.
Kh. Anisur Rahman	Executive Director PRISM Bangladesh Foundation Banani, Dhaka-1213.
Md. Abdul Aleem	Research Investigator ICDDR, Dhaka.
Mohammad Ullah	Professional Practice Leader (Nursing) ICDDR, Dhaka.
Ziaul Haque	Deputy Director Dept. of Environment, Agargaon, Dhaka.

After the grading of selected parameters were done by the eight experts, for each parameter the grading given by the experts were averaged to determine the final weight of that particular parameter. In this way the weights of all the parameters were determined and relatively important parameters were distinguished.

3.4 Survey of Hospitals to Identify the Condition of Parameters

After determining the importance grading of selected parameters, it was necessary to check the actual condition of those parameters in hospitals of our country. In order to do that, 30 (thirty) hospitals including 24 (twenty four) hospitals in Dhaka city and 6 (six) hospitals outside Dhaka city were physically surveyed.

During the survey a questionnaire was prepared that included questions related to all the selected parameters. Authority, staff, ward master, nurses and different people working in those hospitals were interviewed and also the condition of hospital was physically seen to fill up the survey questionnaire. Based on these completed survey questionnaire, all the parameters for each hospital were rated on a scale of 0 to 5. Qualitative descriptions (which will depend on surveyor's judgments) of rating values are given in Table 8.

Table 3.4: Qualitative description of selected waste management parameters for hospitals surveyed in present study.

Rating Point	Qualitative description
5	Excellent
4	Good
3	Average
2	Poor
1	Very Poor
0	Absent

These grading were later used to calculate an index that would generally indicate the waste management condition of that hospital.

3.5 Definition of Hospital Waste Management Index (HWMI)

One of the objectives of this study was to develop a single Hospital Waste Management Index (HWMI) for assessing the overall condition of waste management in the hospitals in Bangladesh. A single hospital waste management index (HWMI) was developed from the physical survey data and the relative importance grading of the identified hospital waste management parameters for different hospitals. HWMI was calculated based on the following formulae:

$$HWMI = \frac{\sum_{i=1}^n w_i x_i f}{\sum_{i=1}^n w_i}$$

Where, x_i = dimensionless score or rating for parameter i ,

w_i = the importance or grading of parameter i , and

n = the number of total parameters.

f = Additional factor depending on the grading and rating of a parameter.

Definition of additional factor, f is given below:

Table 3.5: Definition of additional factor, f .

Grading Range	If rating is from 0 to 3	If rating is above 3
≥ 3.76	$f = 1$	$f = 1$
3.26 to 3.75	$f = 1$	$f = 0.85$
≤ 3.25	$f = 1$	$f = 0.70$

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 General

In this study, 8 experts (from relevant Govt. and non-govt. organizations) have graded the selected parameters to determine the relative importance ranking of the parameters. In total, 30 hospitals were physically surveyed to assess the overall condition of waste management including 24 hospitals inside Dhaka city and 6 hospitals outside Dhaka city. All the survey results were used to determine the Hospital Waste Management Index (HMWI). In this chapter, the final grading of parameters, the results found from hospital surveys and their comparative study will be presented to indicate different aspects which are important in this regard.

4.2 Weightage of Parameters

Based on the grading taken from eight experts, final grading of all the 33 parameters was determined. For every parameter, the individual grading of eight experts was averaged to get the final weightage. Based on this grading a relative importance ranking of the parameters was prepared. Listed parameters with their weightage are given below:

Table-4.1: Weight of parameters and their ranking

Rank	Name of the parameter	Description of the parameter	Average Weight
1	Radioactive, pathogenic & toxic waste managements	Waste management for radioactive, pathogenic and toxic wastes.	4.63
2	Health Safety	Health Safety facilities for the workers doing hospital waste management.	4.25
3	Policy & Strategy	Defined policy and strategy regarding waste management in the hospital.	4.13
4	In house waste management system	Waste management system inside the hospital.	4.13
5	Sharps separation and disposal	Separation of sharp wastes and safe disposal following proper procedure.	4.13
6	Occupational Safety	Occupational safety is related to the job satisfaction of the workers doing hospital waste management.	4
7	Safe Collection	Protective measures to be taken during collection of wastes.	3.88
8	Waste Separation	Separation of wastes at its production place	3.75
9	Sincerity of waste workers and health care personnel	Ethical responsibility of workers for being utmost careful in their job.	3.75
10	Safe Disposal	Safe disposal of non-hazardous waste.	3.75

Rank	Name of the parameter	Description of the parameter	Average Weight
11	Waste Identification	Identification of different types of wastes based on its characteristics.	3.63
12	Safe Transportation	Safe transportation of wastes for temporary preservation.	3.63
13	Chemical Disinfection	Addition of chemicals to the wastes to kill/inactivate the pathogens.	3.63
14	Hand washing Facility	Proper Hand washing facility for workers at every floor of a hospital.	3.63
15	Encapsulation of hazardous, chemical, sharp and pathogenic waste	It refers that these kind of waste should be encapsulated and never be exposed to open air before destroying.	3.63
16	Proper waste storage place	Selection of proper waste storage place with sufficient facilities.	3.5
17	Incineration	Placing incinerators away from populated area.	3.5
18	Colorful Container	After primary separation, keeping different types of wastes in different colored containers where each color indicates a particular type of waste.	3.5
19	Danger Sign/ Indication	Placing a danger sign on the entrance door of the waste storage place to prevent general people from entering there.	3.38
20	Waste Transformation	Transformation of hazardous wastes into non-hazardous waste.	3.38
21	Protected Landfill	Residue from incinerator is dumped into a protected landfill.	3.38
22	First Aid and Treatment	First Aid and immediate treatment facility for workers.	3.38
23	Training Facility	Training on hospital waste management for workers.	3.25
24	Monitoring and Supervision	Effective monitoring and supervision of the waste management system.	3.13
25	Waste Production Control	Minimizing waste production by proper management.	3.13
26	Capacity Development	Developing capacity including manpower, equipment etc.	3
27	Fixed time of collection	Fixed time of collecting wastes everyday	2.88
28	Proximity of disposal site	It refers to the distance at which the waste is being disposed from the location of it's source.	2.75
29	Education	Minimum level of education required for workers.	2.63
30	Record Keeping	Collection of day to day information of amount of waste produced, collected, transported and disposed etc.	2.5
31	Temporary storage	Temporary storage of wastes for certain period of time before final disposal.	2.25

Rank	Name of the parameter	Description of the parameter	Average Weight
32	Waste Measurement	Measuring the weight/mass of the wastes before final disposal on regular basis.	2.13
33	Maintenance of collection trolleys	Cleaning of waste collection trolleys after every time it's used.	2.13

A bubble chart showing experts' weights for each parameter is given below:

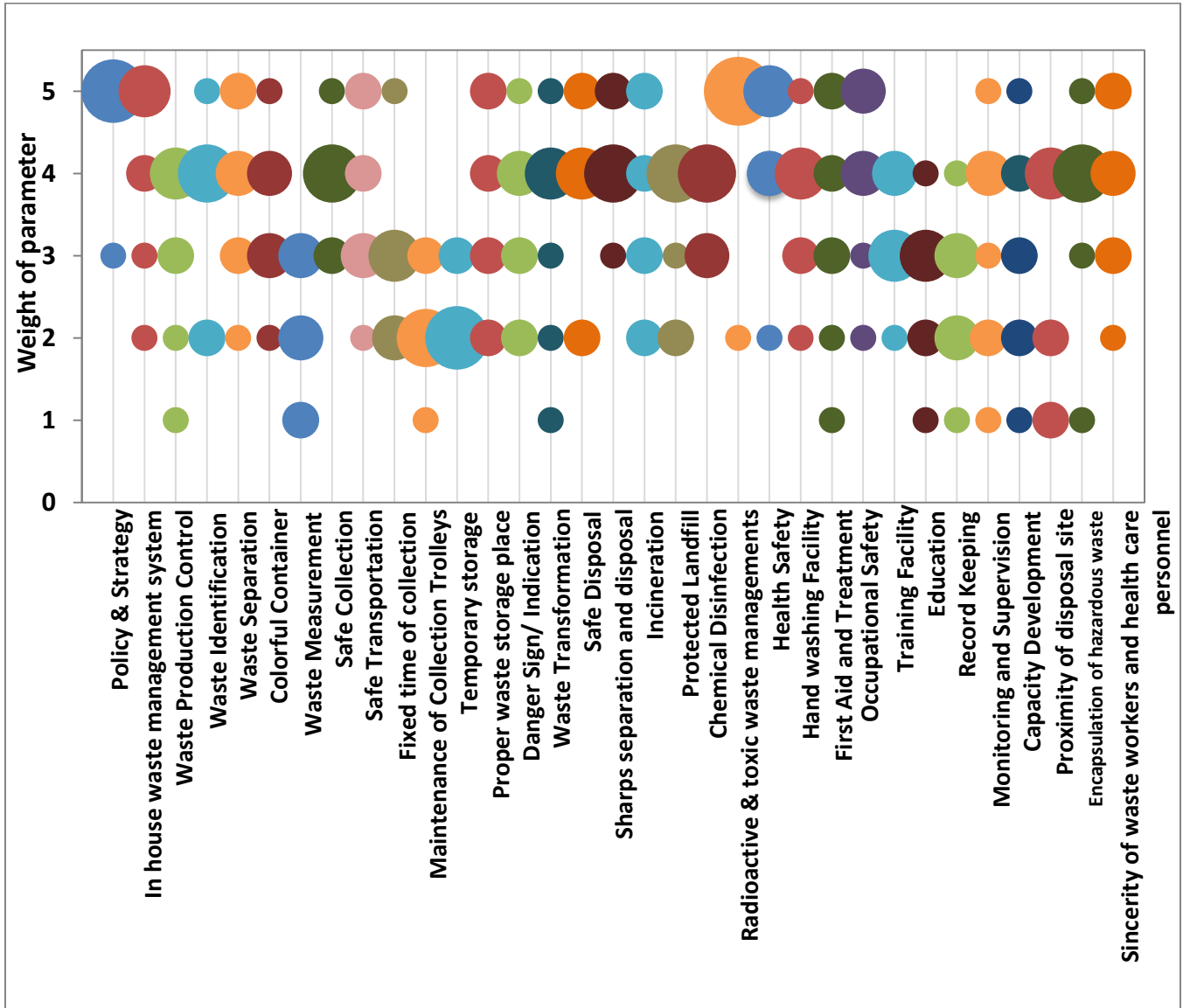


Figure-4.1: Bubble chart for experts' weight for each parameter (size of the bubble represents no. of experts awarding the weight in the Y axis).

4.3 Obtained HWMI of Different Hospitals of Bangladesh

In total 30 hospitals were surveyed all over Bangladesh and based on their condition assessed during survey a Hospital Waste Management Index (HWMI) was calculated according to the following formulae:

$$HWMI = \frac{\sum_{i=1}^n w_i x_i f}{\sum_{i=1}^n w_i}$$

Where, x_i = dimensionless score or rating for parameter i ,

w_i = the importance or grading of parameter i , and

n = the number of total parameters.

f = additional factor depending on the grading and rating of the parameter.

List of hospitals with their calculated HWMI is given below:

Table-4.2: List of hospitals and their obtained HWMI

Name of the Hospital	Location	Final HWMI
Bangladesh Medical College Hospital	Dhaka	2.91
Sir Salimullah Medical College Hospital	Dhaka	2.16
Kurmitola General Hospital	Dhaka	2.73
Gonoshastho Hospital	Dhaka	2.18
Holy Family Medical College Hospital	Dhaka	2.01
Shaheed Shuhrawardi Medical College Hospital	Dhaka	2.33
BIRDEM Hospital	Dhaka	2.64
Mohona Hospital Limited	Dhaka	2.23
National Institute of Neuroscience and Hospital	Dhaka	3.01
ICDDR,B	Dhaka	2.38
Comfort Hospital	Dhaka	2.15
Islami Bank Central Hospital	Dhaka	3.13
Maternal and Child Training Institute	Dhaka	3.19
Infectious Diseases Hospital	Dhaka	2.86
National Institute of Cancer Research and Hospital	Dhaka	2.97
National Institute of Disease of the Chest and Hospital	Dhaka	3.16
Dhaka Metropolitan Hospital	Dhaka	2.37
Dhaka Medical College Hospital	Dhaka	1.98
Shikdar Medical College Hospital	Dhaka	2.75
Al-Helal Specialized Hospital	Dhaka	2.86
National Heart Foundation and Research Institute	Dhaka	2.66
Khidmah Hospital	Dhaka	3.41
Mukti Clinic	Dhaka	2.73
Shirajul Islam Medical College Hospital	Dhaka	1.97
Dinajpur Medical College Hospital	Dinajpur	2.51

Name of the Hospital	Location	Final HWMI
Comilla Medical College Hospital	Comilla	2.73
Shaheed Ziaur Rahman Medical College Hospital, Bogra	Bogra	2.35
MAG Osmani Medical College Hospital, Sylhet	Sylhet	3.03
Mymensing Medical College Hospital	Mymensing	2.10
Chittagong Medical College Hospital	Chittagong	2.67

A frequency distribution chart was plotted with the final HWMI obtained from Table-4.2. From the frequency distribution chart it was found that the HWMI value of 22 out of 30 hospitals were in the range of 2.0 to 3.0. Only 6 hospitals have got HWMI in between 3.0 to 3.5 and none of the hospitals have got HWMI above 4.0.

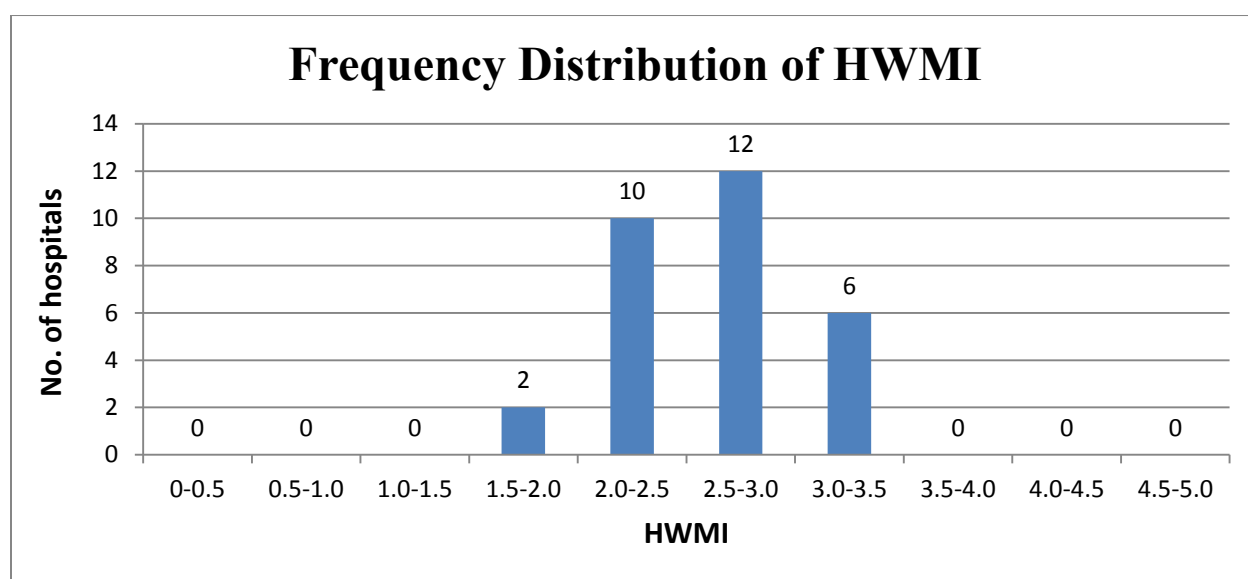


Figure-4.2: Frequency distribution of HWMI.

Figure-4.2 indicates that the HWMI obtained by the hospitals in this country is still very poor and except the six hospitals having HWMI above 3.0, all other hospitals are doing relatively poor job in hospital waste management. So in order to improve on the hospital waste management index there is still so many works to be done by these hospitals. Since the selected hospitals varied in location, size and nature; it can be assumed that same condition will be found in other hospitals of this country also. In some cases, hospitals having worse waste management practice can be found in top cities of this country.

4.4 Hospital Waste Management Scenario in Different Hospitals of Bangladesh

24 hospitals inside Dhaka city and 6 hospitals outside Dhaka city were surveyed. Based on those survey results the waste management condition of those hospitals is discussed below.

4.4.1 Condition of Hospitals Inside Dhaka

In the 24 hospitals surveyed in Dhaka city, there are similarities in obtained grading in some parameters. For example, except few hospitals almost all the hospitals got poor grading for danger sign/ indication, waste transformation, incineration, protected landfill and encapsulation of hazardous waste. While in some parameters like record keeping, education, training facility some hospitals have got good grading but some have got relatively poor grading.

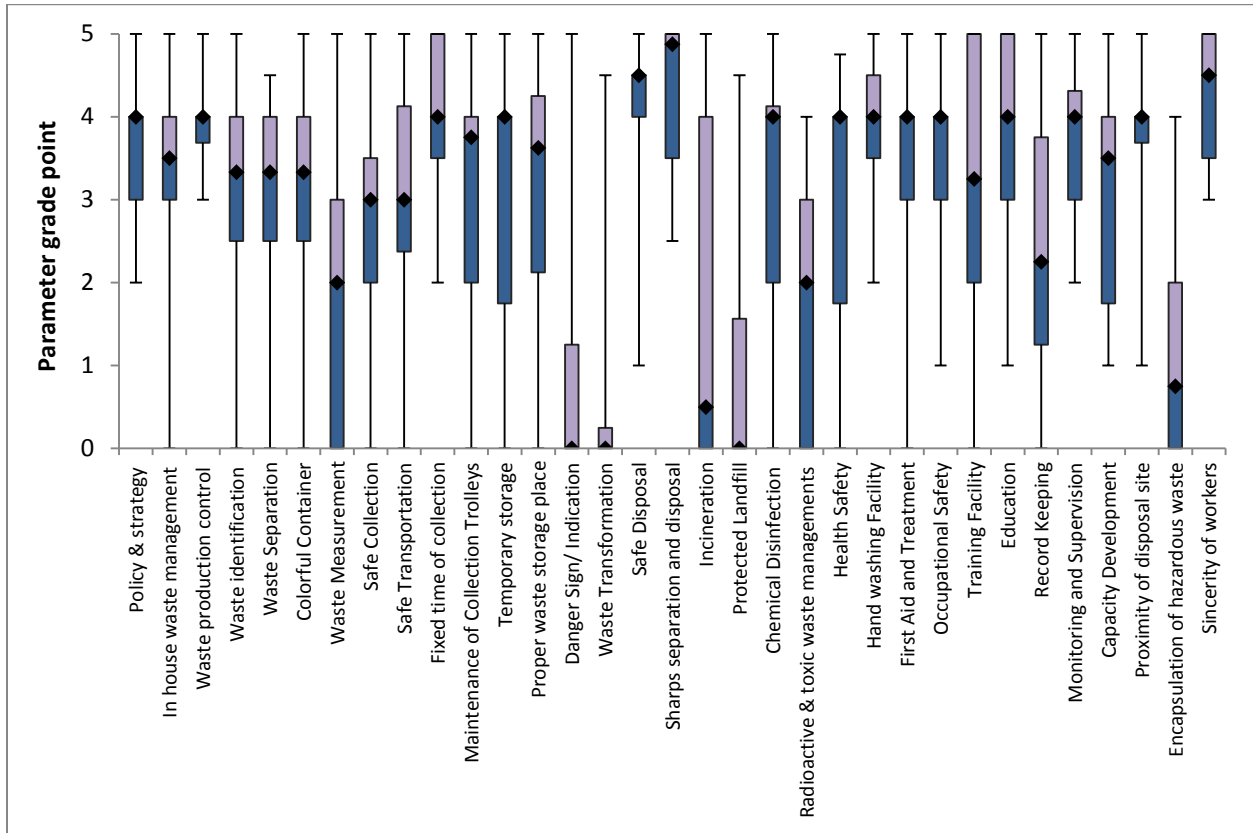


Figure-4.3: Box plot distribution of the scores for different parameters for hospitals inside Dhaka city.

Figure- 4.3 shows the box plot distribution of the scores obtained by different parameters based on surveys inside the Dhaka city. The whiskers represent maximum and minimum obtained scores, diamonds represent median and bottom & top of the box represent 25th and 75th percentiles accordingly. Clearly there are large differences among the parameters in their distribution among the hospitals. Out of 33 parameters, 25 have median grade point of greater than or equal to 3, indicating at least 50% of the hospitals scored 3 or less in those specific parameters. 7 parameters have a median grade point of less than or equal to 2, fortunately those parameters are ranked below or equal 15 out of 33 in the relative importance ranking. So it can be inferred that, the important parameters are at relatively lower risk position for hospitals in Dhaka city, but still a lot of improvement is required since their obtained scores are not high.

4.4.2 Condition of Hospitals Outside Dhaka

In total 6 hospitals were surveyed outside Dhaka city. In those hospitals, the overall condition of waste measurement was found slightly different from the hospitals inside Dhaka city. In parameters like waste measurement, waste transformation, radioactive and toxic waste management and encapsulation of hazardous waste almost all the hospitals were found to have poor scores during survey. But there are some parameters like maintenance of collection trolleys, temporary storage place, danger sign/indication, incineration, first aid treatment for staffs, training facility and educational requirement some hospitals got good scores but some didn't.

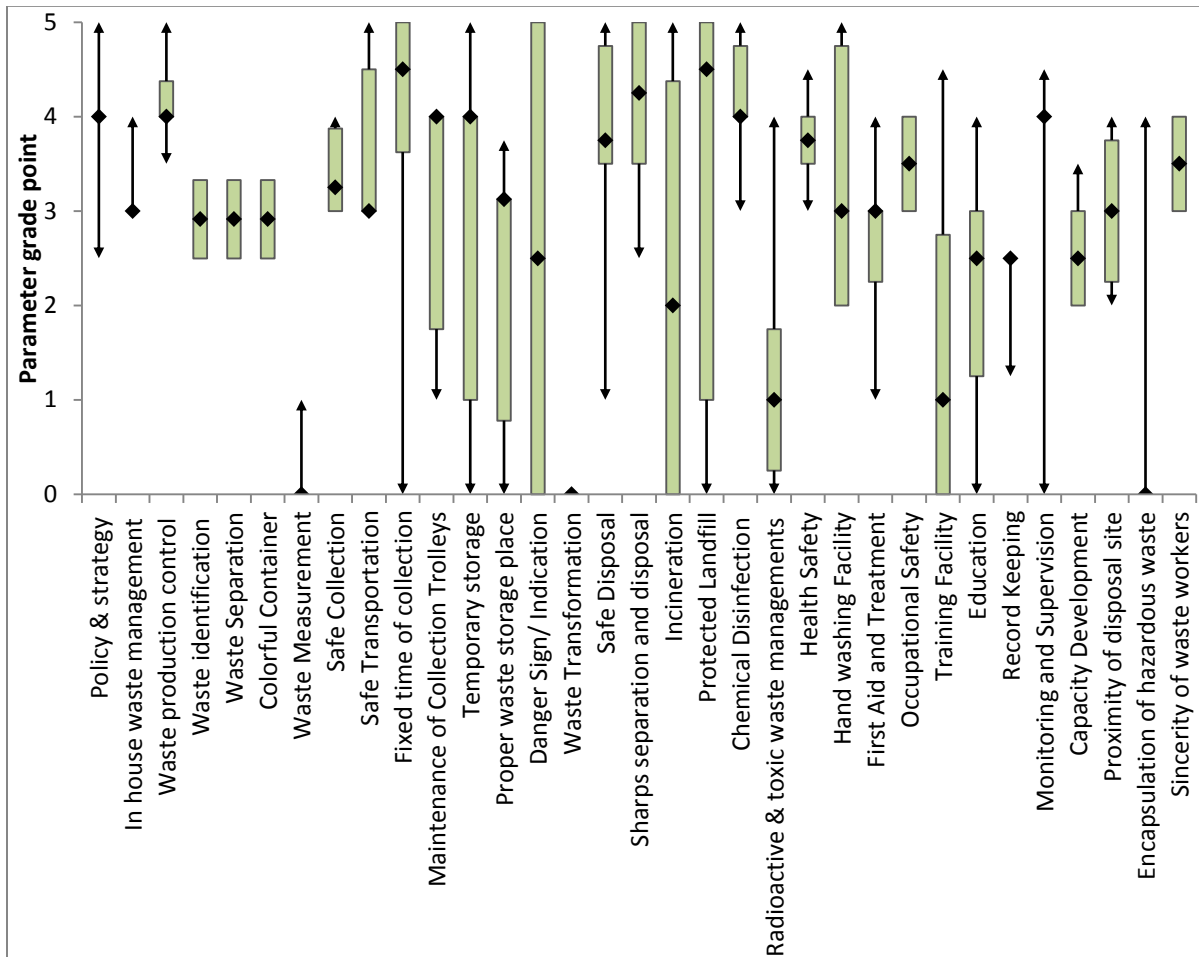


Figure-4.4: Box plot distribution of the scores for different parameters for hospitals outside Dhaka city.

Figure- 4.4 shows the box plot distribution of the scores obtained by different parameters based on surveys outside the Dhaka city. Similar to the previous figure, the whiskers represent maximum and minimum obtained scores, diamonds represent median and bottom & top of the box represent 25th and 75th percentiles accordingly. Out of 33 parameters, 20 parameters have median grade point of greater than or equal to 3, indicating at least 50% of the hospitals scored 3

or less in those specific parameters. 6 parameters have a median grade point of less than or equal to 2. Fortunately 5 of those parameters are ranked below or equal 15 out of 33 in the relative importance ranking but one of them is radioactive, pathogenic and toxic waste management which is the most important parameter according to the relative importance ranking. So it is an alarming thing that hospitals outside Dhaka city are not managing the radioactive, pathogenic and toxic wastes properly. In other parameters there is still a lot of scope for improvement.

4.4.3 Comparison of Govt. Hospitals and Non-Govt. Hospitals

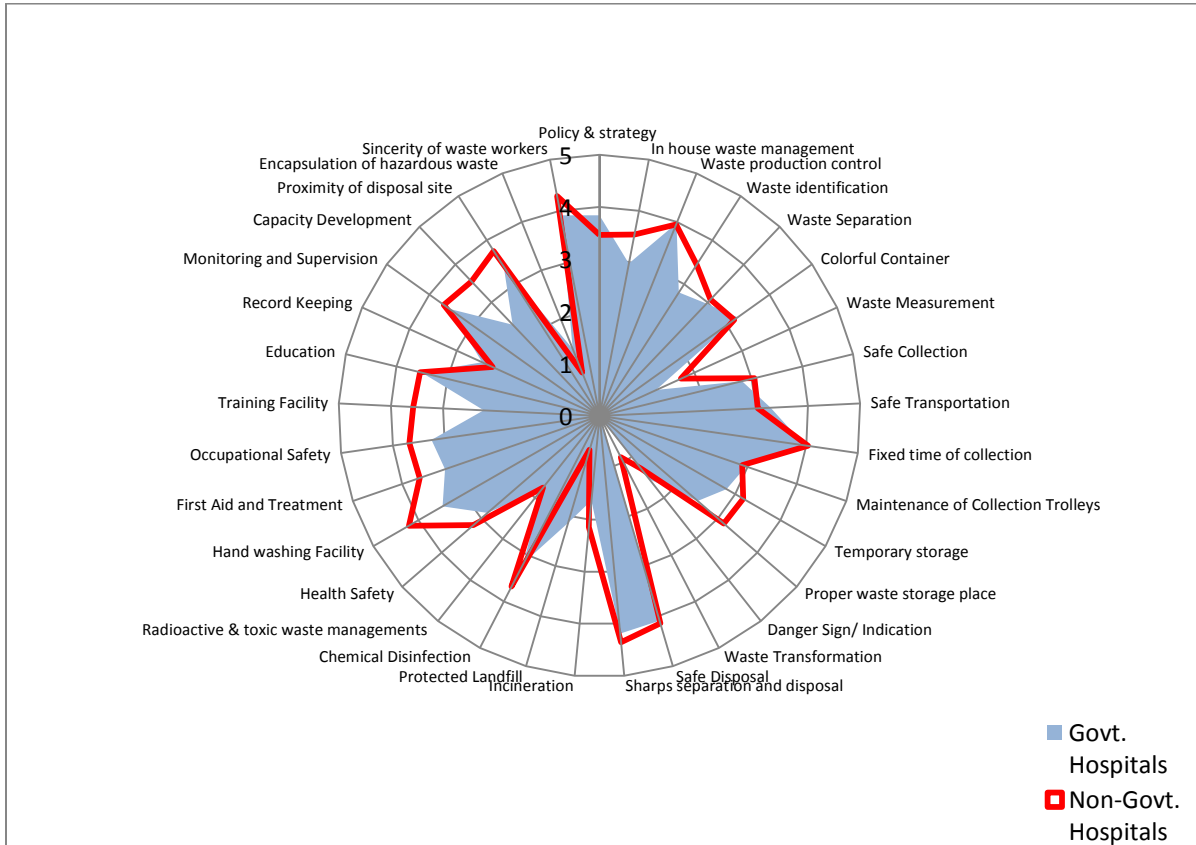


Figure-4.5: Spider diagram for the average scores of the parameters in Govt. and Non-Govt. hospitals.

In order to enhance our understanding of the differences in individual grade points for all parameters in Govt. and non-Govt. hospitals, a spider diagram was plot as in Figure-4.5. Although Govt. hospitals have marginally better scores in 10 parameters, Non-Govt. hospitals have outscored Govt. hospitals in rest of the 23 parameters, many of those by a wide margin. Except Radioactive, pathogenic & toxic waste managements; in top ten most important parameters (e.g. parameters with the largest weights by the experts) Non-Govt. hospitals have performed better than Govt. hospitals. So it can be concluded that, private organizations have better waste management practice, probably due to better facility and more accountability.

The average HWMI for Govt. and Non-Govt. hospitals are 2.85 and 3.07 respectively. From statistical t-test of the average grade points of the parameters for Govt. and Non-Govt. hospitals it is found that the difference is statistically significant ($t = 2.036$, $p = 0.017$).

4.4.4 Comparison of Hospitals Inside Dhaka and Outside Dhaka

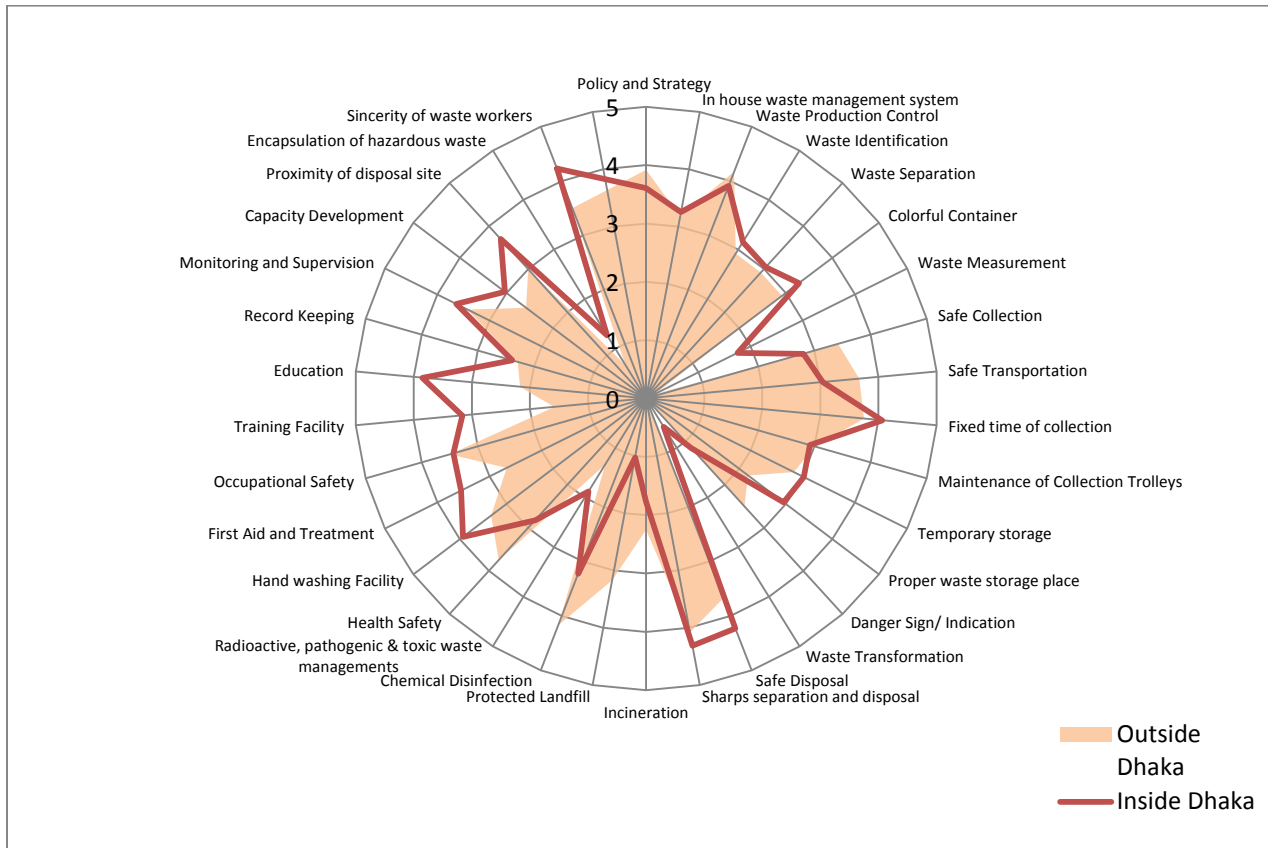


Figure-4.6: Spider diagram for the average scores of the parameters in hospitals of inside Dhaka and outside Dhaka.

From Figure-4.7 it is found that, only in 10 parameters hospitals outside Dhaka scored better grade points than hospitals inside Dhaka, in rest of the 23 parameters hospitals inside Dhaka have outscored hospitals outside Dhaka and in some parameters the difference is considerably high. Health safety, Policy and strategy, occupational safety, safe transportation, chemical disinfection and protected landfill are some very important parameters where hospitals outside Dhaka have scored better grade points than hospitals inside Dhaka. This is a positive sign for those hospitals because these parameters are mostly on the top positions of the relative importance ranking. But there are some parameters like radioactive, pathogenic and toxic waste management, in house waste management system, sharp separation and disposal, sincerity of waste workers were hospitals inside Dhaka have scored much better grade points than hospitals outside Dhaka.

The average HWMI for hospitals inside and outside Dhaka are 2.98 and 2.86 respectively. Although from statistical t-test of the average grade points of the parameters for hospitals inside and outside Dhaka it is found that the difference is not statistically significant ($t = 2.037$, $p = 0.264$).

4.5 Interpretation of Hospital Waste Management Index (HWMI)

Interpretation of Hospital Waste Management Index (HWMI) is very important because ultimately this one index will indicate the overall waste management condition of a hospital. From the experience of surveying and calculating HWMI for 30 hospitals, interpretation of HWMI can be defined in the following way:

Table- 4.3: Interpretation of HWMI

Range of HWMI	Waste Management Condition
4.0-5.0	Excellent
3.5-4.0	Very Good
3.0-3.5	Good
2.0-3.0	Average
Below 2.0	Poor

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 General

Medical waste management is a very challenging job since it requires deep knowledge about different issues related to it, huge manpower to execute works properly and also different technical facilities which are very costly. In Bangladesh there are so many hospitals including private and government hospitals, but lacking in waste management still remains in most of these hospitals. There are already some private hospitals in the country that have very good waste management practice and excellent health safety facilities available for workers and personnel working in those hospitals. Some hospitals are found to have mediocre performance in waste management, but they are also improving with time. But in most of the Govt. hospitals the condition of waste management is really poor, which results in unhealthy environment inside the hospital. A lot of improvement in waste management practice in these hospitals is required to provide the general people a safe and healthy environment while they are inside hospital for work or treatment. One of the main objectives of this study was to establish some parameters that will help improving waste management in hospitals. A total of 33 parameters and a hospital waste management index (HWMI) have been established in this study and it can be expected that by improving in these parameters the waste management condition and overall environment will improve considerably. Also the HWMI developed in the present study will work as a single parameters to assess and monitor the overall hospital waste management scenario in hospitals across the country.

5.2 Conclusions

Following conclusions can be drawn from this study:

- A total thirty three parameters are identified and their relative importance with respect to hospital waste management is also obtained by experts' opinion.
- Twenty four hospitals were surveyed inside Dhaka city from which it was found that hospitals inside Dhaka city are doing poor performance in parameters like danger

sign/indication, waste transformation, incineration, protected landfill, encapsulation of hazardous waste. Some hospitals need to improve on training facilities, record keeping and educational requirements for workers.

- Six hospitals were surveyed outside Dhaka from which it was found that those hospitals outside Dhaka are doing poor performance in waste measurement, waste transformation, radioactive and toxic waste measurement and encapsulation of hazardous waste. Some hospitals need to improve on their maintenance of collection trolleys, temporary storage place, first aid treatment, training facilities etc. but others are doing relatively good.
- Comparison was made between Govt. and Non-Govt. hospitals from which it was found that Non-Govt. hospitals are doing better in most of the parameters. The difference between the average obtained HWMI for these two types of hospitals is statistically significant.
- Comparison was made between hospitals inside and outside Dhaka and it was found that hospitals inside Dhaka are doing better in most of the parameters. The difference between the average obtained HWMI is not statistically significant.
- From the calculated HWMI it was found that most of the hospitals have got HWMI less than or equal to 3.0 on a scale of 5.0. Only six hospitals have got HWMI of above 3.0.

5.3 Recommendations

Following recommendations can be made for future study:

- Similar survey can be conducted to other hospitals of the country. Specially, the secondary and tertiary hospitals can be surveyed to assess the waste management conditions there. If needed, separate parameters can be identified for those types of hospitals and different list of parameters can be made for primary, secondary and tertiary hospitals.
- There are some reputed hospitals in this country like Apollo, Square, United etc. who have very good waste management practice. During this study it was not possible to survey those hospitals due to lack of access. If somehow access is managed and a survey is conducted in these hospitals, then the learning will help us to improve the waste management in other hospitals.

- In this study only eight experts were found who graded the list of selected parameters to make the relative importance ranking of the parameters. It can be mentioned here that, it is still very difficult to find a lot of experts in hospital waste management in this country. But since nowadays there are some Govt. and private organizations working in this regard, in the future more experts can be involved for any expert opinion.

REFERENCES

Hasan, M. M. (2008). Assessment of Healthcare Waste Management Practices in Khulna City Corporation (M. Eng. thesis).

Haque, M. S. (2008). A Study on Healthcare Waste Management in Chandpur Pourashava (M. Eng. thesis)

Rahman, M. H. (2000). Healthcare waste management in Dhaka City, Bangladesh. *Warmer Bulletin, Journal for sustainable waste management*, 75, p.16.

Medical Waste (Management and Processing) Rules, 2008. SRO No.294-Law/2008.

Hospital Services, DGHS. (n.d.). Retrieved March 19, 2015, from <http://www.hsmdghs-bd.org/>

Ministry of Health and Family Welfare (2001). *Manual for Hospital Waste Management*. Directorate General of Health Services, Dhaka, Bangladesh.

Ministry of Health and Family Welfare (2010). *Pocket Book on Hospital Waste Management*. Dhaka, Bangladesh.

Akter, N. (2000). *Medical waste management: a review*. Asian Institute of Technology, School of Environment, Resources and Development, Thailand, 3, pp. 485-486.

Akter, N., et al. (1998). *Medical Waste Disposal at BRAC Health Centres An Environmental Study*. BRAC Research, Research and Evaluation Division 75.

Hossain, M. L. & M. J. Uddin (2014). *Medical Waste Management at Upazila Level in Bangladesh*. *Journal of Environmental Treatment Techniques*, 2(3), pp. 85-94.

Onel, S. (1989). *Medical Waste Tracking Act of 1988: Will It Protect Our Beaches*, 9, pp. 225.

Sarkar, M. K. A., et al. (2006). Hospital waste management in Sylhet City. *ARPJ Journal of Engineering and Applied Sciences*, **1**(2), pp. 32-40.

Zerin, S. & M. Ahmed (2009). Hospital waste management in Dhaka: a threat. *Bangladesh Res. Pub. Journal*, **3**(1), pp. 796-811.

Nasreen, M. (2005). The Right to a Safe Environment. *Human Rights in Bangladesh 2004*, p 218.

World Bank (1991). *Environmental assessment sourcebook, Volume II: Sectoral Guidelines*, World Bank Technical Paper No 140, Environmental Department.

APPENDIX

Table: A (HWMI of Hospitals Inside Dhaka City)

Parameters	Weight factor	Hospital Gradings																							
		Bangladesh Medical College Hospital	Solimullah Medical College Hospital	Kurmitola General Hospital	Gonoshastho Hospital	Holy Family Medical College Hospital	Shaheed Shuhrawardi Medical College Hospital	BIRDEM Hospital	Mohona Hospital Limited	National Institute of Neuroscience & Hospital	Khidmah Hospital, Khilgaon, Dhaka.	Mukti Clinic, Khilgaon, Dhaka.	Shirajul Islam Medical College Hospital, Malibag, Dhaka	ICDDR,B	Comfort Hospital	Islami Bank Central Hospital	Maternal and Child Training Institute	Infectious Diseases Hospital	National Institute of Cancer Research and Hospital	National Institute of Diseases of the Chest and Hospital	Dhaka Metropolitan Hospital	Dhaka Medical College & Hospital	Sikder Medical College & Hospital	AI Helal Specialized Hospital	National Heart Foundation Hospital and Research Institute
Policy and Strategy	4.125	4	2	5	4	2.5	4	4	4	5	4	2.5	5	5	2	2	3	3	3	4	4	3	3.5	4	4
In house waste management system	4.125	4	3.5	3	3	3	3	3.5	3	5	3.5	4	5	5	3	3.5	5	5	0	1	1	1	4	4	2
Waste Production Control	3.125	4.5	3	4.5	3.5	4	3	4	4	4	4	4	5	4	4	4	4	4	4	4.5	3.5	3.5	3.75	3	4
Waste Identification	3.625	3.5	3.33	2.5	3.33	3.33	3.33	2.5	2.5	2.5	3.33	0	4.2	2.5	4	5	4	2	1	3	4.5	4	4	4	3.33
Waste Separation	3.75	3.5	3.33	2.5	3.33	3.33	3.33	2.5	1.67	2.5	3.33	0	4.2	2.5	4	4	1	0	4	4.5	4.5	4	3.75	4	3.33
Colorful Container	3.5	3.5	3.33	2.5	3.33	3.33	3.33	2.5	1.67	2.5	3.33	0	4.2	2.5	4	5	1	4	4	4.5	4.5	4.5	4	4	3.33
Waste Measurement	2.125	3.5	0	2	0	0	0	2	0	2.5	0	0	2	2.5	0	4	3	3	1	2	4	5	2	3.5	0
Safe Collection	3.875	3.75	3	3	0	2	2.5	4	1	3.5	3	3	5	4	3	3.5	3	1	1	3.5	3.5	1	5	3	2
Safe Transportation	3.625	3	4	5	0	3.5	3	3.5	3	4	0	2.5	5	5	5	5	4	3	0	3	2.5	1.5	4.5	1	2
Fixed time of collection	2.875	5	4	5	4	5	3	4	5	5	3	2.5	5	4	2	4	4.5	3.5	3	3.5	4	5	4.5	4	5
Maintenance of Collection Trolleys	2.125	4.5	4	4	2	2	3	4	4	4	0	0	5	4	4	5	3.5	3	0	4	2	3.5	4.5	0	0
Temporary storage	2.25	2	0	1	4	1	4	4	4	4	0	3	4	4	4	1	5	4.5	3	3.5	5	4	4.5	3	0
Proper waste storage place	3.5	3.75	0	0	3.75	0	2.5	3.75	4.375	5	0	3	3	5	3.75	1	4.5	3.5	3	3.5	4.25	4.25	4	5	0
Danger Sign/ Indication	3.375	1	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5	4	0	1	2	4.75	5	0	0
Waste Transformation	3.375	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0	1	0	0	0	2	1.25	4.5	0	0
Safe Disposal	3.75	4	5	4.5	4.5	3.5	4.5	4.5	5	4	4.5	1	5	4	4.5	4.5	4.5	4	4.5	5	4.5	5	4	4	3

Parameters	Weight factor	Hospital Gradings																							
		Bangladesh Medical College Hospital	Solimullah Medical College Hospital	Kurmitola General Hospital	Gonoshastho Hospital	Holy Family Medical College Hospital	Shaheed Shuhrawardi Medical College Hospital	BIRDEM Hospital	Mohona Hospital Limited	National Institute of Neuroscience & Hospital	Khidmah Hospital, Khilgaon, Dhaka.	Mukti Clinic, Khilgaon, Dhaka.	Shirajul Islam Medical College Hospital, Malibag, Dhaka	ICDDR,B	Comfort Hospital	Islami Bank Central Hospital	Maternal and Child Training Institute	Infectious Diseases Hospital	National Institute of Cancer Research and Hospital	National Institute of Diseases of the Chest and Hospital	Dhaka Metropolitan Hospital	Dhaka Medical College & Hospital	Sikder Medical College & Hospital	AI Helal Specialized Hospital	National Heart Foundation Hospital and Research Institute
Sharps separation and disposal	4.125	5	4.5	5	5	3.5	5	5	3	3	3	5	5	5	5	5	2.5	3.5	3.25	3.5	4.5	4.75	4.5	5	5
Incineration	3.5	0	0	0	4	2	0	4	0	0	5	0	0	4	0	4	5	4.5	0	1	1	3	5	0	0
Protected Landfill	3.375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.5	4	4	4	1	3.25	4	0	0
Chemical Disinfection	3.625	4	0	4	4	0	0	3	4	4	5	5	3	5	4	4.5	4	4	1	1	2	4.75	5	4	2
Radioactive, pathogenic & toxic waste managements	4.625	4	3	3.5	2	2	2	2	0	4	0	0	0	3	2	3	3	0	3.5	1.5	1	0	2.5	3	0
Health Safety	4.25	4	2	4	1	1	2.5	2	0	4.5	4	4	4.5	4	4	4.5	4	0	0	4	4.5	0	4.75	2.5	2
Hand washing Facility	3.625	4.5	4	5	4	3	3	4	4	4	5	5	5	4	4	4	3.5	3	3	4	4.5	3.5	4.5	4	2
First Aid and Treatment	3.375	5	4	4	4	4	3	2	4	2	3	4	4	4	4	4	4	3	4	4	4	3	0	5	3
Occupational Safety	4	2	2	4	2	4	4	4	4	5	3	5	4	4	5	4.5	3	2	1	3	3	3	4	4	3
Training Facility	3.25	3	4.5	0	4	0	2	2	3	4	5	3	5	5	5	5	4.5	0	0	3.5	3	5	2.5	5	2
Education	2.625	5	5	5	1	2	2	5	3	5	3	3	5	5	2	4	4	4	4	4	4	4	3.5	5	5
Record Keeping	2.5	5	0	2.5	1.25	2	1.25	0	1.25	5	0	0	2	5	2.5	3.75	3	3	1	2	4	4.75	3	3.75	1.25
Monitoring and Supervision	3.125	3.5	4	4	2	2	2	4	5	5	5	3	5	5	2	4	3	3	3	3	4	4	4.25	4.5	3
Capacity Development	3	4	2	4	1	4	1	1	4	3.5	4	4	4.5	3	3	3	3.5	1	1	3	5	3.5	4.75	4	1
Proximity of disposal site	2.75	4	4	2	3	1	4	4	4	4	4	2	4.5	3.5	4	4	5	4	3	4	4.5	3.75	4.5	4	4
Encapsulation of hazardous, chemical, sharp and pathogenic waste	3.625	2	0	3.5	0	0	2	2	0	4	0	0	0	2	0	1	4	0.5	4	2	1	0	2.5	0	0

Parameters	Weight factor	Hospital Gradings																							
		Bangladesh Medical College Hospital	Solimullah Medical College Hospital	Kurmitola General Hospital	Gonoshastho Hospital	Holy Family Medical College Hospital	Shaheed Shuhrawardi Medical College Hospital	BIRDEM Hospital	Mohona Hospital Limited	National Institute of Neuroscience & Hospital	Khidmah Hospital, Khilgaon, Dhaka.	Mukti Clinic, Khilgaon, Dhaka.	Shirajul Islam Medical College Hospital, Malibag, Dhaka	ICDDR,B	Comfort Hospital	Islami Bank Central Hospital	Maternal and Child Training Institute	Infectious Diseases Hospital	National Institute of Cancer Research and Hospital	National Institute of Diseases of the Chest and Hospital	Dhaka Metropolitan Hospital	Dhaka Medical College & Hospital	Sikder Medical College & Hospital	AI Helal Specialized Hospital	National Heart Foundation Hospital and Research Institute
Sincerity of waste workers and health care personnel	3.75	3	3.5	4.5	3.5	5	3.5	4.5	4	4	5	5	5	4.5	3	4	5	3	4	5	5	4.5	5	3	5
	HWMI	2.93	2.16	2.727	2.183	2.007	2.332	2.639	2.226	3.009	2.378	2.149	3.128	3.185	2.863	2.969	3.158	2.368	1.979	2.747	2.864	2.664	3.405	2.732	1.97

Table: B (HWMI of Hospitals Outside Dhaka)

Parameters	Weight factor	Hospital Gradings					
		Dinajpur Medical College Hospital	Comilla Medical College Hospital	Shaheed Ziaur Rahman Medical College Hospital, Bogra	MAG Osmani Medical College Hospital, Sylhet	Mymensing medical college Hospital	Chittagong Medical College Hospital
Policy and Strategy	4.125	2.5	4	4	4	5	4
In house waste management system	4.125	3	3	3	4	3	3
Waste Production Control	3.125	4	3.5	4	4	5	4.5
Waste Identification	3.625	3.33	2.5	2.5	3.33	2.5	3.33
Waste Separation	3.75	3.33	2.5	2.5	3.33	2.5	3.33
Colorful Container	3.5	3.33	2.5	2.5	3.33	2.5	3.33
Waste Measurement	2.125	0	1	0	0	0	0
Safe Collection	3.875	3	3	3.5	3	4	4
Safe Transportation	3.625	5	3	3	5	3	3
Fixed time of collection	2.875	4	5	0	5	3.5	5
Maintenance of Collection Trolleys	2.125	4	1	4	1	4	4
Temporary storage	2.25	0	4	5	4	0	4
Proper waste storage place	3.5	0	3.125	3.125	3.75	0	3.125
Danger Sign/ Indication	3.375	0	5	0	5	0	5
Waste Transformation	3.375	0	0	0	0	0	0
Safe Disposal	3.75	3.5	3.5	5	5	1	4
Sharps separation and disposal	4.125	5	3.5	3.5	5	2.5	5
Incineration	3.5	0	4.5	5	4	0	0
Protected Landfill	3.375	5	5	5	4	0	0

Parameters	Weight factor	Hospital Gradings					
		Dinajpur Medical College Hospital	Comilla Medical College Hospital	Shaheed Ziaur Rahman Medical College Hospital, Bogra	MAG Osmani Medical College Hospital, Sylhet	Mymensing medical college Hospital	Chittagong Medical College Hospital
Chemical Disinfection	3.625	4	4	4	5	5	3
Radioactive, pathogenic & toxic waste managements	4.625	2	0	1	4	0	1
Health Safety	4.25	3.5	4.5	3.5	3	4	4
Hand washing Facility	3.625	5	5	2	4	2	2
First Aid and Treatment	3.375	4	3	1	2	3	3
Occupational Safety	4	4	4	3	3	3	4
Training Facility	3.25	4.5	0	0	0	2	3
Education	2.625	3	3	0	1	2	4
Record Keeping	2.5	2.5	2.5	1.25	2.5	2.5	2.5
Monitoring and Supervision	3.125	0	4	4	4.5	4	4
Capacity Development	3	3	2	3	3.5	2	2
Proximity of disposal site	2.75	3	3	2	4	2	4
Encapsulation of hazardous, chemical, sharp and pathogenic waste	3.625	0	0	0	4	0	0
Sincerity of waste workers and health care personnel	3.75	3	4	3	4	3	4
HWMI		2.508	2.732	2.352	3.029	2.101	2.669

Table: C (Weightage Factor Determination of Parameters)

Parameters	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Average
	<i>Dr. Saiedur Rahman</i>	<i>Dr. Nazmul Haque</i>	<i>Dr. Tarit Kanti Biswas</i>	<i>ATM Mustafa Kamal</i>	<i>Kh. Anisur Rahman</i>	<i>Md. Abdul Aleem</i>	<i>Mohammad Ullah</i>	<i>Ziaul Haque</i>	
Policy & Strategy	5	0	3	5	5	5	5	5	4.125
In house waste management system	5	2	3	4	5	5	4	5	4.125
Waste Production Control	3	1	2	4	4	3	4	4	3.125
Waste Identification	4	2	2	5	4	4	4	4	3.625
Waste Separation	4	2	3	5	5	3	4	4	3.75
Colorful Container	4	2	3	5	3	3	4	4	3.5
Waste Measurement	2	1	1	3	2	2	3	3	2.125
Safe Collection	3	3	4	4	5	4	4	4	3.875
Safe Transportation	2	3	4	3	5	4	3	5	3.625
Fixed time of collection	2	2	3	5	2	3	3	3	2.875
Maintenance of Collection Trolleys	2	2	1	2	2	2	3	3	2.125
Temporary storage	2	2	2	2	2	2	3	3	2.25
Proper waste storage place	2	3	4	5	2	4	3	5	3.5
Danger Sign/ Indication	2	2	3	3	4	5	4	4	3.375
Waste Transformation	5	3	4	1	4	2	4	4	3.375
Safe Disposal	5	4	5	2	4	2	4	4	3.75
Sharps separation and disposal	4	4	3	5	4	4	5	4	4.125
Incineration	2	3	2	4	5	3	5	4	3.5
Protected Landfill	3	4	2	4	4	2	4	4	3.375
Chemical Disinfection	3	3	3	4	4	4	4	4	3.625

Parameters	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Average
	<i>Dr. Saiedur Rahman</i>	<i>Dr. Nazmul Haque</i>	<i>Dr. Tarit Kanti Biswas</i>	<i>ATM Mustafa Kamal</i>	<i>Kh. Anisur Rahman</i>	<i>Md. Abdul Aleem</i>	<i>Mohammad Ullah</i>	<i>Ziaul Haque</i>	
Radioactive, pathogenic & toxic waste managements	2	5	5	5	5	5	5	5	4.625
Health Safety	2	5	4	5	5	5	4	4	4.25
Hand washing Facility	2	4	3	3	4	5	4	4	3.625
First Aid and Treatment	1	3	2	3	5	5	4	4	3.375
Occupational Safety	2	4	3	5	5	5	4	4	4
Training Facility	2	3	3	4	3	3	4	4	3.25
Education	1	2	2	3	3	3	3	4	2.625
Record Keeping	2	1	2	3	3	2	3	4	2.5
Monitoring and Supervision	2	1	3	5	4	2	4	4	3.125
Capacity Development	3	1	3	2	5	2	4	4	3
Proximity of disposal site	4	2	2	1	4	1	4	4	2.75
Encapsulation of hazardous, chemical, sharp and pathogenic waste	1	4	3	5	4	4	4	4	3.625
Sincerity of waste workers and health care personnel	3	4	3	5	5	2	4	4	3.75

Survey Questionnaire for Collecting Experts' Grading



Research on Hospital Waste Management: Parameters and their Weights

This is a risk ranking survey where we have preselected some hospital waste management related parameters (or attributes). Please rate (or weight) them between 1 to 5 according to their importance. Thanks in advance.

Expert's Information:

Name:

Occupation:

Designation:

Office Address:

Contact Number:

Definition of Weights for Parameters

Weight	Description of Consequences
5	Most Important- If not present, very high damage of both life and health may occur
4	Important- If not present, considerable damage of both life and health may occur
3	Essential- loss of life may not occur, but other losses and injuries are high
2	Essential- damage of health and injuries are considerable
1	Not Essential but preferable

List of the Parameters

Serial No.	Short name of the Parameter	Parameters Description	Weight
1	Policy & Strategy	Defined policy and strategy in this regard.	
2	In house waste management system	Hospital wise modern and high quality waste management system	
3	Waste Production Control	Minimizing waste production by proper management	
4	Waste Identification	Identification of different types of wastes based on its characteristics	
5	Waste Separation	Separation of wastes at its production place	
6	Colorful Container	After primary separation, keeping different types of wastes in different colored containers	
7	Waste Measurement	Measuring the weight/mass of the wastes on regular basis	
8	Safe Collection	Safe collection of wastes	
9	Safe Transportation	Safe transportation of wastes for temporary preservation	
10	Fixed time of collection	Fixed time of collecting wastes everyday	
11	Maintenance of Collection Trolleys	Cleaning of waste collection trolleys every time it's used	
12	Temporary storage	Temporary storage of wastes for certain period of time	
13	Proper waste storage place	Selection of proper waste storage place	
14	Danger Sign/ Indication	Placing a danger sign on the entrance door of the waste preservation place to indicate general people	
15	Waste Transformation	Transformation of hazardous wastes into non-hazardous waste	
16	Safe Disposal	Safe disposal of that non-hazardous waste	

Serial No.	Short name of the Parameter	Parameters Description	Weight
17	Sharps separation and disposal	Separation of sharp wastes and safe disposal following proper steps	
18	Incineration	Placing incinerators away from populated area	
19	Protected Landfill	Residue from incinerator is dumped into a protected landfill	
20	Chemical Disinfection	Addition of chemicals to the wastes to kill/inactivate the pathogens	
21	Radioactive, pathogenic & toxic waste managements	Waste management for radioactive, pathogenic and toxic wastes	
22	Health Safety	Health Safety facilities for the workers doing hospital waste management	
23	Hand washing Facility	Proper Hand washing facility for workers	
24	First Aid and Treatment	First Aid an immediate treatment facility for wounded workers	
25	Occupational Safety	Occupational safety of the workers doing hospital waste management	
26	Training Facility	Training on hospital waste management for workers	
27	Education	Minimum education of workers	
28	Record Keeping	Collection of day to day information of amount of produced, collected and transported waste	
29	Monitoring and Supervision	Effective monitoring and supervision of the system	
30	Capacity Development	Developing capacity including manpower, equipment etc.	
31	Proximity of disposal site	refers that treatment and disposal of hazardous waste take place at the closest possible location to its source	

Serial No.	Short name of the Parameter	Parameters Description	Weight
32	Encapsulation of hazardous, chemical, sharp and pathogenic waste	Refers that these kind of waste should be encapsulated and never be exposed to open air before destroying.	
33	Sincerity of waste workers and health care personnel	Ethical responsibility of workers for using the utmost care in that task.	

Some other important parameters:

If you think there are some parameters that we have missed which are important in hospital waste management, please feel free to inform us.

- 1.
- 2.
- 3.
- 4.
- 5.

Date of Survey:

Location of Survey:

Survey Conducted by:

Survey Questionnaire for Physical Survey of Hospitals



Bangladesh University of Engineering and Technology Research on Hospital Waste Management: Survey Questionnaire

Research Title: Development of a hospital waste management index for major cities in Bangladesh.

Principal Researcher: Dr. Mahbuboor Rahman Choudhury
Assistant Professor,
Department of Civil Engineering, BUET

Institute: Department of Civil Engineering, BUET

Hospital (Name, Location): _____

Type of Hospital (Tick one):

- General
 - Specialized
- If specialized, specialized in _____

Type of Organization (Tick one):

- | | |
|--|--|
| <input type="checkbox"/> Government | <input type="checkbox"/> Autonomous |
| <input type="checkbox"/> Semi-government | <input type="checkbox"/> NGO (National) |
| <input type="checkbox"/> Private | <input type="checkbox"/> NGO (International) |

Which part of Dhaka city is the hospital located?

- North
- South

Number of inpatients: _____ / day

Number of outpatients: _____ / day

Number of beds (total): _____ ,

_____ in _____ ward

_____ in _____ ward

_____ in _____ ward

_____ in _____ ward

_____ in _____ ward

_____ in _____ ward

Type of Solid Waste Produced and Estimated Quantity

Source	Waste Category					
	General	Liquid	Radioactive	Recyclable	Infectious	Sharps
Total (kg / day)						

Questions:

Policy and Strategy related:

1) Do you have any policy or strategy for waste management in your hospital?

Yes

No

Are your policy / strategy sufficient to achieve the goal?

Yes

No

2) Do you have an in house waste management system?

Yes

No

What is the current condition of it?

A	B	C	D	E
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Waste Collection and Transportation Related:

1) How many types of wastes do you identify at the point of generation?

4	3	2	1	No Identification
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2) Do you separate different type of wastes?

 Yes No

3) How many colorful containers do you use for waste collection?

6	4	3	2	No Colorful Container
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What are the colors of them? (tick the colors)

Black	Yellow	Red	Blue	Green	Silver
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4) Do the workers wear globes, masks, gumboots, aprons etc. while collecting wastes?

 Yes No

5) Do you use trolley to transport waste bins in the hospital?

 Yes No

6) What time do you collect waste every day?

AM

AM

PM

PM

Is there any fixed time of collection?

Yes

No

7) Is there any separate route for transporting the wastes inside the hospital?

Yes

No

Operation & Maintenance Related:

1) Is regular maintenance (cleaning, sweeping, washing of wards, cabins and toilets) being done in your hospital?

Yes

No

Sometimes

2) Are the trolleys being washed every day after use?

Yes

No

Sometimes

3) Are the aprons, boots, gloves etc. used by workers washed every day?

Yes

No

Sometimes

4) Do you use chlorine solution / any other solution to disinfect something before reuse?

Yes

No

Sometimes

5) Do you have any record of the following:

- Waste segregation:

Yes

No

- Weight of different type of waste collected

Yes

No

- Time of waste collection

Yes

No

- Person doing segregation, weighing and disposal.

Yes

No

6) Is there any monitoring and supervision team for waste management in your hospital?

Yes

No

Who is/are the authorized persons for this system? Do you have the following people (tick mark if present):

Hospital manager

Hospital engineer

Waste management officer

7) Do you have sufficient staff for waste management?

Yes

No

Do you need further capacity development?

Yes

No

When the last time capacity development was done?

1 year ago	2 years ago	3 years ago	>3years ago
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Waste storage and disposal related:

1) Do you have a temporary waste storage place?

 Yes No

If Yes-

- Is it sufficient in size to store the waste produced every day?

 Yes No

- Do the staffs have easy access in it?

 Yes No

- Does it have a hard, impermeable floor with good drainage?

 Yes No

- Does it have water supply facility?

 Yes No

- Is it above flood level?

 Yes No

- Is the entrance restricted for common people?

 Yes No

- Is it protected from the sun?

 Yes No

- Does it have sufficient ventilation?

Yes

No

- 2) Is there a danger sign placed in front of the storage room?

Yes

No

- 3) Do you process your stored wastes somehow by using chemicals or anything?

Yes

No

- 4) How do you dispose the stored wastes? (Tick one)

- Hand it over to some Organization who collects medical wastes
- Burn it in the incinerator
- Dispose it at the nearby Dustbin
- Others (write down below what they do)

- 5) If you dispose the stored waste somewhere, how close is the disposal site?

- Within the hospital premises
- Very close to the hospital
- At a distant place from the hospital

- 6) Do you use crusher for sharp wastes?

Yes

No

Do you collect the crushed wastes and broken test tube, pipette, slide, cover slip, nail, screw, steel plate etc. in a Red bin?

Yes

No

7) Do you have an incinerator?

Yes

No

Where is it located?

- Outside the hospital premises
- Inside the premises, but at a distance from the building
- Inside the hospital building

8) Do you have a protected landfill for dumping wastes of your hospital?

Yes

No

9) Do you store toxic wastes separately from all other wastes?

Yes

No

Sometimes

Do you use lead shielding for storing radioactive waste?

Yes

No

Sometimes

Do you label the lead shielding containers with the type of radio nuclide, date, storage condition?

Yes

No

Workers related questions:

1) What percentage of workers is present every day?

100 %

80-90 %

60-80 %

< 60%

Do you consider your workers responsible and dedicated towards work?

Yes

Medium

No

2) Do you have proper hand washing facility for workers at every floor?

Yes

No

3) Do you have first aid box and emergency treatment service for workers at every floor?

Yes

No

At Some floors

4) What do the workers feel about their job, salary, working environment and facilities?
(tick one)

- Very Satisfied
- Satisfied
- Slightly Unsatisfied
- Unsatisfied
- Very Unsatisfied

5) What is the minimum educational requirement for waste management workers?

- Secondary School Certificate (SSC)
- Class 8
- Class 5
- Below Class 5
- No Educational Requirement

6) Is there any national/organizational training program for waste management workers?

Yes

No

Do you provide training to your workers before you employ them?

Yes

No